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The problem of continuity testing in radio service work †

By John F. Rider

An analysis of comments received from radio servicemen relative to published information covering continuity testing to be found in radio service manuals. This paper attempts to give the reactions and wants of radio service men.

Definition of Continuity Testing

WE ARE not aware of any standardization relative to the accepted definition of continuity testing. Common practice implies that it covers the testing of a circuit to determine if it is open or closed or to determine its resistance. In view of the fact that an ordinary electrical test to indicate a continuous electrical path where such a path is required is of little value during radio service work, our definition as used in this paper refers to the measurement of the actual resistance. The exception to this case is the test made upon a fixed condenser, where it is necessary to locate the presence of a leak or a short circuit, both of which conditions are undesired and are signs of a defective state. Hence continuity testing if and when applied to condensers should be understood to signify a test to indicate an electrically satisfactory condenser without reference to capacity.

In order to relieve the monotony of repeated mention of the same descriptive phrase, continuity testing and resistance measurement when applied to continuous d-c. circuits are to be considered one and the same.

†*Delivered before the Club, October 14, 1931.*

Classification of Subjects Related to Continuity Testing

Viewed through the eyes of the radio service technician, the subject of continuity testing or resistance measurement of the circuits in a receiver can be classified in somewhat the following manner:

1. Resistance ranges and requirements in radio receivers.
2. Apparatus available with which to make the required tests.
3. Information required to enable rapid and accurate tests.
4. Presentation of continuity test data.

Each of these classifications has several sub headings. Rather than call upon the reader to continually refer back to this part of this paper for these sub headings, they are omitted at this time, but will be listed as each of these classifications is being considered.

The immediately following paragraphs voice ideas and opinions of servicemen. In justice to efforts which have been made by men who have produced and are producing radio receiver service manuals, let it be known that many very closely approach the ideal. It is possible however that one or two minor items may have slipped the mind and mention may be of interest.

Resistance Ranges and Requirements in Radio Receivers

The prime reason for the mention of resistance ranges to be found in radio receivers is one related to the apparatus available for continuity testing, and for the great need for some form of standardization along such lines.

Investigation of receivers manufactured since the popularization of radio shows a fairly wide range of resistance values. These resistances include all forms, carbon, metallized, wire wound, etc., and also inductive and non-inductive windings. The range extends from .1 to about 5,000,000 ohms.

Of course this very great range of resistance is not to be encountered in all receivers, but since the two limits represent the actual values to be found in the ordinary run of receivers, they justify recognition with respect to whatever comment is to follow. The most commonly used range of values extends from about 3 ohms to about 500,000 ohms. A predominant value prior to the popularity of the grid biased detector was about 2,000,000 ohms. If one is to include the receivers manufactured during the past five years, with special reference to the detector grid leaks, the upper limit of the common range becomes 2,000,000 ohms instead of 500,000 ohms. However the importance of knowing the exact value of a 2,000,000 ohm grid-leak resistor is not very great. An idea of continuity indicating a fair approximation of this value is sufficient. Accordingly, we may continue classifying the upper limit as being 500,000 ohms.

If we accept this limit it is necessary to assume that whatever instrument is capable of measuring a 500,000 ohm resistor is capable of at least indicating the continuity of resistors in excess of this value. This is quite important because some means must be available when measurements or tests are desired upon the popular resistances rated in excess of 500,000 ohms. Of course an ordinary continuity test showing an electrical circuit is not very good practice, but since economy is a problem it is necessary to decide upon apparatus wherewith one would be enabled to secure the greatest amount of information at minimum expense. To demand an ohmmeter which will enable actual resistance measurement upon 1, 2 and 5 megohm resistances would greatly increase the cost entirely out of proportion with the number of times when such resistances must be checked.

The measurement of resistance in any part of the receiver must indicate the condition of the circuit or whatever unit is under test. It is difficult to prescribe tolerance limits. The actual tolerance is dependent upon several factors. Among these are the function of the unit, the tolerance during manufacture, the possible effect of a variation, the design of unit and the accuracy of rating. In a way all of these factors are related to each other. Thus a variation of 20 per cent in the resistance of a 50,000 ohm grid filter resistance is of little importance, whereas a variation of 20 per cent in the value of a bias resistance in a detector circuit is apt to be unsatisfactory. Now as far as the tolerance is concerned, one must remember that it is also important that the rating of the resistors be fairly accurate. A plus tolerance of 5 per cent when added to a possible error during the measurement will be productive of an indication which may differ from the rated value as to cast suspicion. In view of the fact that certain tolerance values are allowed during the manufacture of a resistor irrespective of type or during the manufacture of a transformer, certain tolerance values should be stated when resistance ratings are quoted. Whatever the tolerance, the measurement of the resistance should be made with equipment capable of accuracy better than 2 per cent. This fraction is quoted as a compromise between the very close and very broad tolerance values allowed during the manufacture of resistors and fairly high resistance windings.

