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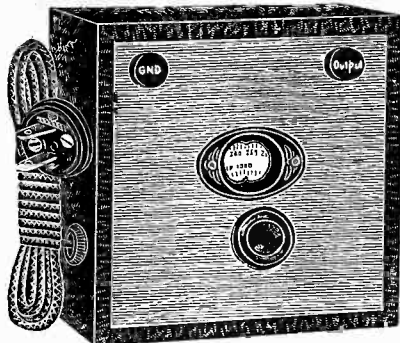
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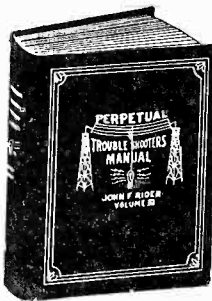
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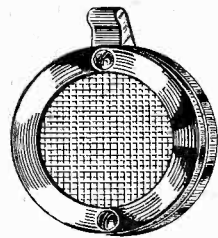
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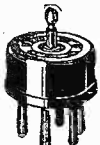
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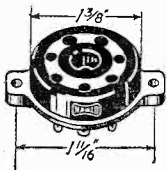


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TESTING TUBES

Shorts, Gas, Power, Emission and Mutual Conductance Determined

By J. E. Anderson

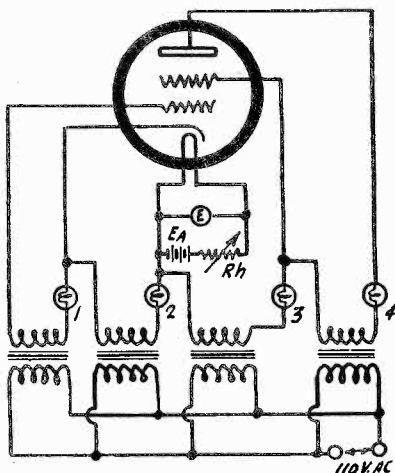


FIG. 1

This circuit is suitable for making short-circuit tests of a tube. One or more lamps light when there is a short, depending on where the short is.

SHORT CIRCUITS frequently occur in vacuum tubes, and when they do, the tube ceases to function. Sometimes a short occurs only when the tube is hot, and at other times it occurs when the tube is cold as well. If it occurs only when the tube is hot, a test on the tube for a short when it is cold will not reveal the trouble. Hence tests should be made when the tube has the normal operating temperature. Occasionally a short is not complete, that is, it is not a "dead short," as there may be a high resistance at the contacts. Allowance must be made for this possibility in making the short-circuit test.

Short-Circuit Tester

In Fig. 1, is a short-circuit tester suitable for a tube having six or fewer terminals. By using more transformers and indicators it may be made to fit tubes having more electrodes. While four different transform-

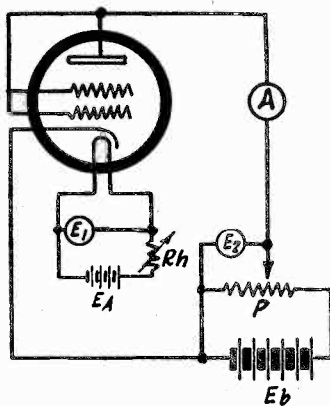


FIG. 2

An emission test on a tube can be made with this circuit. The total current is measured with a low voltage on the anode. The plate and all grids are tied together.

ers are used in this case, a single transformer with four secondary windings can be used equally well. In each of the secondary windings is an indicating lamp. Since there may be a high resistance in one of the shorts, the lamps should be selected so that they will glow on a small current. The voltage of the secondaries, of course, must be selected to fit the lamps that are used as indicators.

When there is a short one or more of the indicator lamps will light, with a bright light if the short is complete and with a red glow if there is a resistance in series. Which lamp, or lamps, will glow depends on where the short is. Suppose there is a short between the control grid and the cathode. Lamp No. 1 will light. If there is a short between the filament and the cathode, lamp No. 2 will light. If the short is between the filament and the control grid both No. 1 and No. 2 lamps will light.

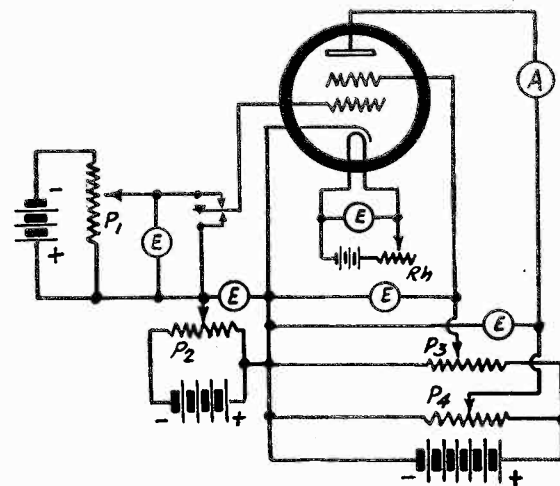


FIG. 3

This circuit measures the mutual conductance of the tube by the "grid shift" method. The potentiometer should be adjusted so that the change in the bias is one volt.

Suppose now that the short is between the screen grid and the filament. Lamp No. 3 will light. If the short is between the screen and the cathode, lamps Nos. 2 and 3 will light, and if the short is between the screen and the control grid, Nos. 1, 2 and 3 will light. If the short is between the screen and the plate, No. 4 will light. If it is between the plate and the filament, Nos. 3 and 4 will light. These are just a few of the combinations that will be tested. There are 21 possible combination in all, consisting of 4 singles, 12 doubles, 4 triples and one quadruple.

In case more than one lamp lights at a time, the fault is not definitely located, because there may be two or more shorts. This uncertainty can be removed by opening up the circuits, which may be done by removing lamps.

Perhaps a simpler short-circuit tester would be one transformer, one indicating

Mutual Conductance and Power Output Measurements

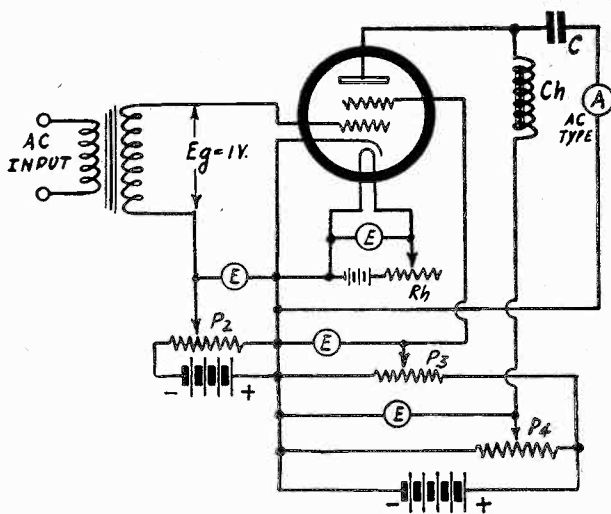


FIG. 4

This circuit measures the mutual conductance of the tube under dynamic conditions. The reading on A divided by the voltage at Eg is the characteristic sought.

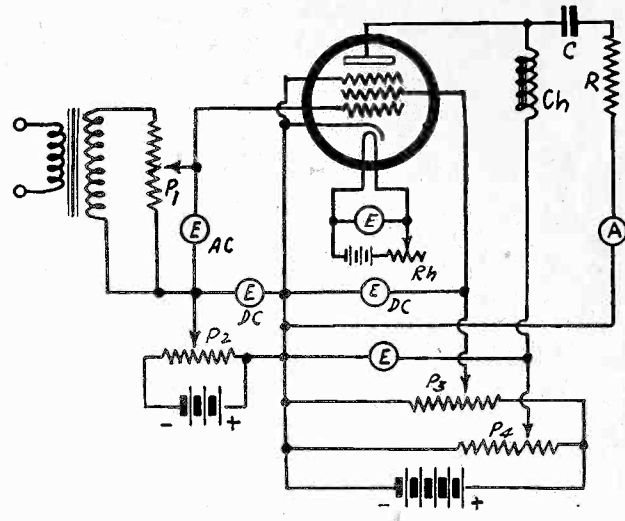


FIG. 5

This circuit is suitable for measuring the output power of a tube. The power output test is one of the best for judging the condition of a tube, even for a voltage amplifier tube.

lamp, and a provision for heating the tube to its normal temperature. The secondary circuit, including the lamp, could then be provided with test prods which could be connected between any two terminals on the tube. Such a tester would apply to any tube regardless of the number of electrodes. When the test prods are used, good contact should be made to reduce the resistance.

Emission Tester

A tube functions only because of its electron emission. As a tube is used, the electrons emitted by the cathode decrease, and finally cease. When the emission has fallen below a certain value the tube becomes useless. Hence it is important to have a means of measuring the emission of any tube.

The emission, or emission current, is the saturation current of the tube; that is, the current determined by the total number of electrons emitted from the cathode at the normal operating temperature. This current, however, is so high for many tubes that it is not practical to measure it. Hence the emission is measured with a comparatively low anode, or plate, voltage. The space charge is depended on for limiting the current. That is, the anode voltage used is so low that it is not able to attract all the electrons emitted. Any tube is rated in terms of a normal tube and it is not necessary to know the actual saturation current. A tube known to be in good condition can first be tested with the same anode voltage, and then the suspected tube. If this gives a much lower plate current the emission is subnormal.

A circuit suitable for the measurement of the emission is given in Fig. 2. It will be noticed that all grids are connected to the plate from the anode. Thus the tube is tested as a diode. The filament voltage is adjusted to normal by the rheostat, with the aid of voltmeter E1. The plate voltage is adjusted by means of the potentiometer P, with the aid of voltmeter E2. For any given type of tube the voltage indicated by E2 should always be the same, and it should have a low value. The emission is read on the milliammeter A. Readings should be taken quickly because if the emission is heavy, the life of the tube is shortened to some extent. This is important in case the tube tested happens to be good.

Mutual Conductance

The mutual conductance of a tube gives a better test of its capability because that measures the amplification. The mutual

conductance of a tube is the ratio of the change in the plate current to the change in the grid voltage producing that change in the plate current, the plate and screen voltages remaining constant. The change in the grid voltage should be very small, but a convenient value of the change is one volt, for when this voltage change is used the change in the current is the mutual conductance.

In Fig. 3 is a circuit suitable for measuring the mutual conductance under static conditions. Batteries and potentiometers are provided for supplying and adjusting the various voltages required. By means of P2 the fixed operating bias is adjusted and by P1 the voltage that is to be added to the bias. The voltmeter across the lower portion of P1 should be adjusted to read one volt. First the current in the milliammeter A should be read when the key in the grid circuit is pressed down, and then again when the key is up. The difference in the grid bias in the two positions of the key is one volt, and therefore the difference between the two current readings is the mutual conductance. This method of measuring the mutual conductance is called the "grid shift" method.

Dynamic Method

A tube does not operate under static conditions and for that reason the preceding method of measuring the mutual conductance is not entirely satisfactory. It is better to measure the mutual conductance under dynamic conditions. This can be done by removing the device supplying the added bias in Fig. 3 and substituting a transformer by which an a-c voltage of one volt, effective value, can be applied to the grid, and then using an a-c milliammeter, dynamometer type, in the plate circuit. The reading on the a-c meter is the mutual conductance. In case the effective input voltage has some other value than one volt, the mutual conductance is the reading on the a-c milliammeter divided by the grid input voltage.

If a dynamometer a-c milliammeter is not available an approximate value of the mutual conductance can be obtained by a circuit such as that in Fig. 4. This is the same as that suggested above except that the d-c component of the a-c current is filtered out in another way. Ch should be an audio choke of high inductance and C should be a condenser of large value. Values of 100 henries and 10 mfd. might be used if the frequency of the signal is 400 cycles per second. This modified method is in error to

the extent that the a-c component flows through the choke coil rather than through the meter.

Power Test

One way of testing a tube that gives a close check on its amplification property is to measure the output power. This gives directly the capability of the power tube and indirectly a tube that functions as a voltage amplifier.

A circuit suitable for measuring the power output of a pentode is shown in Fig. 5, but it is applicable to other tubes with slight modifications. An a-c signal voltage of suitable value is applied to the control grid by means of a transformer and measured by means of an a-c voltmeter. The power output resulting from this input voltage is measured by the a-c milliammeter A and the known value of the resistance R. The d-c component of the output current is separated from the a-c by the usual choke, Ch, and condenser, C. The power is RI^2 , in which R is expressed in ohms and I in amperes.

The sensitivity of the a-c milliammeter depends on the tube and the load resistance, as well as on the input voltage. The input voltage can be adjusted to the maximum value for the tube in question, that is, to such a value that its peak is equal to the fixed bias. The effective value, which is indicated by the a-c voltmeter, is 0.707 as great as the peak. Hence the peak is 1.41 times greater than the effective value.

Choice of Load

The value of R should be that specified as the proper load in the case of a power tube. In the case of a voltage amplifier tube it might have a value comparable to that specified for load resistance, or it may have a lower value in case the sensitivity of the a-c milliammeter is such that no accurate readings can be obtained with the high resistance.

A standard for each type of tube can be established, either by taking the values of rated output power given in tube charts, or, if this is not available, by measuring the output of a tube that is known to be in good condition.

Suppose we are dealing with a pentode requiring a load resistance of 6,000 ohms. R is made this value. The grid bias required may be 18 volts. Hence we might adjust the effective value of the input voltage to 12.5 volts. This might yield an a-c plate

(Continued on next page)

(Continued from preceding page)

current of 22 milliamperes. Hence the power is 2.9 watts. The rating of the normal tube is 3 watts. Hence we conclude that the tube is all right.

Current between the control grid and the cathode flows under certain conditions, and in many cases the misbehavior of the circuit depends on this current. Not all tubes are equal in this respect. Hence it is important to have a means of measuring the current. Frequently the current is so small that it cannot be measured with ordinary deflection meters, and therefore another arrangement is necessary. A typical circuit is illustrated in Fig. 6. It is drawn for a heater type triode, but X indicates that it applies to other types as well. In case the tube has the other elements the specified voltages should be applied to them. Of course, the plate voltage should also be the specified voltage.

First let the grid bias be adjusted to the value at which it is desired to measure the grid current. Then close the switch S. Note the plate current on the milliammeter A. Now open the switch S. This throws resistance R_c in the grid circuit and the grid current will establish a voltage across it which is proportional to the grid current. This voltage is added to the bias, and therefore the plate current will change. Now reduce the grid bias, as measured by E, until the plate current is returned to its original value. The change in the grid bias as read on E is equal to the voltage drop in R_c . Hence if we divide the change by the value of the resistance R_x , we get the grid current. Symbolically this is $I_g = dE_c/R_c$, in which dE_c is the change in the grid bias.

Getting Accuracy

In order to get an accurate value of the change in the voltage, the voltmeter should be one of low range. If the bias is high, it is not necessary to connect the meter across the entire battery, but only across a portion of it, that portion to be such that it covers the change. Just what the adjustment should be is found experimentally by one or two preliminary tests.

In order to get accuracy it is also essential that the plate current be returned to exactly the original value. This is difficult if the total current in the plate circuit has a high value. It is possible, however, to increase the accuracy by balancing out the normal plate current by an arrangement as shown by the dotted lines. This permits the use of a much more sensitive meter in the plate circuit, say a 0-100 microammeter in place of a 0-10 milliammeter. The rheostat R_h is used for effecting the balance. Great care must be exercised in using this balancing method, for the sensitive meter can be ruined both by the plate current and the balancing current. It is only when these two are nearly equal that it is safe to connect the sensitive meter in the circuit. As a precaution, a variable shunt can be connected across the meter during the preliminary adjustment.

Value of Resistance

The value of the resistance R_c depends on the value of the grid current. If this is very small, the grid resistance must be high. For example, it might have to be of the order of 100 megohms. One difficulty in using such high values in determining just what their values are. The determination of the grid current can be no more accurate than the accuracy with which the grid resistance is known. Another factor which might introduce an error is the leakage across the switch. Unless a high order of insulation is used, the resistance of the switch might be of the same order of magnitude as the resistance used. In that case the error would be very large.

The method illustrated in Fig. 6 measures the total grid current, which may be composed of electrons from other electrodes to the control grid, ionization current, leakage current through various insulation materials,

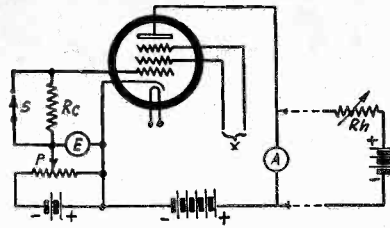


FIG. 6

This illustrates a method of measuring the total grid current when this is so small that it cannot accurately be measured with a milliammeter.

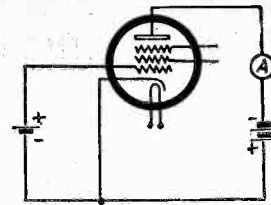


FIG. 7

The gas content in a tube can be estimated by a circuit of this type. The plate is negative, the grid

electron emission from the control grid, and electrons from the cathode which reach the grid by virtue of contact potentials and initial velocities. All these components are not in the same direction, and for that reason the total current may be less than some of the parts. It is the algebraic sum of the various currents that counts and it is that which is measured by the method in Fig. 6.

The ionization current is a large component for low negative voltages and for positive voltages. It flows from the grid to the cathode in the external circuit, or in the opposite direction to the current due to contact potentials and initial velocities. These two currents are numerically the largest. The ionization current is greater in proportion to the gas content of the tube and for that reason it is a measure of the amount of residual gas.

Measuring Ionization

A method of measuring the ionization current is indicated in Fig. 7. The plate is maintained at a negative voltage and the grid at a positive. The cathode temperature, or the heater or filament current, is adjusted so that the grid current is small. Under these conditions the plate current is measured with a sensitive milliammeter. The amount of current gives an indication of the amount of gas in the tube. The low grid current insures that the temperatures will be low enough so that no gas will be emitted by the electrodes. If the tube under measurement has more electrodes these should be maintained at specified voltages.

An alternative method is to apply positive voltage to the plate, as well as to other elements ordinarily positive, and a negative voltage to the grid. The grid current is then measured, which gives an indication of the amount of gas in the tube. If the negative grid voltage is too high there will be no ionization current. For a given type of tube the grid bias used should always be the same.

Measuring Distortion

Harmonic distortion is defined as

$$D = (I_2^2 + I_3^2 + I_4^2 + \dots)^{1/2} / I_1$$

in which I_1 is the amplitude of the fundamental and I_2, I_3, I_4, \dots are the amplitudes of the harmonics. In words the definition states that the distortion is the root mean square of all the harmonic amplitudes divided by the amplitude of the fundamental.

This definition suggests the method of measuring the distortion. If by means of a filter we separate the fundamental from the harmonics and measure the two separately, we get values from which the distortion can be computed. We can measure the effective values and use them, for they give the same ratio as the corresponding amplitudes.

The measurement of distortion may be on a wave generated by an oscillator or some other device or it may be on the output of

an amplifier when the input voltage was distortion-free. The analysis, of course, is the same in either instance. But if we are to measure the distortion occurring in a tube, such as the output tube of a receiver, we must have a means of producing a pure wave for the input voltage. Otherwise we would not get the contribution of the amplifier to the distortion.

Eliminating Harmonics

A pure sinusoidal wave can be obtained from an impure wave by the use of a low-pass filter by placing the cut-off frequency between the fundamental and the second harmonic; that is, twice the frequency of the fundamental. By this means the undesired components of the wave can be suppressed to any degree desired by adding more sections to the filter.

