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POINT-TO-POINT RESISTANCE MEASUREMENTS

The Modern Method of Servicing Radio Receivers

by Clifford E. Denton

A GERNSBACK PUBLICATION

PUBLISHED BY
RADCRAFT PUBLICATIONS, INC.
99 HUDSON ST.-NEW YORK

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RADCRAFT PUBLICATIONS, Inc.

Publishers

99 HUDSON STREET NEW YORK, N. Y.

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Printed in U. S. A.

Fourth Reprint

CHAPTER 1

Advantages of Resistance Measurement Method of Servicing for Radio Work

THE Resistance Measurement method of servicing radio receivers goes back to fundamental principles. It reduces every problem in radio servicing, no matter how seemingly complicated, to a simple elementary basis. Considered from the standpoint of the electrical currents flowing through it, the modern radio receiver is one of the most intricate pieces of apparatus in everyday use. Alternating current circuits are particularly hard to understand and calculate, even for one who has a thorough knowledge of higher mathematics. To the Service Man who has never had the time nor the opportunity to delve into the mysteries of trigonometry and calculus, the calculation of the electrical action within a radio receiver may seen hopeless, but thanks to the introduction of Resistance Measurement methods, and to someone with a keen analytical mind who discarded the notion that a college education in higher mathematics and electrical engineering was necessary to service a radio set, anyone may easily learn its secrets.

Reduced to the simplest terms, the radio set is made up of conductors and non-conductors. All these offer a certain amount of opposition to the flow of direct current, and this opposition is called resistance. Unless there is trouble, due to a defect or through other causes, each part will continue to have a fixed, never-varying resistance.

The value of this idea is immediately apparent. The hard-to-calculate alternating current is cut off from the radio receiver. Instead, a simple source of unvarying direct current, such as a small battery, is used in conjunction with a calibrated meter to check up the resistance of each and every part in the set. Instantly the problem, scarcely solvable by higher mathematics, becomes one which anyone can calculate by simple arithmetic. Complicated formulas and equations are discarded, since they are no longer applicable. Instead, a knowledge of Ohm's Law is all that is necessary. This vital simplification is the true reason for the rapidly increasing popularity of the Resistance Measurement method of servicing. This method is basic and real. It is what the doctor ordered, with the prescription written in plain English instead of in incomprehensible Latin.

Resistance Measurement not only does away with the necessity for using higher mathematics in testing radio sets, but it also eliminates many different types of meters. The whole system involves little more than a good ohmmeter having the necessary resistance range. The measurements may be made at the tube sockets through the use of cables and plugs. This, at once, suggests another advantage. Every Service Man has encountered the type of job where the owner wants an estimate before he will permit the set to be removed from his home. A resistance test may be made without taking the chassis out of its cabinet. Several dozen resistance readings can be taken in fifteen minutes. Armed with this data, the Service Man is in a position to give an immediate estimate of the cost of making repairs, for he knows what the trouble is, and therefore, he does not have to rely on guesswork.

In making a Resistance Measurement test, the readings are taken systematically from point to point until the trouble is located. The entire set of readings may be tabulated, thus permitting a complete analysis. Incidentally, the resistance readings permit the total isolation of each individual unit in the radio receiver, an advantage impossible to obtain with any other method of servicing.

The question will naturally arise as to the relative merits of Voltage Measurement methods and Resistance Measurement methods. Undoubtedly, each system has its particular advantages, but a consideration of the facts presented leads to the conclusion that the Resistance Measurement method of servicing will ultimately supersede the voltage measurement method. Voltage readings are often deceiving in that they do not give a true conception of conditions within the receiver. They involve complex, complicated circuits, rather than individual units, making it more difficult for the Service Man to "spot" the particular point where the trouble originates.

The Voltage Measurement method, in most cases, requires an accurate wiring diagram together with full and complete data on the circuit. Resistance measurements are possible either with or without diagrams and data. In a word, the Resistance Measurement method is undoubtedly simpler, faster and more accurate. Due to the growing importance of this method, several special instruments have been designed and are already on the market for the particular purpose of facilitating resistance measurement tests; some of these will be described in a later chapter. A typical instrument, the Readrite No. 1000, includes an elaborate ohmmeter, together with a capacity tester; a D.C. voltmeter and milliammeter; and, also, a means of checking A.C. line voltages. The ohmmeter is arranged so that it can also function as a voltmeter or milliammeter by rotating a switch. This meter is provided with two cables terminating in plugs for gaining access to all circuits from the various tube sockets. A thirteen-point selector switch permits one to take as many as thirteen different resistance readings, without making the slightest change in the connections between the tester and the radio receiver. Jacks are also available for permitting the tester to be used independently of plug and cable connections for the measurement of resistances and also for measuring voltages and capacities.

In the design of modern radio receivers, the use of high resistance coupling circuits introduces errors in practically all voltage measurements because of the multiplier effects of the resistors in these coupling circuits. Furthermore, potential measurements will vary with every different range of an ordinary service voltmeter applied to high-resistance circuits, so that the voltage readings published by a radio manufacturer may be found quite different by the Service Man when analyzing the set with a voltmeter of the same sensitivity, but of a different range from that used by the radio manufacturer.

Such differences do not exist in making resistance measurements, and hence this point constitutes another powerful argument in favor of the resistance measurement method of servicing radio receivers.

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CHAPTER 2

Basic Principles

A KNOWLEDGE of the elementary principles of electricity is necessary so that all the problems encountered in radio receiver servicing can be isolated and solved by the proper application of fundamental truths.

Without further preamble, let us consider that statement upon which all forms and branches of electrical engineering is based:

OHMS LAW

STATEMENT OF OHMS LAW. "Current flowing in a conductor will increase directly with an increase in voltage, and will decrease directly with an increase in resistance." In other words, voltage is the cause, while current is the effect; and the amount of the effect is directly dependent upon the amount of cause and inversely upon the amount of opposition offered to the effect.

MECHANICAL ANALOGY. Suppose that by exerting a certain effort, a man is able to walk a certain distance, on a smooth city road. With double the effort, he can walk double the distance on the same road. Assume that on a rough country road, with the same effort, he can walk only half this distance, or with double the effort, he can walk the original distance. Applying this analogy to electricity, a certain voltage causes a certain current to flow. Double the voltage will cause double the current to flow, if the resistance is the same. If the resistance is doubled, however, the same voltage will result in only half the current flow. With double the voltage and double the resistance, the same current will flow.

OHMS LAW (EQUATION):

$$I = \frac{E}{R}; \quad \text{Current} = \frac{\text{Voltage}}{\text{Resistance}}$$

Where I, E, and R are expressed in amperes, volts, and ohms respectively. The terms of voltage, current and resistance are used with the understanding that the reader has some elementary knowledge of electricity. In so far as the limitations of this book prevent a complete review of the fundamentals, reference can be made to books covering the subject of fundamentals in electrical engineering.

The equations below all mean the same thing, and serve to express in various forms the idea set forth above.

$$E = I \times R; \quad \text{Voltage} = \text{Current} \times \text{Resistance}$$

$$R = \frac{E}{I}; \quad \text{Resistance} = \frac{\text{Voltage}}{\text{Current}}$$

The substitution of numerical values in place of names or letters will make the meaning clearer. It will be seen that if any two values are known, the third can be determined from these equations.

PROBLEM: A choke used in the filter system of a "B" supply unit has a resistance of 100 ohms, and the voltage drop across the choke is 50 volts. What is the current flowing through the choke?

Using the first statement of Ohms Law, and substituting values for words: I equals 50 volts divided by 100 ohms. Thus, the current is .5 ampere. (Fig. 1A.)

Figure 1B shows another application of the law that can be solved by the third statement. Note should be taken of the fact that the voltage across the resistor R is not 300 volts, but the difference between the two voltages indicated, or 50 volts. Substituting in the equation:

$$R = \frac{E}{I}; \quad R = \frac{50}{.005} = 10{,}000 \text{ ohms.}$$

A common calculation necessary in modern service work is the determination of the value of the bias resistor for a particular tube. This value is easy to obtain, thus:

$E = I \times R$; $E = .005 \times 2{,}000 = 10$ volts.

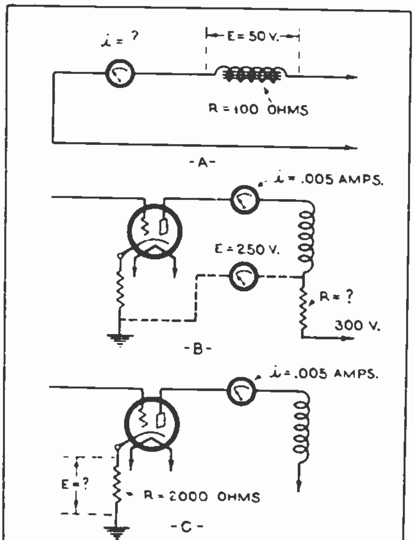

FIG. 1

POWER

DEFINITION. "Power is the rate of doing work." Thus, one man may perform a certain piece of work in a day, while another may do the same thing in an hour. The second man has expended more power. "Electrical power is the product of the voltage times the current," or in symbols:

$W = E \times I$; Power (watts) = Voltage (in volts) $\times$ Current (in amperes).

Problem: In Fig 1B, how many watts are dissipated in the resistor? Watts = 50 volts $\times$ .005 amperes = .25 Watt.

In many cases it is more convenient to find the electrical power loss in terms of resistance. Thus, the equation W equals E times I can be stated in terms of the circuit resistance and the current flowing through it.

W = I times I times R. Watts equal current (amperes) times current (amperes) times resistance (ohms).

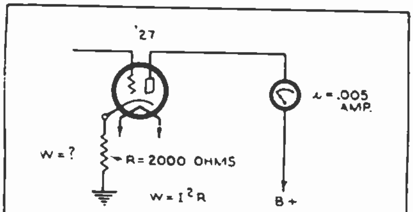

FIG 2

In Fig. 2 there is a circuit with a resistor in series with the cathode and the ground of a '27 type tube. This resistor supplies the bias for the tube. If the resistance has a value of 2,000 ohms, what is the power loss in the resistor?

$W = .005 \times .005 \times 2{,}000 = .05$ watt.

Another form of this equation states the power in terms of voltage and resistance.

$$W = \frac{\text{voltage} \times \text{voltage}}{\text{resistance}}$$

A tube has a D.C. plate resistance of 40,000 ohms and the voltage applied between plate and ground is 200 volts. What is the power lost in the plate circuit of the tube? See Fig. 3.

$$W = \frac{200 \times 200}{40{,}000} = 1 \text{ Watt.}$$

KIRCHHOFF'S LAWS

These laws depend on Ohm's Law. They constitute a further application of Ohm's Law to more complicated circuits.

In addition to simple electrical circuits, conductors may be connected in various complicated networks, all of which come under the heading of "divided circuits." By means of Kirchhoff's Laws, the current in any part of a divided circuit may be found, if the resistances of the various parts, and the e.m.f.'s (volts) are known.

KIRCHHOFF'S FIRST LAW:

"Any current flowing to a point in any electrical circuit is equal to the sum of the currents flowing away from that point."

KIRCHHOFF'S SECOND LAW:

"In any closed electrical circuit, the sum of the impressed electromotive forces will equal the sum of the voltage drops." This statement requires modification, in so far as "addition" of voltages is concerned. Voltages are added, provided that they are in the same direction, but must be subtracted if in opposite directions.

An example of Kirchhoff's first law is seen in Fig. 4 where the sum of the currents, 8 amperes and 4 amperes, flowing towards point A, is equal to the current, 12 amperes leaving point A.

Kirchhoff's second law is also numerically illustrated in Fig. 4. Assume

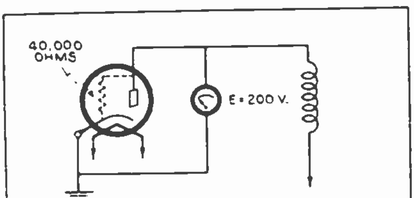

FIG. 3

that the resistances of various parts of the circuit are as marked, and that the total internal resistance of the battery is .06 ohm. Then according to the statement of the second law, if the impressed voltage is 7.12 volts:

Impressed Voltage = 7.12 = total voltage drop through the lower circuit.

Impressed Voltage = 12 $\times$ .1 (C to B) plus 4 $\times$ 1 (B to A in lower branch) plus 12 $\times$ .1 (A to D) plus 12 $\times$ .06 (D to C through battery).

Impressed Voltage = Total of 7.12 volts.

In a like manner, impressed voltage equals **total voltage drop through the upper circuit:**

7.12 = 12 $\times$ .1 (C to B) plus 8 $\times$ .5 (B to A through upper circuit) plus 12 $\times$ .1 (A to D) plus 12 $\times$ .06 (D to C through battery), a total of 7.12 volts.

CONDUCTORS AND RESISTORS

Materials are divided into two classes—conductors and non-conductors. Materials which offer a relatively easy path for the flow of electricity are called "conductors." In general, the

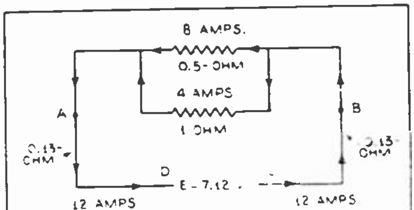

FIG. 4

pure metals are of this class, copper wire being nearly always used as a low-resistance conductor.

In reality there are no materials which are not conductors of electricity, but certain materials are such poor conductors, that they may be classed as non-conductors. When such non-conductors are used to reduce an electric current to a predetermined small value, they are called "resistors."

DETERMINING RESISTANCE
(excepting temperature change)

The material of which a conductor is composed has an important bearing upon it's resistance. Thus a unit length and unit cross-section of aluminum has about one and one-half times the resistance of copper having the same dimensions. Platinum has about six times the resistance of copper.

The longer the conductor, the greater the resistance; while the greater the cross-sectional area, the less the resistance. The length of a conductor is usually expressed in feet, while the cross-sectional area is expressed in circular mils (equivalent to its diameter in thousandths of an inch, squared.)

It can be conveniently remembered that No. 10 copper wire has a diameter of .1 of an inch (100 mils, or 10,000 circular mils), and that 1,000 feet of such wire will have a resistance of 1 ohm. It is possible to calculate the approximate resistances of copper wire (Brown and Sharpe or American Wire Gauge) from the above. Thus, for wires larger than No. 10, the resistance is halved for every third number of larger wire. As an example, No. 7 wire has an approximate resistance of ½-ohm per 1,000 ft. In a like manner, for wires smaller than No. 10, the resistance is doubled for every third number of smaller wire. The resistance of No. 13 is about 2 ohms per thousand feet; of No. 16, approximately 4 ohms per thousand feet, etc. The two numbers between every third may be calculated from the others, since the next smaller size has about 1.25 greater resistance, while the second smaller size has about 1.6 greater resistance. Thus the resistance of No. 11 wire is approximately 1 $\times$ 1.25 equals 1.25 ohms per thousand feet; and that of No. 14, approximately 1.6 ohms per thousand feet.

EFFECT OF TEMPERATURE ON RESISTANCE:

The resistance of practically all electrical conductors increases with increase of temperature.

Two words synonymous with a resistance are "temperature coefficient." The term "coefficient" refers to a number used as a multiplier. The temperature coefficient is that multiplier which will give the increase in resistance per degree rise in temperature for each ohm of the material. For all pure metals, the temperature coefficient is approximately .0023 (where temperature is measured in degrees Fahrenheit). The figure .0023 is close enough for all ordinary work although the temperature coefficient is not constant for all initial temperatures.

CURRENT CARRYING CAPACITY

The allowable rise in temperature of the conductors or resistors in an electrical circuit is the final factor which determines its current carrying capacity. If the conductors or resistors are covered, the maximum allowable temperature of the insulation will impose the limitation, since the insulation or the enamel covering may crack, char, or even burn at high temperatures.

The temperature rise will be determined by the difference between the heat generated and the heat dissipated, or removed. Thus, a certain amount of electrical energy will be converted into heat and some of this heat will be carried away. The remaining heat will serve to increase the temperature. Of course, a certain amount of heat energy will raise the temperature of some materials a great deal more than others. Hence, the material of the conductor will also have some bearing on the temperature rise, aside from its resistance.

The heat generated in an electrical circuit will depend upon the value of the current flowing and upon the resistance in the circuit. If the current is doubled, the heat generated will be quadrupled. If the resistance is doubled, the heat generated will simply be doubled (if the current is constant). Thus, an increase of current has a much greater effect on the amount of heat generated than proportionate increase of resistance. Anything that will increase the resistance of a circuit will increase the amount of heat generated.

SAFE CURRENT CARRYING CAPACITIES:

In cases of resistance replacement, it is wise to replace with a resistor that will dissipate at least three times the power to be wasted in the circuit.

VOLTAGE DROP:

There is a difference in voltage between any two points in a circuit between which there is resistance, and this difference in voltage is known as the voltage drop. The difference in the voltage is determined by the resistance between the two points and the current flowing. If we desire to know the value of the resistance to be placed in series with a 201A type tube in order to operate it from a 6-volt storage battery, we must first determine the voltage drop required between the battery and the filament of the tube, namely 1 volt. Having determined the voltage to be dropped, and knowing the current required by the tube (.25 ampere), we can find the value of the resistance by Ohm's Law. R equals E/I. Thus the resistor has a value of 4 ohms.

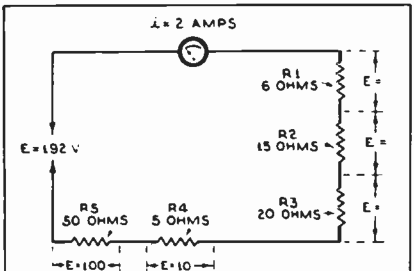

FIG. 5

CIRCUITS:

Circuits can be classified into three general groups: Series, parallel, and series parallel. Examples of which will be covered in greater detail.

CIRCUITS WITH RESISTORS IN SERIES:

If resistances are connected in series, the total resistance is the sum of all of the resistors in the circuit. See Fig. 5. Thus the equation may be written R (eff.) equals R1 plus R2 plus R3 plus R4 plus R5, etc.

It will be noted on examination of the diagram that in series circuits the current is the same through all the resistors, but that the voltage drop across the resistors will depend upon the value of the individual resistor.

CIRCUITS WITH RESISTORS IN PARALLEL (equal values of resistance):

In many circuits there are combinations of resistors in parallel; that is to say, the current path is divided through two or more resistors. If the numerical values of the resistors are equal, then the effective circuit resistance can be obtained from the following equation:

R (eff.) equals R/N,

wherein R is the value of one of the resistors and N is the number of resistors in the circuit.

EXAMPLE: There are 6 resistors in a circuit and they are in parallel. The resistance of each one is 12 ohms. Then dividing 12 by 6 we have the effective resistance, which is 2 ohms.

The solution of equal values of resistors in parallel is an extremely simple operation, but it must be remembered that the formula is useful only when the resistors are equal in value.

A circuit with resistors in parallel is shown in Fig. 6. Note that if the resistors are equal in value, the same current will flow through both resistors, and the same voltage drop will appear across them. The sum of the currents through the resistors will equal the total current flowing out of the battery, E.

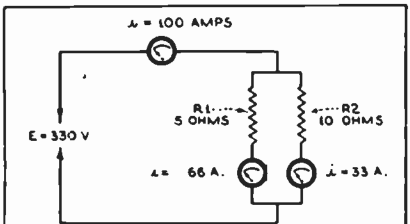

FIG. 6

CIRCUITS WITH RESISTORS IN PARALLEL (unequal values of resistance):

Many times we will come across circuits with resistors in parallel which are unequal in value. This is shown in Fig. 6. If there are but two resistors in the circuit, as shown, then we can use the following formula:

$$R\ (\text{eff.}) = \frac{R1 \times R2}{R1 + R2}$$

EXAMPLE: We have two resistors in parallel of 5 and 10 ohms, respectively. What is the effective value of resistance? Now, 5 times 10 is 50; 5 plus 10 is 15; 50 divided by 15 gives the effective value of resistance which is 3.3 ohms.

Note that in circuits with resistors in parallel, the same voltage will appear across all the resistors, but that the current through the resistors will vary with the value of the individual resistor.

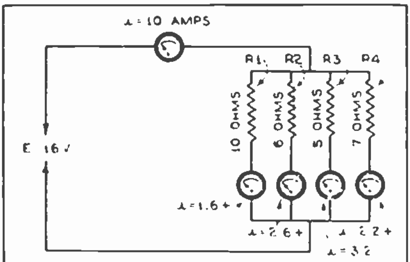

FIG. 7

CIRCUITS WITH RESISTORS IN PARALLEL (two or more of unequal value):

Figure 7 shows a circuit in which there are four resistors in parallel and unequal in value. In this case we would use the formula commonly known as the "reciprocal of the sum of the reciprocals."

