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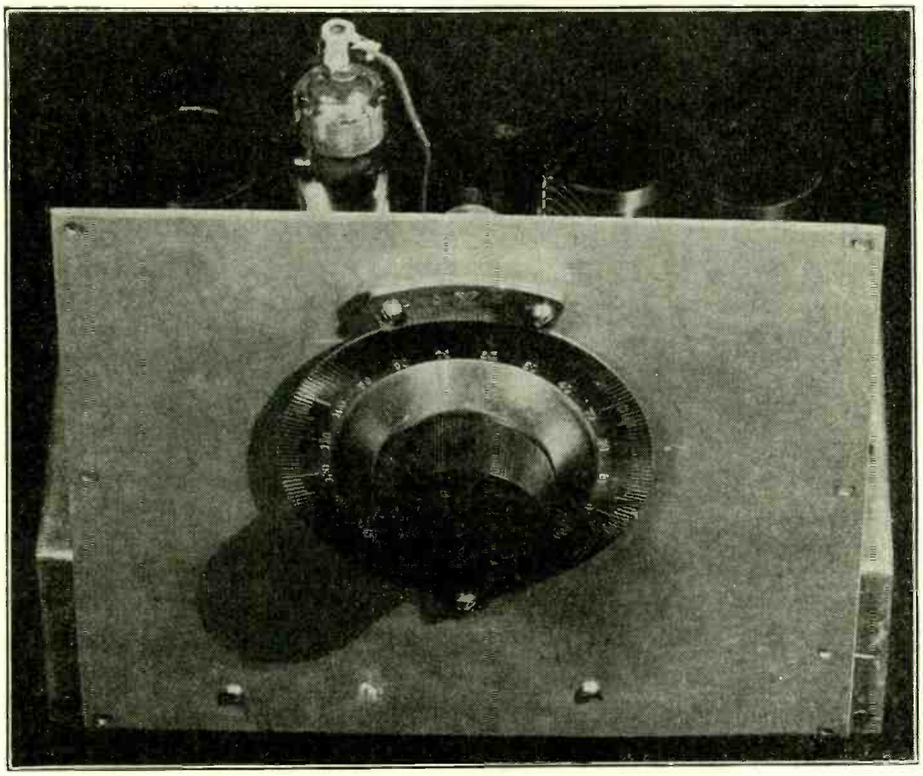

Either a 56 tube or a pentode with plate and screen united may be used in this wide-frequency range oscillator. See page 3.

Making Generated Frequencies Stay Put

Using Your Oscillator for Capacity Values

Amplifier for Use with Microphone

Percentage Modulation Measurement

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"PURE" OSCILLATORS

Grid Current Avoided to Exclude Harmonics

By Herman Bernard

ANY one desiring to build a test oscillator certainly has a variety of circuits from which to choose. The oscillator may be so arranged to work on a.c., on line d.c. or on batteries, or even might be circuited to work optionally on any one of these three power sources.

If any oscillators of this type oscillate at all, at the low frequency end, they oscillate enough all over the dial, and a small output is generally preferable to a large one. The simple modified Hartley oscillator, Fig. 1, was built for a-c operation, line connected to plate and return, and it was possible to develop an oscillation voltage of 300 volts at 50 kc, so that at the low frequency settings there was arcing between closely-separated plates of the tuning condenser. By locating the tap farther down the oscillation may be reduced, and if the tap is too far down, the oscillation will stop.

Proportion of Windings

Fig. 1 is a grid-leak-condenser type oscillator. There is no bias on the grid except that resulting from the flow of grid current. Or it might be preferable to state that the grid current may run so high that if the leak is high the voltage drop across the leak may be 300 volts. Thus ordinary grid leaks would get hot and soon burn out. Something in the nature of a higher-wattaged transmitter leak would then be necessary, for this is a strong transmitter.

With a separate tickler one-quarter the number of grid turns is usual, with rather tight coupling, for triode tubes; more turns and perhaps even tighter coupling for tubes of higher mu, including pentodes. However, for the modified Hartley in Fig. 1, using a 56, the number of turns between tap and return need not be more than one-eighth the total grid turns for other than short waves, as the coupling is extremely tight. The winding is in fact continuous.

The stability of the grid-leak-condenser type of oscillator is pretty good. It is the best stability so far obtained in an extremely simple manner.

What Is Stability?

In discussing stability, due to the wretched condition of radio terminology, it may be apropos to state what the author means. Stability consists of exclusive frequency determination by the intended LCR ratio, where L is the inductance, C the capacity and R the resistance. L would be the inductance of the coil in the circuit, C would include tuning condenser and the distributed capacitative constants, e.g., wiring, tube elements, socket, etc., and R would include a fixed value of tube impedance, leak resistance, socket leakage resistance and other proximate resistances. Therefore the tube should look to the tuned circuit as a pure resistance. The trouble is that tubes do not constitute a fixed but a changing resistance or impedance under changing voltages, unless correctives are introduced.

The presence of grid current lends a proportionality that makes the change in tube resistance practically linear in relationship to the amplitude of the oscillation. A constant plate circuit resistance is not really the requirement, but rather a constant plate impedance. The impedance may be regarded as the quotient of the voltage divided by the current, both a-c values. If there were strict linearity there would be a constant plate impedance, but the circuit goes off a bit at the higher frequencies.

Effect of Terminal Voltages

The effect of the condenser may be considered in this respect. It is well known that instability attaches to coils, whereas condensers are in general stabilizing agencies. Therefore since the LC ratio is high at the higher frequencies, this may help account for the departure from stability. If it is pardonable to reduce the frequency ratio, a fixed condenser may be put across the variable of sufficient capacity to avoid the instability region, and then a practically stable oscillator would result.

The changes in the terminal voltages affect the stability of an oscillator, that is, if changed they may change the frequency, all else unmolested. This marks instability. Voltage of itself has no effect on frequency, so we must look elsewhere. We know that the resistance of the integral tube circuit changes with changes in terminal voltage, particularly grid bias voltage changes, and if we have built sensitive superheterodynes and have used variable-bias control on the oscillator, we know that bias may change the frequency from 1,500 to 1,450 kc without any change in inductance and capacity. The only other thing that could change is resistance, and so we have further proof that resistance also has an effect on frequency. We have known this indirectly all along, since the impedance of a coil depends on the relationship of its reactance to its d.c. resistance.

Other Necessities

The broader objects are to have an oscillator that will always generate the same frequency at the same settings and thus be free from frequency change due to changes in terminal voltage, introduction of amplitude modulation, changes in temperature, pressure and humidity. For the rigid requirement of identical frequencies for given settings, mechanical rigidity of a high order is necessary, but this will not be considered, and is often unstressed even in precision oscillators, because the most rigid condenser and other constructions are used, and little more can be done about it. Temperature and humidity control may be introduced in the form of ovens but barometric correction is hardly ever even considered, as the resultant change in inductance and capacity is so slight.

So within practical limits, a good oscillator may be built on the pattern of Fig. 1, with output taken from the grid circuit principally, for there the harmonics are lower and power greater, so a small piece of insulated wire run for two inches alongside of the connection to leak will constitute a satisfactory condenser plate even for frequencies as low as 50 kc.

Tuned Plate Oscillators

Fig. 1 uses a 56 tube, though other cathode type tubes may be used, including pentodes, by applying the required terminal voltages. In all instances the output will be rich in harmonics, and the harmonics are nearly equally strong to the tenth or more, due to the steepness of the plate current change. The grid swing, as explained, is extremely wide.

Now consider a tuned plate circuit oscillator, Fig. 2. Here a 55 tube is used. There is a step-down ratio between plate and grid. The tube is negatively biased. Hence an operating point on the tube characteristic may be selected where the resultant harmonics will be small, nearly nil. It is valu-

(Continued on next page)

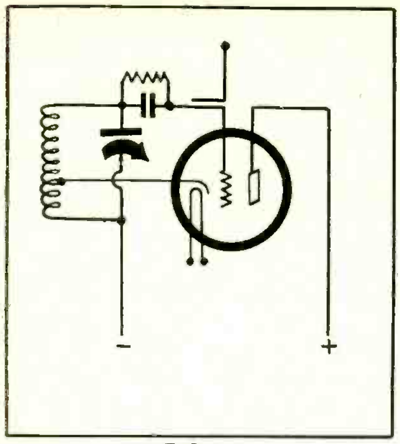


FIG. 1

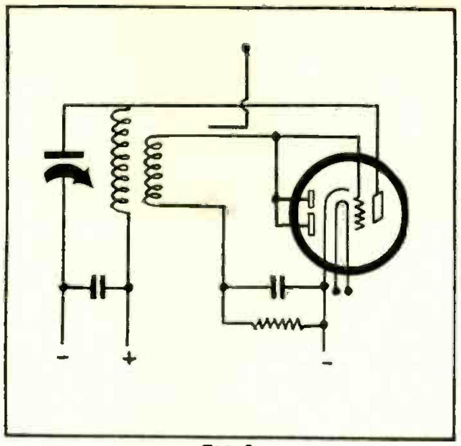


FIG. 2

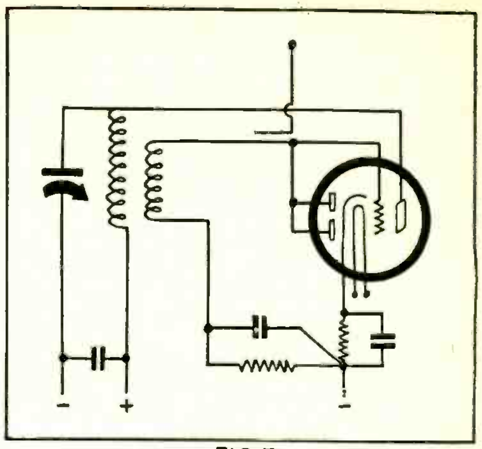


FIG. 3

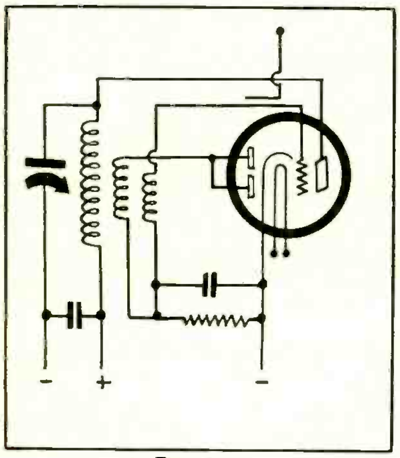


FIG. 4

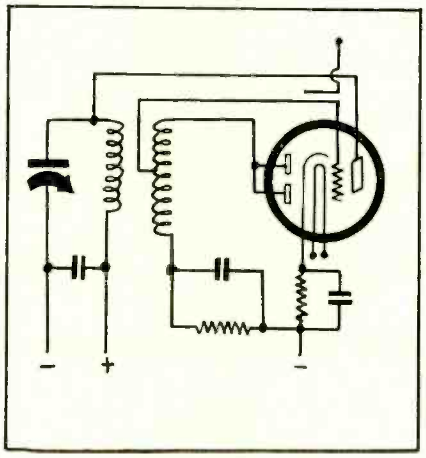


FIG. 5

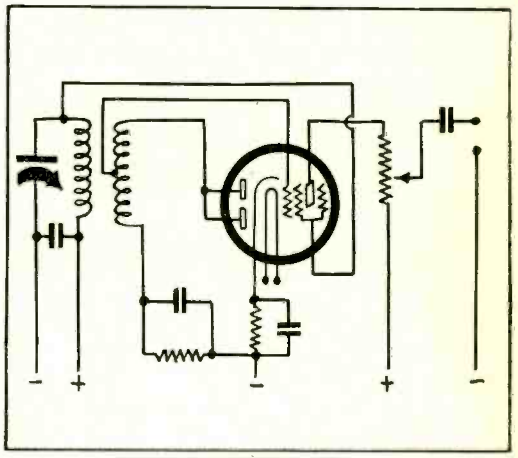


FIG. 6

Upper Row—Fig. 1 is a modified Hartley oscillator, using grid-current bias. Fig. 2 represents an attempt to introduce a rectifier, but the circuit is practically identical with Fig. 1. Fig. 3 introduces a cathode biasing resistor, but practical identity with Fig. 1 is retained.

Lower Row—Since the bias, if derived from the diode, should always be higher than the amplitude of the oscillation, the proper proportioning of turns and coupling in a three-coil system, Fig. 4, could accomplish this. Or, as in Fig. 5, two windings may be used, all of one of them in diode circuit, only part of that winding in the grid circuit. Some auxiliary bias may be used. Fig. 6 shows the Fig. 5 method, with electron-coupled output, using a 2B7 or 6B7 instead of 55, 75 or 85.

(*Continued from preceding page*)
able to have harmonics when they're needed, as is often true of test oscillators, to avoid coil and condenser switching, but for some uses a low harmonic output may be desired.

Normally the grid a-c voltage is much higher than the plate a-c voltage, depending on the coupling, the mu of the tube the d-c voltages and other factors. To keep the a-c grid voltage well within the operating region the step-down ratio may be 1 to 4, or smaller if consistent with preservation of oscillation.

Figs. 1 and 2 Much Alike

The danger of grid current flow in an oscillator intended not to have grid current thus is avoided. However, should grid current flow it would be in the wrong direction and would tend to make an already positive bias more positive, for lack of the usual stopping condenser. It is the obstructive effect of the stopping condenser on the clouds of negative electrons that maintains the grid negative in the leak-condenser type of circuit, where the leak permits the excess to leak off not too fast to destroy this negative-bias effect. But in a circuit without the stopping condenser the electrons do not accumulate at the grid.

Fig. 2 provides negative bias through the drop in the rectifier load resistor, but the action is very much like that of Fig. 1, where the triode is the oscillator and the grid-to-cathode circuit for the leak-condenser combination is the diode. One is just as linear, or as nearly linear, as the other.

Fig. 2 almost has to be as shown, because the load resistor otherwise would be in the tuned circuit, except so far as removed by the condenser. The resistor must be large so that the voltage drop externally will far exceed that inside the tube, which is the requisite condition for linearity. But if the condenser across the load resistor is high, grid blocking may take place, giving the effect of audio-frequency modulation, of any frequency that the constants determine. It isn't particularly useful either, since its amplitude may be enormous, and instead of normal 30 per cent. modulation you may have 1,000 per cent. modulation, another term for severe distortion.

Grid Current

The Fig. 2 method has no self-bias through the cathode leg, and therefore twice during each cycle there will be zero bias (when the amplitude of the oscillation is zero) and the tube will draw more plate current than otherwise. However, the operation is within the limits of the tube, provided the plate voltage does not exceed 250 volts for the 55, or equivalent 85, or similar 75.

No test need be made of Fig. 1 for grid current, as such current is bound to be present and is desired, but in Fig. 2 it is not desired, so a bypassed meter should be put in the grid circuit to determine if and when there is grid current, and coupling would have to be tighter or a higher load resistor used, or both, until there is no grid current at any condenser setting. The likelihood of grid current is extremely high, hence this circuit is not very encouraging, because the rectifier feed is the same as the grid feed, in other words, the circuit approaches true identity with Fig. 1. If it is the same in operation as Fig. 1, and Fig. 1 is pretty good, then Fig. 2 should be pretty good, which is undeniable, but the object in Fig. 1 is to have a grid-current-harmonic oscillator and that in Fig. 2, though unfulfilled, is to have a no-grid-current, no-harmonic oscillator.

Measurement

In Fig. 3 a resistor is put in the cathode leg and grid returned to ground through a load resistor. Now there is a steady bias at no oscillation, but the moment that the oscillation voltage builds up to the value of the bias voltage rectified current will flow. In fact, it will flow when the oscillation amplitude is 0.8 volt less than the self-bias through the cathode resistor voltage drop, due to the grid emissivity of the cathode type tubes. But, again, it will not be rectified current from the diode but rather from the triode, as the interconnection of the two types of elements causes the loss of identity of the type of current flowing or the grid greatly predominates. However, a check may be made by inserting a sensitive meter between diode and grid, the perpendicular line in Fig. 3, and again between grid and diode, the horizontal line to left from grid in Fig. 3. The same fierce modulating troubles may be expected in this circuit, as the cause differs no whit from that in Fig. 2.

If the diode is to be depended on for the bias, and since the bias should always exceed the oscillation amplitude, it is clear that some method should be provided for feeding a greater voltage to the control circuit than to the controlled circuit. Use of three windings, as in Fig. 4, permits tuning the plate, stepping down the voltage put into the grid, and making the voltage put into the diode sufficiently higher than the grid input. Now the grid circuit is separate, grid current may be noted, and the condition of no-grid current satisfied by adjusting the turns or coupling, or both, of the diode-feeding secondary.

Electron Coupling

Fig. 4 is exclusively diode-biased, but Fig. 5 represents the introduction of auxiliary bias through the voltage drop in the cathode leg resistor, a negative bias from the rectifier circuit whenever the rectifier is conducting. Now the voltage put into the grid is only a part of that put into the rectifier, and the tap may be so arranged that no grid current will flow. There will be no rectification until the r-f voltage drop in the rectifier coil exceeds the value of bias voltage derived from the cathode leg, but the cathode drop may be made small, or even omitted, if no grid current remains.

In Fig. 6 the system of Fig. 5 is applied to a pentode, with screen used for feedback, and plate used as feed to the work circuit, so there is electron coupling between generator and work circuit.

The tube in Fig. 6 may be the 2B7 or 6B7.

Separate Treatment

If the coupling is loose in the previous examples, as it would be with the capacity resulting from a couple of inches of paralleled, insulated wire, then there will be very slight, hardly noticeable, detuning so long as one keeps out of short waves, while with the Fig. 6 method of output there would be still less detuning.

Naturally, if any precautions have been taken to keep the oscillator stable as to frequency determination, the connection between oscillator and load should not be such as to destroy the effect of these precautions. But it should be realized that, though protection at output is necessary, it is fairly well provided in any sensible oscillator, and is nevertheless independent of the vices that might arise in the oscillator itself. That is, a stable oscillator is a stable oscillator in its own right, connected to nothing save its voltage sources, and protection of the output coupling, to safeguard against detuning of the generator, does not improve the generator itself in any way, but simply avoids adding such capacity, inductance and resistance thereto which are the effect of the load circuit, to detune the oscillator. The oscillator would be detuned the same way if any equal outside constants were introduced. The oscillator and the coupling method therefore should be considered and treated separately, for a perfect output method does not make an imperfect oscillator better or more stable as a generator.

One Microampere Limit

In trying such rectifier type biased non-harmonic oscillators, the first consideration is to get the oscillator oscillating and to explore the grid current. Next the rectifier may be made to function and measurements made to determine what happens to the grid current. Not until the grid current never appears in measurable quantity (1 microampere) can it be assumed that the harmonic content of the output is low enough to be consistent with the classification of non-harmonic-producing. This holds for oscillators under discussion. There are some non-harmonic grid-current type oscillators.

A Built-up Oscillator

The Fig. 1 circuit was adapted to use, as diagramed in Fig. 7. The front view is shown in Fig. 8 and the rear view is illustrated on the front cover.

In this model plug-in coils were used. The condenser capacity was 0.00025 mfd., and, due to low distributed capacities, and condenser minimum of extremely low value, the factual capacity ratio was 9.3-to-1 yielding, a frequency ratio of slightly in excess of 3.05-to-1. The slight excess, considered at the high frequency end, could be devoted to overlap, especially as short waves were to be included.

The test oscillator was made useful for "all waves." A 25-millihenry coil was put in a plug-in form, connected to form prongs. This coil is a commercial product, tap and all. The form diameter, however, has to be at least 1.5 inches for the coil to fit inside, as the usual 1.25-inch outside diameter forms haven't a large enough inside diameter.