Having obtained a pure sinusoidal voltage we impressed this on the grid of the amplifier, adjusting the voltage to the specified value for the tube in question. Then we measure the distortion in the plate circuit, using for this purpose a suitable harmonic analyzer.

Many different harmonic analyzers have been devised, and all of them are more or less complicated. In measuring the distortion as defined by the above equation, we should separate the fundamental from all the higher harmonics and measure the two separately. Again we can use filters. A high pass filter with a suitable cut-off will suppress the fundamental and pass on the harmonics. With an a-c milliammeter we can measure the effective value of the harmonics. With a low pass filter we can get the fundamental.

Measuring Undistorted Output

In Fig. 8 is a circuit suitable for measuring the undistorted output of a power tube. At left is an audio oscillator and then follows a low-pass filter which suppresses all harmonics and passes only the fundamental to the potentiometer P, an attenuator by which the signal voltage can be adjusted to the desired value before it is impressed on the grid of the tube under test.

Ch is an audio-frequency choke to feed the plate and C is a large condenser to pass the alternating current to the measuring device. The choke must be so designed that it will not introduce any harmonics, and C should be at least 10 mfd. if the test frequency is 400 cycles per second. A is an a-c milliammeter for measuring the total a-c current through the load resistance R, the value of which should be that of the optimum load resistance specified for the tube under test.

The harmonic analyzer following the load resistance passes only the harmonics and the root mean square value of these is measured after the analyzer, which may be a high-pass filter.

In computing the distortion it is permis-

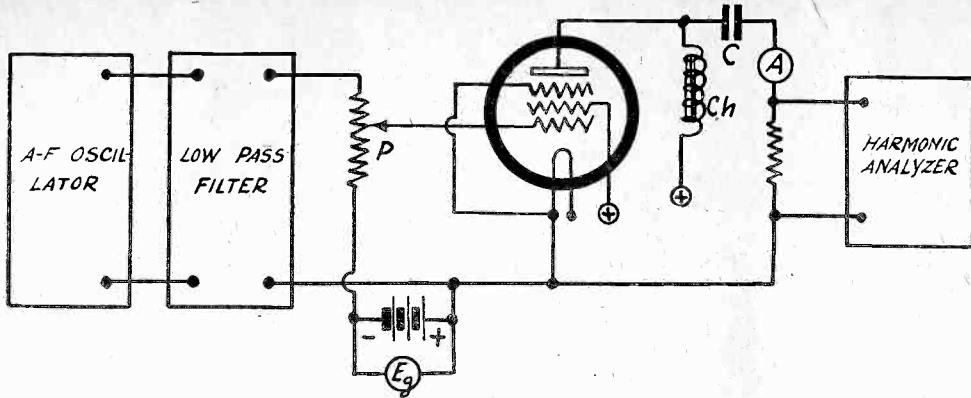


FIG. 8

This circuit shows how the distortion originating in a power tube can be measured. A pure wave is impressed on the grid and the fundamental and harmonics are measured separately.

sible to take the total current in A for the fundamental, for if the test is made under specified conditions of operation of the tube the distortion will not be more than about 5 per cent. The ratio of the total harmonic current to the total current does not differ greatly from the ratio defined, not for such small percentages of distortion.

Power from Plate Curves

The power output of a triode can be obtained from a family of plate voltage-plate current curves for the tube in question. Let Fig. 9 represent such a family of curves. The first step is to draw a load line, AB. Point M on this line is the point zero current and applied plate voltage. Point Q on the line is the point of zero voltage and the current that would result when the applied voltage is in series with the load resistance alone. The second step is to draw a line parallel to this line and passing through the point determined by the operating grid bias and the applied plate voltage. The second load line will determine maximum current and a minimum plate voltage where it crosses the line of zero bias and it will also determine a maximum plate voltage and a minimum current where the line passes through the curve corresponding to twice the bias.

Suppose I_m is the maximum current and E_m is the corresponding plate voltage, and also that I_o is the minimum current and E_o the corresponding plate voltage. Then the output power is obtained by the formula $P = (I_m - I_o)(E_o - E_m)/8$, that is, the power is one-eighth of the product of twice the current amplitude by twice the voltage amplitude.

Numerical Example

In the drawing the maximum voltage is 360 volts, which is E_o , and the corresponding current, I_o is 7 milliamperes. The maximum current, I_m , is 66 milliamperes and the corresponding voltage, E_m , is 130 volts. Hence the formula gives for this case $P = (0.066 - 0.007)(360 - 130)/8 = 1.700$ milliwatts.

The percentage second harmonic can also be determined from the curves. In words the formula for the computation of the second harmonic distortion is: The average of the maximum and minimum currents diminished by the current at the operating bias, divided by the difference between the maximum and minimum currents, multiplied by 100. In symbols, $100[(I_m + I_o)/2 - I]/(I_m - I_o)$, in which I is the current at the operating bias. We now note that the plate current at the operating bias is 0.034 milliamperes. When we substitute this value for I in the formula, together with the values we used in computing the power output, we get 4.24 per cent. as the amount of second harmonic distortion.

This distortion arises from the fact that the plate voltage-plate current curves are not straight lines.

Testing rectifier tubes is essentially a problem of measuring the emission. This

may be done in a way similar to that used for testing amplifier tubes. If normal filament voltage is used, the anode voltage employed should be low, for otherwise the current will be very large. As in other cases, a tube known to be good can be tested under the same condition and then others can be compared with this result. This test can, of course, be carried out with direct voltage on the anode and it may be done without any resistance in the circuit.

A rectifier tube can also be tested in a rectifier circuit, by measuring the voltage obtained under different load conditions, or rather for different values of current drawn. These measurements should be done with a fixed a-c voltage in the circuit. If the regulation curve shows that the voltage falls rapidly as the current is increased, the emission is low. When the rectifier has two independent cathodes each should be tested separately.

Comparison with Average Curves

For each type of rectifier tube, regulation

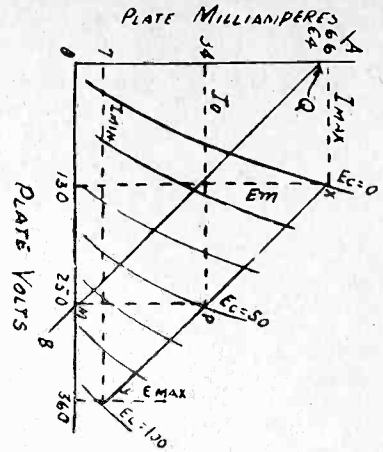


FIG. 9

A family of plate voltage-plate current curves such as this way be used for computing the power output of a tube and also the per cent. second harmonic distortion.

curves are available, giving the performance of average tubes of the type. These curves are given for different effective anode voltages and for current values up to the maximum that should be drawn from the tube in question. They are also given for different values of input condenser. Sample regulation curves are given in Figs. 10 and 11. In Fig. 10 are eight such curves for four different anode voltages and different values of filter input condenser. In this case the two plates of a full-wave rectifier are connected in full-wave manner. In Fig. 11 the regulation curves are given for the same tube when the two plates are connected in parallel, the rectifier being half-wave. It is noted that the output voltage depends to a greater extent on the value of the condenser than it does when the rectifier is full-wave.

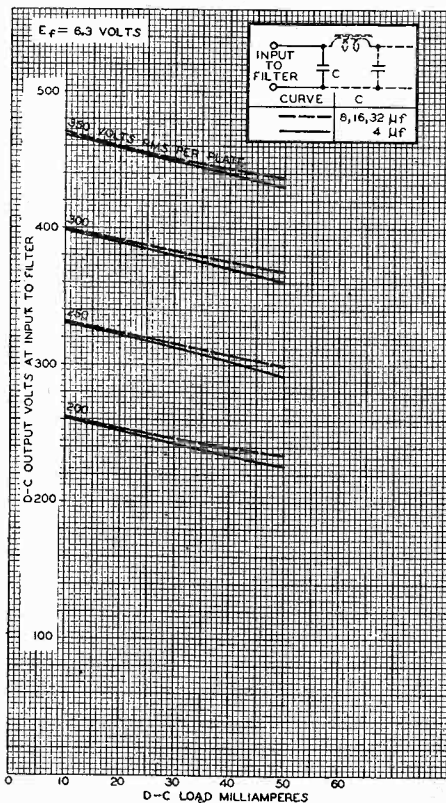


FIG. 10

Regulation curves of a full-wave rectifier for four different effective voltages, per plate, and for different values of the first condenser in the filter. Currents vary up to 50 milliamperes.

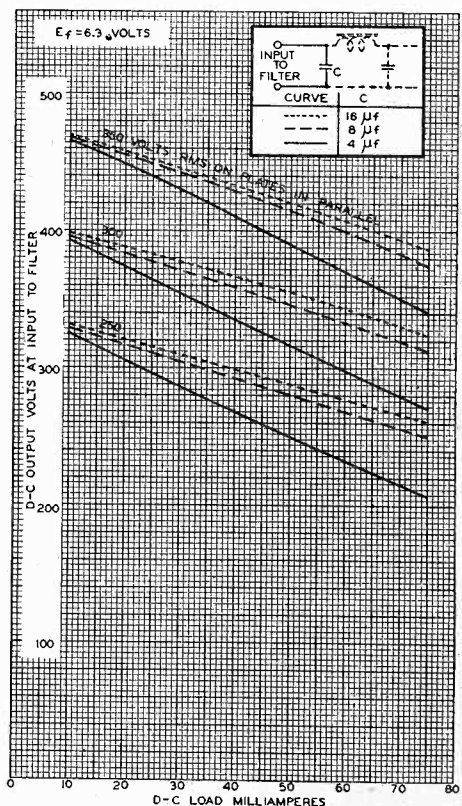


FIG. 11

The regulation curves are for the case when the two plates are connected together. The output voltage, across condenser C, varies much more with the capacity of this condenser than in the full-wave rectifier.

12-WATT AMPLIFIER

Three-Stage Audio, 2A3 Push-Pull Output

By Roger L. Meeker

A high-grade Class A power amplifier, with conservative output rating of 12 watts, using 2A3's in push-pull, is diagrammed in Fig. 1. The input is taken from a tuner, or, with an extra coupling transformer, from a microphone.

The special coupling transformer for microphone use would be such as to present a suitable impedance to the microphone, usually a few hundred ohms, with a high-impedance secondary.

The same considerations of a special transformer, still another unit, would apply for most satisfactory use of a phonograph pickup. The characteristics of the pickup and the microphone can be obtained from the manufacturer, who usually also makes or supplies the proper matching transformer. The precautions for just the right matching should be taken because this is a quality product.

Derivation of Bias

The first audio stage is a single-sided, transformer-coupled one, using a 56 tube. The second stage consists of two 56's in push-pull and this stage drives the push-pull output. The d-c voltages have been so arranged that the proper loading-up will result, and if the negative bias is less than maximum permissible in an amplifier in a preliminary stage, it is only because if the signal were near that maximum there would be overload in the output stage. However, the volume control is put ahead of the first stage, to enable overload correction at its most opportune point in the amplifier.

The negative bias on the three 56 tubes is 8.8 volts. In the first stage this results from the plate current flow through a resistor of 2,200 ohms, but since the next stage is push-pull, hence the direct current is doubled, due to the presence of two tubes, naturally the biasing resistor is one-half that in the previous instance, or 1,100 ohms.

The negative bias on the output tubes is 62 volts, derived from the potential difference between ground and B minus, developed across a resistor of 430 ohms, 5 watts rating. Since B minus is the negative side of the line, and since there is a drop of 62 volts between B minus and the other side of that resistor, which other side is grounded, the notation on the diagram correctly discloses ground as being 62 volts positive.

Fixed Bias Used

The bias on the power tubes is the potential difference between the filament and the grid return, since the 2A3 is a filament type tube, that is, the filament is the cathode or emitter. The center of the push-pull input transformer feeding the 2A3 tubes is returned through a 50,000-ohm resistor to B minus. The filament is grounded. We have noted that the potential difference between these two points is 62 volts. Therefore, since the connections are properly polarized, the bias is negative on the output by that voltage.

Moreover, the bias does not change much with differences in signal level, provided the power transformer regulation is good, as it should be. The negative-leg bias method, where all the current of the amplifier is used for developing that bias, permits of somewhat greater output than does the self-bias method. The present use is sometimes referred to as fixed bias. More general classifications ascribe power outputs of 15

watts for the fixed bias method and 10 watts for the self-bias method, but, as stated, the present amplifier is conservatively rated at 12 watts.

Tone Compensation

The volume control, instead of having arm go directly to ground, has it connected to a bypassed resistor of 100,000 ohms, which resistor is grounded. A bypass condenser of 1.0 mfd. is connected between arm of the potentiometer and cathode and serves as a hum filter as well as a modified tone control at low-volume settings of the control. That is, the attenuation of the low-frequency response due to the reduction of the impedance in the grid circuit when the arm is moved toward the grid is compensated by the attenuation of the high audio frequencies by the effect of the condenser. This is not pronounced, as the effective resistance between cathode and ground is a little less than the value of the biasing resistor (2,200 ohms), due to 100,000 ohms being substantially in parallel. The 100,000 ohms have no effect on the direct current, or bias, but do have an effect on the audio frequencies.

It was found that no bypass condenser was needed across the biasing resistor itself, as the hum filter took care of that particular part of the problem, and the regeneration at audio frequencies, present a little in the amplifier, further supported the omission of the extra condenser that might be considered necessary otherwise.

Output Stage Condenser

In the push-pull stage there are two instances of the use of high bypass capacity. Between the 50,000-ohm resistor and ground is a 20 mfd. condenser, which is compactly obtainable as an electrolytic. This is a hum filter solely. The phase displacement may be made so nicely as almost completely to obliterate the hum from the last stage, but an additional condenser of 10 mfd. is put across the actual biasing resistor of 430 ohms to remove the signal and thus get rid of whatever degenerative effects might be present.

While it is true that in self-biased push-pull stages it is common practice to omit the bypass condenser, this is due to the absence of signal current, for when the true push-pull relationship obtains there is an equal voltage in opposite phase in the resistor due to the signal, hence no effective drop except that due to direct current, and as direct current is zero frequency there is no occasion for bypassing. However, in the fixed bias circuit, as presented here, not only the current of the power tubes flows through the resistor but also the current of the other tubes, as well as some bleeder current, and therefore the bypass condenser is necessary, and 10 mfd. is sufficiently large. Also, there is some residual hum that must be removed from this biasing resistor, a handier method than resorting to nice balancing of the hum filter of 20 mfd.—50,000 ohms.

The rectifier tube is the 5-volt mercury vapor type 83, and the d-c voltage between center taps of the filament and high voltage windings is 396 volts.

The choke input circuit is used for improvement of regulation, and this choke is rated at 12 henries at 140 ma, d-c resistance 236 ohms.

The first filter condenser therefore is not next to the rectifier but comes after this first choke and is 10 mfd. The second filter

condenser is 4 mfd. and comes after the second choke. The rating of the first condenser, 10 mfd., should be at least 400 volts continuous working voltage, and of the second, 300 volts.

The bleeder choke is designated as "speaker field," but the 2,000-ohm choke also may be part of the speaker field, so that the total speaker field resistance if continuous, would be 5,400 ohms.

However, it is preferable that, whether both these chokes be on the speaker field or not, that they be not continuous, in the sense of a tapped winding on a single core, but that they be on separate cores. The d-c continuity will exist in any event, but the separate-core method prevents the flux linkage and thus makes filtration of hum easier. Therefore, in fact, one or the other may be the speaker field, with the extra choke entirely separate.

Currents Measured

An assortment of meters is shown, but not with the intention of including any of them in the actual construction of the circuit, which is one of a small group of circuits included in the new RCA Radiotron-Cunningham Radio Tube Manual. The meters are merely symbols of current readings taken, and it is advisable to use a meter in these positions as part of the testing of the completed amplifier, to insure that the currents are not much different than what they should be. All circuit constants should closely approximate those shown on the diagram.

Two speakers are included, merely to show how they would be connected in series. The matching of the secondary to the voice coil impedance is done by the speaker manufacturer.

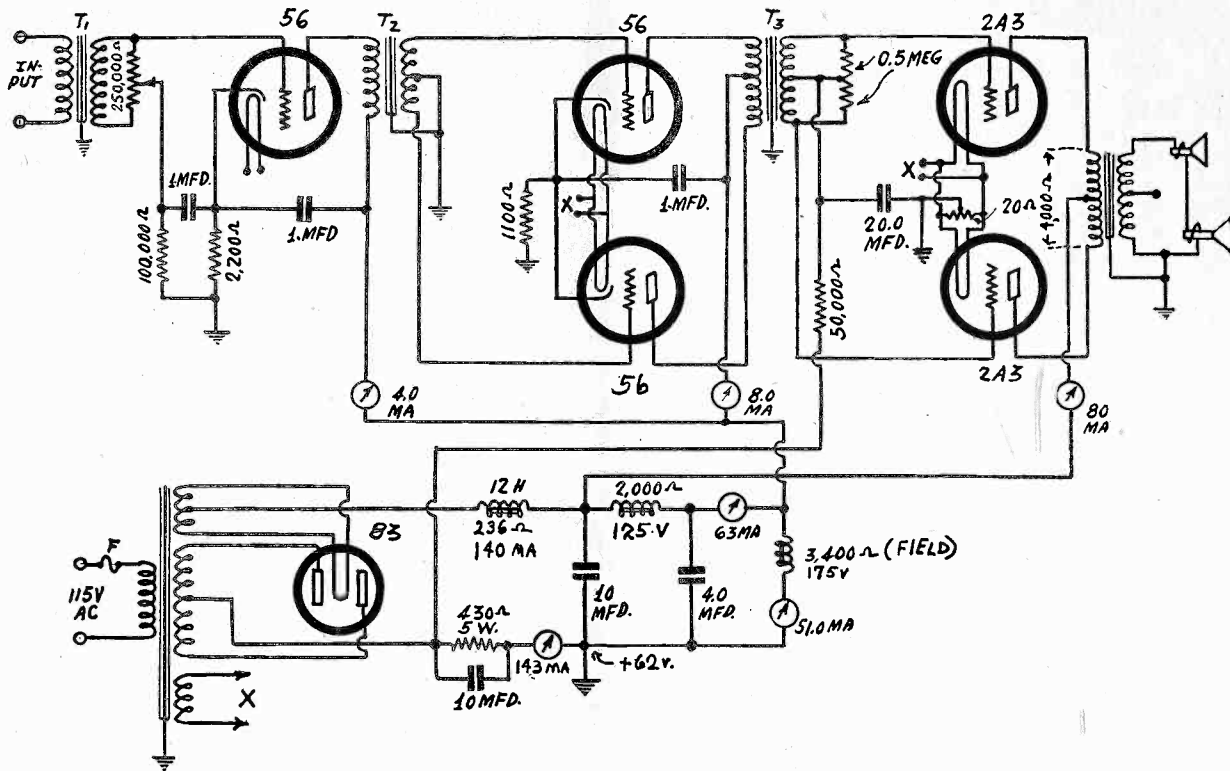
For an amplifier like this only speakers designed for high power are recommended, and in general these weigh from 30 lbs. up, each. It is not imperative that two speakers be used. If a single one is to be used, then the secondary of the output transformer simply feeds a single voice coil instead of two voice coils in series.