Thus

$$R\ (\text{eff.}) = \frac{1}{\frac{1}{R1} + \frac{1}{R2} + \frac{1}{R3} + \frac{1}{R4}}\ \text{etc.};$$

substituting:

$$R\ (\text{eff.}) = \frac{1}{\frac{1}{10} + \frac{1}{6} + \frac{1}{5} + \frac{1}{7}};$$

solving:

$$\frac{1}{10} = .1;\quad \frac{1}{6} = .166;\quad \frac{1}{5} = .2;\quad \frac{1}{7} = .14;$$

adding:

.1 plus .166 plus .2 plus .14 equals .606;

Finding the reciprocal:

$$\frac{1}{.606} = 1.6 \text{ ohms effective.}$$

The sum of the currents in the branches of a parallel circuit will equal the total current flowing into the circuit. From an examination of the circuit, we find that the sum of the currents is 9.6+ amperes.

The complete solution of the problem of Fig. 7 has been carried out so that any one desiring to use these methods of calculation can do so. This solution will serve as a model and aid in studying just how the formula is to be handled. The author has gone to some lengths here in the solution of the problem but his experience indicates that there is never enough said on this subject as far as the average Service Man is concerned. Note that the same voltage appears across all the resistors and that the current through the individual resistors will be dependent on their value.

RESISTANCE NETWORKS (with resistors in series and in parallel):

Circuits are encountered with resistors in series and in parallel. The solution of the effective value of resistance is obtained by breaking up the circuit into its local circuits, solving each portion consisting of parallel circuits, and then resolving them into simple series circuits. Fig. 8 is an example along these lines.

Solution: The first thing to do is to solve all of the branch circuits.

Circuit R1, R2, R3 has an effective resistance of 3 ohms.

Circuit R5, R6, R7 has a resistance of 2.2 ohms.

Circuit R8, R9 has a resistance of 2.2 ohms.

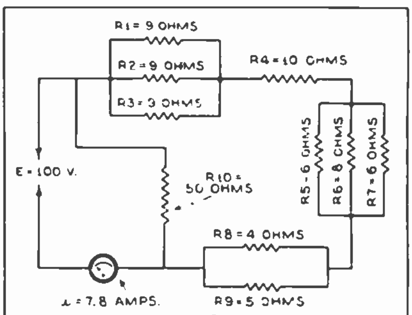

FIG. 8

As the above parallel circuits are in series with resistor R4, we find the effective value of resistance by adding

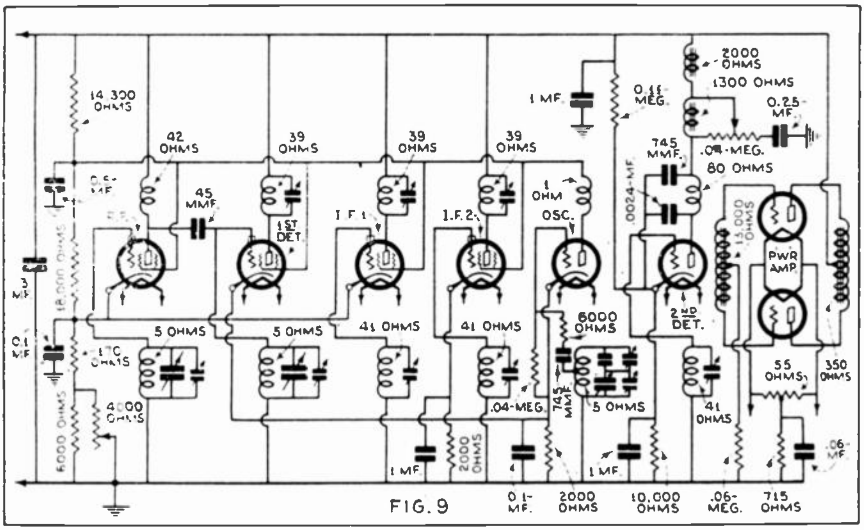

FIG. 9

10, 3, 2.2 and 2.2 together. This totals 17.4 ohms.

Resistor R10 is connected across the voltage supply, and the effective value of the resistance network R1 to R9 is, in turn, connected across R10. Thus, R10 is in parallel to the 17.4 ohm resistance of the network.

Solving for parallel circuits 50 × 17.4 / 50 plus 17.7 we have the effective total circuit resistance of 12.8 ohms.

Knowing that the voltage applied across this network is 100 volts, and that the effective resistance is 12.8 ohms, then 100 / 12.8 is 7.8 amperes, or the total current flowing in the circuit.

The reader may think that a problem of this type can hardly occur, but if he will study the circuit of Fig. 9 he will see the need for some practical knowledge on the solution of similar problems. The circuit of Fig. 9 is a receiver breakdown circuit of the R.C.A. Radiola 80. Note that there are many small series circuits and that they are all in parallel across the power supply which takes the place of the battery E in all the problems set out above.

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CHAPTER 3

Methods of Resistance Measurement

THE art of accurate resistance measurement depends on two important factors—accurate instruments and the ability to read them. So many manufacturers have entered the field of developing good instruments at reasonable prices, that the competition has been helpful to the Service Man. It has enabled the manufacturer to apply large scale production with low prices to an article that a few years ago was out of reach of the Service Man's pocketbook.

Reading the scale of a meter is where the personal element enters into the picture. One of the first lessons to learn in reading meters is to read them correctly when the meter is placed on the table, note that the needle is at the zero position when no current is flowing in the circuit. Try to have the light by which the meter is to be read directly overhead. Do not try to read the meter by the shadow cast on the scale by the pointer. Read the meter so that the shadow cannot be seen. It will then be directly under the pointer and will not affect the accuracy of the reading. Careless readings, like careless workmanship, are detrimental to good results.

WHEATSTONE BRIDGE

The Wheatstone Bridge is used for the accurate measurement of resistance, and has a wider range than any other method. It will give accurate results for all except extremely low and extremely high resistances. The fundamental principle of the Wheatstone Bridge is used in all resistance testing sets, except those sets using a calibrated milliammeter.

Three standard variable resistances, a galvanometer, and a dry cell are necessary for the construction of a "bridge." In "bridges" used for commercial work the apparatus is usually placed in a hardwood case, and convenient means are provided for changing the known values of the resistors.

The three known variable resistors and the unknown resistance are connected in a closed circuit, as in Fig. 10, which presents the theoretical Wheatstone Bridge diagram. A battery and switch are connected between A and B, while a galvanometer and switch are connected between C and D. The ratio arms usually contain coils whose resistances may be varied in multiples of 10. Thus, ratio arm 1 may be varied so that its resistance is the same as ratio arm 2, or 10, 100, or 1,000 times as great. In a like manner, ratio arm 2 may be adjusted so that its resistance will be 10, 100, or 1,000 times as great as arm 1. The various known resistance coils in the rheostat arm are of such value that any whole number may be obtained.

The battery current divides between the arms ACB, and ADB. No current will flow between C and D, provided C and D are at the same potential. If current does flow between C and D, the galvanometer will deflect. The manipulation consists of adjusting the ratio arms and the rheostat arms until points C and D are at the same potential, or, in other words, until the galvanometer no longer deflects. In this case, the arms of the bridge are said to be balanced. Such a condition is always necessary when measuring the resistors and since the method requires no deflection of the galvanometer, that instrument need not be calibrated. Assume that when the galvanometer key is closed, current flows from A to B. Also assume that the various known resistors are so adjusted that when the galvanometer key is closed, there is no deflection of the galvanometer. It is clear that there is then no difference of potential between C and D. Hence, the

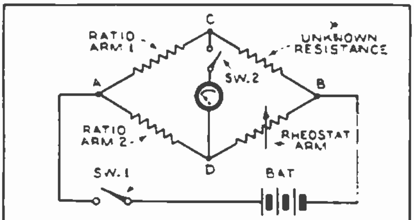


FIG. 10

voltage drop along ratio arm 1 must equal that along ratio arm 2. In like manner, the voltage drop along the unknown resistance must equal that along the rheostat arm. Then according to Ohm's Law the value of these voltage drops may be expressed in terms of current and resistance. Hence, the above equalities may be expressed as follows:

Current $\times$ Resistance (Ratio Arm 1) equals Current $\times$ Res (Ratio Arm 2); and

Current $\times$ Resistance (Unknown Resistance) equals Current $\times$ Res. (Rheostat Arm).

If the former equality is divided by the latter, the following quotation is obtained:

$$\frac{\text{Current} \times \text{Res. (Ratio Arm 1)}}{\text{Current} \times \text{Res. (Unknown Res.)}} \text{ equals } \frac{\text{Current} \times \text{Res. (Ratio Arm 2)}}{\text{Current} \times \text{Res. (Rheostat Arm)}}$$

Since no current flows through CD, the current in ratio arm 1 must equal the current in the unknown resistance; also, the current in ratio arm 2 must equal the current in the rheostat arm. Hence, these values will cancel out of the above equation, and the following equation will be obtained.

$$\frac{\text{Resistance Ratio Arm 1}}{\text{Unknown Resistance}} = \frac{\text{Resistance of Ratio Arm 2}}{\text{Resistance of Rheostat Arm}}$$

Hence, since three of the resistances are known, the unknown resistance can be found by solving as follows:

$$\text{Unknown Resistance} = \frac{\text{Resistance Ratio Arm 1}}{\text{Resistance Ratio Arm 2}} \times \text{Resistance Rheostat Arm}$$

SLIDE WIRE BRIDGE

In this type of bridge, a slide-wire is used in place of the ratio arm 2 and the rheostat arm. This wire is of uniform resistance along its length, and is usually made of German silver. A pointer is moved along the wire until the point is located where the galvanometer gives no deflection. In calculating, the resistance lengths of the slide-wire are used instead of actual resistors, since, in this case, resistance is proportional to the length. Fig. 11 shows a dia-

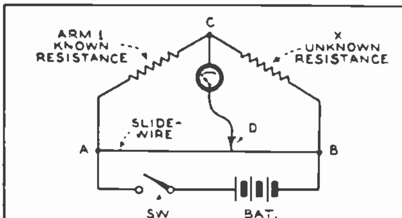


FIG. 11

gram of a slide wire bridge. When the bridge is balanced and there is no deflection of the galvanometer, the unknown resistance may be calculated from the following equation:

$$\text{Unknown Resistance} = \frac{\text{Res. Arm 1} \times \text{Distance DB}}{\text{Distance AD}}$$

In some cases the resistance of arm 1 is made permanent, and a calibrated scale is placed under the slide-wire, so that the value of the unknown resistance may be read directly in ohms from the position of the pointer on the wire. Although the slide-wire bridge is not as accurate as the Wheatstone bridge, it is more convenient in certain cases, and enables us to obtain a quicker balance.

VOLT-AMMETER METHOD

This method can be used but does not give very accurate results. Lack of accuracy is due to the lack of ability to properly read the meter scales and to the meters themselves. Meters used for this purpose should be equipped with long scales. It offers a comparatively simple means of determining values of resistance below 600 ohms. It is necessary to use an ammeter and a voltmeter for these measurements, and the instruments should be accurate. A source of direct-current is also necessary.

The resistance to be measured should be connected in series with the ammeter and the source of voltage. For comparatively low resistances, the voltmeter should be connected at the terminals of the resistance as in Fig. 12. In this case there will be a slight error

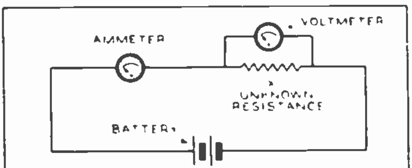


FIG. 12

due to the fact that the ammeter will show the sum of the currents in the resistance and the voltmeter. However, if the voltmeter were connected around the ammeter, it would also indicate the drop in potential across the ammeter, and in the case of a low resistance this would introduce error. For high resistances it is usual to connect the voltmeter around both the resistance to be measured and the ammeter. In such a case, the voltmeter current may be appreciable, as compared with the current through the resistance, and would therefore cause a large error if the voltmeter were connected directly across the resistance terminals.

The resistance can be calculated in accordance with Ohm's Law. Thus, if the voltage reading is divided by the reading of the ammeter, the result gives the resistance of the circuit being measured. It is better to take several readings and calculate the average resistance. Care should be taken to have good connections. Sensitive voltmeters are desirable for use in measuring circuits of this type, as their high internal resistance will reduce the error due to current dissipated in the resistance of the meter.

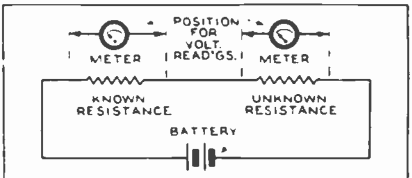


FIG. 13

COMPARISON OF VOLTMETER DEFLECTIONS

(using standard values of resistance):

This method can be used wherever the Voltmeter-Ammeter method is applicable. Both of these methods are often referred to as the "fall of potential" or the "voltage drop" methods.

In this case a voltmeter, a known, or standard, resistance, and a source of power is necessary. For fairly accurate work the voltmeter should have a high resistance (especially in measuring low values of resistance), although it need not be calibrated provided the deflections are proportional to the voltage. The standard resistance should have sufficient capacity to carry the current without heating, and a steady value of current should be employed; the standard resistance should not change its ohmic value when heated by the passage of current. A steady voltage in this case is a voltage that will not vary with a change in the current flowing through the circuit.

The resistance to be measured is connected in series with the standard resistance and a steady source of current. Several new dry cells can be used for the purpose. The voltmeter is first connected across the known value of resistance and its deflection recorded. It is then placed across the unknown resistance and the deflection is again recorded. It can be seen that the same current must flow through the circuit at the time of both measurements. Thus:

The current flowing in the known resistance

$$= \frac{\text{Voltage across Known Resistance}}{\text{Known Resistance}},$$

(in accordance with Ohm's Law).

In like manner:

The current in the Unknown Resistance

$$= \frac{\text{Voltage across Unknown Resistance}}{\text{Unknown Resistance}}$$

Since the two resistances are in series, the current flowing in the known resistance will be the same as that current flowing in the unknown resistance. Hence:

$$\frac{\text{Voltage across Known Resistance}}{\text{Known Resistance}} = \frac{\text{Voltage across Unknown Resistance}}{\text{Unknown Resistance}}.$$

Therefore:

$$\text{Unknown Resistance} = \frac{\text{Known Resistance} \times \text{Voltage across Unknown Resistance}}{\text{Voltage across Known Resistance}}$$

Thus, the value of the unknown resistance can be calculated from the two voltmeter readings and the known resistance. The circuit for such measurements is shown in Fig. 13.

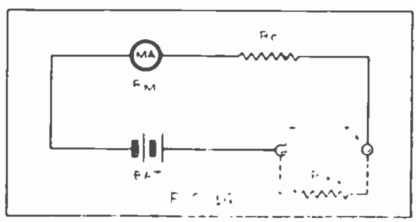
DEFLECTION METHOD

There are other methods which provide a fair degree of accuracy (depending on the quality and accuracy of the parts used), the least expensive being the deflection method.

The low-current range milliammeter that is so readily obtained can be converted into multi-range volt-ammeters and also into multi-range volt-ohmmeters. The 0-1.5 milliammeter (D.C.) is probably the most desirable instrument for the purpose due to the fact that the dry battery has a normal potential of 1.5 volts, or some multiple of this voltage, depending upon the number of cells connected in series which go to make up the total battery. The proper instrument to use will depend upon the range of resistances to be measured and the source of voltage available.

The method of connection is shown in the circuit diagram of Fig. 14. MA is the D.C. milliammeter having an internal resistance Rm; Rc is the calibrating resistance which limits the amount of current flowing through the milliammeter; and Rx is the resistance to be measured.

If MA is a D.C. milliammeter having a full scale deflection of 1.5 ma., and the battery has a value of 1.5 volts, and Rc plus Rm have a total resistance of 1,000 ohms, and the terminals marked T are shorted, the milliammeter should read full scale. Under these conditions there is no resistance at terminals T or the resistance is equal to zero. If Rx has a value of 1,000 ohms the meter should read at the half-scale mark. The current flow under these conditions will be .75 ma. Of course, this statement can be proven by Ohm's Law. Where



$$R = \frac{E}{I}.$$

In this case R equals the total resistance of the circuit, which includes Rx, the resistance being measured; Rc, the calibrating resistance; and Rm, the resistance of the meter. E is the value of the applied voltage from the dry cell, and I is the current indicated by

the meter. Therefore:
Rx plus Rc plus Rm equals E/I.
Transposing,
Rx equals E/I — (Rc plus Rm)
except where extreme accuracy is required.

Scale A of Fig. 15 refers to column 4 of the calibrating table. This setup

1	2	3	4	5
(A)	(B)	(Rc plus Rm)	Rx	
Milliamperes full scale	Voltage	Total resistance required for calibration	Scale	Multiply by
1 1 1	Low 1.5 Med. 4.5 High 22.5	1,500 ohms 4,500 ohms 22,500 ohms	A A A	1 3 15
1.5 1.5 1.5	Low 1.5 Med. 4.5 High 22.5	1,000 ohms 3,000 ohms 15,000 ohms	B B B	1 3 15
5 10	1.5 1.5	300 ohms	A A	.2 .1

The above chart gives the necessary details for setting up ohmmeters using standard milliammeters. Reference is made in this chart to the scales in Fig. 15. This information will permit a rapid decision as to just what ranges of resistance can be measured with the instruments available and provides a means of calibrating a scale directly in ohms. This chart is to assist the ohmmeter builder in determining the proper calibrating resistance according to the range of resistance measurement desired, the voltage used, and the instrument available.

Column 1 of the table refers to the range of the milliammeters; column 3 refers to the total calibrating resistance (Rc plus Rm) necessary to obtain full scale deflection with the terminals marked T shorted when using corresponding voltages as shown in column 2. In order to accurately determine the actual resistance of calibrating resistance Rc, or where the resistance of the instrument, Rm, employed is a considerable portion of the total resistance (Rc plus Rm), the internal resistance of the meter employed (Rm) should be subtracted from the resistance (Rc plus Rm) of column 3. As the resistance (Rm) of most instruments available for this purpose rarely exceeds 30 ohms, Rm can be neglected

requires a 0-1 D.C. ma. scale. Calibration is made directly into ohms where the battery used is 1.5 volts and the calibrating resistance has a value of 1,500 ohms as shown in column 3.

Scale B is an 0-1.5 D.C. ma. calibrated directly in ohms where the battery employed is 1.5 volts and the corresponding calibrating resistance (1,000 ohms) is used.

The range of resistances to be measured by the ohmmeter is increased in direct ratio with the increase of voltage applied.

The range of resistances measured by the deflection method is increased in direct ratio with the increase of the applied voltage. Therefore, as the voltage is increased, it is necessary

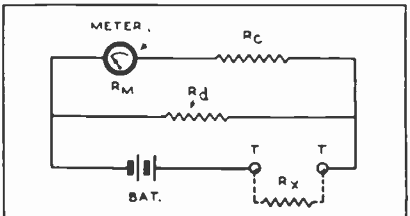


FIG. 16

to multiply the resistance indicated in the scales by the corresponding multiplier indicated in column 5.

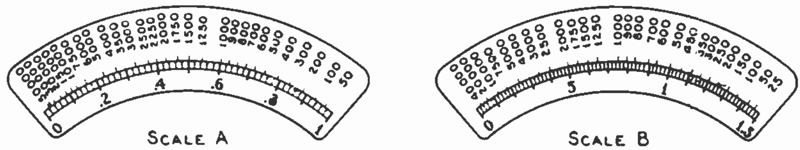


FIG. 15

The range of resistances measured by the deflection method is decreased in direct ratio with the decrease in sensitivity of the meter used. When 0-5 or 0-10 milliammeters are used, only 1/5 or 1/10 of the range of resistance will be measurable as compared with a 0-1 milliammeter when using the same voltage supply.

Many times it is necessary to lower the range of resistances shown on scales A and B without changing the calibrating resistance or the meter. In the case of the 0-1 milliammeter using 1.5 volts, the resistance shown on scale A can be divided by four when a resistance (Rd) of 500 ohms is connected across the meter and the calibrating resistance as shown in Fig. 16. Using the 1.5 milliammeter, the resistance of scale B can be divided by five when a resistance (Rd) of 250 ohms is connected in the same manner.

Greater accuracy of reading can be obtained in the middle of the meter scale and the range should be selected so that the values of resistance commonly measured will fall on or near center scale reading. Readings taken at the extremes of the scale are approximate and should not be accepted as accurate.

Every radio paper today seems to have a description of an ohmmeter which is useful to the Service Man. All of them operate on the principles covered above. Some resistance manufacturers have designed kits of resistors suitably calibrated for use with standard milliammeters and various voltages for those interested in building their own.

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CHAPTER 4

Resistance in Radio Receivers and Amplifiers

RESISTANCE plays an important part in the modern radio receiver or audio amplifier. To most Service Men, the common applications of resistors for bias, screen voltage limitation, and "B" voltage division are "old stuff." Resistance Measurement introduces resistance values which have to deal with coils and condensers, power transformers, and chokes, and even with the wiring of the set.

In Fig. 17, we have the electrical circuit of the RCA Victor R-7A receiver. Note that the values of the resistors are shown in the diagram. The direct current resistance of the radio-frequency coils, radio-frequency chokes, intermediate-frequency transformers, audio-frequency transformers, and speaker field are also shown; and it is these values that are important to the Service Man when it comes to Resistance Measurement circuit analysis.

