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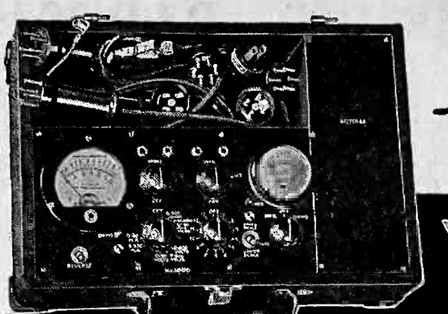

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THE MULTIMETER

A-C and D-C Currents and Voltages Measured in a New Switching Unit

By J. E. Anderson

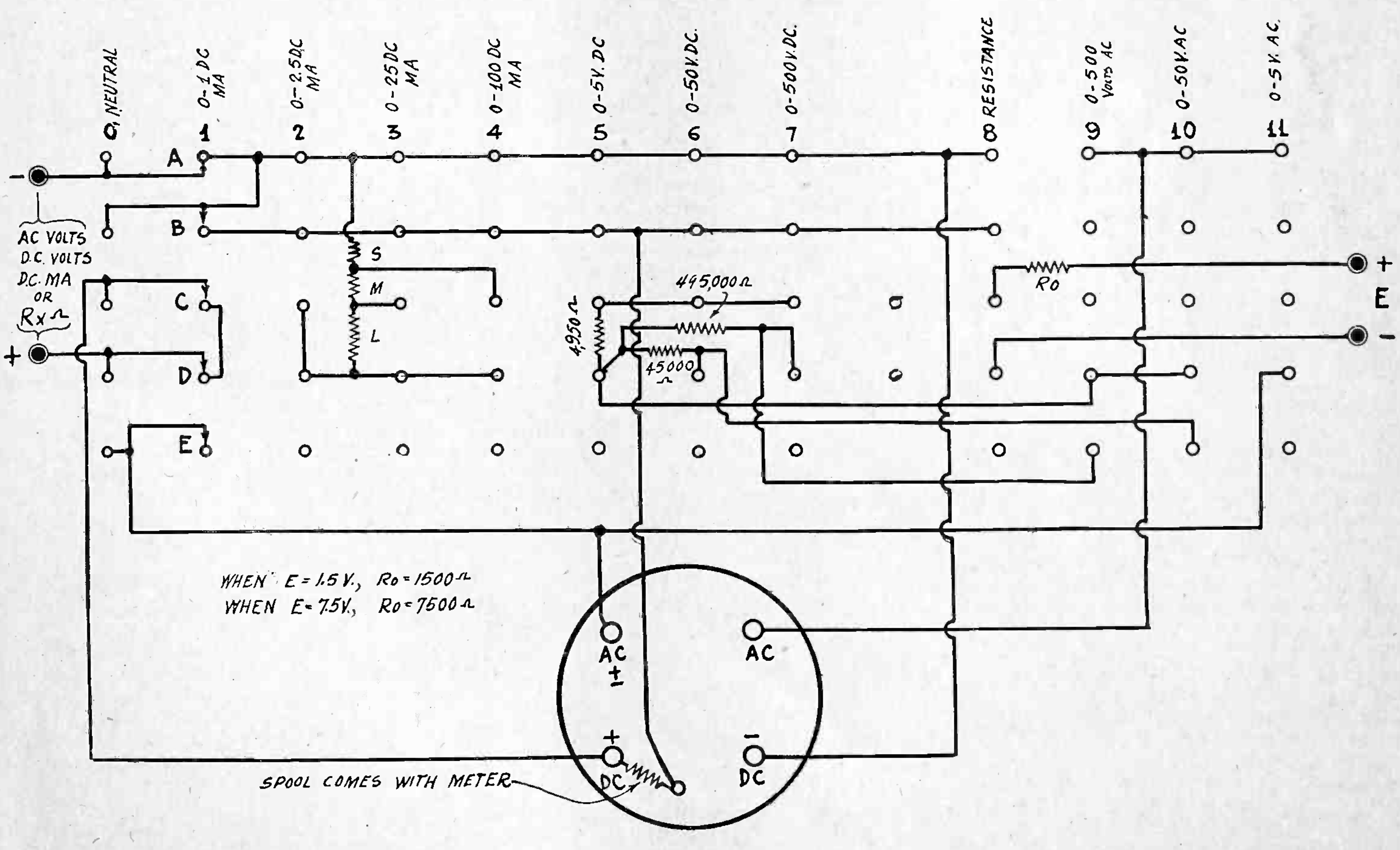

FIG. 1
This schematic shows the wiring of a five-deck, 12-point switch to the universal meter to produce the multimeter.

WORKING out the circuit diagram for a multi-pole, multi-deck selector switch for use with a universal type meter is somewhat of a problem, and even after the circuit has been worked out it requires considerable care in the wiring.

A universal meter for measuring a-c voltages in three ranges, d-c voltages in three ranges, direct current in four ranges, and resistance, requires a selector switch having five decks with eleven points on each deck in addition to a neutral. That is, each of the five decks will have twelve positions.

A diagram that will accomplish the selection of the eleven different functions enumerated above is shown in Fig. 1. The two binding posts at the left are for the unknown, whether this is a-c or d-c voltage, direct current, or resistance. The two terminals at the right are for the battery required when resistance is measured.

The work of wiring the circuit is greatly simplified if we first clearly identify each deck and each point on every deck. Let the first deck next to the panel be designated by A, the next B, the middle deck C, the fourth D, and the last, at the rear,

(Continued on next page)

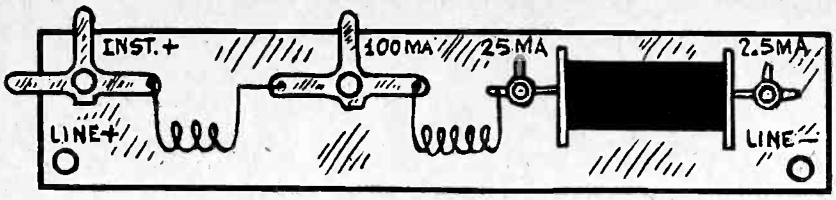

FIG. 2
The arrangement of the spools in the series-shunt current multiplier.

E. On each deck let us number the points in a clockwise direction, with knob pointing toward you, beginning with 0 and ending with 11. No. 0 is the neutral. The circuit diagram shows the decks in horizontal lines with the letter designations at the left and the numbers at the top. By this scheme we can identify any one of the 60 points by its letter and number, thus, A-5, B-3, C-10, D-0, E-11. For simplicity and ease of identification we might mount the switch so that the neutral is either on top or at bottom.

Let us examine each deck in turn and note where the various points are connected. On the first deck A-0 is connected to the negative binding post at the left, and to nothing else. The next eight points, from A-1 to A-8, inclusive, are connected together, and they are also connected to B-0, to one side of the series-shunt resistance, and to the negative side of the universal meter. The remaining three points on deck A, namely, A-9, A-10, and A-11, are joined together and then connected to one of the a-c terminals of the universal meter.

Continuing the Wiring

On deck B we have already disposed of B-0 for it was connected to A-1. The next eight points, from B-1 to B-8, inclusive, are joined together, after which they are connected to the free end of the resistance spool mounted on the back of the universal meter. The remaining three points on deck B, namely, B-9, B-10, and B-11, are left unconnected.

Now let us move over to the middle deck. The neutral C-0 is connected to the positive terminal of the universal meter, and to nothing else. C-1 is connected to D-1, C-2 to D-2, C-3 to one tap on the series-shunt resistor, C-4 to the other tap on this resistor, C-5, C-6, and C-7 are joined together and they are also connected to one side of a 4,950 ohm resistance spool. C-8 is connected to one side of a resistor Ro, which is the limiting resistor for the ohmmeter. The remaining three points on deck C, namely, C-9, C-10, and C-11 are left unconnected.

Deck D is the second from the back. D-0 connects to the positive binding post at the left, and to nothing else. D-1 is connected to C-1 and D-2 to C-2, as was stated before. D-2 is also connected to D-3, D-4, and to the side of the series-shunt resistor not previously connected. D-5 is connected to several points. First it picks up the terminal of the 4,950 ohm resistor not previously connected. Then it picks up one side of a 45,000 ohm resistor and also one side of a 495,000 ohm resistor. It is also connected to D-9 and D-10. D-6 picks up the terminal of the 45,000 ohm resistor not previously connected and it also picks up E-10. D-7 picks up the terminal of the 495,000 ohm resistor not previously connected and also E-9. D-8 picks up nothing but the negative terminal of the small battery used for measuring resistance.

Explanation of Circuit

All the points on deck E actually used have already been accounted for. Hence our wiring is complete.

When the universal meter is used for measuring any d-c voltage or current, the resistance spool mounted at the back of the instrument should be shunted across the two d-c terminals. This is accomplished by deck B. The first eight active positions of deck A are connected permanently to the negative terminal of the meter. Likewise the first eight active positions of deck B are connected permanently to the spool that is to be connected to the negative terminal. Thus the moving arm on deck B accomplishes the desired connection at any one of these eight positions.

In position No. 1 the circuit is adjusted for measuring direct current from zero to one milliampere. Since the d-c part of the instrument is a 0-1 milliammeter there should be no shunt across the terminals in the first position, except the shunt the factory mounted on the back of the meter. Tracing out the leads from the two binding posts to the two meter terminals we find that the desired connections are made.

In position No. 2 the current range is from zero to 2.5 milliamperes. For this we need an additional shunt, so valued that 1.5 milliamperes flow through it when the deflection is full scale. If we put the switch in position No. 2 and trace the circuit we find that the extra shunt, which is connected between A-2 and D-2, is across the terminals of the meter, as well as across the binding posts.

The Series-Shunt

When we wish to measure a higher current by the series-shunt method, all of the extra shunt resistance should remain across the input terminals but the meter should be connected across only a portion of it. When the switch is in No. 3 position the lowest section of the shunt is thrown in series with the line and the meter is connected across the upper two sections. When the switch is in No. 4 position the two lower sections of the shunt are thrown in series with the line and only the upper section is across the meter terminals. The taps are so placed that when 100 milliamperes flow in the external circuit only one miliampere flows in the meter, or so that when 25 milliamperes flow in the external circuit only one flows in the meter.

Measuring Voltage

When direct voltages are measured the d-c meter should be in the 0-1 milliampere connection. If the voltage range is to be 0-5 volts there should be a total of 5,000 ohms in series with the meter. But there is a resistance of 50 ohms in the meter itself so that we only need 4,950 ohms externally. When the switch is in position No. 5 the 4,950 ohms resistor is thrown in series with the positive side of the line but in all other respects the meter remains a 0-1 milliammeter. When we wish to make the meter read voltages between zero and 50 volts there should be a total of 50,000 ohms in series. This resistance is made up of the 50 ohms inside the meter, the 4,950 ohms externally, and an additional resistor of 45,000 ohms. This combination is obtained when the switch is in No. 6 position.

When the range of the meter is to be 0-500 volts there should be a total of 500,000 ohms in series with the meter. This is obtained by putting a 495,000 ohm resistance in series with the 50 ohms of the meter and the 4,950 ohms externally. The correct combination is obtained when the switch is set on position No. 7.

Measuring Resistance

Resistances are measured with direct voltage and therefore on the resistance position, No. 8, we still use the d-c portion of the universal meter. If we put the unknown resistance across the input terminals at the left, all we have to do is to arrange the circuit so that when the switch is on position No. 8, there shall be a voltage in series and also a limiting resistance Ro. This is accomplished by connecting the battery and the limiting resistance, in series, between points C-8 and D-8.

The value of the voltage E and the limiting resistance Ro depend on the values of resistance to be measured. If E is 1.5 volts, the value of Ro should be 1,500 ohms. The practical resistance range is then about 30 to 75,000 ohms. If the value of E is 7.5 volts and the limiting resistance is 7,500 ohms, the range is about 150 to 375,000 ohms. These ranges assume that the current can be read to 0.02 and to 0.98 milliampere.

As the battery used becomes old the meter will show a deflection when the input terminals are short-circuited, due to the resistance in the battery. Therefore when an old battery is used the resistance reading obtained in any case will be higher than it should be. One way to correct this is to make Ro a little less than the required value and then to put a variable resistance in series with it to make up the deficiency. As the battery resistance increases the variable resistance is reduced to compensate for it. To do this the input terminals are shorted and the variable resistance adjusted until the deflection is full scale, or until the indicated resistance is zero.

Another way is to keep Ro at the correct value and then to make a correction for the zero error. First the input terminals are shorted and the indicated resistance obtained. Then the unknown resistance is put across the terminals and another observation made. The difference between the two readings is the value of the unknown. This is the simpler method, and theoretically the more accurate. If the battery is in a reasonably good condition it is not necessary to make any correction except when very low resistances are measured, say below 1,000 ohms.

Measuring A-C Voltages

The universal meter is especially suitable for the measurement of alternating voltages. To measure such voltages the unknown must be impressed across the two a-c terminals of the meter, and the shunt mounted on the back of the meter should be open. As in the case of d-c, the meter should be connected so that it is most sensitive, or so that the meter will have the highest ohms-per-volt sensitivity.

The internal resistance of the a-c meter is 5,000 ohms, most of which is in the rectifying element. Hence when we want to use the meter as a 0-5 voltmeter we do not need any external resistance. Hence the switching arrangement should be such that the 4,950 ohm resistance is always excluded when a-c voltages are to be measured.

Let us see what happens when the switch is in No. 11 position. The upper input terminal is now connected to A-11 and thence to one of the a-c terminals on the meter. The shunt on the back of the meter is open, for B-11 is not connected to anything. The lower input terminal is connected to D-11 and thence to the other a-c terminal of the meter. There is no external resistance in series with the line and there is no shunt across the terminals.

Putting in External Resistors

When the switch is in No. 10 position the meter should be a 0-50 a-c voltmeter.

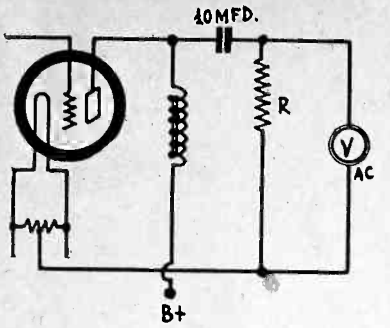

FIG. 3

By this arrangement the multimeter can be used for measuring the output power of a vacuum tube. R is the optimum load resistance of the tube.

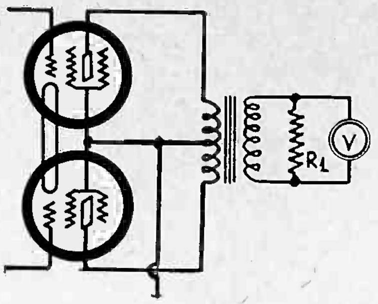

FIG. 4

By this arrangement the output power of a push-pull amplifier can be measured with the multimeter.

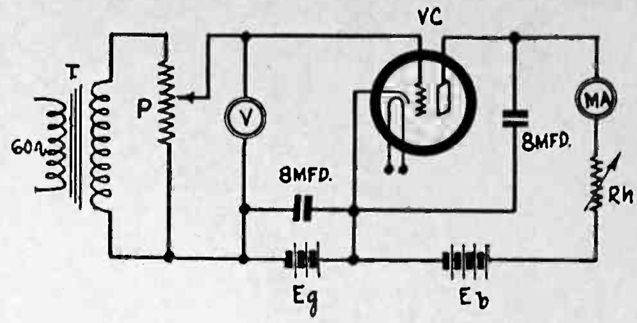

FIG. 5

A vacuum tube voltmeter can be calibrated with this circuit and the multimeter used as an a-c voltmeter. MA may represent the same meter but used as a d-c milliammeter. It is preferable to use two meters.

Therefore all the connections should be as before with the exception that the 45,000 ohm resistor should be in series with the line. The upper terminal, as before, connects to one of the a-c terminals of the meter, through A-10. The lower input terminal picks up D-10, then D-9, and finally the 45,000 ohm resistor at D-5. The other end of the 45,000 ohm resistor is picked up by E-10, which is connected to the a-c terminal of the meter previously not used. When the meter is to be used as a 0-500 volt a-c meter the proper connections are made on position No. 9, for this throws the 495,000 ohm resistor in series.

It will be noticed that most of the wiring of the switch may be done before the switch is mounted. The following connections may be made before mounting: B-0, A-1, A-2, A-3, A-4, A-5, A-6, A-7, A-8; B-1 to B-8, inclusive; A-9, A-10, and A-11; C-1 and D-1; C-2, D-2, D-3, and D-4; C-5, C-6, and C-7; D-5, D-9, and D-10; D-6 and E-10; D-7 and E-9; and D-11 and E-0.

To simplify the subsequent wiring we may also bring out long leads from other points to be connected to the input and the meter terminals and to the resistance measuring accessories. Thus we may bring one lead from A-0 for the upper input terminal, another from D-0 for the lower input terminal, still another from C-0 for the positive terminal on the meter. We may also bring one from E-0 for the a-c terminal on the meter, one from A-8, another from B-8, still another from A-9. We may also bring leads from C-3, C-4, C-8, and D-8. Of course, it may be that it will be just as convenient to await bringing some of these out until the instruments have been mounted.

Note that the upper end of the series-shunt resistance strip is connected to A-1, or to the points connected to it. It could just as well be connected to B-1, or to any point connected to that. Since A-1 is connected to the negative terminal of the meter, and B-1 to the free end of the shunt resistance mounted on the meter, and since these two are connected together through the slider on deck B, the upper end of the series-shunt may just as well be connected to one of the two points of the meter, and this should be done if that makes the wiring easier. Accessibility will determine where the connection is to be made, and that in turn will depend on how the various parts are mounted. Perhaps it is best to connect the upper end of the series shunt strip to the minus terminal of the meter.

Series-Shunt Resistor Designations

On the series-shunt resistor strip are the designations L, M, and S. These refer to the three coils connected in series on the strip. L stands for the largest spool, M for the medium coil, and S for the smallest coil. The large coil L is an actual spool while the two others are only small coils of wire. M is in the middle and it is only a little larger than the smallest coil.

In Fig. 2 is a sketch of the series-shunt resistor strip, designed to give 2.5, 25, and 100 milliamperes. At the left end are two markings, namely, "INST +" and "LINE +", and at the other end is one marking, namely, "LINE —." These do not correspond with the connections in the switch drawing in Fig. 1, but are almost opposite. Hence in wiring the resistor strip disregard the end markings. The end marked "2.5 M. A." should be connected to D-2, the lug marked "25 M. A." should go to C-3, the lug marked "100 M. A." should go to C-4, and the left end, that is, the one marked "INST," should go to A-1 or to the negative terminal of the meter.

Orders of Functions

The stops in any of the decks are disposed in a circle with 30 degrees between them. Therefore No. 11 is 30 degrees to the left of No. 0 and No. 1 is 30 degrees to the right. Hence if we turn the knob to the left from the neutral position we first come to the 0-5 a-c voltage range, next to the 0-50 range, and next to the 0-500 range. As we turn the knob to the right from the neutral position we first come to the direct current ranges, in ascending order, and then to the d-c voltage ranges in ascending order.

When the switch is in the neutral position the line is open, for there is no connection between C-0 and D-0. Therefore this position is safe under all conditions, for the source cannot be shorted and the meter cannot be damaged.

When using the meter certain precautions should be observed in order to protect it. For example, when d-c voltage is to be measured first set the switch on position No. 7, which is the 0-500 volt range. Then if the voltage cannot be read accurately move the switch to No. 6, or to No. 5, if the deflection indicates that it is safe to do so. When a-c voltages are to be measured first set the switch on position. No. 9 and move over to positions No. 10 and No. 11 only if the deflection indicates it is safe to do so. When measuring direct current, first set the switch on position No. 4 and move over to positions Nos. 3, 2, and 1 only if the deflection indicates that it is safe to do so. When resistance is to be measured set the switch on No. 8 before the unknown resistor is connected across the input terminal. In all cases set the switch on the safest position before the unknown is applied.

Never move the switch, no matter how rapidly, over several points without first opening the input terminals. While this may be safely done in some instances it does not do the meter any good, and in most cases it may damage it seriously. Before applying the unknown always assume that its value is the highest that the meter will measure, for that is the safest. That is, assume that the a-c or d-c voltage is 500 volts and that the direct current is 100 milliamperes.

Use of Meter as A-C Milliammeter

The a-c portion of the meter is generally used only for measuring voltage. However, it may be used also for measuring alternating current from 0-1 milliampere. To do so the 0-5 volt a-c position should be used and the meter should be connected in series with the line in which the current is to be measured. The a-c scale is read, not from zero to five volts, but from zero to one milliampere. Since the resistance in series with the line is 5,000 ohms, it will not do to measure alternating current in any low resistance circuit. The meter can only be used accurately for alternating current measurement when the resistance in the circuit is many times the resistance of the meter.

One possible application is to the measurement of the current in the output of an amplifier in which the a-c and the d-c are separated by means of a stopping condenser or some other means. But the results will not be correct unless the combined a-c resistance of the plate circuit and external resistors is large compared with 5,000 ohms. Suppose we wish to measure the signal current flowing in the grid leak. This is separated from the plate of the preceding tube by a condenser and if the succeeding tube is well biased there will be no grid current. Hence only a-c will flow in the grid leak. Since the grid leak resistance is high we have a condition where the meter may be used for measuring current.

Of course, if the grid leak has a very high value, say half megohm, and if the voltage across the leak is only enough to load up a power tube requiring a signal of 20 volts, r.m.s., the current will be exceedingly small and the reading will not be accurate for that reason. As a matter of fact, if the r.m.s. voltage across the grid leak is 20 volts and the value of the leak is half megohm, the a-c will be only 0.04 milliamperes. This value can only be estimated roughly on the a-c scale. Fortunately there is seldom any real need for measuring alternating current when we have a means for measuring alternating voltage.

Position No. 8 is for a direct reading ohmmeter. It is not advisable, however, to mount the calibration curve on the scale, for this requires tampering with the meter, including the breaking of the seal. The instrument is just as useful as an ohmmeter if the calibration data are kept handy, or if they are attached to the case of the box holding the meter. This calibration may be either in the form of a scale giving the relation between the deflection of the meter and resistance or in the form of a curve giving the same relation.

If the instrument is to be direct reading to this extent the limiting resistance

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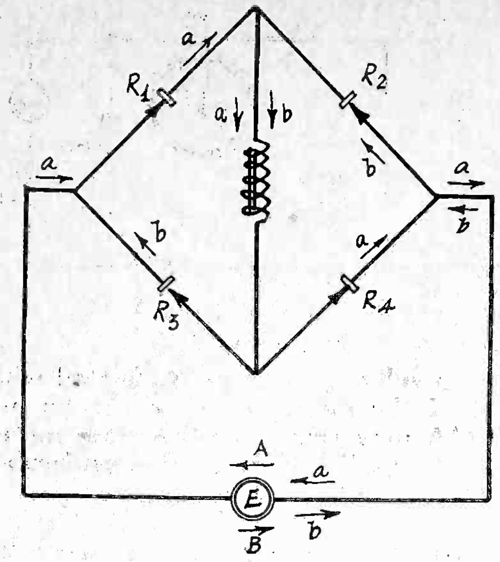

FIG. 6

The rectifier in the meter is of the full-wave type with four rectifying elements connected as in a Wheatstone bridge and illustrated here. The armature coil is the actual bridge, which carries only d-c.

(Continued from preceding page)

Ro and the battery E may be mounted inside the box containing the instrument. If the built-in resistance is 1,500 ohms and the built-in battery is 1.5 volts, the resistance range is from about 30 to 75,000 ohms, as was stated previously. If it is desired to extend the range, a battery of 6 volts and a resistance of 6,000 ohms may be connected externally, in series with each other and in series with the unknown resistance. In making this extension it is necessary to observe polarity so that the summation voltage will be 7.5 volts and not 4.5 volts. If the external battery is connected in the wrong direction the polarity in the circuit will be wrong and the meter deflection will also be in the wrong direction. Therefore this is a quick test of the correct polarity, and it is safe as long as the 6,000 ohm resistance has been added.

Indirect Methods of Measuring Resistance

The meter may also be used for measuring resistances indirectly, by the application of Ohm's law. In this case we first measure the voltage available with a voltage combination and then measure the current through the resistance with one of the current combinations. In all cases we must be sure that the voltage does not change with the current, for if it does, our results will not be accurate.

Suppose, for example, that we have a resistance of the order of 75 ohms and wish to find out its correct value. We may have available a 6 volt storage battery, or a dry cell battery of the same voltage, and one that is fresh. We first measure the voltage with the 0-50 d-c combination and find, let us say, that it is 6.1 volts. We connect this battery in series with the unknown resistance, having previously set the switch on position No. 4. As soon as we close the circuit we get a current reading. Let us assume that it is 95 milliamperes. By Ohm's law the resistance is the voltage divided by the current. Hence we have 6.1/0.095, or 64.2 ohms. This is more accurate than if we had obtained the resistance by the direct reading method because we have read a linear scale.

If the resistance had been less than 61 ohms the deflection would have been more than full scale and it would have been necessary to use a lower voltage source.

Now suppose that we have a resistance which we have reason to believe is of the order of half megohm. The current will be very small with any reasonable voltage and for that reason the measurement will be made on the 0-1 milliamperes setting, but for the sake of safety we set the switch on the 0-100 m.a. position. Suppose we have a battery that measures 90 volts. This we connect in series with the unknown resistance and then connect them across the input terminals. Let us assume that the current reading is 0.17 milliampere. Thus we have 90/0.17 thousands of ohms, or nearly 530,000 ohms. This could not have been measured accurately with the direct reading method. In this manner we may measure almost any value of resistance provided we select the proper voltage and the proper current range.

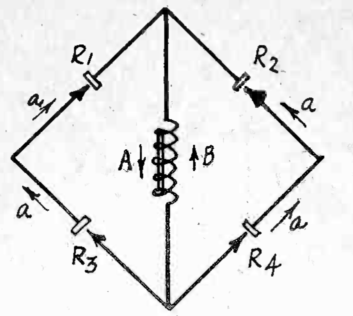

FIG. 7

This circuit illustrates how the universal meter may be subject to external magnetic fields, as an e.m.f. induced in the armature coil will cause a deflection, especially, if one side of the meter is grounded.

Voltmeter Resistance Measurements

We have still another means of measuring resistances. Suppose we measure the voltage of a certain battery with one of the three d-c voltage positions. We get the correct voltage of the battery. But now let us connect an unknown resistance in series with the battery. Now the indicated voltage will be less. From the known internal resistance of the meter and the two voltage readings, we can find the value of the unknown resistance connected externally.

Let V be the voltage reading when there is no external resistance and let v be the reading with the unknown in series. Let the corresponding currents be I and i. We have immediately i/I = v/V = d/D, since either the voltage or the current is proportional to the deflection. By Ohm's law we have V = v + iRx, for V is the voltage applied and this is equal to the voltage drop in the meter, that is, the indicated reading, plus the voltage drop iRx in the unknown resistance. From the current-voltage proportion we have i = vI/V. Making this substitution in the voltage drop equation we have V = v + Rx(vI/V). But V/I equals Ro, the internal resistance of the meter. Hence Rx = Ro (V — v) /v. Dividing through by v and putting d/D for v/V we obtain finally Rx = Ro (d/D — 1).