Reason for Two Speakers

The object of using two speakers is, in general, to attain excellent tone values without going to considerable expense due to speaker cost. One speaker favors the lows, one the highs, but they must be matched, not random, so that the merger is totally acceptable. However, if the extra expense is not a deterrent, a single speaker of commensurable quality may be used, and the two-speaker method then will not constitute any improvement over the single-speaker method. In fact, just as a selling point, two speakers sometimes are included in cheap receivers and power amplifiers, whereas a single good speaker would give far better results.

The two resistors of 500,000 ohms each, across the halves of the secondary feeding the output stage, are there to remove any small peaks that might develop, and thus improve tone. Also they serve to atone for any slight unbalance in the secondary itself, provided the impedance of the secondary is large, as it is likely to be, in a good transformer, say, in the million-ohm class. This has no particular reference to the d-c resistance of the winding, but to the opposition to current flow presented by the winding at some selected frequency, usually 1,000 cycles.

QUALITY CIRCUIT FOR TUNER, MICROPHONE OR PHONOGRAPH PICKUP



A Class A power amplifier of 12 watts power output. The circuit consists of three stages of audio-frequency amplification, of which the second and third are push-pull. The voltage applied to the output tubes is 362 volts, the 62 volts for bias being part of this, so that 300 volts are applied to the plates. While up to 350 volts could be applied to the output tubes, bias extra, the present circuit is conservatively arranged throughout.

20 Watt Class B Audio Amplifier

HERE IS AN AMPLIFIER capable of putting out 20 watts of power. It comprises a 56 voltage amplifier coupled resistively to a 59 Class A power amplifier, which is used as a driver of a Class B stage using a pair of 59 tubes. A single full-wave rectifier utilizing an 82 tube is used to power the circuit. Two speakers are connected to the last stage to take care of the very high output.

The input voltage is delivered to the amplifier through a 0.1 mfd. condenser and a 250,000-ohm potentiometer, the grid of the 56 amplifier being connected to the slider. This provides an adequate volume control. The 56 is biased by a 7,000-ohm resistor in the cathode lead and this is shunted by a condenser of 0.1 mfd. This by-pass condenser would seem small and inadequate if it were not for the treatment of the plate circuit to prevent reverse feedback. It will be noticed that in the lead feeding the plate of this tube there is first a 25,000-ohm resistor, then a shunt condenser of 1.0 mfd., then another series resistor of 25,000 ohms, and finally another condenser of 0.25 mfd. This last condenser goes to the cathode. This condenser, namely, the 0.25 mfd., serves primarily to prevent the signal current in the

plate circuit from getting into the power supply by shunting it directly to the cathode. The second condenser, namely, the 1.0 mfd., serves mainly to prevent signal current that has found its way into the power supply from getting into the first amplifier tube. With such thorough filtering in the supply, there is little need for using a large condenser across the bias resistor.

Applied Voltage

The applied voltage in this circuit is 285 volts and the current in the plate circuit, as measured by the milliammeter between the two 25,000-ohm resistors, is 1.1 milliamperes. From this knowledge we can compute the grid bias, the effective plate voltage and the drop in the filter resistors. The drop in the bias resistor is 7.7 volts, which is the bias. The drop in each of the filter resistors is 27.5 volts. Hence the drop in two resistors is 55 volts. Since the supply voltage is 285 volts and there is a total drop outside the tube of 62.7 volts, the effective voltage on the tube is 222.3 volts. This is adequate to sustain the signal required by the grid of the driver tube.

The output of the first tube is coupled to

the driver by a 0.1 mfd. condenser and a 250,000-ohm grid leak. The time constant of the combination is 0.025 second, which is high enough to insure full amplification at 40 cycles per second.

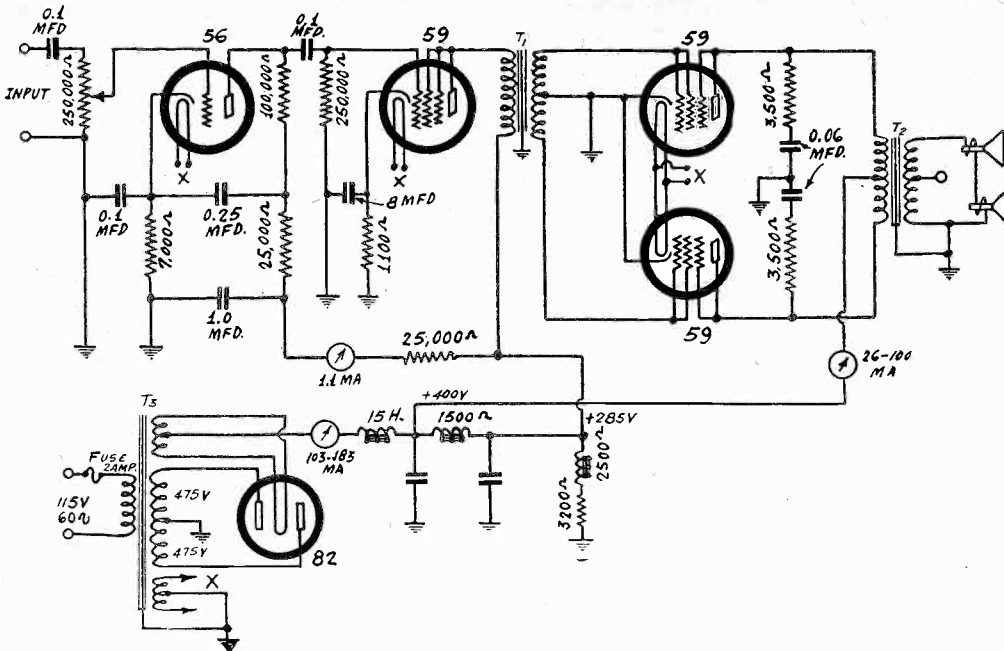
The 59, which is used as a triode, is biased by a 1,100-ohm resistor in the cathode lead, and this is by-passed by a condenser of 8 mfd. An electrolytic condenser may be used here to provide this high capacity. The reason for using such a high capacity at this point is that there exists no filtering in the plate circuit of the type that was used in the preceding stage. The condenser reduces the effective impedance between the cathode and ground to a negligible value for all essential audio frequencies, and therefore the reverse feedback is negligible. The effective plate voltage on the drive is 285 volts, less whatever drop there is in the bias resistor. This drop is approximately 28 volts.

The Driven Stage

The driver is coupled to the driven stage by means of a special transformer T1. This has a ratio of 5-to-1 between the primary and each half of the secondary, or a total ratio between the primary and the secondary of 2.5-to-1. That is, the transformer is of the step-down type.

The two cathodes of the driven stage are tied together and grounded, as is the center point of the secondary of transformer T1. Therefore there is no bias on the two tubes in the Class B stage. The grids of the tubes are so connected that the plate current cut-off occurs at zero bias or at a very low negative bias. This condition obtains when grids Nos. 1 and 2 are tied together to form

(Continued on next page)



A high-quality audio frequency amplifier capable of an output of 20 watts. It contains a voltage amplifier, a power driver stage, and a Class B output stage.

(Continued from preceding page)
the control grid and when grid No. 3 is tied to the plate.

In the output of the Class B amplifier is a suitably designed output transformer T2 with a centertapped primary. This tap is connected to the power supply where the voltage is 400 volts. In the common lead a milliammeter is connected to indicate the flow of plate current to the tubes. This current should vary between about 26 and 100 milliamperes, depending on the strength of the signal. It may even go lower than 26 milliamperes. The current read on this meter is the averaged current of the two tubes over a signal cycle, assuming that the signal is a tone of steady amplitude. If the signal consists of ordinary broadcast noise and music, the needle will jump around a great deal, as the average current will vary rapidly, and the needle tries to follow the variation.

Tone Filter

In the plate circuit of the two Class B tubes is also a tone filter consisting of two 0.06 mfd. condensers and two 3,500-ohm resistors. The object of these is to reduce the gain on the high audio frequencies, to compensate for excessive amplification at these frequencies. These shunt elements are approximately twice as effective at 5,000 cycles per second as at 40 cycles.

Two speakers are connected in series with the secondary of the output transformer. By series is meant that the voice coils are in series. Since the total maximum output of the amplifier is 20 watts, each of these speakers should be able to handle at least 10 watts. Only high power speakers should be used, for otherwise they will become overloaded before the amplifier.

The B Supply Filter

In the B supply next to the rectifier we have a coil of 15 henries, measured at 100 milliamperes and a d-c resistance of 80 ohms or less. The current in this coil will vary between 103 and 183 milliamperes.

The plate return of the Class B amplifier is connected to the supply so that the plate current of the output tubes flows only in the first choke, but the first filter condenser, C6, has a capacity of 16 mfd., and therefore there is considerable filtering of the current to the power tubes.

The second B choke is the field coil of one of the speakers, and it has a d-c resistance of 1,500 ohms. This winding also serves as a filter choke for the supply to the voltage amplifier and the driver stage. The drop in the field is 115 volts, and therefore the current in this field is close to 77

milliamperes. The bleeder choke is the field for the second speaker, and this has a resistance of 2,500 ohms. This field coil is in the bleeder position of the filter and since its resistance is not quite high enough, a resistance of 3,200 ohms and 10 watts rating is connected in series with it. Since the voltage across the 2,500-ohms field and the resistor in series with it is 285 volts, the current is 50 milliamperes. This leaves only 27 milliamperes for the voltage amplifier and the driver tube.

The second condenser in the filter is 8 mfd. This as well as the other is of the electrolytic type.

All the heaters of the amplifier tubes are served by a single winding on the power transformer, the center tap of which is grounded. All the tubes, of course, are of the 2.5-volt heater type, except rectifier.

As a protection against possible short in the power transformer or at any vital point in the amplifier, a 2-ampere fuse is inserted in one side of the primary.

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.

- Thomas L. Oates (designer of audio equipment), 616 27th St., Sacramento, Calif.
- Guy Manning, Box 586, R. 9, College Hill Station, Cincinnati, Ohio.
- Ray K. Bryan, owner of W9NLI (Commercial radio engineering, amateurs, and radio servicemen), 1300 Brownsdale Ave., Austin, Minn.
- Kingston Radio Shoppe, Joseph Ross, 114 Wall St., Kingston, N. Y.
- George T. Kotz, Gray Hawk Community School, Grey Hawk, Ky.
- A. H. Ortman, 151 Gostlin St., Hammond, Ind.
- S. W. Prall, 3825 1/2 Avalon Blvd., Los Angeles, Calif.
- Cyrus H. Fraser (WBEN), 37 East Morris St., Buffalo, N. Y.
- R. W. Baker, care B. & S. Radio Laboratory, 69 Linden Ave., N. W., Atlanta, Georgia.
- Elmer Harrold, R. D. 31, New Stanton, Pa.
- John C. Hooker, Sergeant, U. S. Army, Battery "A" 17th Field Artillery, Fort Bragg, N. C.
- L. O. Walker, Walker & King, Louisville, Miss.
- Geo. H. Sampson, 37 Stukey Apts., Great Falls, Mont.
- Howard A. Oickle, 93 S. W. 11th St., Miami, Fla.
- Rev. Olof Wallin, First Lutheran Church, Comfrey, Minn.
- H. D. Smith, 323 East Lake Drive, Station E., Atlanta, Ga.
- Robt. F. Beach, Port Morien, C. B., Nova Scotia, Canada.
- E. Mohl, 6215 Catherine St., Apt., No. 9, Philadelphia, Pa.
- Dr. Denton N. Higbe, 54 W. Illinois St., Chicago, Ill.
- H. W. Phillips, 6 South Fanthus, Tulsa, Okla.
- H. Pellmann, 1439 20th Ave., San Francisco, Calif.
- B. B. Jackson, 3326 7th Ave., Rock Island, Ills.
- R. B. Gough, 755 Blue Hills Ave., Bloomfield, Conn.

TUBE CHARACTERISTICS

Of the 230 triode amplifier and detector, 231 power tube and 232 screen grid tube, all of 2-volt series.

230

Type of tube.....Filamentary triode
SocketFour contact
PurposeDetector and amplifier
Grid-plate capacity6.0 mmfd.
Grid-filament capacity3.7 mmfd.
Plate-filament capacity1.25 mmfd.
Overall height4 1-4 inches
Overall diameter1 9-16 inches
Filament voltage2 volts, d-c
Filament current60 milliamperes
Ballast for 3-volt supply16.7 ohms
Ballast for 6-volt supply66.7 ohms
Amplification factor9.3
Plate resistance10,300 ohms
Mutual conductance90 micromhos
Optimum load resistance20,000 ohms

Bias Detector

Plate voltage, maximum180 volts
Grid bias18 volts

Amplifier

Plate voltage135 volts
Grid bias9 volts
Plate current3 milliamperes
Max. undistorted output70 milliwatts

Amplifier

Plate voltage180 volts
Grid bias13.5 volts
Plate current3.1 milliamperes
Max. undistorted output130 milliwatts

231

Type of tubeFilamentary triode
SocketFour-contact
PurposePower amplifier
Overall height4 1-4 inches
Overall diameter1 9-16 inches
Filament voltage2 volts, d-c
Filament current130 milliamperes
Ballast for 3-volt supply7.7 ohms
Ballast for 6-volt supply30.8 ohms
Amplification factor3.8

Amplifier

Plate voltage135 volts
Grid bias22.5 volts
Plate current8 milliamperes
Plate resistance4,100 ohms
Mutual conductance925 micromhos
Max. undistorted output185 milliwatts
Optimum load resistance7,000 ohms

Amplifier

Plate voltage180 volts
Grid bias30 volts
Plate current8 milliamperes
Plate resistance3,600 ohms
Mutual conductance1,050 micromhos
Max. undistorted output375 milliwatts

232

Type of tubeFilamentary tetrode
SocketFour-contact
PurposeDetector and amplifier
Overall height5 1-4 inches
Overall diameter1 13-16 inches
Grid-plate capacity0.06 mmfd. (max.)
Grid-filament capacity6.0 mmfd.
Plate-filament capacity11.7 mmfd.
Filament voltage2 volts, d-c
Filament current60 milliamperes
Ballast for 3-volt supply16.7 ohms
Ballast for 6-volt supply66.7 ohms
Screen voltage*67.5 volts

Bias Detector

(0.25 megohm load.)

Plate voltage180 volts
Grid bias6 volts
Plate current0.3 milliamperes or less
Screen currentAbout 1-3 plate current

Amplifier

Plate voltage135 volts
Grid bias3 volts
Plate current1.7 milliamperes
Screen currentAbout 1-3 plate current
Amplification factor610
Plate resistance950,000 ohms
Mutual conductance640 micromhos

Amplifier

Plate voltage180 volts
Grid bias3 volts
Plate current1.7 milliamperes
Screen currentAbout 1-3 plate current
Amplification factor780
Plate resistance1,200,000 ohms
Mutual conductance650 micromhos

*When a high load resistance is used in an amplifier circuit the screen voltage should be much less from 7.5 to 22.5 volts.
The cap of the tube is the control grid terminal and the G-prong on the base is the screen grid terminal.

WHAT IS ON THE WAY

Supers Embody Result of Recent Experience

By Louis Pouy

CIRCUITS for the present season for kit-construction, or custom-built, will show some improvements over those of last season, due principally to the experience gained in the interim, applicable to the superheterodyne as a circuit and also to the newer tubes. These are, in the main, the same tubes available last season, but considerable had to be learned about getting them to work best, and this bridge has been crossed.

Considering the superheterodyne as a circuit, the past season developed the fact that the heterodyne squeals that had been supposed to be necessary to endure, could be obliterated, every one of them, not so much from theoretical consideration of their existence, but obliterated from audibility instead, and that is the practical requirement.

The Solution Recalled

The solution exists in making the selectivity ahead of the modulator (first detector) as high as practical, as this gets rid of the heterodyne interference due to escape of some carrier energy from off-resonance locals to the mixer circuit. The heterodyne squeals can be eliminated from audibility that way, even if a grid-current type oscillator is used, such as the 2A7, which from the very nature of things is a harmonic-producing tube.

The harmonic trouble arises in gaining response from stations of high frequency when tuning the dial to a low frequency. Let us assume the modulator is tuned to 600 kc, that the intermediate frequency is 450 kc, hence the oscillator is at 1,050 kc. The second harmonic of 1,050 kc is 2,100 kc, and subtracting the intermediate frequency, the stray response frequency would be 1,650 kc, and a station transmitting on 1,650 kc could be heard, if enough energy gets by the r-f tuned stages. In the instance of strong locals, including amateurs, this response actually would result, but if the harmonic were suppressed, even by having the oscillator of the non-harmonic-producing type, there would be no response. The second harmonic in the grid current type of oscillator is often one-third the fundamental in strength.

Less Gain, Less Interference

From the foregoing it may be concluded that not a very great amount of gain is to be sought from the r-f level, but that can be made up in the i-f level, whereupon the amount of voltage put into the second detector from the strongest local should not be sufficient to overtax that tube. When this precaution is taken the gain will be less than what most persons might expect, considering the number of tubes already used, which may be five or six, and so if a duplex-diode-amplifier tube is used, it might be a 55, diode-biased, with a higher voltage on the plate load resistor than previously obtained, because of the necessity of making it practical to put in larger signal voltages at the detector (diode) without overloading, that is, saturating, the amplifier (triode).

Push-Pull Circuit

The best way to safeguard against this trouble is to select the triode types, apply enough plate voltage through a high resistance (0.25 meg. and 300 volts suggested) and then have the output of the triode feed a pentode tube, say, a 2A5. Thus there will be enough "kick" of the favorable and de-

sired kind, and fewer "kicks" of the other kind.

So much for the single-sided output. If push-pull is to be used, the tubes should be of the triode type, if the audio is Class A, which seems to be the more sensible audio for home receivers, Class B being preferred for auditoriums.

The circuit as far as the triode of the duplex-diode-amplifier tube may stand as it is, but if the output is to consist of two 2A3's in push-pull (Class A circuit, of course), then there should be a driver additionally. It has been found that the 55 will load up the 2A5, and we know that a negative bias around 20 volts on the 2A5 is all right, so we can not select a driver for the new output condition that will take only a few volts bias.

Thus we rule out the 53 in all forms of connection, and even the 56, and must select some tube that will stand as much input signal voltage as would the 2A5, hence a power tube.

One easy selection is to use the 2A5, not as a pentode, but as a triode, so that there will be suitable impedance for the primary of the push-pull transformer. It is preferable to filter this circuit, so a resistor of 20,000 ohms or so may be in the plate circuit (which circuit consists of screen and plate interconnected), while a large capacity stopping condenser 0.5 mfd. or greater, is connected to the primary of the push-pull input transformer, other end of the transformer primary going to cathode of the 2A5. This gives us the benefit of higher bias (for as a triode we may use even 25 volts negative bias instead of 20), and also an indirectly-heated tube as driver as a precaution against hum.

300 Volts Enough

The next consideration, for largest power output, is fixed bias, and the 2A3's may be given 62 volts negative bias obtained from the negative leg of the rectifier by inserting there a resistor through which all the B current flows.

It is not necessary to use more than 300 volts on the output plates (applied), and adding the bias, the total in the grid-return-to-plate-supply circuit is 362 volts.

The use of 350 volts on the plates of these tubes, bias additional, has been virtually discarded, and is no longer a recommendation in the tube characteristic charts, although cited in the tube data sheets and tentative

characteristics when these tubes were announced.

There has been a little shifting about the ohms load, also. For self-bias, 5,000 ohms plate to plate stands. For fixed bias the latest characteristics sheets refer to 3,000 ohms, but experience gained even since then has led to the recommendation that for fixed bias the ohms load, plate to plate, be 4,000 ohms. At all hazards, if the 4,000-ohm condition is accepted, the negative bias may be raised a little to increase the tube impedance so that the match is more nearly perfect, if it isn't just what it should be in the first instance.