There are certain places in a radio receiver where small tolerances are allowed and accurate measurement is required. Such places are the primary and secondary windings of the r-f. and i-f. transformers. By setting very close tolerances and by quoting very accurate resistance ratings, it is possible to determine a defect in the unit and have the measurement really mean something. At the present time, one has nothing but a complex method of locating shorted turns in transformers. Recognizing that a shorted turn in an r-f. transformer will cause much trouble, an accurate rating and an accurate measurement will enable the serviceman to decide whether or not the trouble is within the transformer without involving the use of searcher coils, etc. At the present time such searcher loops must be applied during the operation of the receiver and replacement is the only accurate check. The time involved in such operations can be greatly reduced by complying with the demand for very accurate and specific resistance data with stipulation of the method of measurement and close tolerance.

Apparatus Available With Which to Make Continuity or Resistance Tests

When considering resistance measuring apparatus suitable for application during radio service operations it is imperative to remember four controlling factors. These are: 1. Low initial cost. 2. Portability and conservation of space. 3. Ease of operation. 4. Attainment of the required resistance range. A major problem confronting the modern radio service technician is that suitable continuity testing apparatus is not available. Perhaps this sounds strange in the face of the many ohmmeters which are being offered for sale. The primary difficulty is one of resistance range. The Wheatstone bridge, whereby the required range and more than the required range is available, is out of the question for several reasons.

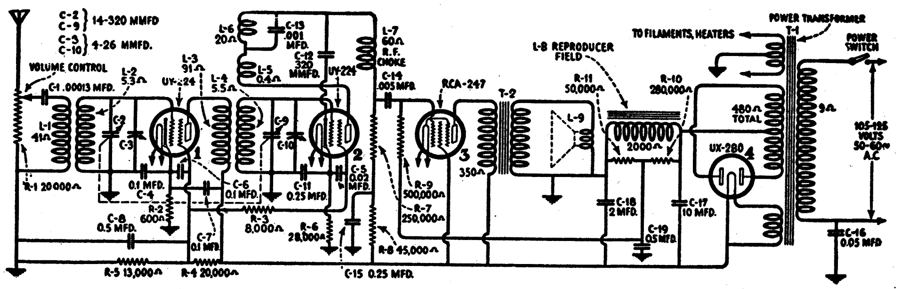

Fig. 1. Schematic circuit diagram of Model R-5.

A survey of the products produced by meter manufacturers and intended for radio service work shows a dearth of equipment with resistance ranges sufficiently great to fulfill existing requirements. The popular units available today may be grouped into three classes according to the maximum values of resistance which are determinable with the instrument. These are 10,000 ohms, 50,000 ohms and 100,000 ohms respectively. One manufacturer has an ohmmeter which is a part of a diagnosing kit, with a range of 25 megohms. With this single exception, the aforementioned resistance measuring units are the only ones available as individual test units or as parts of test kits. Obviously these maximum limits are too low for the requirements of the radio service field. It is interesting to note that a great deal of correspondence has been received relative to the changes required to increase the range of commercial 10,000 ohm, 50,000 ohm and 100,000 ohm ohmmeters to a maximum of from 250,000 to 500,000 ohms. Of course all changes recommended referred to the latter maximum limit.

Another item of importance in connection with available test apparatus for radio service resistance measurement is that concerned with the ease of measurement and the visibility of the pointer indication. The accuracy of a measurement depends upon the degree of accuracy possible when reading the meter. Approximation is not harmful when the possible error is but a very small fraction, but when one is called upon to check a resistance and it becomes necessary to approximate some value lying between 50,000 and 100,000 ohms and a 25 or 30 per cent error is possible because the separation between the .05 and .1 meg. divisions is very small, the utility of the unit is small. Add to this the possible error due to parallax and the total error assumes substantial proportions. There exists a general demand for ohmmeters with more than two ranges, not so much in the case of resistance measuring devices which have low maximums, but definitely so in the case of instruments with maximum values of 10,000 ohms or more.

The majority of ohmmeters have two ranges. In the 100,000 ohms maximum instrument, the two ranges are from 0-10,000 ohms and from 0-100,000 ohms. Because of the characteristics of such instruments, it is difficult to accurately read resistance values between 50,000 and 100,000 ohms. The scale crowds towards the upper limit. Then again, it is a difficult matter to read the low values of resistance, say between 0 and 10 ohms, because of the high resistance in the circuit when the low range extends to 10,000 ohms.