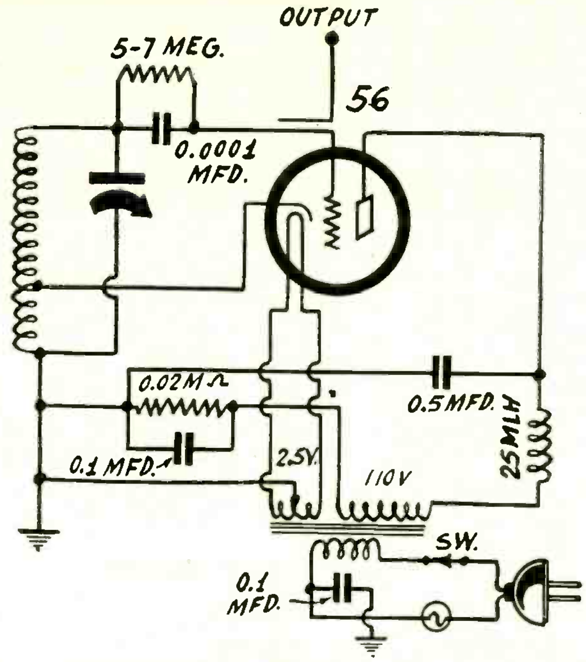


FIG. 7

A test oscillator, using a-c on the plate, and affording 60 to 40,000 kc frequency coverage with a special low-minimum-capacity 0.00025 mfd. Hammarlund condenser. Plug-in coils are used. The tube may be a 56, or pentodes, etc., with screen tied to plate.

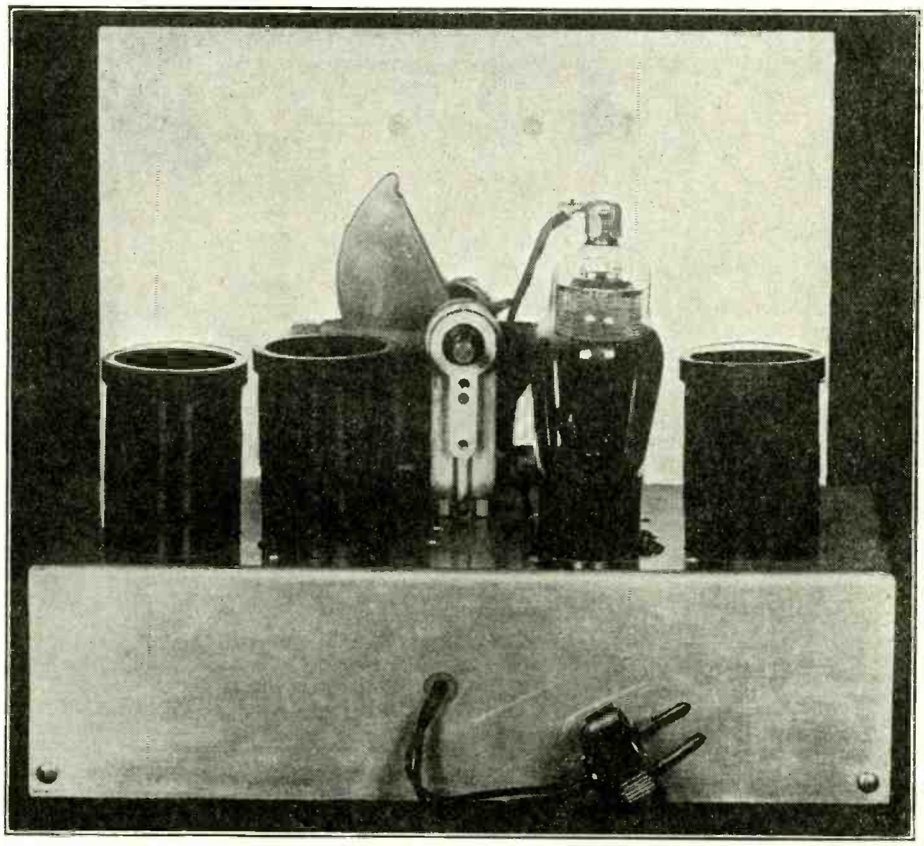


FIG. 8

Front view of the oscillator diagramed in Fig. 7. The extra sockets are for coil receptacles so three coils will be handy at all times for frequency ranges most commonly utilized.

Coil Data

The lowest frequency reached was 60 kc., so the tuning was approximately 60 to 180 kc. Almost the same frequency ratio prevails throughout, and the subsequent inductances are 2.78 millihenries, 300 microhenries, 33 microhenries, 3.7 microhenries and 0.41 microhenry. The other frequencies are approximately 180 to 540, 540 to 1,620, 1,620 to 4,860, 4,860 to 14,580 and 14,580 to above 40,000 kc. The tap on the coils for the two smallest ones should be at center, on the other coils not more than one-quarter the number of turns from the ground end.

The coils for the two lowest frequency bands are honeycombs, and the one for the broadcast band may be likewise. There were 1,300 total turns on the largest coil.

STABLE OSCILLATORS

for Laboratory Work, Using New Methods

By J. E. Anderson

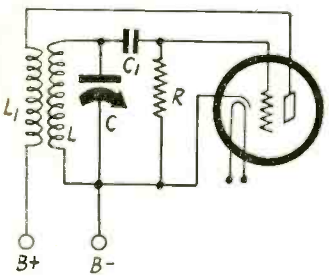


FIG. 1
A simple tuned grid oscillator which is partly stabilized as to frequency by the grid leak and the stopping condenser.

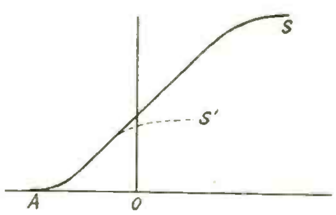


FIG. 2
The grid leak and stopping condenser produce the effect of saturating the plate current at zero bias.

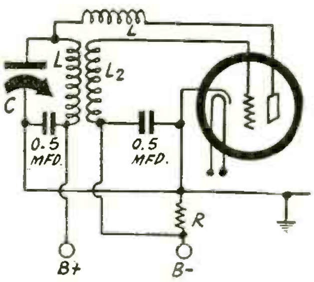


FIG. 3
A tuned plate oscillator stabilized by a reactance in the plate circuit. This works only if no grid current flows.

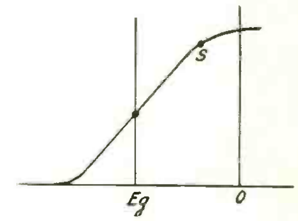


FIG. 4
Grid current can be prevented by confining the grid voltage plate current curve to negative bias values.

STABILIZATION of frequency of oscillators is important not only in transmitters but also in superheterodyne receivers and laboratory oscillators. During the last few years the importance of stability of frequency has been recognized the world over and a great amount of work has been done on stability of circuits.

It has always been recognized that oscillators having a grid leak and condenser were more frequency-stable than those having a low d-c path in the grid circuit. Moreover, such oscillators are usually self-starting, while grid bias oscillators sometimes fail to start themselves. Therefore the grid leak and condenser type of oscillator is nearly always used.

The circuit of a grid leak and condenser type of oscillator is given in Fig. 1. Here LC is the resonant circuit which is supposed to determine the frequency of oscillation. Approximately it does determine the frequency but this is also affected to some extent by L1, the tickler, by the coupling between L1 and L, by the value of the grid condenser C1, by the grid leak resistance R, by the filament voltage, and by the plate voltage. It is desirable to eliminate at least two of these factors, plate voltage and filament voltage, for these are likely to change from time to time.

Effect of Grid Leak

It has been found experimentally that when C1 and R are used the stability of the oscillator is much better than when these are omitted and when grid bias is used instead. It can be shown theoretically that the stability is greater the higher the grid leak resistance, and therein lies the answer to the effect of the grid leak and the stopping condenser. It would seem that when no grid leak is used as in Fig. 1 and when bias is used instead that the grid resistance would be infinite. That is practically the case when the tube is used as an amplifier of a small signal. When the tube is used as oscillator the effective grid resistance may be very small, only a fraction of the plate circuit resistance. The reason for this is that when a tube is oscillating the grid swing is over the entire grid voltage-plate current characteristic. Hence the grid swings positive during a large part of the signal cycle. It is limited only by the saturation of the tube. Large grid currents flow, and the effective grid resistance may be as low as 500 ohms.

In Fig. 2 is indicated a grid voltage-plate current curve from the cut-off A to the saturation S. This is the region over which the grid voltage swings when there is a low d-c resistance in the grid circuit. Now suppose that a grid stopping condenser and a grid leak be inserted as in Fig. 1. The grid can not now go positive to any great extent because as soon as the grid current begins to flow a voltage is set up across R which prevents the grid from going positive. The grid voltage-plate current curve now takes the form AS[1]. That is, an effective saturation begins at zero bias, or even for low negative biases. Under these conditions the oscillation grid voltage is confined to negative values, or at most, to very low positive values. This is equivalent to raising the value of the grid resistance of the tube and therefore of stabilizing the frequency of oscillation.

Oscillation Begins

When the tube is not oscillating the grid voltage is practically zero, where the mutual conductance, or slope of the curve, is high. Oscillation begins as soon as the power is turned on, assuming that when this occurs the cathode is already hot. But the operating bias does not remain at zero. The grid voltage swings far to the left, and may swing far beyond the plate current cut-off point. Indeed, the operating point, that is, the mean value of the grid voltage, may settle down somewhere near the cut-off point.

When this is the case the generated plate current wave is not a pure sine wave but a badly distorted wave consisting mainly of strong pulses. This does not mean that the current wave in the resonant circuit is equally distorted, for this is nearly a pure wave because the resonator responds only to the fundamental of the tickler current. Hence the resonant voltage across LC is nearly pure, and the exciting voltage across R is practically as pure.

The difference in purity between the plate current wave and the resonant current wave has much to do with the performance of a superheterodyne of which the oscillator forms a part. It is clear that if the distorted wave is impressed on the mixer there will be more undesired heterodynes than when the pure wave is impressed on the mixer.

Stabilizing Oscillator

There are many ways of stabilizing the frequency of an oscillator and at the same time purifying the wave. In Fig. 3 is a stabilized oscillator in which the stabilization has been effected by inserting a coil L in the plate circuit, this coil having exactly the same inductance as the coil L in the resonant circuit. In order that this oscillator should generate a frequency that is independent of the tube, it is necessary that the grid resistance be infinite. That is, there should be no current in the winding L2 at any time. But we have just said that this cannot be done by biasing the tube. Yet a bias is necessary or the tube will not oscillate at all, and the requirer bias is critical.

To prevent grid current we must arrange the circuit so that the saturation of the plate current is reached for negative values of grid voltage, if such an arrangement is possible. Suppose that this has been achieved so that the plate current-grid voltage curve lies as in Fig. 4, that is, the saturation point S is well over on the negative side of the grid voltage axis. Then if we adjust the fixed bias to Eg so that the operating point is half way between the cut-off and the saturation points, the tube will oscillate between these points, and there will be no current in the grid circuit. The conditions demanded by the circuit in Fig. 3 are satisfied.

Shifting Saturation Point

But how can the saturation point be shifted to a negative value of grid bias? In one of two ways. For any given filament emission it can be done by increasing the plate voltage, or for any given plate voltage it can be done by reducing the emission by decreasing the filament current.

Now it may be that for normal emission the plate voltage would have to be increased to an unsafe value before the saturation point is sufficiently shifted into the negative region. In that case it is necessary to decrease the filament emission. It may also be that if the plate voltage is maintained as a common value, the emission will have to be reduced to such a value that the circuit will not oscillate even when the optimum bias is chosen. The slope of the curve may not be great enough. In that case it is necessary to increase the plate voltage. Hence in general it is necessary both to reduce the filament voltage and to increase the plate voltage.

Bias Critical

The required bias is somewhat critical, especially if the emission of the tube is low. The circuit will oscillate most easily when the bias is adjusted to the value at which the slope of the curve is greatest. Another advantage of choosing this point is that the generated wave will be nearly pure.

Whether or not the circuit will oscillate under these conditions depends on the L/C ratio of the resonant circuit. The higher this

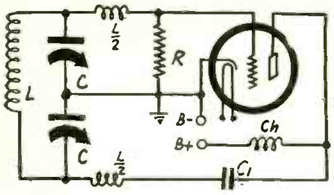


FIG. 5
The symmetrical Colpitts oscillator shown here stabilized by reactances in both the grid and the plate circuits.

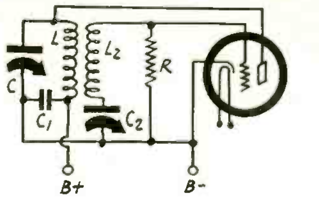


FIG. 6
A tuned plate oscillator can be stabilized by tuning the grid circuit also as is done here. Two condensers are needed.

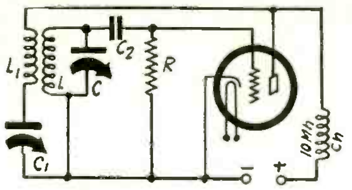


FIG. 7
The tuned grid oscillator can be stabilized by the plate circuit as in this figure. This requires two condensers.

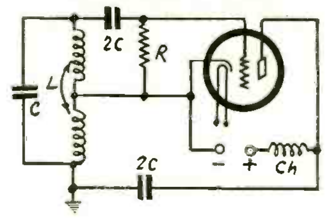


FIG. 8
The symmetrical Hartley oscillator is stabilized regardless of grid current. It is not suitable for a variable frequency.

ratio the more easily will the circuit oscillate. For radio circuits the ratio is likely to be low. Hence to make r-f circuits oscillate it may be necessary to use the highest safe plate voltage in order to permit a high value of emission. When the r-f oscillator is used in a receiver the L/C ratio will vary and therefore when tests are made for oscillation the tuning condenser should be set at maximum value, where the L/C ratio is least. Then if the circuit oscillates at that setting of the condenser chances are good that it will oscillate at all other settings.

Since the correct bias is critical and also comparatively large, it is best to get it from a drop in a resistor in the negative lead of the B supply rather than from the drop of a resistance in the cathode lead of the oscillator tube. This is indicated in Fig. 3 by putting the bias resistor R between B minus and ground. The resistor can be varied to give any required bias.

When there is no current in the grid circuit and when the bias and the amplitude are such that the swing is entirely in the negative region, no power is consumed in the grid circuit, and the oscillator oscillates more easily.

Symmetrical Colpitts

One of the most attractive of the stabilized oscillators is the symmetrical Colpitts. A form of this is shown in Fig. 5. Here C and C are two identical variable condensers which when in series form the tuning capacity. L across these two condenress is the tuning coil. Besides L there are two equal coils L/2, each of which has an inductance equal to one-half of the inductance in the resonant circuit. These are the stabilizing inductances.

C1 in the feedback circuit is used as a stopping condenser. It is a disturbing influence but if it is large its effect on the frequency may be neglected. A suitable value of a broadcast oscillator is 0.01 mfd. Ch is a radio-frequency choke through which the plate of the tube is fed. This, too, is a disturbing influence but if its inductance is of the order of 10 millihenries, or more, its effect on the frequency is negligible. R, the grid leak, may be as low as 5,000 ohms and it should not be higher than 50,000 ohms, or the grid might block.

This circuit is not at all critical in respect to plate voltage or emission, but it assumes that the two tuning condensers remain equal at all settings.

Frequency of Resonance

The frequency of resonance is determined by L and one-half C. Hence for a given value of C the inductance must be twice as large as it would be if only one of the condensers were connected across it. Thus if the oscillator is to cover the broadcast band with two condensers of 350 mmfd., the coil should have an inductance of 480 microhenries. Each of the stabilizing coils should be 240 microhenries.

The circuit in Fig. 5 is of the grid leak and stopping condenser type and therefore it is partly stabilized in this manner. Hence if there should be a slight unbalance it will not be serious. The stability of the frequency will remain good. Rather large variations in filament current and the plate voltage will have only a negligible effect on the frequency. This particular oscillator is especially suitable for a laboratory oscillator, and is due to Llwellyn. For oscillator in a superheterodyne it is not so inviting because of the necessity of using two variable condensers.

In Fig. 5 the choke coil in the plate circuit can be replaced by a resistor of the same value as the grid leak resistance, provided that this is not too large. A resistance of 10,000 ohms can well be used for each.

Theory of Circuit

In Fig. 5 are three tuned circuits. The first is the resonator, consisting of LCC, the second is the grid circuit consisting of one L/2, one condenser C and the grid leak, the third is the other L/2, the other C and the plate circuit resistance. These circuits are in resonance with the same frequency at all times, and it is at that frequency the circuit oscillates. C1 is so large that it does not appreciably affect the resonance, and so is the radio frequency choke when that is used. Because of this simultaneous resonance the current through R and the internal resistance of the grid is in phase with the voltage and the plate current (a-c component) is in phase with the voltage. Hence there is a 180-degree phase difference between the grid and the plate voltages, and that is a condition for independence of frequency of the operating voltages.

If grid current is prevented in the circuit in Fig. 5, which it can be by the method previously discussed, the voltage across the grid leak will be a pure sine wave, for only the fundamental can get through the tuned circuits. But grid current would spoil the purity.

Stabilization with Condenser

In Fig. 6 is a stabilized oscillator in which the stabilization is effected with a condenser C_2 in series with the grid winding. Primarily the oscillator is of the tuned plate type and the resonator is the LC combination. C1 in this is supposed to be so large that it does not appreciably affect the frequency. It should have a value of 0.01 mfd. or larger if the oscillator is to cover the broadcast band.

But the grid circuit also contains a resonant circuit, L2C2. If this is always in tune with the same frequency as the resonator the circuit is frequency stabilized. L2 has the same value as the coil in the resonator then C2 should have the same value as the tuning condenser C. Therefore two equal condensers are required, the two being tuned with the same control.

Effect on Oscillation Condition

It is clear that if L2C2 are resonant to the frequency of oscillation the current in the external grid circuit will be in phase with the voltage. Current will flow in R whether or not current flows in the grid circuit of the tube. Stabilization is not upset if the grid does take current. This oscillator has no particular advantage over the Colpitts oscillator in Fig. 5, for it requires just as many tuning condensers. However, it requires only one coil, although it has two windings of equal inductance. It is noticed that C2 serves the dual purpose of grid stopping condenser and tuning condenser. Since this circuit has a grid leak and a stopping condenser it will have fair frequency stability even if L2 and C2 are not in tune with the oscillation.

In nearly all cases when a condenser or inductance is used for stabilizing the frequency the effect is of bringing the grid voltage and plate current in phase. When they are in phase the circuit is most stable and at the same time the circuit oscillates most readily. Hence these devices will make the oscillator function more easily. The circuit will oscillate with less plate voltage or with less filament voltage than if there were no stabilizing reactances.

Fig. 7 shows a nearly stabilized oscillator in which the grid circuit is tuned. Here the plate circuit is tuned with the oscillation frequency, L1C1 having the same value as LC. The plate is fed through a choke Ch, which should have such a large value that it does not affect the resonance condition appreciably. In this circuit is a disturbing influence in the grid condenser C2. The larger this is the more nearly is the circuit stabilized. But practically it cannot be made larger than 0.001 mfd. The grid leak should be comparatively low in value to prevent the grid from blocking. This circuit also requires two tuning condensers. If they are equal at all settings, the coils L and L1 should also be equal.

Of the two circuits in Figs. 6 and 7 the tuned plate circuit is the better for it requires fewer parts and it is more nearly stabilized. But neither is as satisfactory as the symmetrical Colpitts in Fig. 5.

