PRACTICAL RADIO REPAIRING HINTS

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WE TAKE THIS OPPORTUNITY TO THANK

MR. JOSEPH H. APPEL, JR.

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who was instrumental in the decision to prepare a book of this type, who collaborated with the author and made many extremely valuable suggestions relative to the text and the structure.

INTRODUCTION

The practicing radio service man irrespective of his location or his employer is one of the biggest factors whereby the radio manufacturer creates good will and public confidence. These men have had a long uphill fight, which as yet is by no means completed, to gain the recognition rightfully due them. Complete success is in the offing and when it is achieved, radio as a medium of entertainment and education will be viewed with much greater favor, because each and every radio receiver owner will be assured of satisfaction when service work is necessary.

Practical Radio Repairing Hints has been written for the practical radio worker, service man and experimenter. Theory has been omitted because of the abundance of text books dealing with the subject. The text matter contained in this book is the result of a great deal of investigation carried out upon radio receivers old and new and analysis of more than one thousand wiring diagrams of these receivers. The data selected and tabulated is intended to clarify many radio service problems and to serve as a general guide when making replacements or changes upon defective receivers.

The mode of tabulation of data has been planned to enable most rapid location of information. The tables included are those most frequently required in radio service work. We realize that this book does not cover absolutely every service item. We have omitted those items which are generally considered to be stock knowledge on the part of the practicing service man.

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CHAPTER 1

CIRCUIT CONTINUITY

THE following material should aid when solving tube circuits relative to the plate current and grid voltage paths. An effort made to understand the continuity for one tube will greatly facilitate continuity for any number of tubes.

THE CATHODE OR HEATER TYPE OF TUBE.—An idea of how operating voltages for the cathode or heater type of a three element tube are secured in the modern electric receiver is shown in figures 1 and 2. Figure 1 shows the normal D.C. source of supply for a regular three element tube with the filament as the source of electrons. In figure 2 the cathode replaces the filament as the source of electrons. This cathode is heated by a heater winding operated from the A.C. mains. The normal path of the various currents according to the usual conception of current flow is indicated in the drawing. Continuity in the plate circuit for the correct flow of plate current must provide a complete path from the B+ terminal of the battery to the B— terminal of the B battery through the electron emitter, in this case the filament. The C bat-

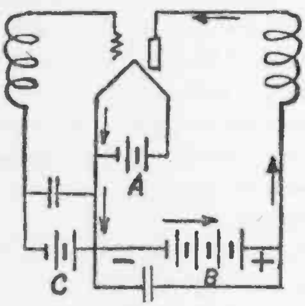


Fig. 1

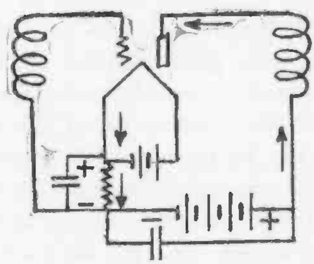


Fig. 1 A

tery in figure 1 supplies the bias for the tube. It is possible however to eliminate the C battery in battery operated receivers by the use of a resistance in the B— circuit so arranged that a voltage drop is produced across this resistance and applied to the grid. This is shown in figure 1A as resistance R. The plate current of the tube flows through this resistance and produces a voltage with the polarity as designated, making the grid negative with respect to the filament by the value equal to the value of R in ohms times the plate current. This arrangement is not in general use. It does however show the method of securing grid bias in electric receivers.

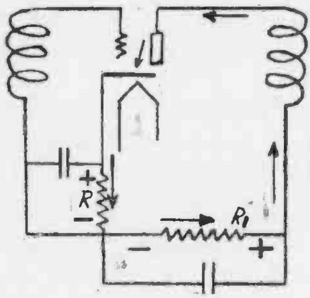


Fig. 2

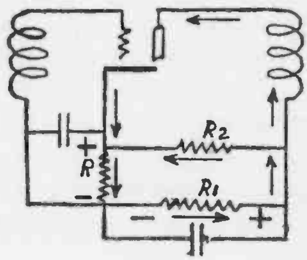


Fig. 3

The complete A.C. circuit in an electric receiver employing the cathode type of tube is shown in figure 2. The B battery in figure 1A has been replaced by an eliminator voltage divider designated as resistance R1. This divider has its own polarity just as if it were a B battery. The grid bias resistance R is now located between the cathode and the B— end of the eliminator voltage divider. The plate current in order to find its way back to the B— end of the divider must flow through the grid bias resistance R thus making the grid negative with respect to the cathode by the voltage developed across the resistance R. The various bypass condensers shown are used to provide a path for the radio or audio frequency currents in the respective grid and plate circuits so that they do not flow through the voltage supply circuits.

Many receivers use an arrangement whereby the current flowing through the grid bias resistance in the cathode circuit of one tube or a number of tubes is not only plate current of that tube but also a bleeder current fed from the plate supply, thus enabling the use of a lower value of resistance for the grid bias unit and also making the grid bias developed across the resistance practically independent of the tube plate current. This is shown in figure 3.

The bleeder resistance is designated as R2 and the various current paths are as shown by the arrows. The current through the grid bias resistance R is the tube plate current and the current through the resistance R2 as shown. The significance of such a system with respect to service work is considered elsewhere in this book and we shall omit the subject at this time.

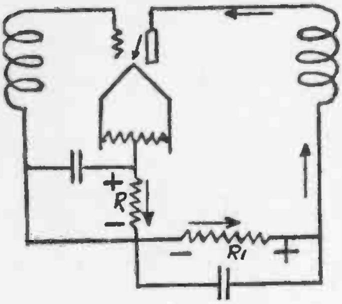


Fig. 4

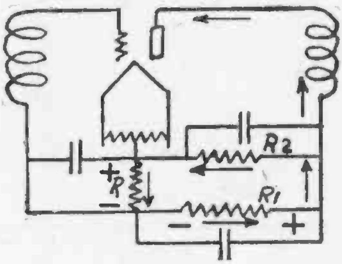


Fig. 5

The arrangements shown in figures 2 and 3 when applied to the filament type of A.C. tube are as shown in figures 4 and 5. The designations shown in figures 2 and 3 are used in figures 4 and 5. The plate current in order to find its way back to the B— must flow through the filament and the resistance R. The filament shunt resistance is used to represent either the filament winding center tapped or a center tapped shunt resistance used to secure the required electrical balance in the filament circuit.