It is true that a variation of from 5 to 10 per cent in a resistance rated at from 25,000 to perhaps 500,000 ohms will not cause grave results as far as correct operation of the receiver is concerned, but this is true only when the resistor or unit being tested is in good condition. If the variation in resistance as measured is due to a defect in that unit and the trouble seems localized in the stage incorporating that resistor, it becomes a highly important item to know that the ohmic value of the unit is not up to standard. Since these meters are calibrated in ohms, it should be possible to determine the resistance with an accuracy at least equal to the tolerance employed in the manufacture of the unit. This means that some changes are required in the scale distribution. If, as has been previously stated, close observation of the accurately rated resistance is to be observed, it is even more important that an accurate reading of the meter pointer be possible. The suggestion has been made that there be a reduction in the types of ohmmeters offered for use among servicemen and that one model be decided upon as a universal type unit. This meter should have five ranges, namely from 0-1000 ohms, 0-10,000 ohms, 0-50,0000 ohms, 0-500,000 ohms and 0-1,000,000 ohms. As previously stated it might be possible to dispense with the highest range as a separate scale by arranging that the 500,000 ohm division be so located that a continuity test of a 1. megohm resistor be possible. A meter of this type may mean the use of two batteries or two values of test voltage in order to allow simple and easy reading of the scale.

Much comment has been received about the low end of the ohmmeter scale. The modern receiver requires accurate measurement of resistances between .1 and 10 ohms. The upper limit of this low range is discernible upon certain meters, but measurement approaching the lower limit is a virtual impossibility when the first division upon the meter is 10 ohms, as is the case with 10,000 ohm maximum scales. When we consider the number of items which are rated at resistance values not in excess of 3 ohms, the need for a maximum range of from 500 to 1000 ohms is evident. By proper selection of a maximum it is possible to spread the 0-10 ohm scale over a suitable portion of the dial.

Another significant item relative to standardization of design has been the subject of correspondence. This is the development of an ohmmeter wherein some form of adjustment is available whereby it becomes possible to use the test battery even if the voltage falls below the rated 3, 4, 5, 6, 22.5 volts, etc. Of course certain ohmmeters have provision for such voltage variations, but the demand is for standardization of this type in all such instruments.

Information Required to Make Rapid and Informative Tests

In a way this part of this paper can be said to be the most important, for it represents the reactions of many men to the work of a few men. There exists a difference of opinion among servicemen relative to the character and type of information required to enable a rapid and informative continuity test.

There have been signs of misunderstanding as to the definition of various types of diagrams. Our reference is to two types. Actually both are referred to as schematics. Both show the connection of the circuits. The major difference between them is that one shows the wiring between the electrical symbols representing the various devices or parts used and the other shows the wiring between the pictorially represented parts and at the same time shows the exact location of the various components relative to each other. The former is shown in Fig. 1. The latter is shown in Fig. 2. The former we shall refer to as the electrical schematic and the latter as the chassis or factory wiring diagram. There are several variations of the factory or chassis wiring diagram, but substantially they are the same, hence these samples should suffice to indicate what is meant by the term.

One group feels that the electrical schematic supplemented by the correct operating voltage values is sufficient data. The statement is based upon the claim that an experienced service technician equipped with such a wiring diagram and the operating voltage data can service the receiver by analyzing the measured voltage data and by checking the circuit under suspicion and the units shown to be part of that circuit. Suspicion is assumed to be cast upon any one circuit by the observed voltages and currents.

Some men do not dispute the claim that a receiver can be serviced with the electrical wiring diagram and the operating voltage data as the only information at hand. However they disagree with the statement as far as rapidity and accuracy of operation are concerned. Considering the function and purpose of the service technician the stand is well taken. Rapid operation and accurate operation are the two major requirements of the successful radio service technician. The ability to remedy a defect, major or minor, at short notice, is a paramount virtue. If the rapid repair is accompanied by accuracy, the ideal has been achieved.

A test question was submitted to a number of servicemen to determine the type of information they desired so as to enable rapid and accurate service operations. A tabulation of the responses would appear in eight items.

1. The electrical wiring diagram.
2. Electrical values of the parts.
3. Color coding of wires and parts.
4. Socket layouts.
5. Internal connections of units sealed in cans.
6. Factory or chassis wiring diagram.
7. Operating voltage data.
8. Tolerance limits in values and voltage data.

Knowledge of the Electrical Values Used in a Radio Receiver

Item 1 is an education in radio. It acquaints the serviceman with changes in design; with changes required when certain tubes are employed to replace other types; with the values commonly employed in certain parts of a receiver, thus proving of aid in the event that obsolete receivers must be repaired—in the event that a replacement unit is required in an emergency—in the event that correction of a certain fault must be accomplished at short notice.

Item 2 creates confidence on the part of the worker and eliminates the hazards of guesswork and the probabilities of trouble because an incorrect value is chosen.

Item 3 enables more rapid continuity testing because experimental adjustments of the test instruments is not required. When the rated ohmic value of a resistor is not known one does not know the adjustment of the range switch of the test meter.