An examination of the values given to the resistors in the diagram show the need for an ohmmeter that will give accurate readings at low ranges of resistance. In general, the best method of measurement for the extreme low values of resistance is the "bridge" method, the deflection method not being as satisfactory on low resistance ranges.

Using the ground as the reference point, note that a path of electrical resistance exists between that ground and the terminals of any of the elements of the tube. Fig. 18 shows a break-down circuit of a '24 type tube with the resistors between the elements and the ground (reference point). The values of resistance which will appear at R1, R2, R3, R4 will depend upon the conditions in the circuit. It will be noted in any case that there will be some measurable resistance if the set is in proper operating condition. Care must be taken in making a reading from a circuit marked as above; see Fig 17, because the values indicated refer to the resistance of the individual parts when measured out of the circuit. The reading with the parts properly connected will differ according to the associated circuit.

An example of this apparent error which may come up in a circuit test should be interesting. What is this resistance which should be measured between the plate and the chassis of the 1st detector (tube 3)?

Study of the circuit shows that there are several resistors and parts with appreciable values of resistance in the circuit. Further examination shows that there are many fixed condensers so connected that they will, if shorted, cause material decreases in the value of resistance that should appear. Assume that all the condensers are perfect. Then we will find that the effective resistance between the plate and the ground will be 93.5 ohms (resistance of the R.F. transformer primary) plus 16,000 ohms (R4) plus 8,000 ohms (R1) plus 150 ohms (R3). When the volume control is in the position for maximum signal, no resistance will appear at R2. If the control is at the minimum volume position then the resistance of R2 must be added to the above. The final figures are 24,243.5 ohms with the volume control in the maximum position and 28,593.5 ohms

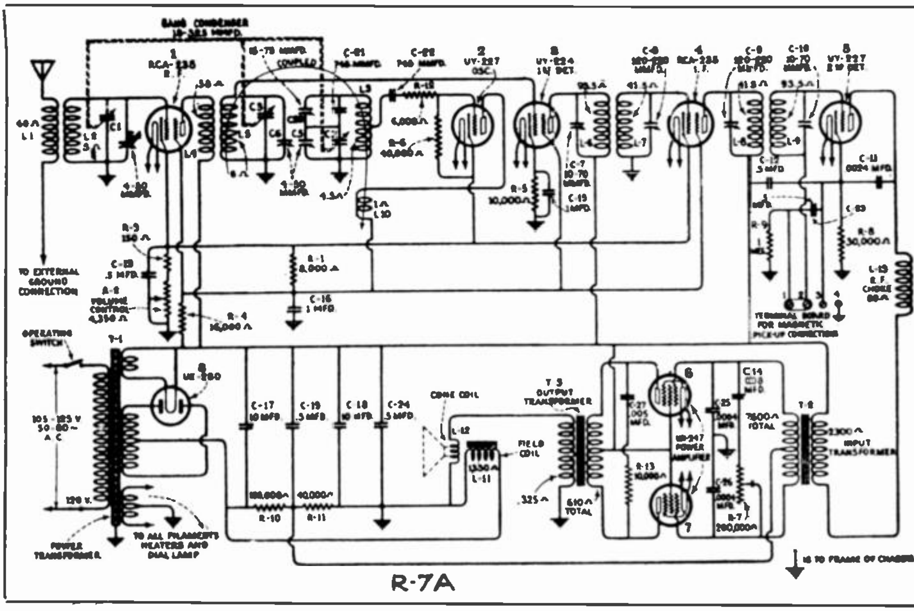


FIG. 17

with the volume control in the minimum volume position.

Each circuit can be traced in a like manner and each circuit will have a definite value or resistance. The total circuit resistance will be made up of the resistance purposely placed in the circuit (bias resistors, grid resistors, isolating resistors) and the direct current resistance of the coils, chokes, etc.

Mention should be made of the necessity of having a good ohmmeter. Shorts in radio-frequency chokes are hard to check. The choke in Fig. 17 has a value of 80 ohms. Instable operation of the receiver, as a whole, could be caused by a faulty choke, and voltage tests would not offer an accurate test for the trouble. If the choke were shorted there would not be a change in the voltage reading between the plate and the ground. Resistance Measurement will enable the Service Man to measure the resistance of the choke, and with the measurement, obtain a true diagnosis. If the ohmmeter does not read at all, the circuit through the choke is open. If the ohmmeter reads full scale, then the choke windings are shorted. Care must be taken that no other equipment is in the circuit at the time of measurement, so check the diagram for resistances which would shunt the choke. If necessary, unsolder the terminals so that other parts of the set will not upset the readings.

Remember, wherever we have an electrical circuit we have resistance. This resistance can be the inherent resistance of the coils, or components placed in the circuit, or they may be resistors placed in the circuit for some definite purpose. Each circuit will have a definite value of resistance when it is in perfect operating condition and will have a different value when the proper operating condition is destroyed. It is this fact that makes Resistance Measurement possible.

Multi-stage amplifiers used in public address systems can be serviced in a similar manner—the same facts hold good here. Every circuit must have some value of direct-current resistance, and if this value of resistance is destroyed, then the circuit will be inoperative; or if it does work, will not function in a proper manner.

An example that will show the possibilities of Resistance Measurement in servicing a radio receiver is found in the case of a receiver that played but developed a bad hum. The hum was so loud that the program could not be appreciated. Voltage analysis proved

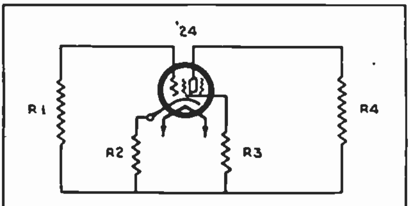


FIG. 18

that the set should operate but did not indicate just where the fault could be found. An ohmmeter connected across one of the filter chokes indicated a complete short circuit. While there was an electrical path for the output of the rectifier, there was no filtering action in the choke, due to the fact that the two leads from the choke winding had shorted in the insulating paper which covered the outside windings of the coil. Forcing the two leads apart and pushing a piece of paper dipped in shellac between the wires, corrected the hum. Voltage readings could have been made in this instance, all night, without finding a satisfactory solution for the problem. An ohmmeter solved it in a few minutes. Time is an ally of the Service Man; that is, when the Service Man can work rapidly. The ohmmeter in this case saved hours of time in making the analysis of the receiver, pleased the customer, and increased his respect for the Service Man.

There are many places in the radio set where Resistance Measurement aids in the quick solution of problems that come up in servicing a radio receiver. Some of these will be covered in figures to follow, along with a statement as to why resistance measurements will give more definite results.

In many of the latest midget model receivers, the field coil of the dynamic speaker is used as the filter system, and the bias for the output stage is obtained by means of two resistors connected across the winding. See Fig. 19. The resistance of R1 and R2 must be high. If the ohmic value of these resistors is too low, there will be a great loss in the efficiency of the filter system. Under normal conditions there will be but little current flowing through these resistors, and if the Service Man trys to measure the voltage across one of the resistors, he will find that the reading will be inaccurate, especially if the reading is made between the grid of the tube and the ground. The meter must consume some current, and if the resistor in the grid circuit is large in value, there will be a voltage drop across it that will not permit accurate readings. With a voltage drop of 60 volts across the choke, and a '47 type tube in the output stage, there will have to be some method of dividing this voltage drop so that the grid circuit has an effective bias of 15 volts.

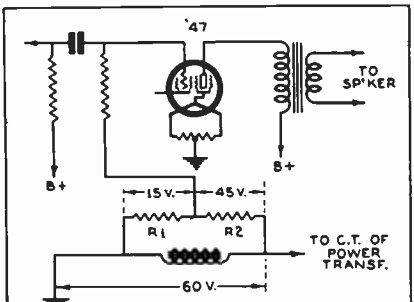


FIG. 19

This voltage is a little lower than the bias voltage specified by the tube manufacturer, but will serve for the purpose of illustration. As the grid should not draw current, the current flowing through R1 and R2 will be the same. Thus the resistance of R1 should be equal to one-quarter of R1 + R2. If R1 is 50,000 ohms then R2 must be 150,000 ohms. Having a voltage reading of the drop across the entire choke, and an ohmmeter reading of R1 and R2, there will be an accurate understanding of the actual bias on the grid of the output tube. This figure will be more accurate than any measurement taken by means of a voltmeter and can be made just as simply.

In many cases it is desired to find the bias voltage applied to the grid of a screen-grid tube used as a detector. The plate current of this tube will approach cut-off, this means that any measuring instrument placed across the resistor R to obtain voltage readings will not be accurate. The circuit of Fig. 20 shows how two readings will give great

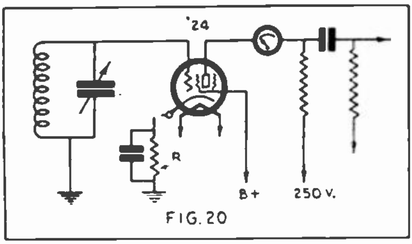


FIG. 20

accuracy. Read the plate current in milliammeters and then check the value of the resistor R with an ohmmeter. The voltage drop across the resistor will be the result of the product of the two figures; thus plate current in amperes times the resistance of R expressed in ohms gives the bias in volts.

Figure 21 illustrates the problem where the tuning condenser is shorted. The quite common voltage tests will not give indications as to the location of the fault. The average tuned secondary of a radio-frequency transformer will have a resistance in the neighborhood

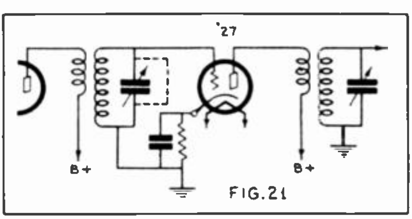


FIG. 21

of 5 ohms. A good low-range ohmmeter is necessary for this test, and if the condenser is shorted, there will be a zero resistance reading on the instrument.

Shorted audio-frequency transformer primaries or secondaries will materially reduce the efficiency of an audio sys-

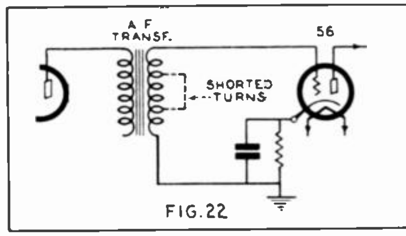


FIG. 22

tem both as to quality and voltage gain. (See Fig. 22.) This can be checked by means of an ohmmeter. The ohmic resistance of audio transformers is high, with the secondary generally having the greater value of resistance of the two. It seems that rules are made

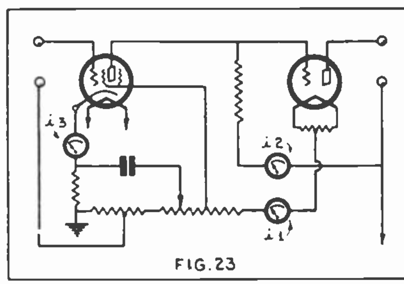


FIG. 23

to be broken, because class "B" transformer secondaries have a lower direct-current resistance than the primary. Output transformers have very low-resistance secondary windings, due to the fact that they are low impedance circuits and are composed of a few hundred turns of wire.

Direct-coupled amplifiers cannot be checked by means of a voltmeter. A knowledge of the current flowing in the indicated circuits (I1, I2, I3) plus an accurate knowledge of the values of the individual resistors will give correct cperating potentials. Of course it is necessary to use Ohm's Law, but if the readings and calculations are carefully made, the results will be more satisfactory than any method of voltage measurement. See Fig. 23.

CHAPTER 5

Point-to-Point Resistance Measurement in Typical Radio Set Using Ohmmeter

POINT-TO-POINT is the most practical method of radio receiver servicing. When analyzing by voltage tests, it is necessary that the tubes be placed in their respective sockets, and that the power supply must work. Readings taken with the tubes out of their sockets will result in false indications of the circuit condition.

Resistance Measurement does not require that the tubes be placed in their sockets, and it is not necessary to have the set connected to the electric-light line. Note that in resistance measurement the tubes do not enter to complicate the problem at all. Often, the entire set is made inoperative due to a poor tube. The testing of the tubes used in the radio set should be done first. If the tubes are satisfactory then the Service Man should look for the trouble in the receiver.

Fig. 18 in Chapter IV indicates the presence of all the resistance in the circuits associated with the tube elements, and since the chassis of the average radio set or amplifier is made of metal, it is used as the return circuit for the power supply system (B—). This chassis provides a reference point for the Point-to-Point system of Resistance Measurement.

A POINT-TO-POINT RESISTANCE ANALYSIS OF A TYPICAL AUDIO AMPLIFIER

This test may be performed with instruments equipped for socket analysis or with an ordinary ohmmeter using standard test prods. For purposes of illustration, the latter method has been selected in this instance, the test being made with the ohmmeter shown in Fig. 24.

The readings were taken on a commercial type amplifier; this being selected merely as an example of a typical amplifier, presenting problems such as the Service Man would be likely to encounter in actual practice. The procedure to be followed with any other amplifier would, in most cases, be practically the same.

The amplifier, shown in Fig. 25, is a three-stage affair, the first stage consisting of two 57 tubes in push-pull, resistively coupled to two 56 tubes in push-pull. The output stage utilizes two 50 tubes in push-pull. The electrical circuit is shown in Fig. 26.

The input transformer, T1, has two primary windings (P1—P2) and (M1—Mc—M2), the latter being center-tapped at Mc. The secondary winding of this transformer is also center-tapped.

The push-pull input transformer, T2, of course, has a center-tapped primary and a center-tapped secondary. The push-pull output transformer, T3, has a center-tapped primary and two secondaries, each being tapped in order to permit suitable matching with various types of speakers. Gain is controlled by means of a dual potentiometer which regulates the current from the secondary of the input transformer T1, to the control grids of the 57 tubes.

The amplifier has its own power supply and filter system. Two half-wave 81 type rectifier tubes are used. The filter system employs two audio chokes bypassed by three electrolytic conden-

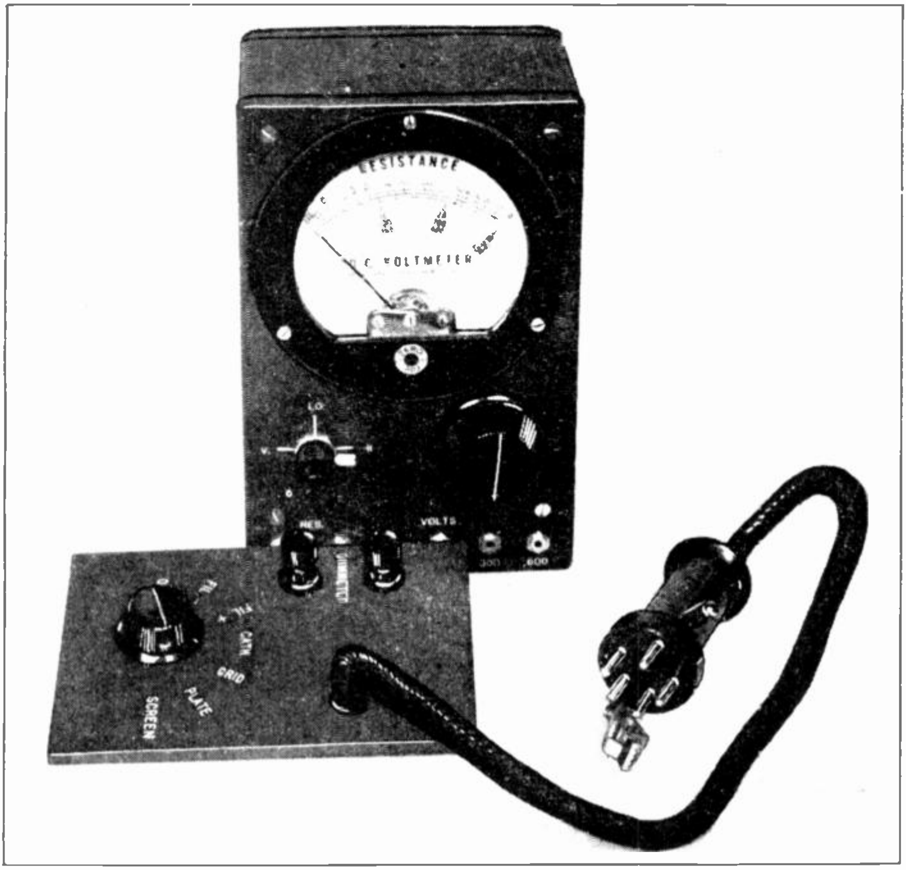


FIG. 24
(Courtesy Lynch Mfg. Co. and Hickok Instr. Co.)

sers. A voltage divider system furnishes all required plate and bias voltages.

In starting the test, the negative lead of the ohmmeter is clipped to the metal chassis or ground and this serves as a reference point. A test probe is then used from the positive side of the ohmmeter to obtain the various readings. In certain cases, two probes must be used instead of probe and clip, as, for instance, where a reading is required between the plate terminals of two tubes.

The first reading is taken at point P1 of the input transformer primary. This gives the resistance between P1 and P2—in other words, this is the resistance of the primary winding (P1—P2). This is found to be 1,000 ohms.

Next a reading is taken with the probe at M1 and the clip at M2. This gives the total resistance of the other primary winding, which is recorded as 116 ohms. A reading between Mc and either of the other M posts shows a

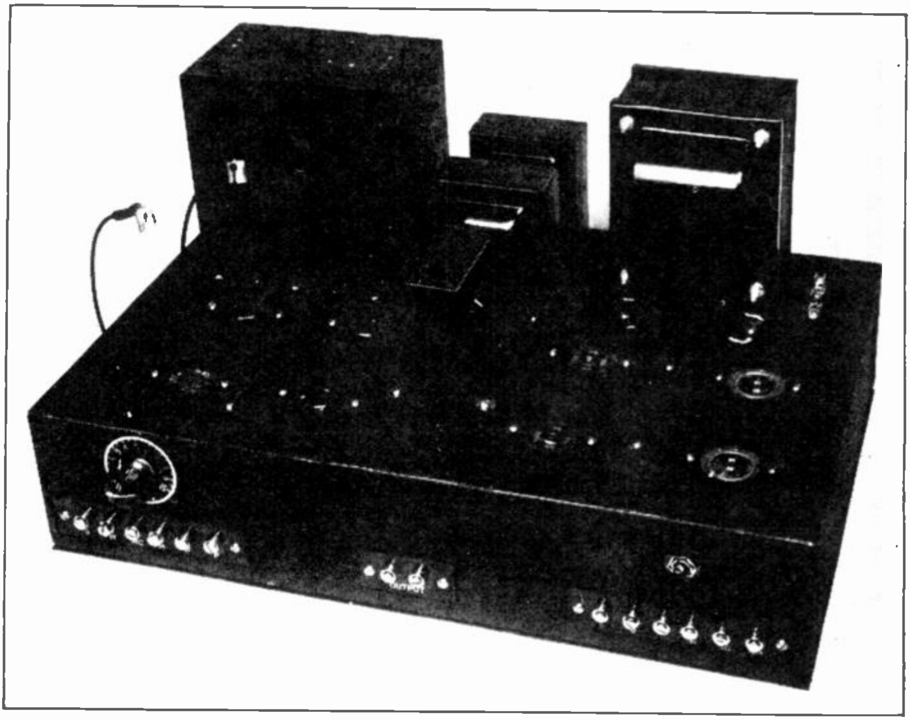


FIG. 25 (Courtesy Federated Purchaser Inc.)

resistance of 58 ohms, indicating that the center tap is O.K.

The next reading is taken with the clip fastened to the chassis and the probe at the control grid terminal (connection to cap) of V1, with the resistance R1 turned to the point of maximum gain. This gives the resistance of one-half the secondary of transformer T1 (neglecting R1 which is very high), which is found to be 30 ohms. A similar reading at V2 also registers 30 ohms. Hence, the resistance of T1 secondary is 60 ohms.

Leaving the clip on the chassis, the test probe is connected to each of the filament terminals—first of V1 and then of V2. All four readings are identical—1 ohm, indicating that the total resistance of the "X-X" filament winding is 2 ohms.

A reading at the screen terminal of V1 shows a value of 1 megohm. This resistance includes R14, R3, R11 and R12. The plate terminal reading is 500,000 ohms. This includes R3, R11 and R12, but excludes R14. Hence the resistance of R14 is equal to the difference between the screen-grid and plate readings, or 500,000 ohms. The reading at the cathode terminal of V1 is 1,400 ohms, which registers the resistance of R7. A similar set of readings is obtained at the screen-grid, plate and cathode terminals of V2.

A reading taken between the plate of V1 and the plate of V2 gives the resistance of R3 plus R4 or 1,000,000 ohms. Dividing this value by 2 gives the value of R3 and R4, individually. A reading between the screen-grid and the plate of V1, gives the value of R14.