Examples

In view of this equation we do not need to read the meter in either current or voltage units, but only in scale divisions. Ro, however, must be known in ohms and it is as soon as we know the sensitivity of the meter and the voltage range used. For a 1,000 ohms per volt meter Ro is 5,000 ohms for the 0-5 volt range, 50,000 ohms for the 0-50 volt range, and 500,000 ohms for the 0-500 volt range. That is, it is numerically equal to 1,000 times the highest voltage reading on each range.

Suppose we have a battery of 45 volts and want to measure the resistance of a resistor thought to be 75,000 ohms. The proper range to use is the 0-50. Now let us further suppose that the scale has 5 large divisions with 10 small divisions for each large one. The value of D in this case will be 45 small divisions. Now we put the unknown resistance in series and again note the deflection. Suppose that the deflection is 20 small divisions. Then D/d equals 2.25 and D/d — 1 equals 1.25. Hence the unknown resistance equals 1.25Ro, and since Ro for the range used is 50,000 ohms, Rx = 62,500 ohms. Had we used the 0-500 volt scale and a voltage source of 450 volts, the value of Ro would have been 500,000 ohms and the unknown would have been 625,000 ohms.

In using this method it is advisable to choose the applied voltage so that the deflection is near maximum when the unknown is not connected. The voltage and the range used should also be such that there is as great a difference between D and d as possible.

Let us take another example, using the 0-5 volt range. Suppose we have three No. 6 dry cells in series as the voltage source. Measurement of the voltage gives us a deflection of 46 small divisions. Now let us connect an unknown resistance in series with the battery and the voltmeter. Let us assume that the deflection now is 5 small divisions. The value of D/d — 1 now becomes 8.2 and Rx = 8.2Ro. But Ro in this case is 5,000 ohms and therefore Rx is 41,000 ohms. Again, let us suppose that the second reading is 45 small divisions. Now D/d — 1 equals 1/45 and Rx is 5,000/45, or 111 ohms.

Measuring Impedances

It is possible to utilize the a-c voltage ranges for measuring impedances by a method similar to the preceding scheme for measuring pure resistances. Suppose we have an impedance that can be regarded as a pure reactance. Condensers come within the requirements and also inductances in which the resistance is small compared with the resistance of the a-c voltmeter.

Let the line voltage be V volts. This can be measured with the a-c voltmeter and it will give a certain deflection D. Now let an unknown pure reactance X be connected in the circuit. The deflection will now be less than before. It will be proportional to the root mean square of the current through the circuit, and this current is V/ $(Ro^2 + X^2)^{1/2}$, that is, it is equal to the effective voltage divided by the effective impedance. The voltage v indicated by the meter will be iRo, which is the value of the effective current given above and Ro is the resistance of the meter. Hence we have X = Ro

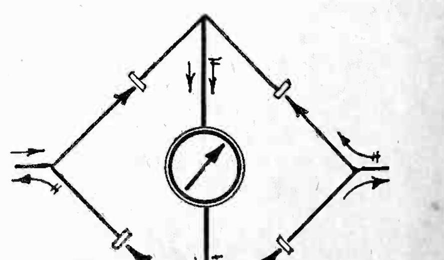

FIG. 8

This circuit shows how current flows in the same direction through the moving coil regardless of the direction of the impressed a-c voltage.

Serves Many Purposes

A well-considered meter device has been designed by J. E. Anderson, technical editor, and is described herewith. It uses a single meter, the Weston Universal, model 301. The primary purposes are the following measurements:

D.C.

0-1, 0-2.5, 0-25, 0-100 *milliamperes.*

0-5, 0-50, 0-500 *volts.*

A.C.

0-1 *milliampere.*

0-5, 0-50-0-500 *volts.*

Resistance (D.C.)

30-75,000 *ohms* (1.5 *volt, cell, limiting resistor* 1,500 *ohms*).

The secondary purposes are:

A.C.

Computing reactance of coils and condensers, hence determining capacity and inductance.

Measuring power output.

Calibration of vacumu tube voltmeter for a-c voltages.

D.C.

150 *to* 375,000 *ohms* (7.5 *volt battery, limiting resistor* 7,500 *ohms*).

—EDITOR.

$[V^2/v^2 - 1]^{\frac{1}{2}}$, or, since $V/v = D/d$, $X = Ro\,[D^2/d^2 - 1]^{\frac{1}{2}}$.

X may be the reactance of either a condenser, or of a coil without appreciable resistance. Suppose our voltage source is a 115 volt a-c line. On the 0-500 volt range this will cause a deflection of 115/500 of full scale. If the scale has 50 small divisions, the value of D will be 11.5. Let a coil be connected in series with the line and assume that the voltage reading will be such that the deflection is 5 divisions. Then d = 5 and D/d will be 2.3. Hence the value of the radical is 1.14 and X = 1.14Ro. But Ro for the 0-500 volt range is 500,000 ohms. Hence the reactance is 0.57 megohms. For a coil, X is Lw, in which L is the inductance of the coil and w is $2\pi f$. If the frequency of the line voltage is 60 cycles per second, we obtain for the inductance L = 1,510 henries.

Measuring Capacity

Suppose we had had a condenser in series with the line and we had got the same deflections. The reactance of a condenser is 1/Cw, and this, then, is equal to 0.57 megohms. Putting in the same value for w and solving for C we obtain 4,540 mmfd. If the condenser is so large that the difference between D and d is very small, we have to use a lower voltage and one of the meter's lower voltage ranges. The lower voltage can easily be obtained with the aid of a step-down transformer.

We can use the a-c voltage ranges for measuring the output power of tubes, provided we do not use an excessively high frequency. On the standard test frequency of 400 cycles per second it is all right, and, of course, it is all right on 60 cycles per second. Indeed, the meter is quite accurate for all audio frequencies.

Measuring Push-pull Output

In order to measure the output power we should first load the tube with a resistance having the optimum value for the particular tube used. This should be coupled to the plate of the output tube through a very large condenser and the plate should be fed through a high inductance choke. The load resistance should be connected between the condenser and the cathode of the tube, or the ground, which amounts to about the same thing. Then the a-c voltmeter should be used for measuring the effective voltage drop across the resistance. Suppose the value of the resistance is R ohms and the effective voltage measured is V volts. The output power is then V^2/R watts. The circuit to be used for a single output tube is shown in Fig. 3.

In case the output stage is push-pull, a transformer is needed. This should have such a ratio that the effective load resistance is that required by the tubes. Suppose, for example, that the optimum load impedance is 15,000 ohms for the two tubes and that we have a transformer with a ratio of 5-to-1. The ratio of the transformer should be the square root of the ratio of the resistances between which the transformer is connected. Let the load impedance be R and the resistance connected to the secondary of the transformer be R_1. Then the ratio of turns is $(R/R_1)^{\frac{1}{2}} = 5$. Hence R_1 should be R/25, or 600 ohms. To measure the voltage drop across this resistance we would undoubtedly have to use the 0-5 a-c range.

Perhaps we have a resistance of known value and wish to provide a transformer with the proper ratio. We have $(R/R_1)^{\frac{1}{2}} = N$. Suppose then that the resistance we have is 100 ohms. Then the resistance ratio becomes 15,000/100, and the turns ratio 12.25-to-1. Undoubtedly, in most cases a transformer of given ratio is available and a resistance must be provided to fit the particular case. A suitable resistance can nearly always be provided.

If the step-down ratio is large the secondary voltage will be very low and for that reason even the 0-5 volt range will not give accurate readings. But on the other hand, if the resistance across the transformer is comparable with the resistance of the voltmeter, there will also be an error because the resistance actually on the transformer then is less than it is supposed to be. When this is the case the resistance of the voltmeter must be taken into account, since it is connected in parallel with the other resistance. Since the voltmeter resistance is always known for any of the three ranges, the proper allowance for it can always be made.

Suppose that the resistance on the transformer is R1 and the resistance of the meter is Ro. Then the resistance really on the transformer during the voltage measurement is R1Ro/(R1 + Ro), and that is the one that should be matched with the step-down transformer. In any case we can vary R1 to suit the case. It will always be larger than it would be if the resistance of the voltmeter could be neglected. Fig. 4 shows how the voltmeter should be connected when measuring the output of a push-pull stage.

The a-c voltmeter can be used for calibrating a vacuum tube voltmeter, and the calibration made with 60-cycle voltage will hold at intermediate and radio frequencies. Fig. 5 shows a suitable circuit for making the calibration. VC is the tube used for the vacuum tube voltmeter, MA is a milliammeter with which the plate current is read, Rh is a rheostat for adjusting the plate current to near maximum deflection when the maximum a-c voltage is applied on the grid, which is such that the peak is nearly equal to the bias. Eb is the applied plate voltage and Eg the grid bias, which should be such that the plate current is nearly zero when no signal voltage is applied. That is, the tube should be operated as a grid bias detector.

The a-c voltmeter is connected between the grid and negative of the grid bias battery. P is a potentiometer by means of which the a-c voltage on the grid can be varied from zero to the highest voltage that may be applied to the tube without driving the grid positive. T is a step-down transformer by means of which a suitably low voltage can be obtained from the 115 volt line. In case the proper voltage range cannot be obtained with the transformer T available it may be lowered by putting a variable resistance in the primary. It cannot be increased, however, without using another transformer. The regulation of the transformer and the value of P are of comparatively little importance because the voltmeter is always across the grid circuit and the grid voltage is whatever the meter indicates.

A calibration run consists of taking the plate current for every volt, or every half volt, on the grid from zero to the maximum voltage the tube will stand without drawing grid current. The data thus obtained should be plotted on cross-section paper, after which the tube may be used for measuring alternating voltages of almost any frequency, at least up to and including the broadcast frequencies. The unknown voltage is applied between the grid and minus C, after the voltmeter, the transformer, and the potentiometer have been removed.

Resistance in Coil

When there is a considerable resistance in the inductance coil that is measured the results obtained with the method described above for the measurement of inductance will not be correct, because the value of d obtained will be too low. This is because d is only due to the drop in the meter resistance and not to the total resistance in the circuit. Hence the method should not be applied unless the resistance in the coil can be neglected in comparison with the meter resistance. If it is not known whether or not the resistance of the coil can be neglected, a measurement of the d-c resistance of the coil can be applied, considering the coil as a pure resistance and measuring it with one of the d-c voltage ranges as explained. The result obtained this way is only the d-c resistance and not the a-c resistance which enters when the impedance is measured. But the d-c methed at least gives the order of the resistance. Suppose, for example, that the d-c resistance of the coil turns out to be 1,000 ohms and that the 0-500 range of the a-c voltmeter is used. Then it is safe to assume that the a-c resistance is negligible in comparison with half megohm, for the a-c resistance is probably not more than twice the d-c resistance. Many coils are designed so that the copper and core losses are equal and for low frequencies the copper losses are practically the same for 60-cycle a-c as for d-c. Hence the a-c resistance would be about 50 per cent. greater than the d-c resistance. Certainly 1,500 ohms would be negligible compared with half megohm, or even compared with 50,000 ohms.

The method for measuring inductance and capacity described above assumes that the coils in the voltmeter are non-inductive. The coils made for this meter are such, as they have been designed for use with a-c as well as with d-c.

Effects of External Fields

The universal meter is subject to external magnetic fields and for that reason it should be kept away from power and audio transformers and from choke coils carrying alternating currents, or else it should be placed inside a steel case.

The reason for its subject to magnetic fields is not far to seek. There is a full-wave rectifier of the copper oxide type built into the instrument, which is essentially as outlined in Fig. 6. R1, R2, R3, and R4 are four rectifying elements, L is the armature coil and the field magnet, and E is an alternating voltage to be measured. The arrows beside the rectifying elements indicate the direction in which the current can flow through these elements.

Suppose that the voltage E is in the direction indicated by the arrow A. The current around the circuit is then as is indicated by arrows a. The current passes through rectifying elements R1 and R4. The direction of the current through L is downward.

Now suppose that the voltage E is in the opposite direction, as indicated by

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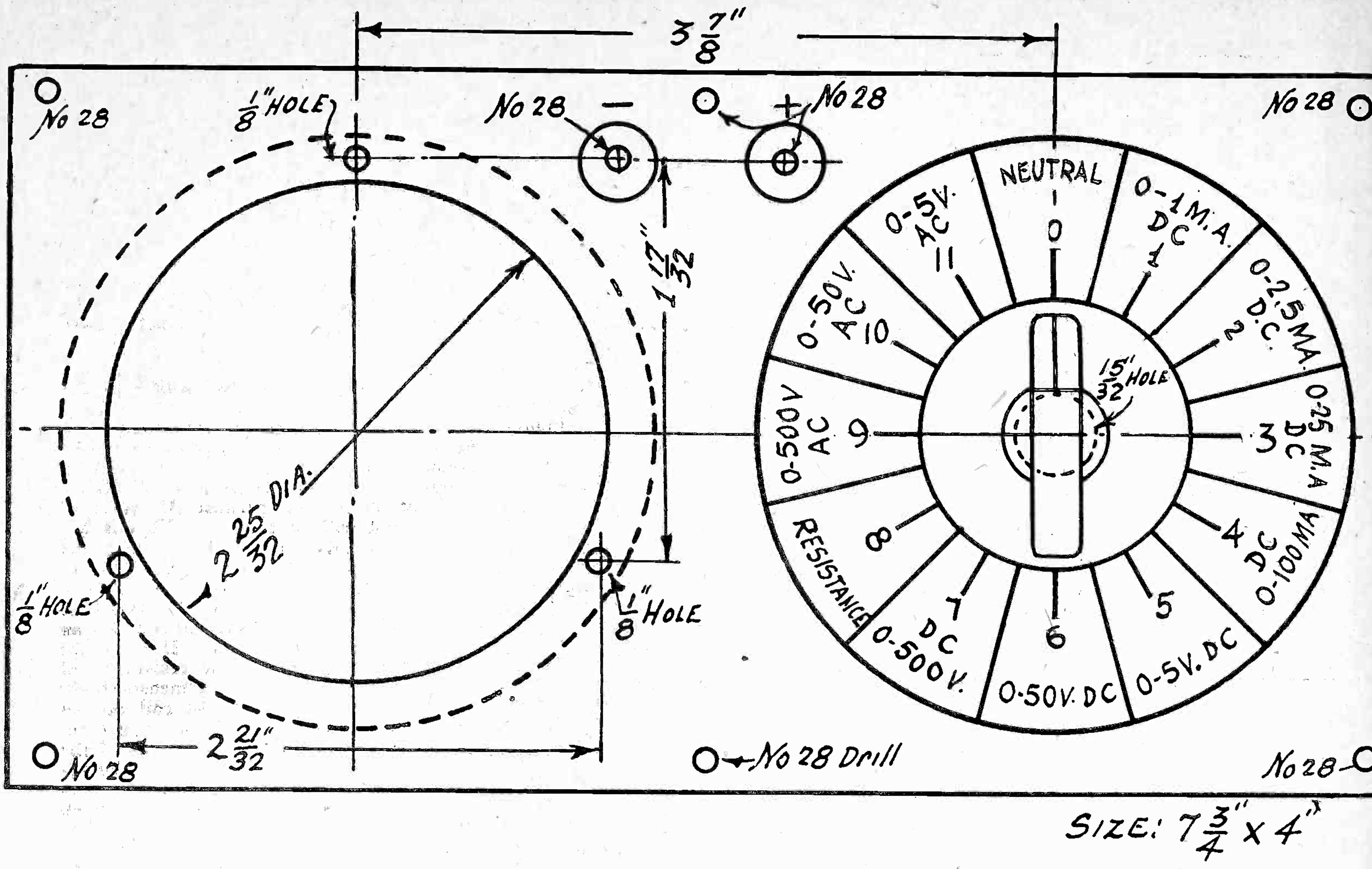


FIG. 9

Panel for the multimeter. At the left is the universal meter and at the right the multi-polar switch together with its dial. The binding posts at top are for d-c measurements, with polarity as indicated, or for a-c and resistance. The container should be 4 inches deep to accommodate switch and hold a 7½-volt battery.

arrow B. The current around the circuit then is in the direction indicated by arrows b, rectifying elements R2 and R3 being effective. The current through L is in the same direction as before. Hence the rectifier is full-wave, current flowing through the armature coil in the same direction on both half-cycles of the e.m.f.

Let us now remove the supply circuit, that is, let us leave the input terminals open. We then have the circuit in Fig. 7. Suppose that the armature coil L is subjected to a strong magnetic field, or suppose that the field magnet is thus affected. In either case there will be induced an e.m.f. in the coil. Suppose this induced e.m.f. is in the direction indicated by the arrow A. A current can then flow around the circuit in the direction indicated by arrows a, and all the rectifying elements are active. Hence a current can flow through the armature coil and there will be a deflection. Now suppose the induced voltage is in the direction indicated by arrow B. Now no current can flow around the circuit because all the rectifying elements have the wrong polarity. Therefore the circuit is a half-wave rectifier, but current can flow during every cycle of the e.m.f. induced in the armature coil. The current pulses will be comparatively large because the resistance has been cut down by the fact that the rectifiers are in series-parallel instead of in series as they are under normal operation.

Meter Reads R. M. S.

Damage can be done to the meter by virtue of this effect and for that reason care should be taken to see that it is not subjected to alternating magnetic fields such as exist about transformers and chokes carrying heavy alternating current. Shielding by means of iron or steel does not completely remove the effect because, necessarily, the face of the meter must be exposed. But shielding helps.

The rectified current through the elements is proportional to the mean value of the current pulses but the scale for a-c is calibrated so that it reads r.m.s. values. For this reason there are two scales on the instrument dial, one for r.m.s. a-c and the other for d-c. The two scales are different so it is essential to read the right scale. The two scales coincide only at the two extremes, that is, at zero and 5. The upper scale is for a-c and the lower for d-c, each being marked appropriately.

The calibration of the scale in terms of r.m.s. values has been done with a pure sine wave. If the wave form of the current or voltage measured has any other shape the calibration in general is not correct, and the error not only depends on the relative magnitudes of the harmonics present but also on their relative phase displacement.

A pure a-c wave can contain the odd harmonics only, such as the fundamental, the third, the fifth, the seventh, etc. harmonics. A root mean square meter measures the square root of the sum of the squares of the effective values of the various components. That is, $v = (v_1^2 + v_3^2 + v_5^2 + \ldots)^{1/2}$. Since only the squares of the effective values enter into this there is no dependence on phase.

Taking Characteristic Curves

The rectifier current is proportional to the simple mean of the instantaneous values and the mean of the various harmonics depends on phase. Hence the indications of the a-c meter depends on phase displacement. If the phase of one harmonic is 180 degrees with respect to the fundamental, the instantaneous value of this is subtracted from the corresponding instantaneous value of the fundamental.

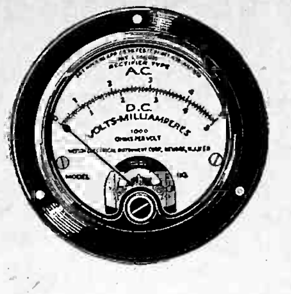
The multimeter is well adapted to taking characteristic curves on vacuum tubes, since both the grid bias and the plate current can be measured with it. Moreover, the applied plate and screen voltages can also be measured. If the same meter is used for both grid voltage and plate current measurements, a circuit should be hooked up so that with a single switch the meter as a voltmeter may be connected across the grid battery and so that it may be connected as a milliammeter in series with the plate circuit. A double pole, double throw switch is about all that is needed for making the change, provided that the selector switch on the meter is set at the proper position after each change, or rather while the double pole, double throw switch is open.

Since the d-c milliammeter will measure up to 100 milliamperes and down to 20 microamperes, the meter will handle practically all tubes used in receiving sets. Moreover, since the highest voltage that may be measured is 500 volts, plate and screen voltages may be checked in nearly all cases, for it is seldom that the applied voltage is higher than 500 volts. Also, since the d-c voltmeter will measure voltages down to 0.1 volt, in steps of 0.1 volt, curves can be taken on tubes having a very high amplification constant.

While it is possible to take curves with the single meter, it is much better to use separate instruments for the grid voltage and the plate current, and two should be used whenever a suitable extra meter is available. Whether to use the extra meter for grid voltage or plate current depends on its range and type. If it is a voltmeter, of course, it must be used for grid voltage measurement and if it is a milliammeter it must be used for plate current measurement. It is better to use two meters because the grid voltage may change when the meter is removed, so that while taking the current

FIG. 10

Top view of the universal meter. It has two scales, the lower for d-c and the upper for a-c.



reading the voltmeter should actually be across the grid battery, and the indicated voltage should be taken to correspond with the plate current reading. Also it is obviously much simpler to use two meters while making a run on a tube.

Measuring Detecting Efficiency

The detecting efficiency of different tubes for different grid bias voltages and other conditions can also be measured with the multimeter. This is essentially the same as taking a characteristic curve of the tube except that alternating voltage is impressed on the grid instead of direct voltage. The voltage used may be 60 cycle, or any audio voltage. The signal voltage impressed, that is, the a-c, is measured with the a-c voltmeter and the plate current resulting is measured with the d-c milliammeter. The detecting efficiency may be taken as the increase in the plate current due to a given a-c voltage impressed on the grid. Thus the plate current with no signal should be measured and then again the current should be measured with the given a-c impressed. The difference between the two gives a number that is proportional to the detecting efficiency for the given a-c voltage and grid, screen, and plate voltages applied.

Since low frequencies must be used to make the a-c voltmeter accurate it is necessary to have a very large by-pass condenser in the plate circuit of the tube to take the place of the small radio by-pass condenser ordinarily employed. As in the case of taking static curves, it is best to have a separate milliammeter in the plate circuit so that the universal meter need only be used for measuring the alternating grid voltage.

Resistance Measurement

Fig. 13 shows calibration curves of the multimeter employed as an ohmmeter, with 1,500 ohm limiting resistor (Ro) and 1.5 volts applied. Scale divisions are given at the bottom and resistances at the left. The total calibration curve is plotted in two sections, one covering the range from 1,000 to about 75,000 ohms and the other from 10 to 1,000 ohms. Both the horizontal and the vertical scales are different for the two sections. The horizontal scale for the low resistance section is twice as great as the scale for the high resistance section. This has been done to spread out the curve more and make readings easier.

The resistance scale at the left applies as it stands between 10 and 1,000 ohms. To get the correct resistance from the left curve the scale readings should be multiplied by 100. Let us give a number of examples to show the use of the scales. Suppose a certain resistor gives a deflection of 16 divisions. What is the value of the resistance? Ordinate 16 crosses the left curve at 30.9. Hence the resistance is 3,090 ohms. Again, suppose the reading is 5.5 divisions. What is the value of the resistance? The ordinate in question crosses the left curve at 120. Hence the resistance is 12,000 ohms.

Let us take a couple of examples on the low resistance section of the curve. Suppose that the deflection of meter with a certain resistance is 49 divisions. What is the resistance? The ordinate for 49 crosses the right hand curve at 30. Hence the resistance is 30 ohms, since we read the left scale directly this time. Again, suppose that the deflection is 35 with some other resistor. What is its resistance? The 35 ordinate crosses the curve at 640. Hence the resistance is 640 ohms.

It will be noted that the left curve is very steep for low deflections and that the right curve is very steep for large deflections. Hence we cannot measure accurately either very high or very low resistances. In fact very little accuracy is obtained below 30 ohms and above 50,000 ohms.

Range Extension

Higher resistance can be measured more accurately by using a higher voltage and a higher limiting resistance. Suppose we multiply the voltage and the limiting resistance by 5, making the voltage 7.5 volts and the resistance 7,500 ohms. Then the resistance for any deflection is also five times greater. The same calibration curve may be used, but after we have obtained the proper reading from the resistance scale we must multiply it by 5. Suppose, then, that we do have a voltage of 7.5 volts and a limiting resistance of 7,500 ohms. What is the resistance if the deflection is 10? Ordinate 10 crosses the left curve at 59. This we multiply by 100, according to directions on the graph, and obtain 5,900. Now we have to multiply this by 5 to get the correct resistance, and we obtain, finally, 29,500 ohms. Suppose the deflection is only 1.5 divisions. Then what is the resistance when the voltage is 7.5 volts? From the curve at the left we obtain 485. Hence the resistance is 485x100x5, or 242,500 ohms.

If we wish we can use any other multiplier provided we multiply the limiting resistance by the same factor. For example, we might use a voltage of 22.5 volts. This is 15 times greater than 1.5 volts. Hence the limiting resistance must be 15 times 1,500 ohms, or 22,500 ohms. Using this combination we can still make use of the resistance calibration curve. For the right curve we have to multiply the readings at the left by 15 and for the left curve we have to multiply by 1500. In this manner we may extend the range to any value we like, but we cannot change it in the other direction to make accurate readings of low resistances. To do it we would either have to use a lower voltage than 1.5 volts or else use more current than is provided on the 0-1 milliampere scale.

Facts About the Meter

The Universal meter used in the Multimeter has four external connections and a shunt resistor that is adjusted to the meter. This shunt is put on the meter at the factory, one side of the shunt permanently connected to the positive side of the d-c meter, the other side of the shunt to be close-circuited with the negative side of the d-c meter whenever any d-c measurements are taken, either current or voltage. This applies, of course, to resistance measurement as well.

The meter has a double scale, the upper scale being used when the instrument is connected to a.c., the lower scale when it is connected to d.c. For any a-c use the upper two terminals are used.

When the d-c factory-mounted shunt is in use the sensitivity is 1 milliampere, and when the a-c terminals are used the sensitivity likewise is 1 milliampere. Thus the voltmeter, either use, is 1000 ohms per volt.

Since a shunt is used for d-c, it is obvious that without the shunt the meter itself is a little more sensitive than 0-1 ma. Hence the equalizing shunt enables the use of the same multipliers for a-c and d-c use.

For use of the d-c scale, 0-5 volts, a multiplier is necessary. Since the meter resistance is 50 ohms, the meter sensitivity 1 milliampere, the series multiplier should be 4,950 ohms. If the series multiplier were not used, the range would be 0-50 millivolts d.c. However, there is scarcely ever any need for measuring such small values of voltage, and this use of the meter is not included in the multimeter.

For the 0-5 volt a-c range no multiplier is necessary, because the resistance of the rectifier unit is 4,950 ohms.