Stabilized Hartley

The tuning inductance is made up of two equal coils the total inductance of which is L. The tuning condenser C is connected across the whole coil. If there is no mutual inductance between the two coils the circuit can be frequency stabilized by means of two condensers, one in the grid circuit and the other in the plate circuit, and each equal to 2C. This oscillator is quite suitable for a fixed frequency oscillator, but not for a variable frequency oscillator, since three variable condensers would be required.

A modification of this oscillator, but unstabilized, is shown in Fig. 9. This occurs in many broadcast superheterodynes because of its simplicity. In this a single coil is used and it is tapped at a point near the center, to which point the cathode of the tube is connected. A single variable condenser C is required and this is connected across the entire coil.

The only stabilizing influence in this circuit is the stopping condenser C1 and the grid leak R. How these parts stabilize the frequency was explained in connection with Figs. 1 and 2.

Low Loss Effect

In any oscillator one condition for frequency stability is that the losses in the resonator be as low as possible. Since most of the losses occur in the tuning coil, it is important to construct the coil so that it have as little resistance as practicable. This rule is violated in nearly all oscillator coils used for superheterodynes because it is found that the circuit will oscillate even when the resistance of the tuning coil is quite high. When frequency stability is not important high losses in the oscillator coil are of no consequence just so the circuit will oscillate.

(Continued on next page)

A "MIKE" AMPLIFIER

Portable Address and Phonograph Magnifier

By Leo Spiser
Harvey's Radio Shop

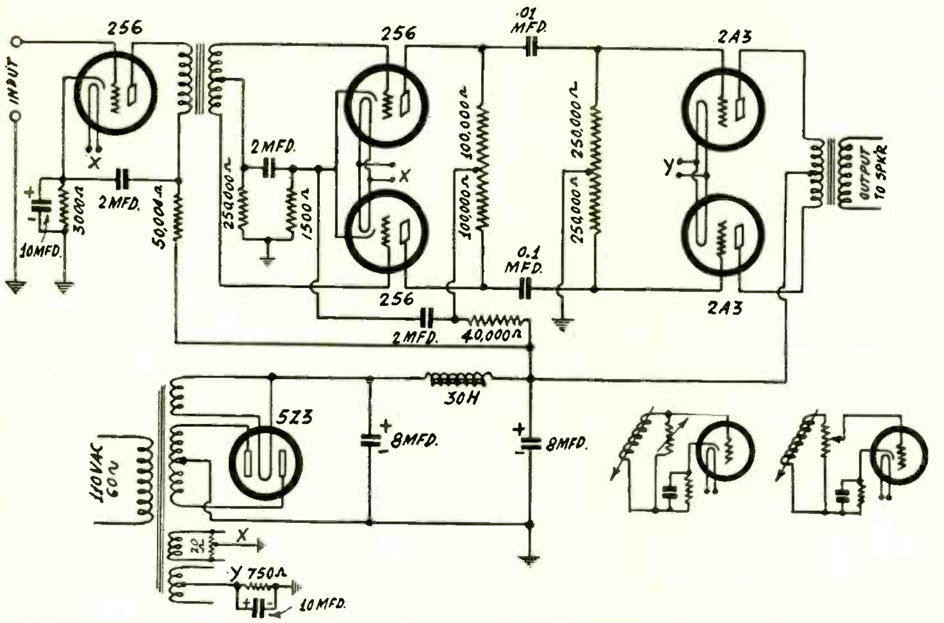


FIG. 1
A three-stage, six-tube microphone amplifier with its own power supply. The push-pull stages insure a high quality amplification. Two methods of controlling the volume in the case when the amplifier is used with a phonograph pickup are shown in inset.

PORTABLE microphone amplifiers are now being built in greater numbers. Many of these are built and operated for hire by service men and radio dealers. The owner supplies not only the amplifier but also the microphone or microphones, together with the operator. Many occasional users have found that hiring the amplifier is less expensive than to purchase one and also that the results are better because of the experienced operators who accompany the equipment. Moreover, the owner of the device has found that there is more profit in hiring out such a device than to sell it.

Just what kind of circuit is suitable for such an amplifier? Well, the circuit in Fig. 1 has been built by a radio dealer who is doing considerable business renting out microphone amplifiers and it is one of the circuits he uses. It is a straightforward amplifier with a single 56 in the first stage, two 56s in push-pull arrangement in the second, and two 2A3 in push-pull in the output stage. The rectifier in the power supply is a 5Z3.

The first 56 tube is biased by means of a 3,000-ohm resistor in the cathode lead. This resistor has a higher value than that usually recommended for this tube. The reason is that there is a 50,000-omh resistor in the plate circuit which cuts the current down to some extent. The function of this resistor, in conjunction with the 2 mfd. condenser connected between the cathode of the tube and the plate resistor, is to filter out stray currents, both of hum and of signal. The filter confines the signal output of the tube to the condenser and the primary of the transformer and it also prevents such currents from entering the tube by way of the B supply.

It will be noticed that a 10 mfd. electrolytic condenser is connected across the bias resistor. This effectively eliminates reverse feedback in the tube itself and hence prevents a reduction of the amplification. The condenser is large enough to be effective even on the lowest essential audio frequencies.

The push-pull audio input transformer between the first and the second stages is one that has been designed for first rate quality, that is, equal amplification of all the audio frequencies entering into speech and musical sounds.

The Second Stage

The second stage is biased by a resistor of 1,500 ohms in the common cathode lead of the two tubes. This possibly is not high enough to give an adequate bias in view of the fact that there is a 100,000-ohm coupling resistor in each of the plate circuits and a common resistor of 40,000 ohms, and it may be that on strong signals the grids will take current. This could be prevented by increasing the bias resistance to about 3,000 ohms. But the lower value was actually used in the amplifier as constructed.

The 250,000-ohm resistor in the common grid return of the two tubes prevents distortion to some extent even when the grids take a little current, which occurs only on the strongest, lowest frequency signals. Even when the grids do not take current

"Wobbulation," or Change in Carrier Frequency

(Continued from preceding page)

Up to the present no attention has been given to frequency stability of the oscillator in broadcast superheterodynes because there have been more important problems to solve. But that will not continue. It will be found that some of the troubles are due to instability of the oscillator and that the solution will be found in stabilization.

Another thing that will receive more attention in the future is the generation of a pure wave for impression on the modulator. The elimination of interfering noises will force this attention. There was a time when radio engineers said that people who used superheterodynes expected a variety of squeals and growls, but they do not do that now, for now they know that the squeals are not unavoidable. Well, one way of eliminating undesirable noises is to keep harmonics out of the mixer. Of course, harmonics are not the only source of squealing in a superheterodyne.

There is a phenomenon in modulation that is called "wobbulation." This is a change in the frequency of the carrier resulting from the changes in the circuit effected by the modulating voltage. In other words, it is a frequency modulation on top of the amplitude modulation. One of the main reasons for stabilizing oscillators of transmitting stations is to avoid "wobbulation" for simultaneous frequency and amplitude modulation gives rise to distortion.

In a superheterodyne we have a generator and a modulator and they are closely coupled. It is reasonable to suppose that in most superheterodynes there is "wobbulation" since the frequency has not been stabilized. This must give rise to distortion even if the output of the modulator is a superaudible frequency, the intermediate frequency. This suggests that it is at least desirable to design broadcast superheterodynes with as as high frequency stability as possible. If the frequency cannot be changed by changes in plate and filament voltages, there will be no change as a result of mixing. Then one source of distortion and noises has been eliminated.

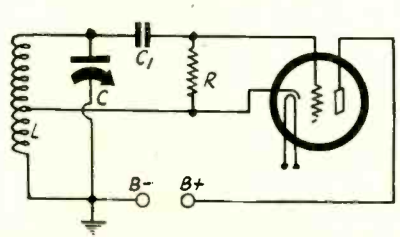


FIG. 9
This simple Hartley is suitable for a variable frequency oscillator but it can only be stabilized at one frequency.

If, on top of this, the generated wave be made free of harmonics before it is impressed on the mixer tube, another prolific source of distortion and squealing will have been removed. Many of the latest oscillator circuits are not only unstabilized but they are such that the wave impressed on the mixer tube by the oscillator is extremely distorted. Yet the circuit gives fairly good results as judged by freedom from noises. How much better it would be if only pure waves were mixed!

There is a good reason, of course, why mixing of distorted waves is used in many popular circuits—the sensitivity is greater. Where the greatest gain is to be obtained with the least possible number of tubes, it is not practical to throw away anything just to get rid of undesired noises.

the resistor in the grid circuit helps to improve the quality.

In this stage also, although it is push-pull, a 10 mfd. electrolytic condenser is used across the bias resistor. It is also connected so that it is across the 250,000-ohm grid resistor. This makes the condenser many times more effective in preventing reverse feedback than if it were connected across the bias resistor alone.

Plate Filtering

As in the preceding stage, a plate circuit is also used in this push-pull stage. It consists of a 40,000-ohm resistor in the plate supply lead and a 2 mfd. condenser between this resistor and the cathodes. This effectively confines the signal to the tubes and keep any disturbances that may exist in the B supply, such as hum and signal frequencies, from entering the amplifier circuit proper. Of course, the push-pull arrangement is also effective in keeping disturbances out.

The output of the first push-pull stage is passed on to the next through two 0.01 mfd. condensers and two grid leak resistances of 250,000 ohms each. The condensers are sufficiently large to insure transfer of the lowest audio frequencies without any appreciable reduction on volume. Moreover, the grid leaks are not so high in value that grid current will cause distortion by blocking the grids. Yet they are high enough to prevent loss of signal voltage.

Output Stage

The output stages contain two 2A3 tubes in push-pull, and therefore the amplifier is capable of enormous undistorted output, assuming that an adequate speaker and the proper output transformer are used between the power stage and the voice coil. With a 5,000-ohm load on each tube and a bias of 62 volts, the rated undistorted output is 10 watts.

The tubes are self-biased with a 750-ohm resistor connected between the centertap of the filament winding and ground. Since the plate current of each tube is 40 milliamperes and the current through the bias resistor is twice that, the bias is 60 volts. That is the operating bias, but, of course, the voltage varies little due to the fact that the tubes are self biased. To prevent wide fluctuations in the grid voltage by reverse feedback, a 10 mfd. condenser is connected across the bias resistor.

Filament Supply

There are two 2.5-volt windings on the power transformer for supplying the filament current. One of these is used for the 2A3 tubes and the other for the three 56s. The terminals of the winding for the 56s, which are indicated by XX, are shunted by a 20-ohm, centertapped resistor, with the tap grounded for the purpose of eliminating hum from this source.

The power transformer also has a 5-volt winding for supplying the filament current for the 5Z3 rectifier. The winding is not centertapped since this is not necessary to avoid hum.

Then there is also a high voltage winding on the transformer, which is centertapped. This is wound so that with 110 volts on the primary the rectifier will supply 300 volts for the plates of the 2A3s and the necessary bias of 60 volts.

Across the d-c line are two 8 mfd. electrolytic condensers and in series with the positive lead is a 30-henry choke. This filter is adequate to remove hum to the extent that none is heard in the output of the speaker, provided, of course, that the speaker itself does not hum.

High Power Speaker

A high-power speaker should be employed for otherwise the design of the amplifier has been futile. It is assumed that the speaker has its own field supply, since no provision has been made for it in the amplifier. Any speaker that is worthy of use in a public address system capable of putting out 10 watts of undistorted power usually has its own power supply. This, however, does not prevent the use of a large speaker that has a high resistance field that may be connected in parallel with the last filter condenser, for such a field will not overload either the rectifier or the filter. An adequate power transformer ought to be used in any case.

The output transformer shown in the amplier may be the transformer built into the speaker if this has been designed to match impedances. Otherwise a special matching transformer should be used for best results.

Input to Amplifier

The coupling between the amplifier and the microphone depends on the type of microphone and the volume control employed. If a single button carbon microphone is used, a microphone to tube transformer without a centertap on the primary should be employed, but if a double button microphone is used a similar transformer with a centertap should be employed. In either case the secondary should have a high impedance since it is to work into a tube. If a potentiometer is to be used for volume control it should be connected across the secondary of the microphone transformer and the grid of the tube should be connected to the slider. In such a case the transformer will work between two definite resistances, the resistance of the microphone and that of the potentiometer. The transformer then could be designed to work between these two impedances to give the best results. Moving the slider over the resistance of the potentiometer does not appreciably change the impedance as long as the grid of the tube does not draw current. Hence it is not necessary to provide a constant impedance device for controlling the volume.

Phonograph Pickup

The same amplifier can also be used with a phonograph pickup without any alterations. However, in that case a very good volume control is required, for the amplification in the circuit is greater than is necessary. The volume control can be a potentiometer in this case also. No coupling transformer is required because the pickup unit can be connected directly to the grid, or across the potentiometer. It would be connected directly to the grid if there is a shunt variable resistor built into the pickup and to the potentiometer if no volume control is built into the unit. The variable shunt control is not the best because varying the resistance across the pickup varies the quality. On weak volumes the pickup unit would work, practically, into a short circuit and on strong volumes it would work into a high resistance. With the potentiometer it would also work into the same high impedance, determined by the resistance of the potentiometer. In Fig. 2 are shown the two potentiometer.

Inserts Explained

Two small inserts in Fig. 1 show the two methods of controlling the volume. The left insert shows the variable shunt and the right shows the potentiometer. The right insert circuit also shows the method of controlling the volume when the input signal is derived from a microphone. It is only necessary to imagine that the winding is the secondary of the microphone transformer.

The input devices here shown are for a single source only. Where there are two or more microphones, or pickup units, special mixers are required, devices which not only control the volume of all combined but also which control them individually.

A THOUGHT FOR THE WEEK

FRED STONE, that fine actor, real gentleman and excellent citizen, is a decidedly worthy addition to the list of players now appearing before the microphone. Mr. Stone and his daughters are splendid examples of what the speaking stage can offer to the radio public. Mr. Stone is something more than a successful actor—he is an ornament to the stage and has done much to add to the good name and importance of the world of the footlights.

TUBE CHARACTERISTICS

236

Type of tube—Heater tetrode.
Socket—Five contact.
Purpose—R-F amplifier and detector.
Overall height—4 11/16 inches.
Overall diameter—1 9/16 inches.
Grid-plate capacity—0.010 mmfd., maximum.
Grid-cathode capacity—3.7 mmfd.
Plate-cathode capacity—9.2 mmfd.
Heater voltage—6.3 volts.
Heater current—0.3 ampere.

Bias Detector

Plate supply voltage—180 volts.
Plate load resistance—0.25 megohm.
Screen voltage*—67.5 volts.
Grid bias—6 volts.

Amplifier, 90-Volt Plate

Plate voltage—90 volts.
Screen voltage—55 volts.
Grid bias—1.5 volts.
Plate current—1.8 milliamperes.
Bias resistance—625 ohms.
Amplification factor—215.
Plate resistance—0.25 megohm.
Mutual conductance—850 micromhos.

Amplifier, 180-Volt Plate

Plate voltage—180 volts.
Screen voltage—90 volts.
Grid bias—3 volts.
Plate current—3.1 milliamperes.
Bias resistance—725 ohms.
Amplification factor—370.
Plate resistance—0.35 megohm.
Mutual conductance—1,050 micromhos.

*Screen voltages as low as 7.5 volts may be used and better quality is usually obtained with the lower screen voltages.

* * *

237

Type of tube—Heater triode.
Socket—Five contact.
Purpose—Detector and amplifier.
Overall height—4¼ inches.
Overall diameter—1 9/16 inches.
Grid-plate capacity—2 mmfd.
Grid-cathode capacity—3.5 mmfd.
Plate-cathode capacity—2.2 mmfd.
Heater voltage—6.3 volts.
Heater current—0.3 ampere.
Amplification factor—9.2

Bias Detector

Plate supply voltage—180 volts.
Grid bias—20 volts.
Load impedance—High resistance or transformer.

Amplifier, 90-Volt Plate

Plate supply voltage—90 volts.
Grid bias—6 volts.
Plate current*—2.5 milliamperes.
Bias resistance*—2,400 ohms.
Plate resistance—11,500 ohms.
Mutual conductance—800 micromhos.
Maximum undistorted output—30 milliwatts.
Optimum load resistance—17,500 ohms.

Amplifier, 180-Volt Plate

Plate supply voltage—180 volts.
Grid bias—13.5 volts.
Plate current*—4.3 milliamperes.
Grid bias resistance*—3,000 ohms.
Plate resistance—10,000 ohms.
Mutual conductance—950 micromhos.
Maximum undistorted output—175 milliwatts.
Optimum load resistance—20,000 ohms.

*The give bias resistances apply only when the specified plate currents flow. If the load on the tube is a high resistance a higher value of bias resistance must be used.

* * *

Type LA

Type of tube—Filamentary power pentode.
Socket—Five contact.
Purpose—Power amplifier.
Overall height—4 11/16 inches.
Overall diameter—1 13/16 inches.
Filament voltage—6.3 volts.
Filament current—0.3 ampere.

Amplifier, 135-Volt Plate

Plate voltage—135 volts.
Screen voltage—135 volts.
Grid bias—9 volts.
Plate current—12 milliamperes.
Amplification factor—100.
Plate resistance—53,000 ohms.
Mutual conductance—1,900 micromhos.
Maximum undistorted output—700 milliwatts.
Optimum load resistance—9,500 ohms.

Amplifier, 165-Volt Plate

Plate voltage—165 volts.
Screen voltage—165 volts.
Grid bias—11 volts.
Plate current—17 milliamperes.
Amplification factor—100.
Plate resistance—48,000 ohms.
Mutual conductance—2,100 micromhos.
Maximum undistorted output—1,200 milliwatts.
Optimum load resistance—8,000 ohms.

MODULATION RIGS

VTVM a Simple Means of Measuring Effective Percentage

By J. E. Anderson

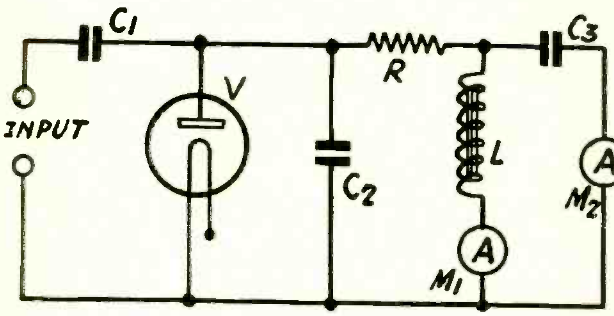


FIG. 1
This circuit can be used for measuring the percentage modulation when the rectifier presents a high impedance at speech frequencies.

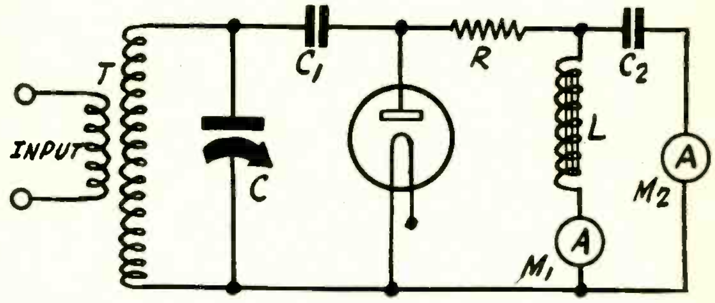


FIG. 2
This circuit should be used for measuring percentage modulation when the rectifier presents low impedance at speech frequencies.

ADVANCED radio experimenters often have occasion to measure the percentage of modulation of radio frequency signals, usually those which they themselves have produced in the laboratory for the purpose of making tests on receivers. Such measurements are not as difficult as at first thought they appear to be. Let us outline methods by which they may be made, using simple equipment.