Item 4 enables definite conclusion of the condition of the circuit and its components when the test shows an appreciable variation; also when the voltage test shows a normal condition, yet the defects exist as manifest by imperfect operation of the receiver. An example of this is a shorted r-f. transformer primary or secondary. The r-f. transformer is defective, yet the operating voltages remain unchanged and normal.

Item 5 enables the selection of test apparatus whereby the information may be secured with greatest ease.

Item 6 enables replacement. It obviates the need for extensive measurements to determine the correct value of resistance required in any one circuit in the event that the unit has been found defective and therefore cannot be measured to determine the correct value. (In connection with 6, the correspondent takes into consideration the replacement problem situation. He adds—in the event that conditions demand

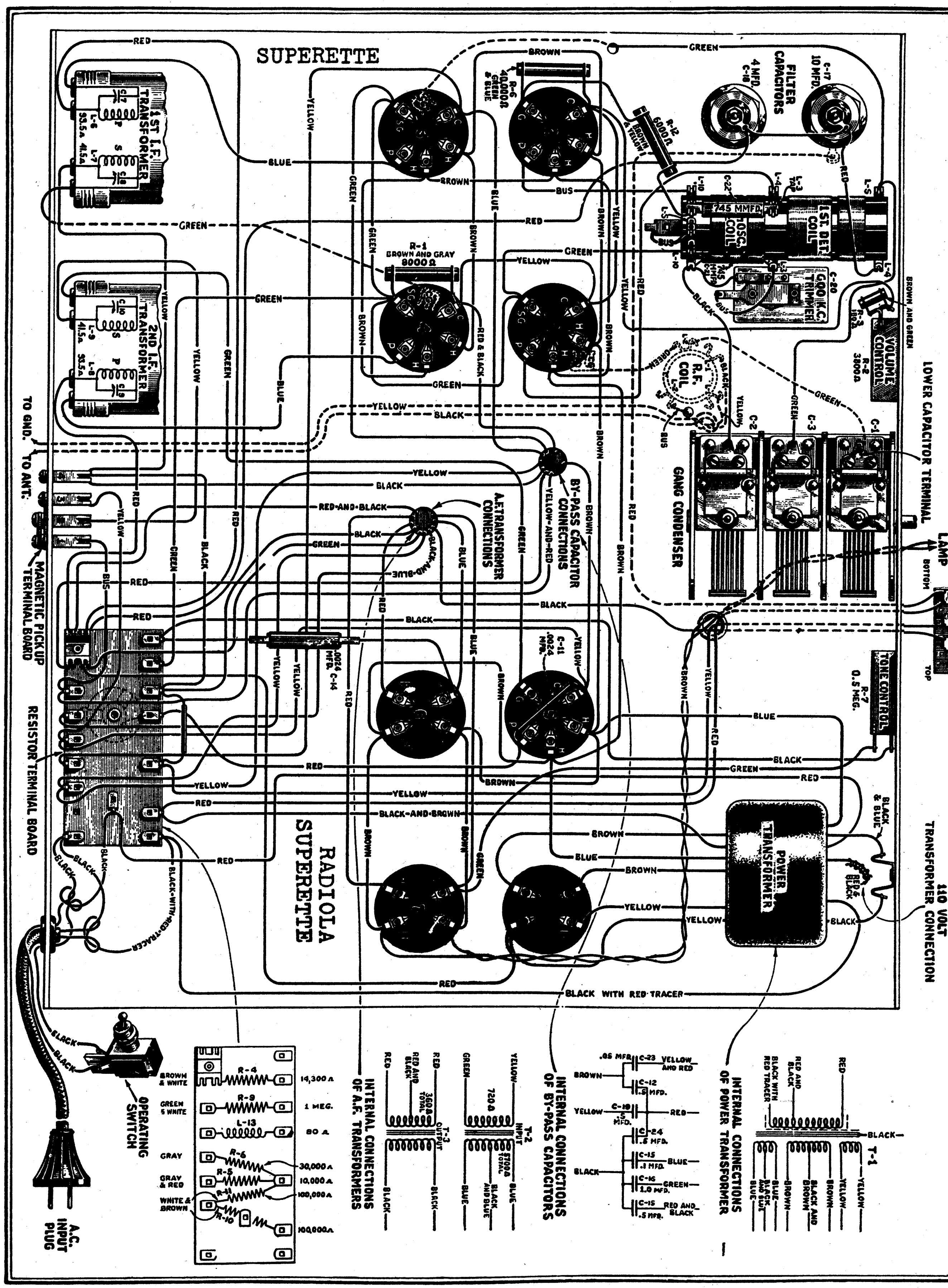

Fig. 2

that a replacement unit be secured from the original manufacturer, and if this means a delay of several days because of the location of the nearest jobber or of the original manufacturer, knowledge of the electrical values enables the use of a temporary replacement unit and an operative receiver, with great satisfaction to the customer. Of course such temporary repairs are possible only in the event that the defect is not major.)