Extending Downward

It is hardly worth while to extend the

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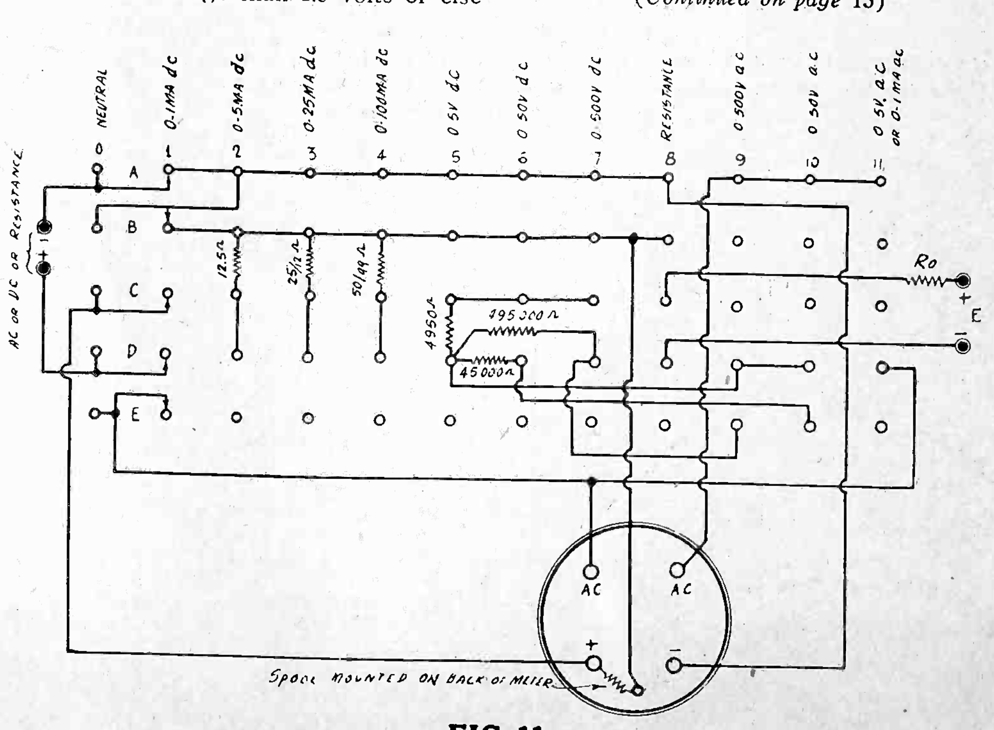


FIG. 11

If parallel shunts are used instead of series shunts the multi-polar switch should be wired this way.

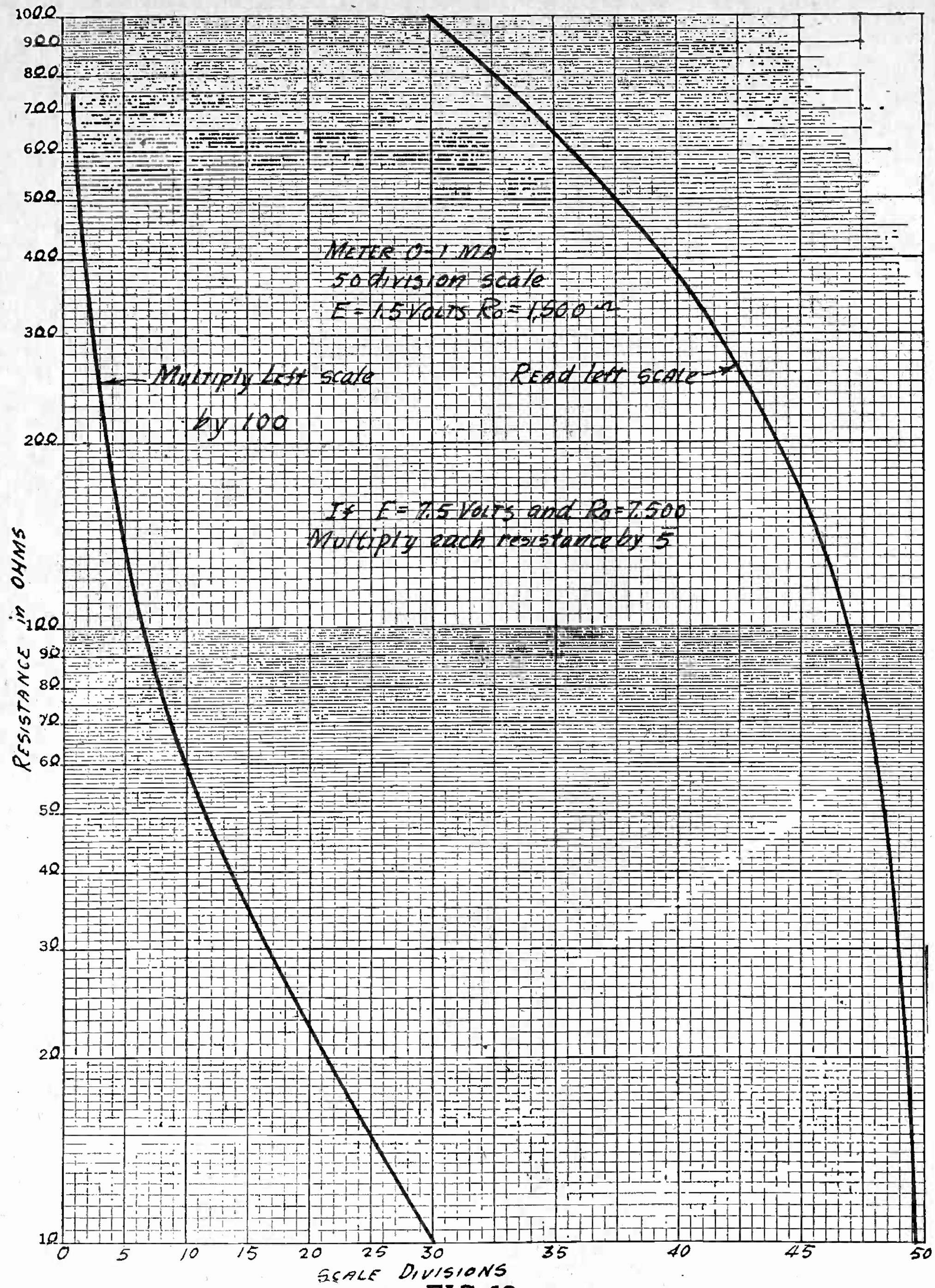


FIG 12

A resistance calibration curve of the ohmmeter in the multimeter. The curve is based on a voltage of 1.5 volts and a limiting resistance of 1,500 ohms, but can be used for 7.5 volts and 7,500 ohms if resistance readings on the ordinate are multiplied by 5. In fact the scale applies to any multiple of 1.5 volts, if the limiting resistor is multiplied accordingly, and reads on ordinate likewise.

resistance range downward because when a very low resistance, say between 10 and 50 ohms, is to be measured, we can apply Ohm's law. Suppose we use a fresh No. 6 dry cell. Its voltage is 1.5 volts. Now let us connect the resistance and the battery in series and measure the current flowing with the 0-100 milliampere scale. Suppose the deflection indicates that the current is 50 milliamperes. What is the resistance? By Ohm's law we have 1.5/0.05, or 30 ohms. Since the greatest current measurable is 100 milliamperes, we cannot go lower than 15 ohms by this method. However, we can use a differential method. Suppose we first measure a resistance and find that it is 15 ohms. Then we can connect this in series with a lower resistance and measure the resistance of the two. Suppose we get 17 ohms this time. Then the added resistance was 2 ohms. Thus we can measure very low resistances.

At this point it is well to call attention to a possible error. The series resistance has been assumed to be 1,500 ohms, or 7,500 ohms. The meter has a resistance of 50 ohms and for that reason the resistance connected externally should be 50 ohms less than that specified. That is, instead of using 1,500 ohms externally we should use 1,450 ohms in one case and 7,450 ohms in the other. The error committed by using 1,500 and 7,500 ohms is very small. For the 1,500 ohm case it amounts to about 3 per cent. and for the 7,500 ohm case to about 2/3 per cent.

If the resistance of the meter, that is, 50 ohms, is subtracted from the indicated resistance there is no error. This may be done in the same way as correction is made for the resistance of the battery. Indeed, there is no reason why any distinction should be made between the two. The curves have been computed on the basis that there is no other resistance in the circuit than the unknown and the limiting resistance. Since the resistance of the battery as well as that of the meter are unknown, they are added to the unknown resistance under measurement. Hence the correction for the zero error by the method explained gives the value of the unknown.

The Multimeter therefore serves a variety of purposes, and serves them admirably. It enables the testing of all d-c voltages and currents in the run of receivers, also all audio frequency voltages, and a-f current in the 0-1 ma range. Thus any typical receiver can be subjected to those tests considered most vital, including even output power. An example of a typical t-r-f receiver is given in Fig. 13, which is the circuit of the Five-Tube A-C Diamond of the Air.

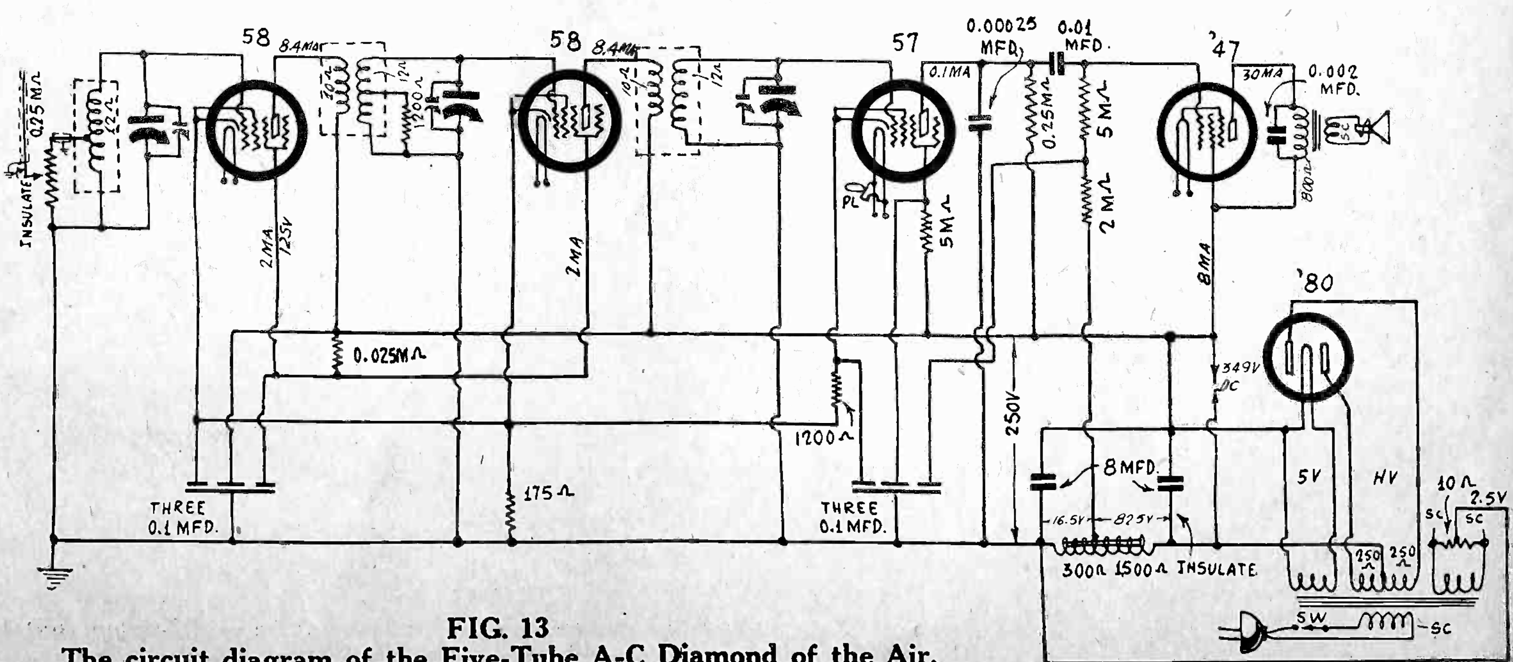


FIG. 13
The circuit diagram of the Five-Tube A-C Diamond of the Air.

LIST OF PARTS

One Weston Model 301 Universal meter
One Jewell Rotary Switch, 12 point, 5 deck (JA 100-578)
One Weston series parallel shunt, 2.5, 25, and 100 milliampere
One Weston 4,950 non-inductive resistance spool (No. 89 spool)
One Weston 45,000 ohm non-inductive resistance spool (No. 89 spool)
One Weston 495,000 ohm non-inductive resistance spool (No. 89 spool)
One 1,500 ohm (or 7,500 ohm) resistor for ohmmeter
One 4x7 ⅞x3/32-inch bakelite panel, drilled.
One 4x7 ⅞x4-inch steel box, inside dimensions
Two binding posts
One 1.5 or 7.5 volt battery.

Weston's Chief Engineer Reports on the Meter

W. N. Goodwin, Jr., chief engineer of the Weston Electrical Instrument Corporation, has written a paper on "Rectifier Type Instrument" which is printed herewith in full, with special permission. This paper discusses particularly the errors to which such meters are subject:

General

This type of instrument is used principally for the purpose of measuring alternating currents of such small magnitude that they cannot be measured readily by means of the ordinary types of A. C. instruments such as thermal, soft iron and electrodynamometer types.

It is also useful where accuracy is not of so much importance as ruggedness and ability to withstand heavy overloads without damage.

Construction

It consists of a sensitive direct current permanent magnet movable coil instrument used in connection with a rectifier made of four sets of copper oxide discs arranged in the four arcs of a Wheatstone bridge circuit, the instrument being connected as the usual galvanometer in the bridge circuit. The copper oxide discs are so arranged that both halves of the A. C. wave pass through the instrument in the same direction as shown in the sketch.

Principle of Operation

As stated above, each half of the A.C. wave is rectified and passes through the instrument in the same direction, and since the instrument is a permanent magnet movable coil type the indications are proportional to the simple average value of the wave, and not to the squares of instantaneous values as is the case in A.C. instruments of the ordinary type, which are universally calibrated in root mean square values (R.M.S.)

As it is very desirable, however, to measure alternating currents in the conventional R.M.S. values, the rectifier instruments are calibrated by using an alternating current having a pure sine wave shape, and the scale figured in R.M.S. values.

It is obvious, therefore, that if the alternating current to be measured has any other shape than sinusoidal, errors will result, since the relation existing between R.M.S. and average values for sine waves in general is quite different from the corresponding relation for other wave shapes. This and other sources of error will be considered below.

Accuracy

The principal sources of error in the rectifier type instrument are temperature, frequency, wave form, and the fact that the resistance of the rectifier varies with the amount of current passing through the discs. In addition to these, there may be permanent changes which may take place in time, but which experience thus far has not fully established.

Temperature Errors

Errors due to temperature changes depend upon the resistance of the circuit and upon the current passing through the rectifier. In voltmeters this is equivalent to stating that temperature errors depend upon the range in volts and upon the resistance in ohms per volt.

Temperature errors are the result of two changes which occur in copper oxide. When the temperature increases the rectifying property diminishes, or stated technically, the rectification ratio is reduced, and at the same time the resistance of the rectifier is reduced. These two effects are in opposite directions upon the instrument indications, and fortunately, in most practical instances, actually neutralize each other near room temperature.

For voltmeters of the usual resistance of 1000 or 2000 ohms per volt, and for ranges from 1.5 to 20 volts, if used between temperatures of 18° C. and 35° C. (64° F. to 95° F.), errors due to temperature alone will probably not exceed 2%.

For ranges above 20 volts, and for milliammeters, the temperature range may be 18° C. to 30° C. (64° F. to 86° F.) without exceeding an error of 2%.

As the temperature effects increase rapidly for temperatures outside the above limits, it is very desirable to make all measurements within the temperatures stated.

These errors are of course in addition to the usual scale calibration and adjustment errors.

Frequency Errors

Up to 35,000 cycles per second the instrument indications decrease at a substantially uniform rate of approximately ½ of 1% for each 1000 cycle increase in frequency. For example, at 4000 cycles per second the instrument would indicate 4 x ½ — 2% low.

Errors Due to Change in Current Density

The resistance of a given rectifier depends upon the magnitude of the current passing through it, or in other words, upon the voltage drop across it. The resistance increases as the current density or voltage drop decreases. An instrument, therefore, has a lower resistance for full scale current or voltage than at any lower part of the scale.

In voltmeters, this resistance change is calibrated into the scale and, therefore, results in no error as far as the instrument indications are concerned. However, since the resistance changes, the instrument acts as a varying load on the circuit tested and if the circuit has a relatively high resistance, the instrument resistance variations may affect the terminal voltage in the circuit being tested, although the instrument will correctly measure the actual voltage applied to its binding posts.

When a rectifier type milliammeter is connected in a circuit, it affects the circuit conditions on account of its added resistance like any other type of instrument except that the effect depends upon the magnitude of the current passing, and the error will depend upon the total resistance of the circuit including the instrument, and also upon the current, that is, upon the scale indication.

For example, the rectifier usually used in a 500 microampere instrument of the 3½ inch size (Model 301) will have a resistance of approximately 710 ohms including the D.C. instrument at full scale, 500 microamperes, and 1540 ohms at 0.3 scale or 150 microamperes.

If the circuit resistance is relatively very high then this change will result in negligible errors. If, however, the circuit under test has a low resistance, say 1000 ohms, then the total circuit resistance for a current of 500 microamperes would be $1000 + 710 = 1710$ ohms and the current indicated will be $1000/1710 \times 100 = 58.8\%$ of that which would have resulted if the instrument had not been in circuit. For a current of 150 microamperes, the circuit resistance would be $1000 + 1540 = 2540$ ohms and the current indicated is, therefore, $1000/2540 \times 100 = 39.4\%$ of that which would have resulted had the instrument not been in circuit.

It must be remembered, however, that the instrument correctly indicates the actual current passing at any time, but the magnitude of this current depends partly upon the presence of the instrument in the circuit, as in the case of any other type of milliammeter.

Another effect produced by the varying resistance of the rectifier is to slightly distort the wave form of the current in the circuit, which may cause a slight error.

As a guide in estimating the effects of the varying resistances of the rectifier type instrument, the following tabulated values are given for Model 301 instruments.

Range	*Approx. Res. at Full Scale Ohms*	*Aprox. Res. at 0.3 Scale Ohms*
500 microamperes ..	710	1540
1 milliampere	440	930
2 milliamperes ..	290	590
5 milliamperes ..	180	325

Wave Form Errors

As stated above, since a D.C. instrument is used, the rectifier type instrument actually measures the average values of the rectified wave.

The conventional manner of designating alternating currents or voltages is to state them in terms of their root mean square (R.M.S.) or effective values, for the reason that the ordinary A.C. instruments indicate these values, and power is proportional to these values.

For this reason, rectifier instruments are calibrated with currents or voltages having a sinusoidal wave form and the scale is figured in R.M.S. values. It is obvious, therefore, that the instrument indicates correctly only if the currents or voltages measured have sine wave shapes. For other wave shapes errors will result, of varying magnitudes depending upon the variation from the true sine wave shape.

As a simple illustration to show the possible magnitude of errors due to wave form, consider the rectangular wave shown in the sketch below. This shape of wave is that which would be produced by commutating the voltage of a battery or other D.C. source.

From simple inspection it is seen that the maximum R.M.S. and average values

(*Continued on next page*)

(Continued from preceding page)

of the rectified wave are all equal and equal to v.

If, however, a voltage of this wave form is measured on the rectifier instrument it will indicate the R.M.S. value of a pure sine wave which has the same average value v that the actual wave has. Now it is well known that the R.M.S. value of a sine wave, whose average value is v, is 1.11 v so that the instrument will indicate about 11% too high for this wave form.

Any wave form can be expressed as the sum of a series of pure sine waves consisting of a fundamental and of harmonics, the harmonics having frequencies of 2, 3, 4, 5, etc. times the fundamental frequencies.

Pure A.C. waves can consist of the odd harmonics only, 3, 5, 7, etc.

For example, the above rectangular wave consists of a fundamental wave of a magnitude of say 100%, and the following series of harmonics, 33 1-3% third, 20% fifth, 14.3% seventh, etc.

The errors produced by distorted wave shapes depend not only upon the magnitude of the harmonic, but upon its phase relation. The effective or R.M.S. value of any distorted wave is equal to the square root of the sum of the squares of the R.M.S. values of the fundamental and each harmonic, that is

$$V = (v_1^2 + v_3^2 + v_5^2 + \ldots)^{\frac{1}{2}}$$

whereas the average value of a rectified distorted wave is the average value of the fundamental plus or minus the value of each harmonic averaged over a half fundamental cycle, depending upon the phase.

The following tabulated values give some idea as to the magnitude of errors produced in measuring distorted wave shapes.

Harmonic	*Magnitude in Percent of Fundamental*	*Phase Displacement*	*Ratio of Indication to True R.M.S. Value*
3rd	10	180	0.961
3rd	20	180	0.927
3rd	30	180	0.862
3rd	33 1-3	180	0.840
3rd	33 1-3	0	1.052
5th	10	180	0.970
5th	20	180	0.943
5th	30	180	0.900
3rd & 5th	30 & 30	0 & 0	1.063
3rd & 5th	30 & 30	0 & 180	0.952
3rd & 5th	30 & 30	180 & 0	0.877
3rd & 5th	30 & 30	180 & 180	0.775

Conclusion

It is quite evident from the above discussion that among the errors which may be encountered in the use of rectifier type instruments, those resulting from wave form are the most serious.

There is also the possibility that a permanent change may take place in time in the copper oxide itself, but observations to date indicate that such changes are small, probably of the order of 1% or less.

In general it may be stated that if the instrument is used on wave forms closely approximating sine waves, such as found on lighting circuits, and if used at room temperature, the indications may be relied upon to within about 5% of full scale value. Errors due to frequency can be corrected.

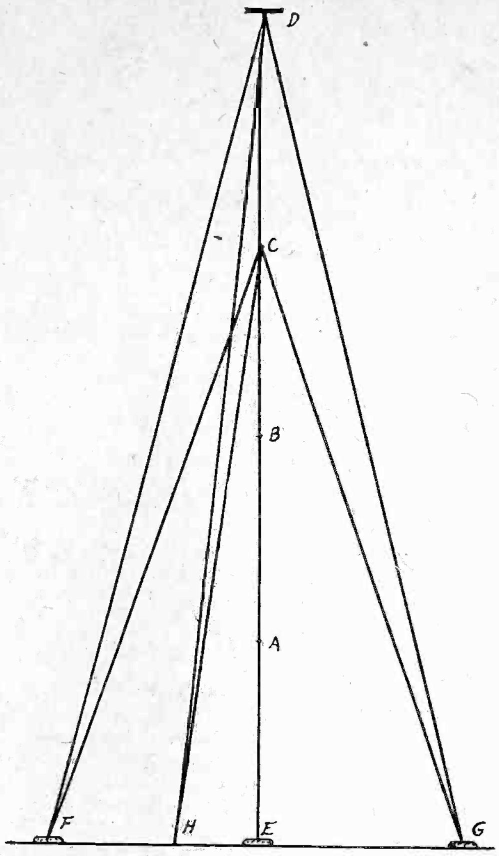
MAAS AND LEBERMAN APPOINTED

San Francisco.

Harry Anderson, sales manager of the Pacific Division, National Broadcasting Company, has announced the appointment of Henry C. Maas as sales traffic manager, and the addition of P. K. Leberman to the staff of sales representatives.

LEW FROST IN NEW POST

The San Francisco National Broadcasting Company has named Lew Frost program manager of the Pacific division, to succeed Thomas H. Hutchinson, resigned. Frost had been production manager of the division. He was born in Denver, Colorado.



Better Rural Service Promised By Board

Washington.

The radio broadcasting service to the 60,000,000 rural residents in the United States will be improved by the development of high-power stations, according to the Federal Radio Commission. It has been found that city residents now receive 300 per cent. better service than residents in rural areas, while all residents pay about equally for the service through taxes and the purchase of goods sold or manufactured by program sponsors.

The rural listener receives his greatest service from clear channel stations which may be received at large distances from the transmitter without interference. Therefore the solution to the problem of unequal service is the use of high-power stations. The Commission has granted an experimental license for a broadcasting station to operate with a power of half a million watts, which is ten times greater than the power of the largest regularly licensed stations now used. Considerable experimental work has already been done with hundreds of thousands of watts in this country and the experiments are already in the stage where they can no longer be considered as tests. Foreign countries have had success with high-power stations but this country has been lagging in the development of super-stations.

The Pyramid Radio Co., 71 Dey Street, N. Y. City, has taken over the balance of the ground floor at that address. This expansion was necessary to carry a larger stock of replacement parts for the serviceman and experimenter, and to have more space for the repair department. This is one of the few establishments in the city that does radio repair work of practically every description.

* * *

Weber Distributing Co., 45 E. 20th Street, N. Y. City, announces the appointment of Sam Kavish as sales manager of the electrical and radio division. Jack Weber taking over the toys and novelties division.

AN ANTENNA MAST FOR $10

By George T. Case

Staff Announcer, WCKY, Cincinnati

LIST OF PARTS

13 feet of 2 inch galvanized pipe
10 feet of 1¾ inch galvanized pipe
10 feet of 1½ inch galvanized pipe
10 feet of 1 inch galvanized pipe
One reducer, 2 to 1¾ inches
One reducer, 1¾ to 1½ inches
One reducer, 1½ to 1 inches
One tee, 1 inch
Two galvanized pulleys, 1½ inches
250 feet galvanized guy wire
200 feet heavy clothes line
Cement, sand and gravel for bases of F., H., E., G.

An antenna mast that can be constructed for less than $10 yet be durable and look attractive is the ambition of many radio enthusiasts. This antenna mast has a height of 40 feet. First steps are to purchase the equipment listed. The local dealer in pipe and the corner hardware store need be your only purchase points. The approximate costs follow:

Pipe (four pieces)	$3.80
Reducers and Tee	.75
Pulleys	.25
Galvanized Wire	1.25
Clothes Line	1.00
Cement, Sand & Gravel	1.75
Breaking Insulators	.50
Total cost	$9.30

This cost, however, is only estimated. Costs in your local community may be greater or smaller but nevertheless the cost will be very close to $10.

Assemble all the parts on the ground, making sure that the reducers are at correct points A, B, C and that tee connection is at D. Attach the guy wires and pulleys at D and also guy wires at C. Thread the clothes line through pulleys, leaving enough to spare, so that each may be reached after the pole is in place. Guy wires DF, CF, DG, and CG pull to both sides of pole, while DH and CH pull to rear of pole. Additional guy wires may be connected between BF, BH, and BG. Sink the pole in three feet of cement and lay all guy wires, fastenings at F, H, G in cement bases.