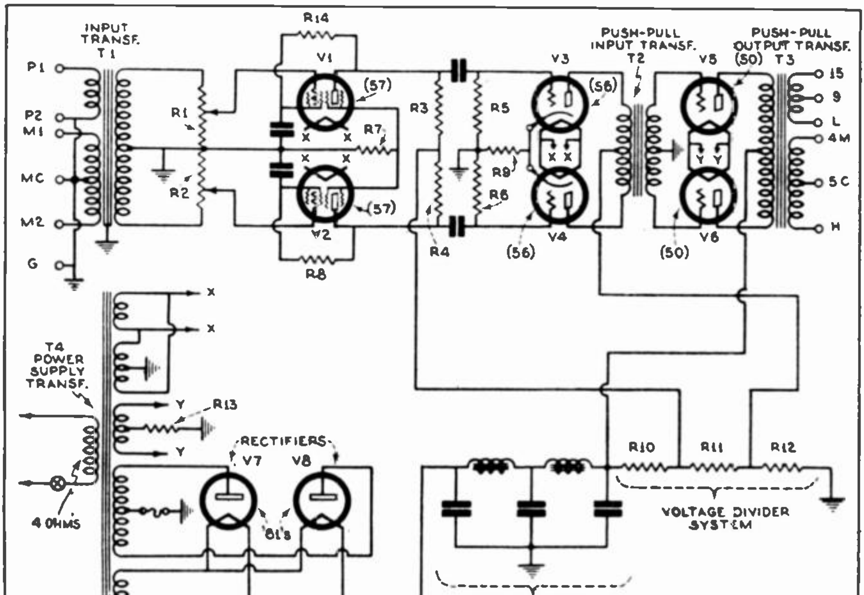


FIG. 26

This is found to be 500,000 ohms. The resistance of R8 is found in the same way—by taking a reading between the screen-grid and the plate of V2.

With the clip again connected to the chassis, the probe is touched to the control-grid terminal of V3. The ohmmeter now records 500,000 ohms. This then, is the resistance of R5. At the plate terminal of V3, a reading of 10,000 ohms is obtained. This consists of one-half the resistance of the primary of the push-pull input transformer T2, plus R12. The reading of the resistance between the plate terminals of V3 and V4, 1,500 ohms, gives the total primary resistance of transformer T2. Dividing this by two gives the value to the center-tap. Subtracting this value, 750 ohms from the original plate terminal reading of 10,000 ohms at V3, gives the resistance of R12, which is 9,250 ohms.

With the clip attached to the chassis and the probe touched to the cathode terminal of V3, a reading of 1,400 ohms is obtained. This is the resistance of R9. A reading taken between the grid terminal of V3 and the grid terminal of V4 gives the total resistance of R5 plus R6. This reading is 1 megohm. Hence, R5 and R6 each have a resistance of 500,000 ohms. Filament readings are the same as those obtained at V1 and V2.

Starting with the various terminals of V4, a similar set of readings may be taken as a further check.

The next step is to take a reading at the control grid of V5. This is found to be 3,000 ohms. A similar value is recorded at the control grid of V6. Hence, the total resistance of the secondary of T2 is 6,000 ohms. A reading between the plate terminals of V5 and V6 of 400 ohms, gives the resistance of the primary winding of transformer T3. A reading at the plate terminal of V5 gives the resistance of half the primary of T3 plus R10, R11 and R12. Since the primary resistance is known, and, also, resistance of R12, it is easy to determine the resistance of R11 plus R10. From the readings taken at V1, resistance of R11 can be determined thus giving the resistance of R1 Check readings may be made at V6.

Next, readings are taken between the secondary winding terminals of T3: from L to 9, the resistance is .25-ohm; from L to 15, the resistance is .5 ohm; from H to 5C, the resistance is 160 ohms; from H to 4M, the resistance is 650 ohms.

A reading between either side of the filament lines going to V5 and V6, with clip on chassis, shows a value of 1,250 ohms. This is the resistance of half the filament winding "Y-Y" plus R13. By taking a reading between the two sides of the line, the resistance of the filament winding "Y-Y" may be determined and by subtracting half of this value from 1,250, the exact value of R13 may be calculated quite readily.

A reading between the plates of V7 and V8, indicates that the plate voltage winding has a resistance of 250 ohms. The resistance of the primary of T4 is found to be 4 ohms.

The internal circuit of the resistance meter is shown in Fig. 27.

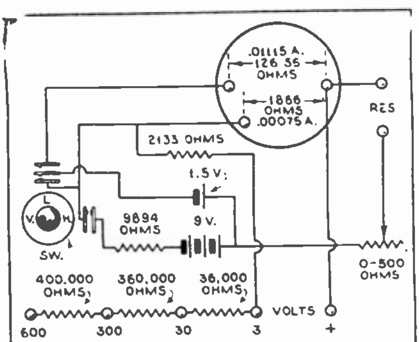


FIG. 27

POINT-TO-POINT RESISTANCE READINGS OF COMMERCIAL RECEIVERS

The following point to point resistance measurements have been taken on standard radio receivers. For convenience, the readings are tabulated. These tables contain not only the resistance values, but also the purpose of each resistor and its original color code. The values have been tabulated by the International Resistance Company of Philadelphia. Any service man may obtain similar tabulations for all standard commercial receivers by sending to the International Resistance Company.

Tabulated resistance values are given below for Crosley models (53, 54, 57), (77-1), (59 A.C.) and (84). Tables are also given for Philco models (90 & 90A), (70 & 70A) and (76); for U. S. Radio model 26 P Gloritone; and for the Majestic model 110 Auto Radio. The circuits are shown in Fig. 28 A, B, C, etc.

Purpose of Resistor	Resistor Connections: From	Resistor Connections: To	Color Code of Orig.	Resist. Value
Limits R.F. Control Grid Bias.	High Side Vol. Control	Ground	Red Black Orange	20,000 ohms
R.F. Fixed Bias Res.	R.F. Cathode	High Side Vol. Control	Yellow Yellow Black	440 ohms
[illegible] Det. [illegible]	Low side sec. Det. R.F. Trans.	Ground	Brown Black Green	1 meg
Det. Control Grid Bias. Res.	Det. Cathode	Ground	Brown Black Orange	10,000 ohms
Voltage Div. Res.	Low Side Pri. R.F. Trans.	R.F. and Det. Screens.	Brown Black Orange	10,000 ohms
Voltage Div. Res. R.F. Screens	R.F. and Det. Screens	Ground	Brown Black Orange	10,000 ohms
Voltage Div. Res. R.F. Plates	Low Side Filter Choke	Low Side Pri. R.F. Trans.	Brown Black Orange	10,000 ohms
Det. Plate Coupling Res.	Low Side Filter Choke	Low Side Det. R.F. Choke	Brown Green Orange	150,000 ohms
Grid Leak 245 Output Tube	Grid 245	Ground	Brown Black Green	1 meg
Bias Res. 245	Mid Tap 245 Fil. Winding	Ground	Brown Black Red	1650 ohms

CROSLEY Models 53-54-57 Crosley Radio Corp

Purpose of Resistor	Resistor Connections: From	Resistor Connections: To	Color Code of Orig.	Resist. Value
Fixed Bias Res. R.F. Control Grids	High Side Vol. Control.	R.F. Cathodes		225 ohms
Voltage Divider Det. and R.F. Screens	1st and 2nd. R.F. Cathodes	1st and 2nd. R.F. Screens		300,000 ohms
Voltage Divider Det and R.F. Screens	Low end Pri. 2nd R.F. Trans.	1st and 2nd. R.F. Screen Grids		100,000 ohms
Det. Plate Coupling Res.	Detector Plate	Pentode Screen Grid		300,000 ohms
Pentode control grid leak.	Pentode control grid R.F. Choke	#7 and #8		1 meg
Voltage drop Res.	Fil. Rectifier	Pentode Screen Grid.		1100 ohms
Voltage divider Pentode Control Grid Bias	Mid-Tap Rect. Plate Winding	Low end Pentode Control Grid Lead.		1 meg
Voltage divider Pentode Control Grid Bias	Low end Pentode control grid lead.	Ground		300,000 ohms
Det. Control Grid Bias	Det. Cathode	Ground		40,000 ohms
Filter Res. Detector Screen Grid	R.F. Screen Grids	Detector Screen Grid		1 meg

CROSLEY Model 59 A.C. Crosley Radio Corp

CROSLEY
Model 84
Crosley Radio Corp

PURPOSE OF RESISTOR	RESISTOR CONNECTIONS FROM	TO	COLOR CODE OF ORIG.	RESIST. VALUE
R.F. Screen Filter Res.	R.F. Screens	Resistors #4 and #5		10,000 ohms
R.F. Control Grid Bias	R.F. Cathodes	Ground		270 ohms
1st A.F. Bias Resistor	1st A.F. Cathode	Ground		300 ohms
V. Divider Res. R.F. Screens	1st A.F. Cathode	#5 Res.		1100 ohms
Voltage Divider	Low Side Pri. 1st A.F. Trans.	#4 Res.		2500 ohms
Det. Control Grid Bias Res.	Det. Cathode	Phono. Switch		20,000 ohms
R.F. Det. Control Grid Stabilizing Res.	Low End Secondary Det. R.F. Trans.	Ground		60,000 ohms
Det. Pl. Coupling Res.	Det. R.F. Plate Choke	Low End Pri. A.F. Trans.		100,000 ohms
Det. Screen Filter Res.	Low End Pri. A.F. Trans.	Det. Screen		1 meg
Bias Res. 245	Mid Tap 245 Filament.	Ground		864 ohms
R.F. Control Grid Bias Feeder	Low End Secondary 1st R.F. Trans.	Low End Secondary 2nd R.F. Trans.		60,000 ohms
R.F. Control Grid Bias Feeder	Low End Secondary 2nd R.F. Trans.	Low End Secondary 3rd R.F. Trans.		60,000 ohms
R.F. Control Grid Bias Feeder	Low End Secondary 3rd R.F. Trans.	Low End Secondary 4th R.F. Trans.		60,000 ohms

PHILCO
Models 70 and 70A
Philadelphia Storage Battery Co

PURPOSE OF RESISTOR	RESISTOR CONNECTIONS FROM	TO	COLOR CODE OF ORIG.	RESIST. VALUE
Self Bias	Cathode 1st Det.	Cathode Osc.	Green Black Red	5,000 ohms
Uniform Oscillation over Wave Band	Junction Grid and Plate Osc. Coils	Ground.	Green Brown Orange	50,000 ohms
Osc. Plate Feeder	Plate Osc.	Scr. Grid 1st Det.	Brown Orange Orange	13,000 ohms
Det. Screen Filter	Scr. Grid 2nd Det.	Scr. Grid I.F.		250 ohms
Detector Bias	Cathode 2nd Det.	Ground	Green Brown Orange	50,000 ohms
Det. Plate Filter	Speaker Field	Res. #7	White White Orange	0.1 meg
Detector Plate Coupling	R.F. Choke in 2nd Det. Plate Circuit	Res. #6	Red Yellow Yellow	0.25 meg
Output Tube Grid Leak	Central Grid Pentode	C.T. High V. Winding Power Transf.	Red Yellow Yellow	0.25 meg
Voltage Divider	I.F. Screen	Speaker Field	Tubular Resistor	1,000 ohms
Voltage Divider	I.F. Screen	Volume Control	Tubular Resistor	2,300 ohms
Osc. & 1st Det. Bias	Ground	Volume Control and Osc. Cathode	Tubular Resistor	[illegible] ohms
Output Bias	Ground	C.T. High Voltage Winding Power Transf.	Tubular Resistor	[illegible] ohms

CROSLEY
Model 77 1
Crosley Radio Corp

PURPOSE OF RESISTOR	RESISTOR CONNECTIONS FROM	TO	COLOR CODE OF ORIG.	RESIST. VALUE
Limits R.F. Control Grid Bias	High Side Vol. Control	Ground		11,000 ohms
Prevents Detector Overloading	Low End Sec. Det. R.F. Trans.	Ground		60,000 ohms
Det. Control Grid Bias	Det. Cathode	Ground	Red Orange Spot	20,000 ohms
Det. Screen Filter Res.	Low End Pri. R.F. Trans.	Det. Screen	Brown Green Spot	1 meg
Det. Plate Coupling Res.	Low End Pri. R.F. Trans.	Low End Det. R.F. Choke	Brown Yellow Spot	150,000 ohms
1st A.F. Grid Leak	Grid 1st A.F.	Ground.		300,000 ohms
R.F. Screen Filter Res.	R.F. Screens	#8 and #10	Brown Orange Spot	10,000 ohms
Voltage Div. Res.	Cathodes 1st A.F.	#7 and #10		2,000 ohms
1st A.F. Bias Res.	Cathode 1st A.F.	Ground	Brown Orange Spot	235 ohms
Voltage Div. Res.	Low End Pri. A.F. Trans.	#7 and #8	Brown Orange Spot	1750 ohms
Bias Res. 245	Mid Tap Fil. Winding 245	Ground	Brown Orange Spot	825 ohms
Fixed Bias R.F. Control Grids	High Side Vol. Control	R.F. Cathodes		260 ohms

PURPOSE OF RESISTOR	RESISTOR CONNECTIONS FROM	TO	COLOR CODE OF ORIG.	RESIST. VALUE
Ant. Shunt Res.	Ant.	Ground		5,000 ohms
Shunt Res. Local-Dist. Sw.	Ant.	Local-Dist. Sw		20 ohms
Det. Control Grid Bias Res.	Det. Cathode	Ground		100,000 ohms
Det. Screen Fil. Res.	Det. Screen	V. Divider #10 and #11		250,000 ohms
Det. Plate Isolating Res.	Speaker Field Term.	#6		100,000 ohms
Det. Plate Coupling Res.	#5	Det. Plate		500,000 ohms
1st. A.F. Grid Leak.	1st. A.F. Grid	Mid Tap Sec. First A.F. Trans.		500,000 ohms
Bias Res. 245	Mid Tap 245 Fil. Winding	Mid Tap Rect. Plate Winding		800 ohms
Voltage Div. Res.	Low End 1st. A.F. Pri.	R.F. Screens		2000 ohms
Voltage Div. Res.	R.F. Screens	#11 Res.		1300 ohms
Voltage Div. Res.	#10	High Side Vol. Control.		1400 ohms
1st A.F. Bias Res.	Ground	Mid Tap Rect. Plate Winding		250 ohms

PHILCO
Model [illegible]
Philadelphia Storage Battery Co

PHILCO

Models 90 and 90A
Above Serial No. 217,001
Philadelphia Storage Battery Co.

PURPOSE OF RESISTOR	RESISTOR CONNECTIONS		COLOR CODE OF ORIG.	RESIST. VALUE
	FROM	TO		
Ground Ant.	Ant.	Ground	Brown Black Orange	10,000 ohms
A.V.C. Voltage Divider	Sec. 2nd I.F. Transformer	Res. #4	Green Brown Orange	51,000 ohms
A.V.C. Voltage Divider	Cathode 2nd Det.	Res. #3	Green Brown Orange	51,000 ohms
2nd Det. Coupling Resistor	Sec. 2nd I.F. Transformer	Det. Rect. Det. Amp. Coupling Condenser	White White Orange	99,000 ohms
Det. Amplifier Plate Coupling Resistor	Plate Det.-Amp.	Res. #6	Green Brown Orange	51,000 ohms
Det.-Amplifier Plate Filter	B+ max.	Res. #5, Det.-Amp. Plate Coupling Res.	Violet Black Orange	70,000 ohms
1st A.F. Grid Leak	Grid 1st A.F.	Res. #17	Red Yellow Yellow	0.24 meg
1st A.F. Plate coupling Resistor	Plate 1st A.F.	Res. #9	Red Green Orange	25,000 ohms
1st. A.F. Plate Filter	B+ max.	Res. #8	Red Green Orange	25,000 ohms
Grid Leak 2nd A.F.	Grid Control Pentode.	Res. #17	Red Yellow Yellow	0.24 meg
A.V.C. Bias Feeder 1st R.F.	1st R.F. Grid Coil.	Sec. 2nd I.F. Transformer	Yellow White Yellow	0.49 meg
Self Bias 1st Det.	Cathode 1st Det.	Cathode I.F.	Green Black Red	5,000 ohms
Osc. Plate Feeder.	Plate Osc.	B max.	Green Brown Orange	51,000 ohms
A.V.C. Bias Feeder I.F. Tube	Sec. 1st I.F. Transf.	Junction Res. #3 and Res. #4	Yellow White Yellow	0.49 megs
Voltage Divider	I.F. Screen	Ground	Violet Black Orange	70,000 ohms
Voltage Divider	I.F. Screen	Spk. Field	Red Green Orange	25,000 ohms
Grid Bias Filter 1st & 2nd A.F.	Junction Res. #7 and Res. #10	C.T. High V. Winding "B" Supply	Red Yellow Yellow	0.24 megs
Uniform Oscillation over Wave Band	Osc. Coupling Coil	Ground	Green Brown Orange	51,000 ohms

PURPOSE OF RESISTOR	RESISTOR CONNECTIONS		COLOR CODE OF ORIG.	RESIST. VALUE
	FROM	TO		
A.V.C. Bias Feeder 1st R.F.	Sec. Ant. Trans.	Sec 1st R.F. Trans.	......	0.2 meg
A.V.C. Bias Feeder 2nd R.F.	Sec. 1st R.F. Trans.	Sec Untuned R.F.	......	0.2 meg
A.V.C. Bias Feeder 3rd R.F.	Sec. 2nd R.F. Trans.	Junction Res. 6 and 7	......	0.2 meg
1st A.F. Grid Resistor.	Sec. Untuned R.F.	Grid 1st A.F.	......	0.1 meg
R.F. Plate circuit Decoupling Resistor.	Pri. Untuned R.F.	Primary 2nd R.F. Coil	......	750 ohms
A.V.C. Voltage Divider	Sec Untuned R.F.	Res. 7	......	50,000 ohms
A.V.C. Voltage Divider	Cathode Det.	Res. 6	......	50,000 ohms
Det. Bias	Cathode Det.	Ground	......	50 ohms
1st A.F. Plate Coupling.	Plate 1st A.F.	Shield grid Pentodes	......	0.1 meg
Output Bias	Cathodes Pentodes	Ground	......	400 ohms

MAJESTIC

Model 110 Auto Radio
Grigsby-Grunow Co.

Continued

PURPOSE OF RESISTOR	RESISTOR CONNECTIONS		COLOR CODE OF ORIG.	RESIST. VALUE
	FROM	TO		
2nd A.F. Bias	Center Tap High Voltage Winding of Power Transformer	Ground	Tubular Resistor	180 ohms
Det. Amp. Bias	Osc. Cathode	Ground	Tubular Resistor	60 ohms
Bleeder	Osc. Cathode	Speaker Field	Tubular Resistor	3,500 ohms

PHILCO

Models 90 and 90A
Above Serial No. 217,001
Philadelphia Storage Battery Co.

Continued

PURPOSE OF RESISTOR	RESISTOR CONNECTIONS		COLOR CODE OF ORIG.	RESIST. VALUE
	FROM	TO		
2nd Detector Plate Resistor	R.F. Choke 2nd Det. Plate Circuit	Res #2	Red Yellow Yellow	0.25 megs
2nd Det. Plate Filter	B+ max.	Res #1	Red Yellow Yellow	0.25 megs
Grid Leak 1st A.F.	Grid 1st A.F.	Center Tap sec. of Push Pull Input Transf.	Brown Black Green	1.0 megs
Filter 2nd Det. Screen	Screen Grid 2nd Det.	Screen Grid 1st Det.	Red Yellow Yellow	0.25 megs
Power Tube Bias	C.T.P.P. Filament Transformer	C.T. High Voltage Secondary	. . . .	800 ohms
Uniform Oscillation over Wave Band Oscillator	Uniform Oscillator Grid and Plate Coils.	Ground	Green Brown Orange	50,000 ohms
Plate Feeder	Osc. Plate	R.F. Choke	Brown Orange Orange	13,000 ohms
2nd Detector Bias	Cathode 2nd Det.	Ground	Green Brown Orange	50,000 ohms

PHILCO

Models 90 and 90A
Below Serial No. 217,001
Philadelphia Storage Battery Co.

U. S. RADIO

Model 26 P. Gloritone
U. S. Radio & Television Corp.