Since continuity testing represents the major part of the actual service work, whatever time saving can be effected must be in this direction. There can be no reduction in the charge made for the actual replacement because the price of the unit is fixed by the sales organization or the manufacturer. The price latitude is found only in the time required to make the repair. With a fixed charge and in some cases a fixed maximum charge above which it is impossible to levy because of competition and other factors, nothing but rapid and accurate operation enables the service technician to carry on. A saving of 15 minutes on each job during a day means the difference between success and failure at the end of the week.

What Electrical Values Are Desired

It might be well at this time to ascertain the exact significance of electrical values. As far as resistors are concerned, the actual resistance value is important for testing and replacement. If the receiver manufacturer has a lenient replacement policy, the wattage rating of each resistor is also necessary. For that matter the wattage rating is at all times important inasmuch as it is possible that the exact parts list showing the various parts numbers is not available and if two resistors of like ohmic value but unlike wattage rating are found in a receiver, confusion is apt to result if, when ordering, the wattage rating is not mentioned.

Inductance values of windings quoted in henrys or fractions thereof have been stated as being of little utility in continuity testing or even general service work. Of infinitely greater import is the d-c. resistance of the winding. It is true that certain test kits incorporate inductance measuring meters but the resistance check is of actual importance during the work and has much more value than the inductance figure. The measurement of inductance is far more complicated than the measurement of resistance.

Knowing the rated resistance of a winding enables the checking of the circuit. Knowing the inductance of a winding means very little for several reasons. First, no service technician will attempt winding an r-f. transformer to replace a defective unit in the receiver. As a rule the r-f. transformers are replaced as a gang. Second, the service technician by making an accurate resistance test can ascertain whether or not a turn is shorted much more rapidly than if he must make an r-f. inductance test. The first check can be made without removing the r-f. transformers from the chassis. The sectest requires its removal. The second check for inductance requires specially calibrated circuits and apparatus. In iron core windings the inductance is a variable depending upon the voltage applied.

Conditions which would tend to cause a deviation in inductance from the rated value, with the possible exception of current flow and damage to the core in iron core windings, would also tend to change the d-c. resistance. Thus, measurement of the latter would automatically show a variation in the former.

It is necessary to make mention of the place in a receiver where the inductance value is of importance. This is in the filter system of the power pack and possibly in the r-f. choke used as a part of the low-pass filter in the detector plate circuit or in the output tube plate circuit. Here both the resistance and the inductance are required. The resistance because of continuity testing and the inductance because of the tuning of the system and the need for accurate replacement. Since inductance is available in many shapes and many values of d-c. resistance, it is well to know both values.

We cannot omit the importance of knowing the resistance of a winding when that unit is sealed within a can and is but one of the units within that can. Individual access is impossible without disrupting the entire assembly, thus the only form of valuable information is the d-c. resistance.

As to condenser values, capacity and voltage ratings are equally in demand. This information is required primarily because of replacement work, although knowledge of the capacity is educational, and with capacity meters in test kits a more accurate test upon a condenser is possible. Response to the publication of filter and by-pass condenser voltage specifications has been very favorably received. The demand for the capacity rating of tuning condensers has been very slight.

Color Coding of Wires and Parts

Suitable color coding of wires and parts is very helpful during continuity testing because it enables rapid recognition of any unit which must be tested. It is also of aid because it enables more rapid tracing of the circuit.

Socket Layouts

Socket layouts are important because they indicate the exact tubes used and thus help select the respective circuits. It might be well to mention that a separate illustration showing the position and the types of tubes is not required when a chassis or factory wiring diagram is available.

Internal Connections of Units Sealed in Cans

Nothing in the way of a time loss is as great as the lack of such information. It is a conservative estimate to say that a serviceman wastes 10 to 12 hours a week if he is called upon to service a number of receivers which have units sealed in cans and the exact wiring is unknown.

Factory or Wiring Diagrams

Servicemen have repeatedly voiced the sentiment that the electrical wiring diagram even when replete with electrical specifications, color coding and part numbers, remains but part of the information required to enable rapid continuity testing. Of equal importance is the chassis or wiring diagram. In order to make a routine continuity test, the servicemen must locate the components of the suspected circuits. Since the electrical wiring diagram shows the various units located in each circuit, the technician has an idea of what he seeks, but where is he to seek these units upon the chassis? The arrangement of the tubes and parts indicated upon the electrical wiring diagram has no connection with the arrangement of the parts upon the chassis. The electrical wiring diagram of a midget resembles the electrical wiring diagram of a console model. The electrical wiring diagram shows the r-f. detector, a-f. amplifier and power-pack as a complete system. Yet an examination of the actual receiver shows the r-f. amplifier and detector in one part of the receiver and the power-pack and amplifier upon a separate chassis. To attempt to locate the corresponding units is productive of delay. The only means is to show the chassis wiring diagram so that when the occasion arises to check the receiver a diagram is available whereby one can instantly locate the *exact position* of any one unit upon the chassis.