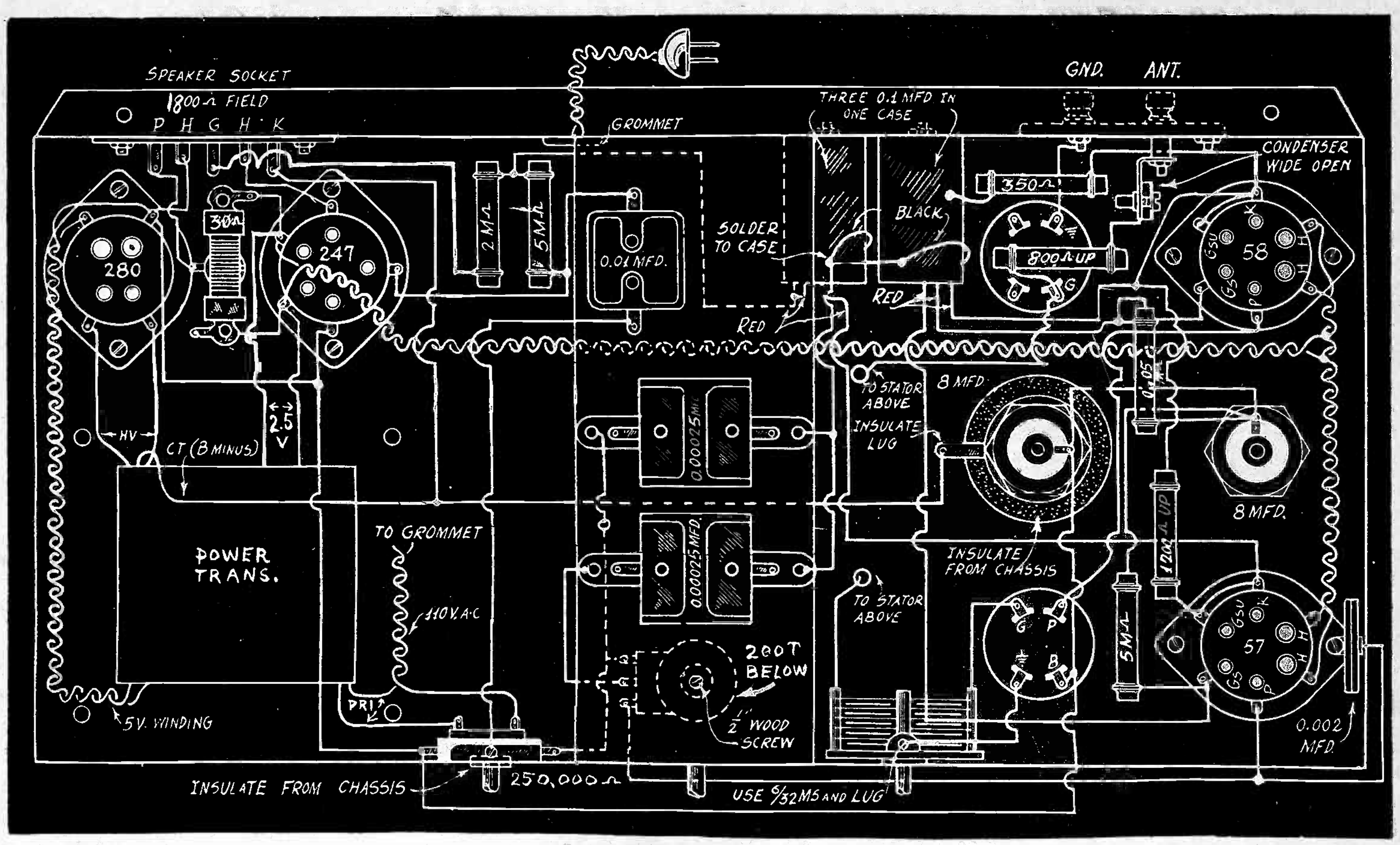
After the pole is assembled on the ground, and the hole is dug, slide the pole slowly along the ground into hole. Before doing this have a six-inch base of cement in the hole. After the pole is up and in place fill the hole with cement, making sure that the pole is straight and the cement is packed in tightly. This pole will be very substantial and will last a lifetime if proper precaution is taken in assembling and putting in place. If desired a pulley may be used at C or B for additional aerial connections. Insert breaking insulators in guy wires about every ten (10) feet.

Schedule of Standard Frequency Transmissions from WWV

The Bureau of Standards transmits each Tuesday on 5,000 kc from WWV, Washington, D. C., on the following schedule: Continuously from 10 a. m. to noon and continuously from 8 p. m. to 10 p. m., EST. This new schedule went into effect recently.

The accuracy is better than one cycle per second at all times, or 1 part in 5,000,000. The transmission is therefore of great value in frequency calibration.

Four-Tube Diamond With Tapped B Choke



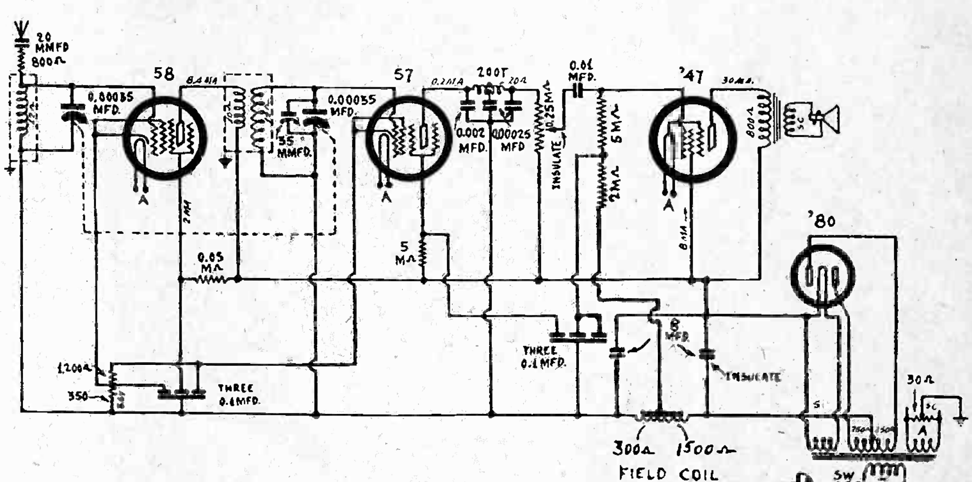
Pictorial diagram of the Four-Tube 1933 Diamond of the Air, using a tapped field coil as the B supply choke and pentode bias supply.

THE Four-Tube 1933 Diamond of the Air has been described in these columns, using a dynamic speaker with 2,500-ohm field coil. Two resistors, of 0.1 and 0.02 meg., were used across this coil for bias purposes. However, many have or prefer a tapped field coil, and therefore the circuit diagram and pictorial wiring are printed this week to accommodate their desires.

The field coil has a total resistance of 1,800 ohms. The tap is at 300 ohms from one end. By returning the pentode grid to the tap and grounding the extremity 300 ohms removed, the negative bias is applied to the pentode. The other extremity goes to B minus, the center tap of the high-voltage winding of the power transformer.

Therefore two fewer parts are needed (the resistors mentioned above). One of the 0.1 mfd. sections of a condenser block that formerly went to one of these resistors is added to the capacity across the 2 meg. resistor in the auxiliary filter. Thus two 0.1 mfd. are in parallel to constitute 0.2 mfd.

These are the only changes in the circuit. The full data on construction and testing were published in the September 3d, 10th and 17th issues. As a full understanding of the circuit will assist materially in obtaining best results, prospective builders of this circuit are referred to those three issues.

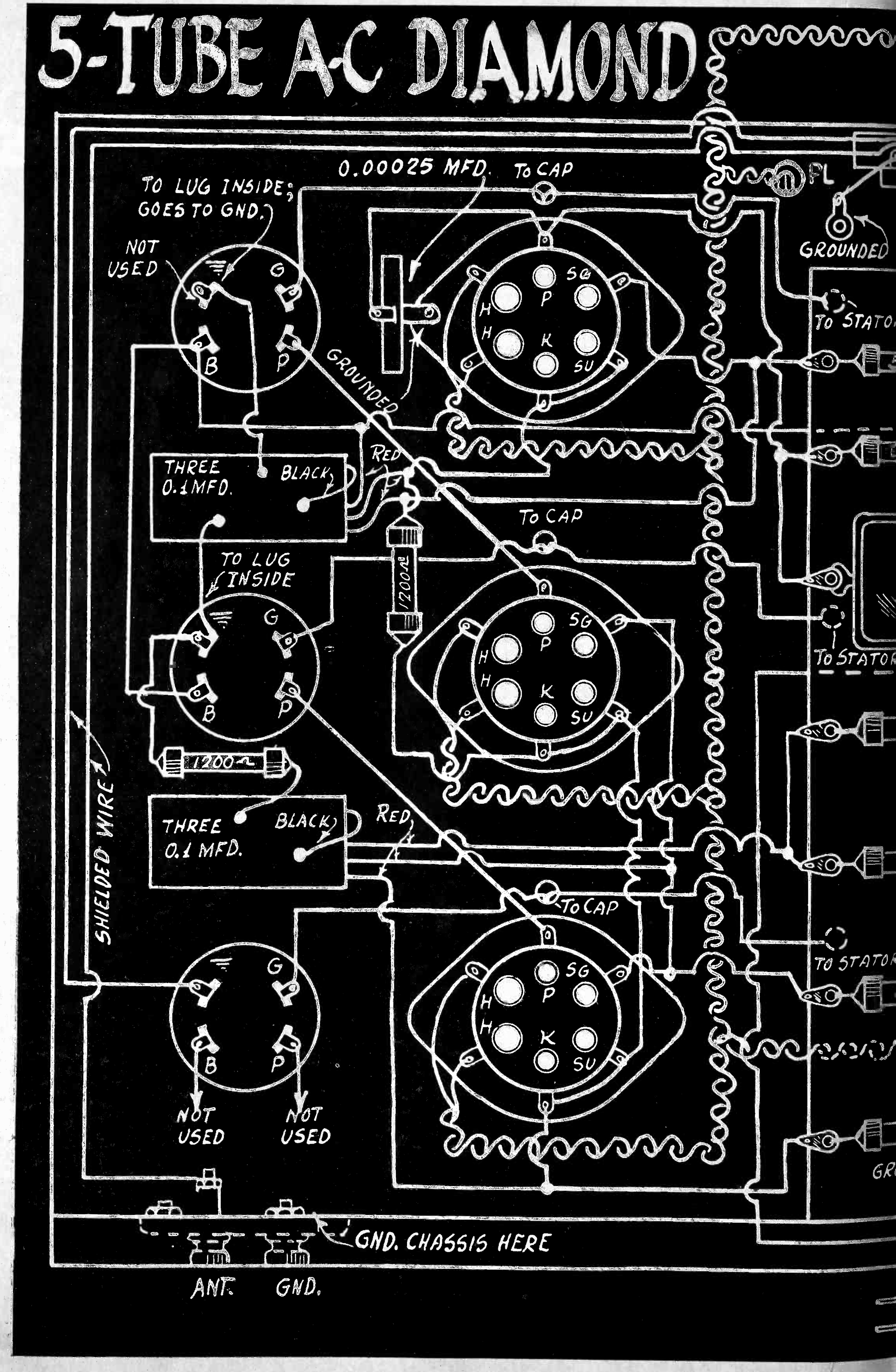


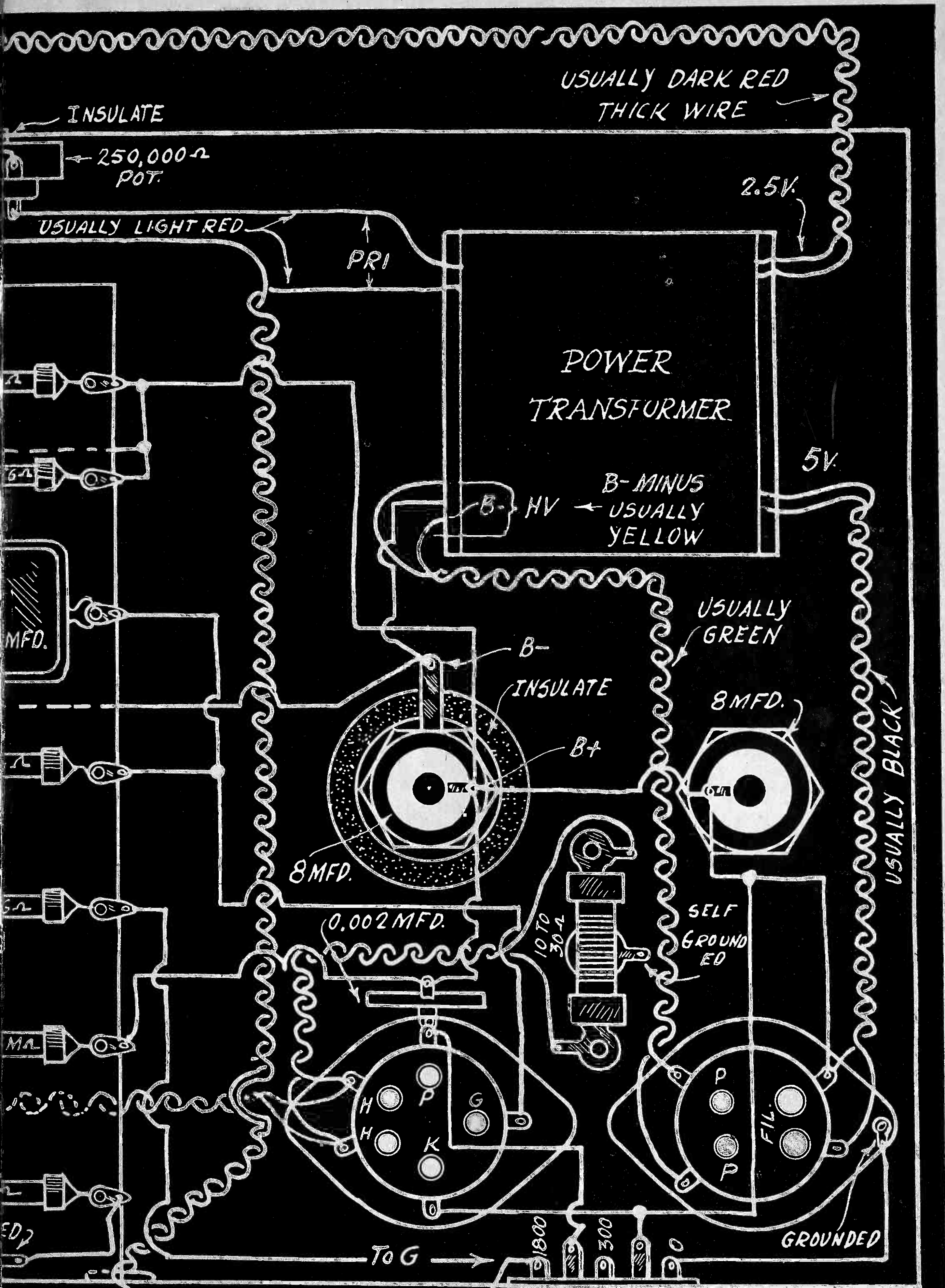
The circuit diagram, corresponding in all particulars to the pictorial diagram printed above.

5-Tube Diamond Picture Diagram

Articles on the theory and construction of the Five-Tube A-C Diamond of the Air, a circuit using three tuned stages, with two of them radio frequency amplifiers (58 tubes) and the third the detector input (57 tube) were published in the September 24th and October 1st issues. This week, on pages 16 and 17 there is published the full-scale picture diagram of the wiring of this receiver.

A slight defect in the circuit diagram of the 5-tube set, printed last week, made the second r-f stage lack definition. It consists of the usual transformer with tuned secondary, but a 1,200-ohm fixed resistor is connected between a tap on the secondary and ground. On the commercial coils the ground symbol represents this tap, hence ground symbol does not go to ground. See confirmation of this on the picture diagram this week. The ground connection is made to a side lug within the coil shield, nearer the bottom. See Fig. 13, page 12.


5-TUBE A-C DIAMOND
0.00025 MFD.
TO CAP
TO LUG INSIDE; GOES TO GND.
NOT USED
G
B
P
SG
P
H
H
K
SU
GROUNDED
FL
GROUNDED
TO STATOR
RED
THREE 0.1 MFD.
BLACK
TO CAP
TO LUG INSIDE
1200Ω
TO STATOR
SHIELDED WIRE
1200Ω
THREE 0.1 MFD.
BLACK
RED
TO CAP
TO STATOR
NOT USED
NOT USED
GND. CHASSIS HERE
ANT.
GND.


USUALLY DARK RED
THICK WIRE
INSULATE
250,000 Ω
POT.
USUALLY LIGHT RED
PRI
2.5V.
POWER
TRANSFORMER
5V.
B-
HV
B-MINUS
USUALLY
YELLOW
USUALLY
GREEN
B-
INSULATE
B+
8 MFD.
8 MFD.
USUALLY BLACK
0.002 MFD.
10 TO 30 Ω
SELF
GROUNDED
H
H
P
G
K
P
P
FIL.
GROUNDED
TO G
1800
300
0
K H G H P
1800 OHMS
TAPPED @ 300 Ω
SPEAKER PLUG
(REVERSE H&H ABOVE AS HUM TEST)

PIONEER DAYS

When Interference Was Interference

By C. H. Stoup

Chief Engineer, WIL, St. Louis, Mo.

Back in the good old days when commercial radio operators argued with one another about which one had the most sensitive crystal detector, radio was just as interesting and considerably more mystifying than in the present day with its much more complicated crystal control, master oscillator, power amplifier and 100% modulation circuits.

During the seasons of 1911 and 1912 from morning to night the mysteries of radio were being explained to the curious public. Very mystifying indeed were some of the explanations. Many operators could discuss very fully the questions asked, even though they were possibly more baffled at times than the curious customers who asked the questions.

Foolish Messages

In those days the central point of interest aboard ship was the "wireless station." It was generally crowded, especially when the operator was sending a message, which caused plenty of noise from the old spark transmitter. The mystery and fascination of radio were so great that many operators, on good runs, made a tidy little sum in commissions for sending out foolish paid messages such as: "Greetings from mid lake," etc. These messages were sent by hundreds of persons.

Life aboard ship was very fascinating and agreeable to most of the boys except during very stormy weather, at which times some of the operators hung over the rail with both eyes shut.

Personally I never saw the weather so rough that I could not have stood more. Heavy seas, if they don't make one sick, induce lots of pep and break the monotony of continuous sailing. If my wife ever leaves me I am going back to the good old sea and find out if I can still ride the heavy weather and enjoy it.

Operators Fat But Healthy

Some of the best and most enjoyable days I ever spent were spent on the water. By the way, in those days that's about all a fellow had to spend, as salaries were close to zero. Operators, however, generally managed to keep fat and healthy, as meals were served them in the main dining room with the ship's officers. I can still remember those dinners which equalled meals served in the best hotels in this country today.

I have lost contact with nearly all of my operator friends of that day. One of them, a graduate electrical engineer, is conducting a very successful radio training school for operators. Another, with whom I spent much time in and around Chicago, and whose name is familiar to all radio men, rose to the very top rung of the radio ladder. Another has become a successful inventor. And so it goes. Good friends separate and drift out of one's life and new ones come into it. I'll never forget the old ones with whom I spent so many happy hours.

I wonder how many operators today can remember the days of commercial radio before the United States Government had anything to say about it. At that time rival radio companies had men stationed at their station's transmitter with orders to interfere with all messages of other companies.

Real Interference Then

The writer went through this ordeal, and what an experience it was. It sometimes took an hour or more to get off a ten-word message and then because of interference it was often quicker to carry the messages to the dock and send them to points inland by wire.

At first when rival companies began their interference we operators on the ships were almost unable to send messages, but we soon found that their operators would stop the interference occasionally and listen in. Then we would send out a few words of our messages before they got their "static boxes" going again. The station to which we were sending would advise us the last word received by them. (On the boats we could receive through the interference because we were much farther from the interference and therefore could tune it out.) We would wait for another opening and keep working away until we received an OK to our message.

This interference was kept up until one night a ship blew a cylinder head and was stalled for a number of hours. The usual interference prevented our getting a message to the mainland for quite a while and the damage was done. Then the Government stepped in and closed the stations causing the trouble and the "static boxes" were a thing of the past. Radio operating once more became a pleasant occupation.

250 Miles Long Distance!

At that time, if I remember correctly, the long distance record with a commercial transmitter for night broadcasting during the summer was 250 miles. Now it is considered nothing for the radio amateur to correspond by code with foreign stations many thousands of miles away, and he uses a tube only slightly larger than one in your receiving set. In fact, some expert amateurs, I understand, just about reach every state in the Union with a common 201A tube, on the amateur or short-wave band. The 20, 40 and 80-meter bands are most commonly used by the amateurs and also by a great number of commercial and government stations.

A few years ago the short-wave band which was allotted to the amateurs was considered practically worthless but now the amateurs would not trade their wavelengths for all the broadcast bands. Why should they? Today they can work much farther with their high frequencies than they could on the long waves, and with much less power.

Early-day apparatus now looks like a huge joke. Ten or fifteen years from now possibly the present-day, highly-developed and very efficient instruments will seem just as laughable. Who knows?

$50,000 ORDERS FOR W. E.

Orders for nearly $50,000 worth of its new type of aviation radio-telephone apparatus have been received by the Western Electric Company, the company announced. The bulk of the orders has been placed by American Airways and United Air Lines. Ten Stinson tri-motor planes just placed in service by American Airways will have their existing radiophone equipment completely replaced by transmitters and receivers of the newly-designed type. United Air Lines have ordered 90 of the new superheterodyne receivers for installation both in planes now in service and for new ships.

Immortality Data Sought

Realm of Higher Vibrations Studied

Experiments carried on in high frequencies of matter by modern scientists make very thin indeed the dividing line between the so-called "occult" and the accepted facts of science and research. The miraculous of yesterday is the commonplace of today, and what now seems charged with mystery and magic may seem prosaic and unexciting in the light of the knowledge of tomorrow.

An example of this principle is a series of exhaustive experiments being conducted by scientists at Galahad College in Asheville, North Carolina.

The forces in which these men deal extend so far into the realm of higher vibrations as to seem entirely out of contact with physical matter, yet it is being demonstrated that these forces operate under definite natural laws and are subject to control just as is electricity and magnetism, or perhaps it would be more accurate to say that the forces can be used by working in harmony with the laws governing them, which cannot be varied by human tinkering.

Atoms Drive Plane Engine

A series of experiments has been conducted at the college to produce a power plant in which energy is developed by partially disintegrating atoms. Many obstacles have been encountered in this work, including the need of special alloys to withstand high heats and endure excessive strains, but the crew working on this project has succeeded in forcing an airplane engine weighing 60 pounds to deliver more than 300 horsepower for a short period of time.

Another department at the college is experimenting to develop a form of cold light whereby interiors may be illuminated without use of light bulbs or centers of light, the radiance being diffused evenly throughout the atmosphere by creating a certain type of etheric vibration.

In a third laboratory of this unique college a group of engineers has made definite progress in the perfection of an extremely sensitive type of radiophone which responds to vibrations finer than any yet recorded by mechanical devices.

Quest of Immortality Data

"It is hoped that this instrument," says a college announcement, "can be made so sensitive that it will make possible direct telephone communication with intelligences on higher planes of matter and thereby establish definitely the survival of life after death of the physical body. The completion of this instrument will take the theory of immortality out of the realm of speculation and establish it as a proved material fact.

"Another class in this college is delving into practical processes of thought transference, which is predicted to become the customary form of communication between individuals in the course of time, supplanting the slower and more clumsy method of speech.

Transformation Deemed Possible

"To the man in the street it may seem that these folk at the North Carolina institution hope for more than is possible, but visions of men of constructive imagination have ever seemed extreme to the less advanced, and discoveries coming out of the experiments may transform the life of the next generation as the work of Thomas A. Edison changed the lives of people of his time."

A TEST FOR GAS

In Vacuum Tubes That Is Easily Made

By J. Howard Sandidge

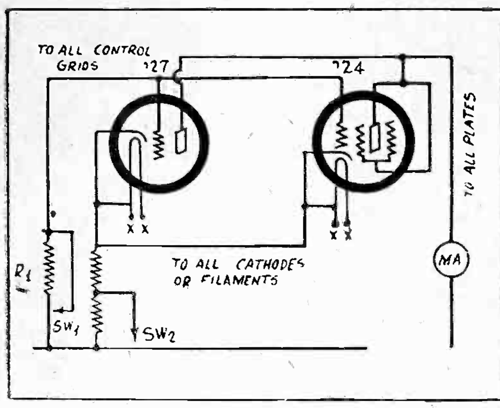


FIG. 1
Circuit typical of a tube tester, except that SW1 and R1 are included instead of a continuous wire, to enable gas test.

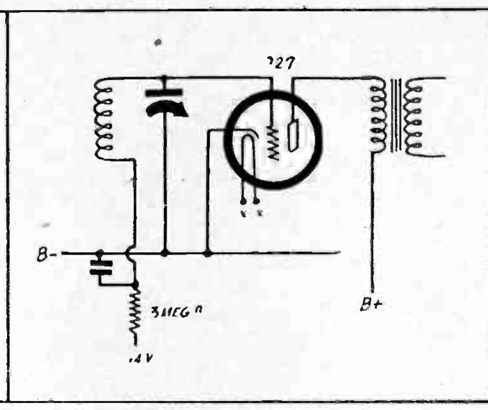


FIG. 2
Detector stage of Grebe SK-4 shown in its essentials. The tube tester showed 3.8 ma a change in plate current.

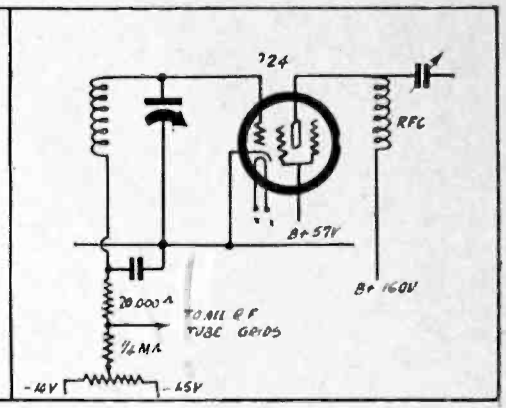


FIG. 3
First r-f stage of Grebe SK-5. The plate current change was 3 ma, due to closing Sw2 of Fig. 1, thus changing the bias.

THE presence of gas in a tube envelope, even in relatively small quantities is, I think, the cause of many radio troubles, particularly fading and creeping up of volume. Often erroneously these difficulties are attributed to faults in circuit or parts, and much time and trouble may be saved by a quick and accurate diagnosis of their true origin. It is the purpose of this article to outline certain simple changes in any tube tester, which will permit a reliable and delicate test for gas, but first a few typical examples will be shown.

A '37 tube in the first a-f stage of an automobile radio, resistance coupled out of a '36 detector. Routine test in a tube tester gave these plate current values: Minimum, 1.7 ma; maximum, 5.7 ma. Minimum with Sw-2 open, maximum with Sw-2 closed. See Fig. 1. The set, powered by one of the new, vibrator type, B supply units, would operate well for about three or four minutes, and then would die out. When battery-operated, it would lose only part of its volume after this time. The '37 was gassy, although the tester did not indicate it, and the extra plate current drawn from the B eliminator was enough to drop the terminal voltage of this already overloaded device so much that normal volume could not be obtained. No blue discharge was noted about the tube elements.