THE A.C. SCREEN GRID TUBE.—The advent of the screen grid tube into radio receiving systems introduced another circuit. So much has been written about the function of the screen grid and the design of the tube that tube characteristics shall not be discussed at this time. The only mention necessary is that a positive voltage is applied to the screen grid and that this voltage is generally variable since it is possible to control amplification by varying the screen grid voltage. A simple screen grid tube circuit of the D.C. type is shown in figure 6. Everything is as in figure 1, except that the bias for the control grid is secured by means of a voltage drop across a part of the resistance in the filament circuit. In contrast to the drop due to the plate current, here it is due primarily to the filament current. The drop across the resistance R makes the grid negative with respect to the filament by I_fR. Both R and R1 in this case control the filament current. The plate voltage is secured from the B battery and the potentiometer resistance R2 connected across a part of the B battery makes avail-

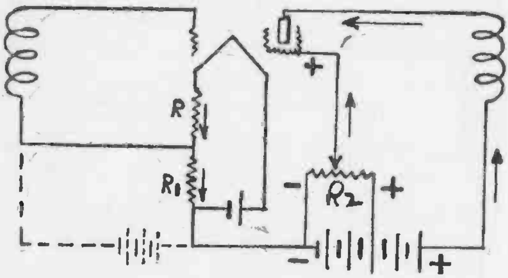


Fig. 6

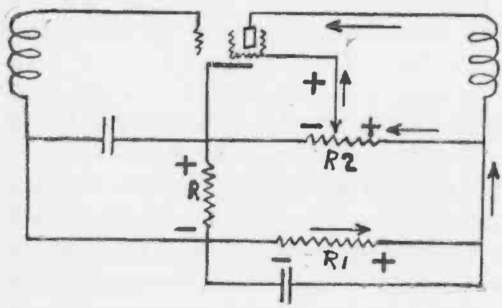


Fig. 7

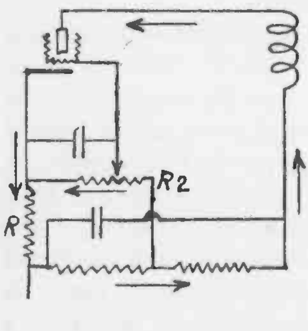


Fig. 7 A

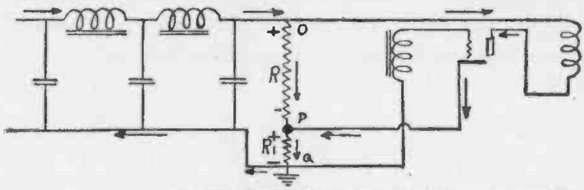
able a variable "+" voltage for the screen grid. If we were to eliminate the use of the resistance R to supply the grid bias, the location of the C battery would be as shown in dotted lines.

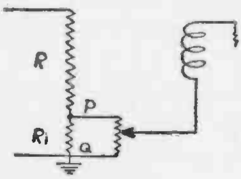
If we change this tube and use a cathode type of screen grid tube, operating in an electrified system, the circuit structure is as shown in figure 7. The control grid bias is secured by means of the cathode resistance R. The B battery has been replaced by the eliminator voltage divider R1 and the potentiometer R2 in figure 6 is now the unit R2 in figure 7. This resistance provides a variable bias voltage for the screen grid. At the same time it functions as a bleeder resistance and passes current to the regular control grid bias resistance. It is not imperative that the resistance R2 shunt the entire divider. It can be arranged to shunt a portion of the eliminator divider as in figure 7A.

As to the production of grid, plate or screen grid voltages for individual types utilized for any special function, the methods shown are generally applicable. Thus the system used to produce grid bias in a cathode tube circuit is used for cathode type tubes employed as radio frequency amplifiers, detectors or audio frequency amplifiers. The method used to produce the required voltages in the screen grid tube circuits is likewise applicable when the tube is used as a radio frequency amplifier or detector and as an audio frequency amplifier in resistance coupled circuits.

BIAS VOLTAGES FROM ELIMINATORS.—By properly determining the return point for the plate currents in a receiving or measuring system it is possible to arrange for the generation of a bias voltage in the power supply device. Two separate items must be considered. First, the use of the A.C. power supply with the cathode type of A.C. tube and second, the use of the stated system with the filament type of A.C. tube, such as the 326 and the 345.

A simple eliminator filter system with a simple voltage divider feeding the plate and grid voltages for a cathode type of tube is shown in figure 8. The arrows indicate the path of the plate current according to conventional conception. The rectifier arrangement is omitted. The total divider consists of R and R1. The plate current for the tube is assumed to leave the eliminator at the terminal O and flow to the plate as indicated by the arrows. It flows from the plate to the cathode within the tube and through the cathode to the junction of R and R1. This point indicated by the heavy dot is the B— C+ for this tube but the plate current cannot reach the negative eliminator return circuit unless it passes through the resistance R1. A voltage is therefore developed across the resistance R1 between the points P and Q. The grid is con-





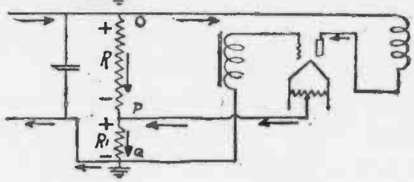


Fig. 9 B Fig. 8 (top) Fig. 9 A

nected to the point Q and the cathode to the point P. The voltage across these two points is the voltage across the grid and the cathode, hence the negative grid bias.