The connection to the units are likewise of importance. This is necessary to avoid the trouble of tracing the circuit.

An analysis of service manuals shows three different forms of chassis layout presentation. These are:

1. The actual wiring diagram of the various units, showing the exact posi-

tions of the units, the color coding of the cables, the color coding of the resistors and condensers and the electrical continuity of whatever units are sealed in cans. (It is understood that the color coding is in the form of written comment rather than the actual color.)

2. A layout of the apparatus showing the containers only and the respective parts numbers.

A photographic reproduction of various views of the chassis with arrows pointing to the different units and printed legend designating the different units and their electrical values.

Of these three forms the first has been received with the greatest favor for several reasons. Several suggestions have been received relative to the type of information desired. The ideal would be a specification for the purpose of each unit, its electrical value and color coding. Naturally, all of this information is impossible due to the space limitations.

The concensus seems to recommend the omission of the actual function of resistors and condensers, but publication of data which will immediately designate the association between a part shown upon the electrical wiring diagram and a part shown upon the chassis wiring diagram. To show the electrical value of a resistor and its color code is satisfactory in the case of old receivers where solid colors were used. Even here difficulty may be encountered if more than one resistor of like size and design has the same resistance and the same coloring. A better arrangement is that used in some manuals, where an R designating letter followed by a number accompanies each resistor upon the electrical wiring diagram and a similar form of designation is used to indicate the same resistor upon the chassis wiring diagram. The electrical wiring diagram and the chassis wiring diagram also carry the electrical value of that resistor.

The advantage of showing the electrical value upon the chassis wiring diagram is that it enables an immediate measurement of any one unit without the necessity of referring to another illustration for the electrical ratings. Standardization of color coding is still too recent to ask an individual to memorize the electrical equivalents. And if we recognize the fact that all types of resistors, inclusive of wire wound, are not yet standardized with respect to color coding, mention of the electrical value is by far the best method. Mention of the electrical value of a resistor or a condenser is not required upon the electrical wiring diagram if that value is shown upon the chassis wiring diagram, but since it is not yet standard practice to show chassis wiring diagrams, the electrical value should appear upon the diagram. Of course a parts list showing parts numbers which correspond with some designating symbol upon the electrical wiring diagram can be used, providing that this list also shows the electrical value, but such an arrangement requires reference to two sources of information. Furthermore, since it is possible to service a receiver without the chassis diagram, with only the electrical wiring diagram as the data at hand, it is best if the electrical values are shown upon the diagram. If some designating symbol accompanies each unit, this symbol should be listed upon the parts list and correlated with the part number.

Mention of the part number upon the diagram is not a necessity according to the letters received. First because it represents printing and therefore complicates the diagram. Second, the need for the part number presents itself only after the defective unit has been located, therefore it appears in but one operation during the entire service procedure and is not of importance so far as continuity testing is concerned.

The information desired upon the electrical wiring diagram and the chassis wiring diagram is that which will enable the selection of a common reference point for the testing of any one circuit. What with the similarity of circuit structure of biased detectors and amplifiers, it is necessary that the tube function be indicated upon the electrical wiring diagram and the chassis wiring diagram, as for example first r-f., second r-f., oscillator, etc. This will enable the selection of some part of the tube socket as the reference point.

There exists a need for designation of the socket terminals upon chassis wiring diagrams. As a rule these diagrams show the underside of the chassis. This means that the terminals of the sockets are reversed with respect to the normal positions. This is confusing. Such designations would be H,H,F,F,P,Scr Gr, etc., depending upon the type of tube. This subject is of further importance because the exact placement of the sockets is not always the same and the various terminals are in different positions in different receivers; that is, with respect to the front or the rear of the chassis. All of this data enables the rapid selection of a reference point and further checking of the circuits.

Obviously the electrical wiring diagram cannot show the color coding of every wire used. But it can show the color coding of the power transformer cables. One of the most annoying problems is the tracing of the power transformer cables when the leads emerge from an opening in the power transformer housing and no designating data is given.

Mention of the color coding of the plate circuit leads upon the electrical diagram would be an advantage when the chassis wiring is checked because it would help locate the parts of that circuit. Mention of the color coding of all of the wires upon the chassis wiring diagram is desirable to allow rapid testing of continuity in any of the circuits. This is equally applicable with cabled wiring because it is possible to probe the cabled wires for the one with the required coloring and thus check the continuity of the wire itself.