Referring to Fig. 1, V is a diode rectifier on which the signal is impressed. C1 is merely a stopping condenser to prevent direct current to flow in the input circuit. It should be so large that it offers a low impedance to the carrier frequency. For a broadcast signal a value of 0.005 mfd. might be used. Resistance R should have a large value so that its resistance is large compared with the resistance of the rectifier tube when this is conducting. A value of 1 meg is suggested. C2 is a by-pass condenser for the carrier current. Its value should be such that its reactance at carrier frequencies should be small compared with the resistance of R and such that its reactance is large compared with the resistance R at speech frequencies, e.g., 0.0001 mfd.

Separating Components

L is a high inductance, low resistance choke coil, say, 100 henries, and C3 is a large condenser which has negligible reactance at the speech frequencies, say, 10 mfd. The object of L and C3 is to send all the current of speech frequencies through current meter M2 and all the direct current resulting from rectification through current meter M1. M1 may be any milliammeter and M2 an a-c meter that will measure about the same range of currents. It should be accurate on speech frequencies, and hence may be a thermo-couple type of meter.

The combined impedance of L1 and C3, with the meters, should be low compared with the resistance R at speech frequencies.

The circuit is in effect a vacuum tube voltmeter in which the current through R is directly proportional to the amplitude of the carrier voltage and in which this current follows the modulation. If a non-current drawing oscillograph is connected across R, the percentage modulation could be measured from the graph obtained. But an oscillograph is not to be found in every experimenter's laboratory.

Again referring to Fig. 1, suppose that the d-c meter M1 gives a current reading I_1 and the a-c meter M_2 gives a reading I_2, both expressed in the same units, then the effective percentage of modulation is $141.4I_2/I_1$. This holds when the carrier is modulated with a single tone. In most cases only a single tone is involved, that is, when the modulated carrier has been produced in the laboratory for test purposes. It is not necessary to complicate the tests by having several modulating frequencies at the same time.

A Circuit Variation

The circuit in Fig. 1 is supposed to be used when the rectifier presents a high impedance at speech frequencies. A diode rectifier can be considered as having a high impedance. When the rectifier presents a low impedance at speech frequencies the modulation meter should be arranged as in Fig. 2.

The method of measuring the effective percentage modulation as indicated in Figs. 1 and 2 is available to almost every one who does any experimenting with radio and receivers because all the parts are at hand. There are few indeed who do not have a d-c milliammeter with a range of about 100 milliamperes and an a-c meter with about the same range. Oscillators which may be modulated with an audio tone are either easy to build or are already available.

Vacuum Tube Voltmeter Method

A method similar to the above is indicated in Fig. 3. Here we have a regular diode rectifier with a high load resistance R, which is shunted with a condenser C1 that serves to remove the carrier. This sort of rectifier is well known, for it appears in every radio receiver equipped with a diode detector. When a signal is impressed on the rectifier a d-c voltage E appears across the load resistance R. This voltage can be measured with a voltmeter of very high resistance, or, preferably, with a peak voltmeter. The voltage E is practically equal to the peak values of the carrier voltage impressed. Thus by measuring the peak of the modulated and the unmodulated voltages we can get a relation of the two. The ratio of the two peaks is 1 + k, where k is the modulation factor and 100k is the percentage of modulation.

This method, however, is not very accurate because the voltmeter will not accurately measure the peak voltages, nor, what is worse, will it measure the two with the same percentage error. But if the peaks are measured with a true peak vacuum tube voltmeter, the accuracy is good.

Peak Voltmeter

Fig. 4 shows the connections of a peak voltmeter. Let the tube be one that has a very sharp cut-off of plate current, that is, a tube with a very high mu and one that is not of the exponential type. A 57 or similar tube is suggested, or any triode with a very high mu. Connect the input terminals of this meter across the voltage to be measured, such as R in Fig. 3. First short circuit the terminals and adjust the bias on the voltmeter tube until the plate current, as indicated by a sensitive meter M, is just brought to zero. Measure this bias. Now open the short and let the voltage across R act act in the grid circuit. There will now be plate current because the positive swings of the alternating voltage will make the bias less than the cut-off bias. Increase the bias until the plate current again is just brought to zero, and then measure the bias. The difference between the two bias values is equal to the peak of the voltage across R.

If the voltage across R is first measured in this manner when it is unmodulated and then again when it is modulated we have a means of computing the percentage modulation, and this is accurate to about 5 per cent.

If k is the factor of modulation and E is the amplitude of the carrier, the modulated peak voltage is E (1 + k) and the unmodulated peak is E. Hence the ratio of the two is 1 +k. We have just measured this ratio. Let us call it A. Then the factor of modulation is A—1, and the percentage of modulation is 100 (A—1).

Elimination of Rectifier

When the peak vacuum tube voltmeter is used we might as well dispense with the rectifier, for it only introduces one more element of error. The carrier voltage might exist across a tuned circuit, such as that in Fig. 2. Then connect the input terminals of the peak voltmeter, Fig. 4, across the condenser C and proceed as before. This is the most accurate of the simple methods.

When applying the peak voltmeter, a d-c voltmeter should be connected across the bias, that is, from the slider of P to

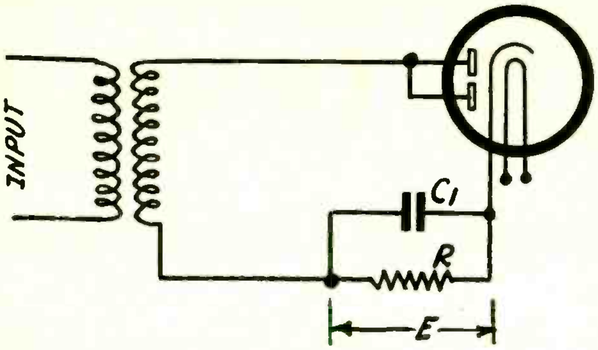


FIG. 3
Modulation percentage can be measured with a diode rectifier of this kind by measuring E when current is modulated and when it is not.

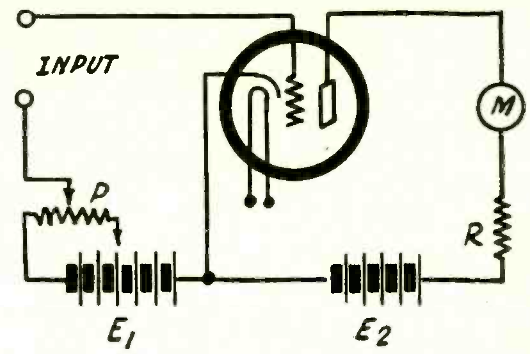


FIG. 4
This is a peak vacuum tube voltmeter which can be used in modulation measurements. The peak method is accurate to about 5 per cent.

the cathode of the tube, and this meter should be left in the circuit all the time a measurement is under way. This is merely a precaution to insure that the two values of bias be accurately measured.

Another way of measuring the percentage modulation that is similar to the peak voltmeter method involves the use of a cathode ray oscillograph. If the voltage to be measured is impressed on one set of deflection plates and another voltage of such value that at least one full modulation cycle will appear on the screen is impressed on the other pair of deflection plates, a picture of the modulated wave will appear on the screen. If the carrier voltage is held constant a few minutes there is time to measure the maximum double amplitude as well as the minimum double amplitude on the screen, which can be done with a ruler held against the screen.

The minimum double amplitude is proportional to $1 - k$ and the maximum is proportional to $1 + k$, in which k is the modulation factor. Now if the measurement gives B for the minimum and A for the maximum, we have the proportion $(1 - k)/(1 + k) = B/A$, whence $k = (A - B)/(A + B)$, and the percentage modulation is 100 times this ratio.

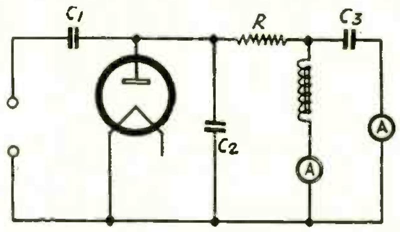
This method is applicable to any oscillograph that is fast enough faithfully to follow the carrier swing.

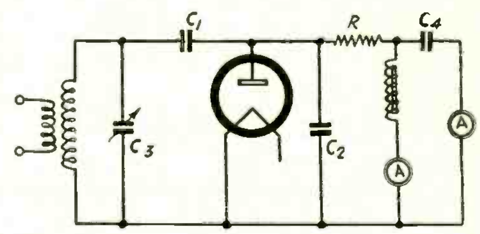
An estimate of the percentage of modulation can also be obtained by making use of the fact that there is more power in a modulated wave than in an unmodulated wave. If the effective value of the current in a modulated wave be measured with an a-c meter, such as a thermocouple, the result is $I(1+k^2/2)^{1/2}$, in which I is the effective value of the unmodulated wave and k is the factor of modulation. Thus if we first measure the current of the unmodulated and then of the modulated, with the same instrument, we get the ratio $(1+k^2/2)^{1/2}$. Let the measured ratio be A. Then the modulation factor is given by $k=1.414\ (A^2-1)^{1/2}$.

If the wave is completely modulated, that is, if $k=1$, there is 50 per cent. more power in the modulated than in the unmodulated wave, the two having the same carrier amplitude.

It was said above that the current should be measured in both instances with the same instrument. It should also be measured in the two cases under conditions of equal load. If the load changes it is not correct to set the squares of the two currents as proportional to the powers. As an example of the use of the power method of measuring the percentage of modulation, suppose we insert an a-c milliammeter in series with the tuned circuit and tune to resonance in both instances. Here the load is now the resistance of the milliammeter and the squares of the currents are proportional to the powers. If we use a thermocouple galvanometer, we may take the two deflections for they are proportional to squares of the current.

PERMISSIBLE PERCENTAGES OF MODULATION





The close control of modulation in radio broadcasting is of utmost importance because upon the percentage depends the quality and the carrying power. The higher the percentage modulation of a certain carrier is, the greater will be the carrying power of that wave. It is therefore economical to use the highest possible percentage modulation. Other advantages besides economy derive from a high percentage modulation.

But it is not practical to go to 100 per cent. modulation. Indeed, it is not practical to go above a certain percentage which may be considered low. The reason for this is that when non-linear modulators and detectors are used, the amount of harmonic distortion introduced into the signal rises rapidly.

All detectors are non-linear even though they may be called linear because they happen to be considerably more nearly linear than some other detector. It is customary to say that the diode rectifier is a linear detector. It approaches linearity as the load resistance is increased in comparison with the internal resistance of the rectifier element and as the amplitude of the signal rises. But to say that such a detector is linear to the extent that harmonic distortion is eliminated is being entirely too optimistic. There is plenty of curvature in the diode rectifier characteristic even when the device is working under optimum conditions.

The nature of broadcast sound is such that 100 per cent. modulation is not possible because one sound may be 100,000 times, and even more times stronger than another. Such wide variations occur almost instantaneously and it is not possible for the monitor to prevent it.

Even if it were possible it would not be permisible because the variation constitutes the essence of what is broadcast. Hence transmitters are constructed so that they have a modulation capability of 100 per cent., or some percentage somewhat less. This does not mean that the wave ever is modulated to the limit of its capability. It is best always to have a factor of safety to prevent overmodulation on unexpectedly strong signal.

High percentages of modulation occur as a rule only on the lowest audio frequencies. On loud crashes of such sounds it may be that the wave is overmodulated momentarily.

DIODE-TRIODE R

Improved by Circuit and Vol

By Wayne L. Hemstree

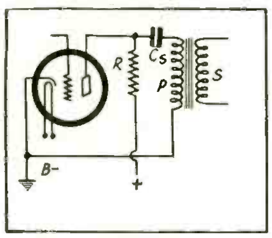


FIG.1

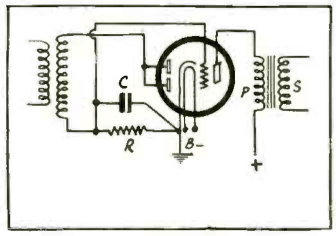


FIG.2

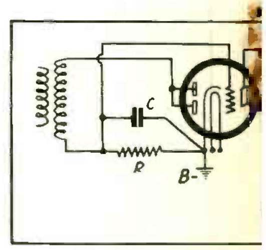


FIG.3

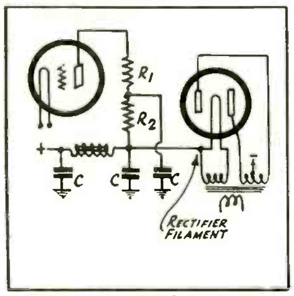


FIG.5

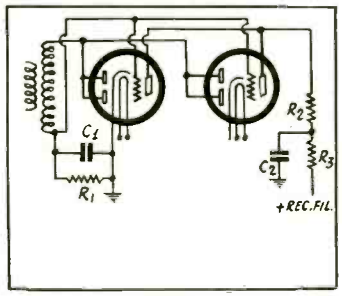


FIG.6

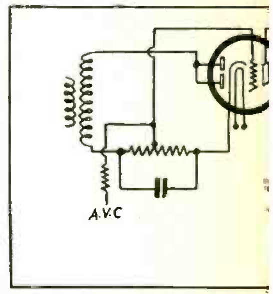


FIG.7

Top Row—Fig. 1 shows filtered output, where R is the plate load resis P and S the audio transformer. Fig. 2 reveals transformer primary directly triode, and Fig. 3 with filtered input to primary, so-called parallel feed. rectified voltage, where M is the meter proper and R is the voltage-mu meter. As at least 0.5 meg. is required, M would have to be a 0-0.5 mill sensitive instrument. R is the diode load resistor and C is the

Bottom Row—Fig. 5 shows how the voltage applied to the plate is raised drop in R2, and an extra filter condenser, at right, introduced to prevent h tubes paralleled. Fig. 7 gives the diode full voltage and the triode and aut than that voltage. Fig. 8 shows how a.v.c. may be included or excluded voltage put into the triode, both by switc

THE reason for filtering a transformer-coupled audio circuit, by using resistor and stopping condenser, or choke and stopping condenser, is to keep the direct current out of the primary and in that way maintain the primary inductance at its highest practical value. Particularly since the direct current may change considerably, it may become too large, and thus bring about saturation of the core. This is particularly true the better the transformer, as high-grade transformers have special cores of high permeability. The flux density changes rapidly and thus the core more quickly reaches saturation. The situation is not unlike that in a high mu tube.

If a choke is to be used for the circuit, and direct current passed through it, the characteristics of the choke should be exceptionally good. This increases the expense. Therefore a resistor may be used, being inexpensive and also highly suitable. The value of the resistance is not critical, but it is well to experiment with different values, for when the right one is found the sensitivity is greater. The value of resistance is related both to the impedance of the primary and to the impedance of the tube circuit.

Trouble with Diode-Triodes

While the 55 tube, for instance, is now recommended for higher value plate load resistors than formerly, this is true only for resistance-coupled audio, for if a transformer is used, much better results may be obtained with the resistor value around 20,000 ohms.

With transformer coupling it is usually recommended that diode-biasing be not used, with the 55 and similar tubes. Only the triodes are suitable for transformer coupling in any instance, hence the 55, 85 and 75 are included. The primary impedance would scarcely be large enough for tubes of higher plate impedance, which includes all pentodes.

However, one point in favor of diode-biasing, even with transformer primary directly in the plate circuit, is that the direct current through the primary is less the greater the amplitude of the carrier or modulation. If the circuit is so arranged that there is always enough voltage at any carrier intensity to cause diode rectification there should be no trouble, as not only would the plate current be held low enough, but also distortion avoided on low-intensity signals.

The use of the diode-biasing method, or the duo-diode tubes in general, with triode or pentode amplifiers, has not been perfected, otherwise there would not be so much trouble to double-hump tuning, apparent lack of selectivity, and presence of heterodyne squeals in superheterodynes.

Limitation of Triode Input

While it is not pretended that heterodyne squeals are caused exclusively in the diode, or in the triode amplifier unit, it is nevertheless true that whenever there is double-hump tuning there is a circuit producing rich harmonics, and these yield heterodyne squeals.

The double nature of the vice in duo-diode-triode and duo-diode-pentode tubes has been pointed out recently in these columns and consists of the previously-mentioned distortion at low signal values and the cutoff of plate current, with accompanying distortion, on high amplitudes. The negative bias is equal to the rectified component of the carrier and its modulation, and while little information has been given as to how much the diode will stand, it is safe practice to keep within 15 or 20 volts of rectification for a single diode, or 25 microamperes. Automatic volume control is helpful, in that it protects against premature saturation of the amplifier tube in the dual-content envelope.

Since there are two separate diodes, with common cathode, and in fact cathode also common to the amplifier, a choice has to be exercised between full-wave rectification and half-wave rectification, but the solution is easy when one considers that a certain amount of voltage has to be fed to the rectifier before it will rectify, and that meanwhile there would be nothing but distortion.

Half-Wave Rectifying Diode

Full-wave rectification has advantages in a B supply, because filtration is simplified by the frequency-doubling, but the voltage is twice as great with half-wave rectification, and with carrier frequencies we do not have filtration trouble.

If full-wave rectification is used the rectified d-c voltage is approximately equal to the peak a-c voltage of the carrier. The only requirement is that the load resistor shall be high enough, and a value of 0.5 meg. is sufficient. However, the higher the load resistance, the greater the voltage across that resistor, and if we are after high rectified voltage to avoid the low-intensity distortion we may use values around 1.0 to 5.0 meg.

If there is a bypass condenser across the resistor, and one is commonly needed for the further assistance of holding up the voltage, the higher the resistance the smaller the condenser should be. For instance, for 0.5 meg. no higher than 50 mmfd. should be used, and 20 mmfd. would be sufficient. For load values in megohms the condenser across the resistor need be only 10 mmfd. and may be made up of two insulated parallel wires about three inches long, as the two plates of the condenser. Otherwise a 20 mmfd. equalizer, set at minimum, plates "all out," might be used. Values like 0.0001 mfd. and upward, sometimes recommended in circuits, are far too high.

The object is to attain a sufficiently high rectified voltage for complete absence of distortion on any signal that is

RESULTS

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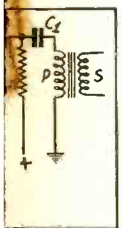


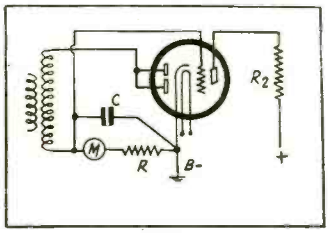
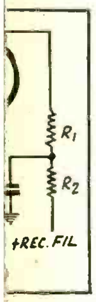


FIG.4



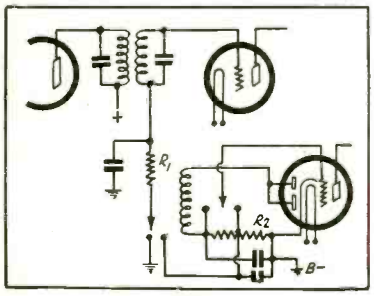


FIG.8

tor, CS the stopping condenser, and in the plate circuit of a diode-biased Fig. 4 is a circuit for measuring the ltiplier resistor associated with the iammeter at 300-volt range, or more small bypass condenser.

by the drop in the B choke, less the ium getting through. Fig 6 shows two omatic - volume - controlled tubes less , and all or less than all of the rectified hing.

audible. There might be some audibility, with distortion, when the amplitude is too low for complete rectification, but this is to be avoided. Hence high gain is to prevail at the intermediate level at least, and may be introduced at the radio-frequency level as well. The remedies for distortion due to the other extreme, too high a carrier amplitude, will be considered later.