PURPOSE OF RESISTOR	RESISTOR CONNECTIONS		COLOR CODE OF ORIG.	RESIST. VALUE
	FROM	TO		
R.F. Bias	R.F. Cathodes	Volume Control	.....	350 ohms
Det. Plate Coupling	Detector Plate Filter Resistor #3	Detector Plate	.....	400,000 ohms
Det. Plate Filter	Detector Plate Coupling Resistor #2	B+ Maximum	.....	60,000 ohms
R.F. Filter	Pentode Grid Condenser	Detector Plate	.....	60,000 ohms
Output Tube Grid Leak	Pentode Grid	Voltage Divider #2	.....	200,000 ohms
Filter Resistor	R.F. Screens	Speaker Field Tap	.....	25,000 ohms
Detector Bias	Center Tap High Voltage Secondary	Detector Cathode	.....	200,000 ohms
Voltage Divider	Ground	Detector Screen	.....	2640 ohms
Output Tube Bias	Ground	Output Tube Grid Leak	.....	360 ohms
Bleeder Res.	Center Tap High Voltage Secondary	Resistor #9	.....	640 ohms

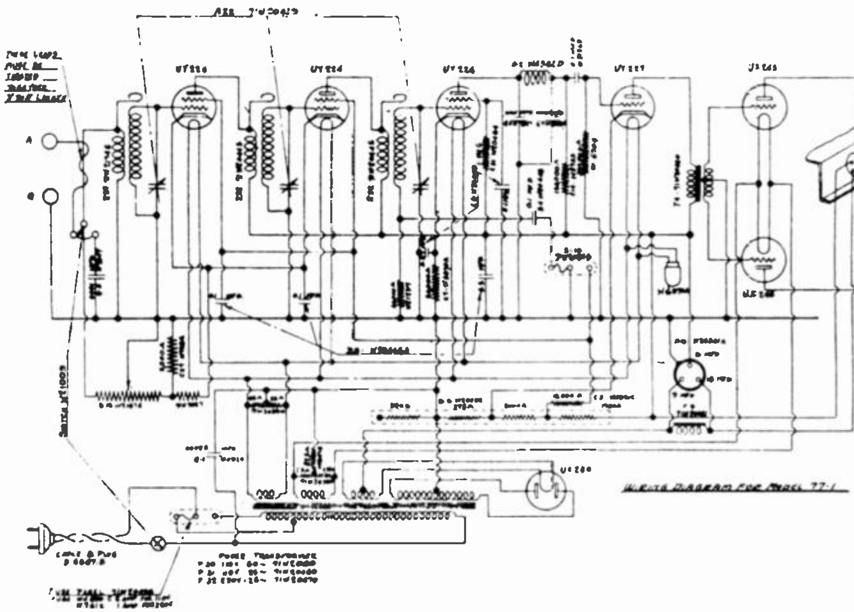


FIG. 28 A

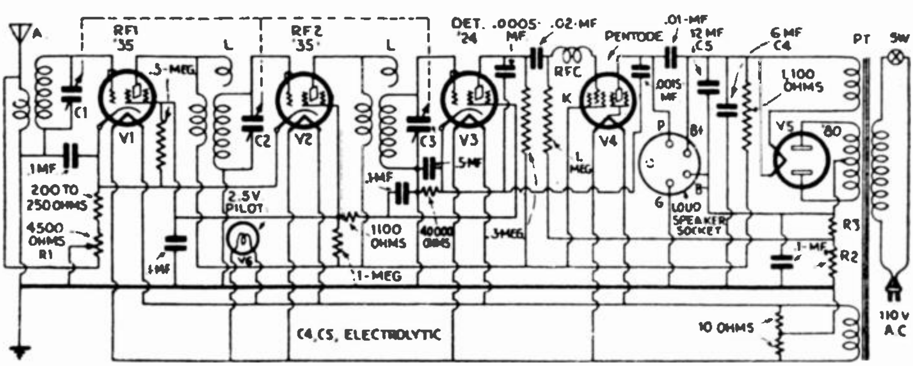


FIG. 28 B

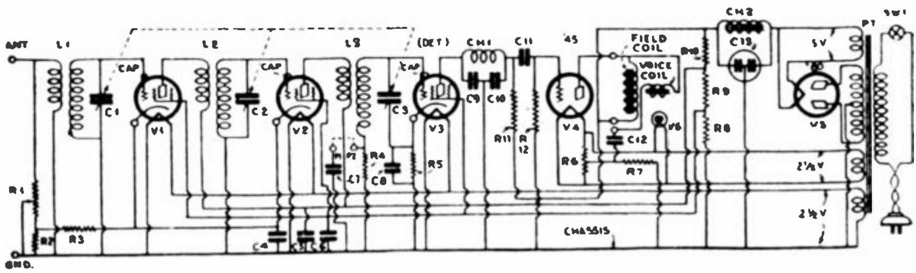


FIG. 28 C

———o———

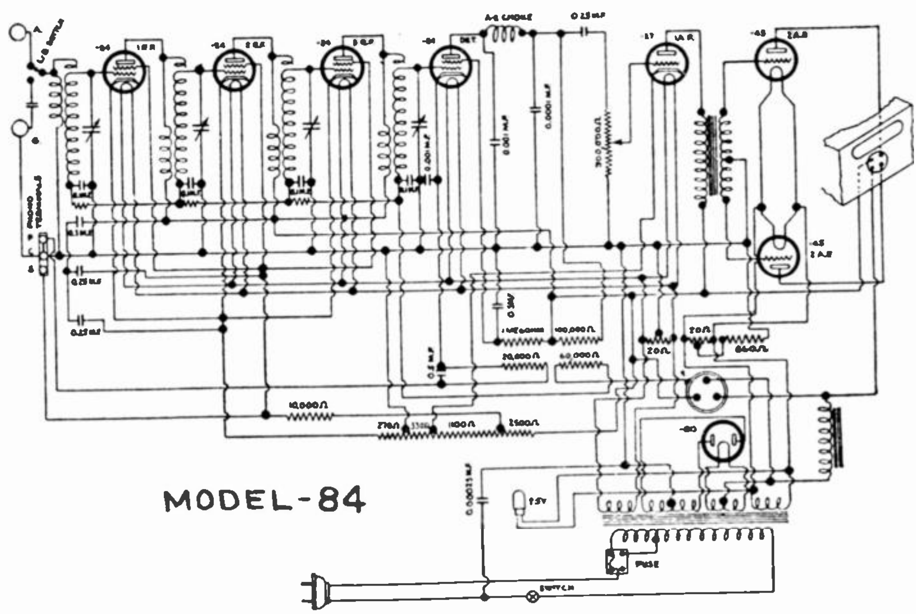
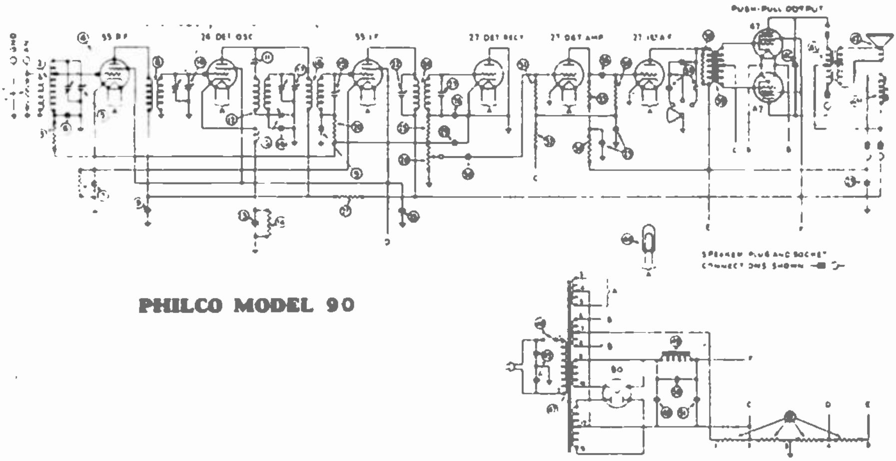


FIG. 28 D



PHILCO MODEL 90

FIG. 28 H

MODELS 70 AND 70-A

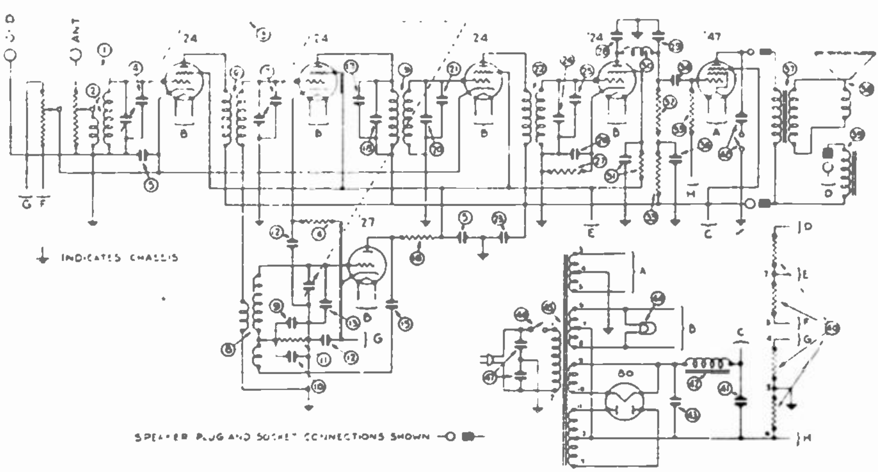


FIG. 28 I

Philco Model 76

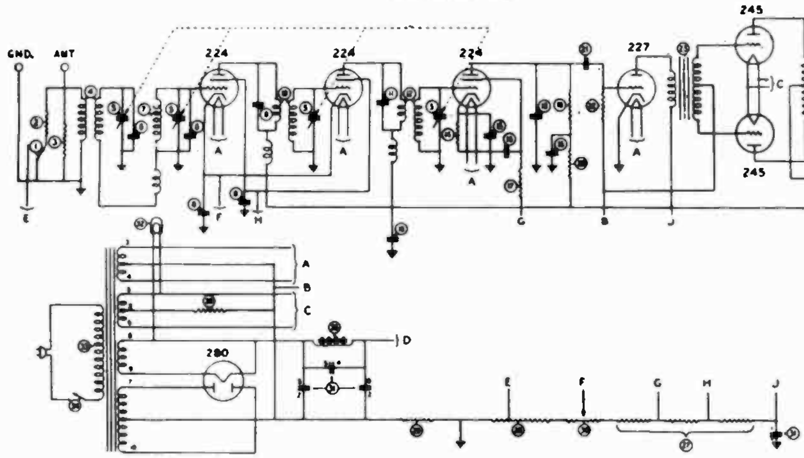
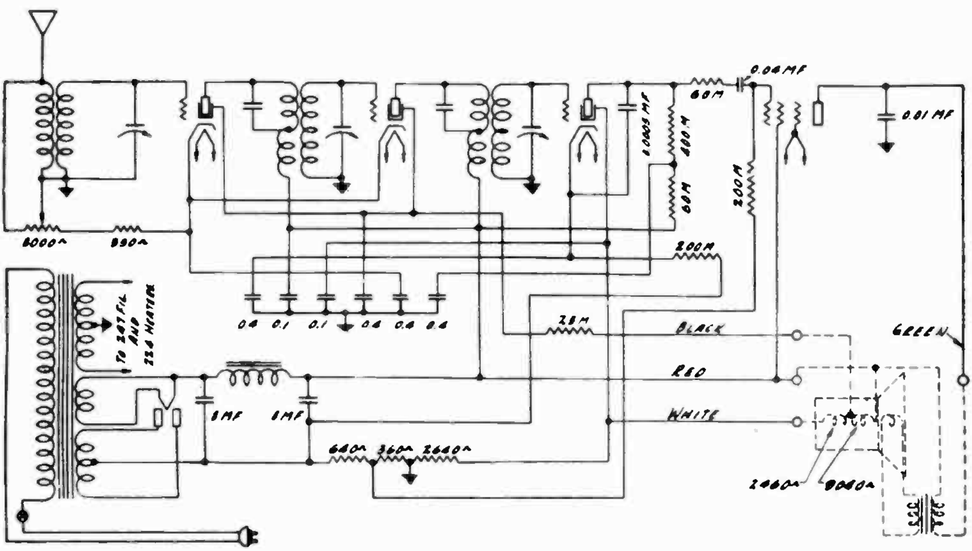
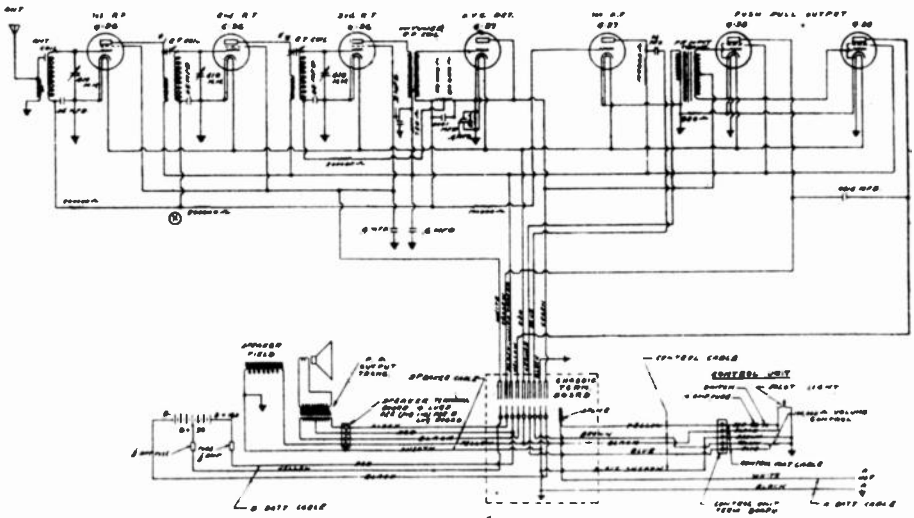


FIG. 28 G



Gloritone 26P

FIG. 28 H



SCHEMATIC DIAGRAM MAJESTIC
AUTO RADIO
MODEL-110

FIG. 29

CHAPTER 6

Modern Testers Available for Resistance Measurements

THE rapidly increasing popularity of the resistance method of servicing, has been a great incentive to manufacturers to produce suitable equipment for employing this system. As a result, the Service Man will find a wide variety of such instruments available, from simple ohmmeters to elaborate combination outfits, and in every price range.

WESTON MODEL 663

The Weston Model 663 Volt-Ohmmeter, shown in the accompanying illustration is a typical example of the excellent apparatus being produced for resistance measurement analysis. This device answers the demand for an ohmmeter capable of measuring both very low and very high resistances. The voltage and current ranges have been added to make this instrument as universal in its application as possible.

The No. 663 employs the circuit shown in Fig. 30. A molded black bakelite panel is used. A Weston model 600 microammeter is employed, having a full scale sensitivity of 50 microamperes. This sensitivity is required for the higher resistance ranges. A very small diameter tubular pointer on the meter, with a knife edge tip, is also used. An etched scale, showing 0-1,000 ohms above, and 0-2.5—5—10 volts and milliamperes below the arcs, is supplied.

Energy for the ohmmeter ranges is supplied from self-contained batteries. Three Burgess No. 5360 or Eveready No. 781 and one Burgess No. 2 Unit Cell or Eveready No. 950 Unit Cell, are required. These batteries fit into clips mounted on the rear of the panel where they are accessible by removing the panel from the case.

A twenty-four position, one-deck switch is mounted under the panel. This switch is arranged to operate through eight positions only, giving seven ohmmeter ranges and one position both for "Volts and Milliamperes". Battery voltage compensation is provided for. The control knob is designated as the "ohmmeter adjuster".

Seven tip jacks are used on the upper left-hand side of the panel for the six voltage ranges. These jacks are connected to the meter only when the switch is in the "Volts-Milliamperes" position. All voltage ranges are on the basis of 1,000 ohms per volt—a recognized voltmeter sensitivity for all classes of vacuum tubes.

Five tip jacks are used for the seven ohmmeter ranges. The particular range required is selected by means of the switch, the designations of which indicate the multiplying factor which should be used on the ohmmeter scale to secure the proper range.

Five tip jacks below the ohmmeter jacks are supplied for the four milliampere ranges. These ranges, 0—1—5—25—100 ma., are all given with a drop of 500 millivolts.

The ohmmeter ranges are so arranged that very good readings are available over the entire range from .1 to 10,000,000 ohms. The voltmeter ranges provide very good reading over the range from .05 to 1000 volts. The milliampere ranges provide readings from .02 to 100 milliamperes. Current

The new model 663 volt-ohmmeter.

FIG. 30

readings are not generally provided on volt-ohmmeters, but are supplied on this device.

The Weston 663 Volt-Ohmmeter is a very excellent instrument for point-to-point resistance checking, as the ranges provided are well suited for this type of work.

SUPREME MODELS

Another efficient, economical and useful instrument for resistance measurement work is the model 33 ohmmeter, made by the Supreme Instruments Corporation. This is shown in Fig. 31. It is a self-contained instrument suitable for resistance measurements and continuity tests. A large 3½" bakelite-cased meter is employed accurately calibrated in resistance ranges of 0—1,000 and 0—100,000 ohms, and actuated by a self-contained flashlight battery. It is provided with external connections for a 45-volt battery to extend its range to 1,000,000 ohms. A set of test leads are included in the equipment.

The Supreme model 44; Fig. 32, D.C. Volt-Ohmmeter is an unusually compact instrument, useful for resistance measurements, voltage measurements, and continuity tests. It uses a self-contained flashlight battery for resistance measurements in the ranges 0—1,000 and 0—100,000 ohms, with the same provision for extension of the range to 1,000,000 ohms as in the model 33 ohmmeter. Four D.C. voltage ranges of 0—10, 0—100, 0—250, and 0—750 volts, are available. The instrument is contained in a good-looking hardwood case and is available in shop or portable models.

It might be well to mention at this point, that the better-designed set testers, analyzers and similar comprehensive instruments which have been on the market for several years, readily lend themselves to use in connection with the resistance measurement method of servicing.

As an example, let us consider the Supreme AAA-1 Diagnometer, shown in Fig. 33. This tester combines five instruments in one. It is an analyzer, a tube tester, a shielded oscillator, an ohmmeter-megohmmeter and a capacitor tester. Although the AAA-1 Diagnometer was placed on the market before the resistance method of servicing started to attract attention, this in-

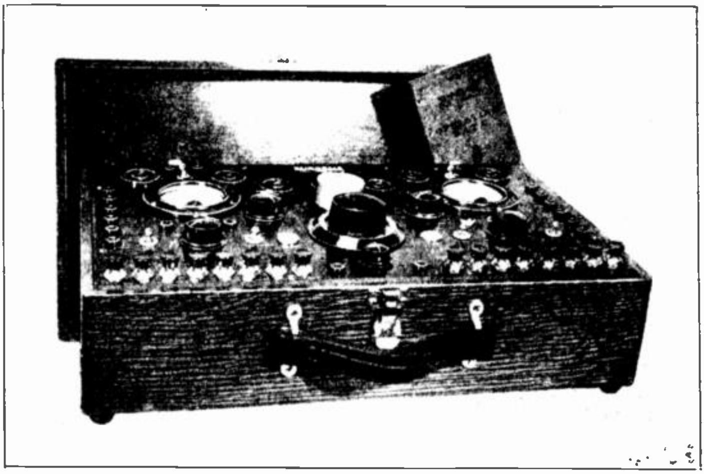


FIG. 33

strument is so flexible in its design that it can be adapted to resistance testing methods with the greatest ease.

To use the AAA-1 Diagnometer for resistance measurements, test conductors are employed between the ohmmeter terminals and the contacts of the 'Analyzer" sockets. The measurements may also be made from the chassis, rectifier socket, or from any other reference point recommended. During resistance analysis, the radio receiver is disconnected from the power supply socket, but the "on-off" switch of the receiver may open only one side of the power supply circuit, making it possible to ground the closed side of the line through the meter when making certain measurements.

The ohmmeter in the Diagnometer employs a sensitvie D'Arsonval movement, which is calibrated directly in ohms. The resistance ranges are five times those usually obtainable with the same applied potential. A rheostat shunting the meter serves as an "ohmmeter zero adjuster," providing for a zero adjustment which permits compensation for the diminishing voltage of the three-cell flashlight battery utilized for actuating the movement of the Ohmmeter-Megohmmeter. The same

FIG. 31

FIG. 32

"adjuster" rheostat is employed for adjusting externally-applied potentials used for the higher ohmmeter ranges.

The low resistance range is from 0—5,000 ohms. The next range is from 0—500,000 ohms. An indicating range of from 0—5 megohms is available by using an external 45-volt battery. An indicating range of 0—25 megohms can be obtained by employing the self-contained potential of 250 volts, direct current from the Diagnometer output circuits. These resistance ranges are ideally suited for complete resistance analysis.

mf. to 10 mfs. In many instances, this latter feature will be extremely useful. Many other desirable tests may be made with the AAA-1 Diagnometer, but a description of these is beyond the scope of this book.

For those Service Men who do not require, or who cannot afford as comprehensive an instrument as the AAA-1 Diagnometer, there are several other analyzers made by the Supreme Instruments Corporation which provide splendid facilities for resistance servicing and which at the same time incorporate many other useful features.

FIG. 31

Of course, an elaborate device such as the Diagnometer has many other features which can be used to immense advantage. For example, the tube tester is always instantly available and supplementary voltage readings may be made directly from the sockets, using the same analyzer cable and plug. A capacitor tester is also provided, capable of indicating capacities from .002

The Supreme model 90 Set Analyzer (Fig. 31) is provided with an ohmic scale for the direct reading of resistance values up to 500,000 ohms in two ranges of 0—5,000 ohms and 0—500,000 ohms, the lowest division of this range being $2\frac{1}{2}$ ohms. A "zero-ohms" adjuster is provided on the panel for adjusting the meter sensitivity to take care of battery potential variations.