The same circuit with a filament type of tube instead of the cathode type of tube is shown in figure 9A. According to figures 8 and 9A the total B voltage is being applied to the plate of this one tube. Such is not always the case in actual practice. Other B voltages may be tapped off the resistance R or another series resistance may junction at the point O.

Recognizing the development of a voltage across the resistance R1, one can very readily comprehend that a voltage may be secured across any portion of R1 and if a voltage divider is connected across R1 of the type shown in figure 9B, any portion of the total voltage developed across R1 may be secured as a grid bias. This method is used in many instances when the speaker field coil is used as a choke in the negative lead of the eliminator and the voltage developed across this choke is employed as the grid bias voltage for the output tube. Such an arrangement is shown in figure 10. The position of the field coil in this case is the same as the resistance R1 in figure 9A, except that the location of the ground has been changed. This field coil has a definite value of D.C. resistance and the total eliminator current flow passes through this choke and produces the bias voltage.

If this voltage is excessive and a fraction of it is desired, the circuit is arranged as shown in figure 11. The system is identical to that shown in figure 10 with the exception that the voltage divider R1 R2 is shunted across the field winding and a portion of the total drop is applied to the tube grid.

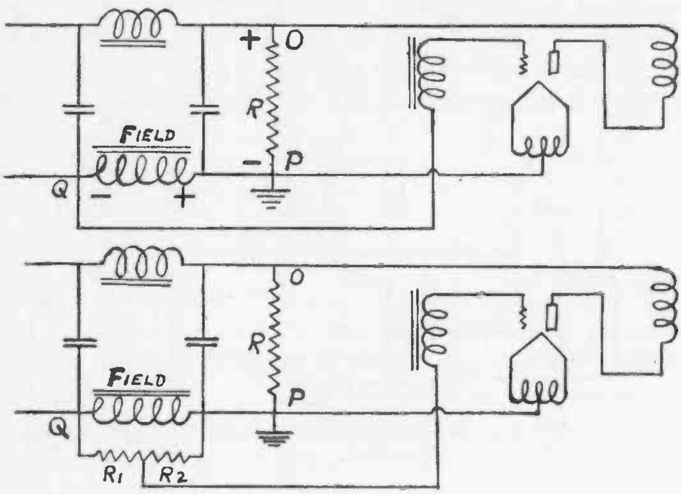


Fig. 10 (upper) Fig. 11 (lower)

COMBINED GRID BIAS VOLTAGES.—The use of grid bias resistances in such fashion that more than one tube receives a common value of bias and another tube receives the bias developed across more than one resistance is popular in radio receivers. Such a circuit using the cathode type of tube is shown in figure 12. The voltage for the plates of the tubes is secured from the eliminator. The divider across the eliminator output is the resistance R2. Two taps are shown but without the points of destination. The direction of the plate current flow is indicated by arrows. The first tube has its own bias in the cathode circuit and the plate current of that tube flows through the resistance R. The other tubes have a common bias resistance R1 which carries the plate current of tubes 2 and 3 and also the plate current of tube 1. The grid return of tube 1 is such that the voltage applied to the grid of the tube is the combined voltages of R and R1. The most negative point with respect to the grid is the point O, to which point the grid is joined, therefore the total voltage between the cathode and the point O represents the potential difference between the grid and the cathode.

The situation is different in the other tubes. They have a common bias resistance R1. The total plate current of these two tubes flows through this resistance and produces the drop that is applied to the grid of the two tubes. These two grids are joined to a common terminal. The location of this terminal is such that the potential difference between the respective grids and cathodes of the tubes is that developed across the resistance R1.

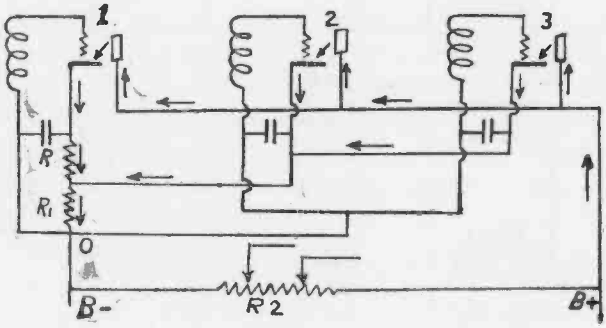


Fig. 12

CHAPTER 2

THE DISTRIBUTION OF B VOLTAGE IN A.C. COMMERCIAL RECEIVERS

THE man who is familiar with the conventional form of power pack operated upon A.C. lines will find that many modern receivers incorporate systems and units which are actually foreign to the conventional systems. The present demands for stability and quality of reproduction have made scientific construction a necessity. It is impossible to tabulate the exact systems or peculiarities, if we may call them that, found in different receivers. Models change and systems change, but if the man concerned is warned of the various systems in use and how they differ from the conventional arrangements of yesteryear, he can recognize the presence of an unconventional system and be guided accordingly.

These new systems alter continuity. They must be known and their presence recognized in order that diagnosis be carried on in correct fashion. The wiring diagram is of aid, but only when the man concerned is aware of the fact that various systems are possible does he realize that examination of the diagram is necessary in order to determine the system in use. The design of the modern receiver is such that nothing can be taken for granted. Furthermore recognition of a system is possible by means of symptoms present during tests. Such recognition is possible only when the man is aware of the fact that various systems are used and that each system has its own peculiarities and can be recognized by the reactions.

In view of the fact that modern receivers are of a definite type, that is designed for operation upon A.C. or D.C. power mains and since the "A" eliminator has died its natural death, further mention of that device shall not be made in this section. Repair hints pertaining thereto are to be found in other parts of this book.

A.C. POWER PACKS AND ELIMINATORS.—The modern A.C. operated B eliminator resembles the old in many respects, but certain variations have been introduced. This statement should not be construed as signifying that all eliminators of modern vintage differ from the old. Such is not the case, but the fact that many differ is the reason for this discussion.