A makeshift way of testing for this is to use a test oscillator in a receiver, modulated by the line frequency, and adjust the bias on the output tubes for maximum response, changing nothing but the bias, and that in an upward direction.

Mechanical Aids

Aside from circuit considerations there are mechanical factors of interest to the discerning radioist. One of the advantages that nearly all technically-inclined radioists and DX hunters desire is a frequency-calibrated dial, where the dial frequencies accurately coincide with the circuit's response, and there are 10 kc divisions all along the spectrum, and not merely between the middle of the dial and the low-frequency end, with 20 to 50 kc for the higher frequency divisions. The 10 kc dials are on the way and will be accurate.

An automatic volume control is desired by many, despite its expense in the way of sensitivity, this will continue to be included, but the gain at audio frequencies will be built up, along lines already discussed, so that the former drain of a.v.c. will be compensated for.

Tuning Indicators

Additionally, a tuning indicator of some sort is preferable, and it may be a regular meter, but also may be a neon lamp, as discussed elsewhere in this issue. More elaborate neon devices have been in expensive receivers for two years, but the smaller lamps, that fit in candelabra bases, are coming into favor. They may be used for resonance indication, carrier-controlled, or for both that and pilot illumination, although it is somewhat more difficult to have the same lamp do double service that way, and if it doesn't work out to complete satisfaction, there will be the standard pilot lamp (tungsten filaments) and neon lamps for resonance indication only.

Some sets will have a neon lamp built in additionally, as an output meter, with a switch attached, so that service men and others, who may not happen to have such a meter, or at least not with them at the time, nevertheless will be able to line up the set.

Information at a Glance

Moreover, experience with various sets soon will disclose to service men the amount of illumination to be expected when their test oscillators are coupled in a standard way, and then literally at a glance it will be possible to determine that a set isn't up to snuff, although ascertaining just what the trouble may be is another matter. When the trouble finally is located, the lamp will tell the happy story, for its face will be brighter even than the service man's, though, of course, much redder.

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THE small neon lamp of the candelabra base or pigtail type may be used as a tuning meter in radio receivers, and even the combined use of tuning meter and pilot lamp may be enjoyed. These lamps draw so little current they may be put anywhere that the voltage is available. In general, they work on alternating or direct current, although one particular model is specified for alternating current only.

The illumination is the familiar orange light of the advertising signs. The lamp is the same as used in the signs, except smaller. When excited by d.c. the lamp has a steady glow, and when excited by a.c. it has an unsteady glow, for it actually goes out twice as many times a second as the frequency of the a.c. However, no frequencies that would be derived from a receiver would cause a condition of objectionable unsteadiness, for even the 60 cycles of the line give an effect equal approximately to that of continuous light. That is, the persistence of vision creates the illusion of practically continuous light, or the observed flicker is too scant to gain attention or, at least, prove troublesome to the eye.

Practically Instantaneous Response

The use of the lamp as a tuning meter is made possible by the rapidity of the lamp's response. An ordinary incandescent lamp, pilot type or household variety, is too sluggish for this purpose, as the illumination effect lags too far behind the changes present in the source. The neon lamp is practically instantaneous, that is, no lag. That is why it has been a practical instrument of conversion in television, although the illumination is too low for full acceptance in television receivers, even if the lamp is of the so-called crater type, that is, point source of light.

To call the lamp a tuning meter is to stretch a point, because there is no actual measurement, but just relative differences in intensity of illumination observed. However, it is much nearer to being a meter than is a "potentiometer," even though the lamp's relative differences in illumination are not calibrated. It might be possible to calibrate these differences with a very sensitive series meter or with some photocell auxiliary, but such matters are beyond the present purpose, which is to utilize the small, inexpensive lamps instead of expensive instruments.

Illumination varies because of the variation of current through the lamp, and it is orthodox to refer to the lamp as a "current-operated device." These variations in current are produced normally by variations in voltage.

Direction of Modulation

If we have a receiver that has tubes subject to automatic volume control, the variation in current through a series resistor may be expected to be larger than if there were no a.v.c. Thus a series resistor R in Fig. 1, between the common lead of the B returns of the coil primaries, and B plus, would have a varying voltage drop, depending on the carrier amplitude. The higher the amplitude, the greater the bias due to a.v.c., and possibly the less the current. Therefore the voltage drop across the resistor is less the greater the carrier amplitude, and the lamp would modulate downward, so to speak. There would be less illumination the greater the amplitude, or, resonance might even cause the lamp to go out.

Canvassed preference is for the lamp to light more brightly, the greater the amplitude. Resonance should constitute maximum illumination under the conditions imposed. This does not mean that a certain brightness of illumination should indicate resonance for all settings, since not all stations will develop the same voltage, even if the lamp were placed in some more acceptable position, and even if there were a.v.c. Indeed, if a.v.c. caused the voltage to be always

the same, since there would be no difference, the illumination would be the same.

One can not say offhand, in respect to all receivers, that the lamp will modulate upward or downward in the Fig. 1 circuit, because the effect of the signal itself is to reduce the bias, and if the a.v.c. is not more effective than the signal, then the signal will reduce the bias more than the a.v.c. will increase it, and while some benefit from a.v.c. would be present, nevertheless the lamp would modulate upward (brightest at resonance), with not much illumination change at best.

Also the d.c. voltage drop at no signal is important. The lamp may be of the 110-volt type, and while the full 110 volts

SMALL NEON

As Tuning Meters and as

By Herm

the phase by connecting the lamp between the coil return side of a resistor and ground without reducing the actual voltage more than a little, or the series resistor R may be selected on the basis of the lamp included in the circuit to ground.

Shifting the Phase

Fig. 2 shows the series resistor R, the lamp and the limiting resistor Rx, which may be inserted to hold the illumination low. Assuming that 250 volts or so are present at the left-hand side of R, and the lamp is of the 110-volt type, the resistance Rx normally would be more than 100,000 ohms, and the excess would depend on the type of lamp, the voltage rating and the

FOUR CIRCUITS FOR USING THE O

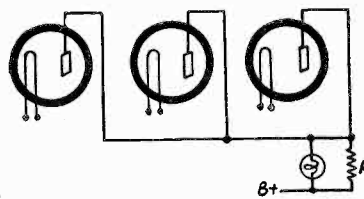


FIG. 1
A neon tube used as a carrier-control type tuning meter. The tube is connected across a limiting resistor that drops the maximum B voltage of a power supply to the voltage required for the automatic - volume - controlled amplifier tubes. The lamp may modulate upward or downward, depending on circuit conditions.

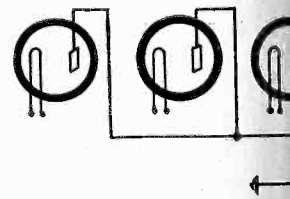


FIG. 2
The phase of the modulation may be reversed by connecting one side of the lamp to the common plate returns of the controlled tubes, the other side of the lamp to ground. A limiting resistor Rx would be required even if a resistor is built into the lamp, because the applied voltage, without the external resistor, is not to exceed 110 volts.

would not be necessary or even advisable for illumination, enough voltage drop must be developed at first to get some illumination from the lamp. This may be around 70 volts or so, possibly less. It is advantageous to have low illumination where the modulation is upward, because then it is easier to detect small difference in voltage in terms of relative illumination, and besides the lamp is protected against overload. If the voltage is much too high the lamp will get quite hot, and its life will be shortened, much the same as any other overloaded lamp.

May Be Put Anywhere

Since the neon lamp draws very little current it may be put almost anywhere in a circuit. Therefore it is possible to shift

degree of no-signal illumination desired at no signal. Since the candelabra type lamp has a resistance built in, for 110 volts, the external resistance might be less than 100,000 ohms in that instance.

If the effect in the receiver circuits is such as to cause the modulation to be upward with lamp across the resistor, then the Fig. 2 circuit could be used, with this change, that the bottom connection of Rx, instead of going to grounded B minus, goes to the B plus lead. The same reason exists for including Rx, to keep the minimum illumination low. It would still be sufficient to illuminate a dial scale, if that scale is not opaque, or, if translucent, is not too "thick." A transparent scale would be somewhat better.

If the modulation is downward, the lamp darkens with resonance, but the phase shift

LAMPS USED

Output Indicating Devices

Bernard

results, as stated, if the lamp is returned through Rx to ground. If the voltage in R goes down, naturally the voltage at the plates of the receiver tubes goes up, because it is the drop that is less. If one side of the lamp is grounded this increase in voltage is applied to the lamp, whereas if the lamp were in parallel with R the phase would shift 180 degrees and the illumination would decline with any increase of the amplitude.

Illumination Control

In some circuits the voltage drop in a resistor may change greatly, and this is true particularly of a direct-coupled tube in a non-reactive circuit, an example of which

the maximum voltage, that would not help at all in supplying a minimum voltage, which would be even nearer zero than if the lamp were across the total plate load. Besides, the modulation is downward, (least illumination, or extinction of the lamps at resonance or even before resonance is reached) and it should be upward, preferably.

The rheostat Rh in Fig. 3, which may be a potentiometer used as a rheostat, enables adjusting the lamp for any degree of illumination less than maximum, to get a sensitive starting point, or low illumination, rendering resonance determination easier. A limiting resistor Rx should be included, so that the no-drop condition in the plate load will not result in the full positive voltage on

the intermediate level, then the result is a steady glow, because the modulation is a steady note. Thus the lamp is, like a regular output meter, an indicator of resonance in lining up the receiver. Due to the tuned circuits into which the modulated carrier of the test oscillator is put, detuning the test oscillator just a bit, or detuning the r-f or intermediate channels a bit, leaving the test oscillator intact, puts out the lamp. So whether a receiver is to be lined up, or the frequency of an existing channel measured with the test oscillator, the neon lamp serves the purpose. It is only necessary that the a-c voltage across the primary of the output transformer (or other reactor in that plate circuit) be high enough to light the lamp, which may be regulated by the coupling of the test oscillator, although for the run of receivers the type of coupling ordinarily used is all-sufficient. (Fig. 4).

Need Special Sockets

Sometimes when the lamp is connected to one side of a circuit, the other side intended to be grounded or to be at a positive potential, a faint glow will be perceived, accompanied by a slight interfering modulation of a signal, if the other side of the lamp merely is held by the fingers. This is due to body capacity, that is, completion of the circuit through the capacity of your body to ground potential.

There are no neon lamps commercially produced to fit the pilot lamp brackets of radio receivers, the smallest neon base type being the candelabra type, which is about half again as large in diameter. However, one enterprising manufacturer is preparing a dial with the candelabra type socket to be attached to the condenser frame by a bracket, the lamp to be used as combination pilot and resonance indicator.

Resistance Built In

The candelabra type neon lamp to fit into this socket has the resistance built in for 110 volts.

The pigtail type lamp is smaller and of the kind found in the d-c polarity indicators, testers, trouble-shooting testers, etc., which indicate if the voltage is 104 volts or more (with no distinction as to what it is) and also indicate whether a source is a.c. or d.c., and if d.c., which is negative and which positive, as the lamp will light up only when connected in a given direction to d.c. This hint should be utilized in all d-c applications if the lamp fails to light.

Since the lamp has one-way conductivity on d.c., the question arises what degree of rectification would exist on a.c. if one electrode were purposely made larger than the other. We have mercury vapor rectifiers in radio work, but as yet no neon gas rectifiers, but perhaps some day these, too, will come along.

The neon lamp has a negative co-efficient of resistance, that is, the resistance decreases with increase of current. This offers further possibilities of exploration, for if the reduced impedance can be satisfactorily related to an increased impedance in a tube circuit, a constant impedance may be developed, useful for various purposes, including simplified stabilization of oscillators.

A.V.C. of One I-F Stage Occasionally is Sufficient

If an intermediate amplifier is very sensitive of itself, the amount of voltage at the second detector is large, therefore often it is sufficient to have one stage of i.f. subjected to a.v.c., instead of two.

If both are subjected to such control any reduction in the sensitivity may be overcome by using more audio-frequency amplification.

GE-GLOW BULBS FOR ECONOMY

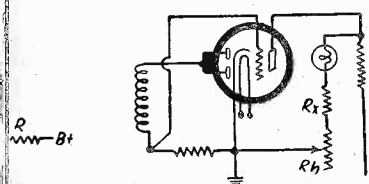


FIG. 3

In wide-swing circuits special protection must be afforded the neon lamp. One of the most violent examples is the diode-biased triode, where the voltage drop may change between nearly zero and a couple of hundred volts. Correct modulation phase and protection of the lamp are illustrated, the tube used being the 55 duplex-diode triode.

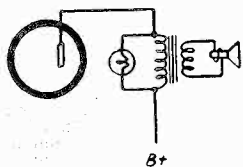


FIG. 4

The neon lamp may be used as an output meter. No filtration is needed, as it is substantially present, due to the d.c. drop in the plate reactor being only around 30 volts, not nearly enough to light the lamp. The modulation voltage will light it in nearly all modern receivers, but on broadcasts this is unsteady, of course.

As the diode-biased triode in Fig. 3. If the tuner is very sensitive some local stations will cause the plate current in the triode to be reduced almost to zero, because the signal, which is the biasing voltage, is so high. For the 55 tube illustrated, this saturation signal-voltage might be around 30 volts or so.

At no signal there might be 100 volts effective on the plate, at maximum signal there might be nearly 300 volts (the applied voltage), and if the lamp were across the resistor the actual voltages applied to the terminals of the neon lamp would vary from 100 to 0. It is not to be expected that the lamp will light on less than 60 volts, nor that it will last long under conditions of 100 volts impressed on it.

While the lamp could be put across part of the resistance in the plate circuit, to limit

the lamp. So Rx could be 100,000 ohms and the potentiometer could be 250,000 ohms or more. Besides, the preferred modulation aspect prevails (brightest at resonance), because the signal reduces the voltage drop in the plate load.

Output Indicator

The same type of lamp may be used as an output indicator. This has no service value on broadcasting, no more than a regular output meter has, because the d-c voltage drop is far too small to light the lamp, and only the audio frequencies cause it to glow, so modulation, ever-changing, determines the illumination. It is interesting to watch this change while listening to a program, but not of any particular value.

If a modulated test oscillator is used, and connected either at the antenna input or to

A NEW USE FOR THE 1A6

Half-Wave Diode Rectification and Tetrode Amplification

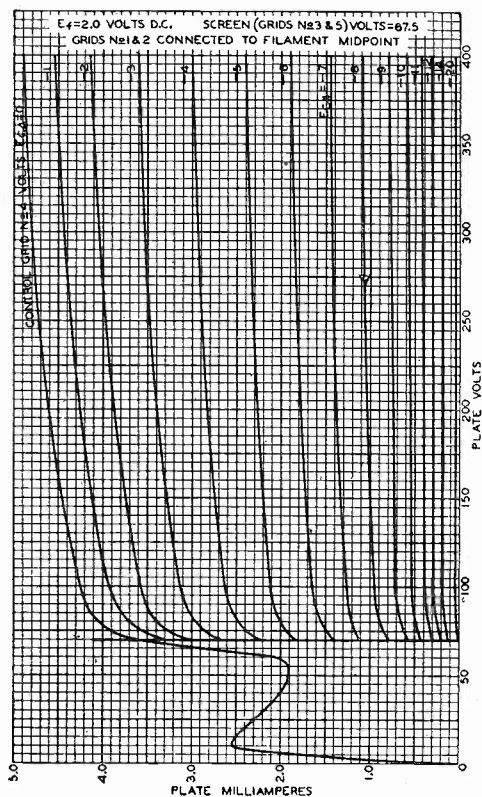


FIG. 1.

The plate characteristics of the tetrode portion of the 1A6. The screen voltage was 67.5 volts, while grids Nos. 2 and 3 were tied to filament center. The curves are of plate voltage, plate current, for control grid negative biases.

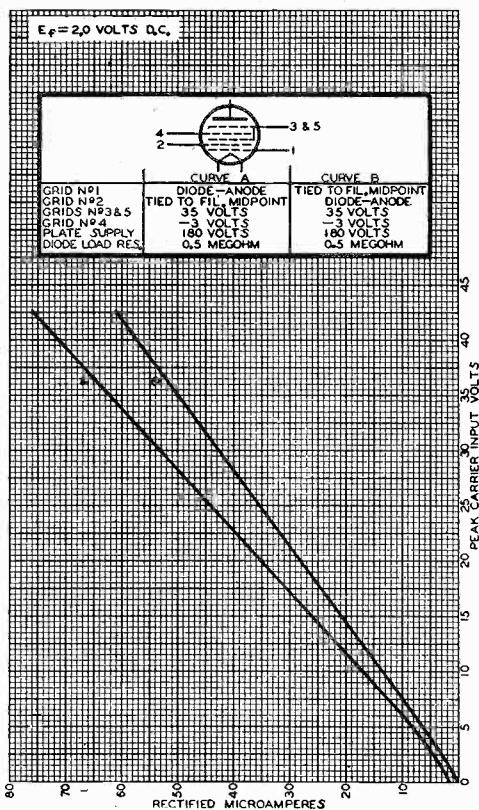


FIG. 2

Typical rectification characteristics of the diode portion of the 1A6, when the tube is connected as a diode-tetrode, are shown in Fig. 2. Curves A and B compare the difference in rectification efficiencies. Curve A is the current-voltage curve of the diode portion with the No. 1 grid as anode. Curve B represents grid No. 2 used as diode anode, grid No. 1 connected to filament. Fig. 3 shows typical detector characteristics of the 1A6 diode portion as the result of applying an r-f input modulated 30 per cent.

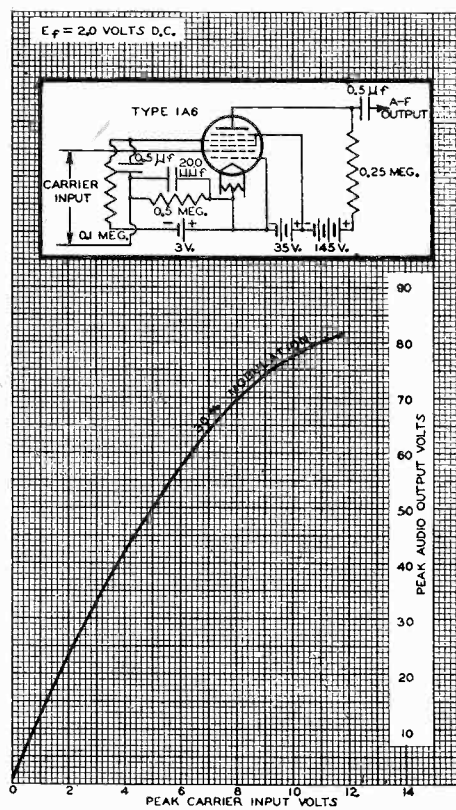


FIG. 3

Typical detector characteristics of the 1A6 diode portion as the result of applying an r-f input modulated 30 per cent.

THE 1A6 tube, a 2-volt pentagrid converter, may be used not only as an oscillator-mixer but also as a combination diode-tetrode. An arrangement whereby two elements perform the functions of a half-wave diode and certain other elements perform the function of a tetrode makes feasible the application of this tube as a diode detector and an audio amplifier. The 1A6, when so used, is similar in application to the 55, 75 and 2B7. The 2A7 and 6A7 may also be used in the manner to be described, for the 1A6, say RCA Radiotron Co., Inc., and E. T. Cunningham, Inc.