Gassy Tubes Tracked Down

A '27 tube in the detector stage of a Grebe SK-4. The essentials of the circuit are shown in Fig. 2. Plate current readings in tube tester: Minimum, 1.6 ma; maximum, 5.4 ma. No blue discharge around the elements of the tube. Marked instability of volume was noted, with a generally rising characteristic. As will be further shown, the tube was less gassy than the '37 but the varying C bias must have moved the operating point of the tube into and out of the point of best detection, and so caused the variation in volume. As the C bias supplied also varied with the volume control setting the performance of the set was erratic.

A '24 tube in the first r-f stage of a Grebe SK-5. Fig. 3 shows the circuit. Tester readings as follows: Minimum, 1.4 ma; maximum, 4.6 ma.

All these sets were "climbers." No matter where the volume control was set, even in the zero position, the volume would rise to unbearable heights after a few minutes. In no case was the characteristic gas discharge color noted about the tube elements.

Now, in all the above cases, and in a large number of exactly parallel cases, the tubes in question were gassy. The readings on ordinary tube testers and test sets were about normal; certainly within the allowable limits of variation. None of the tubes showed a visible gas discharge, and it is evident that we need a delicate test for a small amount of gas.

Typical Tester

Nearly everyone who works at all with radio has some kind of tube tester. Fig. 1 shows the circuit typical of all these devices. Normally the lead containing Sw-1 and R-1 is a continuous wire, and the inclusion therein of these two parts is the only change necessary to make the tester show the presence of gas. R-1 may be 2 or 3 meg., Sw-1 should be a momentary contact switch, ordinarily closed, and which will snap back to the closed position when released. Unless Sw-1 is opened the tester is in its original condition, and no changes will be noted in tube readings.

The use of the tester is not changed in any manner, except that opening Sw-1 will indicate the presence of gas in the envelope, even in small quantity, by a noticeable increase in the plate current of the tube under test. This increase will be evident with Sw-2 either open or closed, but the additional needle swing will be much greater if the gas test is made while Sw-2 is closed. In other words, merely flipping Sw-1 will tell whether the tube is gassy, and the experience gained in a few tests will indicate the amount of gassiness. Now let us open Sw-1 and take a look at the meter readings of the three tubes referred to:

'37 tube, minimum, 5.7 ma; maximum 8.4 ma; gas change, 2.7 ma.
'27 tube, minimum, 3.8 ma; maximum, 7.4 ma; gas change, 2.0 ma.
'24 tube, minimum 3.7 ma; maximum, 6.7 ma; gas change, 2.1 ma.

Large Enough Changes

Since the meter was calibrated 0-10 ma, the above "gas change" increments are large enough to be readily apparent, and to leave no doubt in our mind as to the presence of gas. It must be noted that nearly every tube will show a small increase in plate current when Sw-1 is opened. On the tube tester used for these particular tests, this increase is usually about 0.1 ma and some such small deflection may be regarded as normal.

Only a word of explanation is necessary about the theory of operation. Gassy tubes draw grid current. If we supply the grid bias voltage to the tube through a high resistance this grid current will cause a drop in the grid voltage, which in turn increases the plate current. Sw-1 is used simply to see and compare the amount of plate current increase.

There is no reason why Sw-1 and R-1 should not be installed in any portable test kit or set tester. This may be very easily done, and will prove of great help when using the set's own socket voltages for tube testing. It must be remembered, however, that tests made in this manner on tubes in resistance-coupled stages will not yield as great a "gas change" as when tested in a regular tube tester. This is caused by the fact that there will be two resistances in series in the grid circuit, only one of which can be added or subtracted by Sw-1.

Blue Glow Not the Real Test

When using the gas test shown herein one must somewhat revise his ideas about gassy tubes. We are used to thinking that gassy tubes have a blue emission betwen the cathode and plate, inside the elements of the tube. Very gassy tubes do display this phenomenon, but the danger point is very far indeed below the visibility point. In none of the cases shown above was gas "visible," but it was large enough to stop reception in each case.

Again, most of us think that the gas effect is most dangerous and most evident in a cold tube just after starting the set, while,

(*Continued on next page*)

WHAT'S NEW?

Features of Commercial Receivers for Coming Season

By B. H. Sonderan

THE year of grace 1932 reveals in commercial radio sets a gradual and substantial improvement, principally in the direction of better tone quality and incidentally providing greater selectivity, although these two considerations are antagonistic under certain circumstances.

There is less of the "amazing revelation," "sensational discovery" and "unparallelled performance" in the advertising, that is, less lying, consistent with the gradual rise of the radio industry to a form of conduct befitting its importance, although the bad habits of trade childhood still attach to many radio practices. However, the licensed set manufacturers themselves have outgrown this state of moral irresponsibility long since, and the jobbing and retail trade are responsible for most of the unwholesome tactics that still prevail.

Dilemmas Fewer

Even the names of the receivers, for all receivers, like parlor cars, seem to require a special name, are more modest. There are no more "masterpieces," but only more modestly designated offerings, greatly superior to the "masterpieces" of the past. Since new developments are slowly and steadily being added, future refiinements are to be expected. It became dangerous to public confidence to have the "masterpiece" of day before yesterday superseded by something new, "the last word in radio," for if the first was the masterpiece, what more could the second be, and what indeed was there left to say about a future model, especially since its predecessor was the last word?

The set manufacturers have been engaged in a long struggle not only with one another but also with the problem of telling the public what they have, without becoming technical. It just can't be done successfully. Radio is extremely technical. To state generalizations is to introduce inaccuracies, for the truth requires the necessary particularization, and it may not be possible to particularize in such a manner that he who runs or even is just able to walk may read. Therefore, in the vast limbo between the technically accurate statement, such as appears in the technical press, and the generalities that the public is believed to understand better, there is plenty of room for stretching points, and it's being done by even some of the best and biggest manufacturers.

Class B Amplification

For instance, Class B amplification, which is gaining a prominent place, is described as "absolutely distortionless," but every engineer knows it is otherwise, just as well as he recognizes its real value and its place in the modern receiver.

Class B amplification is in many of the best receivers, and this year is obtaining its first run, although no doubt it will last a long time as an audio amplification form. It is a rather expensive circuit to build, requires special parts, and is based on the principle of operating two tubes in quasi-push-pull output circuit very close to plate current cutoff at no signal input, the signal driving the grids positive.

Part of the extra expense is due to the grid current of such an arrangement, so that Class B requires a driver stage, and to serve the two purposes a tube type was brought out a few months ago, the 46, which has five base pins, including one for extra grid. When the two grids are tied together the tubes serve for Class B purposes, and when the extra grid is tied to the plate Class A operation results. The alphabetical designation were introduced by engineers, Class A being the familiar amplifier circuit of long standing, Class B being new, at least as applied to a-c operated tubes.

Why There's Distortion

Since in the Class B output the grids of the two tubes run positive at any signal input, of course there is distortion, but the system permits of very great volume at considerably less distortion than a Class A amplifier would produce. Actual tests, whereby listeners could hear only the amount of distortion, as all but distortion was filtered out, conclusively proved this point about higher distortion at low signal values, but the Class B amplifier at volume rise soon produced better results than the Class A.

The general public is likely to get the wrong idea about Class B amplification, if based on nothing but the facts already stated, or on the bare advertising reports, because many intended purchasers of radio sets "would not want so much volume," so they'd say. But if they are music lovers, and especially if they listen to symphony orchestras, perhaps they will change their mind when they remember the sudden and severe changes in volume of sound from one passage to another. The receiver may be set to medium volume, but the middle course is merely average. A strongly played passage with full orchestra, especially with drums, bass viols and other low-note producing instruments, will produce momentary volumes of sound hundreds of times greater than the medium average for which the volume control was set, and Class B amplification is the only one found in receivers today that copes with such a situation.

Another Method

However, it is not stated here that the positive grid method is the best one, nor is it believed by this author that it will survive in its present form, but rather than eventually it will be like the first or battery-type Class B amplifiers, intended to permit greater power output from small tubes, and using a high negative bias. The 46 tubes in Class B formation have little or next to no plate current at zero bias, due to their very high mu, and this method is economical, but if a separate C bias supply were used, the cutoff of plate current could be accomplished by high negative bias, and the tubes worked on the negative side of the no-signal line, instead of on the positive side, thus preventing grid current flow.

The Class B amplifier is being advertised considerably by those manufacturers who in their planning for the end of '32 and virtually all of '33 were hopeful as to business conditions, for although very reasonably priced, naturally the sets cost more than simpler Class A systems, and are mainly console or consolette types.

The Class B quality, all things considered, may be fairly stated as being superior to Class A, although not to the extent that Class A will be replaced by any means, especially as there are receivers on the market for as little as $10 (four tubes extra).

Two Speakers

In the quality category also is the growing vogue for two speakers where formerly there was one speaker. The twin reproducers are very dissimilar for twins, which are expected to look alike even if they don't act alike. The speakers look and act differently. The smaller of the two is for the higher audio frequencies, the larger for the lower audio frequencies, and when the speakers are in series they produce a net result that affords a fairly flat speaker characteristic (which means plenty of bumps still remaining in the curve, to any one who knows speaker curves), and also tends to reduce if not wholly eliminate cavity resonance of the infamous "man in the barrel."

When two speakers are used they must be phased so as to aid and not so as to buck, otherwise the results will be very bad.

The twin or dual speaker idea is backed by the engineers, and indeed they were the ones to sell the idea to the sales manager, in contrast to the usual factory formula of the sales manager in a sense designing the set. So since the idea came from the engineers and was brought to a head by them against the resistance of a depressed market, it can be seen they believe in it wholeheartedly, and their word ought to be taken on engineering subjects. Therefore, to put it differently, the public will find something that it really wants in the dual speaker idea.

Some of the manufacturers have taken special pains to treat the cabinet acous-

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How to Test for Gas Content of a Vacuum Tube

(Continued from preceding page)

on the contrary, in every case of heater-type tubes tested the gas effect became evident after a considerable delay in time, often as much as five minutes. As regards power tubes it is common observation that the high plate current due to gas will subside to normal after the tube has been in use a short time, but this subsidence of plate current in heater tubes is long deferred, if it occurs at all.

With Figs. 2 and 3 as a basis some interesting deductions are in order. It is evident that gassy tubes concern us vitally only when the grid of the tube is isolated by a resistor of high value, for only in this case does the drop in bias voltage occur. We might have a very gassy tube in a transformer coupled stage and never know it! Again, except that the variation in bias voltage is manually supplied, Fig. 3 is a classic picture of an a-v-c circuit. So, watch out for gas in the r-f tubes supplied with automatic bias, for, if gas is present the a-v-c feature probably will be absent!

tically so as further to reduce, if not eliminate, cavity resonance, again proving that they are really trying hard to give the public quality reproduction, something that radio has lacked in the commercial field, as a general proposition, since the very beginning, and in many instances even up to last year.

Static Reducers

What standards of inferiority of tone have been applied to make a manufacturer forgive himself for many of the offenders he has released in the past it is hard to imagine. To find things really getting better in the tone line, without too much nonsense and downright lying about it, is consoling.

Of course interference of all kind must be classed in the tone offense category, and therefore transmission lines to render the antenna input as free as possible from static-laden energy are used in some receivers. The circuit is a simple one and not costly, and the scheme can be applied to virtually any receiver. The effect is excellent, although of course the remedy is not a pancea, and many who don't know if they'll ever have decent radio reception, due to a railroad line with sparking shoes near at hand, or a power house of the electric company, may still have to keep on wondering.

Tuning Convenience

As for tuning convenience, visual methods auxiliary to the dial include the meter needle and the glow tube. Usually the glow tube is long and slender and resonance indicated by the greatest height the glow reaches in a rising column of illuminated neon gas.

Automatic volume control, due to new tubes, particularly the 55 and 85, both duplex diode-triodes, is much more successful than formerly. The previous attempts were generally abortive. Silent tuning is a really new feature. Nothing heard between stations! Isn't that something?

Radio receivers that are equipped with automatic volume control are therefore being advertised as noiseless between stations, and the question arises, How is it done? It is well known that ordinary a.v.c. equipped receivers bring out background noise strongly when the tuner is between stations. The reason for this noise is that when there is no signal present the set is in the most sensitive adjustment and tube and circuit noises are greatly amplified. When a signal is present the carrier makes the set less sensitive, and the stronger the signal the less sensitive the set.

The noiseless receiver has an additional control that eliminates the interchannel noise, and this is called noise-suppression-control, or simply, n.s.c.

The n.s.c. is arranged so that when there is no carrier present the first tube in the audio amplifier is biased beyond the cut-off so that nothing can be amplified. As soon as a carrier comes in the n.s.c. tube changes the bias on this amplifier to such a value that amplification can occur.

A Simple Arrangement

In one of the simplest circuits combining a.v.c. and n.s.c. the 55 tube is used as automatic volume control, noise suppression control, and detector. One of the anodes of the diode is used for a.v.c., the other for detection, and the triode part as n.s.c. When the arrangement is applied to a superheterodyne, the input to the a.v.c. anode is taken from the primary of the last intermediate transformer, the input to the detector from the secondary of the same transformer, and the input to the triode, that is, to the n.s.c., from the drop in the detector load resistance.

There is no difficulty about getting the a.v.c voltage, for the usual arrangement is used, except that the signal is taken from the primary. But it may be taken from the secondary as well. The detector circuit is also typical except that additional filtering is necessary.

The input to the first audio amplifier is taken from the load resistance of the detector anode through a suitable stopping condenser. There is nothing out of the ordinary in this arrangement. The only thing different about is the method of controlling the operating bias of the amplifier. In the first place there is a limiting bias, say of three volts, obtained from the drop of a resistor in the voltage divider. The variable bias, which is effective in cutting off the amplification, is obtained from the drop in the plate resistance of the triode of the 55. Suppose this plate resistance is connected between the plate and the negative end of the limiting bias resistance. If a current flows through the load resistance it must necessarily make the grid of the audio tube more negative, and the greater the current the more negative it is. Therefore when there is no d-c drop in the diode load resistance, which occurs when there is no carrier present, there is a high bias on the audio tube, for then there is a large current through the triode load resistance.

Effect of Signal

When a carrier comes through there is rectified current in the diode load resistance and hence there is a d-c drop in it. This drop biases the triode grid and cuts off the plate current in the load resistance of the triode, and the bias on the first audio tube assumes a value which allows it to amplify. And at the same time there is something to amplify, since there is also an audio voltage drop across the diode load resistance.

The bias on the 55 triode grid should be pure d-c. Hence it is necessary to filter the voltage on the grid, but this must be done in such a manner that the audio signal in the rectifier circuit is not cut off. A resistance of about one megohm connected between the grid and the load resistance will prevent short circuiting of the audio voltage, and a condenser of 0.05 mfd., or more, will remove the audio signal from the grid.

It was said that the condenser may be larger than 0.05 mfd. However, it must not be too large, for then the response will be sluggish. That is, it will take too long a time for the bias on the audio amplifier to assume a value that will allow amplification.

The combination of a.v.c. and n.s.c. is compaartively inefficient and in general requires the use of at least one more tube. This added tube is usually a screen tube, say a 57. This tube is suitable because it requires only a small grid voltage to cut off the plate current, that is, to put it in a condition where it will not amplify. Moreover, its high amplification offsets the general lack of efficiency of the scheme.

Low Voltage on 55

We need very little current in the plate circuit of the triode and for that reason we need only a low voltage. The effective plate voltage, for example, may be 25 volts, and this too should be taken from the voltage divider. But the resistance supplying this voltage must be connected below the bias resistance for the audio amplifier, that is, on the negative side of it.

This is the general scheme of the noise suppression arrangement. There are many refinements to make the n.s.c. "take hold" at the right time and to the right degree. By "right time" we mean at the right carrier value. For example, the automatic volume control might cease to become effective when the circuit is detuned 10 kc. The n.s.c. should have begun to take effect a little before. Otherwise there may be a region on the fringes of a carrier where the noise will come through due to the fact that the a.v.c. has ceased to control the amplification and the n.s.c. has not yet begun.

One of these refinements is the introduction of a retardation voltage. This voltage is applied so that the automatic volume control does not take effect until the a.v.c. voltage has reached this value. When the a.v.c. voltage is greater than this retardation voltage the automatic volume control is effective in decreasing the amplification. The more the a.v.c. voltage exceeds the retardation voltage the more the amplification voltage is suppressed. The retardation voltage is also taken from the voltage divider and the resistance is placed between B minus (ground) and the cathode of the 55 tube.

Detailed circuits will be given later showing the connections of the noise suppression circuit and its relation to the other portions of the receiver.

NEW BOOKS

THERMIONIC EMISSION, A Survey of Existing Knowledge with Particular Reference to the Filaments of Radio Valves, issued by the Department of Scientific and Industrial Research and published by His Majesty's Stationery Office, London, England. Compiled by W. S. Stiles, Ph. D. Special report No. 11 on Radio Research...70c

The book follows the development of thermionics from the earliest experiments and theories by Richardson in 1901 up to the present day, giving references to all the principal papers that have come out on the subject with a statement what each paper contributed to the knowledge of the emission of electrons from heated electrodes. The report is divided into 9 sections covering the following topics:

General Outline.
The Theory of the Temperature Emission of Electrons.
Variation with Temperature of Specific Electron Emission in Vacuo and Values of the Richardson Constants.
Heat Effects in Thermionic Emission.
The Distribution of Velocities of Thermionic Electrons.
Effect of Applied Electric Field at the Surface of the Emitter (Schottky Effect).
The Photo-thermionic Effect.
Thoriated Filaments and other Thin Film Emitters.
Oxide-coated Filaments.

Besides these sections there is a complete bibliography and an authors' index.

For those who have studied the subject of thermionics the book is a valuable review for those who wish to make a study of it it is a still more valuable guide.

Tube List Prices

Type	List Price	Type	List Price
11	$3.00	'38	2.80
12	3.00	'39	2.80
112-A	1.55	'40	3.00
'20	3.00	'45	1.15
'71-A	.95	46	1.55
UV-'99	2.75	47	1.60
UX-'99	2.55	'50	6.20
'100-A	4.00	55	1.60
'01-A	.80	56	1.30
'10	7.25	57	1.65
'22	3.15	58	1.65
'24-A	1.65	'80	1.05
'26	.85	'81	5.20
'27	1.05	82	1.30
'30	1.65	'74	4.90
'31	1.65	'76	6.70
'32	2.35	'41	10.40
'33	2.80	'68	7.50
'34	2.80	'64	2.10
'35	1.65	'52	28.00
'36	2.80	'65	15.00
'37	1.80	'66	10.50

THE ACCESSOR

To Test All Sets, Including Those with Seven-Pin Tubes

By Herman Bernard

PROBLEM: How to build an Accessor that will also handle the seven-prong tubes. An Accessor, it will be remembered by those who have read the most recent issues of RADIO WORLD, is a device for rendering the voltages and currents of an operating receiver accessible, done by plugging in and switching. Use the meter or meters you have. The Multimeter (see page 5) may be combined with this Accessor to constitute a set analyzer.

Before solving the problem it is advisable to state that seven-prong tubes are not standard yet, that a few of the smaller tube manufacturers make them, and that these tubes now are power tubes that usually serve a variety of purposes, depending on how extra grids are connected. There are seven pins in the base, but there is no grid cap. Probably new and other tubes in the near future will have seven-pin bases, however.

Six-prong testers can be accomodated to seven-prong testing if the testing of one of the standard elements is omitted and the seventh element replaces it, as by consolidation of suppressor and cathode. With some tubes, nearly all circuits, these are identical and the method is simple. Other times, as with the 55 tube, the base pin referred to as "suppressor" in the terminology of the 57 and 58, is now an anode and completely separate, hence an extra adapter would be needed to effectuate separation.

Individual Tests Preserved

The present method therefore is one that permits of the individual testing of each connection, and does not consolidate any of them.

Let us see what the requirements are:

Since a seven-prong tube is to be tested there must be seven leads from the analyzer plug, that is, all connections from the receiver socket must be brought to the Accessor. Six are taken care of by the six leads from the six-pin base of this plug. But the seventh lead is quite special and ingeniously provided. It is introduced into the plug at an inside lug that connects to a latch, and a wire is run from the frame of this latch to two grid cap inserts in the analyzer plug. So if the tester has a universal socket, one that takes UX, UY and six-prong tubes, an adapter is needed that has a six-pin bottom and a seven-hole top, so the tube removed from the receiver can be fitted into the tester, otherwise a seven-prong socket would have to be used on the tester in addition to the universal socket. There is no universal socket that also provides for the seven-prong tube.

Why No Seven-Prong Plug

At the receiver end there is no trouble whatsoever. We have a plug with six-prong bottom or base (906-WLC). This is now standard equipment and there is no present intention of the adapter and plug manufacturers to put out a seven-prong analyzer plug, as it would require the use of an adapter every time a test was to be made, except only for the seven-prong tubes, and since the six-prong tubes are the dominant ones, at present the seven-prong analyzer plug would be unhandy.

So all we need at the receiver end is to have the necessary adapters to be able to insert the adapter into the desired set socket and then, with all receiver adapters having six-hole tops, simply insert the analyzer plug into the chosen adapter. The necessary adapters for the run of tubes are shown on the diagram, while if special tubes are to be tested, such as UV-199, WD-11, WD-12, Kellogg, etc., more adapters are needed, and concerning these questions may be addressed to Trade Editor, RADIO WORLD, 145 West Forty-fifth Street, N. Y. City.

The diagram shows a universal socket at top, with springs interconnected in such manner that plates, filaments and grids are picked up correctly, no matter what type of tube is inserted that fits directly into the socket without adapters, provided there is no control grid cap on the tube. If there is a control grid cap, then would be a seven-connection tube, for the cap would be the seventh, hence the connection would be made by putting the grid clip in the receiver to the nearer grid cap insert of the analyzer plug, and connecting the corresponding lead at the universal socket, consisting of a grid clip, to the control grid of the tube. Thus even for six-pin tubes, if there is to be no consolidation of purposes in the cable, a seven-lead cable is needed.

The Seventh Lead

Let us consider all type tubes with UX, UY or six-pin bases. These will fit in the Accessor (that is, tester) socket. At the receiver end the analyzer plug will fit directly into a six-spring socket, and will fit into the adapters that themselves fit into the other types of sockets, for the adapters are at the receiver end all have six-hole tops. The only digression is in the case of the adapter for the Accessor's universal socket, which adapter, as explained, has a seven-hole top and a six-hole bottom.

Now, the one point that has not been fully explained regarding the communication of elements through the cable is the seventh lead. It has been stated there are two grid caps on the side of the Analyzer plug and there is a seventh cable lead for this device. It has been stated, also, that the seventh lead is used as control grid connection when the tube is of the type that has grid cap at top ('22, '24, '32, 55, 57, 58, etc.)

What has to be cleared up is the handling of the seventh lead at the receiver end. This problem has to do with the use of the seventh connection, whether a seven-prong tube is used or a six-prong tube that has control grid on cap on top, hence really uses seven different connections.

It can be seen that all the adapters for use at the receiver end have a center stud sticking out at top. The Analyzer plug which is put into these adapters has a hole at bottom (not shown) to clear this stud and a little beyond this hole is the special latch that holds the adapter to the analyzer plug. A latch is necessary so that the adapter will not stick into the receiver socket, and the analyzer plug alone will come out, for a stuck adapter is sometimes hard to remove, for lack of room. However, when the entirety is pulled out, an inevitable consequence using the present system, the adapter can be detached from the analyzer plug simply by pressing a little latch spring on the side.

The center stud is the one that makes conductive connection to the stationary part of the latch and also to the two grid caps at sides of the handle, and this lead is continued through the seventh cable lead to the grid clip at upper right in the drawing.

The Seven-Prong Adapter

The type of seven-prong-bottom, six-prong top adapter used at the receiver end is one in which the control grid prong of the adapter base, corresponding to control grid of the receiver tube socket, connects to the center stud of the adapter (967-SS) and thus connecting to the latch of the analyzer plug. Since the latch has a place to which the extra wire of the cable is connected, the same lead as the control grid cap terminals on the side of the analyzer plug handle, all seven connections are made to the contacts of a seven-prong tube. So the Accessor 7-pin adapter (upper right) has to have a grid cap at side to pick up the control grid of the tube placed in the adapter that goes into the universal socket.

As for the analyzer plug, this is a new item, just as are the adapters. See 906-WLC in the diagram. The plug has a latch operated by a spring. This latch slips over the slot in the center stud of any of the three adapters at lower center of diagram. That is, the stud is grooved on its diameter so that the latch will "snap into it." The plug diameter and height are so calculated that there will be no difficulty in putting the analyzer plug into sets equipped with small tube base sockets and close dimensioned shielding. The cable is five feet long.

Now, as to the Accessor itself, since the plugging and adapting have been described, a few words about the switching will be given, although repeating, for the most part, what has been said about the Accessor in previous issues.

Main Switch

The main switch is a unit of four decks, consisting this time of eleven different positions. Since current readings are to be taken it is necessary to put the meter in series with the line, but when one particular element is subjected to current readings the lines to the other current-accessible circuits must be closed. Therefore we need a switching arrangement whereby the circuits are primarily closed, but at a given position one circuit is opened while the others remain closed. Since there are only five current readings, (plate, screen, suppressor, cathode and grid), the close-circuit switch need apply to only those positions. All other readings are for voltage, and are taken from the tube element to filament center or heater center. Thus only half the filament or heater voltage will be read, and this reading must be multiplied by two. Also, remember that the terminology throughout has been in reference to 57 and 58 tubes, whereas other tubes have some correspondingly positioned elements of an entirely different nature (e.g., the 55, 85 etc.), and the user should have the tube data handy, or should prepare a chart so that he will know what's what about the new tubes particularly. Refer to the chart printed in the September 3d issue as the basis of preparing a chart of your own to comprise the uses and purposes of the present tester.

Besides the closed-circuit switch that is opened at any one of four positions when the other three positions remain closed, it is necessary to perform the function of closing open circuits, so that the meter can be put into the opened live. In the current-reading instances the closed-circuit switch and the corresponding numerical position of the open-circuit switch are connected in parallel. Thus as the current line is opened the meter actually closes it.

The close-circuit switch being ignored and not needed for voltages, center of filament or heater is brought to the row of six voltage positions as to one side of the open-circuit switch, the other sides of the switch going to the respective points between which and filament or heater the voltages are to be read.

The open-circuit switch may be connected to the meter directly, or any standard pilot light may be put in series with the line, and any single-pole single-throw switch used for keeping the meter closed until there is a certainty the lamp doesn't light, for this protects the meter if there's a short. However, if any tube is in the Accessor socket that draws 100 ma or so, there will be a small glow in the tube, and still no need for fear. If current burns out the pilot lamp the meter faces an open circuit and is protected, in case of a real short rather than merely a heavy but expected load current.