We shall as a basis for discussion, show various forms of A.C. operated B eliminators, illustrating the various types of rectifying systems, the conventional filter and the two popular types of conventional voltage dividers or distributing systems. The rectifiers, filter and divider arrangements have been separated so as to show that any one type of rectifier is suitable for the same filter and either form of divider may be used with the filter and any one of the rectifying systems. These arrangements are the ones generally understood as being representative of an A.C. type of B and C eliminator. Comparison with the systems to be shown will illustrate the differences introduced by modern design.

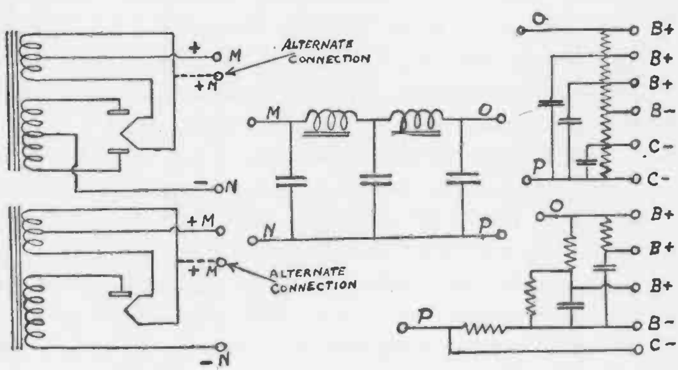


Fig. 13 (upper)
Fig. 14 (lower)

Fig. 15

Fig. 15 D (top)
Fig. 15 E (bottom)

RECTIFYING SYSTEMS.—As far as the rectifying system in power packs is concerned, very little change has ensued since their advent, other than a gradual increase in the popularity of the filament type of rectifier, until at the present writing, practically all radio receivers use the filament type of rectifier tube. The old circuits shown in figures 13 and 14 are those in use today. One item of interest in connection with such rectifiers is the use the full wave type of tube bearing the designation —80 is used as a half wave rectifier with the two plates joined. However, such cases are rare.

FILTER CIRCUITS IN "B" ELIMINATORS.—Filter systems have undergone certain changes. The usual conception of a B eliminator filter is that shown in figure 15, an electrical structure consisting of two chokes and three condensers. Many radio receivers use such systems, but the number of deviations from such systems justifies this discussion. First and foremost are the number of sections, that is, the number of chokes and capacities. Two chokes and three condensers are generally classed as being a complete filter. Many radio A.C. power plants of the type being discussed use but one filter choke. In other words the complete filter system consists of but one "pi" section, one choke and two condensers, as in figure 15B.

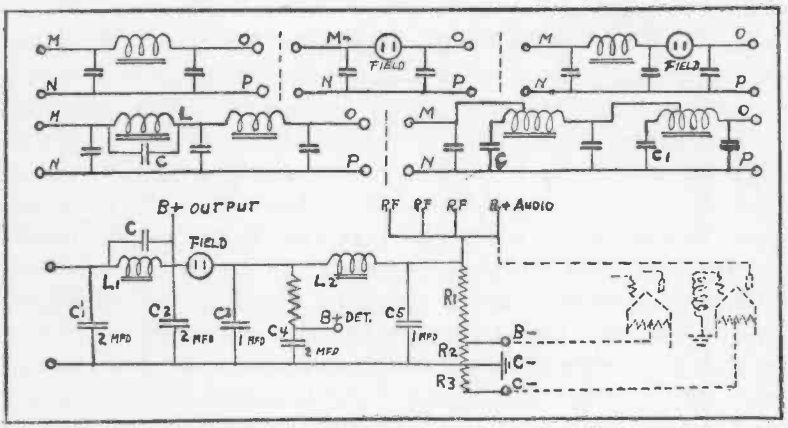


Fig. 15 B (top)
Fig. 16 (middle)

Fig. 15 C (top)
Fig. 19 (bottom)

Fig. 17 (top)
Fig. 18 (bottom)

Another modern deviation from the conventional is the use of associated equipment in place of the conventional choke. In days of old, the chokes in the filter were of special construction and bore the designation "filter choke." In many modern receivers one of these chokes is replaced with the field winding of the dynamic speaker. Several manufacturers of radio receivers employ the speaker field winding as the only choke in a single section filter as in figure 15C. Thus one choke of a two section filter is replaced by the speaker field coil. It is also possible that the filter is a single section arrangement with the speaker field winding as sole choke.

While upon the subject of speaker field winding as filter chokes, we wish to make the statement that all speaker field windings are not used in this fashion.

In addition to the single and double section filter systems with or without the speaker field winding as one of the chokes, several receivers employ three section filters. Two sections employ regular chokes and the third is the speaker field winding. As to the location of the filter chokes, one would, because of common practice imagine all chokes to be in the positive lead of the eliminator. That is true in the majority of cases, but one must bear in mind that some receivers are designed with the filter chokes in the negative leg of the supply.

RESONANT CIRCUITS.—Reference to figure 15 shows a simple low pass filter network wherein the design is such that it is supposed to eliminate or filter all frequencies. The demand for greater freedom from hum has necessitated superior filter circuit design and one of these changes is the use of a parallel resonant circuit in one of the filter sections as in figure 16. The basic structure of this system is similar to that used in the conventional arrangement, but the change is found in the use of the resonanting capacity C, connected across the filter choke L. This circuit is tuned to the major hum frequency and reduces the intensity of this hum to a degree greater than that possible with the other arrangement. By properly selecting the choke L and the capacity it is possible to greatly minimize the fundamental hum frequency in the eliminator rectifier output. If this condenser is open the hum increases.

We have shown the resonating capacity across one of the filter chokes. All receivers are not wired in this fashion. Some utilize the speaker field winding as the inductance L. Thus in figure 16 L would be the speaker field and the other winding would be the regular filter choke. A condenser across a speaker field winding when used should not always be classed as an ordinary bypass. It serves a definite function and must be considered when analyzing the circuit. In this connection, we must mention that this capacity is not always connected directly across the field winding, instead it may be connected across the female plug terminals which make contact with the field winding when the male plug is inserted. The position of this condenser in connection with the speaker field, when it is used, can be better comprehended by imagining such a capacity connected across the two contacts marked "field" in figure 17.