The Elements

The 1A6 has five grids, a plate, and a two-volt, 0.06-ampere filament. The approximate characteristics of the tetrode portion of the tube when grids Nos. 1 and 2 are tied to the zero-potential point of the filament are:

| | | |
|--|--------|-----------|
| Filament Voltage (E _f) | 2.0 | volts |
| Filament Current (I _f) | 0.06 | ampere |
| Plate Voltage (E _b) | 180 | volts |
| Control Grid Voltage. (E _{c4}) | -3 | volts |
| Screen Voltage (E _{c3} and 5) | 67.5 | volts |
| Plate Current (I _p) | 4.0 | ma. |
| Screen Current (I _{cs} and 5) | 5.0 | ma. |
| Mutual Conductance... (g _m) | 525 | micromhos |
| Plate Resistance..... (r _p) | 360000 | ohms |

Plate Characteristics

The plate characteristics of the tetrode portion of the 1A6 are shown in Fig. 1.

Measurements for these curves were made with E_{c3} and 5 at 67.5 volts and with grids Nos. 1 and 2 tied to the center tap of the filament.

A somewhat unusual condition is observed in that there is a tendency for the grid-bias lines to become crowded at both low- and high-bias values. Since the middle range is uniform, this tube has the unique advantage of giving low distortion with low plate loads—loads of such value that the operating point falls in the middle-bias region.

The construction of the 1A6 tube is such that in diode-tetrode service the No. 1 grid (oscillator-grid) may be used as a single diode anode. The No. 2 grid (anode-grid) may be tied to the filament to provide a slight shielding effect between the diode and tetrode elements. Conceivably, the No. 2 grid could be used as another diode anode to provide full-wave rectification but such use would be unsatisfactory. Grids Nos. 3 and 5 (screen grid) act effectively to shield electrostatically the control grid (No. 4) from the No. 1 grid. The plate serves its usual purpose as a part of the tetrode portion of the tube. This portion operates as a screen grid audio amplifier, audio voltage being supplied to its control grid by the diode. Used in this manner, the rectification efficiency of the diode approaches that of the diodes in such tubes as the 55, 2B7, and 75. Fig. 2, curve A, is the current-voltage curve

of the diode portion of the 1A6, with the No. 1 grid used as anode.

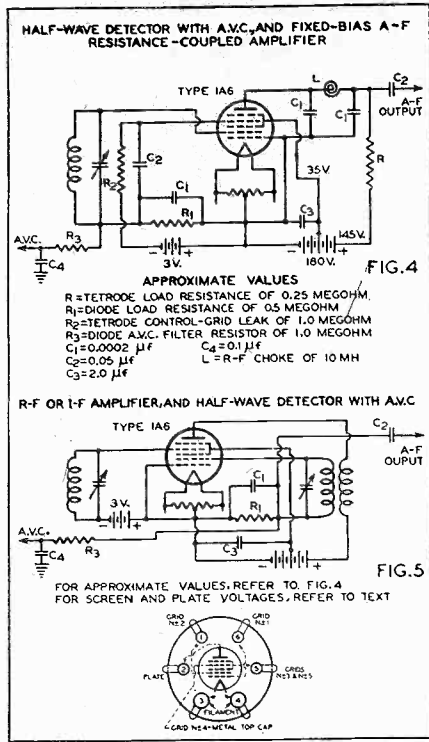
Rectification Efficiency

A point to be mentioned in connection with the use of the No. 1 grid as the diode anode is that, regardless of whether operating voltages are applied to the tetrode elements, the rectification efficiency is slightly higher when grid No. 2 is connected to the zero-potential point of the filament. Also, the rectification efficiency is, as expected, a little higher when no voltages are applied to the tetrode elements, that is, the efficiency is from 3 to 5 per cent. higher when no plate and screen voltage are used.

Under the operating arrangement suggested, the plate current is approximately 0.36 milliamperes and the screen current, 2.0 milliamperes with no signal applied (zero bias on grids Nos. 1 and 2); hence, the cathode current is well within limits.

R-F Filter for Plate

This arrangement may be found objectionable in that, with a modulated carrier on the No. 1 grid, a modulated electron stream is supplied to the tetrode portion of the tube. Although grids Nos. 3 and 5 serve to shield the No. 1 grid from the plate electrostatically and to prevent any capacity reaction, the action of the diode grid on the electron



FIGS. 4 and 5

The Nos. 2 grid used as diode anode involves some sacrifice in rectification efficiency, but is extremely useful (Fig. 4). Another possibility (Fig. 5), with screen supplying r-f or i-f voltage to grid No. 2 as diode.

stream may result in undesired detection in the tetrode portion of the tube.

For this reason another arrangement is suggested. Since the No. 2 grid, by design, has but little effect on the electron stream, it may be used as the diode anode. The No. 1 grid is then connected to the filament. This arrangement, shown in the circuit of Fig. 4, is particularly useful but involves some sacrifice in rectification efficiency. It should be noted that rectification will not occur when the No. 1 grid is tied to the filament unless tetrode voltages are applied. This is because electron emission from the filament fails to reach the No. 2 grid unless a sufficiently high screen voltage is present.

A Comparison

A comparison of the difference in rectification efficiencies given by the two methods may be obtained from curve A and curve B of Fig. 2. In Fig. 2 the voltage on grids Nos. 3 and 5 is specified as 35 volts. This voltage rather than 67.5 volts is used to correspond to the reduced plate voltage caused by a plate resistor.

It is of interest to note that, when using the No. 2 grid as the diode anode the effect of contact potential or initial electron velocities is much less. This means that little or no bias voltage is developed across the diode load when no signal is applied.

Fig. 3 shows the relationship between modulated carrier input and peak audio output volts when No. 1 grid is at zero potential and No. 2 grid serves as the diode anode. The input was a 175 kc carrier modulated 30%. The peak audio output voltage was measured across a plate load of 200,000 ohms. The circuit diagram is self-explanatory. An r-f filter may be made a part of the plate circuit if occasion requires, although none is shown, since in these tests high-frequency voltage on the plate appeared to be negligible.

Lower Voltages for Safety

Another possible method of using the 1A6 is that suggested by Fig. 5. Here, the screen grid portion of the tube operates as an r-f

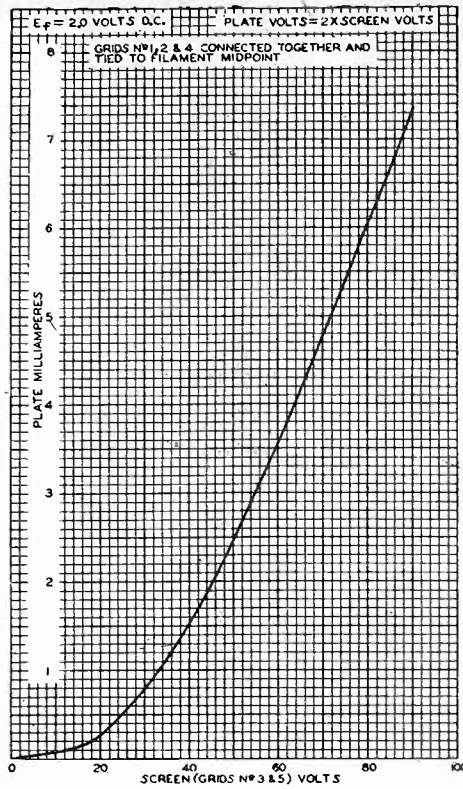


FIG. 6

The average transfer characteristics of the 1A6 tetrode portion, tube connected as a diode-tetrode, are shown in Fig. 6. Conversion factors are shown in Fig. 7.

or i-f amplifier to supply carrier voltage to the No. 2 grid as a diode through the medium of a tuned transformer. Since this circuit may have a tendency to regenerate or oscillate, suitable precautions should be taken in the circuit design and construction.

It must be remembered that the d-c plate load is practically zero and then, when no signal is applied, both the No. 1 grid and the No. 2 grid are at zero potential. In this case, both plate and screen grid current will be high if the voltages recommended for converter service are used. With these voltages, the cathode current approaches the 9 milliamperes specified as the absolute maximum for this tube. For average use, therefore, somewhat lower voltages are suggested. To assist in design, the transfer characteristic of the tetrode portion of the 1A6 is given in Fig. 6. Conversion factors are shown in Fig. 7.

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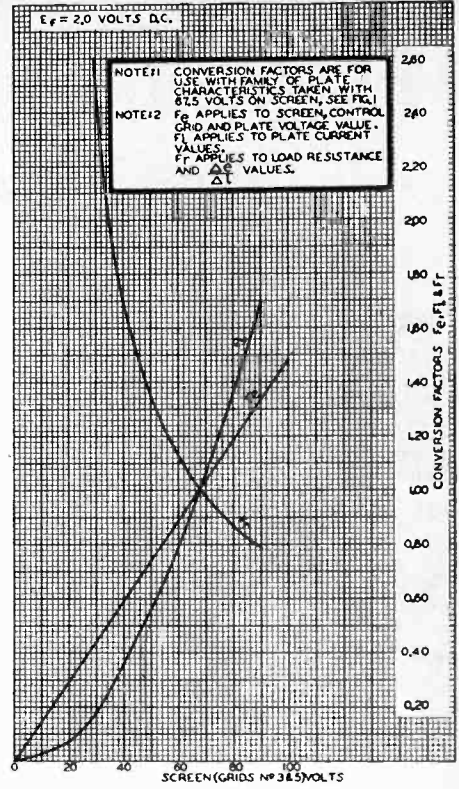


FIG. 7

Forum

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MEASURING THE I. F.

By Beating Two Broadcast Carriers

By Brunsten Brunn

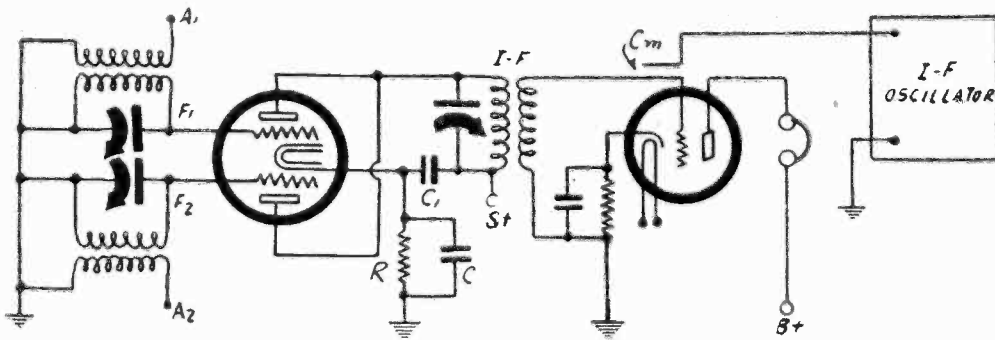


FIG. 1

A simple mixer circuit of this type can be used for obtaining an I-F standard of frequency by utilizing the beat between two broadcast stations.

A METHOD of obtaining frequency in the intermediate frequency band is illustrated in Fig. 1. It presupposes the availability of two broadcast station frequencies of high accuracy which differ by the desired frequency. For example, if we wish a 50 kc frequency two possible frequencies are 660 and 710 kc, or 710 and 760 kc, or any other two differing by the same amount.

The method, of course, is not limited to 50 kc, but applies to any difference from 10 kc to at least 900 kc, in steps of 10 kc. The requirement is a means of receiving the two broadcast frequencies with a strength sufficient to cause an audible beat when a local oscillator is tuned to the difference and made to beat with it. Even with simple equipment, this takes in practically every station in the country, because the beats are audible even when the beating frequencies themselves are entirely too weak to be heard. This is especially the case if one of the beating radio frequencies is strong and also when the local intermediate frequency is strong. It is always possible to select one strong station and to make the local oscillator strong.

Mixing the Two

At left in Fig. 1 are two tuned circuits, which may be separate tuners set up especially for this experiment or tuners existing in some radio receivers. One of them is tuned to one of the beating radio frequencies and the other to the other frequency. The two frequencies which have been separately tuned in are impressed on the grids of a tube having two independent grids, such as the 53 tube shown in the figure.

When the two signals are impressed on the grids they will independently affect the plate current of the tube, the plate current of the two elements tied together to form a single anode. There will be a component of the plate current having the frequency of the difference of the two r-f frequencies. To make this strong, the grids of the tubes should be biased for detection.

Now we have established a standard of frequency that is equal to the difference between the two radio frequencies. This standard is one of a fairly high constancy, although, of course, it is not nearly as reliable as either of the beating frequencies alone. Yet it is sufficiently accurate for all ordinary laboratory experiments, especially

those involved in tuning intermediate frequency amplifiers.

The desired component of the output of the mixer is selected by means of a tuned circuit adjusted to the intermediate frequency. The main purpose of this tuner is to intensify the desired beat and to suppress those products of the mixing which are not desired. This treatment makes use of the beat simpler and avoids confusion.

The Oscillator

The object of the device, of course, is to calibrate some oscillator against the standard of frequency obtained in this manner. Hence we have an intermediate frequency oscillator at the right. This is only shown in functional form. The output of this is coupled loosely to the grid of a tube in the mixer circuit. Loose coupling must be used to prevent overloading of the tube by the local oscillator.

Just what the coupling should be depends largely on the strength of the beat frequency as generated by the beating of the two r-f signals. It should not be any closer than absolutely necessary to render the beat between the standard and the local oscillator audible. But there is a very wide range between the minimum strength for audibility and that which may be applied to the tube before there is overloading.

The oscillator to be calibrated is supposed to have been constructed so that the frequency is approximately equal to the beat desired. This can always be done by computation from inductance and capacity. For example, if we desire a frequency of 50 kc, we know that the product LC should be equal to 10,120, L being expressed in millihenries and C in micromicrofarads. Therefore if the coil in the i-f oscillating circuit has a value of 50 millihenries, the capacity should be 202.4 mmfd. This should be a variable condenser so that adjustments of frequency may be made.

Use of Variable Condenser

Of course, if a fixed condenser is preferable, the adjustment in the frequency can be made by making adjustments of the turns on the coil. This is not quite so simple, but it may lead to a more constant oscillator once it has been adjusted. It is more difficult to adjust by means of the turns because at first the beat between the standard and the local oscillator may not be

within the audible range, and then it is difficult to know whether there are too many or too few turns on the coil. If the condenser is variable the beat in the headphones can be brought to the zero beat condition quickly.

If the condenser is variable it is possible to arrange the oscillator so that a large number of different frequencies can be obtained in the same manner and recorded on the dial.

It is very convenient to have an oscillator which generates a frequency of 50 kc, either without any special adjustment or whenever it is set at a predetermined setting. By means of such an oscillator and its harmonics any broadcast set can be tuned over the broadcast range in steps of 50 kc. The broadcast band begins with the 11th harmonic and ends with the 30th. All of these harmonics can be utilized without any difficulty.

Finer Adjustments

It is also convenient to have an intermediate frequency oscillator that can be adjusted in finer steps, and it is for that reason that the variable condenser is a valuable adjunct. Suppose, for example, that the frequency can be adjusted from 50 to 100 kc, or over any other 2-to-1 range that includes 50 kc. It is then possible to tune different intermediate frequency circuits even though these have frequencies above the range of the oscillator. A common intermediate frequency now is 456 kc. This can be obtained if the oscillator is set at 91.2 kc, for then the fifth harmonic will be equal to 456 kc. Or, if the oscillator goes up to 114 kc, the fourth harmonic will yield 456 kc.

An objection may be raised against the use of a beat frequency as a standard, for it is well known that the percentage of error in the beat may be many times greater than the percentage of error in the individual frequencies beating. Suppose, for example, that the absolute error in one is A and that in the other B. Then the absolute error in the beat may be A+B, because the errors may have opposite sign.

Summation of Errors

Now if the beat frequency is low compared with the beating frequencies, the percentage of error is multiplied by the ratio of reduction. We may start out with two frequencies the mean of which is 1,475 kc and end up with a beat of only 50 kc. The frequency step-down ratio is 29.5 and the percentage of error is multiplied by that ratio. And this does not take into account the fact that the errors in the two add up. Therefore if the errors in the two beating frequencies are the same, the percentage of possible error is multiplied by 59.

But even this large possible percentage error may be entirely negligible in certain cases. Suppose, for instance, that the errors in the two original frequencies are 50 cycles per second out of 1,500 and 1,450 kc and also that they are in opposite directions. The percentage error we may set at 2/590. If we multiply this by 59 the resulting percentage error in the beat is 0.2.

In other words, the percentage error in the beat under the worst conditions is only 0.2, which is less than it is possible to read an ordinary dial that is likely to be used.

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Use of Two Speakers

WHAT IS THE idea back of using two loudspeakers on the same radio receiver? Is the idea that the speaker manufacturers should sell more speakers, or is it that the quality is better? If the quality is better, why is it?—E. H.

The use of speakers on each set is a recognition of the fact that any one speaker cannot reproduce all the audible frequencies with equal efficiency. If one speaker has been designed to be especially effective on the low notes and another to be particularly effective on the high, the two can be combined so that the output of the receiver is practically independent of frequency. There will be an improvement if the combination is done right. But just connecting two speakers of different characteristics to a receiver is likely to make the quality worse than by using one good speaker.

Frequency Doubling

WHAT IS A frequency doubler? That is, what kind of device? I know its purpose.—W. E. H.

A detector of any kind is a frequency doubler, but a grid bias type detector is particularly effective. If a voltage of given frequency is impressed on tube biased for detection, the plate current of that tube will contain a strong component of twice the frequency, that is, the second harmonic. If a circuit tuned to twice the frequency is put in the plate circuit, this double frequency is picked out and intensified. It may be amplified and used as it is or it may again be doubled in the same manner. By continuing the process of doubling it is possible to start with a low, steady frequency and end up with a very high frequency of equal relative stability. The system is used in ultra-short wave transmitters.

Irregular Characteristics

THE PLATE CURRENT-PLATE voltage characteristics of some tubes are very irregular while in others they are regular. I refer particular to the 35 and the 24 as irregular. What is the cause of the irregularity and why does it not show up in all tubes of the same general class?—J. D.

The irregularity of which you speak must be that which occurs when the plate voltage is less than the screen voltage. First of all, this irregularity is due to the screen voltage. However, the irregularities can be reduced by using a suppressor in the tube. That is why the 35 is better in this respect than the 24, for the 24 does not have a suppressor while the 35 does. Later tubes like the 58 and tubes of its class are still more regular, because the suppressor is more effective in them.

Wave Forms and Peak Voltages

IT IS USUALLY said that the peak voltage of an alternating wave is equal to 1.41 times the effective value. Does this hold for all wave forms? Some waves are complex and others are simple, some are peaked and others are practically flat-topped. It is difficult to see how the same factor could hold for all the different wave shapes.—R. E. T.