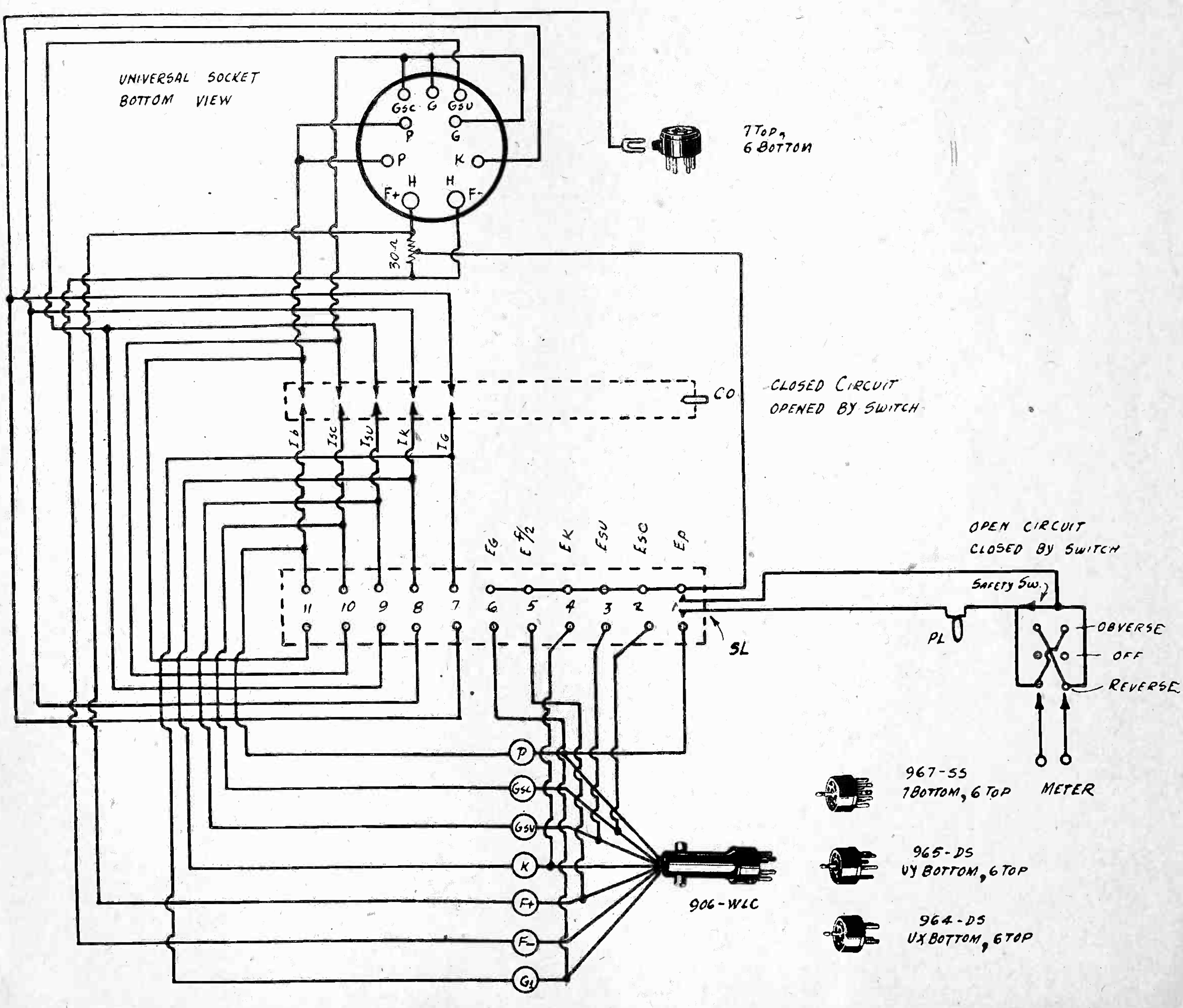
The remaining switch, double pole, triple throw (two decks, three positions) serves the dual purpose of enabling readings in the right direction when current through the meter is reversed (by reversing the meter connections) and establishing an off position, when the meter is totally out of circuit, which off position should be established when you have finished using the tester. Also, when finished, turn the main switch to read plate voltage, for then if the meter is later connected in any circuit unintentionally the meter will have fullest protection, and the mistake may be noticed before injury to the meter, a happy sequence of events.

Perkins Says His Mail Shows Depression's Wane

Ray Perkins, NBC radio jester, detects the return of prosperity in the United States by the type and calibre of his fan mail.

When Ray first began on radio several years ago during the expansion market, his mail was cheerful, full of puns, jokes and generally bantering and gay. With the depression, not only did the quantity of mail drop, but there was little cheer in the letters, practically no humor and a general lethargy.

Within the last month, Ray's fan mail again is assuming pre-depression aspects. His notes are optimistically worded, jokes prevail and the writers have thrown off their depression cares. In addition, fan mail is once more coming from business men who, due to worries, stopped writing completely as a class during the last eighteen months.



The five positions at upper left in the dashed oblong are for enabling current readings. It is necessary to have a closed circuit switch, to be opened at any one position only, to enable getting the meter between the two otherwise closed contacters that the insulated circuit opener, Co, pries apart. The voltage purposes are served by the familiar open circuit switch, closed at contact positions. Some ask if the closed circuit switch is really necessary. Of course it is. The two swiches enclosed in dashed lines are one mechanically.

Radio University

A QUESTION and Answer Department. Only questions from Radio University members are answered. Such membership is obtained by sending subscription order direct to RADIO WORLD for one year (52 issues) at $6, without any other premium.

RADIO WORLD, 145 WEST 45th STREET, NEW YORK, N. Y.

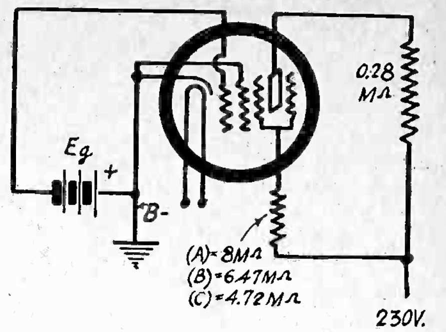


FIG. 1033

Running Tube Curves

CURVES printed in last week's issue (October 1st) showing the performance of the 57 tube as detector in the 5-tube Diamond, but applicable to other similar detector hookups using this tube, proved interesting. I happen to have a 0-1 milliammeter and therefore believe I can run some curves myself. Please state the procedure and show hookup.—O. W. A., Danbury, Conn.

The circuit used in conjunction with the B voltage of a receiver is shown in Fig. 1033. Assuming that you have a set in operation, using the 57 detector, measure the value of the plate load resistor and of the screen resistor also. This can be done by using your 0-1 ma with high-range voltage multiplier for total voltage measurement and putting the unknown resistor between one side of voltmeter and ground, the other side of the meter to maximum B plus. The current when the unknown resistor is in series is noted. Compute the total resistance by Ohm's law, and subtract the resistance of the meter's multiplier. One reason for knowing the value of these load resistors is to be able to compute the effective voltage, as it can not be measured accurately on meters that draw current from the measured source. Now, to run the curves, disconnect the cathode from its biasing resistor, and connect cathode and suppressor grids to ground (which is assumed to be B minus, or a branch of that line if B choke is in the negative leg). Put the meter in series with the plate circuit, as a 0-1 ma, and connect positive of a C battery to ground. Remove the grid return of the detector secondary coil and make it a handy flexible lead that may be put to any of the C biasing voltages as obtained from the battery. Apply the plate voltage with maximum negative bias, which may be 15 volts if you have two 7.5-volt batteries in series. Probably there will be no reading, as the plate current cuts off a little beyond 13 volts negative bias. Next try 13.5 volts, next 12 volts, etc., and write down the biasing voltages and next to them the values of plate current. When you have reached the next to the lowest biasing voltage, 1.5 volts, if the needle does not come too close to full-scale, and it shouldn't, apply zero grid bias voltage (return to ground), and take the reading, which probably will be near 0.5 ma. These readings enable making the Ip-Eg characteristic curve. The applied plate voltage has been constant, especially if the rest of the tubes in the set are operated, so that a substantial external drain exists, but the negative bias has been changed and the equivalent current values read. If plotting paper is used, bias voltages along the bottom, current values along the perpendicular side, then the values already determined may be communicated to points on the paper and a curve drawn. If more information is desired about the lower values of grid bias, a potentiometer may be put across the 3-volt battery section, plus of battery to ground, arm of potentiometer to grid return, although a voltmeter should remain between ground and pointer, so that real values of voltage will be known, not merely apparent values, which requires two meters. The plate circuit may be restored, the meter put in the screen circuit, and the bias voltages altered as formerly, with current values recorded next to biasing values. With your meter it may be hard indeed to get a close idea of the screen current at the higher biasing values, but do the best you can, and plot the curve. Now you can determine the effective voltages, which, due to current changing with bias voltage changes, will be different for different bias values. So if you measure the current in the plate circuit or the screen circuit of the receiver when the set is restored for operation you may determine the actual operating point, closely enough, by consulting the curve. Of course the screen circuit may be used instead for this determination. The effective plate and screen voltages are ascertained by multiplying the resistance in ohms by the current in amperes, and subtracting this voltage drop from the applied voltage. Curves may be drawn also for the changes in effective voltage produced by the bias changes, no further reading being necessary, as the computation will give the approximate result. In actual receiver operation, however, the applied plate and screen voltages are reduced as much as the negative bias is increased, due to the actual voltage depending on the difference between cathode in both instances and screen and plate in one or the other instance. For this reason there will be a slight discrepancy when the battery-run curve is applied to the a-c operated receiver that has its bias influenced by plate current, which would include the effect of the signal on the bias. The discrepancy, however, is small, and may be ignored. The curves of current plotted against grid bias voltage permit the use of the detector as a vacuum tube voltmeter. Since the operating point is known or ascertainable, the voltage applied to the detector, whether by signal or from some other source, is represented by the voltage differences as represented by the voltage differences in the current readings. For instance, if at 4 volts negative bias, no signal, the plate current is 0.1 ma, if the current becomes 0.135 ma, the actual bias has become 2 volts (as the curve shows), so the external or signal voltage applied was the difference, or 2 volts.

* * *

Difference in Hum

HAVING BUILT two sets on practically the same plan, one a four-tube, the other a five-tube t-r-f set, I find that with the same filter choke and filter capacity the hum is low enough on both, but lower on the four-tube model. Can you explain this, and if possible tell me how to make the larger set just as low in hum as the smaller one?—U. T. R., Portland, Ore.

The reason is that the extra tube, which we assume is an r-f tube, adds considerably to the current, probably 25 per cent., and as the effectiveness of the filtration, using the same filter choke and condensers, changes inversely to the amount of current, you do not filter as well at 50 ma as at 40 ma. Actually, the inductance of the choke, even if it be the field coil of a dynamic speaker, decreases with current, and the permeability may be such that the change is quite rapid. We suggest you add a low resistance choke of 20 or 30 henries or so, putting it between rectifier and the present system, and either moving the present first condenser to the filament side of the filter or putting in an extra filter condenser for the added midposition. If you do not use a resistor-capacity filter system as additional hum reducer, please try it. Interrupt the grid return of the power tube with a resistor of 0.1 meg. or greater value, and put a small condenser across it, 0.25 to 0.1 mfd. being satisfactory. The free end of the resistor goes of course to the grid return point.

* * *

Neon Oscillator

PLEASE LET ME KNOW whether those small neon tubes, the maximum diameter of which is about the same as the diameter of the face of a wrist watch, are all right for audio frequency oscillators. If so, what frequency?—K. R., Tampa, Fla.

Yes they are. The tube may be put in an Edison screw base socket, and with a 2 meg. leak in series may be connected to the usual maximum B voltage of a receiver, assumptively 250 to 400 volts. It is well to have an adjustable voltage, however, so that the series resistor need not be molested. The oscillating voltage is critical and oscillation usually obtains when the tube glows so faintly that one might assume it was not functioning. However, inside near the tube bottom the pin-point glow will be found. What the frequency will be will depend on the tube and the external impedances and voltage. A radio frequency tuning condenser across the 2 meg. resistor will alter the frequency. In a given case (2 meg. and 0.0002 mfd.) the frequency could be varied from about 500 cycles to 5000 cycles. The higher pitches are especially suitable for modulating an oscillator, because the note is so distinctive and piercing. The lower limit is excellent for use in conjunction with an output meter, for such meter use requires a steady modulation, the multi-amplitude modulation of broadcasting stations being utterly unsuitable because causing the meter to wobble all over the scale.

* * *

Sensitizing a Meter

TELL ME what is the best way to improve the sensitivity of my meter, a 0-6 volt voltmeter that draws 12 ma at full-scale deflection. I would like it to be of the 0-1 milliammeter type.—K. D. S., Long Beach, Calif.

We wish we knew. There'd be a lot of money in it for us all. The sensitivity of the meter depends on the construction of the meter and is therefore integral with the meter and can not be increased except by rebuilding the meter. It is cheaper and better to buy a meter of the desired sensitivity of course. Neither is there any way of actually reducing the sensitivity of the meter itself, for the parallel shunts used for reading higher current values simply detour some or much of the total current through the shunt, whereas the meter's actual sensitivity is unchanged. When the reading is half-scale, for instance, half of the full-scale meter current is flowing through the meter in any and all instances.

* * *

Amplifier Tube Linearity

WHAT CAN I do to make the curve of a vacuum tube quite linear, and thus avoid the curvature that defeats many purposes to which I desire to put tubes?—U. S. W., Council Bluffs, Iowa.

We do not know what you can do to make

an amplifier tube's curve strictly linear. Of course voltages and loads may be altered to reduce curvature so that over an operating portion there is virtual linearity, but strict linearity has not been accomplished, so far as we know. Theoretically it can be accomplished, as in true push-pull. With the detecting function a very close approach to linearity is developed in the diode, when the input load resistor is very high in comparison to the internal resistance of the tube (anode to cathode). Perhaps some of your purposes can be served by the diode, but we suspect you are looking for a perfectly linear amplifier.

* * *

What an A-C Meter Reads

MY A-C METER reads something or another in the a-c line and I'd like to know just what, as I am all mixed up about average voltages, maximum voltages and whatnot. Can not something be simplified along this line so a fellow will readily understand it?—K. W. Q., Nome, Alaska.

What a-c voltage your meter reads you can ascertain from the manufacturer. Usually a-c meters read the root mean square, unless otherwise stated on the meter. The reason why alternating voltage may read differently with different meters is that the voltage itself is changing and the meter indicates one condition. For instance, an a-c peak voltage of 100 volts is the maximum voltage of a cycle that includes all voltages from zero to 100. An alternating voltage (or current) reverses its direction twice as many times per second as the frequency, and twice in each cycle actually comes to rest at zero voltage (or current). The cycle consists of a positive alternation and a negative alternation. Therefore the maximum or peak value can be grasped readily. The usual measurement is that of the heating effect of the current through the meter or other known resistance and may be read as voltage or current depending on the meter scale. This heating effect, equal to the heating effect of d-c through the resistor, is the root mean square value. There are two other values to be considered: the instantaneous value and the average value. The instantaneous value is the value at any instant of the cycle, but meters do not read this. A great number of the instantaneous values of the cycle may be computed and the sum divided by the number of instantaneous values to give an average instantaneous value, or average value. But the average value then would be zero. To encompass the complete cycle the squares of the instantaneous values are added, and the square root of the sum taken, and this is the root mean square referred to above. These considerations apply to true a-c meters. Another type is growing in use, the d-c instrument with rectifier. This, too, will give rms values unless otherwise stated, but can be calibrated of course in giving any values.

* * *

Chassis of 5-Tube Diamond

KINDLY SHOW a diagram of the chassis layout of the five-tube A-C Diamond of the Air, the circuit that was described in the September 24th and October 1st issues.—P. R. W., Passaic, N. J.

Fig. 1034 shows the diagram of the chassis layout, and from the photograph on the front cover of the September 24th issue, the constructional directions in the issues of September 24th and October 1st, and the full-scale picture diagram of the wiring, printed this week on pages 16 and 17, you should have no trouble in building the receiver. The only semi-uncertainty concerns the 1,200-ohm resistor across part of the secondary of the second r-f coil. If the set oscillates, then this resistance should be of lower value. If there is no trace of oscillation, then the sensitivity may be increased by using a somewhat higher value of resistance in this position. The 1,200-ohm resistor specified was found a satisfactory average after several tests. See pp. 12 and 15.

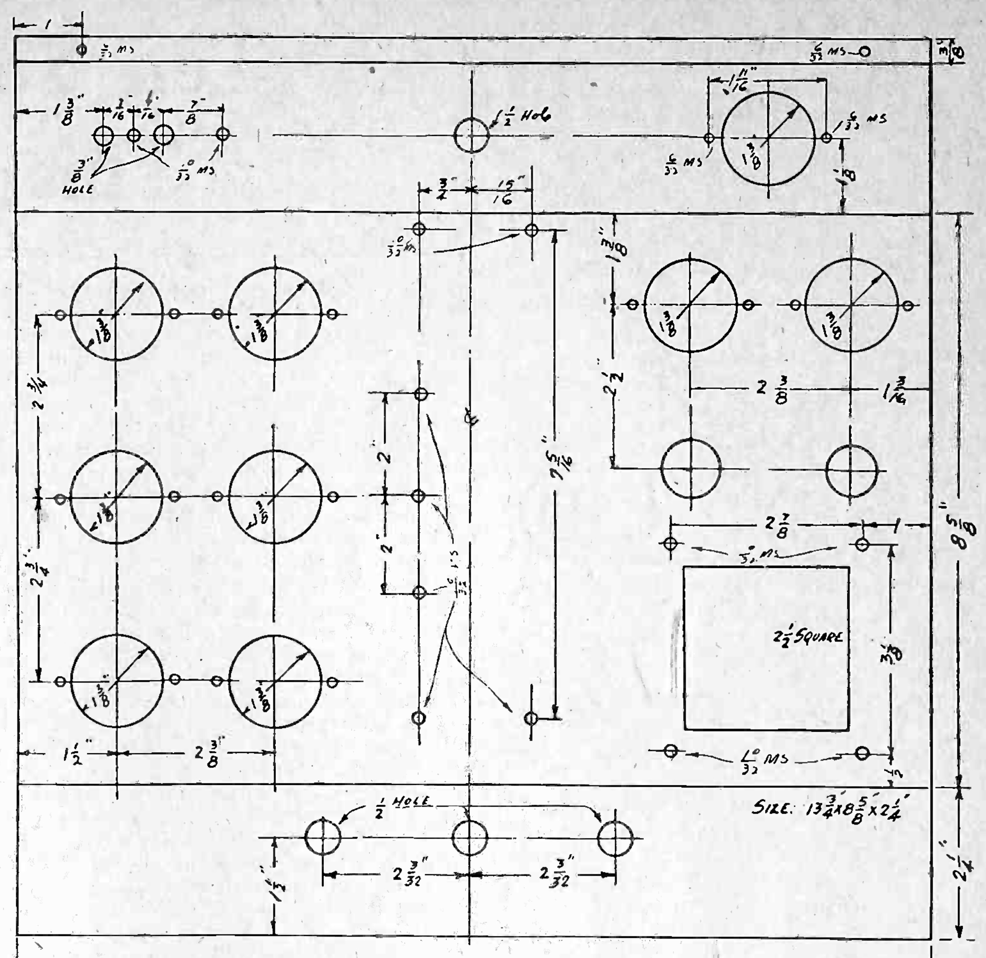


FIG. 1034

Plan for the chassis. The front flap is below, the top is next and the rear flap, with right-angle mounting extension, on top. Three front holes are provided so those having potentiometers without switch attached may use a separate switch.

All-Wave Switching

CAN NOT good results be obtained on short and long waves by switching devices, so as to avoid plug-in coils? Why are plug-in coils so largely recommended, especially since it is quite troublesome to use them?—U. R., Newark, N. J.

It is possible to obtain good results on either long or short waves, using switching methods of band changing, with fixed coils. However the switch contacts have to be most excellent, and also of minimum and uniform resistance. It is in the switch that the rub is. A switch that will serve the purpose well is difficult to make and is therefore expensive. The general run of switches in popular all-wave circuits is far from satisfactory. A satisfactory switch lists at around $7 and as it is a precision instrument the discount is only 25 per cent. Plug-in coils, though introducing some inconvenience, produce the same results at lower cost.

Page with Lapel Mike Makes Speeches Audible

At a recent meeting of sales representatives of the International Business Machines Corporation in New York City a page, wearing on his shoulder the same type of Western Electric lapel microphone which helped broadcast the National Democratic and Republican Conventions, stood poised on his toes at the head of the hall. As speakers were given the floor, the chairman asked them to step into the aisle nearest their seats and the page dashed up in front of them.

The microphone picked up their words and amplified them through a portable public address system which was set up in the hall and which, with its volume carefully controlled by the chairman's assistant, gave high andibility to even the most modestly after several tests.

A THOUGHT FOR THE WEEK

"ALBUM of Familiar Music" is one of the finest programs on the air. Howard Claney is an excellent announcer, Frank Munn makes the radio crooners sound awful in comparison, and Victoria Wiggins is one of radio's finest singers.

BUT—why does Mr. Claney, in announcing the song numbers read—very well he does it, too— a few lines of the lyrics instead of giving the titles of the numbers? Does he take it for granted that everybody knows every song rendered before the microphone? And is it fair to the author composer and publisher? It is NOT!

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Title Reg. U. S. Pat. Off.

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Eleventh Year

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Roland Burke Hennessy, editor; Herman Bernard, managing editor and business manager; J. E. Anderson, technical editor; J. Murray Barron, advertising manager.

More Frequency Service

IT is welcome news that the Bureau of Standards, Department of Commerce, is planning an enlarged frequency transmission, possibly 24-hour service every day. At present a standard frequency signal, 5,000 kc, is sent from WWV, Washington, D. C., by the Bureau, 10 a.m. to noon, and 8 p.m. to 10 p.m. (EST), each Tuesday. Previously the Bureau had been on the air also four hours each Tuesday, though the time was different.

More than merely being on the air all the time with a standard frequency, the Bureau will send out different frequencies, and these will include high frequencies. The importance of the service is recognized, due to the higher degrees of accuracy required in all branches of the radio science, transmitting stations in particular. However, the experimenter will profit no less than the commercial enterprises, because he can use these standard frequency transmissions for calibration purposes. It will be remembered that the present 5,000 kc transmission achieves an accuracy at all times better than 1 cycle (1 part in 5,000,000), and accuracy of that sort, applied to various frequencies, certainly is inviting.

The new stations to perform the service will be at Beltsville and Meadows, Md. The transmitting set is being installed in one of the three new buildings at the United States Experimental Farm at Beltsville. The necessity for such field stations was recognized when funds were appropriated last year so that the Bureau would have adequate means of helping transmitters to avoid mutual interference.

Government recognition of a high responsibility in this direction is in line with the long-standing policy of the Government in regard to frequency standards. Not only does the United States require a higher degree of accuracy of frequency transmission of the broadcasting stations it licenses than any other country, but it was the first to establish a monitoring station of world-wide and all-frequency range, the one at Grand Island, Nebr., now operated under the jurisdiction of the Federal Radio Commission. The Grand Island station depends on the Bureau of standards for the accuracy of its calibrations, and the combined efforts make the United States first in monitoring performance in all the world, in fact it has the only monitoring station that has such distance and frequency range. Tuned radio frequency receivers with plug-in coils are used.

Ten Years Ago This Week

INTERRUPTING circumstances have made impractical the correction of a mistake in a diagram previously printed in RADIO WORLD, and with the indulgence of the reader we would like to make a belated rectification. Or, rather, our preference is not for the belatedness thereof but for the strict adherence to accuracy, which has always been our goal. Every one makes mistakes, even the most learned authorities, and so we call attention to the short-circuiting of the signal line in a diagram printed on page 7 of the October 7th issue. Of course the issue you are reading is dated October 8th, but it mustn't be assumed we have become a daily. Our ambitions to turn daily were small even when business was at its best. No, the October 7th issue we mean is the one published in 1922, ten brief years ago.

If you have your copy of this issue handy, please turn to it, and you will find the circuit diagram of a tuned radio frequency amplifying stage, a crystal detector and a stage of transformer coupled audio. As related, there was a short—not a high-voltage short or anything of such a serious nature, but just a short that would positively keep the signal out of the audio transformer, hence cheat the phones of their ambition to be moved.

Act Now! Why Delay?

There was the unusual tuned input, condenser across a tapped secondary, and even the antenna primary was tapped. The bugle blew taps from reveille to taps in those days. The plate circuit was tuned, also, for regeneration, coil returned to B plus. Then the crystal was connected directly from plate to one side of the audio transformer primary. It was a waste of effort, however, because the tickler winding had a few ohms resistance, and that's the short-cut that the lazy signal must have taken. Any who have been wondering during the few intervening years where that signal has been hibernating may locate the receiver and remedy the trouble now.

As stated, it wasn't much of a mistake, and any one familiar with radio could correct it without trouble, and probaly hardly one of the thousands who must have built that device was really perplexed over inoperation.

Otherwise the circuit was somewhat trail-blazing, for many builders had been wondering if it were at all practical to use t-r-f with a crystal following, and then to feed from crystal to the primary of an audio frequency transformer.

Crystal Versus Tube

The debate was raging as to whether this would work — and barring a little error here and there it would—and if it did work, whether the regenerative tube detector were not preferable. Here, you see, the t-r-f stage was regenerated. Well, the answer as given in that article was that the crystal method was better, because of the pure tone of the crystal. To-day we can quarrel with that statement and hold our ground. In those days any one suggesting anything was as pure in tone as the crystal was in danger of serious attack. We know now that crystal rectification is on the same operating principle as grid leak detection and diode detection, provided the load resistance is high enough in the tube, and the results then are substantially linear. A crystal, by the way, would overload quite readily. But then there was that infernal audio transformer, and as we remember the transformers of a decade back they twisted the frequencies and wave forms as suited their perverted ideas of quality, so whether one used crystal or tube or perhaps the eye of wart hog, the results would be just as sweet in quality.

So even serious engineers themselves made some mistakes. If they were not mistakes of construction (and these the best did very well, too) they were mistakes of theory. And if we had been doing the work we would have been making the mistake then, too, because the radio room was dark and there had to be considerable groping.

The leading article in the October 7th, 1922, issue was "Superheterodyne Receiver as Applied to the Armstrong Superregenerative Circuit," written by Charles R. Leutz. This was no less than an 11-tube receiver, and it was imposing and immense, as were all multi-tube receivers of those days. For instance, every tube had a separate filament rheostat. (Thus we start with eleven minor controls). The antenna coil was fed through a variable condenser to one side of a variometer, and this variometer side was tapped as was the ground side, so we had two switches and each switch selected one of twelve taps. So there were, to the moment of writing, thirty-six options. It must have been difficult to make up one's mind how to tune the set. And seeing that it was a 1922 superregenerator we are now doubly confirmed in that assumption.

Oh, Much More

But wait! There were six main tuning dials. Each had extra vernier knob. And there were 24 binding posts on the front panel, but you didn't have to turn them more than once an evening. Two meters were on the front panel, but everything else was omitted, perhaps for lack of room.