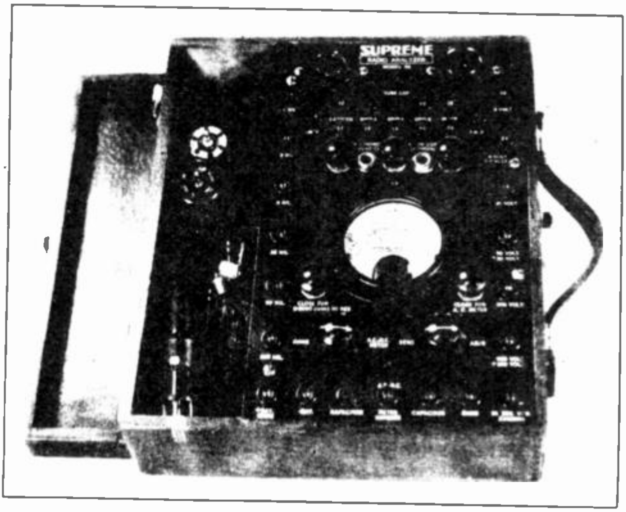
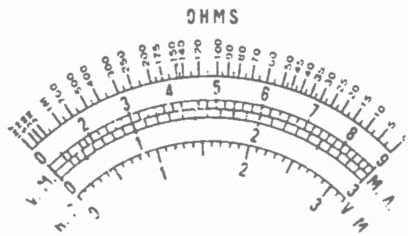


FIG. 35

FIG. 36

This analyzer, in addition to its use for resistance measurement work, also provides six A.C. and six D.C. voltage measuring ranges and five A.C. and five D.C. current measuring ranges. The A.C. and D.C. currents and volt-



Millimeter Scale

Model 56

ages are directly indicated on one scale with the same distribution, thereby eliminating the necessity of an extra scale for A.C. readings with the attendant confusing calibrations.

The Supreme model 56 Set Analyzer (See Fig. 35), is designed to provide a complete resistance analysis directly on the analyzer panel shown in Fig. 36.

The usual analyzer provides the possibility of only two reference circuits for connecting the 4½-volt battery: (1) control grid; and (2) normal grid circuits. Taking the 6-prong and 7-prong tubes for example, the model 56 Analyzer provides battery connections to any of the grid and plate circuits. The extreme flexibility of this arrangement is desirable since it permits complete resistance analysis of all circuits of any tube socket directly from the analyzer panel. Any one of the circuits may be taken as a reference point for the resistance measurements, or, if desired, the radio chassis or ground may be taken as the reference circuit. These facilities have been provided especially to enable the Service Man to realize to the fullest extent, the advantages of complete resistance analysis.

The meter of the 56 Analyzer has an "ohms" scale capable of indicating resistance values in the low range from 0 to 5,000 ohms and in the high range from 0 to 500,000 ohms.

This analyzer also has facilities for making all usual voltage-current analysis, for making capacitative measurements and for a number of other useful servicing tests.

HICKOK

Another instrument illustrated in Fig. 37 which is well adapted for use in connection with the resistance method of servicing is the Hickok StatiKtester. The following is a general description of the ohmmeter and capacity meter employed in this instrument.

FIG. 37

Referring to Fig. 38, rheostat "R" is used for making line voltage adjustments for the tube tester, the capacity meter, and the ohmmeter. The ranges of the ohmmeter are controlled by the switch located to the right of same and on position 1, the ohmmeter scale is read direct; when on position marked 100, multiply by 100, or add two ciphers, and when on position marked

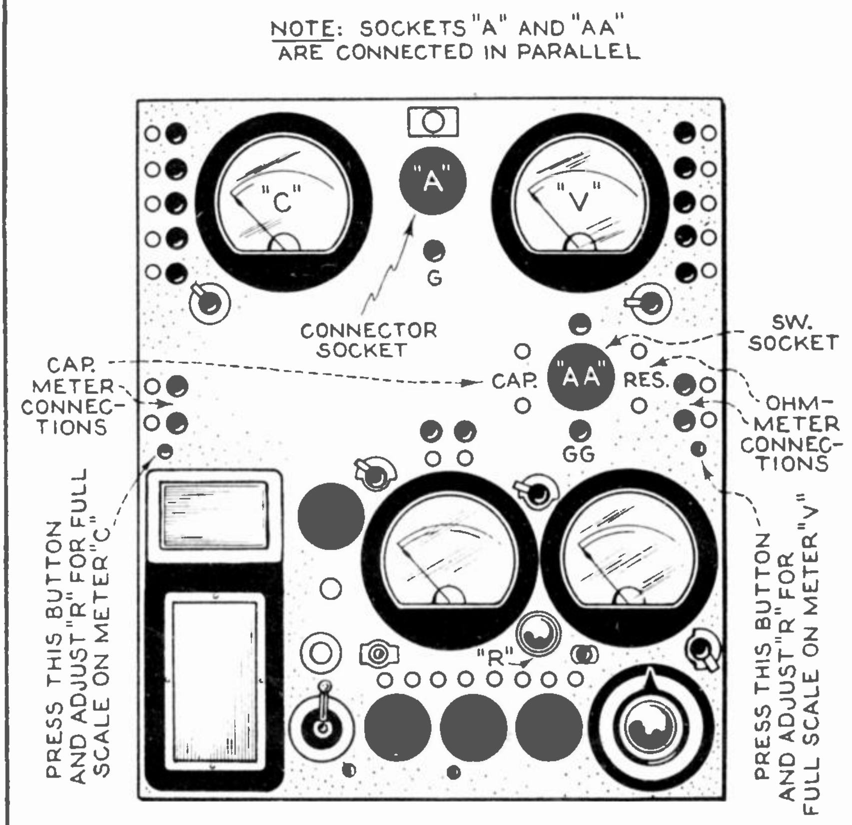


FIG. 38

10,000, multiply by 10,000, or add four ciphers.

The ranges of the capacity meter (C) are controlled by the switch located to the left of same, and when switch is on the position marked "L" the lower scale (.05 to 1 mf.) is read; when on high, the high scale (¼ to 15 mfs.) is read.

When using the ohmmeter adjustment is first made to full scale by pressing the button as shown in Fig. 38 and adjusting the rheostat "R" until the ohmmeter reads full scale. It is always necessary when using this ohmmeter, to have a 280 tube in the internal socket of the tester, and it is recommended by the manufacturer that this tube be carefully tested for this purpose and that it be left in the tester at all times. When testing battery-operated sets for resistance or capacity, batteries should be entirely disconnected.

The socket "A" (Fig. 38) is used for a connection to the cable 1-K only, and its contacts are connected in parallel with socket "AA", which is used for making resistance or capacity measurements from the sockets of receivers.

The socket "AA," when used with special connector 4-K, serves as a switch whereby either capacity or resistance measurements may be made from any of the terminals in the receiver socket and between these terminals and ground. With the connector 4-K in the two holes marked "Cap," connection is made to the capacity meter. This socket "AA" constitutes a switch by which any combination of connections can be made and are at the same time visible in the same manner as if the connection was actua ly made at the receiver socket.

The terminals marked "GG" are in parallel with "G," and the ground cable No. 6-K should be connected to the chassis of the receiver and the other terminal placed in "G." It therefore follows that any resistance or capacity between any of the socket terminals of the receiver may be measured by using the switch connector "AA" and connecting between terminal "GG" and any of the terminals of "AA."

To enable the Service Man to take auxiliary voltage readings, combination binding posts and pin jack terminals are provided for the D.C. voltmeter "V" and the A.C. voltmeter "C." Thus the Service Man is provided with either type terminals according to which may be the most suitable for the work at hand. When the D.C. voltmeter is used as a separate meter to read volts, the resistance range change switch should be in the position "100" or "10,000."

The measurement of resistances and capacities in parallel in a radio receiver can easily be made with this equipment, by first measuring the value of the resistors with the ohmmeter. Assuming that there is no leakage in the condenser paralleling the resistor, the measurement of the resistor is made in the same manner as if it were not in parallel with the condenser. After the value of the resistor is found, the value of the condenser can be found by making a capacity measurement with the capacity meter, the reading of which will be a combined reading of the A.C. current passing through the condenser and the resistor. By means of the chart and tables in the appendix, the correct value of the condenser may be obtained, after taking into account the current passing through the resistor.

A careful scrutiny of the wiring diagram of any receiver, assuming that the diagram contains complete information as to the values of all the resistances and capacities of the circuit, will reveal that practically any network of resistances and capacities may be measured by making the proper connections which will segregate the different units to be measured. Frequently, a connection from the plate of one tube to the plate of another will complete a circuit whereby a resistance can be measured which could not be measured from any other socket terminal; or very frequently connections from the grid of one tube to the plate of another, or cathode of one to the plate of another, will give a circuit which will include the necessary unit to be measured.

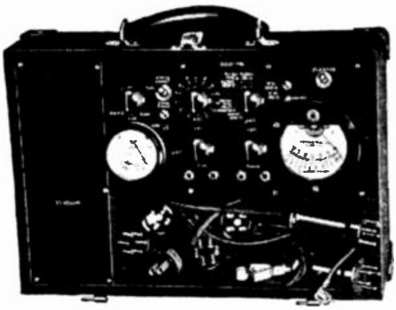
To Measure the Leakage and Resistance Values of Electrolytic Condensers

The StatiKtester may also be used to measure the leakage and resistance values of electrolytic condensers. These present an entirely different problem than paper or mica type condensers as there is always some D.C. leakage present and this leakage value does not fall to its minimum until after direct current of the proper polarity has been applied to the condenser for approximately one minute. The D.C. plate supply of the tube tester incorporated in this instrument, constitutes an entirely satisfactory source of D.C. to apply to electrolytic condensers to measure leakage.

To measure the leakage and built-up effective D.C. resistance of electrolytic condensers, the following procedure is used. The plug of one of the 3-K cables is inserted into the plate hole of the 227 socket of the tube tester. The plug of the other cable is inserted in the cathode hole of this socket. Care should be taken that these cables do not touch each other, as a short will result if they do.

The cable from the plate hole of the socket is connected to the positive termminal of the electrolytic condenser and the one from the cathode hole to the negative terminal. With the StatiKtester in operation, approximately 200 volts D.C. will be impressed upon the electrolytic condenser and the leakage can be read directly on the plate milliammeter of the tube tester. This leakage should not exceed ¾ milliampere after being left in the circuit one minute.

After being left in the circuit, as outlined in the preceding paragraph, quickly connect the capacity meter on the high scale and the capacity can be read directly on the capacity meter. Electrolytic condensers, when being measured for capacity, should not be left connected to the capacity meter for



IG. 39

more than 15 seconds without again connecting to the D.C. supply, for a longer connection to the capacity meter will result in raising the leakage value and giving erroneous readings.

In addition to its uses for measuring resistance capacities, the StatiKtester also functions as an excellent tube tester and is equipped to give voltage and current reading from the receiver sockets, whether these are to be used to supplement the resistance measurement method of servicing or for thorough voltage method tests.

READRITE

The recently announced Readrite No. 1,000 Resistance-Continuity and Capacity Tester, Fig. 39, is a well-designed instrument for servicing by the Resistance Measurement method. This device is built around a good ohmmeter and includes in its design a capacity tester and a D.C. voltmeter and milliammeter. It also contains a means of checking A.C. line voltage. In addition, it is provided with suitable cables and plugs for making the necessary tests and for gaining access to all circuits directly from the various tube sockets.

A thirteen point selector switch permits one to take as many as thirteen different resistance readings if necessary, without making any changes whatsoever in the connections between the tester and the radio receiver. The result is remarkable rapidity in completing an analysis. The various resistance scales (0—500 ohms; 0—50,000 ohms; 0—3,000,000 ohms) are available through another convenient selector switch. Provisions are made for the attaching of a 90,000 ohm current limiting resistor and two 22½-volt batteries, to permit the reading of resistances up to 6,000,000 ohms. Voltages are readable on the same D.C. meter and three positions on the thirteen point selector switch may be used to obtain plate, grid, and screen voltages at any socket. Jacks are also available which permit the tester to be used independently of plug and cable connections, to measure resistances, voltages and also capacities.

CHAPTER 7

Routine Testing Where Circuit Diagram is Available and Where Resistances are Known

THE actual method of making a resistance analysis where the circuit diagram is available and where the resistances and other constants are known, will be illustrated by means of a routine test performed on a model K-140, Kolster 10-tube Superhetero-dyne. The Readrite No. 1000 tester, described in chapter 6, was used to make this test.

Before starting, there are a few points regarding resistance measurement, which should be clearly understood: first of all, it is desirable, and, in fact, essential, that the condition of all tubes should be checked up in a suitable tube checker. The tube checker may be independent of the tester, or it may be an integral part of it, as in the case of the Diagnometer described in the last chapter; secondly, it should be definitely understood that the resistance measurement system of servicing may need to be supplemented under certain conditions, by voltage measurements. Furthermore, a routing check of condenser conditions is obviously necessary, since an open-circuited bypass condenser will not necessarily change a resistance reading . On the other hand, a shorted condenser may cause variations in resistance readings at a number of different points. Knowing that the bypass condensers are not shorted, it is possible to diagnose the resistance readings more rapidly and more accurately.

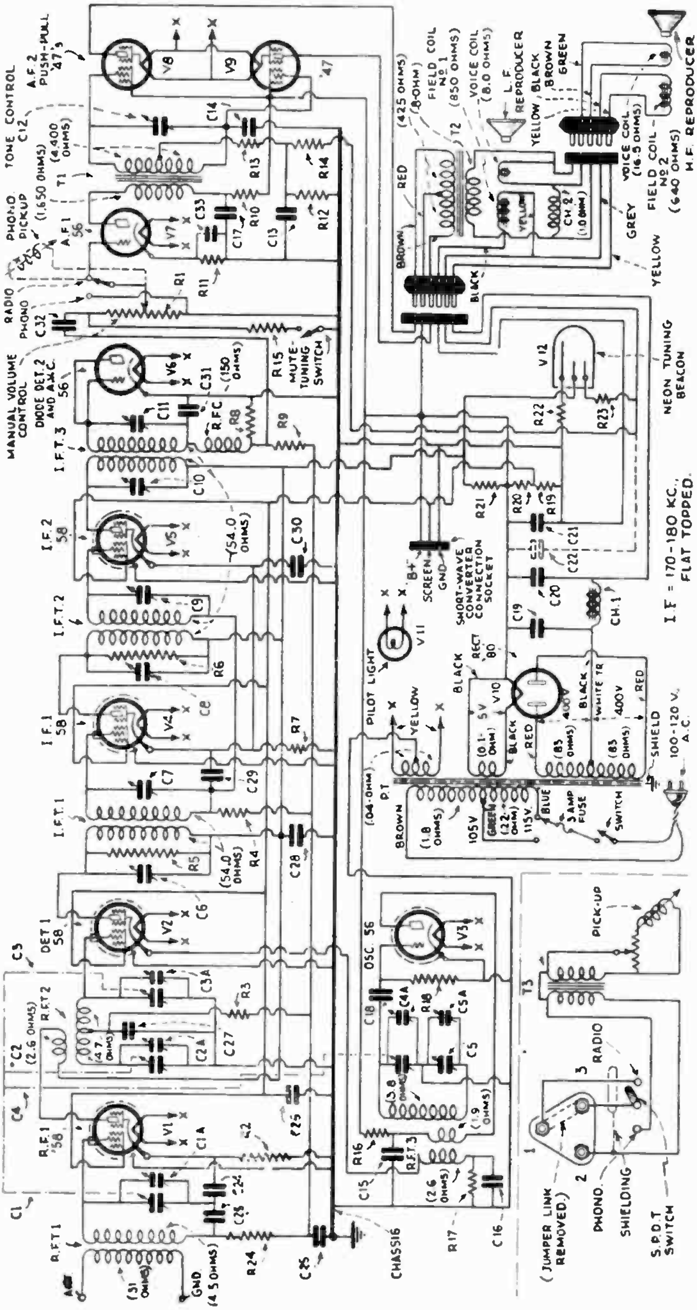
Getting back to the test of the Kolster K-140, in Fig. 40, the first step is to remove all tubes from their sockets and to disconnect the set from the A.C. supply source. The condensers in the radio set are discharged by connecting a wire between the rectifier tube filaments and the chassis. Then the left-hand cable plug of the No. 1000 Tester is inserted in the rectifier tube socket. It is necessary in this case, to utilize the five to four prong adapter. The right-hand cable plug is next placed in the first R.F. socket. (See schematic diagram, Fig. 40.)

The black wire is clipped on the set chassis, while the red wire is connected to the control grid lead of the radio set. Next, the selector switch located directly underneath the capacity meter, is placed in the "Ohms" position.

The selector switch on the right-hand side of the tester is now turned to the No. 1 position. In this position, it measures the resistance from the heater to the chassis, which in this case is found to be a small fraction of an ohm (.02). This measurement is made with the left-hand selector switch on the 0—500 ohm scale. The ohmmeter is adjusted to full scale before the reading is taken, by holding down the button marked "Ohms" and rotating the knob marked "Ohms", until the needle shows full-scale deflection, which is zero ohms. The button is then released and the reading on the ohmmeter for the 0—500 ohm scale is correct.

The right-hand selector switch is then turned to the No. 2 position. This measures the resistance between the cathode and the chassis. This is 500 ohms, comprising the resistance of R2.

Turning the selector switch to position No. 3, we obtain the resistance measurement between the screen-grid (grid at socket) and the chassis. It



TONE CONTROL C12
A.F.2 PUSH-PULL 47'S
PHONO PICKUP
(1,650 OHMS)
(4,400 OHMS)
A.F.1 56
RADIO
PHONO
MANUAL VOLUME CONTROL
DIODE DET. 2 AND A.V.C. 56
MUTE-TUNING SWITCH
I.F.T. 3
I.F. 2 58
I.F.T. 2
I.F. 1 58
I.F.T. 1
DET. 1 58
R.F.T. 2
(2.6 OHMS)
R.F. 1 58
R.F.T. 1
GND
(4.5 OHMS)
(31 OHMS)
CHASSIS
OSC. 56
R.F.T. 3
PILOT LIGHT
YELLOW
BROWN
(1.8 OHMS)
105V
115V
BLUE
3 AMP FUSE
SWITCH
100-120 V. A.C.
SHIELD
RECT. 80
BLACK
RED
(85 OHMS)
400V
WHITE TR
SHORT-WAVE CONVERTER CONNECTION SOCKET
B+
SCREEN
GND
I.F. = 170-180 KC., FLAT TOPPED.
NEON TUNING BEACON
(425 OHMS)
(8 OHM)
FIELD COIL No. 1
(850 OHMS)
VOICE COIL (8.0 OHMS)
L.F. REPRODUCER
YELLOW, BLACK
BROWN
GREEN
VOICE COIL (16.5 OHMS)
FIELD COIL No. 2
(640 OHMS)
H.F. REPRODUCER
GREY
PICK-UP
RADIO
PHONO
SHIELDING
S.P.D.T. SWITCH
(JUMPER LINK REMOVED)

FIG. 10

will be noted at once that this resistance is too high to be measured on the 0—500 scale, so therefore, the selector switch at the left is turned to the 0—50,000 ohm scale, and the ohmmeter is again adjusted to full scale deflection. using the push-button and the knob marked "ohms," as explained above. This procedure must be followed each time the position of the scale selector switch is changed. The 0 to 50,000 ohm scale is read by multiplying the 0 to 500 scale by 100. The resistance R19 is found to measure 25,000 ohms.

At position No. 4, the resistance from plate to chassis is measured. It is now necessary to adjust the selector switch at the left to the 0 to 3 megohm scale. In reading the ohmmeter, that scale reading should always be selected which will give the widest deflection on the ohmmeter for the various resistances being measured. In this case the total resistance is found to be 60,000 ohms. This includes the primary resistance of the R.F. transformer 2, plus R21 which is 10,000 ohms, R20—25,000 and R19—25,000 ohms. Since the resistance of the primary of the R.F. transformer is only 2.6 ohms, this value is too small to be noticeable when totalled with the other three large resistances, so a separate primary resistance check-up will be necessary.

Position No. 5 is used to measure the resistance from the control grid to the chassis. This measures a total resistance of 1 megohm, including as it does, resistances R24, R9, R8 and the secondary of R.F.T.1. This latter value, being very small in proportion to the others, must be checked up separately.

Position No. 6 is provided to measure the resistance between the suppressor grid and the chassis. In this instance, the suppressor grid is connected at the socket terminals to the cathode, so that the reading will be the same obtained with the selector in position No. 2.

Turning the switch to position No. 7, measurement is made of the resistance between one rectifier plate terminal and the chassis. The following resistances are included in this measurement: one-half of the power transformer secondary (83 ohms); Choke No. 1 (negligible); field coil No. 2 (640 ohms) and field coil No. 1 (850 ohms). The parallel circuit containing R14 (250,000 ohms) and R12 (75,000 ohms) being relatively high in resistance may be disregarded.

Position No. 8 measures the resistance between the other rectifier plate and the chassis, and naturally the reading should be the same as obtained at No. 7.

The selector switch is then turned to position No. 9 in order to measure the resistance between the heater of the rectifier tube and the plate of V1. This resistance comprises the negligible 2.6 ohms resistance of the primary of the R.F. transformer R.F. 2 plus the resistance of R21, which is 10,000 ohms.

Position No. 10 measures the resistance between the heater of the rectifier tube and the grid terminal of the socket under test. In other words, this is the resistance between the screen grid of V1 and the filament of V10. This is R20. having a resistance of 25.000 ohms.