TAPPED INDUCTOR.—Another prominent change in some eliminator filter systems is found in the use of a tapped choke arrangement shown in figure 18. Contrast this filter which employs five condensers and the equivalent of four chokes with the conventional arrangement. As is evident each choke is tapped and both sections are wound upon the same core. The action of the choke can be described in simple fashion to be as follows. First is the fact that only the large portions of these chokes carry direct current. The small portion of each choke carries A.C. only. The flow of alternating current through this portion of the winding and through the associated capacities C and C1 induces a voltage (A.C.) in the large portion of each winding which is of such phase (instantaneous direction) that it greatly reduces the A.C. voltage across the output of each filter stage. It is another means of securing greater freedom from hum.

DISTRIBUTION OF D.C. VOLTAGES.—An examination of the conventional filter and voltage divider systems shown in figures 15, 15D and 15E discloses that the points at which the output voltages are distributed are definitely located in one section of the power pack. The voltage divider performs the function of distributing the output voltage according to the specific requirements and as is obvious, its position in the circuit is definitely limited to one point. It constitutes the output end of the conventional complete power pack.

Modern receiver and eliminator design has changed matters in many cases. Not that the conventional form of structure is no longer used, because many receiving systems employ such arrangements, but rather that many receiver systems use filter-voltage divider arrangements of somewhat unconventional character.

Figure 19 illustrates one such system, wherein the respective plate circuits are isolated, three filter sections are used, one of which is the speaker field, another is tuned, and the complete voltage divider arrangement is not at the tail end of the eliminator and an unconventional means of securing bias is utilized. An examination of the circuit shows, first, a conventional two section filter, L1 the first tuned by means of capacity C. The speaker field winding, is the second choke. The plate voltage for the output tubes is secured at the midpoint junction of L and the speaker field. The plate voltage for the detector is secured by means of the resistance R. Another choke L2 junctions at the connection between the detector plate voltage reducing resistance and the high voltage lead, and functions both as a voltage reducing resistance and in connection with the capacity C5 as another filter section. The drop across L1, the field and L2 reduces the voltage so that it is applicable to the radio frequency and first audio frequency plates. The resistance R1 is the bleeder resistance with one junction at B plus and another junction as B minus, which in this system is not grounded. The resistance R2 connects between the ungrounded B minus and the grounded negative, completing the circuit for the bias voltages of the 226 tubes. The ungrounded B— is the B negative for the 226 and the 227 tubes in the receiver. The resistance R3 connecting between the grounded C— and the ungrounded C— supplies the grid bias for the output tubes. At first glance one would wonder how it is possible to supply the grid bias for the 226 tubes when the B— is ungrounded. The electrical circuit is shown in dotted lines. The B— is connected to the center tap of the 226 tube filament winding. The plate current must flow through R2 in order to return to the negative side of the eliminator. With the grid grounded, the potential developed across the resistance R2 is applied to the tube grid. The same condition prevails in the case of the output tubes which secure their bias from R3. While the voltage divider circuit R1, R2 and R3 appears complicated, it is to a very large extent, the duplicate of the conventional old type system shown in figure 15D. The filter system on the other hand is of unconventional character. A thorough examination of the divider circuit will explain that what appears to be a positive bias being applied to the amplifying tubes actually is a negative bias.

Another example of a peculiar filter and divider system is shown in figure 20. The choke L and the condenser C, C1, and C8 with the accompanying figures designating the capacity, constitute a single filter section with a parallel resonant circuit. This is quite ordinary. The voltage for the detector tube is secured from the junction of L and L1 via the fixed resistance R and the choke L2, both of which are influential in the reduction of the voltage to the value required for the tube and in the isolation of the detector tube plate current. The choke L2 operating in conjunction with C2 helps filter the detector plate supply. The voltage through field coil L1, after reduction because of its D.C. resistance is then applied to the plates of the radio frequency tubes through two additional

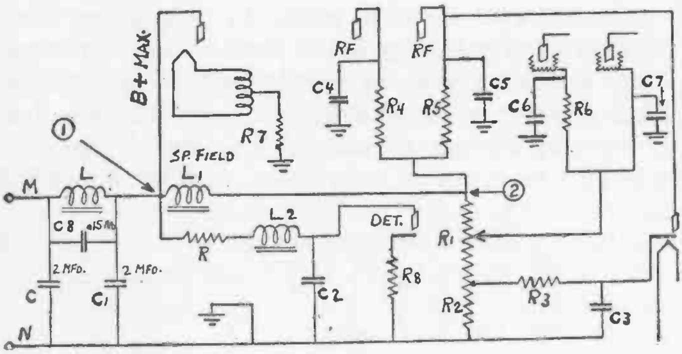


Fig. 20

voltage reducing resistances R4 and R5. The screen grid voltage is secured by means of a potentiometer type of resistance R1 connected across the output of the eliminator. Operating in conjunction with this resistance is another R6 located in one of the screen grid circuits. The other screen grid receives the voltage secured from the potentiometer. The control grid voltage is secured by means of the cathode resistances, R2 and R3. Contrast this method of dividing the eliminator output voltage with either of the conventional arrangements. An examination of the circuit shows different current paths for the various classifications of tubes in the system. L is the only choke that carries current common to more than one circuit. The output tube plate current goes out at terminal 1 and returns to the negative eliminator return through the finalment center tap resistance R7 to ground. The R.F. tube plate current leaves at point 2 and returns through the cathode and resistances R3 and R2. The detector tube plate current leaves through R and L3 and returns through the detector cathode resistance R8 to ground.