We must therefore select half-wave rectification, to protect the diode rectifier, whenever there is any audible signal. When there is no audible signal, as between channels, since no rectification will take place, there will be noise-suppression automatically present, without a separate squelch circuit. About the only exception is that the intermediate and radio-frequency amplifiers must not be oscillating, but such an elementary precaution is taken for granted. Such oscillation will introduce inter-channel noise, because raising the amplitude to rectifying values without any station carrier, and will also cause heterodynes with each and every carrier.

We must use a condenser of small value across the load resistor.

We must put the full rectified voltage into the triode.

Higher Voltage for Triode Plate

Now, although the diode requires being well fed with voltage, we are limited as to the triode. If the load resistor in the triode plate circuit is high, say, 0.25 meg., the resistor may be returned to the voltage next to the rectifier filament. Hum would be present for want of the extra filtration from the B choke and the condenser bank after the choke, but can be compensated by using a series resistor of around 50,000 ohms, and an 8 mfd. condenser.

The expedient of raising the B voltage on the triode is therefore taken without requiring any increase in voltage from the power transformer or from any other source, and the higher the carrier amplitude, the higher will be the effective plate voltage, because as the current through the limiting resistor becomes less, the less the drop in those resistors. Before saturation is reached the voltage at the plate (effective voltage) is almost equal to the applied voltage, that is, the drop in the resistors is small. To the same general purpose is a distortionless relay described in last week's issue.

While it is customary to speak of "how much voltage the diode will stand," it is more sensible to consider the current. The voltage is limited by the breakdown, and this is far removed from any voltage likely to be put in, although it will be shown that the rectified component of the carrier may reach an astonishing value. The limiting factor is the current, and since we have two diodes and half-wave rectification, we may parallel the diodes and thus double the current-handling capacity.

Two Tubes Paralleled

Moreover, there should be no objection to using two 55 tubes, although parallelism would prevail throughout, because then the current handling capability is four-fold, compared to a single diode, since four diodes are tied together, and by parallelling the plates, grids and the cathodes of the two envelopes, we have a much better performing triode, one with its plate-current cutoff point farther "to the left," that is, more negative biasing may prevail. This bias, be it remembered, is carrier-controlled.

It is a fact that as much as practical should be put into the diode, and let us see how much that may be on occasion. An 8-tube superheterodyne was built, consisting of a t-r-f stage, a tuned input to the modulator, a tuned oscillator, two stages of i-f, a duodiode detector, triode of 55 diode-biased, and a filtered input to a push-pull transformer that fed 2A3's. The oscillator-modulator was a 2A7. The eighth tube was the 5Z3 rectifier.

120 Volts from WOR

The strongest local station at the testing point was WOR, Newark, N. J. No automatic volume control was included at this time. The rectified voltage, measured in the diode load circuit, for WOR, was 120 volts. Nothing but hash was heard, naturally, as the following tube was a triode, the normal bias for which at 250 volts is 12 volts, and at 350 volts as used in the manner previously explained, might be 17 volts normally, and could be 20 volts without any serious consequences. Naturally, with an input to the triode six times as great as the triode could stand, nothing could be expected to come out of the triode except noise. The voltage was indeed just large enough to load up the push-pull tubes, by skipping the triode entirely, which might be done could a suitable method be found for coupling the diode load to the push-pull stage. A transformer primary would not have a high enough impedance, however coupled, as the diode in this respect may be likened to a tube of very high plate resistance.

Stations like WEAF, WJZ and WABC developed voltages around 60 to 80, also out of question so far as the triode was concerned, although with four diodes paralleled as described, the needle wobbled only a little in the diode circuit even under the exacting excitation of 120 volts. While there was no likely way of utilizing this high voltage, at least the diodes stood up under it, and the triodes constituted the limiting factor.

Effect of A. V. C.

So, while it is true that as much as practical should be put into the diode, not all of what goes into the diode should be put into the triode, unless the diode input is itself limited necessarily. This condition would exist if automatic volume control were appled to the two intermediate amplifier tubes. When this application was made the strong locals gave about the same value of rectified voltage, around 6 volts. The equalization was manifest, especially as the wide disparity between 120 volts for WOR and 60 to 80 volts for three other local stations, was wiped out.

Naturally one would ask what is the sense of developing sensitivity only to sacrifice it? The expenditure on a.v.c. is quite enormous. Not only does amplification or sensitivity decline, but there is some reduction in the selectivity as well. This follows from the introduction of high resistances in the grid circuits, no matter if bypassed completely in theory, and from the broadening of the resonance point due to unequal frequency changes resulting from resistance alteration in the tube circuits. Automatic volume control of course changes the plate resistance of the controlled tubes, and may not change it quite to the same extent, due perhaps to difference in the tubes themselves. Change in resistance represents a change in frequency, since resistance has an appreciable effect on frequency, noticeable even at the low frequency levels of commercial intermediates.

Atmospheric Conditions

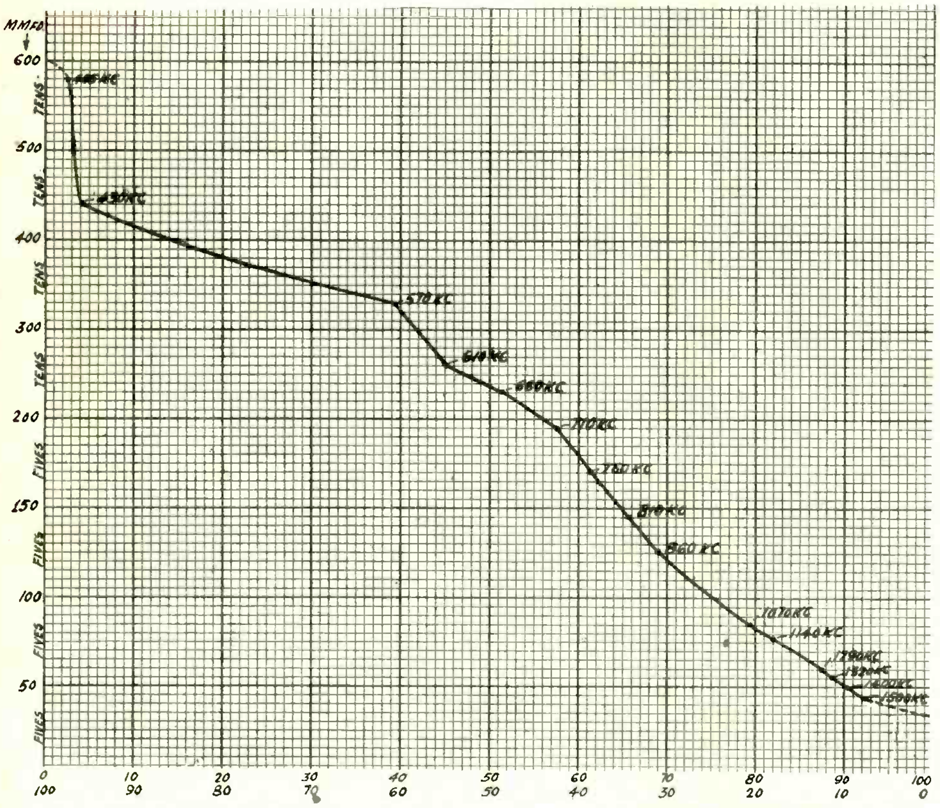
However, there was no blasting when tuning through locals, the a.v.c. was effective on all loud signals, but it did reduce also the sensitivity on weak signals, for the reason that it reduced sensitivity generally, only more so, of course, on the stronger carrier amplitudes.

There is little likelihood of getting into distortion trouble on a 6-volt input to the triode, but conditions affecting the performance of the receiver in all ways except perhaps only tone may be expected, due to atmospheric conditions, so 6 volts at the time of measurement may be 12 volts at some other time of use, when no measurement is taken. While 6 volts will not give double-hump tuning, 12 volts might; therefore it is preferable still to put as much as possible into the diode, but not to take out of the diode the full voltage for input to the triode. Some fraction of it may be taken, say, half or three-quarters. And, since as much as possible is put into the diode, and as the effect of a.v.c. is perhaps greater than was at first suspected, we might take the a.v.c. voltage from the triode input point, rather than from the negative extreme of the load

The foregoing considerations apply particularly to the broadcast band of frequencies.

CAPACITY AND FREQUENCY
Measured in an Oscillator

By Wendell Adams



Curve based on tuning condenser capacity, using a test oscillator with the tuning condenser G-R 247 and a coil having an inductance of 260 microhenries. The ordinates represent micromicrofarads, the abscissas the dial settings for both directions of numerical reading. The frequencies of the basic points are given.

Capacity Table, with Key to Running a Frequency Curve

Using a particular condenser, General Radio 247, and a particular inductance, 260 microhenries, most of the intermediate frequencies, all of the broadcast frequencies, and a few police frequencies may be reached with a single condenser-coil combination in an oscillator. The capacity in the circuit at any frequency may be computed, and this was done, using one reference point, 440 mmfd., obtained from a precision condenser. It checked fairly. The experimenter need not make this check-up. The capacity answers in the chart are for the 247 alone, not including some small part due to tube, wiring, socket, etc., which may be evaluated also, as described in the accompanying article.

The measuring method of removing the tuning condenser and substituting a condenser of unkown capacity can not be applied accurately without knowledge of the amount of the capacity contributed by the tuning condenser alone in the original calibration. The following table gives frequency, dial setting and equivalent capacity, using the aforementioned condenser and coil. As an approximation it is satisfactory to use the substitution method. The strays may be 15 mmfd.

Dial Setting	*kc*	*mmfd.*
2.5 or 97.5	405	580
4.1 to 95.9	430	440
39.2 or 60.8	570	330
45.0 or 55.0	610	260
51.6 or 48.4	660	230
57.7 or 42.3	710	195
61.4 or 38.6	760	170
65.3 or 34.6	810	145
68.6 or 31.3	860	125
79.5 or 20.5	1,070	86
82.0 or 18.0	1,140	78
87.5 or 12.5	1,290	60
88.3 or 11.7	1,320	56
90.5 or 9.5	1,400	49
91.0 or 9.0	1,420	47
92.5 or 7.5	1,500	44

A TEST oscillator was constructed, using General Radio Company's 247 condenser, rated capacity 500 mmfd., with tuning coil of 260 microhenries inductance. The frequency span was from 401 kc to about 1,600 kc, a frequency ratio of about 4, hence a capacity ratio of 16-to-1. By exterpolating the curve, though in an erratic region, the maximum capacity appeared to be 600 mmfd., which of course included the distributed capacitative constants of the circuit, hence the minimum would be 34+ mmfd., and from 44 mmfd. to lower values the curve is exterpolated.

While the curve gives the capacity existing, to determine the amount of capacity introduced by the condenser alone, it would be necessary to deduct the distributed constants. These are principally the tube capacity, the distributed capacity of the coil, the capacity due to wiring, socket, etc., ordinarily a stumbling block for any one lacking precision instruments. However, it is practical to reach a good approximation by the following method:

A 56 tube was used in a Hartley circuit. The mutual capacity, grid to plate, of such a tube is 3.2 mmfd., the grid-to-cathode capacity is 3.2 mmfd. and the plate-to-cathode capacity is 2.2 mmfd. The mutual is across the tuned circuit. The two others are effectively in series, equalling 1.3 mmfd., therefore the tube contributed $3.2 + 1.3 = 4.5$ mmfd. The table of tube capacity constants appears in Edward M. Shiepe's book, "The Inductance Authority."

It is merely a matter of interest to know what these capacities are likely to be, for the other distributed capacities preponderate. The tuning condenser capacity is not now considered.

Since the solenoid type of coil construction develops a distributed capacity effectively a ratable condenser across the extremes of the winding, if the stator connection of the tuning condenser is removed, the sum of the distributed capacities will be sufficient to let the circuit oscillate. An additional test oscillator is necessary to check the new frequency, or a calibrated receiver that operates in the so-called police band. Since the inductance of the coil is known, the sum of the distributed capacities can be computed from the frequency obtained, or the result may be read from the inductance-capacity-frequency chart that is a supplement of Mr. Shiepe's book. This chart reads from 1 mmfd. up to 0.1 mfd.

So if the frequency is 3,000 kc the distributed capacities amount to 13 mmfd, and since the total with condenser included was 38 mmfd., the minimum of condenser alone is 25 mmfd. So if an unknown capacity is to be determined by substitution for the tuning condenser, 13 mmfd. (or other determined value) should be subtracted from the values obtained from the curve, or a new curve made representing capacities 13 mmfd. less than the apparent.

The capacity curves for any condenser may be run by the user himself, especially as the results herewith given will be approximately correct for him if the coil is duplicated. The coil he can wind, using No. 32 enamel wire on 1-inch diameter tubing, putting on 130 turns, tapped at the 20th turn from the ground end. The tap connects to cathode of the tube. The line a.c. may be used on the plate. The grid condenser may be 50 mmfd. and the grid leak 2 meg., connected as a parallel circuit in series with the tuned circuit. The diagram as on page 5 may be followed.

The coil is not shielded, as shielding would change the inductance and also the capacity in a manner not readily ascertainable. The circuit constants will be duplicated, so the higher capacity end of the condenser may be taken as a check-up at 440 mmfd. for 430 kc., or other frequency used, assuming one has a calibrated condenser additionally. If the dial reads larger numerical settings for higher frequencies (as on the curve) this setting would be about 4.1, but if the dial reads higher numbers for higher capacity, the reading would be 95.9 for the 247 condenser, which is widely distributed, and many experimenters have it. Also, if they have the type 247-E, which has straight-line capacity plates, and is calibrated, a double check may be made. If 247-E is used as the tuning condenser exclusively, while the capacities may be read directly from the dial, the dial is not one particularly suitable for oscillator frequency calibra-

(Continued on page 18)

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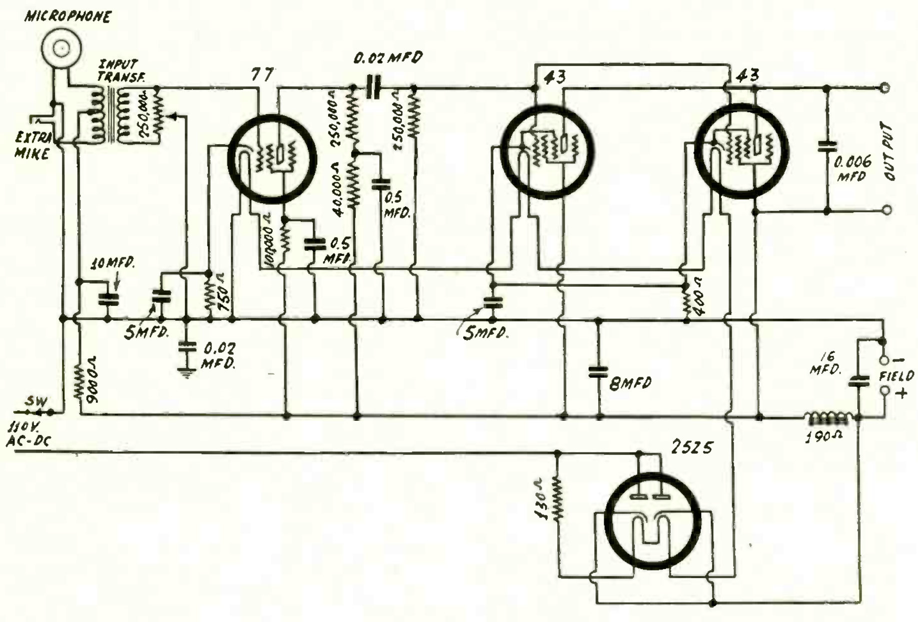

A microphone amplifier circuit that can be used on either d-c or a-c lines. The heaters are in series and the rectifier is in the circuit all the time.

Microphone Amplifier for D-C

IF YOU HAVE a diagram of a d-c operated amplifier that can be used with a microphone, please publish it. I should like to have two tubes in the output stage, either push-pull or in parallel. It is important that the amplifier do not weigh much.—E. R. Y.

The diagram of this page is a d-c and a-c amplifier. The filaments of all the tubes are connected in series and the last two tubes are in parallel. Resistance coupling is used between the stages in order to minimize weight. The necessary high gain is mainly obtained from the 77 tube.

* * *

Use of 53

COULD A 53 tube be used as a superheterodyne mixer by impressing the oscillator frequency on one grid and the signal frequency on the other, and then tying the two plates together for connection to the first intermediate transformer? If this is not feasible, could you suggest any other ways of using this tube as mixer? —W. H.

Specific data are not available on this tube in the application. But the theory indicates many ways of utilizing the tube as mixer. Undoubtedly, mixing would result when the tube is connected as you suggest, provided that the biases of the two grids were adjusted correctly. Another possibility is to use one side of the tube as oscillator and the other as modulator, the two plates being tied together. This appears to be a good use for the tube. But there is no assurance that the net results would be better than those obtained in the regular mixer connections. It is possible that they would not be as good as those obtained with a pentagrid tube. There is much opportunity for experimenting with the 53 along this line. Both static and dynamic curves should be taken on the tube with the idea of finding the conditions of operation that will give the best results. Such experiments will be reported as soon as we have obtained the data, whether from some other laboratory or our own.

* * *

Application of 53

IS IT POSSIBLE to bias the two grids of a 53 or of a 19 differently when the two sections of either tube have the same cathode? How can this be done?—S. G.

Surely, it is possible. It may be done several ways. First, batteries can be used for grid bias. Second, voltage drops in the B supply return can be used, in which the two grids are connected to different points on the resistor. Third, in the case of the cathode type tube, a cathode resistor can be employed to give the bias. If the resistor is chosen so that it gives enough bias for the tube that requires the higher, the grid of the other section can be returned to a tap on this resistor.

* * *

Antenna Arrays

WHAT IS AN antenna array and for what purpose is it used?—M. M.

An antenna array is a system of simple antennas arranged in a definite geometric pattern, usually in a horizontal line or in a vertical column, all elements being similar and all fed from the same source in phase. The object of such a system is to transmit in, or receive from, a given direction. Great improvement in transmission and reception has been effected by such systems.

* * *

Faulty Terminology

JUST WHAT IS the meaning when the sensitivity of a receiver is expressed in microvolts per meter? I have never been able to understand this expression. —A. N. C.

Apparently the expression has no meaning and is the result of confused terminology. The expression "microvolts per meter" refers to field strength. A receiver does not respond to field strength but to volts. The sensitivity of a receiver should be expressed in terms of volts. It may be given as the number of volts, or microvolts, that will give standard output. Although this does not exactly express sensitivity, it is, perhaps, the best way to put it. The sensitivity is really the amplification. But what amplification? It should be power amplification, but then there is no way of determining what power is put in. If we express the amplification in terms of a voltage ratio we have difficulty at the output end.

* * *

Transconductance

WHAT IS THE meaning of the term transconductance? Please define it in simple terms. Is it the same as mutual conductance?—E. P.

Transconductance is defined as the ratio of the change in the current in the circuit of an electrode to the change in the voltage on another electrode. Thus the grid-plate transconductance is the ratio of the change in the plate current to the change in the grid voltage. The grid-plate transconductance has been called the mutual conductance. When the term is used alone it usually means the grid-plate transconductance, that is, the mutual conductance.

* * *

Harmonics in Oscillator

DOES THE grid leak and stopping condenser type of oscillator generate a pure wave or does it produce the harmonics as well as the fundamental? If the output is rich in harmonics how can these be eliminated before they are impressed on the mixer tube in a superheterodyne? It is my idea that much squealing is due to the harmonics in the oscillator and that if these could be eliminated there would be a great improvement in the circuit.—E. A.