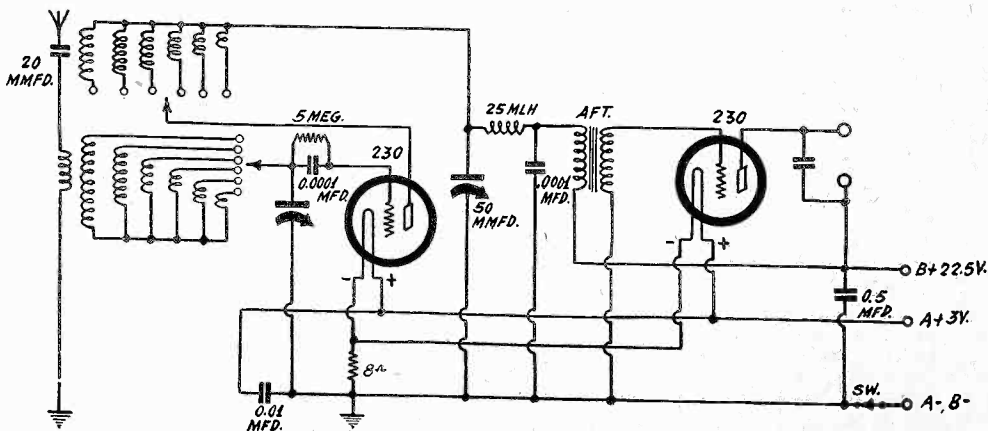
The factor 1.41 holds only for a purely sinusoidal wave, that is, a wave in which no harmonics are present. In any case, the effective value of a wave is the square root of the sum of the squares of the harmonics.

If the wave is peaked the peaks will be greater than 1.41; if it is flat-topped it will be less. When measuring current with an a-c instrument, or voltage too, the effective value is given, because the instrument has so been calibrated. If the peak is required the factor 1.41 can only be used if the wave is purely sinusoidal or if the harmonics are negligible.

Ratios for Short Waves

WILL YOU PLEASE give me some guide as to determining ratios for a short-wave set? I am not able to compute inductance. Is switch operation OK.?—J. C. W.

Take the tuning condenser you have and connect it across a regular broadcast coil, ascertain the extreme frequencies, and then divide the lower into the higher to obtain the frequency ratio. Thus, if you tune from 1,600 to 740 kc the ratio is 1600/740 or 2.16 plus. You may use a little less than the actual ratio for computation purposes, thus the numbers after the second decimal place are disregarded. The capacity ratio is the square of the frequency ratio, therefore the capacity ratio in this instance is $2.16 \times 2.16 = 4.6656$. The frequency ratio discloses how many coils you will need and, knowing the inductance required for the lowest frequency attainment, the capacity ratio indirectly discloses the inductance required for the other coils. Suppose the circuit is to be built for tuning in waves from 2 meters to 200 meters. The sixth power of 2.16 is approximately 100. The lowest frequency is 1,500 kc, the highest 150 mc. The low frequency inductance can be obtained from Edward M. Shiepe's book, 'The Inductance Authority,' on the basis of the capacity in circuit at maximum, which would be about 10 mmfd. (minimum \times the capacity ratio, 4.6656, or, roughly, 50 mmfd., to be on the safe side. The inductances for the succeeding coils would be the reciprocal of the capacity ratio, applied to the previous inductance. Thus, $1/4.66$ of the now ascertained inductance is the required inductance for the next coil, and $1/4.66$ of the new coil for the second succeeding coil, etc. The numbers of turns for various sizes of wire may be obtained from the same book. The circuit may be built according to the diagram, and switch included, if it is a good switch, that makes snappy, positive contacts,



A circuit, using a switch, for bringing in short waves. There are a regenerative detector and a stage of audio. Battery operation is intended. Data on ascertaining the coil ratios, etc. are contained in an answer printed on this page.

and has low capacity. The switch method works all right, but in the upper frequencies of the extreme range just cited the switch will not do so very well.

Use of Slide Rule

IN AN EXPERIMENT I have to use the formula $t = (2S/g)^{1/2}$ for a large number of values of S. If these problems are to be solved by the slide rule how would you go about it? This is not a problem in radio, but I thought it was suitable for practice on the slide rule.—E. W. L.

We assume that this is a problem of falling bodies and that g is the acceleration of gravity and that it has the constant value 980 cm/sec². In that case prepare the problem by finding the square root of 2/980. It is 0.0452. Set index of C-scale on S on the A-scale and read the result under 0.0452 of the C-scale on the D-scale.

Mathematical Symbols

SOMETIMES YOU express the change in a voltage, current, or other quantity by prefixing a small "d" in front of the symbol for the quantity changed. Just why is this done and what is its significance?—W. C. N.

The "d" is the mathematical symbol for a differential, or for an infinitesimally small change in a quantity. It really indicates the difference between two values of a variable quantity resulting from an infinitesimal change in another quantity. As used, the "d" has not been an infinitesimal quantity, but rather a small finite quantity. This use is only one of convenience. It is not conventional.

Wave Filter Characteristics

IN A WAVE FILTER is it permissible to assume that there is no loss or attenuation in the pass region or is it necessary to make allowance for some loss?—F. W. C.

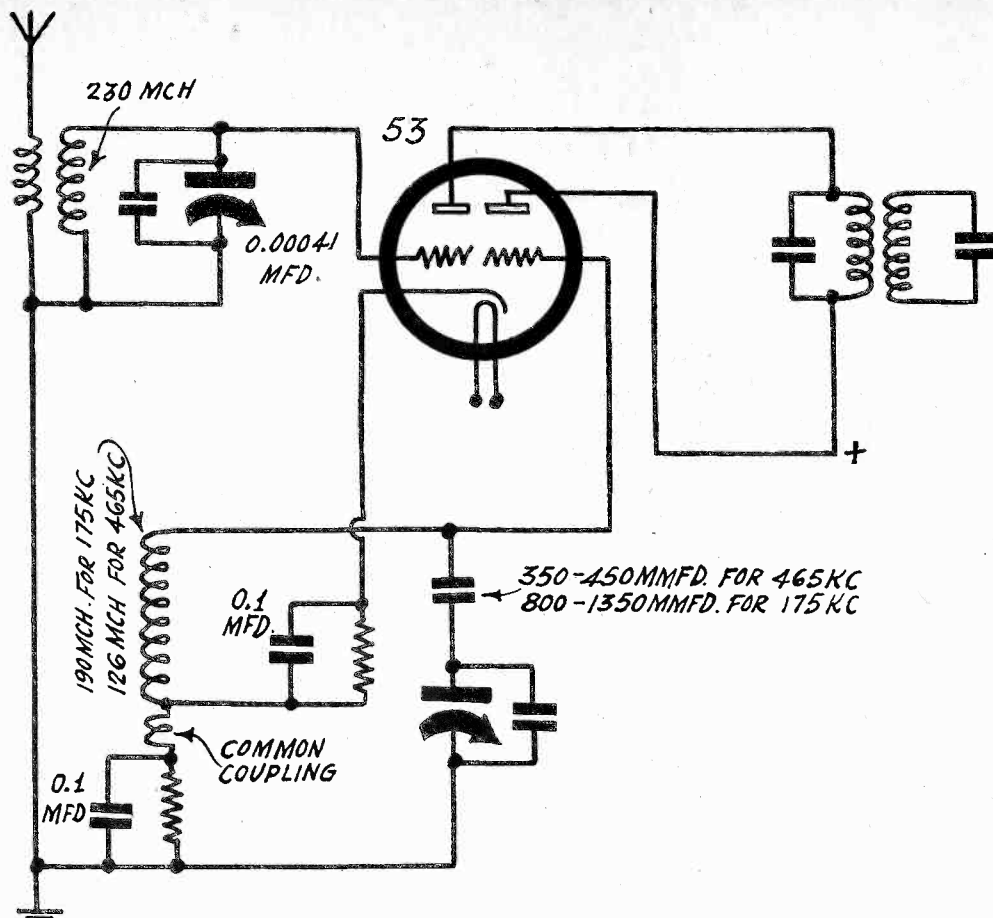
There is no attenuation in the pass region, but there is some loss, depending on the resistance in the coils. This loss must be taken account of in some applications of the filter.

Calibrating Oscillators

WHEN AN OSCILLATOR is to be calibrated against broadcast stations is it necessary to have a receiver so sensitive that it can pick every station in the country, or at least a station on every channel, or is there another way in which it can be done?—F. W. C.

There are two other ways in which it can be done. First, a low frequency oscillator can be set up and tuned against a local station, using harmonics of the oscillator. This oscillator can then be used for a large number of points on the calibration chart. Then it can be tuned to other local stations and the process repeated to fill in other points. It is not difficult to pick out every channel in this manner. By local here is meant a station that can be picked up identifiably well

(Continued on next page)



Mixer for short waves or broadcast frequencies, using a single tube, the 53. The padding condenser is for the broadcast band only and may be the same for 465 kc or 456 kc, although different, as noted, for 175 kc.

(Continued from preceding page)

with an ordinary radio receiver. This method, perhaps, is not the simplest. A better way is to set up a one-tube regenerative receiver that can be made to oscillate at every point of its dial. Listen in with a headset. With this receiver it is possible to pick up the squeal with every channel in the country on which there is a station working. As guides in this process, all the local stations should be picked up first and identified and their calibration points put down on the curve. After that it is easy to fill in the rest as they can be identified by their relative positions on the dial. It will help to draw the calibration curve tentatively before all the points have been obtained and then check the remaining stations against the curve. Chances are that only two or three will be off the curve, if this has been drawn accurately. Many of the points can be located by a harmonics in this method also, for the squeals on the harmonics will in many cases be stronger than the squeals on the fundamentals of distant stations. Half of the points between 540 and 1,500 kc can be located by harmonics.

Cures for R-F Oscillation

HOW MAY I stop oscillation at the radio-frequency level? I have little such trouble with r-f.—T. C. H.

To stop r-f oscillation, use shielded wire for connections to all r-f and detector grids, also plate leads, and ground the shields. Use tube shields and ground them. Use any r-f choke in each r-f plate circuit and bypass with 0.002 mfd. up. If not fully stabilized then, reduced capacity of bypass condensers across r-f biasing resistors. Finally take plate return of two r-f tubes and connect unbypassed few-hundred-ohm resistor to common return of coils, other side of resistor to usual B plus feed. If this makes matters worse, reverse connections to primary of first interstage coil. Increase antenna primary or put 5,000 across present antenna primary.

Use of the 53

CAN A 53 tube be used as a short-wave mixer? Is any coupling necessary except

that which is present in the tube? How would additional coupling be introduced, if needed for broadcasts?—W. D. C.

The 53 tube can be used as a mixer and there will be enough coupling without any extra common coupling, but if any extra is desired, it may be provided by a turn or so of wire as diagramed. If the broadcast band is to be included, still there will be enough coupling in the tube, plus stray coupling, to enable dispensing with the common coupling shown on the diagram. The inductance values of the secondaries for the broadcast band are given. The broadcast inductance for the modulator input is the same, no matter what the intermediate frequency. The two values for the oscillator secondary are for 175 kc and 465 kc intermediate frequency. For 456 kc i. f. the oscillator secondary may be 153 microhenries.

Constant Coupling I-F

IS THERE ANY advantage in using a constant coupling device for an intermediate frequency transformer? If so, will you kindly give the coupling constants for a 456 kc transformer?—W. E. T.

The coupling will be constant because the frequency does not vary. The only way to get a variable coupling would be to arrange the circuit so that the mutual is variable, in case inductive coupling is used, and so that the coupling condenser is variable, in case condenser coupling is used. It is difficult to conceive a case where variable coupling, in a broadcast superheterodyne, would be anything but a disadvantage.

Neon Tube As Polarity Tester

CAN A NEON TUBE be used as a polarity tester of batteries and B supply devices? If so, what precautions are necessary to insure that it will work in all cases?—R. T. M.

Surely, a neon tube can be used as a polarity tester, providing that the voltage is high enough to cause a glow. Insuring adequate voltage is the first precaution that must be taken. The second is to put a high resistance in series with the neon tube to prevent excessive current and damage to

the tube. Since the neon tube requires a certain minimum voltage before it will glow, it is clear that as a polarity tester it is limited to high voltages, higher than this minimum. However, by polarizing the tube with a battery of the minimum voltage, it is possible to extend its usefulness to lower voltages. If the polarizing voltage is just enough to start the glow, then if the tested voltage is opposed to this, the tube will fail to glow but if it aids it will. Even with the polarizing voltage there will be a range over which no test will result for the reason that the glow will not start and stop at the same voltage.

Construction of Precision Oscillator

HOW MANY OSCILLATOR coils are required to cover a frequency range from 90 kc to 6,000 kc when the distributed capacity, or minimum capacity, is to be such that the dial for each coil covers a 2-to-1 ratio, plus a slight overlap? I want this ratio because I want to spread out the frequencies as much as practicable.—P. N.

The frequency range you want to cover is 6,000/90, or 66.7-to-1. If you raise 2 to the 6th power you get 64. Hence you need seven coils. If you limit the total frequency coverage to 64 you need only 6 coils.

Padding A Tracking Condenser

THE TRACKING condenser I have has been designed for 175 kc intermediate and the broadcast range of frequencies. Now I want to use this condenser in a 456 kc superheterodyne, and I have been wondering if it is possible to pad the oscillator section so that it will fit the higher intermediate frequency. I can see no reason why such a condenser could not be padded as well as one that is equal to the condensers used in the r-f tuners.—T. R. B.

No doubt padding can be used to secure fair tracking provided that the inductance, the minimum capacity, and the series capacity are properly selected. However, since the rate of change of the tracking condenser section in respect to the rate of the r-f condensers is not known, it is difficult to predict what these constants should be. However, an approximate tracking can be effected by assuming that the capacities in the oscillator and r-f circuits is the same at 1,500 kc on the r-f dial. This assumption will yield an inductance which is close to the correct value. Then it is only necessary to adjust the series condenser at a low frequency, say 600 kc, until the tracking is good here. The deviation cannot be very great, but no doubt, it will be somewhat worse than if a regular tracking condenser designed for the 456 kc i-f were used. The inductance in the oscillator circuit should be $0.59L$, where L is the inductance of the r-f circuit. At 600 kc the capacity in the oscillator circuit should be $0.03845/L$ micromicrofarads, where L is in henries. If the oscillator condenser has been designed for 175 kc, it is likely that the capacity is $0.0715/L$ micromicrofarads at 600 kc. At this rate the series condenser should be $0.901/L$ micromicrofarads. Now if the inductance, L , in the r-f circuits is 246 microhenries, the series condenser should be 3,660 micromicrofarads. This value may be wide of the mark but it at least gives the order of magnitude as a guide in making the adjustment. If the curves and specifications for the tracking condenser in question are available a much closer estimate of both the required inductance and the required series condenser can be obtained.

Motorboating Neglected

SOME YEARS AGO causes and cures for motorboating were discussed frequently in radio literature. But now it is entirely neglected. What is the reason? Is not this subject as important now as it ever was?—T. R. B.

The reason it is neglected now is that the audio amplifiers used in nearly all modern receivers are not subject to the trouble. Not enough audio stages are used to cause the trouble. Most amplifiers now consist

of two stages, one an a-f voltage amplifier and one a power amplifier. This would give rise to motorboating under certain conditions if the detector were of the plate bend type, but when it is of the diode type there is little chance for motorboating.

Solving for Reactance

WHEN THERE IS a coil in an alternating circuit the reactance is $6.28fL$ and when there is a condenser it is $1/6.28fC$. That we have seen so many times that there is no difficulty computing the reactance in either case, but when there is both a coil and a condenser, in series or in parallel what is the reactance then? Please give formulas for computing.—T. R.

When a condenser and a coil are in series, the reactance of the combination is the difference between the two reactances as computed by the two formulas above. The condensive reactance is negative and the inductive is positive. Hence if the difference is negative the resultant reactance is condensive. Otherwise it is inductive. When the coil and condenser are in parallel, the reactance of the combination is equal to the reactance of the coil divided by $1 - LCW^2$. In this case also the resultant reactance can be either positive or negative.

Classes A and B Amplification

WHAT IS THE MAIN distinction between Class A and Class B amplification? This is not quite clear to me. O. D. N.

In Class A amplification the grid bias operating point is such that the plate current can decrease about as much as it can increase, without grid current. That is, operation takes place with negative voltage on the grid at all times. Either a single tube or two tubes in push-pull can be used. In Class B the operating point is near the plate current cut-off so that the plate current can only increase. Grid current may flow provided that the coupling devices are such that the grid current will not unduly reduce the input voltage. In Class B two equal tubes must be used, one to amplify one side of the wave and the other to amplify the other side. In the latest Class B amplifiers the tubes have been designed so that the operating point, and hence the plate current cut-off, is at zero grid bias. When such is the case grid current will flow and much power is wasted in the grid circuit. This must be compensated for by using a driver stage, which is of the Class A type. A Class B amplifier cannot be self-biased. For this reason tubes have been designed with the cut-off at zero bias.

Mixer Tube

WHICH TUBE would you recommend for mixing two radio frequencies voltages, the pentagrid or the dual tube like the 53 when the two oscillators use different tubes?—R. E.

The pentagrid would be preferable because of the possibility of shielding provided by the extra grids, and also of the possibility offered by these grids for applying different voltages, that is, for changing the operating conditions of the two grids involved in the mixing.

Getting Beats Between Stations

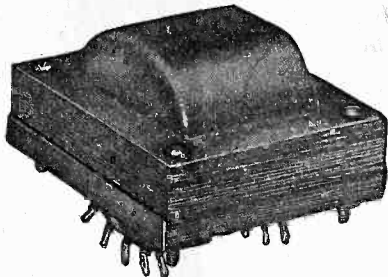
SUPPOSE we wish to build an oscillator and adjust it to exactly 50 kc, is it possible to take two broadcast stations differing in frequency by 50 kc and adjust oscillator frequency to the beat between these two? That is, will the beat frequency be accurately 50 kc?—J. W. A.

A broadcast station of the better class may be off 50 cycles, plus or minus. Hence the beat between the two may be off 100 cycles. Hence you would have a possible accuracy of 100 cycles out of 50,000, or 0.2 per cent. That is an accuracy not often obtained. Chances are that the accuracy of the beat frequency standard would be much better, for the high class stations might not be off more than a few cycles, and they may be off in the same direction

at that. There would be greater chance of error in copying the frequencies than in the frequencies themselves.

Meaning of Term

WILL YOU show what is meant by the "flush type" power transformer, and what is the difference between that and the "shell type"?—O. F. W.



Flush Type Transformer

The two names are used for describing the same type of transformer. There is a shield cover on top, the laminations are visible on all four sides, and the insulation around the winding is visible below, with either wire outleads or lugs for connections to the windings. The illustration shows this type of transformer.

Range of Rectilinear Propagation

IF RADIO WAVES travel in straight lines between two antennas of heights H_1 and H_2 , how is the distance computed between the two stations, that is, the greatest distance along the surface of the earth that these stations may be if the wave from one is to reach the other by the direct route? I know that waves travel greater distances but I just want to know how to compute the straight line distance.—T. U.

For any towers, or even mountains, on which the transmitting antennas may be we may assume that the tangents are equal to the arcs. With this assumption, which holds very closely, we have $S = S_1 + S_2 = (2R)^{1/2}(H_1^{1/2} + H_2^{1/2})$, in which R is the radius of the earth and H_1 and H_2 are the two altitudes in question, all distances being measured in the same units. R may be taken as 4,000 miles. Hence if we express S in miles and the two heights in

feet, we have $S = 1.232(H_1^{1/2} + H_2^{1/2})$ miles. The transmitting antenna H_1 may be 400 feet high and the receiving antenna H_2 may be 25 feet. Then the sum of the square roots of the altitudes will be 25 and the distance S will be 30.8 miles. If we put the two antennas on mountains 1,000 feet high, with no mountains between them, then the distance S is 78 miles. It is clear that if any distant station is received, the wave must come over a curved path.

Stuttering in Receivers

WHILE TUNING superheterodynes there is frequently a stuttering noise which sounds like motorboating. It is not motorboating because it occurs even when there is no audio amplification at all. The trouble seems to be associated with the oscillator. What is your explanation?—R. W. L.