The idea of the set was that you could do business from 50 to 200 meters, another item of importance, showing the drift to lower wavelengths, and one of the first attempts to conquer the problem commercially.

The outfit was sponsored by Experimenters Information Service, 220 West Forty-second Street, New York City, but don't write to them now for the blueprint that they were ready to furnish then, for no doubt they have moved, and also that the blueprint edition is exhausted.

It so happens there was no crystal in that set, but tube detectors were used in the first and second instance, thus showing that Major Edwin H. Armstrong wasn't being deterred by current opinion, which then was quite partial to the crystal, although constantly bemoaning the critical and short-lived adjustment for greatest sensitivity.

Advice On Aerials

How to erect the best type of antenna was as absorbing a topic then as now. Dr. Austin of the U. S. Navy was kind enough to furnish five rules:

(1)—The higher the receiving antenna, the stronger the signal.

(2)—The "height" of the antenna is the distance above ground of its "middle point."

(3)—For any particular wavelength there is a best overall length for the antenna.

(4)—The antenna should be as far away as possible from any other wires, particularly grounded ones.

(Continued on next page)

STATION SPARKS

By Alice Remsen

The Old Church Bell

FOR SETH PARKER

WEAF Sundays, 10:45 p.m.

When I was a tiny tot I remember well
Listening on a Sunday morn for the old church bell.
As it started ringing out, off we kids would go,
Mother following behind walking rather slow.

To the little village church we would wend our way,
There we'd hear the parson preach, hear the organ play.
On our hearts there would descend holy peace and calm,
As our voices rose on high, chanting out a psalm.

We were young and innocent in those far-off days,
Had not learned about the world and its wicked ways.
And our hearts were merry then, eyes were bright and clear;
We were guided by the hand of our mother dear.

Now in retrospective mood, memory will limn
Pictures of those Sunday morn; when we hear a hymn,
Silently we drop a tear, wish that we could go
Back again through all the years, to days of long ago.

—A. R.

* * *

AND IF YOU LISTEN IN TO SETH PARKER and his hymn-singing neighbors, your memory, too, will stray back to the dear days of childhood, the old church and the little Sunday school. No matter what your creed there is sure to be a responsive spark, so listen!

* * *

The Radio Rialto

Was I busy today—well, rather . . . up at seven o'clock, a hurried breakfast, then over town to the R. C. A. Photophone Studio to synchronize an Aesop Fable cartoon, where I shrieked my lungs out until twelve-thirty. . . . From there dashed madly over to the fur emporium of I. J. Fox and selected a coat for the winter—no, not a sable, but it will keep me warm just the same. . . . A bite of lunch at Park and Tilford's and a taxi over to the Amsterdam Roof, where I rehearsed the Stanco program from 1:30 until 4:30.

This is the Times Square Studio of NBC and in case you've never been there I must tell you about it. . . . It is atop the Amsterdam Theatre on 42nd St., seats about fifteen hundred people. Stage is not very large, but plenty big for a radio broadcast; in fact it's too big, as the sound sometimes seems to disappear up in the flies, or around back of the scenery; radio engineers have a fine time overcoming the acoustical difficulties of this stage studio, but usually manage to send out a very creditable program. . . . Between the audience and the artists on the stage is a glass curtain, which prevents foreign sounds from interfering with the broadcast, and yet permits the audience to view the proceedings whilst listening to the result from a loud speaker. On the stage are three microphones, one for the orchestra, one for the singers and one for the speakers. It is quite an interesting proceeding and if you care to witness one of these broadcasts, write to NBC for passes.

Finish rehearsal at four-thirty. . . . To the hairdresser's, as we have an audience tonight and must dress up. . . . Now home, where poor Octavia worries herself sick thinking I shan't have time enough to eat, but her worry is needless, because I do eat; in fact I'm jolly hungry. . . . Every woman loves to dress up and I'm no exception to the rule. . . . Knowing she is well-groomed gives a woman great satisfaction, and aids her in overcoming that inferiority complex attributed to her by the mere male. . . . And so I dress up. . . . In orange and brown taffeta, ladies . . . with orange and brown satin slippers, and with a brown velvet cape trimmed with mink. . . . How's that! . . . It did look stunning, so that fact takes away my tired feeling and I taxi over to the theatre. . . . Do the broadcast. . . . Afterwards, an ordeal I always dread, being introduced to the audience and making a curtain speech; then being besieged by autograph hunters and signing my name until I get writer's cramp.

All right; that's over. . . . Now what! . . . By golly, must get some news from somewhere, this week has been so hectic have not had a chance to dig up anything, so from here, where shall I go? . . . WOR is the handiest; I'll take you right along; we'll walk from 42nd and Seventh Ave. to 40th and Broadway. . . . Here we are. . . . Up in the elevator to the 25th floor. . . . My word, but the reception room is crowded tonight. . . . Oh, yes, it's the Market and Halsey Street audience; we'll listen to that later. . . . Well, well, if it isn't pretty Mildred Hunt, the original radio sweetheart. "What are you doing here, Mildred? On six nights a week, at 10:45 p.m. . . . good for you!" . . . Mildred is looking fine, slightly thinner, but that makes her all the more alluring. . . . We'll pop into studio two. . . . Willard Robison is getting ready to rehearse his Deep River orchestra. We shake hands and he tells me he has several new songs, unpublished. A very serious-minded young man, all wrapped up in his music, very uncommercial, but what an artist! . . . There's Basil Ruysdael, the resonant-voiced announcer, tall, kindly; and there's his sweet little wife, Rose. She's an English girl; used to be a dancer with a Tiller group; now she's content to be just Basil's wife, and they're both very happy. . . . Basil is looking over the continuity for Willard's program. . . . If you have never listened to this program, do so by all means. It is on three times weekly, Mondays, 8:30 p.m.; Tuesdays, 11:00 p.m. and Wednesdays at 9:30 p.m.

In studio 3. Heywood Broun, noted author and columnist, is interviewing Hendrik Van Loon, also a noted author; they are talking about the latter's latest book on geography. . . . Broun is such a jolly man, nice, large and lumbering. . . . Well, time to get into the control room of Studio 1, if we're going to watch the Market and Halsey Street broadcast. . . . Here we are, in a little room full of electrical gadgets. . . A broad window looks out onto the studio. . . . There's Roger Bower, the nutty master-of-ceremonies, hopping about like a flea. Cute little Beth Challis, dressed very becomingly in blue, is the bright particular star of this broadcast. (By the way; Beth tells me she will open on WEAF, October 23rd, with Ohman and Arden, for a series of programs sponsored by Pyro). . . . Lee Cronican is conducting the orchestra. . . Very clever chap, Lee, and an excellent pianist. . . . The Three Gibson Girls are also on the program; these girls are great; voices blend perfectly. . . . Gene King, tenor, Roy Shelley, the poet of the uke; Don Trent, character artist: and the three dancing girs, comprise the rest of the cast. . . . "Sweet and Low" is just finishing; the control engineer flips a switch and the show is on.

This broadcast is not as realistic as the old Market and Halsey of a year or so back. . . . We miss the newsreel, and Roger's stentorian cry of "Popcorn and peanuts" . . . but it's a good show. . . . The audience laugh and applaud when necessary; they have a jolly good time and it all comes over the microphone very smoothly. . . . Passes to view this broadcast may be obtained from Station WOR, 1440 Broadway, New York.

Well, that's over; Mildred Hunt is now crooning; she's doing a good job these days. . . . Listeners are wondering what instruments she uses for accompaniment. . . . I could tell you, but it's intended to be a secret, so supposing you tune in one of these nights, and figure it out for yourself; anyhow, the accompaniment is very delightful. . . . Time for me to meander home. . . . So into a taxi and over Queensboro Bridge. . . . I've been going since seven this morning without a let-up; it's now eleven-thirty p.m.—don't you think it's time I went to bed? . . . So do I! . . . Good night, and pleasant dreams. .

* * *

TEN YEARS AGO THIS WEEK

(Continued from preceding page)

(5)—If it is necessary to cross other wires, run as nearly as possible at right angles to these, and as far as you can above them.

Since then many radio writers have been paid adequately for saying no more, but taking many more words in which to say less.

That issue contained a list of broadcasting stations giving call, owner and location. Not a word about frequency or wavelength, or about power, or limited service, time-sharing and other modern trimmings. The reason no wavelength was given was that it must have been known to all readers that all these 510 stations (there are 610 now) were on one wavelength, 360 meters. There was another wavelength on which stations were to be assigned if they could come up to requirements—satisfactory programs, and 500 watts output. These were to be the Class B stations, but no actual operation under a Class B license evidently had been attempted yet. The whole matter was before the illustrious Secretary of Commerce, one Herbert Hoover, who exercised over radio whatever jurisdiction there was.

Only two stations had been authorized to transmit on the 400-meter Class B wave, up to this time. They were the St. Louis Post-Dispatch station and the Chicago Westinghouse station. And, by the way, California had the greatest number of stations (66), Ohio was second (34), New York third (28) and Pennsylvania fourth (27).

Biographical Brevities

ABOUT ANDRE BARUCH

Andre Baruch, the popular Columbia announcer, was born in Paris, France, on August 20th, 1906. When eleven years old he came to New York. He very quickly learned to speak English, having studied its fundamentals at school in Paris. . . . Completing his elementary studies here he enrolled at Columbia University, graduating from there in 1929 with an A.B. degree. . . . There followed a year of art study at the Pratt Institute, Brooklyn, and a scholarship which took him to the

(Continued on next page)

Station Sparks

By Alice Remsen

(Continued from preceding page)

Beaux Arts in Paris. . . . He also studied piano technique under Hans Bachman in New York.

To help pay for his tuition at Columbia, Andre did part time work, such as drafting in a construction company and posing for art classes. . . . As early as his freshman year he made his radio debut quite by accident. . . . One day when he was passing the Coney Island Hotel, where Station WCGU was located, he was inspired to step in and apply for a job as staff pianist. The impulse bore immediate fruit, but he was soon graduated to the role of announcer; his remaining college years were well filled with radio dates, classes, considerable athletic participation, and free lance commercial art.

Trying his hand at both illustration and advertising, some of his work appeared in the Saturday Evening Post, Collier's and other magazines. . . . During his college days his announcing was heard through Stations WCGU, WBBC, WSGH, WGBS (now WINS) as well as WLTH in Brooklyn and WTIC, Hartford.

Active in athletics, Andre represented Columbia on the football, basketball and swimming teams. . . . He also found time to draw for "The Jester," Columbia's comic magazine. . . . He still swims to keep himself fit. . . . His specialty is the dashes, although he held a backstroke record won in a Paris sectional meet, and won the Metropolitan Diving Championship in a New York meet. . . . After his return from Paris in 1930 he decided to cast his lot with radio and applied for a position as staff pianist at the Columbia studios. . . . But just before he turned in his application blank he changed his mind and scratched out the word pianist, to replace it with the word announcer. . . . Several interviews and an audition followed, and he was accepted. . . . His "au 'voir" is now familiar to all of Columbia's listeners. . . . Andre speaks seven languages, an accomplishment that any announcer would welcome. . . . He is fluent in English, French, Spanish, and Italian, and he can carry on a fair conversation in Dutch, Flemish and Portuguese. . . . When he gets excited, however, he is apt to burst into a barrage of French, and he still blushes in memory of a time he did just that on the air.

He is a very likeable chap, with a ready wit, a pleasant smile, nice looking, well-groomed and very intelligent.

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(If you would care to know something of your favorite radio personalities, send a card to the conductor of this page. Address hers Miss Alice Remsen, care Radio World, 145 W. 45th St., New York, N. Y.)

New Incorporations

Amalgamated Broadcasting System, New York City, radio and television broadcasting—Atty., J. P. Bickerton, Jr., 220 West 42nd St., New York City.

Brunswick Engineers, New York City, radio business—Atty., E. Ebenstein, 175 Fifth Avenue, New York City.

Superb Furniture and Radio Corp., New York City—Attys., Hyman & Hyman, 103 E. 125th St., New York City.

American Radio System, Inc., Dover, Del., general broadcasting—Attys., United States Corporation Co., Dover, Del.

Grebe Radio and Television Corp., New York City—Atty., H. Goldman, 120 Broadway, New York City.

New York School of Radio Technique, New York City, broadcasting instruction—Atty., H. Emerson, 1450 Broadway, New York City.

Rotor Electric Co., Jersey City, N. J., electrical business—Atty., Morris F. Pearlman, Jersey City, N. J.

David Bogen Co., Brooklyn, N. Y., electrical supplies—Attys., Albany Service Co., 315 Broadway, New York City.

CORPORATE CHANGES

Radio Circular Co., New York City, Mergers Norge Refrigerator Co. of New York.

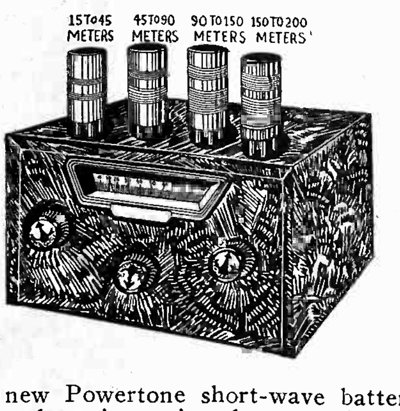
Davega, New York City, City Radio Stores Corp., forming Davega-City Radio.

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.*

Jacob Till, Jr., 823 Rose St., Youngstown, Ohio.
Ebenezer B. Peebles, 2059 W. Roosevelt Rd., Chicago, Ill.
W. F. Woodward, Riverside Military Academy, Gainesville, Ga.
F. Mascardelle, 223 Thorne St., Sault Ste. Marie, Ont., Can.
G. Arlowe Bryant, (low priced midget), 857 W. Broad St., Columbus, Ohio.
Herman Finberg, 207 So. Alden St., Philadelphia, Pa.
J. F. Williams, 1209 Lincoln Ave., Steubenville, Ohio.
H. C. Dickey, 2811 Brush Street, Detroit, Mich.
Arthur J. Willett, 806 So. Barstow St., Eau Claire, Wis.
Charles E. Campbell, 4217 34th Ave. (Oakley), Cincinnati, Ohio.
William F. Strigel, 5224 Sylvester St., Philadelphia, Pa.
Patch and King, Courier Bldg., Youngsville, Pa.
Albert Suedtke, 643 E. Potter Ave., Milwaukee, Wis.
John Stupar, 3412 W. 117th St., Cleveland, Ohio.
A. F. Ruiz, P. O. Box 99, Banes, Oriente, Cuba.
Ernest Ash, 77 Patrick Street, St. John's Newfoundland.
Hilbert Davis, 827 Dufferin Ave., London, Ont., Canada.
A. P. Hornbuckle, 239 Edna Place, Macon, Ga.
Chas. H. Hardee, c/o Turnipseed Motor Co., Ocala, Fla.
Elvin F. LaSalle, LaSalle Bros., Chesterville, Ont., Canada.
J. B. Cleveland, 278 Hernando St., Memphis, Tenn.
J. L. Stuart, 3323 Warren Blvd., Chicago, Ill.
Ambrose Radio Service, O. Ingmar Oleson, Ambrose, No. Dak.
Richard L. Rossee, 174 Central Ave., Bogota, N. J.
Southwest Radio Service, 107 S. St. Paul St., Dallas, Texas.
Excel Elec. Service Co., 1935-1941 W. 23rd St., Chicago, Ill.
Jenkins Radio Repair Shop, Ensley, Ala.
Arthur Hall, 2321 Shady Brook Drive, Fort Wayne, Ind.
L. Haleet, Power Lake, N. D.
Edgar Brisman, R. R. No. 1, New Lebanon, Ohio.
S. H. Burns, Amenia, N. Y.

Try-Mo Uses 2-Volt Tubes for Short Waves



A new Powertone short-wave battery-operated receiver using the two-volt tubes and Hammarlund condenser, complete with four coils covering from 14 to 200 meters, is being merchandized by Try-Mo Radio Co., of 85 Cortlandt Street, New York City.

Extensive experiments have shown excellent result with the use of the new two-volt tubes. Greatly increased sensitivity is obtained and current consumption kept lower. The parts are sturdily mounted on a metal base, and beautifully housed in a crackle finished metal cabinet which completely shields the set. A '32 screen grid tube and a '33 power amplifier tube are used.

SHORT-WAVE CLUB

Walter F. Clark, Box No. 31, Excelsior, Minn.
Daniel Wisner, 2019 Leamington Ave., Chicago, Ill.
Frank Switalski, Jr., 2819 Victoria Ave., Cincinnati, Ohio.

Tradiograms

By J. Murray Barron

Mathematics

Servicemen and also experimenters in radio very often find themselves limited in their work if they have failed to equip themselves with a good groundwork in mathematics. Those who possess this naturally would be lost without it and very often many of the others while knowing there is much they can not seem to grasp, do not fully appreciate the great value of arithmetic. To many, figures is a great big headache, and yet there is no trade or business that can get along successfully without arithmetic.

You must have a working knowledge of mathematics to succeed in radio, and without it you are simply working in the dark and losing much valuable time and making a lot of unnecessary work and worry for yourself. To those who feel backward about letting the world know of this lack of knowledge, it might be said that this information can not be concealed, for in discussing radio you can not do so in generalities when you attempt to get into the techincal part of it. Possibly you may not need to take up calculus, but trigonometry will prove valuable and in any event one should have a knowledge of algebra. Even to one with practically no knowledge of arithmetic or very little it is possible to acquire this information through home study. There are some very excellent books on mathematics, and likewise simple courses that carry you through step by step. There are short cuts and methods that will save many hours of your work and aid you to do your work. This knowledge, once acquired, will open up new avenues of thought and make many so-called problems fade out. To those who may feel that books and courses are not the way to learn things, and there are many who feel that way, it might be well to remind them that books are in reality just the printed records of performances of the past.

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Radisco reports excellent results from installation of R. C. A. Victor Antennaplex in Hudson County, New Jersey. In one retail radio store which is located within 25 feet of a Public Service generator power house, where the worse kind of electrical interference had been a constant source of annoyance, a decided improvement of reception and the elimination of interference were brought about since the installation of the Antennaplex System, also a larger increased sale of radio receivers, due to clearer reception.

* * *

Sam Roth, president of Federated Purchaser, 25 Park Place, New York City, gives some very good advice in the October 1st issue of the Federated Microphone, which is issued by the above company, to the effect that servicemen who are wise will get into the public address end of radio. There are rich profits to be had and the application of sound amplification is so widespread that one need not go outside his own natural territory to obtain plenty of business. Sales points are very evident and easily demonstrated, the installation not difficult, and results and profits gratifying. One should of course use only good equipment. Mr. Roth gives a thumbnail sketch of the radio business since 1925 and the natural developments, showing the various improvements that came to pass and which aided to help stimulate business at times when perhaps it was getting into a slump. With that thought in mind he offers the public address as a real stimulator of business and a natural line for the serviceman.

The conversion table printed on the page herewith is highly accurate, because worked out by the factor 299,820. Most tables are based on the factor 300,000, which is erroneous to 6 parts in 10,000.

The table is entirely reversible, for instance, 10 meters equal 29,982 kc., or 29,982 meters equal 10 kc. Any quantities not included in the table may be read by shifting the decimal point. If moved to the right for frequency the point is moved to the left for wavelength, and vice versa. The shift is therefore in opposite directions.

The factor 299,820 is based on the velocity of a radio wave, which is equal to the velocity of light, or 299,820,000 meters per second. By dropping the three ciphers (dividing by 1,000), the factor 299,820 is used, and the answer reads in kilocycles.

Wavelength in meters frequency in kc.