This type of oscillator generates a wave that is badly distorted, that is, one that is rich in harmonics. No doubt, these harmonics interfere with clear reception if they are allowed to reach the mixer tube with any appreciable strength. In the above we mean by generated wave the shape of the plate current wave. The resonant current in the tuned circuit is practically free from harmonics because the circuit is excited only by the fundamental. Therefore, if the voltage that is to be impressed on the mixer is derived from the resonant current, for example, from a small winding placed on the tuning coil, very little of the harmonic voltages get to the mixer tube directly. They may, of course, get to the tube through the plate circuits. Unless the distorted wave is prevented from getting into the plate supply by means of by-pass condensers and chokes, the plate voltage of the mixer will be affected by the plate current, and there will be considerable harmonic voltage impressed on the mixer.

* * *

Use of 2B7

IN THE MAY 27th issue, on page 19, is the circuit of a t-r-f receiver in which the 2B7 is used in an odd way. Will you kindly explain how the tube functions in this receiver?—L. W.

It is not particularly odd the way that tube works. Ordinarily the diode of this tube is first used as detector and then the amplifier is used for audio amplification. In this case the amplifier is first used for radio frequency amplication and then the diode is used as detector. That seems to be a good way of utilizing the tube.

* * *

Change of Sets with Weather

IS IT NOT a fact that tuned circuits are affected by weather conditions, such as temperature, moisture, and barometric pressure? What effect does such variations, if any, have on the sensitivity of a

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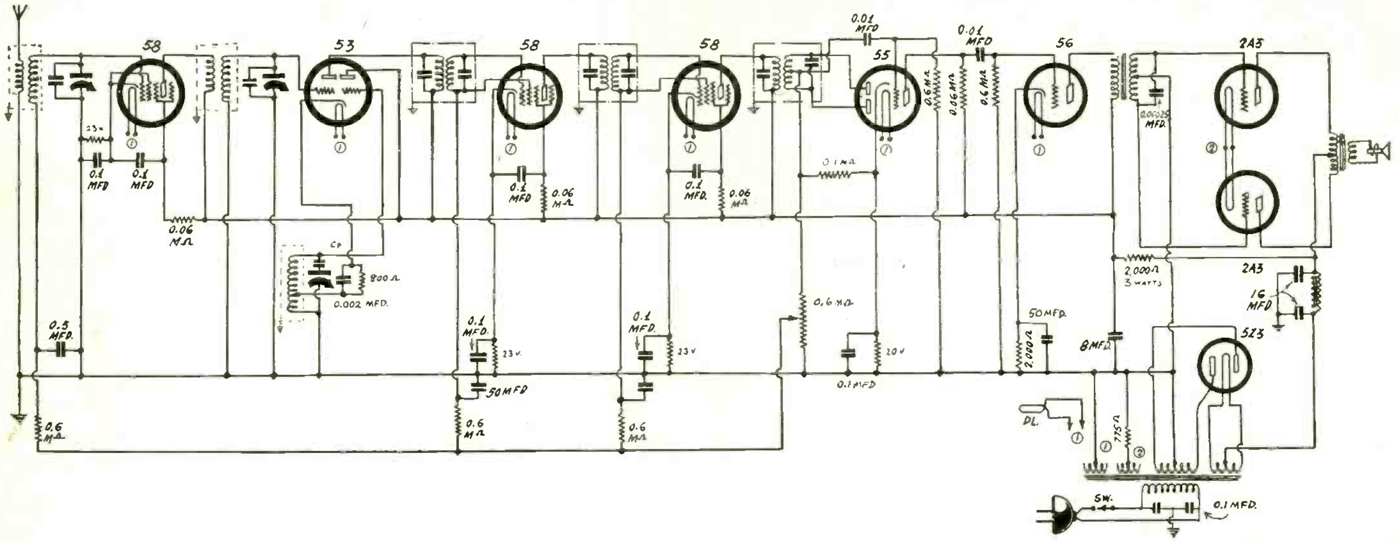

In this nine-tube superheterodyne the 53 tube is used as oscillator and mixer. A part of the oscillator coil is common to the two circuits by virtue of its being in the the cathode lead.

(*Continued from preceding page*)
nicely balanced circuit like a superheterodyne?—G. W. N.

It is a fact that the tuned circuits are affected by weather conditions. Temperature and moisture in particular affect them. The effect on a superheterodyne is that one day the receiver may work as well as or better than it did on the day it was tuned up and on the next day it may be all out of adjustment. First the radio frequency circuits may change, then the oscillator frequency may change, and finally the intermediate frequency tuners. Moisture has a tendency to reduce the selectivity by increasing losses in the tuned circuits, and it also changes the tuning. Temperature changes mostly change the tuning. A slight change in the frequency of the oscillator may upset the adjustment badly because of the fact that it determines the difference frequency. One day the difference frequency may be entirely wrong. This means that the oscillator will not track and hence that the selectivity and the sensitivity of the receiver are poor.

* * *

Audio Choke

CAN THE SECONDARY of an audio transformer be used as filter choke in a circuit in which the total current is not more than one milliampere? The d-c resistance of the coil I have in mind is 5,000 ohms and I am wondering if the drop in the voltage would not be excessive. Besides, the core of the transformer may be saturated so that there will be little choking effect.—C. O'B.

If the current through the coil is not over one milliampere and if the resistance of the winding is 5,000 ohms, the drop in the voltage will not be over 5 volts. This is surely not an excessive drop. The saturation of the core will not be serious, for undoubtedly the transformer has been designed to carry over one milliampere. Of course, that means one milliampere in the primary, which does not have as many turns as the secondary. The saturation when one milliampere flows in the secondary will be greater, but even so the transformer should make a good choke at this current.

* * *

Air Dielectric I-F Condensers

WHAT IS THE advantage of using tuning condensers with air dielectric in the tuners of an intermediate frequency transformer? Are these condensers more constant or do they have lower losses? —L. W.

The capacity of these condensers is affected less by moisture, temperature changes, and vibration than compression type condensers. Moreover, they have lower losses and therefore they will yield a superheterodyne that is more selective and more sensitive than a similar circuit in which poorer condensers are used in the tuners. Since they stay put after they have been adjusted, the circuit of which they form a part will perform more consistently.

* * *

Plate Voltage-Grid Current

IF THE PLATE voltage varies as a result of the signal, is there any variation in the grid current? Is this effect as great as the change in plate current with changes in the grid voltage?—J. M. B.

If grid current flows at all, it is affected by changes in the plate voltage. The effect, however, is very much smaller than the reverse effect.

* * *

Use of 53 As Oscillator

WILL YOU KINDLY show a circuit in which the 53 tube is used as oscillator and mixer in a superheterodyne?—E. L.

The diagram is printed herewith. The signal is impressed on one of the grids and the other grid is used as control grid for the oscillator. The plate of the section serving as mixer feeds into an intermediate transformer and the other plate goes directly to the high voltage line. The plate end of the oscillator coil, that is, the end that is next to ground, is common to the oscillator and mixer tubes. Hence there is coupling between the two circuits even though the plates are not joined.

* * *

Oscillator with A.C. on Plate

IN BUILDING an oscillator for testing, using a.c. on the plate, may I establish zero beats by introducing an aerial, tuning the oscillator, and putting 'phones in series with the plate voltage supply?—J. T. D.

No. You will hear a constant hum and this will be louder than any signal you would receive. Theoretically zero beat may be said to be obtainable, representing resonance, but actually you can never hear the zero beat because it is hidden or drowned out by the hum. So, too, over-modulation in general drowns out zero beats. The hum is of course modulation in the case of the oscillator with a.c. on the plate.

* * *

T.R.F. and Super Compared

IS IT A FACT, as sometimes stated, that the selectivity of a tuned radio frequency set can not compare with that of a superheterodyne? Can not the t-r-f set be made as sensitive as the super?—L. W.

The almost unanimous swing to superheterodynes in the last two years has been due to the selectivity requirement, which is more readily achieved in a superheterodyne, where there are at least as many fixed-tuned circuits as variably-tuned circuits. The limit of sensitivity may be reached by either system, and that limit is approximately the noise level. Since gang tuning is the vogue, and since it is not practical to have each condenser section exactly the same in capacity at all settings, unavoidable mistuning is introduced, and if variable-condenser tuning is the only tuning in the set, as in t-r-f models, naturally the selectivity may not rise high enough at all settings, though at some it may be adequate. There are, however, abundant uses for t-r-f systems, where the higher selectivity of superheterodynes, and almost certainly higher sensitivity, are not required.

* * *

Calibration Troubles

IN ATTEMPTING to calibrate a test oscillator for short waves I have run into trouble. I am using a superheterodyne receiver and beating the oscillator with it, but I get points for my curves that do not justify at all, hence I can not proceed with the plotting. Another thing, one station on the set gives me beats at one setting, at a closely adjacent setting and at a setting far removed. Please clear up these mysteries.—T. R. D.

For calibrating a test oscillator it is far better to use a tuned radio frequency set, rather than a superheterodyne, and particularly a set with three or four tuned circuits, to avoid the possibility of multiple responses. In the superheterodyne you would get a response in when your test oscillator is at a given setting, representing the frequency to which the r-f part of your super is tuned, another representing the set's oscillator frequency, which is the one close by, and at least one other, representing the second harmonic of the original signal frequency in the super, and possibly still another, due to the second harmonic of the oscillator frequency. Besides, if the r-f selection is not sharp, since the super is sensitive, strong locals off resonance of the super will get by the super's tuner or mixer sufficiently to give a weak response in connection with a test oscillator setting, and it is hard to identify these different responses. This condition produces the off-curve points you mention, although in reality all the points are on the curve, only you misidentify them. It would be much better if you used a t-r-f set, constructed a coil for the broadcast frequencies, used that in your test oscillator as a start, calibrated this coil-condenser combination, and developed the curve shape. Practically the same shape will prevail at higher frequencies, so the next smallest coil could be wound to start where the other left off. Then as a first approximation, from this single lowest-frequency test oscillator starting point, the curve may be drawn for the second coil, and the calibration repeated with greater

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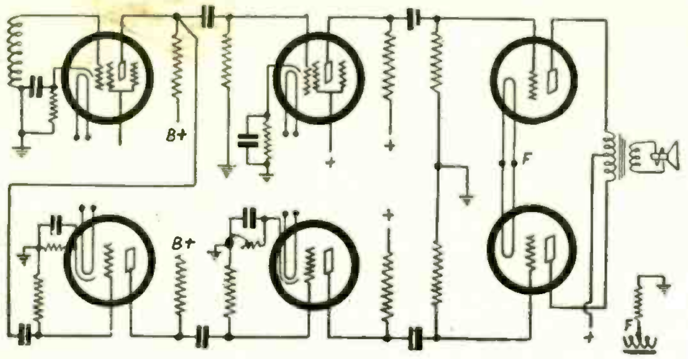
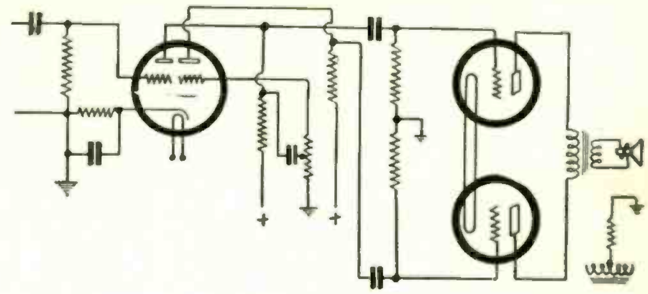


A phase-inverter tube may be used to establish the push-pull relationship. Thus, there are two audio amplifiers on top and three on bottom. Voltage Signal voltage equalization must be introduced. This is not shown.



The 53 may be used as phase inverter. A detector tube ahead of the 53 is assumed. The plate of one section of the 53 is coupled to the grid of the other section, and the output (plate) of the second section has a means of voltage equalization.

ease and rapidity, as now you have a clue to the frequency identities. Subsequent coils would be treated in the same way. If the tentative higher frequency curves are in pencil at first, they may be altered readily as calibration proceeds, and the final result inked in. There must be harmonic generation in the receiver to permit response from frequencies of the test oscillator higher than broadcast frequencies, but evidently these are present in your super and you are familiar with the fact. The detector in a t-r-f set used for calibration may be of the leak-condenser type to improve the harmonic richness. If the frequency selection is favorably made in the receiver, and the set's harmonic response is too weak, it is practical to zero beat the test oscillator with a low frequency of the set, hold oscillator setting, and increase the frequency in the set until the beat is heard again, whereupon the second frequency in the set is twice the first frequency. The test oscillator may be calibrated against the second or higher harmonics of the new frequency. Only by starting at the very lowest end of the frequency spectrum of the set could the third harmonic be reached, and this on only some sets, where the tuning ratio equals or exceeds 3-to-1 in frequency. In connection with your calibrations it may be helpful to remember that the capacity ratio of the condenser is the square of the frequency ratio and that the inductance, for picking up where a previous coil left off, would be inversely proportionate to the capacity ratio. Thus, if the capacity ratio is 9-to-1 (frequency ratio, 3-to-1) and the coil for the broadcast band is 234 microhenries, the coil for the next highest frequency band could be 234/9=26 microhenries.

* * *

Phase Shifting for Push-Pull

HOW MAY I introduce phase shift so as to work a push-pull resistance-coupled audio amplifier?—D. B. C.

This is done by introducing an extra tube. Since the tube reverses the phase approximately 180 degrees, the change will be just about right. However, the signal voltages will be wrong, as the phase-shifting tube will amplify, and to the extent that it does amplify, it will cause the signal voltage on one side to be greater than that on the other. In the diagram at left the upper left-hand tube is the detector, the two tubes at upper right audio amplifiers, the three tubes on the bottom row audio amplifiers. No compensation for the disparity of the signal voltages is shown. Since the 53 tube consists of two equal tubes in one envelope, space is conserved by using this tube, as diagramed at right. The 53 is the first audio amplifier for one leg, the second for the other leg, and the compensation is shown, consisting of taking off sufficiently less from the signal-voltage drop in one resistor to establish equality of voltage input to the output stage. The 53 is a sensitive tube, but will not stand much input, since the bias is only 3 volts. The effect is simply that of a single unit of the 53 driving output tubes, as the phase-inverter unit is a no-gain tube, but the working mu may be around 20, so that it is practical to load up some triode outputs. It is not practical to load up all triode output tubes in push-pull for the output tubes must be of the type biased by a voltage a bit more than half of the total signal voltage across the two push-pull grids.

* * *

Speaker Cable "Sensitive"

WHEN I PUT my hand on the cable the leads from set to speaker there is a noticeable response in the speaker. Sometimes this is like a low roar, other times it is like code, and on other occasions the result is slight or perhaps absent.—J. R.

This is due to over-keenness in radio-frequency or intermediate-frequency amplifier, which is oscillating or on the verge of oscillation. The cause may be simply that the detector output has not been filtered of radio frequencies to a sufficient extent, or the bias on the r-f or i-f tubes is too low for practical purposes, or any other contributant to oscillation. Change in weather and temperature conditions may alter the degree of oscillation, hence account for the different results, sometimes howling, sometimes subdued. The code you hear is due to the intermediate frequency being tuned to the frequency of the code transmission, your body acting as an aerial to pick up this transmission and feed it directly to the intermediate amplifier. The amplification of one stage is enough to produce audibility. Improve the r-f and i-f filtration in your set, with condenser-bypassed r-f chokes in each plate leg, and, if need be, the same choking system in the cathode legs.

* * *

Fading

DISTANT STATIONS fade on my receiver. Is there a remedy?—I. H.

There is no authenticated cure for fading, which is due to the arrival of different components of the transmitted waves at different times (phase displacement). Automatic volume control helps reduce it if the original signal intensity is sizable, but if the distant stations are weak, as may be expected, even a.v.c. will not help much.

* * *

Phase

OCCASIONALLY you see discussions of phase, phase shift, phase difference, and phase reversal. Will you kindly define the expressions?—G. Y.

One definition of phase is the time elapsed from the beginning of a periodic phenomenon up to the instant considered. The time of beginning is arbitrary because of the periodic recurrence. Another definition is the instantaneous aspect of a periodic phenomenon. The former definition is preferred in connection with radio and electricity in general. Phase difference is the time difference betwen two periodic phenomena having the same frequency. A phase shift is usually a change in the phase difference. A phase reversal is a phase shift amounting to one-half a period. "In phase" indicates that there is no phase difference, or that the two periodic phenomena assume corresponding values at the same instant. We may have a phase difference between a voltage, and the current resulting from that voltage. This phase difference is the same regardless of the phase of either. That is, it is the same throughout a cycle of voltage or of current. The current may lag behind the voltage, or it may lead it. When a phase shift occurs between these two there is a change in the lead or lag. There may be phase differences between two voltages, or two currents, in different parts of the same circuit. Thus in a direct-coupled amplifier the phases of the instantaneous voltages on two successive grids are opposite, or the time difference is half a period. In this case it is somewhat better to regard the instantaneous aspect than to consider time. Phase, phase difference, and phase shift are usually expressed in angular measure. It is sometimes expressed in time units, such as quarter period, half period.

* * *

Short Wave Intermediate

IF A SHORT-WAVE superheterodyne were to be constructed so that only waves of the 20 and 40 meter bands were to be received, would it be practical to use an intermediate frequency of the order of 1,500 kc? Would there be any advantage of using this frequency in preference to a frequency around 450 kc? Please give reasons for your answers.—X.

About the only advantage of such a high intermediate frequency would be that the i-f transformers could be made with small coils and air dielectric condensers. The circuit would be more selective with a lower frequency. It is now possible also to get excellent intermediate coils with air dielectric condensers that are tuned to around 450 kc.

* * *

Removing Distortion

IT HAS BEEN said that an audio amplifier with an even number of stages will give less distortion than one with an odd number because the distortion that is introduced by one tube will be eliminated by the next. Is that statement true? I have also read that after distortion has once entered the signal there is no way of removing it. If that is true the former statement cannot be.—W. E. N.

To a certain degree it is true that an even-stage amplifier will give less distortion for the reason stated, provided that the voltage phases are opposite in the two stages. They always are if the two tubes are coupled together directly. When they are coupled by transformer they may or may not be depending on the connections of the terminals. The compensation is not complete. Perhaps it may be said that once distortion has entered it cannot be removed. but that does not deny

(*Continued on next page*)

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the possibility of preventing the distortion by means of push-pull, even stages, or by other means of symmetrical or near symmetrical amplification. The main difficulty, perhaps, is that when the signal is complex there is modulation in each tube, and the resulting distortion cannot very well be eliminated.

* * *

Tracking Condensers

ARE TRACKING condensers available for 450 kc as well as for 175 kc? Am I right in assuming that a different tracking condenser is required for each intermediate frequency? Will you explain why it is possible to track by the padding method regardless of the intermediate frequency selected?—R. E. B.

A tracking condenser has been made for 456 kc and any i-f transformer that has been designed for 450 kc can also be tuned to 456 kc. Yes, you are right. The reason padding can be applied to any intermediate frequency is that the proper rate of change of capacity can be effected for any intermediate frequency by selecting the proper inductance, by adjusting the shunt, or minimum, capacity, and by adjusting the series capacity. The special shaping of the oscillator plates is to bring about the correct rate of change of capacity when the difference frequency is to have a specified value. If the tuning condensers are equal, the same rate of change can be effected by the padding method.

* * *

High Resistance Voltmeter

IN THE AUGUST 12th issue you have a report to the effect that a very sensitive microammeter, one giving full-scale deflection on 20 microamperes. It occurs to me that such a meter would make an excellent voltmeter. If it were so used, what would be the ohms per volt of the instrument?—G. H.

Yes, indeed, it would make a good voltmeter. The ohms per volt is always obtained by taking the reciprocal of the current at full scale. In this particular meter the full-scale reading is 20 microamperes, when the ohms per volt would be 50,000. But such a voltmeter would be rather expensive if it were to be constructed to measure high voltages accurately. Suppose it were to read only 100 volts. The total resistance in series with the meter would then be 5,000,000 ohms. A resistor of this value is costly when it is wound with wire of negligible temperature coefficient.