Many chassis wiring diagrams show not only the shape of the various parts and containers, but also the electrical continuity of the parts within these containers. Of course the electrical symbol is used. This information has been considered of the utmost advantage.

Chassis layouts showing parts in pictorial fashion, that is, just the shape of the unit, and parts numbers without wiring information are considered to be of but limited utility. It is said that the chassis wiring diagram supplies this data relative to the location of the parts and that a tabulation in the form of a list giving the function of the unit, the part number, the electrical value and list price is of equal value. Of course the presentation of the part number accompanying the unit in the form of a chassis layout is easiest to follow, but the danger of poor printing resulting in imperfect recognition of the number and incorrect ordering is a hazard.

Photographic views of the different sides of the chassis have their functions but the comment received was favorable only when the photographs were fairly large and clear. The problems of photography where the color contrast between units is not very marked makes it difficult to recognize the various units. On the other hand photographs of the upper side of the chassis showing the various trimmer adjusting screws are in great demand providing that the proper legend accompanies the illustration. A photograph showing the various units but bearing part numbers only has been considered of little value. Further comment has been received relative to the screen used during the making of the cuts of this illustration. Rough screens used with reduced reproductions produced pictures which were of little help. Another comment relative to photographs of the underside of the chassis was that it did not show the color coding of the wires or the insides of the containers.

It might be of interest at this time to record several tests carried out to determine the relative efficacy and value of the electrical wiring diagram, the combination of the electrical and the chassis wiring diagram, and only the chassis wiring diagram. The defects produced were of the type which would interfere with the normal operations of the receiver, yet have no effect upon the operating voltages. The men were called upon to alternately repair these defects. The time spent was averaged. The routine voltage test consumed about the same amount of time in all cases and was not influenced by the type of circuit data available. The receivers selected were those which did not have automatic volume control tubes. The results showed a very great advantage in favor of the combination of the two drawings. Operating with nothing but the electrical wiring diagram and whatever test equipment the man required, the time consumed to locate the defect was about 60 percent longer than with both the electrical and the chassis wiring diagrams. In one instance, where the defect created was a short circuit across the r-f. transformer secondary, a low resistance winding, lack of knowledge of the correct electrical resistance of the winding caused the loss of so much time that the charge based upon $2.00 per hour for the analysis would have been entirely out of proportion with the initial cost of the receiver. Operating with nothing but the chassis diagram, the cost of servicing was so great as to be entirely out of the question.

Presentation of Continuity Test Data

Supplementary to what information is contained upon the electrical or chassis wiring diagram, great interest is evinced in the actual presentation of the continuity test data when it appears in tabular form. Information of this type has appeared in several forms among which are:

1. As the stipulated voltage to be found between two specified points, thus indicating the condition of the components in that circuit between the two stated points.
2. As definitely specified resistance to be found between two stipulated points.
3. As a certain voltage indication upon a continuity tester consisting of a specified voltmeter (10 volts d-c. high resistance meter) and a 6-volt test battery, which system is connected between two specified points.
4. The same as mentioned in description number 3, except that the voltmeter is a 50-volt instrument (high resistance type) and a 45-volt battery.
5. The same as numbers 3 and 4 except that the meter is a 15-volt low-resistance type voltmeter and a 4.5-volt battery.
6. As a full or partial indication upon a voltmeter used with a battery.
7. As a definitely stipulated fraction of full scale deflection upon a certain specified voltmeter-battery combination.
8. As a certain indication upon a low range milliammeter (d-c.) which is used in one of several ways. One of these systems utilizes a simple series combination of the meter, a resistance and a battery. Another combination employs a variable voltage, a variable series resistance and several shunts.

The following is a summary of comments relative to these methods of checking continuity and the value of the tabulations. The voltage test made between any two points as outlined under heading 1, is the same as the conventional voltage test made with a set analyzer. The difficulty experienced with such a system is that a variation in voltage is to be found only under certain conditions, assuming that the test voltage remains constant during the test. These conditions are: A. when the circuit is of high resistance and carries current; B. when the circuit is of low resistance and carries appreciable current; C. when the circuit is open; D. when the normal voltage drop across the units in the circuit is appreciable. If the conditions A, B, C or D are fulfilled, a defect in the circuit will show a variation in voltage, but when the circuit is of high-resistance, but carries no current as in the grid circuits of amplifying tubes, a short circuit across that resistance will have no effect upon the voltage between the two points. The same is true when the circuit is of very low resistance and carries little or no current as is to be found in r-f. grid circuits or r-f. plate circuits across the r-f. transformer primaries. Thus the voltage measurement has certain limitations and is not universally applicable. As a matter of fact it is possible to have an open circuit in a system without interfering with the voltage indication. Such cases are open condensers in tuned r-f. systems, resistance-coupled audio systems, etc.