Still another variation of filter circuit structure is shown in figure 21. Here three sections are found in the filter. Two of these sections employ regular filter chokes and the third is the speaker field winding. It may be said that this winding also serves as a voltage reducing resistance. The distribution of voltages are much simpler, the arrangement being the equivalent of a combination of the two conventional systems. The plate voltage for the output tube is taken off after the first choke L. The other two chokes carry all of the current flowing in the plate circuits of the remaining tubes. The resistance R is the bleeder unit. The total output of the eliminator is secured from the point X and the maximum voltage after the drop through L1 and L2 is applied to two of the R.F. tube plates and the first A.F. tube plate. The other two R.F. tube

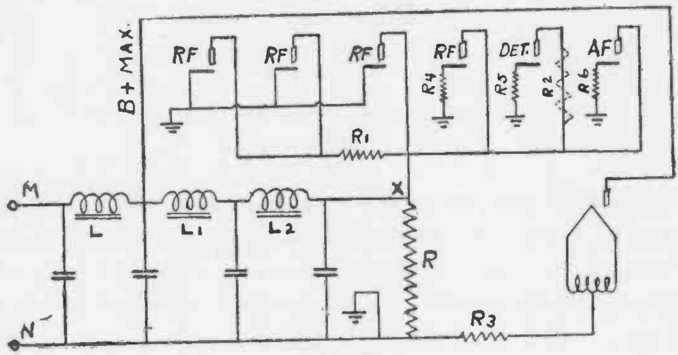


Fig. 21

plates receive a lower voltage because of the drop through the series resistance R1. The voltage for the detector tube is likewise secured from the point X and is applied to the tube plate through the plate coupling resistance R2. The bias for the output tube is secured through the filament center tap resistance R3 which returns to ground and carries the plate current of the output tubes. The bias for the R.F. tubes is common through a variable cathode resistance which returns to ground. The same applies individually to the detector tube and to the first audio tube.

The use of the three section filter evokes no other comment than that one must remember that all receiver power packs are not limited to two section filters. The simplicity of the voltage divider arrangement is self evident. This is an example of the possibility of simple voltage divider networks and evidence of the fact that one cannot be too certain of any one arrangement. Contrast the major plate supply lead in this system with the isolated arrangements in the previously discussed power supply devices.

Another installation that employs a three section filter, wherein the speaker field is one section and at the same time reduces the voltage is shown in figure 22. This diagram happens to be that of one of the latest models. The simplicity of the structure is self evident. In contrast to that shown in figure 21 the first or input condenser is omitted. Here is evidence that one should not assume that the general structure of filters relative to the number of filter

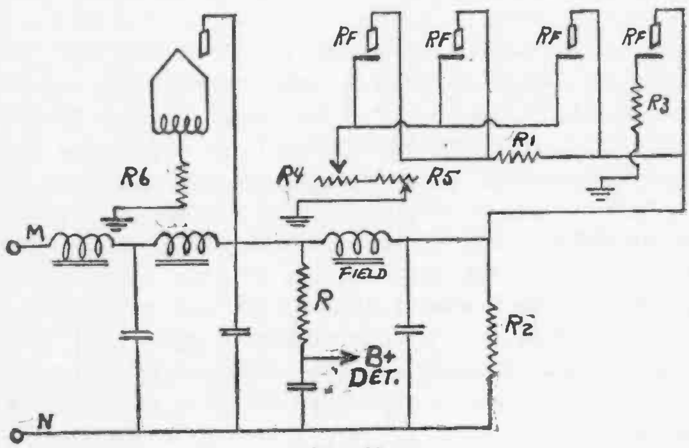


Fig. 22

capacities is at all times uniform. The voltage divider network approaches the conventional parallel resistance arrangement shown in figure 15E, and because of the resistance R resembles the arrangement shown in figure 20. The output tube plate voltages are secured by means of a tap at the output side of the first two filter chokes. The total output, after reduction by the three filter chokes, is applied to the plates of two R.F. tubes and the other two R.F. tubes receive a lower value of voltage because of the series resistance R1. The resistance R2 is the bleeder unit across the eliminator.

Several other forms can be cited. One wherein the filter consists of two sections and one choke is in the positive lead and the other choke, the speaker field is in the negative lead. Still another is a tapped choke constituting a single section filter with the output tube plate voltage secured from the tap.

Very little need be said about peculiarities in A.C. type B eliminator or power pack filter circuits. Having covered the respective tuned systems, the remainder are more closely allied with economical construction than special design. If we are to summarize we can make but few statements. A study of these arrangements will acquaint the individual with the filter structures in use today.

VOLTAGE DIVIDERS.—The three systems shown in connection with the filters in figures 19, 20 and 21 are only a few of the many in use today. A cursory glance is sufficient to show that a study of voltage dividers as they are used today cannot help but provide information required for circuit analysis and trouble diagnosis. The simple dividers have been superseded by more complex arrangements. Modern receiver design makes use of many more voltage reducing resistances than the old systems. Plate circuits are linked with grid and control bias circuits. The need for greater stability requires isolation of plate and grid circuits; the use of individual instead of common bias resistances. This does not mean that new voltage divider systems bear no resemblance to the old. They do, yet are different in many respects. Many confusing situations arise when checking for defective parts because many resistances in these systems carry currents other than those utilized in connection with the associated part of the circuit. In days of old the grid bias resistance located in the cathode circuit carried nothing but the associated tube plate current. In the modern set, the grid bias resistance carries the tube plate current and additional bleeder current. Thus the voltage developed is not the product of the grid bias resistance and the tube plate current, but also the current fed to the bias resistance through the bleeder unit.