Usually it is due to blocking of grids in which the grid leak resistance is excessive. Most likely in a superheterodyne is that this blocking occurs in the oscillator itself. The oscillator stops and starts oscillation at a rate depending on the amount of grid current and the rate of leakage through the grid leak resistance. If this is the cause of the trouble it should disappear when the grid leak of the oscillator is reduced. If this does not stop the blocking the trouble it may be caused by overloading somewhere else where there is a grid leak of inadequate conductance. This explanation is more likely to be the correct one if the trouble occurs only on very strong signals.

CORPORATE ACTIVITIES

CORPORATION REPORT

World Radio Corporation—Net loss for year ended July 31, 1933, \$67,150, compared with net income of \$5,970 in the preceding fiscal year.

ASSIGNMENTS

Wolfe Radio Co., Inc., of 2 West 18th Street, New York City, to Edward J. Ryan, 80 Fifth Ave., New York City.

BANKRUPTCY SCHEDULE

Musique Radio Co., of 142 Liberty Street, New York, N. Y.; Assets, \$8,284, principal item being accounts \$4,929; liabilities, \$8,250.

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Name

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The Review

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

Questions

1. Classify the 84 tube and state its output limit at 350 volts applied. Define the applied voltage.
2. State briefly what is the new code for tubes.
3. If one has a test oscillator covering considerably lower frequencies, how may broadcasting stations be used as standards of frequencies in calibrating the oscillator, and specifically how many points on the test oscillator representing 50 and 100 kc fundamentals be verified?
4. With an inductance of 25 millihenries, what capacities across the coil are necessary to produce the following frequencies: 25, 20, 17, 14, 12, and 10 kc?
5. Which of the following types of tuners is preferable and why: tuned grid, tuned plate, and tuned grid-tuned plate?
6. Does the capacity between two windings of a transformer add to or subtract from the coupling, or may it do one or the other, and if uncertain, what is the determining factor?
7. What is meant by uniform coupling in a radio-frequency transformer? What is the difference between a uniform coupling transformer and a constant-gain transformer?
8. State the reason for using a tube of power-tube type as driver for push-pull output 2A3's or 45's following the triode of a 55.
9. Why is a volume control sometimes equipped so that it acts as a tone control, and what realm of audio frequencies is attenuated at low volume settings?
10. What is the maximum current to be taken from a 5Z3 at what maximum rated voltage?
11. Is a bypass condenser necessary in a true push-pull stage, across the biasing resistor serving those tubes? If so, why so? If not, why not? Suppose other tubes have their bias supplied from the same source?
12. How many amateur licenses are now being held and what was the figure in 1929?
13. Give the three expressions for power computation.
14. When a diode is used for driving push-pull output tubes what must be the general type of such output tubes and why? For what type of circuit is the diode-driving of the output pair particularly suitable?
15. If a filament transformer is rated at 10 amperes, 2.5 volts, what would the voltage be if a 58 tube were connected to the 2.5-volt winding, three such tubes, 10 such tubes? If there is any change in voltage, what determines it, and in general would the change be great or small?

Answers

1. The 84 is a rectifier tube of the heater type with 6.3-volt heater. At 350 volts rms applied to the plate or plates the current maxima are (a) for full-wave rectification 50 ma, (b) for half-wave rectification 75 ma. For full-wave rectification the plates are used separately, for half-wave rectification they are interconnected. The voltage meant is, as stated, the rms at the plate or plates.
2. The new code for tubes provides in general that there be both alphabetical and numerical designations. The alphabetical order is A, B, C etc., for amplifiers and detectors, and Z, Y, X etc. for rectifiers. That is, the progression is away from A for the one group and away from Z for the other. The prefixed numerical designation gives an indication of the heater or filament voltage and the suffixed numerical designation gives an indication of the number of useful elements of the tube brought out as terminals. The voltage designation for filament or heater usually indicates that the voltage is

greater than the number specified but not as great as the next succeeding whole number. For instance "2" would refer to voltages between 2.1 and 2.9. When the voltage is a whole number, the number generally specifies the voltage exactly, e. g. 25, whereas to avoid confusion with existing designations some tubes are not strictly classified, e. g., the 2-volt series takes the prefix "1" to avoid a mistake between 2-volt and 2.5-volt tubes. Examples: the 2A5 is an amplifier having 2.5-volt filament, heater, with five useful terminals brought out; the 25Z5 is a 25-volt heater type rectifier with five useful terminals brought out; and the 1A6 is a 2-volt filament amplifier-detector tube requiring with six useful terminals brought out.

3. If one has a test oscillator that covers frequencies considerably lower than those frequencies represented in the broadcast band, then harmonics of the test oscillator will be equal to broadcast frequencies, and the test oscillator may be zero-beaten with broadcasting stations, which are thus used as standards of frequencies. Points on the dial of the test oscillator representing 50 and 100 kc, respectively, may be ascertained by beating with one local station that has a frequency a multiple of 50, and picking up the same beat with the receiver dial now tuned to a second local 50 kc removed from the other. The beat will not be heard until one reaches the station 50 kc removed. This serves as verification. For 100 kc fundamental registration, two locals 100 kc apart are used in the same way as frequency standards.

4. Using 25 mlh inductance, the capacities required to attain the stated frequencies are: 0.00156 mfd. for 25 kc; 0.0025 mfd. for 20 kc; 0.0035 mfd. for 17 kc; 0.005 mfd. for 14 kc; 0.007 mfd. for 12 kc and 0.01 mfd. for 10 kc.

5. The tuned grid type tuner is preferable because the selectivity is greater and the gain is higher.

6. The capacity between two windings of a transformer may either increase or decrease the coupling, depending on the sign of the mutual inductive coupling.

7. Uniform coupling in a radio-frequency transformer means that for equal input at all input frequencies the voltage across the secondary is practically the same at all those frequencies. A uniform-coupling transformer and a constant-gain transformer therefore are one and the same.

8. The reason for feeding the output of a 55 triode to a driver tube of the power-tube variety is that the output of the 55 is so large that a tube of adequate voltage-

input capabilities, i. e., high enough negative bias, is required. Output tubes of large power-handling capability, as the 2A3's and 45's are required, in respect to the driver, for the same general reason of overload prevention.

9. A tone control is sometimes associated with a volume control when the volume control is at the audio-frequency level so that the reduction in the intensity of the low notes at low-volume settings is compensated. Therefore the effect of the tone control is to reduce the amplification at the higher audio frequencies at the low volume settings.

10. The maximum current is 250 ma at 500 volts rms per plate. The maximum current of the receiver under discussion, page 9 last week, was 125 ma, and this was incorrectly stated as the maximum current also of the rectifier tube.

11. A bypass condenser is not necessary in a true pushpull circuit, across the biasing resistor serving those two tubes, as there is no current through the resistor at the frequencies of operation. That is, there is no signal or carrier current, hence no object in trying to remove what is not there. If the stage is unbalanced there would be current at the operating frequencies and then a condenser might be advisable, but it would be better to balance the stage and omit the condenser. If other tubes are biased from the same source, which is inadvisable, a condenser would be needed, but if the other tubes were at a radio-frequency level, the push-pull tubes at an audio-frequency level, the condenser could be small. Even so it is bad practice to try this unison.

12. There are 42,000 amateur licenses now held, whereas in 1929 there were 17,000, an increase of 25,000 in four years.

13. Power may be computed by any one of the following: (a) the product of the voltage and the current, expressed in volts and amperes, formula $P=IE$; (b) the product of the resistance and the square of the current, formula $P=RI^2$; (c), the quotient of the square of the voltage divided by the resistance, formula $P=E^2/R$.

14. When a diode is used for driving a push-pull output the output tubes should be of the high- μ , i. e., pentode type, because of the high sensitivity of such tubes, required by the relatively small output of the diode. The diode-driving circuit is most suitable for push-pull resistance coupling.

15. If a filament transformer is rated at 10 amperes, 2.5 volts, then the voltage actually will be 2.5 volts so long as the rating of 10 amperes is not exceeded by the drain. Thus, 1-ampere tubes such as the 58, up to ten such tubes, would not change the voltage, which still would be 2.5 volts. However, the resistance of secondary winding of the transformer has the effect of reducing this voltage a trifle, but not until the amount of current drawn approaches the rating does this decrease come within ready notice. Hence the change is small.

TRADIOGRAMS

By J. Murray Barron

The smaller, independent set manufacturer is behind on production, so rushed with orders that immediate deliveries in large lots are impossible.

To the many who think that higher prices in radio is just talk, it might be well to consider the higher price now for raw materials. A recent new price increase was the cost of tubes to the set manufacturer. That there will be additional prices raised before the holidays can hardly be doubted.

* * *

Quite naturally one either prefers to deal with his local store or does so through habit. It's a good idea to patronize the local man who pays taxes and etc., however very often many of these stores handle a limited line and if they be of the ultra-conservative type may not have the most up-to-date stock.

Then again it is their policy to try to sell what is in the stock rather than what is in demand.

Just why many of those who know of reliable manufacturers or read their advertisements in radio publications and newspapers do not buy more by mail is not always easy to understand, except perhaps that even with all the knowledge they possess they have not fully grasped the opportunities that the mail-order business offers them. This applies not alone to purchases for one's own use but likewise those for resale. If many of these readers could only realize the ease with which sales can be made and the real favors they would actually be doing their neighbors, not to speak of the profits they would be making, they wouldn't hesitate.

MARCONI KEEN AFTER VIEWING OUR TELEVISION

During his return visit to the East, after being honored at the Century of Progress in Chicago, Guglielmo Marconi visited several radio experimental and developmental establishments and also places where he saw commercial message apparatus in operation.

At Camden, N. J., he and David Sarnoff, president of the Radio Corporation of America, were the guests of E. T. Cunningham, president of RCA Radiotron Co., Inc., which has a branch in Camden, though its plant is in Harrison, N. J.

In Camden Mr. Marconi visited the RCA-Victor laboratory and was given a demonstration of cathode ray transmission and reception of television, an RCA-Victor development. An oscillograph tube is used for pickup, actuating a field composed of 3,000,000 photo-cells, and a fluorescent-screen oscillograph tube of more familiar type at the receiving end.

Impressed by Television

Senator Marconi was impressed with the demonstration as marking the well-advanced state of television in this country. He thought that a demonstration so convincing must presage the early readiness of television sets for the American market.

Mr. Sarnoff said that tests have been conducted quietly and with all possible safeguards against rash publicity, because television's repute had suffered badly, due to exaggerated descriptions and prophesies published some years ago.

Due to the tendency to use very high frequencies for television carrier transmission, Mr. Marconi reiterated his prophecy that perfection of ultra-wave work would make possible cheaper communication between ocean liners and shore, with less interference.

Sees His 1900 Shack

He visited the Central Radio office, in New York City, and the radio stations and laboratories, of RCA Communications, Inc. at Rocky Point, Long Island.

He inspected the company's facilities for transmission and reception of facsimile pictures by radio, the facilities for handling international broadcast programs to and from the studios of American networks and the direct radiotelegraph circuits which radiate from New York to more than thirty countries.

Although radiotelegraph signals are ordinarily received silently on tape recorders, on the occasion of Marconi's visit the signals from the short-wave Marconi beam station in England were connected to a loudspeaker for his benefit. This British station was one of the original short-wave beam installations designed by Marconi for regular commercial service. The American and British ends of the circuit have been in continuous operation since the service was inaugurated in 1926.

At Rocky Point, the first sight to meet the radio inventor's eyes was a small white-washed shack, about 8 feet square—the original building used by Marconi for his first commercial coastal radiotelegraph station in America. The station was erected at Babylon, Long Island, in 1900.

Meets Old Friends

After years of disuse the shack was rediscovered in 1930 by Major E. H. Armstrong, an American radio inventor, who moved it

WSOC Becomes Member Of the NBC Network

WSOC, Charlotte, N. C., joined the National Broadcasting Company Southeastern network, in response to a demand by organizations and radio listeners for an NBC outlet in that part of the State.

The station, operating on 247.8 meters, 1,210 kilocycles, serves Charlotte and the surrounding country to which it will broadcast the pick of the NBC programs during the daylight hours and evenings. Earl J. Gluck is president of the operating company.

The newest NBC affiliate was welcomed to the network with a half-hour program over hookup from Chicago. Harold Stokes's orchestra, the Morin Sisters, the King's Jesters, Mary Steele, contralto, and Edward Davies, baritone, inaugurated the programs in Charlotte with a broadcast of modern songs and dance music. WSOC recently operated in Gastonia, N. C., the move to Charlotte gives better broadcasting service to listeners in that section of the State.

to its present location at Rocky Point and presented it to RCA.

Enjoyed Reminiscences

After luncheon the inventor inspected the buildings containing many powerful radio transmitters, remotely controlled from the central radio office in New York. There were reminiscences about the gradual trend of radio development for long-range communication through the years from very long waves to very short waves. During his visit to the laboratory Marconi renewed his acquaintance with H. H. Beverage, B. S. Y. Clifton, H. O. Peterson, C. W. Hansell, Philip Carter, and Nils Lindenblad, engineers of the Radio Corporation.

Marconi and his technical assistant, George Mathieu, compared notes with the engineers on the development of radio transmission on micro waves. The visitors evinced considerable interest in some of the recent developments on this side of the Atlantic among which were multiple-wave-length directive antennas, which types of radiator differ considerably from the Marconi reflector type, and the RCA "long-line control" apparatus for application to ultra-short-wave work.

Replaces Crystal Control

The so-called long-line control development is a distinct contribution to making the ultra-short waves commercially useful in that this apparatus keeps an ultra-short wave transmitter from straying or "drifting" from a definite operating frequency. It replaces the crystal control method of accomplishing the same result which is now in use generally in radiotelegraph and broadcasting stations throughout the world.

The advantage lies in eliminating a vast amount of frequency doubling equipment which, in the case of an ultra short wave station, might be so cumbersome and complicated as to cost more than the power producing section of the transmitter. By comparison with former complicated circuits, the long-line control is an extremely simple apparatus.

One of Biggest Problems

One of the biggest problems in generating the micro-waves is to make vacuum tubes deliver more power when they are oscillating at the terrifically high frequencies of waves only a few centimeters in length. American engineers are examining into the possibility of using high voltage to force more power through the tubes to the small antennas. The production of higher power on ultra-short waves, it is generally considered, will hasten the day when the secrets of this new field of radio transmission are unlocked to science.

NET STATIONS RAISE RATES

Increases in NBC network rates for time on the air are announced by the following stations:

- WJR, Detroit, Mich.
- WEEI, Boston, Mass.
- WFAA-WBAP, Dallas and Forth Worth, Tex.
- WSB, Atlanta, Ga.
- WMS, Nashville, Tenn.
- WKBF, Indianapolis, Ind.

The new rates follow.

- WJR, Detroit:
 - One Hour..... \$500.00
 - Half-Hour 312.00
 - Quarter-Hour 196.00

for periods between 6:00 p.m. and 11:00 p.m. local Detroit time. All other periods at one-half foregoing rates.

The old rate was established when WJR joined the NBC Blue Network in 1927. At that time WJR operated with 5,000 watts power, and the Detroit market area contained less than 450,000 receiving sets. Today, transmitting with 10,000 watts on a clear channel, WJR is the most powerful station in Michigan, while the number of sets in the market area is now in excess of 727,000.

WEEI, Boston:

- One Hour..... \$400.00
- Half-Hour 250.00
- Quarter-Hour 156.00

for period between 6:00 p.m. and 11:00 p.m. local Boston time. All other periods at one-half foregoing rates.

The previous network rate for WEEI was established in September, 1927, when WEEI was operating with 500 watts power, and there were only 215,000 receiving sets in the Boston market area. Today the Boston territory contains upwards of 570,000 receiving sets and WEEI uses power of 1,000 watts.

The rates of three stations, not changed since 1927, now are:

| | 1 Hr. | ½ Hr. | ¼ Hr. |
|-------------------|-------|-------|-------|
| WFAA-WBAP, | | | |
| Dallas-Fort Worth | \$300 | \$188 | \$118 |
| WSB, Atlanta | 300 | 188 | 118 |
| WSM, Nashville | 300 | 188 | 118 |

for periods between 6:00 p.m. and 11:00 p.m. local time in each city. All other periods at one-half foregoing rates.

WKBF, Indianapolis, is available for optional service on either the NBC-Red Network or the NBC Blue network. WKBF broadcasts on a full-time wavelength of 214.2 meters and a power of 500 watts. Rates for WKBF are \$190 per hour, \$120 per half hour and \$74 per quarter hour.

PAGE CHIEF A LIFE-SAVER

Adam Yung, NBC night page supervisor, who is life guard in his spare time, was recently appointed Headquarters Captain of the United States Volunteer Life Saving Corps.

In three short swimming seasons Adam has saved close to 100 lives, on and off duty, earned three medals and commendations, earned a Captaincy, an instructorship and judge's position at life saving meets and tests and organized his own station at one of the most dangerous beaches for swimmers. Adam is just 21.

STARTED CAREER WITH WKBF

When Station WKBF of Indianapolis recently joined the NBC networks, Emil Seidel, well-known pianist for the NBC in New York, was particularly elated. Emil started his radio career with the Hoosier station.

Station Sparks

By Alice Remsen

TRANSCRIPTIONS AND TALENT

It is evident that WOR, WMCA and WBNX will get some of the overflow commercials unable to buy time on the major networks. This is a good thing, for it will help to put the smaller stations on a paying basis so that they can offer their listeners better programs with paid talent. Many of the sustaining programs on these stations have been offered gratis with a promise behind it of pay to talent if sold to a sponsor; the sad part of it is, that seldom, if ever, are these gratis artists even auditioned for commercials; usually the sponsor or his advertising agency picks talent elsewhere. . . . Spot broadcasting is gaining weight with many advertisers. Many of the larger firms see the wisdom of electrical transcriptions on the smaller stations in special territory. The cost is less in the long run, with greater coverage for the money and perfect programs when the records are fresh, and even when the records are scratched up a bit they still sound better than some live broadcasts.

SINGIN' SAM'S GOOD WORK

And now Singin' Sam has an orchestra of handpicked men, six of 'em, but it might as well be a symphony, for each man plays five or six different instruments at different times during the broadcasts, and the effect is as good as that produced by a large organization. The old Barbasol Man waves the baton himself and does a pretty good job of it, too, judging from the way it sounds via a loudspeaker. . . . H. V. Kaltenborn, Columbia's crisp commentator on current events, will be heard on a new schedule, twice-weekly: Sundays from 7:30 to 7:45 p. m., and Thursdays from 6:00 to 6:15 p. m. EST. . . . The Silver Dust evening program with Jack Denny, Scrappy Lambert and Jeannie Lang, has been renewed and also given a network extension of twelve Eastern stations; the new schedule calls for Mondays, Wednesdays and Fridays, from 6:45 to 7:00 p. m. EST over WABC. . . . The Curtis Symphony Orchestra, one of the world's outstanding student ensembles, has returned to a Coast-to-Coast WABC-Columbia network for its fifth consecutive season; each Thursday, from 3:45 to 4:30 p. m. EST; under the direction of Fritz Reiner, former conductor of the Cincinnati Symphony and New York Philharmonic Symphony; the orchestra consists of ninety pieces and originates in the studios of WCAU in Philadelphia; the programs will be under the auspices of the Curtis Institute of Music, in Philadelphia, which was founded nine years ago by Mary Louise Curtis Bok, widow of Edward Bok, and daughter of Cyrus H. K. Curtis. . . . Olsen and Johnson first met each other nineteen years ago—in 1914, to be exact; the spot was about a half mile from where these famous comedians now broadcast, at the offices of a Chicago music publisher in the old Garrick Theatre Building; Olsen, who was at that time a saxophone player in "The College Four," a vocal and instrumental quartet, was there in search of a new piano player; the publisher was racking his brains to think of a likely pianist, when "Chic" Johnson strolled past the open door; Chic must have been thinking of the girl he'd met on his last vaudeville date, for he was whistling the then popular favorite, "Oh, You Beautiful Doll;" it was a lucky break for both the boys, for Chic was drafted forthwith, and the two of them teamed up shortly after that; the Chicago Civic Theatre, where the Olsen-Johnson program, "The Swift Revue," is broadcast, over the WABC-Columbia chain, each Friday at 10:00 p. m., is only a few blocks from the Garrick. . . .