kc or m	m or kc	kc or m	m or kc	kc or m	m or kc	kc or m	m or kc	kc or m	m or kc	kc or m	m or kc	kc or m	m or kc	kc or m	m or kc	kc or m	m or kc	kc or m	m or kc
10	29,982	1,010	296.9	2,010	149.2	3,010	99.61	4,010	74.77	5,010	59.84	6,010	49.89	7,010	42.77	8,010	37.43	9,010	33.28
20	14,991	1,020	293.9	2,020	148.4	3,020	99.28	4,020	74.58	5,020	59.73	6,020	49.80	7,020	42.71	8,020	37.38	9,020	33.24
30	9,994	1,030	291.1	2,030	147.7	3,030	98.95	4,030	74.40	5,030	59.61	6,030	49.72	7,030	42.65	8,030	37.34	9,030	33.20
40	7,496	1,040	288.3	2,040	147.0	3,040	98.62	4,040	74.21	5,040	59.49	6,040	49.64	7,040	42.59	8,040	37.29	9,040	33.17
50	5,996	1,050	285.5	2,050	146.3	3,050	98.30	4,050	74.03	5,050	59.37	6,050	49.56	7,050	42.53	8,050	37.24	9,050	33.13
60	4,997	1,060	282.8	2,060	145.5	3,060	97.98	4,060	73.85	5,060	59.25	6,060	49.48	7,060	42.47	8,060	37.20	9,060	33.09
70	4,283	1,070	280.2	2,070	144.8	3,070	97.66	4,070	73.67	5,070	59.13	6,070	49.39	7,070	42.41	8,070	37.15	9,070	33.06
80	3,748	1,080	277.6	2,080	144.1	3,080	97.34	4,080	73.49	5,080	59.02	6,080	49.31	7,080	42.35	8,080	37.11	9,080	33.02
90	3,331	1,090	275.1	2,090	143.5	3,090	97.03	4,090	73.31	5,090	58.90	6,090	49.23	7,090	42.29	8,090	37.06	9,090	32.98
100	2,998	1,100	272.6	2,100	142.8	3,100	96.72	4,100	73.13	5,100	58.79	6,100	49.15	7,100	42.23	8,100	37.01	9,100	32.95
110	2,726	1,110	270.1	2,110	142.1	3,110	96.41	4,110	72.95	5,110	58.67	6,110	49.07	7,110	42.17	8,110	36.97	9,110	32.91
120	2,499	1,120	267.7	2,120	141.4	3,120	96.10	4,120	72.77	5,120	58.56	6,120	48.99	7,120	42.11	8,120	36.92	9,120	32.88
130	2,306	1,130	265.3	2,130	140.8	3,130	95.79	4,130	72.60	5,130	58.44	6,130	48.91	7,130	42.05	8,130	36.88	9,130	32.84
140	2,142	1,140	263.0	2,140	140.1	3,140	95.48	4,140	72.42	5,140	58.33	6,140	48.83	7,140	41.99	8,140	36.83	9,140	32.80
150	1,999	1,150	260.7	2,150	139.5	3,150	95.18	4,150	72.25	5,150	58.22	6,150	48.75	7,150	41.93	8,150	36.79	9,150	32.77
160	1,874	1,160	258.5	2,160	138.8	3,160	94.88	4,160	72.07	5,160	58.10	6,160	48.67	7,160	41.87	8,160	36.74	9,160	32.73
170	1,764	1,170	256.3	2,170	138.1	3,170	94.58	4,170	71.90	5,170	57.99	6,170	48.59	7,170	41.82	8,170	36.70	9,170	32.70
180	1,666	1,180	254.1	2,180	137.5	3,180	94.28	4,180	71.73	5,180	57.88	6,180	48.51	7,180	41.76	8,180	36.65	9,180	32.66
190	1,578	1,190	252.0	2,190	136.9	3,190	93.99	4,190	71.56	5,190	57.77	6,190	48.44	7,190	41.70	8,190	36.61	9,190	32.62
200	1,499	1,200	249.9	2,200	136.3	3,200	93.69	4,200	71.39	5,200	57.66	6,200	48.36	7,200	41.64	8,200	36.56	9,200	32.59
210	1,428	1,210	247.8	2,210	135.7	3,210	93.40	4,210	71.22	5,210	57.55	6,210	48.28	7,210	41.58	8,210	36.52	9,210	32.55
220	1,363	1,220	245.8	2,220	135.1	3,220	93.11	4,220	71.05	5,220	57.44	6,220	48.20	7,220	41.53	8,220	36.47	9,220	32.52
230	1,304	1,230	243.8	2,230	134.4	3,230	92.82	4,230	70.88	5,230	57.33	6,230	48.13	7,230	41.47	8,230	36.43	9,230	32.48
240	1,249	1,240	241.8	2,240	133.8	3,240	92.54	4,240	70.71	5,240	57.22	6,240	48.05	7,240	41.41	8,240	36.39	9,240	32.45
250	1,199	1,250	239.9	2,250	133.3	3,250	92.25	4,250	70.55	5,250	57.11	6,250	47.97	7,250	41.35	8,250	36.34	9,250	32.41
260	1,153	1,260	238.0	2,260	132.7	3,260	91.97	4,260	70.38	5,260	57.00	6,260	47.89	7,260	41.30	8,260	36.30	9,260	32.38
270	1,110	1,270	236.1	2,270	132.1	3,270	91.69	4,270	70.22	5,270	56.89	6,270	47.82	7,270	41.24	8,270	36.25	9,270	32.34
280	1,071	1,280	234.2	2,280	131.5	3,280	91.41	4,280	70.05	5,280	56.78	6,280	47.74	7,280	41.18	8,280	36.21	9,280	32.31
290	1,034	1,290	232.4	2,290	130.9	3,290	91.13	4,290	69.89	5,290	56.68	6,290	47.67	7,290	41.13	8,290	36.17	9,290	32.27
300	999.4	1,300	230.6	2,300	130.4	3,300	90.86	4,300	69.73	5,300	56.57	6,300	47.59	7,300	41.07	8,300	36.12	9,300	32.24
310	967.2	1,310	228.9	2,310	129.8	3,310	90.58	4,310	69.56	5,310	56.46	6,310	47.52	7,310	41.02	8,310	36.08	9,310	32.20
320	936.9	1,320	227.1	2,320	129.2	3,320	90.31	4,320	69.40	5,320	56.36	6,320	47.44	7,320	40.96	8,320	36.04	9,320	32.17
330	908.6	1,330	225.4	2,330	128.7	3,330	90.04	4,330	69.24	5,330	56.25	6,330	47.36	7,330	40.90	8,330	35.99	9,330	32.14
340	881.8	1,340	223.7	2,340	128.1	3,340	89.77	4,340	69.08	5,340	56.15	6,340	47.29	7,340	40.85	8,340	35.95	9,340	32.10
350	856.6	1,350	222.1	2,350	127.6	3,350	89.50	4,350	68.92	5,350	56.04	6,350	47.22	7,350	40.79	8,350	35.91	9,350	32.07
360	832.8	1,360	220.4	2,360	127.0	3,360	89.23	4,360	68.77	5,360	55.94	6,360	47.14	7,360	40.74	8,360	35.86	9,360	32.03
370	810.3	1,370	218.8	2,370	126.5	3,370	88.97	4,370	68.61	5,370	55.83	6,370	47.07	7,370	40.68	8,370	35.82	9,370	32.00
380	789.0	1,380	217.3	2,380	126.0	3,380	88.70	4,380	68.45	5,380	55.73	6,380	46.99	7,380	40.63	8,380	35.78	9,380	31.96
390	768.8	1,390	215.7	2,390	125.4	3,390	88.44	4,390	68.30	5,390	55.63	6,390	46.92	7,390	40.57	8,390	35.74	9,390	31.93
400	749.6	1,400	214.2	2,400	124.9	3,400	88.18	4,400	68.14	5,400	55.52	6,400	46.85	7,400	40.52	8,400	35.69	9,400	31.90
410	731.3	1,410	212.6	2,410	124.4	3,410	87.92	4,410	67.99	5,410	55.42	6,410	46.77	7,410	40.46	8,410	35.65	9,410	31.86
420	713.9	1,420	211.1	2,420	123.9	3,420	87.67	4,420	67.83	5,420	55.32	6,420	46.70	7,420	40.41	8,420	35.61	9,420	31.83
430	697.3	1,430	209.7	2,430	123.4	3,430	87.41	4,430	67.68	5,430	55.22	6,430	46.63	7,430	40.35	8,430	35.57	9,430	31.79
440	681.4	1,440	208.2	2,440	122.9	3,440	87.16	4,440	67.53	5,440	55.11	6,440	46.56	7,440	40.30	8,440	35.52	9,440	31.76
450	666.3	1,450	206.8	2,450	122.4	3,450	86.90	4,450	67.38	5,450	55.01	6,450	46.48	7,450	40.24	8,450	35.48	9,450	31.73
460	651.8	1,460	205.4	2,460	121.9	3,460	86.65	4,460	67.22	5,460	54.91	6,460	46.41	7,460	40.19	8,460	35.44	9,460	31.69
470	637.9	1,470	204.0	2,470	121.4	3,470	86.40	4,470	67.07	5,470	54.81	6,470	46.34	7,470	40.14	8,470	35.40	9,470	31.66
480	624.6	1,480	202.6	2,480	120.9	3,480	86.16	4,480	66.92	5,480	54.71	6,480	46.27	7,480	40.08	8,480	35.36	9,480	31.63
490	611.9	1,490	201.2	2,490	120.4	3,490	85.91	4,490	66.78	5,490	54.61	6,490	46.20	7,490	40.03	8,490	35.31	9,490	31.59
500	599.6	1,500	199.9	2,500	119.9	3,500	85.66	4,500	66.63	5,500	54.51	6,500	46.13	7,500	39.98	8,500	35.27	9,500	31.56
510	587.9	1,510	198.6	2,510	119.5	3,510	85.42	4,510	66.48	5,510	54.41	6,510	46.06	7,510	39.92	8,510	35.23	9,510	31.53
520	576.6	1,520	197.2	2,520	119.0	3,520	85.18	4,520	66.33	5,520	54.32	6,520	45.98	7,520	39.87	8,520	35.19	9,520	31.49
530	565.7	1,530	196.0	2,530	118.5	3,530	84.94	4,530	66.19	5,530	54.22	6,530	45.91	7,530	39.82	8,530	35.15	9,530	31.46
540	555.2	1,540	194.7	2,540	118.0	3,540	84.70	4,540	66.04	5,540	54.12	6,540	45.84	7,540	39.76	8,540	35.11	9,540	31.43
550	545.1	1,550	193.4	2,550	117.6	3,550	84.46	4,550	65.89	5,550	54.02	6,550	45.77	7,550	39.71	8,550	35.07	9,550	31.39
560	535.4	1,560	192.2	2,560	117.1	3,560	84.22	4,560	65.75	5,560	53.92	6,560	45.70	7,560	39.66	8,560	35.03	9,560	31.36
570	526.0	1,570	191.0	2,570	116.7	3,570	83.98	4,570	65.61	5,570	53.83	6,570	45.63	7,570	39.61	8,570	34.98	9,570	31.33
580	516.9	1,580	189.8	2,580	116.2	3,580	83.75	4,580	65.46	5,580	53.73	6,580	45.57	7,580	39.55	8,580	34.94	9,580	31.30
590	508.2	1,590	188.6	2,590	115.8	3,590	83.52	4,590	65.32	5,590	53.64	6,590	45.50	7,590	39.50	8,590	34.90	9,590	31.26
600	499.7	1,600	187.4	2,600	115.3	3,600	83.28	4,600	65.18	5,600	53.54	6,600	45.43	7,600	39.45	8,600	34.86	9,600	31.23
610	491.5	1,610	186.2	2,610	114.9	3,610	83.05	4,610	65.04	5,610	53.44	6,610	45.36	7,610	39.40	8,610	34.82	9,610	31.20
620	483.6	1,620	185.1	2,620	114.4	3,620	82.82	4,620	64.90	5,620	53.35	6,620	45.29	7,620	39.35	8,620	34.78	9,620	31.17
630	475.9	1,630	183.9	2,630	114.0	3,630	82.60	4,630	64.76	5,630	53.25	6,630	45.22	7,630	39.29	8,630	34.74	9,630	31.13
640	468.5	1,640	182.8	2,640	113.6	3,640	82.37	4,640	64.62	5,640	53.16	6,640	45.15	7,640	39.24	8,640	34.70	9,640	31.10
650	461.3	1,650	181.7	2,650	113.1	3,650	82.14	4,650	64.48	5,650	53.07	6,650	45.09	7,650	39.19	8,650	34.66	9,650	31.07
660	454.3	1,660	180.6	2,660	112.7	3,660	81.92	4,660	64.34	5,660	52.97	6,660	45.02	7,660	39.14	8,660	34.62	9,660	31.04
670	447.5	1,670	179.5	2,670	112.3	3,670	81.70	4,670	64.20	5,670	52.88	6,670	44.95	7,670	39.09	8,670	34.58	9,670	31.01
680	440.9	1,680	178.5	2,680	111.9	3,680	81.47	4,680	64.06	5,680	52.79	6,680	44.88	7,680	39.04	8,680	34.54	9,680	30.97
690	434.5	1,690	177.4	2,690	111.5	3,690	81.25	4,690	63.93	5,690	52.69	6,690	44.82	7,690	38.99	8,690	34.50	9,690	30.94
700	428.3	1,700	176.4	2,700	111.0	3,700	81.03	4,700	63.79	5,700	52.60	6,700	44.75	7,700	38.94	8,700	34.46	9,700	30.91
710	422.3	1,710	175.3	2,710	110.6	3,710	80.81	4,710	63.66	5,710	52.51	6,710	44.68	7,710	38.89	8,710	34.42	9,710	30.88
720	416.4	1,720	174.3	2,720	110.2	3,720	80.60	4,720	63.52	5,720	52.42	6,720	44.62	7,720	38.84	8,720	34.38	9,720	30.85
730	410.7	1,730	173.3	2,730	109.8	3,730	80.38	4,730	63.39	5,730	52.32	6,730	44.55	7,730	38.79	8,730	34.34	9,730	30.81
740	405.2	1,740	172.3	2,740	109.4	3,740	80.17	4,740	63.25	5,740	52.23	6,740	44.48	7,740	38.74	8,740	34.30	9,740	30.78
750	399.8	1,750	171.3	2,750	109.0	3,750	79.95	4,750	63.12	5,750	52.14	6,750	44.42	7,750	38.69	8,750	34.27	9,750	30.75
760	394.5	1,760	170.4	2,760	108.6	3,760	79.74	4,760	62.99	5,760	52.05	6,760	44.35	7,760	38.64	8,760	34.23	9,760	30.72
770	389.4	1,770	169.4	2,770	108.2	3,770	79.53	4,770	62.86	5,770	51.96	6,770	44.29	7,770	38.59	8,770	34.19	9,770	30.69
780	384.4	1,780	168.4	2,780	107.8	3,780	79.32	4,780	62.72	5,780	51.87	6,780	44.22	7,780	38.54	8,780	34.15	9,780	30.66
790	379.5	1,790	167.5	2,790	107.5	3,790	79.11	4,790	62.59	5,790	51.78	6,790	44.16	7,790	38.49	8,790	34.11	9,790	30.63
800	374.8	1,800	166.6	2,800	107.1	3,800	78.90	4,800	62.46	5,800	51.69	6,800	44.09	7,800	38.44	8,800	34.07	9,800	30.59
810	370.2	1,810	165.6	2,810	106.7	3,810	78.69	4,810	62.33	5,810	51.60	6,810	44.03	7,810	38.39	8,810	34.03	9,810	30.56
820	365.6	1,820	164.7	2,820	106.3	3,820	78.49	4,820	62.20	5,820	51.52	6,820	43.96	7,820	38.34	8,820	33.99	9,820	30.53
830	361.2	1,830	163.8	2,830	105.9	3,830	78.28	4,830	62.07	5,830	51.43	6,830	43.90	7,830	38.29	8,830	33.95	9,830	30.50
840	356.9	1,840	162.9	2,840	105.6	3,840	78.08	4,840	61.95	5,840	51.34	6,840	43.83	7,840	38.24	8,840	33.92	9,840	30.47
850	352.7	1,850	162.1	2,850	105.2	3,850	77.88	4,850	61.82	5,850	51.25	6,850	43.77	7,850	38.19	8,850	33.88	9,850	30.44
860	348.6	1,860	161.2	2,860	104.8	3,860	77.67	4,860	61.69	5,860	51.16	6,860	43.71	7,860	38.14	8,860	33.84	9,860	30.41
870	344.6	1,870	160.3	2,870	104.5	3,870	77.47	4,870	61.56	5,870	51.08	6,870	43.64	7,870	38.10	8,870	33.80	9,870	30.38
880	340.7	1,880	159.5	2,880	104.1	3,880	77.27	4,880	61.44	5,880	50.99	6,880	43.58	7,880	38.05	8,880	33.76	9,880	30.35
890	336.9	1,890	158.6	2,890	103.7	3,890	77.07	4,890	61.31	5,890	50.90	6,890	43.52	7,890	38.00	8,890	33.73	9,890	30.32
900	333.1	1,900	157.8	2,900	103.4	3,900	76.88	4,900	61.19	5,900	50.82	6,900	43.45	7,900	37.95	8,900	33.69	9,900	30.28
910	329.5	1,910	157.0	2,910	103.0	3,910	76.68	4,910	61.06	5,910	50.73	6,910	43.39	7,910	37.90	8,910	33.65	9,910	30.25
920	325.9	1,920	156.2	2,920	102.7	3,920	76.48	4,920	60.94	5,920	50.65	6,920	43.33	7,920	37.86	8,920	33.61	9,920	30.22
930	322.4	1,930	155.3	2,930	102.3	3,930	76.29	4,930	60.82	5,930	50.56	6,930	43.26	7,930	37.81	8,930	33.57	9,930	30.19
940	319.0	1,940	154.5	2,940	102.0	3,940	76.10	4,940	60.69	5,940	50.47	6,940	43.20	7,940	37.76	8,940	33.54	9,940	30.16
950	315.6	1,950	153.8	2,950	101.6	3,950	75.90	4,950	60.57	5,950	50.39	6,950	43.14	7,950	37.71	8,950	33.50	9,950	30.13
960	312.3	1,960	153.0	2,960	101.3	3,960	75.71	4,960	60.45	5,960	50.31	6,960	43.08	7,960	37.67	8,960	33.46	9,960	30.10
970	309.1	1,970	152.2	2,970	100.9	3,970	75.52	4,970	60.33	5,970	50.22	6,970	43.02	7,970	37.62	8,970	33.42	9,970	30.07
980	303.9	1,980	151.4	2,980	100.6	3,980	75.33	4,980	60.20	5,980	50.14	6,980	42.95	7,980	37.57	8,980	33.39	9,980	30.04
990	302.8	1,990	150.7	2,990	100.3	3,990	75.14	4,990	60.08	5,990	50.05	6,990	42.89	7,990	37.52	8,990	33.35	9,990	30.01
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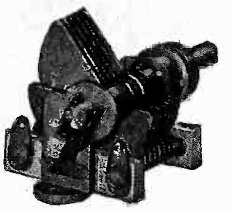

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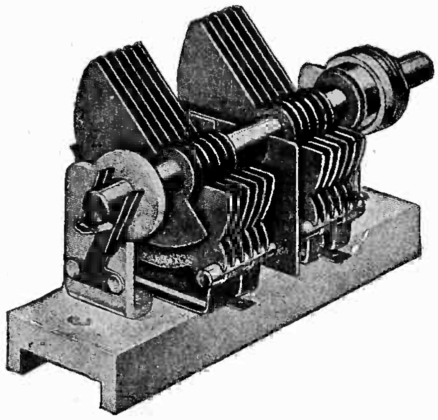

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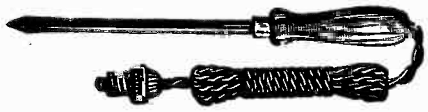

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Of Radio World published weekly at New York, N. Y., for October 1, 1932.

State of New York }
County of New York } ss.

Before me, a Notary Public in and for the State and county aforesaid, personally appeared Roland Burke Hennessy, who, having been duly sworn according to law, deposes and says that he is the Editor of the Radio World, and that the following is, to the best of his knowledge and belief, a true statement of the ownership, management (and if a daily paper, the circulation), etc., of the aforesaid publication for the date shown in the above caption, required by the Act of August 24, 1912, embodied in section 411, Postal Laws and Regulations, printed on the reverse of this form, to wit:

1. That the names and addresses of the publisher, editor, managing editor and business managers are: Publishers Hennessy Radio Publications Corp., 145 West 45th St., N. Y. C. Editor Roland Burke Hennessy, 145 West 45th St., N. Y. C. Managing Editor, Herman Bernard 145 West 45th St., N. Y. C. Business Manager Herman Bernard, 145 West 45th St., N. Y. C.

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3. That the known bondholders, mortgagees, and other security holders owning or holding 1 per cent or more of total amount of bonds, mortgages, or other securities are: (If there are none, so state.) None.

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ROLAND BURKE HENNESSY
(Signature of Editor.)

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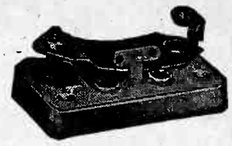

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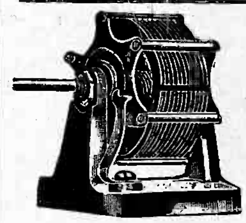

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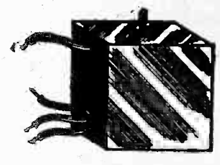

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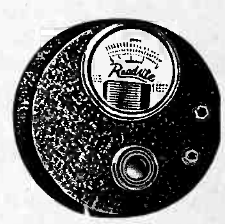
RADIO WORLD, 145 West 45th Street, New York. (Just East of Broadway)

THREE-IN-ONE TESTER *FREE!*

EVERYBODY who does any radio work whatsoever, whether for fun or for pay or for both, needs a continuity tester, so he can discover opens or shorts when testing.

A mere continuity tester is all right, but—



Often it is desired to determine the resistance value of a unit, to determine if it is correct, or to measure a low voltage, and then a continuity tester that is also a direct-reading ohmmeter and a DC voltmeter comes in triply handy.

So here is the combination of all three:

A 0-4½-volt DC voltmeter, a 0-10,000-ohm ohmmeter and a continuity tester. A rheostat is built in for correct zero resistance adjustment or maximum voltage 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. Weight, 1 lb. Sent you with an order for one year's subscription for RADIO WORLD (52 weeks) at the regular rate of $6. Order Cat. PR-500. Use Coupon below.

Radio World, 145 W. 45th Street, New York, N. Y.

Enclosed please find $6 for one year's subscription for Radio World (one copy a week, 52 issues). Send Cat. PR-500 as premium.

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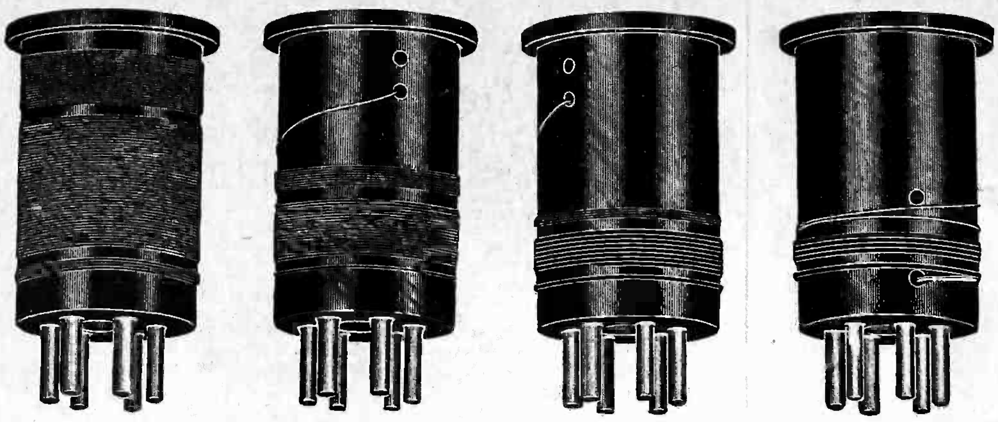
6-Pin Plug-In Coils

200 to 15 Meters with 0.00014 mfd.

SHORT - WAVE plug - in coils with three separate windings for detector circuit produce best results as they avoid the broadness of plate-circuit tuning or the losses of r-f choke load on plate circuit due to damping. The lower winding is for r-f plate circuit, if t-r-f is used, or for aerial otherwise, the center winding is the tuned secondary, while the top winding is for feedback. The coils are accurately **wound on 1.25** inch diameter Bakelite and have a 1/8-inch flange for gripping. Thus the actual **winding need never be touched** when you're handling the coils, and they are suitable for calibration.



Cat. SWB—Four plug-in coils, 6-pin base; primary, secondary, fixed tickler....................$1.70
Cat. SZ—Six-spring wafer socket for use as coil receptacle for six-pin coils....................11c
Cat. SWA—Four plug-in coils, UX base, primary and secondary; primary may be used for feedback if condenser connects serial to grid....................$1.35
Cat. SX—Four-spring (UX) wafer socket for use as coil receptacle for four-pin coils....................10c
Cat. H-14—Hammarlund junior midline 0.00014 mfd. condenser with Isolantite insulation....................$1.20
Cat. H-20—Hammarlund junior midline 0.0002 mfd. condenser with Isolantite insulation. Used as feedback control....................$1.35

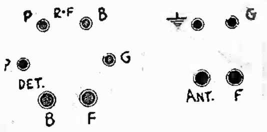
THE secondary is to be tuned with 0.00014 mfd. capacity. Using four coils, there will be sufficient overlapping of bands, also assured coverage to above 200 and below 15 meters. Also, 0.00015 mfd. may be used instead for tuning, with slightly greater overlap. Regeneration may be controlled by a 0.0002 mfd. variable condenser from detector plate to ground, or by a plate voltage rheostat or other means.

The standard six-pin tube socket may be used for coil receptacle.

For antenna stage tuning only two windings are needed, where no stage of t-r-f is included when use SWA.

HOW TO USE THE COILS FOR HIGHEST EFFICIENCY AND SMOOTHEST OPERATION

In building short-wave receivers using our plug-in coils be careful to locate the coils so that the centers of their cores are at least 6 inches apart, otherwise in sets with t-r-f- the r-f tube may oscillate. Even if a volume control in the r-f stage controls any oscillation present the recommended separation should be maintained, otherwise a critical circuit results.



The connections to make are diagrammed herewith. Bottom views of sockets are shown. For the 6-pin coil P-B RF goes to aerial and ground if there is no r-f. Standard UX and 6-pin sockets serve as coil receptacles.

HIGH-GAIN SHIELDED COILS FOR T-R-F

DIRECTIONS FOR BEST RESULTS

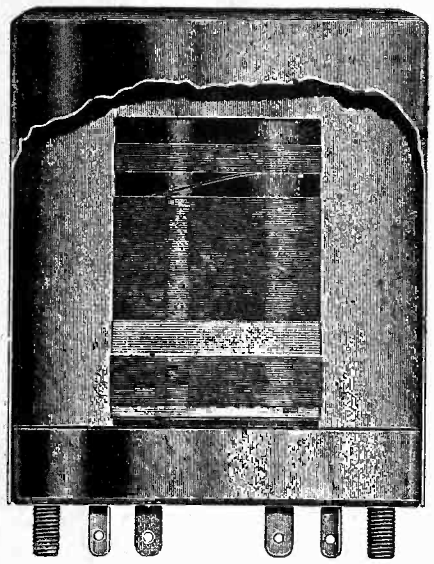
THE shielded coils for tuned radio frequency sets are supplied in matched sets of three or four, with secondary inductance equalized (plus or minus 0.6 microhenry). Thus any lack of sensitivity due to mismatched secondaries is avoided. As inductive discrepancies could not be compensated for by parallel capacity trimming, this high degree of inductive accuracy is important. Complete coverage of the wave band with the specified capacity condensers is absolutely guaranteed.

The coils may be used (set of three) for t-r-f, and with minimum value of negative bias for r-f tubes may oscillate a little at the very highest frequencies, say 1500 to 1580 kc, as they will be tuned below the broadcast band about that much. The negative bias should be increased until oscillation completely stops. Thus also selectivity is improved by heightened permanent or limiting bias.

In using four coils (three stages of t-r-f and tuned detector) each screen and plate lead should be carefully filtered, using 300-turn honeycomb coils and 0.002 mfd. or higher capacity in the filter, and the coil centers placed at least 4 inches apart.

The diameter of the form is 1 inch, the aluminum shield 2 5/8 inch diameter, 2 1/2 inches high. The shield has a small protected opening at top so the lead for the grid cap may be brought through. The opening is bevelled. This constitutes the protection against fraying the insulation of leadout wire to grid cap.

In the four-coil system, reversing connections to primary of second coil often stops oscillation in poorly filtered sets.



Cat. No. 1—Three t-r-f coils for 0.00035 mfd., 80-meter tap....................$1.35
Cat. No. 1-F—Four coils, 0.00035 mfd.....$1.80
Cat. No. 3—Three t-r-f coils for 0.0005 mfd., 80-meter tap....................$1.35
Cat. No. 3-F—Four coils, 0.00035 mfd......$1.80
Cat. DCH—Diode r-f choke, center-tapped..$ .40
Cat. 3DS—Three-deck long switch for above coils, to utilize 80-meter tap............$2.50

80-METER TAP PROVIDED

EACH coil for the t-r-f sets has secondary tapped, so that if desired a long switch may be used to shift the tuning condenser stators to extreme of winding (200-555 meters) or to tap (80-200 meters). The tap is represented by a ground symbol stamped on the shield base. Please note ground is not to be connected to ground symbol. Grid return is the side lug inside the shield. P, B represent primary, G and side lug secondary.

The 80-meter tap does not have to be used, but is advantageous to those desiring to tune in television, amateurs, police calls, some relay broadcasting and other interesting transmissions in a band of frequencies replete with novelties for the usual broadcast listener.

High impedance primaries are used, the number of turns chosen so that the same coils may be used for antenna coupler and interstage couplers.

For diode t-r-f circuits, either full-wave or half-wave detector, a diode choke may be inserted inside the detector form. This choke has three terminals, with outleads: two extremes and center. For full-wave use two extremes to anodes of 55 or 85, center to cathode resistor. For half-wave use two extremes and ignore center tap.

Except in rare hookups the diode circuit requires an input free from grounding, and as the tuning condenser rotor and frame are grounded the choke pickup affords any potential output.

T-R-F sets using the 55 or 85 should have three stages of resistance audio, e.g., first stage the triode unit of the 55 or 85, second stage screen grid audio, third stage power tube or tubes (output).

COILS FOR 4-TUBE DIAMOND (CAT. DP) @ 90c—COILS FOR 5-TUBE DIAMOND (CAT. DT) @ $1.35

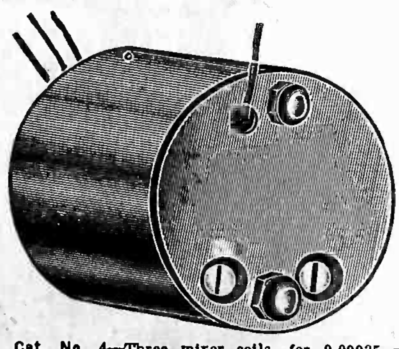
MIXER AND INTERMEDIATE TRANSFORMERS

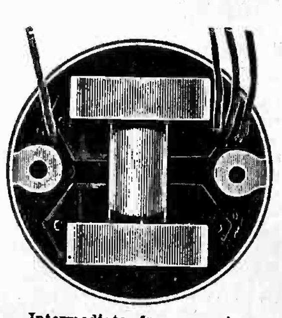
PADDED SETS

For circuits using 175 kc. or 400 kc. intermediate frequency we have two coils for a stage of t-r-f and first detector, and accurately chosen inductance for the padded oscillator for these intermediate frequencies. There is no 80-meter tap provided on these mixer coils.

The coils are of the same type of mechanical construction as the t-r-f coils. Since there is no secondary tap, the code for connecting the t-r-f coils of the superheterodyne combination is different: P and B, primary; G and ground symbol, secondary. P would go to plate or antenna, G to grid cap, while B and ground symbol are the returns.

The oscillator has a smaller inductance secondary, for padding, and moreover is a three-winding coil. The three windings are: pickup, secondary and tickler. The pickup winding consists of 10 turns, and is brought out to two side lugs. The polarity of its connections unusually is of no importance. The secondary is represented by G and ground symbol, G going to grid and ground symbol to grid return, usually ground. The tickler connections for oscillation usually require that the lug at B be conected not to B plus but to plate, hence the P lug goes to B plus. In any case, if no oscillation results, reverse the tickler connections.





Cat. No. 4—Three mixer coils, for 0.00035 mfd. Intermediate frequency intended, 175 kc. Price includes padding condenser, 700-1000 mfd......$1.80
Cat. No. 5—The mixer coils for 0.0005 mfd., 175 kc., 700-100 padder....$1.80
Cat. No. 7—Three mixer coils, for 400 kc; padding condenser included is 350-450 mfd. $1.80

SCREEN GRID COIL CO.
145 WEST 45TH STREET, NEW YORK CITY

INTERMEDIATE TRANSFORMERS

The intermediate transformers consist of two honeycomb coils, wound with low resistance wire, coils spaced 1 inch apart, and thus affording loose coupling, stability and high selectivity. Primary and secondary tuned.

Cat. FF-175—Shielded intermediate frequency transformer, 175 kc.......$1.10
Cat. FF-175CT—Same as above, center-tapped secondary, for full-wave diode detector $1.25
Cat. FF-450—Shielded intermediate frequency transformer, affording choice by condenser adjustment of frequencies from 380 to 480 kc..............$1.30
Cat. FF-450CT—Same as above, center-tapped secondary $1.45

Padding Condensers @ 45c Each

Cat. PC-710—For 175 kc intermediate. Put in series with oscillating tuning condenser. Capacity 700-1000 mmfd. Hammarlund, Isolantite base.
Cat. PC-3545—Same as above, except 350-450 mmfd. for 380-480 kc intermediate.

Cat. CH-300—A 300-turn r-f choke, inductance 1.3 millihenries $0.30
Cat. CH-800—An 800-turn r-f choke, inductance 10 millihenries..........$0.35