One such arrangement is shown in figure 23. The filter circuit is conventional and warrants no discussion. A resistance R functions as the bleeder across the eliminator output. Another resistance R1 of the potentiometer type is shunted across a section of the main bleeder unit and provides the screen grid voltage. The maximum voltage is then distributed to the detector, audio frequency tubes (exclusive of the output tubes) and the radio fre-

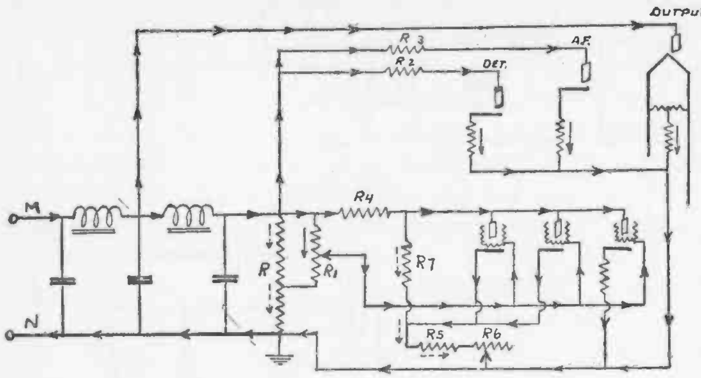


Fig. 23

quency amplifiers by a series of individual voltage reducing resistances, R2, R3 and R4. The bias for the radio frequency tubes is secured by means of a fixed resistance R5 in series with a variable resistance R6 common to two of the cathodes and returned to ground. The current flow through these resistances is the plate current of the first two radio frequency stages plus the bleeder current through the resistance R7 which connects between the common radio frequency plate voltage lead and the first two cathodes. The grid bias for the third stage is secured by means of a single resistance in the cathode circuit of that tube. The use of two resistances, a fixed and a variable in the grid bias circuit provides a fixed minimum and a variable maximum grid bias. If we rearrange the units so as to conform with the usual method of showing voltage divider circuits the system would appear as in figure 24. The plate current paths are shown in connection with the respective bias resistances for all tubes. The use of the arrows to indicate direction of current flow is based upon the usual conception of normal current flow in vacuum tube circuits.

A novel system is shown in figure 25. The field winding L is used as a choke but so located that the voltage developed across

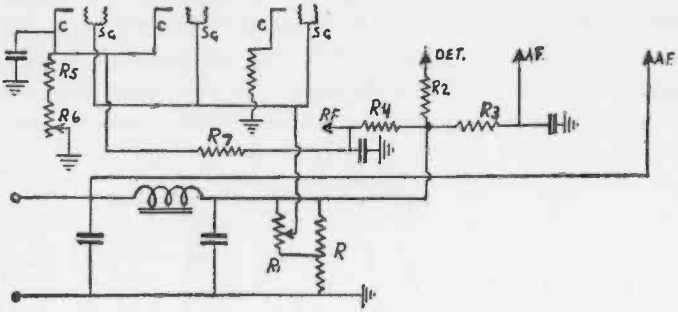


Fig. 24

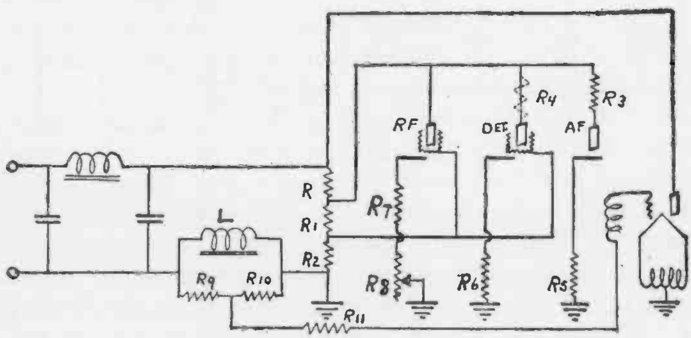


Fig. 25

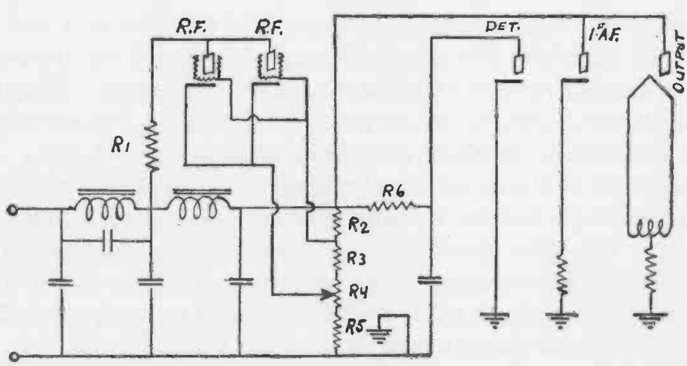


Fig. 26

it is negative with respect to the B— terminal and a portion of it is applied as the grid bias for the output tubes. A divider consisting of three resistances R, R1 and R2 is connected across the eliminator filter output. The maximum voltage is applied to the plates of the output tubes. The maximum voltage less the voltage dropped across R is applied to the radio frequency tubes and through a resistance R3 to the first audio tube plate and through the plate coupling resistance R4 to the detector tube. The screen grid voltage for the radio frequency and detector tubes is common and secured from the eliminator at the junction between R1 and R2. The latter resistance, R2 is the bleeder unit. The grid bias for the first audio frequency tube is secured from a cathode resistance R5 returned to ground. The same system is used for the detector bias through the resistor R6. The bias for the radio frequency tubes is common and secured by means of a series system of a fixed and variable resistance, returned to ground whereby the minimum bias is fixed and the maximum is variable. These units are R7 and R8. So far the circuit is conventional. The interesting portion is the grid bias for the output tubes. The speaker field coil is located in the negative return of the eliminator so that the voltage developed across it is negative with respect to the ground. A divider consisting of two fixed resistances R9 and R10 is connected across the field coil and by proper apportionment of the tap upon this divider, the correct voltage is fed to the grid of the audio tube, the grid return connecting to this tap through the filter resistance R11. The isolating filter resistance R11 does not influence the bias voltage but serves to isolate the tube grid circuit.