* * *

Cobalt Steel Magnets

COBALT STEEL and its desirable magnetic properties have been known for many years, yet, apparently, there has been little application of the material. Why is it not used more?—F. L.

Cobalt steel is expensive and very difficult to work. While it could be worked with comparative ease while it is hot, permanent magnets must be formed at a comparatively low temperature, or they will not be permanent magnets, just lumps of steel. The difficulty of working the steel is the main reason why it is not being used more than it is. Just the same, this steel is used very extensively for instruments where no other magnet steel will do, now that cobalt steel is known.

CAPACITIES

(*Continued from page 14*)

tion, though it has 0-100 divisions, besides the capacity calibration.

By the way, this is not supposed to be a precision instrument, and the capacities are accurate mostly toward the high capacity end. Any desiring to improve the accuracy at the lower capacities of the 247-E may do so by introducing a correction term by the method previously described. This is simply the relation of capacity to known frequency and known inductance.

The frequencies are determined from zero beats. A tuned radio frequency receiver covering the broadcast band should be used. The low frequency settings of the test oscillator may be determined on the basis of second harmonics thereof beating with broadcast stations. Thus, to ascertain 405 kc, tune in a station on 810 kc and beat the second harmonic of the test oscillator with the station frequency. The oscillator may be calibrated directly at 810 kc also. For 430 kc the oscillator second harmonic may be beaten against WABC's wave, 860 kc. While these particular stations or frequencies may not be tuned in at all locations, frequencies close to them are of course available, and may be used. The approximate dial settings for the 247 condenser and 260-inch coil may be obtained from a curve drawn from data herewith.

The frequency range is very large, as stated, and moreover it includes the broadcast band and also all the popular intermediate frequencies, from about 402 kc up. The only bothersome frequency would be 175 kc, and as the capacity needed for that would be about 0.0035 mfd., a fixed capacity of 0.003 may be used, in paralell with the tuning condenser, to achieve this one point, and the dial turned until a beat is obtained with 700, 1,050 or 1,400 kc tuned in on a t-r-f set. A switch may cut this fixed condenser in or out, and indeed if desired, the calibration may be run on the basis of the condenser in, to cover the low frequencies, from about 169 to 180 kc. The 0.003 mfd. value may be built up by using 0.002 and 0.001 mfd. in parallel.

Forum

Proposed Dealers' Code

Editor Radio World:

I HAVE STUDIED the proposed "Code of Fair Competition, Business Ethics and Procedure," as was submitted to Washington, D. C., recently by the San Diego Bureau of Radio and Electrical Appliances.

The writer is part-owner of a small retail and service business in National City, Calif., and there is no one more anxious to help in the NRA drive, but the proposed code as submitted, while containing many things of great benefit, smacks of nothing but suppression of the smaller dealer and service organization. I call your attention to the following paragraphs:

> No. 6. This prohibits a person from building any kind of a radio, including short-wave equipment, even though he complies with underwriters' requirements, and can also be interpreted as meaning that no used sets may be sold that are not licensed, of which there are thousands throughout the United States. Does this not smack of suppression of the set builder and serviceman?
>
> No. 7. This prohibits the service man from selling a completed unit, such as a radio set, public address equipment, short-wave receiver, etc., sale and wiring of kit sets and, in fact, deprives him of one of the mainstays of his business.
>
> No. 14. The ban of consigned stocks. Why cannot a dealer who has consigned stocks do business in a fair way, just as the dealer who owns his stock? The provision tends to abolish the smaller dealer or curtail him in doing business to the benefit of the large business houses, who very rarely have consigned stocks on hand.

It is our belief that all such clauses as above should be kept out of any code that is finally adopted.

The code should not be confused with the manufacturers' code as the one under discussion was made up for the retail end of the business and is different from the electrical code, which the radio manufacturers have adopted.

C. W. LEE,
National Electric and Radio Service
915 National Ave., National City, Calif.

* * *

Gives Him a "Kick"

Editor Radio World:

GETTING RADIO WORLD each week gives me a kick. Accept my thanks for your recent improvement in the scope of your text, and for your world's best Q. and A. Department (University). Cherrio!

ALAN HOOD,
Roanoke, Va.

The Review

Questions and Answers Based on Articles Printed in Last Week's Issue

Questions

1. What intensity region principally introduces distortion in a diode? What effect has this on the location of the manual volume control?

2. What is a remedy for premature cutoff of plate current in a diode-biased triode, such as the 55, 85 and 75? Is "cutoff" an actuality?

3. Is the 58 tube particularly useful as an audio frequency amplifier with resistance plate load? With resistance plate load and choke grid load in the next tube? With transformer coupling?

4. What is the principle of d-c voltage apportionment in a non-reactive audio amplifier?

5. Although the grid of a power tube is returned to the maximum B voltage in a non-reactive amplifier, may there still be a negative bias on the grid, without introduction of external voltage sources?

6. What are the three general ways of obtaining the characteristics of a photocell?

7. Name two ways of varying the amount of light flux entering a photocell.

8. State direction of change in recommendations for the plate load resistors of the 55 and 85 tubes, comparing application data as newly supplied with those given when the tubes were announced originally.

9. In connection with specification for a certain tube for resistance-coupled audio, if a certain value of grid resistor is specified, to what circuit does this apply, and why?

10. In tuning a short-wave set, should the dial be turned more slowly for the higher or lower frequencies? Why?

Answers

1. The low-intensity region principally introduces distortion in a diode, due to the rectification being incomplete, or the requirement of a certain threshold voltage. The effect on the location of the manual volume control is to necessitate its location after the diode, hence not at the radio-frequency or intermediate-frequency level, but at the audio-frequency level.

2. Since the plate current's so-called "cutoff" is due to too high a negative bias introduced by the signal in a diode-biased triode, one remedy is to increase the plate voltage considerably, for then the negative bias may be increased approximately proportionately before plate current cuts off. It should be noted that "plate current cutoff" never really takes place, since so long as there is a voltage across a resistor there is current, but the phrase is used to describe saturation, or a condition of non-operation, or one of serious distortion.

3. The 58 is not particularly useful as an audio-frequency amplifier. This is true no matter what the type of plate load. If a resistor is the plate load it is easy to present a suitable impedance to the plate circuit, but if a choke coil or transformer primary is used, the impedance of the load will be too low. Also, if a resistor plate load is used, followed by a grid choke, the low-impedance load condition prevails, since the choke is effectively in parallel with the resistor.

4. The principle of d-c voltage apportionment in a non-reactive amplifier is that the available B supply voltage is utilized as a series circuit. Hence, if there are two tubes, one a driver, the other the power output tube, and 500 volts are available, the 500 volts would have to be apportioned between them.

5. With grid of power tube in a non-reactive amplifier returned to maximum B plus a negative bias still could prevail at the grid, if the cathode voltage were lifted considerably by the usual biasing resistor, and the current through the plate load resistor of the prior tube, which resistor is also common to the grid circuit, were large enough to cause the necessary voltage drop in this resistor. For instance, if the resistor were 100,000 ohms and the current 1.0 milliampere, the drop of 100 volts would cause the potential difference between B plus and grid to be 100 volts negative toward grid, and if the biasing resistor in the cathode leg lifted the cathode 116 volts, the grid would be negative by 16 volts, suitable for a '47 tube.

6. The three general ways of obtaining the characteristics of a photocell are: (a) get them from the manufacturer of the cell; (b) get them from experience with the tube; (c) run experiments in special setups.

7. The amount of light flux entering a photocell may be varied by increasing or decreasing the distance between the cell and the light source and also by altering the diameter of the aperture.

8. The direction of change in recommendation in resistance value for load in the plate circuit of the 55 and 85 is distinctly upward. When these tubes were announced values of 20,000 ohms or so were suggested, but now values of 0.25 meg. and 0.5 meg. are recommended.

9. Where the value of grid resistor is recommended in connection with a certain tube to be used in resistance-coupled audio anywhere ahead of a power tube, the resistor meant is the one in the grid circuit of the following tube. The application to the following circuit is due to the fact that precautions must be taken in the event of possible grid current. The greater the susceptibility of the following tube to grid emission, the smaller must be the leak value, so that the d-c potential difference across the grid resistor will be kept as low as practical, to avoid serious loss of bias in the tube in the grid circuit of which the resistor is placed.

10. The dial should be turned more slowly for the higher frequencies because the difference in frequency for any given linear distance on the dial is so much greater.

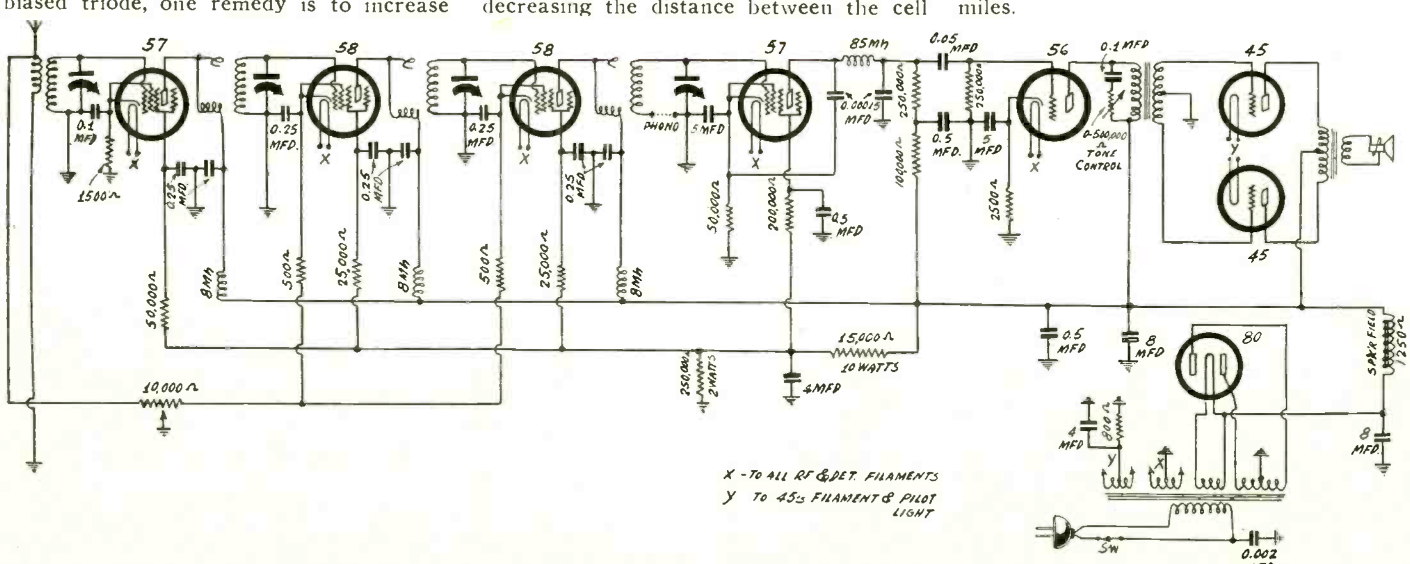
Big Problems Faced Bringing Byrd's Voice from Little America

The broadcast of regular programs from Little America to the United States is the most difficult commercial engineering problem ever undertaken, in the opinion of technical experts working on the scheduled broadcasts over the WABC-Columbia network by the Byrd Expedition.

For instance, the transmitter at Byrd's base in the Antarctic will have a power of only 1,000 watts, less than double the power of the ordinary household electric iron.

From this Antarctic transmitter it is tentatively planned to have the programs routed to New York via Buenos Aires. Although short-wave facilities now exist between the Argentine and the United States, they compare in no way to wire lines which are used between various points in an ordinary hook-up. These facilities have functioned sufficiently well to merit a commercial classification, but like every other question of radio transmission, 100 per cent efficiency cannot be expected 100 per cent of the time.

A far more imposing obstacle is the great uncertainty of the Little America circuit and weather conditions. The total distance of the short-wave links is 10,000 miles.



Note the 57 detector. If the resistance load for grid circuit is specified, what grid is meant? See question 9 above, also answer in last column.

Station Sparks

By Alice Remsen

A COLORFUL FIGURE GONE

At this writing Radio Row, and all Broadway, is mourning the passing of a colorful figure in theatrical journalism—that of Sime Silverman, publisher of Variety. "Sime" was noted for his fearless policy, which dominated the whole of the theatrical world; feared by some, loved by many, honored by all, he will be greatly missed by his associates and all with whom he came in contact. . . . Good news comes from New Rochelle, N. Y., where Jack Foster is recovering from a recent collapse; Jack is now allowed out of bed for a couple of hours a day; let's hope he will soon be back at his post—the city desk of the New York "World-Telegram." . . . Quite a few new programs on the air now. It's a big hurrah for the "March of Time" series, which opens October 13th, 8:30 p. m., on WABC and network. . . . Bing Crosby started the Parade of the Champions on September 30th, at 9:15 p. m.; this is the new Columbia series which originates in Los Angeles; it's a spectacular six-broadcast program featuring nationally-known stars of stage, screen and radio: Ethel Barrymore was October 1 feature, and Morton Downey on October 2. . . . Heard the initial program of "Songs My Mother Used to Sing," and like it very much; Sundays, from 6:00 to 6:30 p.m., featuring Muriel Wilson, who was an NBS soprano, but who now evidently is doing free-lancing, and Oliver Smith, with the Jacques Renard Orchestra; a lovely combination; this series is sponsored by the Wyeth Chemical Company. . . .

BING CROSBY COAST TO COAST

Bing Crosby has been signed for a weekly series of half-hour programs over a Coast-to-Coast WABC-Columbia network beginning October 16th, 8:30 p.m. . . . Columbia is also presenting two significant sustaining series for a fall and winter schedule; "Harlem Serenade," Thursdays, 8:30 to 9:00 p. m., interpreting the moods of Harlem, New York's city-within-a-city, featuring Claude Hopkins, the country's leading colored jazz pianist, and his orchestra, together with the famous Hall Johnson Choir; the second series, "Legend of America," a cavalcade of American history, may be heard on Tuesdays, from 10:00 to 10:30 p.m., and will attempt to give dramatically a new history of America, accomplished by means of actual episodes from our history and the history of Europe where it directly affects our own; dramatized by Earl Hildreth, and produced under the direction of Herman Biberman, formerly actor and director with the Theatre Guild; a cast of twenty or more actors and a narrator will be used. . . . "The King's Henchmen" program shifts to Saturdays, from 7:00 to 8:00 p. m., and the Columbia network, carrying it, enlarges from a New York state group to an eastern chain as far south as Washington; Jane Froman, Charles Carlile and Fred Berren's orchestra will still comprise the talent. . . . As I write this, Johnny Green is concluding his interesting series of programs in "The Modern Manner," Johnny did very nobly, proving himself an extremely capable conductor and master of ceremonies; it is hoped he will be heard again shortly. . . . Smilin' Ed McConnell, radio's original one-man show, has been given an additional CBS spot by his sponsor, Acme Paint; in addition to his regular Sunday broadcasts at 6:30 p. m., McConnell is now heard also on Wednesdays at 12:15 p. m. . . .

THE PICKARDS WITH COLUMBIA

The Pickard Family, "Pa" Obed, "Ma" Leila, Obie, Jr., Ruth and Little Ann, will bring their songs from the Tennessee hill country to the audience of the WABC-Columbia network every Wednesday, from 3:15 to 3:45 p. m.; several seasons ago, Dad Pickard placed his family in their flivver and started out for a few days' vacation; they never did return home, probably because they also carried along Dad's jewsharp, harmonica and guitar, Ruth's violin and a spare guitar for Obed, Jr., just for fun; when they got to Louisville, someone persuaded them to put on a program of their native music over a local radio station; they made such a success that they were sent to other stations in Detroit, Cincinnati, Buffalo and finally New York; now Dad Pickard, who used to be a traveling salesman, lets the airwaves do the travelling for him on a coast-to-coast radio hookup. . . . A pleasant interlude just finished on WJZ, Fred Stone and daughter Dorothy, in excerpts from "The Red Mill." . . . Another death in the publishing world was just this minute announced by Walter Winchell—Horace Liveright, one of the better book publishers. . . . Arthur Boran, funny man, opens on WOR with a beer program on October 6th. . . . Phil Spitalny opens with a coal commercial over an NBC network on October 1. . . . Paul Whiteman opens at the Capitol Theatre, New York, on October 6th, and at the same time he will open at the Paradise restaurant, just a few blocks away from the theatre; jolly good business, Paul! . . . Raoul Marlo is back on WOR after a long absence with a new script series entitled "That's Life." . . .

HERE'S A PROGRAM

The gala premiere of the new Seven Star Revue, formerly "The Bath Club" revue, sponsored by the Corn Products Refining Company, makers of Linit, and presenting one of the most elaborate programs on the air, started over WABC and the coast-to-coast network of the Columbia Broadcasting System on Sunday, October 1, from 9:00 to 10:00 p. m. EST; Nino Martini, Julius Tannen, Jane Froman, Erno Rapee, Ted Husing, the Vagabond Glee Club and Mr. Rapee's Symphony Orchestra, comprise the seven-star talent. . . . A series of consecutive Sunday afternoon programs have been started over WABC. From 1:30 to 3:30—a two hour show—starting with Lazy Dan, the Minstrel Man, for the first half hour; then Helen Morgan for the next half hour, and then Abe Lyman's orchestra in "The Big Hollywood Show"; quite an ambitious program, what! . . . The Boswells are playing vaudeville here and there. . . . Don Voorhees Orchestra has been chosen to accompany Albert Spalding during his series of programs over WABC, which started on Wednesday, October 4, at 8:30 p. m. . . . For those who have wondered what happened to Ward Wilson, the radio engineer who turned radio mimic; he is playing the Loew vaudeville theatres. . . .

ALL IN A BUNCH

Arrangements have been made to bind together in cooperative effort three of the principal super power stations of the central and southern states in a chain to be known as the "Center of Population Group" to present sustaining and commercial service; WCKY, Covington, Kentucky; WHAS, Louisville, and WSM, Nashville, Tennessee, are the stations. . . . Have you heard those "Mountain Music" programs conducted by William Wirges, over WJZ, Sundays, 10:00 p. m.? If not, be sure to catch them; they are worth while. Mr. Wirges has great support in Ed Smalle and Jerry Macy, Frank Novack, Eddie Grosso and Johnny Colli; and if you should happen to tune them in on October 6th, and hear a one stringed fiddle wailing away, you must know that history is attached to that little old one-stringer; Bill Wirges made it when he was a kid, fifteen years ago, out of one of his daddy's cigar boxes, a piece of wire from his mother's cinder sifter, and the knob from the kitchen screen door for the key on which to turn the wire; Bill got spanked for that, but he played on it, and still can draw—(I say draw advisedly) a tune from it; if you don't believe me, listen in for yourself. . . . And another good Sunday night program is Phil Duey and his Fireside Songs, 10:15-10:30 p. m., WJZ and network. . . . And now, until next week, must say so long; am so sleepy I can scarcely hold my eyes open.

HONORS HEAPED ON MARCONI IN HIS VISIT HERE

Guglielmo Marconi, arrived in New York City on the Italian liner Conti di Savoia enroute to the Century of Progress Exposition in Chicago to attend during "Marconi Day," celebrated in recognition of the inventor's contributions to modern scientific progress.

As the ship brought the Marchese and Marchesa Marconi up the bay a description of their arrival was broadcast on short-wave radio, an application of "Marconi wireless" to mass communication. The following day the inventor was invited to visit the New York office of R. C. A. Communications, Inc., the largest radiotelegraph center in the world, and inspected the new National Broadcasting studios in Radio City.