At position No. 11, it is possible to measure the resistance from the filament of V10 to the cathode of V1. This includes R2, R19 and R20. These values respectively are 500 ohms, 25,000 ohms and 25,000 ohms, totalling 50,500 ohms.

Continuing the test, the left-hand cable remains plugged into the rectifier socket, while the right-hand cable is now plugged into the 1st detector socket, V2. Starting at position No. 1 of the right-hand selector switch, the same routine is again followed, passing from one position to another and reading the ohmmeter each time in order to check the various resistances, exactly as in the case of V1. The various readings are all carefully tabulated.

Next the right-hand cable is plugged into the oscillator socket, V3; then into the 1st intermediate socket, V4; then it is plugged into the second I.F. socket, V5; then into the 2nd detector socket, V6. Tests from the audio sockets V7, V8 and V9 follow. In each case, the selector switch is swung through its various positions and the necessary readings of the ohmmeter are taken.

Position No. 12 of the selector switch may be used to measure the resistance from plate to plate between any two sockets. Position No. 13 is used to measure the resistance from grid to grid between any two sockets.

Resistances such as the primary of the antenna coupler, R.F.T. 1, which cannot be checked from the sockets by the cable plugs, may be measured by means of the test prods connected into the separate jacks provided for this purpose.

By continuing the analysis from socket to socket as indicated above and checking results each time with all available data on the circuit under test, it is possible to locate the defective resistor, coupling transformer or filter condenser in remarkably rapid time. This particular point should be emphasized strongly, namely, that the entire set of readings outlined above can be run through in a very short time. Obviously, it takes a long time to give a detailed description of each operation and the reason for performing it, whereas it is possible to plug the cable into a socket and take eleven or twelve readings in less than five minutes by merely rotating the selector switch and regulating the deflection of the ohmmeter.

CHAPTER 8

Routine Testing Where Circuit Diagram is Not Available and Where Resistances are Unknown

IT is problems like the foregoing that present the best test as to the ability of the Service Man. After all necessary information has been given to the Service Man by the manufacturer, it is a simple problem to service a set. But, when you encounter a receiver about which you know nothing, the fun begins.

Careful reading of Chapters Four, Five, Six and Seven should furnish a background for the procedure to be followed in servicing by Resistance Measurement. Knowing that each tube element has its own circuit, and that every circuit will have some value of resistance is the starting point in receiver analysis forms.

Certain factors can be counted on to hold true for all types of radio sets and amplifiers. These are tabulated below and should be tucked away in the mind for future reference.

FILAMENT CIRCUITS

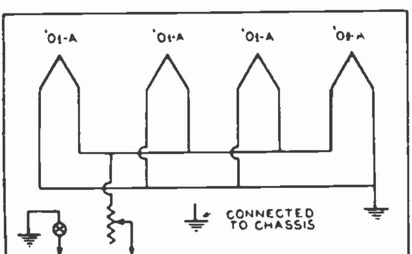


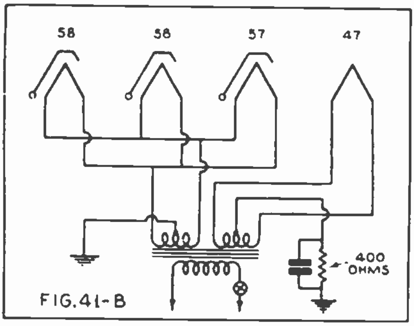
FIG. 41-A

All filament circuits have a connection to the ground or the chassis whether the set is A.C., D.C. or battery operated. Ninety-nine out of one hundred tests will show that the resistance between the ground and the filament is zero or some value of resistance less than 2,000 ohms. Filament circuits are held above ground potential by the bias resistors used to supply the bias for the particular tube (generally the power tube). Cathode type tubes generally have their filaments at absolute ground potential so that ohmmeter readings will simply indicate the fact that the connection between the filament winding of the power transformer is or is not completed to the ground.

Common forms or types of filament circuits are shown in Fig. 41 A, B and C. In A, battery type tubes are used in the standard parallel connection, and ohmmeter tests between the ground and negative filament connections of the sockets will give full scale deflection. No reading will be obtained from the positive side if the tubes are out of the sockets, and the batteries are not connected to the receiver.

Heater type tubes are used in the circuit shown in B, and a full scale reading will be noted on an ohmmeter connected from ground to heater. Some resistance is in the circuit, but that resistance is very low as the total resistance lies in the filament winding of the power transformer and the leads running to the sockets. In the power stage the ohmmeter will read 400 ohms due to the resistor placed in series with the center tap of the filament winding and the ground. If there were no reading at this point, then the fault would lie in a defective resistor or shorted condenser. Open circuit in the resistor will result in no reading whatsoever.

Direct current electric sets generally have their filament circuits connected in series as shown in C. Here readings can be made to the various filament terminals only when the tubes are in their sockets. In the drawing the filaments of the tubes are shown connected to the socket terminals by the dotted lines. When the tubes are in their sockets, resistance readings can be taken and the resistance measured will be that of the tube filaments. Of course,



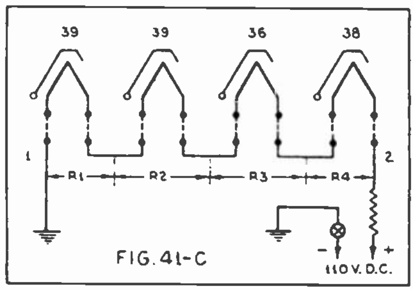
the power supply plug should not be connected to the electric outlet while these tests are being made. Note that the filaments are in series, and as the readings are taken above ground, increased values of resistance will be indicated. The resistance R1 plus R2 plus R3 plus R4 will be the sum and effective value of resistance between points 1 and 2.

GRID CIRCUITS

RADIO FREQUENCY: All grid circuits must have a return to ground either through a "C" battery or direct connected. Different values of resistances will be indicated on the scale of an ohmmeter depending on the form of coupling used. See Fig. 42. The average receiver will have radio frequency coils with a very low direct-current resistance which is hard to read on the average ohmmeter. Some detector circuits will have a resistance of 1 or 2 megs. as indicated in the resistance coupled grid circuit under the heading "Power Tube." In that case the plate circuit of the preceding tube is the tuned circuit. Certain superheterodynes have tuned plate circuits in their intermediate-frequency amplifiers and would also come under this classification.

AUDIO FREQUENCY: The three common forms of audio-frequency amplification will, by the different types of equipment used, offer varying values of resistance depending on the equipment used. Transformer coupled stages will have comparatively low values of resistance in the grid circuits. Resistance coupled stages will have values between ¼ and 1 meg. in most modern sets. These high values of resistance would give false readings on voltmeters connected between the grid and the cathode; the error is caused by the voltage drop in the grid resistor. In Fig. 42 grid circuits are shown and a meter is indicated connected so as to read the voltage applied to the grid of the tube. Impedance coupled amplifiers are seldom used in the modern receiver but the grid circuit is generally resistive.

If possible, trace the leads running to the tube sockets and study the way that the grid circuit is connected. If the ohmmeter does not give satisfactory indications on high values of resistance, and the grid circuit is



known to be resistive, it would be wise to accept the fact that any movement of the indicating pointer means a closed circuit through the high resistance. If there is no reading or movement of the indicator, then an open should be looked for.

Grid circuits of audio-frequency amplifiers will be resistive or inductive. If they are resistive, then the values of the resistances will generally be 1 meg. or less. If transformer coupled, the resistance will run from a few hundred to several thousand ohms. The types of tubes used in the output stages will give an idea as to the value to be expected there. Tubes used in Class A connections will have grid circuits with comparatively high values of resistance. Class B type transformers have low direct-current resistances due to

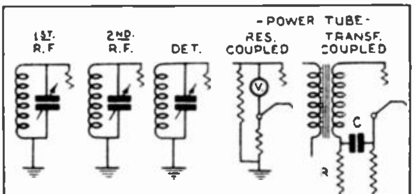


FIG. 42

the current requirements of the secondary and the fact that a step down ratio is used. If screen-grid type tubes are used in audio frequency stages, resistance coupling will generally be found in the grid circuit. This statement will not hold for all cases but resistance coupling should be looked for first. Three element tubes are generally used with transformer coupled amplifiers so the grid circuit resistance will be low, unless resistance-capacity isolator circuits are used (R and C Fig. 42)

PLATE CIRCUITS: Plate circuits will be inductive in radio-frequency amplifiers, resistive and inductive in detector circuits; and the same in audio-frequency circuits. Screen circuits will be resistive as indicated in Fig. 43. A resistance is generally used between the screens of screen-grid tubes and the ground, serving as a bleeder resistance for the power-supply unit. This resistance is indicated at R, and if an average value is to be placed on this resistor, it will be about 20,000 ohms. Variation in resistance between ground and screen seems to fall between 10,000 and 50,000 ohms.

Variations in the resistance between the plate of a tube and ground runs between 1,000 ohms and 1 meg., depending on the circuit in which the tests are made.

POWER SUPPLY UNITS

Resistance measurement of the various circuits in a power supply system can be made from the rectifier tube socket. In Fig. 44 the standard 80 type tube is shown in a full-wave connection. This circuit arrangement is common to thousands of radio receivers.

Measuring from one plate of the rectifier tube will give the direct current resistance of one-half the high voltage secondary. No reading will mean an open in the coil. Read between the other plate and the ground for the resistance of the other half of the secondary. This value will hardly run more than 200 ohms total. That means the total resistance from plate to plate connection of the power transformer.

The filament winding of the rectifier can be measured across the filament socket terminals. This will be a few ohms at the most.

Condensers can be checked for leakage and the resistance of the individual chokes can be measured by means of prods with the chassis turned over. Chokes have resistances which are seldom greater than 200 ohms.

Many sets have a speaker field connected in the filter circuit and the inductance of the field winding is used for the choke. The circuit for this con-

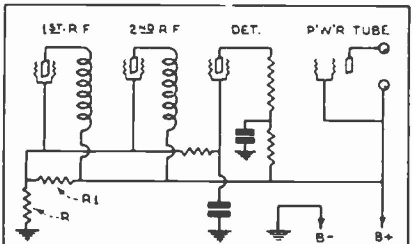
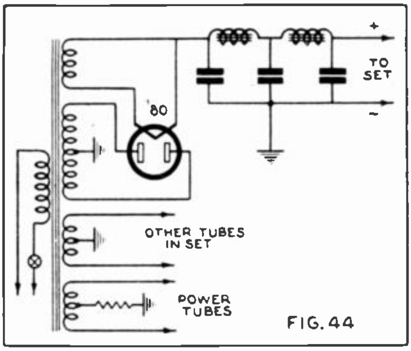


FIG. 43

nection is shown in Fig. 45 and differs from Fig. 44 because the inductance is connected in the negative leg of the filter system. In this case the ohmmeter will read the sum of the resistance in the circuit when measuring from plate of the rectifier tube to the ground or chassis. A simple way to

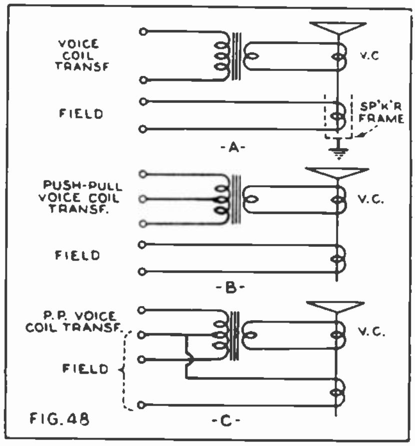


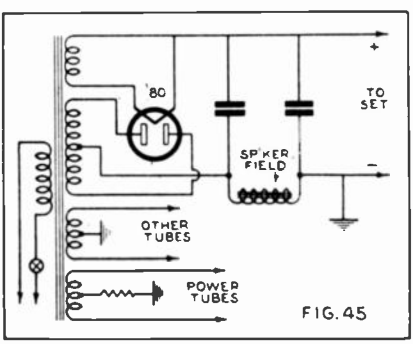
find out if the speaker field is being used as a choke is to pull out the plug connecting the speaker to the set. If the ohmmeter gives NO reading when the field of the speaker is removed from the circuit then the field is connected as shown in Fig. 45. Speaker fields range in resistance values from 1,000 ohms to 2,500 ohms. The 2,500 ohm size being very popular.

Several sets use the 81 type tube in a full wave connection and the only difference in conducting the tests and measurements lies in the fact that the plate to chassis analysis must be made from two sockets instead of one. A conventional circuit for 81's in a full-wave circuit is shown in Fig. 46.

Gas type rectifiers are used in many sets, especially auto receivers, Fig. 47. Older model sets and "B" eliminators used this tube exclusively. Resistance measurements of the power transformer secondary is carried on in the same manner except for the fact that the high voltage terminals of the power transformer are connected to the filament terminals of the rectifier socket. The plate terminal of the rectifier socket going to the center tap of the power transformer and to ground (chassis).

Note the use of bypass condensers across the high voltage winding of the power transformer. These condensers should be checked for leakage, especially in old power supply units. As condensers age and are subjected to heat, the insulating qualities of the paper used in the condensers for the dielectric are destroyed. Condensers with low leakage values should be replaced as they drain current from the power transformer causing excessive heat and low output voltage. Good condensers have a leakage resistance of about 200 megohms per microfarad. If a condenser is found that has a resistance that can be measured on an ordinary ohmmeter, it is time to change.





SPEAKER AND FIELD CIRCUITS

At times, speaker fields short to the metal frame of the speaker and in some sets the frame of the speaker is grounded. If the field winding is used in the filter circuit then a direct short will be found. This will result in low voltages, over heated power transformers, and rectifiers that either burn out or show gas. Three common methods of speaker field and voice coil connections are shown in Fig. 48 A, B and C. In some cases the field is connected on the negative side of the filter and in others on the positive side.

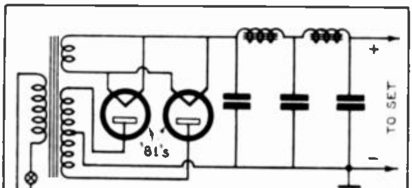


FIG. 46

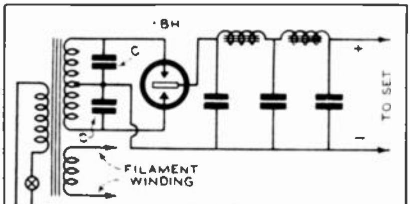


FIG. 47

In every case the additional windings of the power transformer (filament windings) are measured from the sockets of the tubes in the set

———o———

CHAPTER 9

The Relation of Voltage Testing Methods to Resistance Measurement

EXPERIENCE suggests to the author that the Service Man of the future will combine Voltage Testing and Resistance Measuring to his service problems, plus the use of such devices as are capable of checking condensers and inductances in alternating current circuits. The function of coils and condensers in direct current test circuits is not the final criterion as to the worth of the particular unit. More experience is required on the part of the Service Man and the manufacturer of test equipment to develop the combination of equipment which will prove ideal.

Resistance Measurement offers the most practical solution to the problems of radio servicing at the present time, overshadowing the advantages offered by devices which would cover the action of circuit components under alternating current test conditions.

Practical test equipment must be universal in it's application. It must test all of the conditions that can be encountered in service work. Instruments suitable for testing coils and condensers have to be able to cover extreme ranges due to the tremendous difference in the electrical constants encountered.

Coils have inductance values ranging from a few microhenries to hundreds of henries. This means that the instrument must have suitable circuits, switching devices and indicating scales to cover this great range. No manufacturer has been able to develop such an instrument, although several manufacturers have inductance meters suitable for use in testing power chokes and other inductances. Tests of inductance will not be satisfactory until the choke and the transformer manufacturer furnish the Service Man with values of inductances and impedances at some standard frequency. Sixty cycles should be the standard as this would permit a standard source of frequency for alternating current testing. As the impedance of a coil or inductance is dependent on the electrical value of the coil expressed in henries and the frequency, it would be imperative that some universally obtainable frequency be used as a standard.

Condenser meters are available covering limited ranges suitable for determining the capacity values of filter condensers. Here the frequency used for the tests and measurements will be sixty cycles.

Inductance-capacity tests have their field of usefulness to the Service Man, but a combination of voltage and resistance measurement will be the best ally for the busy Service Man. The more thought given to the problem, and the more comprehensive the fundamental knowledge of electricity, the more practical the combination becomes.

Figures 19 to 23 of Chapter IV are good examples of what can be done in the way of obtaining accurate information as to circuit conditions. Voltmeters, no matter how sensitive. are operated by power, and in many radio circuits the energy consumed by the meter used for a test will be greater than the energy used in the circuit under normal operation.

Voltage testing alone has been satisfactory in the past and will have it's

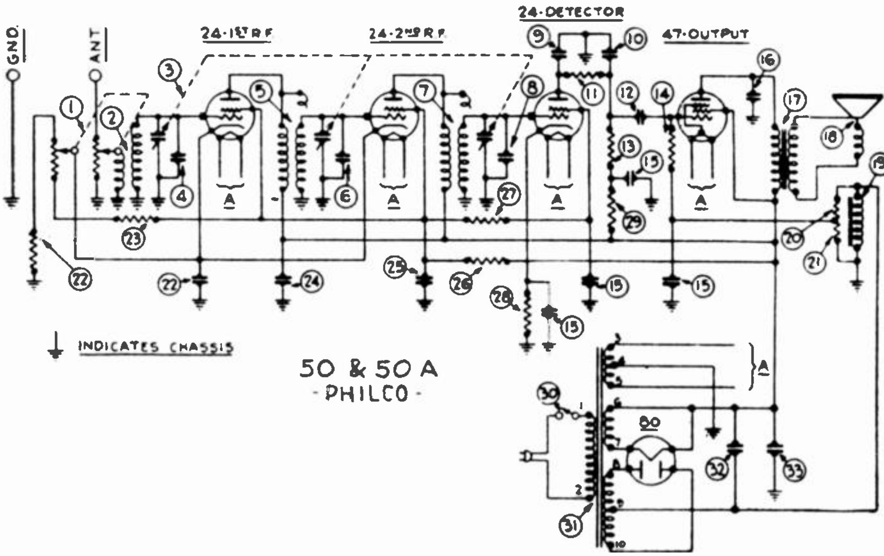


FIG. 49

place in future service problems; but the demand for greater speed and accuracy necessitates additional methods to supplement voltage analysis.

Perhaps the best way to compare the two methods of radio receiver servicing would be to take a circuit diagram from the 1932 Official Radio Service Manual and analyze various circuit faults that could develop in the life of the set. See Fig. 49.

One fact must be assumed, that all the tubes are up to the standard required for the normal operation of the set. Tube testing, being outside the scope of this section, validates this assumption. Most Service Men have devices that will test tubes with a reasonable degree of accuracy. In general, if the tubes are defective, the set is otherwise in good running order. If the tubes are in good condition, then the fault, if any, lies in the set proper.

A quick socket analysis by the "Voltage Testing Method" will give the Service Man an idea if any of the voltages applied to the tubes do not compare with the voltage readings as specified in Table 1 of Fig. 49. Voltage tests will indicate if there is a discrepancy, but will not give a reason for the difference.

It is at this point that "Resistance Measurement" methods enters the picture. "Resistance Measurement" enables the Service Man to locate the cause of the discrepancy in jig time. In other words, this method carries the process of servicing beyond general circuit testing and gets down to the testing of the individual part.

Suppose the condenser (15) were shorted. This would increase the current flow in resistor (27). Any increase in the current flow will cause a greater voltage drop across this resistor and the result will be a decrease in the voltage applied to the screen of the detector tube. Low voltages at this point will cause poor quality, lack of sensitivity, and reduced radio-frequency amplification due to the added drop in screen voltage on the first two tubes. In this case voltage testing will indicate the effect but will not point out the direct cause. Resistance Measurement will solve this problem by finding the cause.

After voltage measurements have

Table 1—Tube Socket Readings Taken with AC Set Tester AC Line—115 volts

Tube		Filament Volts	Plate Volts	Screen Grid Volts	Control Grid Volts	Cathode Volts	Plate Milli-amperes
Type	Circuit						
24	1st R.F.	2.4	245	90	2.5	3.0	4.5
24	2nd R.F.	2.4	250	90	2.5	3.0	5.5
24	Det.	2.4	100	42	8.0	8.0	0
47	Output	2.4	175*	190*	1.0*	......	2.7*
80	Rect.	5.0	......	......	.—	......	30/

Note—Volume Control on full; Station Selector turned to Low Frequency End.
*These readings must be taken from the underside of the chassis, using test prods and leads unless the set checker is specially equipped for testing pentode tubes.