THOSE LITTLE CHURCH FOLK

The weekly program which originates in the "Happy-Am-I Preachers" little church on the banks of the Potomac, first started as a local morning feature of Station WJSV, Washington; within a short time, however, it had attracted enough attention to interrupt the morning schedule of senators, milkmen and cabinet members alike, and since then, Elder Solomon Lightfoot Michaux and his singing congregation have won a nationwide audience; if you are interested in this unique program, tune in an hour later than usual, for the time has been changed to 9:00 p. m. EST, each Saturday evening, over a WABC-Columbia network. . . . WHOM, New York, is becoming quite a station for night clubs, the latest one to install its lines being Billie Gallagher's, from which Mike Landau's Orchestra broadcasts at 11:15 p. m. on Sundays, and 11:00 p. m. on all other evenings; the Red Rooster Club and the Club Richman are already on the station. . . . Frank Crumit and Julia Sanderson have two new additions to their family—Boston Bean and Lady Julia, offspring of Muggsy Dee and Tiny Princess, their pedigreed Boston bulldogs; doing quite well, thank you! . . . Adele Ronson, who plays Wilma Deering in the fantastic "Buck Rogers" program, is busy these days making movie shorts, recordings and personal appearances. . . . Milton Berle was a lucky chap when he was going to school, for in his class were Ruby Keeler, Lillian Roth, Nancy Drexel, Helen Chandler and Marguerite Churchill. . . .

WSB DOING WELL, THANK YOU!

Station WSB, Atlanta, Georgia, is patting itself on the back this season; it has no less than ten NBC commercials going through its transmitter, nine local commercials and five electrical transcriptions. Pretty good business, WSB! . . . Martha Crane's Homemaker's program on WLS, Chicago, has doubled its time; henceforth this popular feature will be a full hour in length; Martha, who has conducted this program for nearly five years, brings to her listeners a variety of interesting features, ranging from talks on attractive menus, household hints, music, home and community parties, to one-act plays; daily except Saturday and Sunday, from 2:00 to 3:00 p. m. CST. . . . Bob Haring is now with WMCA as the director of that station's dance orchestra; Bob is an oldtimer in radio, having been heard on many commercial programs over both the Columbia and National networks; he also was musical director for the Brunswick recording company for a long time. . . . By the way, Billie Dauscha, who returned to New York recently after a period at WLW, Cincinnati, is singing with Bob's orchestra over WMCA. . . . Charlie Mack, the large, drawing member of the team of Moran and Mack, has an interesting hobby; he is rather an authority on Norman architecture, and in his spare time he plans and builds houses; he thinks it's more fun than golfing. . . . The "preview" broadcast of "Nymph Errant," the newest Cochrane musical comedy from London, was such a success that fifteen more of these backstage broadcasts have been arranged between NBC and the BBC of England—and am I glad? Well, rather; and so will you be if you watch your local papers for announcements and listen to these different re-broadcasts. . . .

DONALD NOVIS COMING

It's good news to me that Donald Novis will return to the air via NBC in November; Donald has had his tonsils out during his vacation at his home near Los Angeles; he is quite well now, however, and will play

one or two vaudeville engagements during his trip East; it is expected that he will arrive in New York and be on the air by Thanksgiving. . . . The Goldenrod Revue is on a new time schedule: Saturdays, 8:30 to 9:00 p. m. EST. WABC and Columbia network. . . . And November 19th is the official date set for Frank Parker's debut with The Revellers. Frank is taking Jimmy Melton's place with that famous quartet of singers; here's wishing him luck! . . . Another NBC warbler, Shirley Howard, is very ill; Carolyn Rich is in a hospital also. . . . Harriet Lee re-signed with the Wonder Bakers program last week. . . . The latest rumor has it that Palm Olive will go back on the air again and that they are auditioning Olga Albani and Veronica Wiggins; it would be a very nice combination. . . . Potash and Perlmutter have a time change; now heard at 7:30 p. m. WJZ each evening. . . . And Harry Hörlick has just started his eleventh year of broadcasting with his A. & P. Gypsies; that's a grand record. . . . And they do say that more radio artists come from Kansas than from any other state; perhaps it's a good state to come from—what say! . . . I know that the state I'm in now makes me believe that tea would comfort me, so here goes for a sip of the cup that cheers but doesn't inebriate.

CAN'T GET AWAY WITH IT

When radio artists and employees have vacations they find it hard to get away from business. James Melton, tenor, overcomes that handicap by sailing away to nowhere on his 50-foot cruiser, Melody, which has everything from a refrigerator to a shower—with hot and cold running water, but no radio.

On a recent trip, however, when Jimmy was host to 21 NBC page boys seeking respite from radio, business was brought home to them when they met Yoichi Hiraoka, Japanese xylophonist, and Serge de Somoy, radio engineer, who were fishing quietly and contentedly until they were nearly swamped by rollers from the cruiser.

HUTCHINS SEES JOBBERS

H. A. Hutchins, general sales manager of National Union Radio Corporation, left the New York office on an extensive tour of the principal jobbing centers in the Middle West, as far as Kansas City.

Mr. Hutchins stated that he was confident that the recent upward surge in tube sales was not the result of an artificial condition, but indicative of a renewed interest in radio generally. One of the principal reasons for his trip is to investigate actual conditions in the field to determine the soundness of present optimism.

NATURAL TO HIM

Tim Frawley, who played the role of the dying "Pete" in NBC's dramatization of "The Last Roundup," is a native of the Far West and once rode the range, so that "Git along little dogie, git along!" had a very definite meaning for him. Frawley also plays the role of "The Old Ranger" in the Death Valley Days dramas, reminiscent of the gold

A THOUGHT FOR THE WEEK

MARIE DRESSLER on the air is surely a novelty, and the vast radio audience that listened to Miss Dressler's acknowledgement of the many fine things said about her at the dinner given in her honor recently at the Hotel Roosevelt in New York City was thrilled by her characteristic humor and very human sentiments. This actress was for decades a noted figure in the flesh on our stage and later became famous for her comely and appealing personality on the screen. Marie Dressler is an ornament to whatever field of entertainment she dedicates her talents. She is beloved by all her associates, because she is a big-hearted woman first and an artiste afterwards. All who know her were amused in a serious way when she declared before the microphone at the Hotel Roosevelt dinner: "If I am clever I hope I'll never know it." That's Marie Dressler!

NO MORE CALCULATING OF INDUCTANCE!

Get your answers accurately from curves in the only book of its kind in the world, "The Inductance Authority," by Edward M. Shiepe, B.S., M.E.E. Two charts, one in the book, the other (18x20 inches) as a supplement, relate inductance, capacity and frequency, the large one from ultra to audio frequencies. Thirty-five charts, with 13 curves on each, cover the numbers of turns and inductive results for solenoids, for 35 wire sizes and insulation types. Wire sizes are Nos. 14, 16, 18, 20, 22, 24, 26, 28, 30, 31 and 32. Insulations: single silk, double silk—single cotton, double cotton and enamel. Form diameters: 3/4, 7/8, 1, 1 1/8, 1 1/4, 1 1/2, 2, 2 1/4, 2 1/2, 2 3/4 and 3 inches. Pages 9x12, printed on one side only. Price, \$2.00 postpaid, including supplement.

RADIO WORLD
145 WEST 45TH ST., NEW YORK CITY

CIRCUITS AND SERVICE DETAILS OF COMMERCIAL RECEIVERS in issues of Radio World as follows: The Philco Model 15 Superheterodyne, Oct. 29, 1932; Philco's 4-tube Superheterodyne, Dec. 10, 1932; The Philco 37, Dec. 31, 1932; Philco Service Bulletin—No. 146, Models 89 and 19, Jan. 21, 1933; The Model 28, Newest Sparton Set, Nov. 5, 1932; Sparton 14, 14A, and 18, Jan. 7, 1933; The Majestic 324, Nov. 12, 1932; Stromberg-Carlson's Latest Circuits, Nos. 37, 38, 39, 40, and 41 Receivers, Nov. 19, 1932; The Pilot Dragon, Nov. 19, 1932; National Co. Short-Wave Receivers, Dec. 3, 1932; The New Fada Chassis, Dec. 24, 1932; Howard Model M, Jan. 7, 1933; The Comet "Pro," Jan. 14, 1933; Gulbransen Series 322, Jan. 14, 1933; United American Bosch Service Corp. Instructions, Jan. 21, 1933; Crosley Models 132-1 and 141, Jan. 28, 1933; The Colonial C-995, Feb. 11, 1933; Kennedy Model 563, Feb. 11, 1933; U. S. Radio No. 700, Feb. 18, 1933; Bosch 250 and 251, also Clarion Model 300, and Zenith 430 and 440, Feb. 25, 1933. 15c a copy, any 8 issues, \$1.00. Radio World, 145 W. 45th St., New York City.

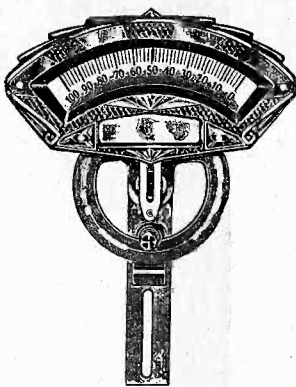
WAFER SOCKETS

6/32 mounting holes, 1-11/16 inches apart; central socket hole recommended, 1 1/4 inches, although 1 1/4 inches may be used.

UX, with insulator.....10c
UY, with insulator.....10c
Six-pin, with insulator.....11c
Seven-pin, with insulator.....12c

HENNESSY RADIO PUBS. CORP.
145 WEST 45TH STREET, N. Y. CITY

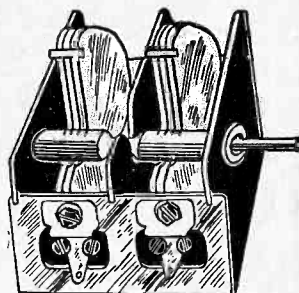
Matched Combination of Dial, Condenser, Coil



Dial obtainable with either of two numerically divided scales or with frequency scale.

Travelling light dial, bulb, esutecheon, 6-to-1 vernier, smooth action. Hub is for 3/8-inch shaft but 1/4-inch reducing bushing is supplied. This dial is obtainable with either type numerical scale (100-0 is illustrated) or with frequency-calibrated scale, marked 500 to 150. The frequency scale requires 0.00037 mfd. condenser and 250 microhenries inductance for the broadcast band, or 0.00037 mfd. condenser and 20 millihenries inductance for actual 500 to 150 kc. fundamentals.
Cat. DJAD—0-100 for condensers that increase in capacity when turned to the right. Scale, 0-100.....75c
Cat. DJAD—100-0 for condensers that increase in capacity when turned to the left. Scale 100-0.....75c
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Cat. RFCW—(TH)—Honeycomb coil of 30 millihenries inductance. Two extreme taps for total windings. Center tap is top.....45c
Cat. TRF-250—Radio frequency transformer 2 1/2-inch diameter shield; primary and tapped secondary. Tap may be used for oscillation in cathode leg of detector tube.....45c
Cat. DJA-14-D—Two gang 0.00014 mfd. short-wave condenser with compensators.....\$1.96
Cat. DJA-37—Single tuning condenser, compensator built in; 0.00037 mfd.....98c

Short-Wave Condenser



Two-gang condenser for short-waves. Low minimum. Sturdy construction. Ball race at front and back of shaft. Compensators built in at side. Shaft is 1/4-inch Aluminum plates. Useful with all standard make short-wave coils. 3/8-inch bushing supplied.

RELIABLE RADIO CO., 143 West 45th St., NEW YORK, N. Y.

PADDING CONDENSERS



Either capacity, 50c

A HIGH-CLASS padding condenser is required for a superheterodyne's oscillator, one that will hold its capacity setting and will not introduce losses in the circuit, for losses create frequency instability. The Hammarlund padding condensers are of single-condenser construction on Isolantite base, with set-screw easily accessible, and non-stripping thread. For 175 kc. intermediate frequency use the 850-1350 mmfd. model. For i.-f. from 460 to 365 kc., use the 350-450 mmfd.

0.0005 HAMMARLUND S. F. L. at 59c.

A sturdy, precision straight frequency line condenser, no end stops. The removable shaft protrudes front and rear and permits ganging with coupling device, also use of clockwise or anti-clockwise dials, or two either side of drum dial. Front panel and chassis-top mounting facilities. True straight line. This rugged condenser has Hammarlund's high quality workmanship and is suitable for precision work. It is a most excellent condenser for calibrated radio frequency test oscillators, any frequency region, 100 to 60,000 kc., short-wave converters and adapters and TRF or Superheterodyne broadcast receivers. Lowest loss construction, rigidity; Hammarlund's perfection throughout.

Order Cat. H05 @59c net

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Radio World, 145 W. 45th St., N. Y. C.

"SOUND PICTURES," by Cameron & Rider. Over 1,100 pages, 500 illustrations. The whole question of Sound Motion Pictures treated from a new angle. A Complete Guide for Trouble Shooting. Explains in detail the construction, operation and care of sound recording and reproducing equipment. Price \$7.50. Radio World, 145 W. 45th St., New York City.

NEW MODEL SHIELDED TEST OSCILLATOR!

Either 50-150 kc Fundamental Model, a-c or battery; or 500 to 1,500 kc Fundamental Model, (broadcast band) a-c or battery, available.

Either model FREE with two-year subscription for Radio World (104 issues) \$12.00

An improved modulated test oscillator, fundamental frequencies, 50 to 150 kc, enabling lining up of intermediate frequency amplifiers, t-r-f and oscillator circuits, is now ready. It is shielded in a metal box 9 1/2" wide x 6 1/2" deep x 4 1/2" high, with beautiful Japanese finish. The test oscillator is obtainable in two models, one for a-c operation, the other for battery operation. The same cabinet is used for both.

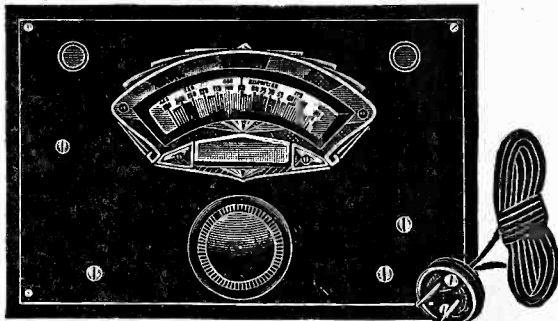
The a-c model not only is shielded but has the line blocked, that is, radio frequencies generated by the oscillator cannot be communicated to the tested set by way of the a-c line. This is a necessary counterpart to shielding, and a special circuit had to be devised to solve the problem.

The modulation in the a-c model is the a-c line frequency, 60 cycles, effected by using the line voltage on the plate of the tube. In the cabinet there is a very high resistance between the shield cabinet and the a-c, a double preventive of line-shorting and application of a-c line voltage to the user.

The oscillator is equipped with an output post. No ground connection need be used, as the circuit is sufficiently grounded through the power transformer capacity to prevent body capacity effects in tuning.

The frequencies are more accurately read than normal use requires, being never more than 2% off, and usually not more than 1% off, many readings being right on the dot (no discernible difference). The frequency stability is of a high order from 100 to 50 kc, and somewhat less from 100 to 150 kc. Zero beats are guaranteed at all frequencies.

The oscillator was designed by Herman Bernard and is manufactured under the supervision of graduates of the Massachusetts Institute of Technology.



The test oscillator has a frequency-calibrated dial, 150 to 50 kc, with 1 kc separation between 50 and 80 kc and 2 kc separation between 80 and 150 kc. Intermediate frequencies are imprinted on the upper tier. Broadcast frequencies are obtainable on tenth harmonics (500 to 1,500 kc).

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

THE a-c model is completely self-operated and requires a 68 tube. The battery model requires external 22.5-volt small B battery and 1.5-volt dry cell, besides a 230 tube. The use of 1.5 volts instead of 2 volts on the filament increases the plate impedance and the operating stability. The battery model is modulated by a high-pitched note. Zero beats are not obtainable with the battery model.

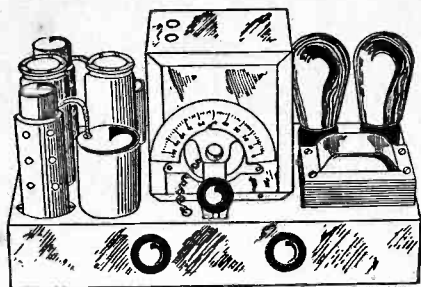
Directions for Use

Remove the four screws and the slip cover. Insert the 68 tube in its socket, restore the cover and screws, connect the a-c attachment plug to the wall socket, and the a-c test oscillator is ready for service.

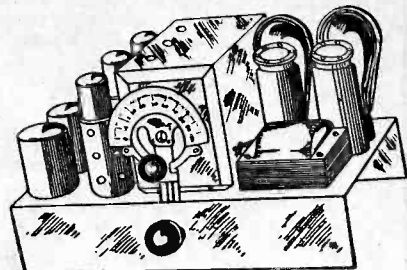
For testing some particular set, follow the directions given by the designer or manufacturer. In the absence of such directions, use the following method.

Mentally affix a cipher to the registered frequencies on the lower tier (so 50 is read as 500, and 150 as 1,500), and set the dial for any desired broadcast frequency. Connect a wire from output post of test oscillator to antenna post of set. Leave aerial on for zero beats, off otherwise. At resonance the hum will be heard. Off resonance it will not be heard. For testing intermediate frequencies, connect the wire to plate of the first detector socket. The first detector tube may be left in place and bare wire pushed into the plate spring. The intermediates then are tuned for strongest hum response. If an output meter is used, tune for greatest needle deflection.

The battery model is connected to voltage sources as marked on oscillator outleads and is used the same way.



BLUEPRINTS, COILS and CHASSIS FOR THE TUNED R-F **DIAMOND OF THE AIR**



FOUR-TUBE DIAMOND

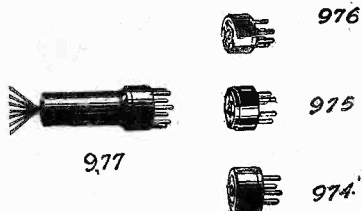
Extremely fine performance, including fetching tone quality, marks the Four-Tube A-C 1933 Diamond of the Air, blueprint of which is now available (half-scale). Many have been surprised that so much can be accomplished on a t-r-f set that costs so little to build. The circuit uses a two-gang 0.00035 mfd.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

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.

RIDER'S MANUAL

The standby of the service man is John F. Rider's "Perpetual Troubleshooter'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.

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.

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.

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"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.

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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.

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