The resistance form of specification while not 100 per cent applicable, remains the best form of presentation. Its only point of failure is an open condenser. Obviously it is applicable to all resistors, r-f. chokes, transformers, a-f. windings, etc. Another advantage is that of economy. A single ohmmeter of suitable range is applicable as previously stated to all resistances commonly employed in a radio receiver.

The methods specified from 3 to 8 represent special systems and special meters. In the first place, each of these special systems and special meters is suggested for a certain receiver. The six systems are suggested for six receivers. Thus if a serviceman were called upon to test these six receivers and attempted to utilize the tabulated continuity test data he would require six different testing circuits, and several different meters. Since each meter is intended for a certain system, the calibrations for that system are not interchangeable with any other. Consider just one of these. A certain voltmeter and battery when connected between the plate of one tube and ground indicates 5.2 volts. Let us say that this indication represents 1,000 ohms. What is happening is that the 1,000 ohm resistance (the ohmic value of the circuit) acts like a multiplier for the meter. Whatever multiplying ratio is secured when the external resistance is 1,000 ohms with this meter of say 6,000 ohms resistance, will be secured only so long as the meter resistance is 6,000 ohms. In turn the voltage indication of 5.2 volts when the external resistance is 1,000 ohms is available only when the test voltage remains at its original value. The specification of 5.2 volts assumes that the test voltage remains constant. Any variation in test voltage will cause a variation in reading. The use of a meter with a different value of internal resistance will cause a variation.

On the other hand if the resistance of 1,000 ohms is specified as resistance without mention of voltage indication or any special type of meter, any ohmmeter with suitable range is satisfactory. The design of the meter is of no consequence. The test voltage is of no consequence. Nothing matters just so long as the ohmmeter is accurate and capable of indicating the required resistance.

The need for standardization of this type does not exist in the service shop of the jobber who handles but one line of radio receivers and the continuity test data as prepared is based upon a special type of meter which is assembled in the shop. But the need for standardization is repeatedly voiced by dealers and independent servicemen who may be called upon to service any one of a thousand radio receivers.

What is true in the case of the example cited is true in all of the others where special meters with special calibrations in other than ohms are recommended. Each of these systems is intended for a special case, at least the calibrations are special and in order that the meter combination be suitable for some other receiver, it is imperative that the continuity test data for the other receivers be based upon the same type of continuity test equipment.

Partial or full indications and fractional specifications are open to objections on the ground that too much latitude is offered during testing. The definition of partial or full is quite broad. If the meter is of the voltmeter-battery type, a full indication is impossible inasmuch as every series resistor will act like a multiplier. The extent of the range increase and therefore the deviation from the full scale reading depends entirely upon the resistance of the meter. As to partial indications, anything between zero and full scale is partial.

Viewing the subject from another angle, a voltmeter is much less expensive than an ohmmeter, but if several are required in order to service a number of receivers of different manufacture, the purchase of an ohmmeter is less expensive in the long run. Furthermore, portability of a single ohmmeter is simpler than that of a number of meters. In connection with ohmmeters, there exists no rigid regulation that they must be of the commercial type. The important item is that the continuity test data be given in the form of resistance values.

We cannot close without reference to two suggested methods of actual continuity testing. One system recommends a point to point test wherein each unit has two designating numbers and the test is made between these numbers. The numbers are marked upon a chassis layout showing the parts with or without wiring. The other system recommends a test between a common point such as ground and various points along a circuit until the point of highest potential above ground is reached, or until the point most distant from ground along that circuit is reached. Queries show that the latter is preferred because it is much faster and simpler. The fact that one test prong is fixed at the common reference point enables progressive testing.

In closing we wish to point out that many service manuals prepared by radio receiver manufacturers fulfill many of the requirements as set forth by servicemen, but there remain some items to be desired.

SUGGESTIONS TO CONTRIBUTORS

CONTRIBUTORS to the Proceedings, by bearing in mind the points below, will avoid delay and needless expense to the Club.

1. Manuscripts should be submitted typewritten, double-spaced, to the Chairman of the Papers Committee.* In case of acceptance, the final draft of the article should be in the hands of the Chairman on or before the date of delivery of the paper before the Club.

2. Illustrations should invariably be in black ink on white paper or tracing cloth. Blueprints are inacceptable.

3. Corrected galley proofs should be returned within 12 hours to the office of publication. Additions or major corrections cannot be made in an article at this time.

4. A brief summary of the paper, embodying the major conclusions, is desirable.

5. The Club reserves the right of decision on the publication of any paper which may be read before the Club.

* For 1931 the Chairman of the Papers Committee is Mr. F. X. Rettenmeyer, 463 West Street, New York City.