Marchese and Marchesa Marconi remained in New York two days prior to their departure for Chicago. They were met by David Sarnoff, president of the Radio Corporation of America, whose guests they are while in America, and who on behalf of Rufus Dawes, president of A Century of Progress, issued to them the invitation for the visit to Chicago.

General James G. Harbord, Chairman of the Board of the Radio Corporation, and Mr. Sarnoff were hosts at a dinner in Marchese Marconi's honor at the Ritz Carlton Hotel.

The National Broadcasting Company presented a program portraying the rise and service of radio and dramatizing important episodes of Marconi's work and the history of the industry. The broadcast announced the opening of Radio Progress Week, which ends this Saturday.

Representatives of the city, the Century of Progress, the Italian Government, and the American Legion met Marchese and Marchesa Marconi upon their arrival in Chicago. After attending church services with his wife, the inventor was the guest of the Italy-America Society at luncheon.

TRADIOGRAMS

By J. Murray Barron

North American Radio Corp., 1845 Broadway, New York City, represent the Grunow products, manufactured by the General Household Utilities Co. of Chicago, Ill.

* * *

Henry B. Gentry, son of H. B. Gentry, founder of Gentry Brothers Circus, and a radio advertising specialist, has joined the organization of Brooke, Smith & French, Inc., Detroit advertising agency, as radio director and will be active in planning and executing radio campaigns for their clients.

* * *

Thor's Bargain Basement, 167 Greenwich Street, New York City, is in production on its new 8-tube Blue Eagle t-r-f kit and will supply free diagrams.

* * *

Postal Radio Corp., 135 Liberty Street, New York City, announces a complete Fall line of radio receivers and the 1934 International Professional Short-Wave Receiver.

* * *

When one figures the large number of catalogs that is sent out by the average mail order house and the expense it would seem that there might be a better way of getting the message across. A circularizing list seems a cheaper way, yet in most cases does not show up satisfactorily. To advertise for requests for a catalog is one logical way. A strict check-up should be made of catalogs and all dead wood eliminated. The worth of a publication as a business-getter and not mere number of pages should be considered. Large numbers of inquiries unless they materialize into orders are often expensively disappointing.

* * *

Universal Microphone Co., Inglewood, Cal., announces a catalog in loose-leaf form. New sheets will be in size and form to insert in salesmen's manuals. Supplements will be issued monthly.

* * *

Fans, experimenters and home constructors who have in mind buying radio parts, kits or sets, should not wait any longer than absolutely necessary. Prices are now lower than they will ever be again this season.

Literature Wanted

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

M. Forssberg, 814 S. Hermitage St., Chicago, Ill.
R. W. Fordyce, Service Mgr., Buckhannon Electric Shop, 20 West Main Street, Buckhannon, West Va.
J. Epstein, 1710 Carroll St., Brooklyn, N. Y.
Philip E. Cummings, 8 Garden St., Thompsonville, Conn.
S. J. Dusharme, 207 No. Schuyler Ave., Kankakee, Ill.
Erwin E. Shambeau, 1221 N. Jefferson St., Apt. 408, Milwaukee, Wisc.
Sherman Hill, Jr., Box 95, Martinton, Ill.
O. K. Beard, 2435 Laurel Ave., Beaumont, Tex.
J. T. Kennedy, P. O. Box 271, Gilbertville, Mass.
Milton Dideum, 1304 W. Walnut St., Shamokin, Penna.
Emil Oressy, 1119 Blan Ave., Scranton, Penna.
Boris Tolmachoff, "Plum Cottage," Vance Ave., Lavallette, N. J.
Jack Litwin, 576 James St., N., Hamilton, Ont., Canada.
J. J. Black, 1773 Marks Ave., Akron, Ohio.
P. L. Antonich, 620 East Park Ave., Anaconda, Mont.
R. J. Stier, Fountain Square Hotel, Vine St., bet. 4th and 5th, Cincinnati, Ohio.
C. H. Weant, 4308 Springwood Ave., Baltimore, Md.
Geo. A. Hadsell, Mgr. The Radio Laboratory, Galion, Ohio.
Ralph B. Brehm, 92 Nutt Ave., Uniontown, Penna.
George I. Viall, Jr., 5 North Water Street, Rochester, N. Y.
Hugo Menzel, Rte. 3, Box 804, San Jose, Calif.
C. A. Kemnitz, Eldorado, Wisc.
Frs. Coupal, Brebeuf, Co. Terrebonne, P. Q., Canada.
John Meehan, 219 Genesee St., Utica, N. Y.
N. M. Dahlberg, Valemount, B. C., Canada.
C. M. Findley, 133 E. State St., Kennett Square, Penna.
H. M. Ryder, 257 So. Palm Drive, Beverly Hills, Calif.
Joseph Ingentoff, 336 Locust Ave.
Oval L. Robinson, 306 Tippett Ave., Morehead, Kentucky.
G. D. Gratton, c/o A. E. D. Co., Island Falls, Ont., Canada.

RCA Defeats Cable in Tube Case Appeal

The United States Circuit Court of Appeals for the Second Circuit has handed down a decision sustaining the contentions of the Radio Corporation of America in a suit against Cable Radio Tube Corporation. The decision affirms previous decissions of the District Court of the United States for the Eastern District of New York, from which the defendant appealed to the Circuit Court.

An appeal was taken after the Federal District Court adjudged the tube company in contempt and imposed fines for violation of writs of injunction forbidding it to continue to manufacture radio tubes defined in the court's decree in 1930 as violations of RCA patents. Consolidated with the tube company's contempt appeal was its appeal from a denial by the same court of a motion to vacate or modify the injunctions.

Cable had been sued by RCA for $39,118 royalties under a written agreement licensing the tube company.

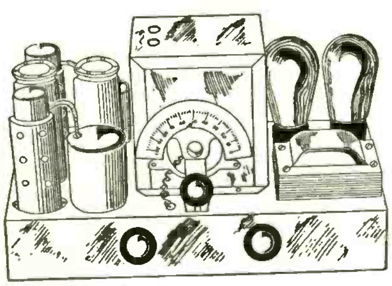
RMA Compiling Data on Automobile Radios

Radio Manufacturers Association's Committee on automotive radio, of which Virgil M. Graham of Rochester, N. Y., is chairman, has been active in obtaining authoritative data on built-in car antennas and battery polarity directly from the car manufacturers. This work is being carried on through the cooperation of R. S. Burnett, standards manager of the Society of Automotive Engineers. The information received is forwarded to the members of the committee promptly, and as soon as all the car manufacturers have supplied their data, a compilation will be made.

The committee is also beginning the consideration of standardization of ignition suppression resistors with the idea of eliminating some of the present excessive number of types and designs.

High Transmitting Point for Ultra Waves

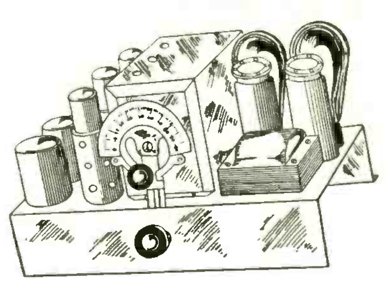
When ultra-short waves are used in communication an endeavor is made to erect the transmitter and the receiver on high points, without any obstacles between them. But in the successful experiments over the comparatively long distances, the heights have not been great enough to overcome the entire curvature of the earth between the two points.



BLUEPRINTS, COILS and CHASSIS

FOR THE TUNED R-F

DIAMOND OF THE AIR



FOUR-TUBE DIAMOND

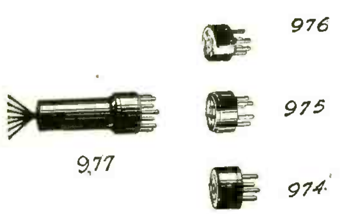
Extremely fine performance, including fetching tone quality, marks the Four-Tube A-C 1933 Diamond of the Air, blueprint of which is now available (half-scale). Many have been surprised that so much can be accomplished on a t-r-f set that costs so little to build. The circuit uses a two-gang 0.00035 mfd. condenser. Special coils are required. The chassis is metal, 13.75 x 6.75 x 2.5 inches.

Send $3.00 for six months subscription (26 issues) and get the blueprint, two official shielded coils and the drilled metal chassis free. Order PRE-D-4-COMB.

FIVE-TUBE DIAMOND

The Five-Tube A-C 1933 Diamond of the Air provides greater sensitivity than the four-tube model, also somewhat more selectivity, as a three-gang condenser is used. An infallible method of permanently suppressing oscillation is introduced, so that besides having a sensitive and selective set one will have a stable receiver. The tone is most excellent. Send $4.00 for 34 weeks subscription (34 issues) and get the blueprint, three shielded coils and drilled metal chassis free. Chassis is 13.75 x 9 x 3 inches. Order Cat. PRE-D-5-COMB.

Analyzer Plug and Adapters



For constructing a set analyzer, an analyzer plug, to go into a receiver socket, is necessary. We offer the exclusive seven-pin analyzer plug, plain long handle as illustrated, and three adapters that enable putting the plug connections into UX, UY and six-pin receiver sockets. The plug has 5-foot 7-lead cable. All four parts sent free on receipt of $6.00 for one-year's subscription (52 issues). Order Cat. PRE-ANPLAD.

0-10,000-Ohm Resistance Meter

A 0-10,000-ohm ohmmeter and continuity tester. A rheostat is built in for correct zero resistance adjustment. The unit contains a three-cell flashlight battery. Supplied with two 5-foot-long wire leads with tip plugs. Case is 4-inch diameter baked enamel. Sent you for an order for one year's subscription for RADIO WORLD (52 weeks) at the regular rate of $6. Order Cat. PRE-500.

We do not pay postage on resistance meter. Average postage 17c.

RADIO WORLD and RADIO NEWS } $7.00

Get both of these mazagines for one year for $7.00, although the regular subscription price of RADIO WORLD alone is $6.00 a year and that of "Radio News" alone is $2.50 a year. Instead of paying $8.50 you pay $7 and you get 52 issues of RADIO WORLD (one a week) and 12 issues of "Radio News" (one a month). "Radio News" recently bought "Citizens Radio Call Book," and "Technical Review" and consolidated them with "Radio News." This offer at this combination price applies only to United States and possessions. Send $7.00 and order Cat. PRE-RWRN.

To Canadian and other Foreign subscribers the combination price offer is at $8.50 for these two magazines. Order Cat. PRE-FOR-RWRN.

RIDER'S MANUAL

The standby of the service man is John F. Rider's "Perpetual Trouble Shooter's Manual."

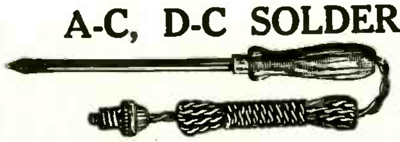
Vol. 2 contains additional diagrams on the same basis as above, but in Vol. 2 there is no duplication of any of the diagrams printed in Vol. 1.

To get Vol. 2 free, send $9.00 for 1½-year subscription (78 weeks) and order Cat. PRE-RM-2.

PHONOGRAPH MOTOR

Allen-Hough synchronous phonograph motor, 78 revolutions per minute; takes up to 12-inch records. Works from a-c line, 50-60 cycles, 105-120 volts. Equipped with felt-covered turntable. To start the motor give it a slight impetus. Fits into 3-inch depth, hence handy for compact installations. Given free with 34-weeks subscription at $4.00. Order Cat. PRE-PHOMO.

A-C, D-C SOLDERING IRON



A serviceable iron that works on a-c (any frequency) and d-c, 105-120 volts. Sent free on receipt of $1.50 for three-months subscription (13 issues). Order Cat. PRE-SOLIN.

DOLLAR SPECIALS

R-F CHOKE COILS

These coils have 50, 100, 200, 400 and 800 turns, diameter 1 inch, and are suitable for detector plate filtering, screen filtering, grid and plate loads, etc. The 50 is for short waves, 100 for television band, 200 for broadcast band, 400 for high intermediate frequencies (450 to 300) and 800 for lower intermediate frequencies. Any four, or four of a kind, or combinations not exceeding total of four, sent free on receipt of $1.00 for 8 weeks trial subscription. Order Cat. PRE-4-CH and state chokes desired, by quantity and number of turns.

TWO BOOKS BY ANDERSON AND BERNARD

"The Superheterodyne," by J. E. Anderson and Herman Bernard. A treatise on the theory and practice of the outstanding circuit of the day. Special problems of superheterodynes treated authoritatively.

"Foothold on Radio." A simple and elementary exposition of how broadcasting is conducted, with some receiver circuits and an explanation of their functioning. Both books sent free on receipt of $1.00 for 8 weeks trial subscription. Order Cats. PRE-SH-FH.

CHOICE OF PANEL TYPE METERS

One meter sent free with each $1.00 trial subscription (8 weeks). Order Cat. PRE-MTR and add the number of the meter to the catalogue number. Any number of meters may be ordered on the equivalent extended subscription basis.

0-6 Voltmeter D.C.	No. 326
0-50 Voltmeter D.C.	No. 337
6-Volt Charge Tester D.C.	No. 23
0-10 Amperes D.C.	No. 338
0-25 Milliamperes D.C.	No. 325
0-50 Milliamperes D.C.	No. 350
0-100 Milliamperes D.C.	No. 390
0-300 Milliamperes D.C.	No. 399
0-400 Milliamperes D.C.	No. 394

HANDY PACKAGE OF PARTS

One grid condenser of 0.00025 mfd., with clips; one 5-to-7 meg. fixed grid leak; one knob with ¼-inch shaft; one a-c cable and plug. All sent on receipt of $1.00 for 8-weeks trial subscription. Order Cat. PRE-HANPKG.

SHIELDS FOR 57, 58 TUBES

Aluminium shields of the type specified by the tube manufacturers for sensitive circuits, so that the shield top fits snugly about the tube dome, are obtainable, six free on receipt of $1.00 for 8 weeks trial subscription. Order Cat. PRE-TUBSH.

RADIO WORLD, 145 West 45th Street, New York, N. Y.

(WE PAY POSTAGE ON ALL PRODUCTS LISTED ON THIS PAGE, EXCEPT OHMMETER).

Quick-Action Classified Advertisements

7c a Word—$1.00 Minimum

Dial Reads Frequencies Directly!

A *NEW* TEST OSCILLATOR

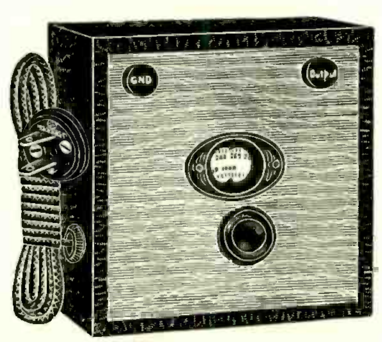
That Works on A.C., D.C., or Batteries!

Over-All Size Is Only 5x5x3"!

For Lining Up Intermediate and Broadcast Frequencies at An Average Accuracy of 1%!

A NEW TEST oscillator, Model 30, has been produced by Herman Bernard, so that all the requirements for lining up broadcast receivers, both tuned radio frequency and superheterodyne types, will be fully and accurately met. This device may be connected to 90-120-v a.c., any commercial frequency, without regard to polarity of the plug, and will function perfectly. It may be used also on 90-120-volt d.c. line, but plug polarity must be observed. One of the plug prongs has a red spot, denoting the side to be connected to positive of the line. If you don't know the d.c. line polarity, you may connect either way, without danger. The oscillator will work on d.c. only when the connection is made the right way. Moreover, 90 volts of B battery may be used instead of either of the foregoing, simply by connecting two wires between the plug at the batteries, observing polarity. No separate filament excitation is required. The oscillator is modulated with a strong, low note under all circumstances. It uses a 30 tube.

SHOWN ONE-THIRD ACTUAL SIZE!



THE dial of the Bernard Model 30 Test Oscillator is directly calibrated in kilocycles, so there is no awkward necessity of consulting a chart. The fundamental frequencies are 135 to 380 kc, so that nearly all commercial intermediate frequencies as used in present-day superheterodynes are read on the fundamental. The points for other intermediate frequencies, e.g., 400, 450, 456 and 465 kc, are registered on the dial also, two harmonics, with which the user need not concern himself, being the basis of these registrations. Besides, the broadcast band is taken care of by the fourth harmonic and the dial is calibrated for that band, also.

The divisions on the dial for the fundamental band, 135 to 380 kc, are 1 kc apart from 135 to 140 kc, 2 kc apart for 140 to 180 kc and 5 kc apart for 180 to 380 kc. For the broadcast band, 10 kc apart from 550 to 800 kc, 20 kc apart from 800 to 1,500 kc.

The test oscillator may be used also for short waves, by resorting to higher harmonics.

Anywhere There's a Set This Oscillator Can Be Worked!

IT is an outstanding advantage to have a test oscillator that is constantly modulated and that will work anywhere there is a set (unless it be only a crystal set), for no matter what power the set owner uses for running his receiver, it will run the oscillator. Besides, there is the comforting assurance of accuracy such as only costly precision instruments exceed.

THE test oscillator will give distinctive zero beats when worked on d.c. or batteries, but zero beats may not be distinctive, or may be absent, when the oscillator is used on a.c. Users are eagerly encouraged to check up the accuracy of the test oscillator with broadcast stations' carrier frequencies and will find that the amazing accuracy is indeed a fact!

MODEL 30 TEST OSCILLATOR, COMPLETE WITH 30 TUBE . . . $6.50

EDWARD M. SHIEPE

**135 LIBERTY STREET
NEW YORK, N. Y.**

Coil Winding for All Radio Frequencies Without Any Computation Whatever!

"The Inductance Authority"

By EDWARD M. SHIEPE, B.S., M.E.E.

THE ONLY BOOK OF ITS KIND IN THE WORLD, "The Inductance Authority" entirely dispenses with any and all computation for the construction of solenoid coils for tuning with variable or fixed condensers of any capacity, covering from ultra frequencies to the borderline of audio frequencies. All one has to do is to read the charts. Accuracy to 1 per cent. may be attained. It is the first time that any system dispensing with computation has achieved such very high accuracy and at the same time covered such a wide band of frequencies.

A condensed chart in the book itself gives the relationship between frequency, capacity and inductance, while a much larger chart, issued as a supplement with the book, at no extra charge, gives the same information, although covering a wider range, and the "curves" are straight lines. The condensed chart is in the book so that when one has the book with him away from home or laboratory he still has sufficient information for everyday work, while the supplement, 18 x 20 inches, is preferable for the most exacting demands of accuracy and wide frequency coverage.

From the tri-relationship chart (either one), the required inductance value is read, since frequency and capacity are known by the consultant. The size and insulation of wire, as well as the diameter of the tubing on which the coil is to be wound, are selected by the user, and by referring to turns charts for such wires the number of turns on a particular diameter for the desired inductance is ascertained.

There are thirty-eight charts, of which thirty-six cover the numbers of turns and inductive results for the various wire sizes used in commercial practice (Nos. 14 to 32), as well as the different types of covering (single silk, double silk, single cotton, double cotton and enamel) and diameters of ¾, ⅞, 1, 1⅛, 1¼, 1⅜, 1½, 1¾, 2, 2¼, 2½, 2¾ and 3 inches.

EACH turns chart for a given wire has a separate curve for each of the thirteen form diameters.

The two other charts are the tri-relationship one and a frequency-ratio chart, which gives the frequency ratio of tuning with any inductance, when using any condenser the maximum and minimum capacities of which are known.

The book contains all the necessary information to give the final word on coil construction to service men engaged in replacement work, home experimenters, short-wave enthusiasts, amateurs, engineers, teachers, students, etc.

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