Table 2—Power Transformer Voltages

Terminals	A.C. Volts		Color
1-2	105 to 125	Primary	Black (Small Gauge)
3-5	2.5	Filament of 24 and 47	Black
6-7	5.	Filament of 80	Light Blue
8-10	700.		Yellow
4	....	Center Tap of 3-5	Black, Yellow, Tracer
9	. ....	Center Tap of 8-10	Yellow, Green Tracer

Table 3—Condenser Data

No. on Figs. 2 and 3		Container
(9) (10)	.00025	Yellow
(12) (16)	.01	Black Bakelite Container
(25)	.05	Black Bakelite Container
(22)	.05 and 150 Ohm resistor	Black Bakelite Container
(15)	.1, .15, 2-.5 (50-60 cycles)	Metal Container
	.05, .15, .25, 2-.5 (25-40 cycles)	
(24)	.05	
(33)	(50 to 60 cycles) 6.	Electrolytic
	(25 to 40 cycles) 10.	Electrolytic
(34)	6.	Electrolytic

Table 4—Resistor Data

No. on Figs. 3 and 4	Power (Watts)	Resistance	Color		
			Body	Tip	Dot
(22)		150 and .05 Mfd.	Black Bakelite Container		
(11)	.5	10,000	Brown	Black	Orange
(23)	1.	15,000	Brown	Green	Orange
(26)	1.	25,000	Red	Green	Orange
(28)	.5	32,000	Orange	Red	Orange
(27) (29)	.5	99,000	White	White	Orange
(21)	.5	160,000	Brown	Blue	Yellow
(13)	.5	240,000	Red	Yellow	Yellow
(14) (20)	.5	490,000	Yellow	White	Yellow

FIG. 49 Continued

been made, the Service Man is confronted with the necessity of determining the cause. Two things outside of Resistance and Voltage Measurement will help the Service Man at this point: EXPERIENCE and a REASONING MIND. "Experience is the best teacher," it is said, but where is the Service Man who has just entered the field going to get this experience? Knowledge by experience comes after a time, but some means of speeding up this process is necessary. Some men have had so much experience servicing a particular type of receiver that when they are confronted with a receiver of different make or type they have to stop and start all over again. While it pays to be a specialist in one manufacturer's product and know the service problems that are encountered, it is not the best way to become a real Service Man. Another point, in many sections, Service Men are called upon to service ten different types of sets in a day. That is no place for a specialist. Such work requires an all around, bang-up man.

The ability of a man to reason places him in an excellent position, especially when it comes to service work. Voltages wrong? What circuit and what parts in that circuit will be defective? Reason will indicate that some component in that immediate circuit or an associated circuit is faulty. Just what part is defective can be checked by Resistance Measurement quickly. Some Service Men have had so much EXPERIENCE that their REASONING is limited by their past experience.

CHAPTER 10

Appendix

KOLSTER MODELS K-140 AND K-142 10-TUBE SUPERHETERODYNE

(Dual reproducers, dual band-selectors, antenna transmission line, phono.-radio operation; A.V.C.; provisions for connecting remote control and an S.W. converter; neon-tube visual tuning.)

A radio receiver that excellently represents the advances which have been made in radio receiver design is the Kolster model K-140 (50- to 60-cycle) and the model K-142 (25- to 60-cycle) 10-tube superheterodyne.

Following are the condenser values employed in these chassis: C1, C2, C3, C4, 4-gang tuning condenser unit; C1A, C2A, C3A, C4A, R.F. trimmer condensers; C5, padding condenser, 600 mmf.; C5A, pad R.F. trimmer condenser; C6 to C11, I.F. trimmers; C12, tone control, 50 mmf. to .0045-mf.; C13, 0.5-mf.; C14, C31, 100 mmf.; C15, C16, C23, C24, C29, 0.1-mf.; C17, 1. mf.; C18, C25, 500 mmf.; C19, C20, C21, dry electrolytic, 8 mf.; C22, dry electrolytic, (25 cycles, only), 4 mf.; C26, C28 C30, 0.25-mf.; C27, .01-mf.; C32, .025-mf.; C33, electrolytic, 4 mf.

Resistor R1, manual volume control, 0.5-meg.; R2, 500 ohms; R3, R4, R5, R6, R9, R14, R23, 0.25-meg.; R7, 750 ohms; R8, 0.5-meg.; R10, R16, R19, R20, 25,000 ohms; R11, R15, 5,000 ohms; R12, 75,000 ohms; R13, 50,000 ohms; R17, 3,000 ohms; R18, 0.1-meg.; R21, 10,000 ohms (60 cycles), or 8,000 ohms (25 cycles); R22, 10,000 ohms.

Tube operating characteristics at a line potential of 115 V. are as follows: Filament potential, V1 to V9, 2.3 V.; V10, 4.7 V. (The following potentials are measured to the cathode of the respective tube indicated.) Heater potential, V1, V4, V5, 2.5 V.; V2, 6 V.; V3, V6, zero; V7, 10 V. Control-grid potential, V1, 0.2-V.; V2, V6, 1. V., and V7, 1. V. (with vol. control at maximum) to 10 V. (with vol. control at minimum); V3, 2V.; V4, 6 V.; V5, 3.6 V.; V8, V9, 4 V. Screen-grid potential, V1, 85 V.; V2, 80 V.; V4, V5, 110 V.; V8, V9, 245 V. Plate potential, V1, 130 V.; V2, 120 V.; V3, 90 V.; V4, V7, 175 V.; V5, 180 V.; V6, zero; V8, V9, 225 V.; V10, plate-to-plate potential, 725 V., A.C. Plate current, V1, 1. ma.; V2, 0.4-ma.; V4, 1.1 ma.; V5, 1.2 ma.; V8, V9, 5 ma.

Any attempts to align the I.F. circuits of the K-140 chassis in the usual manner will result in instability and poor over-all fidelity, if adjustments are made in the conventional manner and with a modulated oscillator, tuning for maximum output. In fact, no attempt should be made to vary these settings, which are determined by special test equipment at the factory for obtaining 10 kc. selectivity throughout the entire broadcast band, unless it is absolutely necessary. The procedure is as follows:

Remove the voice-coil shunt connection and connect the output meter to the secondary of transformer T2. Next, remove the oscillator tube and the cap lead of V5, and connect the output of a 175 kc. service oscillator to the cap of the tube. Then, adjust C10 and C11 for maximum output. Replace the cap lead, couple the service oscillator to V4, and adjust C8 and C9 for maximum output at 175 kc. Next, couple the service oscillator to V2 and adjust C6 and C7 for maximum at 175 kc. The oscillator output should be coupled directly to the grids, without a dummy antenna. If the oscillator is capacitatively coupled the open grid circuit may result in circuit oscillation; in this case the grid circuit may be completed to ground through 1,000 ohms.

Now, to obtain the full tone quality for which the reproducers and the balance of the set are designed, it will be necessary to flatten out the I.F. channel so that it presents uniform gain for frequencies of 170 and 180 kc. (The gain with the flat-topped adjustment is less than when the circuits are adjusted for peak resonance.)

Set the service oscillator at 180 kc. and adjust the I.F. trimmers to obtain a preliminary output reading; repeat this performance, at 170 kc., to obtain the same output reading. (It will be necessary to go over the six trimmers several times.) When thus aligned the I.F. amplifier portion of the receiver should indicate the same gain at 170 and 180 kc., and less at 175 kc.

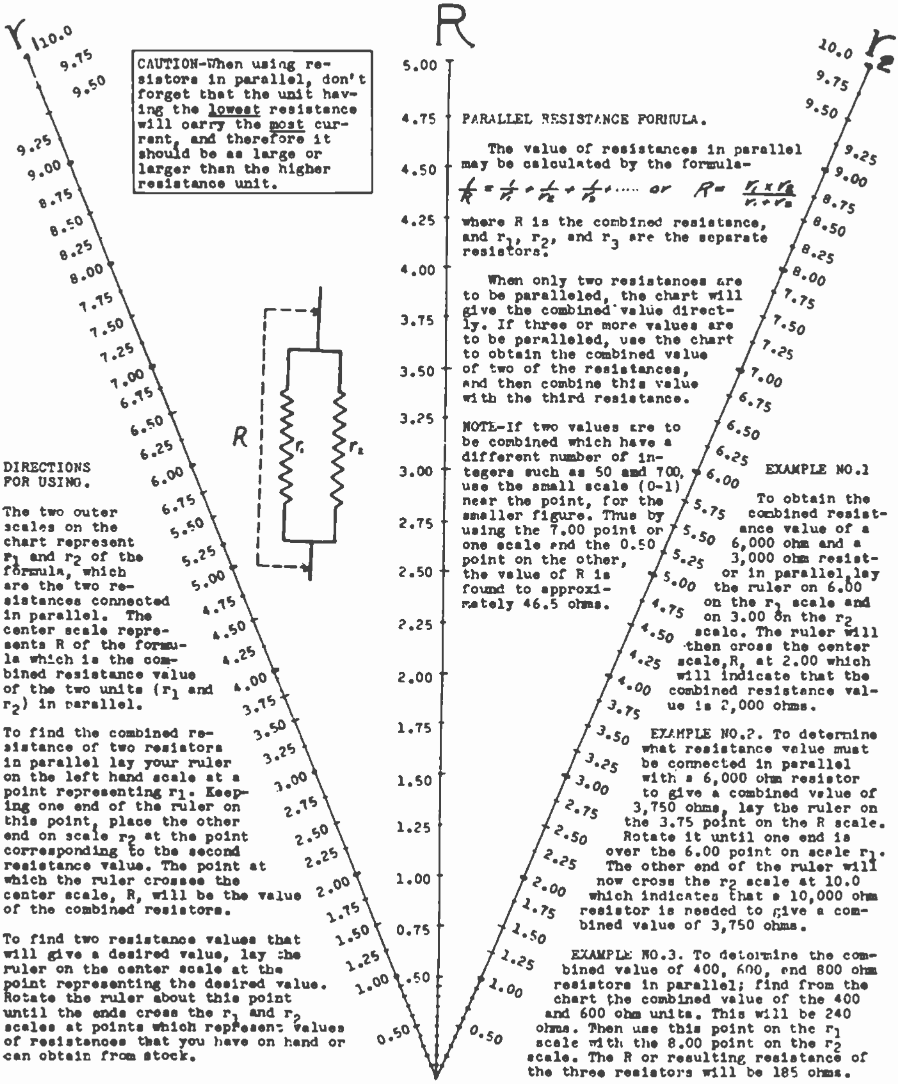
In aligning the R.F. circuits, it is necessary that the R.F. selectivity be superimposed on the middle of the I.F. selectivity graph in order that the overall selectivity figure will be symmetrical. Replace the oscillator tube and shield, couple the service oscillator to the antenna and ground terminals of the chassis (not the antenna terminal and the chassis), and operate the service oscillator at 600 kc. Adjust C4A for maximum output, while rocking the tuning dial across the 600 kc. setting, until the output remains fairly constant with a shift of several kc. either side of 600 kc.; then, finish by adjusting C1A, C2A and C3A. Reset the service oscillator to 1,400 kc. and align the oscillator circuit first. By adjusting the oscillator trimmer it is easy to locate the two peaks and the dip in the middle; the oscillator should be aligned for this dip. Finally, align the remaining R.F. circuits by adjusting C1A, C2A and C3A for maximum output. Alignment at 1,400 kc. should not affect alignment at 600 kc.

The insert indicates the circuit arrangement at the rear of the chassis for phono-radio operation; also, remote control (terminals 1 and 2). Transformer T3 and resistor R1 must be matched to the pickup, if it is of low-impedance type; T3 may be omitted if the pickup is of high-impedance type.

If the neon beacon tuning beam does not extend sufficiently high during the reception of distant stations, it may be necessary to reduce the value of resistor R2 to perhaps 7,000 ohms. If the value is made too low, the beam length will extend too far during the reception of local station programs.

A complete Kolster installation includes an antenna "rejectostat" (coupler), an R.F. transmission line (as contrasted with the relatively inefficient "shielded lead in" ordinarily used) up to 1,000 ft. long, and a receiver "rejectostat" (coupler); this greatly reduces the proportion of noise pickup. The R.F. transmission line is No. 18 rubber-covered twisted pair, shielded with copper-braided sleeving, and protected with a 1/16-in. ruhber covering; (or Belden Transmission Line Shielded Cable may be used).

Appendix



CAUTION–When using resistors in parallel, don't forget that the unit having the lowest resistance will carry the most current, and therefore it should be as large or larger than the higher resistance unit.

PARALLEL RESISTANCE FORMULA.

The value of resistances in parallel may be calculated by the formula–

$$\frac{1}{R} = \frac{1}{r_1} + \frac{1}{r_2} + \frac{1}{r_3} + \ldots\ldots \text{ or } R = \frac{r_1 \times r_2}{r_1 + r_2}$$

where R is the combined resistance, and r_1, r_2, and r_3 are the separate resistors.

When only two resistances are to be paralleled, the chart will give the combined value directly. If three or more values are to be paralleled, use the chart to obtain the combined value of two of the resistances, and then combine this value with the third resistance.

NOTE–If two values are to be combined which have a different number of integers such as 50 and 700, use the small scale (0-1) near the point, for the smaller figure. Thus by using the 7.00 point on one scale and the 0.50 point on the other, the value of R is found to approximately 46.5 ohms.

DIRECTIONS FOR USING.

The two outer scales on the chart represent r_1 and r_2 of the formula, which are the two resistances connected in parallel. The center scale represents R of the formula which is the combined resistance value of the two units (r_1 and r_2) in parallel.

To find the combined resistance of two resistors in parallel lay your ruler on the left hand scale at a point representing r_1. Keeping one end of the ruler on this point, place the other end on scale r_2 at the point corresponding to the second resistance value. The point at which the ruler crosses the center scale, R, will be the value of the combined resistors.

To find two resistance values that will give a desired value, lay the ruler on the center scale at the point representing the desired value. Rotate the ruler about this point until the ends cross the r_1 and r_2 scales at points which represent values of resistances that you have on hand or can obtain from stock.

EXAMPLE NO.1

To obtain the combined resistance value of a 6,000 ohm and a 3,000 ohm resistor in parallel, lay the ruler on 6.00 on the r_1 scale and on 3.00 on the r_2 scale. The ruler will then cross the center scale, R, at 2.00 which will indicate that the combined resistance value is 2,000 ohms.

EXAMPLE NO.2. To determine what resistance value must be connected in parallel with a 6,000 ohm resistor to give a combined value of 3,750 ohms, lay the ruler on the 3.75 point on the R scale. Rotate it until one end is over the 6.00 point on scale r_1. The other end of the ruler will now cross the r_2 scale at 10.0 which indicates that a 10,000 ohm resistor is needed to give a combined value of 3,750 ohms.

EXAMPLE NO.3. To determine the combined value of 400, 600, and 800 ohm resistors in parallel; find from the chart the combined value of the 400 and 600 ohm units. This will be 240 ohms. Then use this point on the r_1 scale with the 8.00 point on the r_2 scale. The R or resulting resistance of the three resistors will be 185 ohms.

(Courtesy Ohmite Mfg. Co.)

DETECTORS AND AMPLIFIERS

Socket Connections	Symbol	Type	Purpose
		WD-11	Detector or Amplifier
		WX-12	Detector or Amplifier
		44	R.F.-I.F. Amplifier
		56	Detector Amplifier Oscillator
		57	Biased Detector Amplifier
		58	R.F.-I.F. Amplifier 1st Detector
		112A	Detector or Amplifier
		199	Detector or Amplifier
		200A	Detector
		201A	Detector or Amplifier
		222	R.F. Amp. A.F. Amp.
		224 224A	R.F. Amp. Detector A.F. Amp.
		226	Amplifier
		227	Detector Amplifier
		230	Detector or Amplifier
		232	R.F. Amp. Detector
		234	R.F.-I.F. Amplifier 1st Detector
		235	R.F. Amplifier
		236	R.F. Amplifier
		237	Detector or Amplifier
		239	R.F.-I.F. Amplifier
		240	Voltage Amplifier
		841	Voltage Amplifier
		864	Detector or Amplifier or Oscillator
		Wunderlich	Detector

OUTPUT POWER TUBES

Socket Connections	Symbol	Type	Purpose
		41	Power Pentode
		42	Power Pentode
		46	Power Amplifier
		112A	Power Amplifier
		120	Power Amplifier
		171A	Power Amplifier
		210	Power Amplifier-Oscillator
		231	Power Amplifier
		233	Power Amplifier
		238	Power Amplifier
		245	Power Amplifier
		247	Power Amplifier
		250	Power Amplifier
		LA	Power Amplifier

RECTIFIERS

Socket Connections	Symbol	Type	Purpose
		82	Full-Wave Rectifier
		BA	Full-Wave Rectifier
		BH	Full-Wave Rectifier
		280	Full-Wave Rectifier
		281	Half-Wave Rectifier
		866	Half-Wave Rectifier

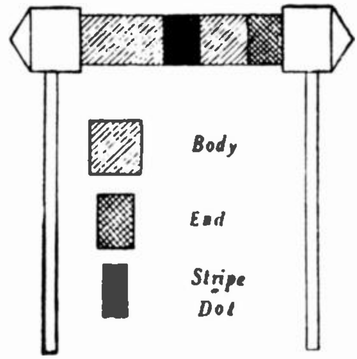
VOLTAGE REGULATORS

Socket Connections	Symbol	Type	Purpose
		874	Voltage Regulator
SCREW BASE		876	Current Regulator (Ballast Tube)
SCREW BASE		886	Current Regulator (Ballast Tube)

(Courtesy Radio Trading Co.)

RMA Standard Resistor Color Code

Figure	Color	Figure	Color
0	Black	5	Green
1	Brown	6	Blue
2	Red	7	Violet
3	Orange	8	Gray
4	Yellow	9	White



EXPLANATION OF USE:

Ten Colors are assigned to the Figures as shown in table above.

The Body of the Resistor (see diagram) is Colored to represent the First Figure of the Resistance Value.

One End is Colored to represent the Second Figure.

A Stripe, or Dot, of Color, representing the Number of Ciphers following the first two figures is located within the body color.

EXAMPLES, ILLUSTRATING THE STANDARD, ARE AS FOLLOWS:

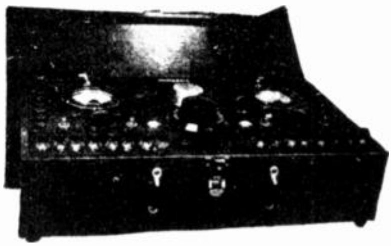
Resistance	Body	End	Dot
10 Ohms	Brown 1	Black 0	Black No Ciphers
200 Ohms	Red 2	Black 0	Brown One Cipher
3,000 Ohms	Orange 3	Black 0	Red Two Ciphers
3,400 Ohms	Orange 3	Yellow 4	Red Two Ciphers
10,000 Ohms	Yellow 4	Black 0	Orange Three Ciphers
44,000 Ohms	Yellow 4	Yellow 4	Orange Three Ciphers

TABLE OF RESISTANCE VALUES

and RMA Standard Color Code

Megohms	Ohms	Body	End	Dot
.0005	500	Green	Black	Brown
.00075	750	Violet	Green	Brown
.001	1,000	Brown	Black	Red
.0015	1,500	Brown	Green	Red
.002	2,000	Red	Black	Red
.0025	2,500	Red	Green	Red
.003	3,000	Orange	Black	Red
.004	4,000	Yellow	Black	Red
.005	5,000	Green	Black	Red
.006	6,000	Blue	Black	Red
.007	7,000	Violet	Black	Red
.008	8,000	Gray	Black	Red
.009	9,000	White	Black	Red
.01	10,000	Brown	Black	Orange
.012	12,000	Brown	Red	Orange
.015	15,000	Brown	Green	Orange
.02	20,000	Red	Black	Orange
.025	25,000	Red	Green	Orange
.03	30,000	Orange	Black	Orange
.04	40,000	Yellow	Black	Orange
.05	50,000	Green	Black	Orange
.06	60,000	Blue	Black	Orange
.075	75,000	Violet	Green	Orange
.09	90,000	White	Black	Orange
.1	100,000	Brown	Black	Yellow
.15	150,000	Brown	Green	Yellow
.2	200,000	Red	Black	Yellow
.25	250,000	Red	Green	Yellow
.3	300,000	Orange	Black	Yellow
.4	400,000	Yellow	Black	Yellow
.5	500,000	Green	Black	Yellow
.75	750,000	Violet	Green	Yellow
1.	1,000,000	Brown	Black	Green
1.5	1,500,000	Brown	Green	Green
2.	2,000,000	Red	Black	Green
2.5	2,500,000	Red	Green	Green
3.	3,000,000	Orange	Black	Green
4.	4,000,000	Yellow	Black	Green
5.	5,000,000	Green	Black	Green
6.	6,000,000	Blue	Black	Green
7.	7,000,000	Violet	Black	Green
8.	8,000,000	Gray	Black	Green
9.	9,000,000	White	Black	Green
10.	10,000,000	Brown	Black	Blue

5 Times Better Resistance



. . . Ranges

All Supreme Instruments offer resistance ranges five times higher than any competitive instrument with equivalent battery power.

Famed throughout the Radio Service world as the "greatest testing instrument in history." Combining in the one compact case SUPREME DIAGNOMETER, plus SHIELDED OSCILLATOR, plus ADVANCED TUBE TESTER, plus OHM MEGOHMMETER, plus CAPACITOR TESTER—5 complete and essential instruments in one for the price of 1!

SUPREME DIAGNOMETER

AAA 1 - $147.50

Dealers Net Price, F.O.B. Greenwood, Miss.

5 *Ultra modern instruments in one for the price of* **1**

Complete Resistance Analysis Made On Panel

SUPREME SET ANALYZER

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