Another variation is shown in figure 26. Here the plate voltage for the radio frequency tubes is taken off at the output of the first filter choke, the usual position for the output tube plate voltage. R1 is the voltage reducing resistance. A four section voltage divider R2, R3, R4 and R5 is connected across the eliminator output and serves to supply the voltage for the radio frequency screen grid and to allow the flow of current through the radio frequency grid bias resistances, so that the total bias current is that of the radio frequency tubes and the bleeder current through R3, R4 and R5. The eliminator output after reduction by the resistance R6 is fed to the detector plate. The output tube plates and the first audio tube receive the same plate voltage. The return circuit for the first audio tube is a resistance in the cathode circuit and for the output tubes, it is a resistance between the filament center tap and ground.

Figure 27A is another example of a bleeder resistance coupled circuit. The current flowing towards the first audio tube is divided between the plate of the tube and the grid bias resistance in the cathode circuit. This is accomplished by the use of a bleeder resistance R3 located between the first audio tube plate voltage lead and the cathode so that the current through R3 flows through the grid bias resistance R4 and the sum of the tube plate current and the current through R3 produces the drop across R4. The voltage for two of the screen grid tubes is secured through a voltage reducing resistance R5 connected in series with two other resistances R6 and R8 across the eliminator and functions as the divider. A tap at R5 supplies the screen grid voltage for the detector and the second radio stage. A variable control makes available a variable voltage from R6 which is applied to the screen grid of the first radio tube through a series resistance R7. This resistance serves to limit the maximum voltage. The bias for the two radio frequency tubes is secured across the resistance R8 connected to ground, but the current which produces this is not only the plate current of the two radio frequency tubes but also the bleeder current through R5 and R6. Figure 27B illustrates the system shown in figure 27A, with a rearrangement of the parts so that the complete circuit is arranged in the conventional manner. There should be no difficulty in correlating the resistors shown in both schematics.

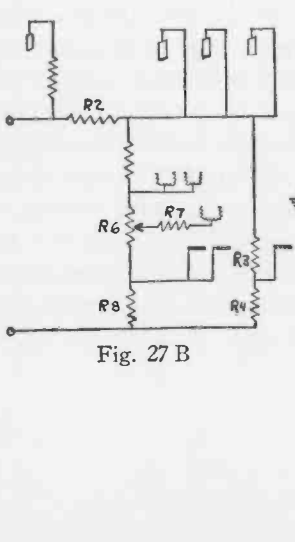


Fig. 27 B

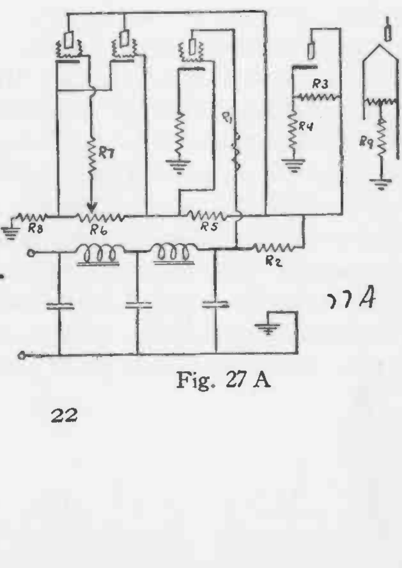


Fig. 27 A

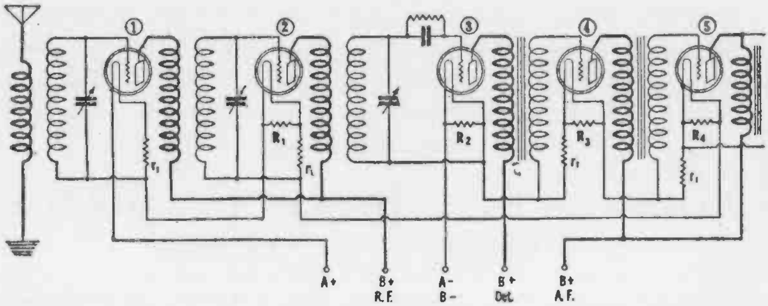
CHAPTER 3

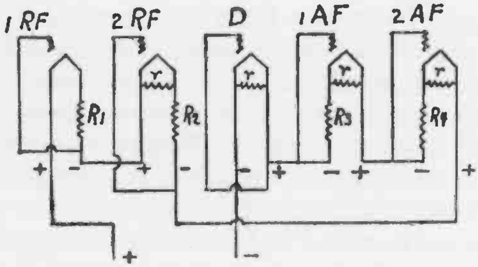
VOLTAGE DISTRIBUTION IN DIRECT CURRENT SYSTEMS

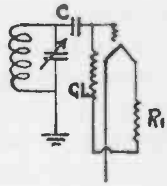
While it is true that a great number of variations in direct current filament receivers is possible, there exists a very definite similarity between all such systems. With this in mind we illustrate a few representative commercial direct current radio receivers. An examination of these systems and comparison of the method of distributing the operating voltages should acquaint the reader with the general mode of design. Mastery of Ohm's law as it is applied to series and parallel circuits is the greatest asset to comprehension of the direct current radio receivers.

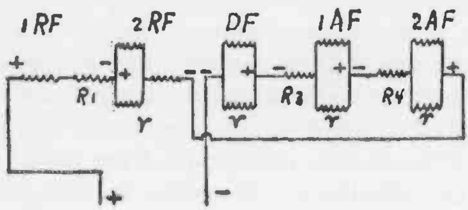
It might be well to mention that batteries still find application in direct current receivers. It is not a strange thing to locate several small batteries employed to furnish the grid bias for the audio frequency tubes. The exact number of stages supplied by one battery is a matter of individual design. The important item is to remember that the presence of batteries is a possibility.

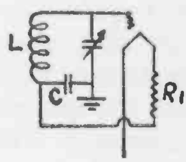
SERIES FILAMENT WIRING.—As far as the testing and the application of the B potentials is concerned the direct current receiver presents no complications. Extended investigation discloses that the puzzling item associated with direct current series filament receivers is the grid bias. As to the filaments one can comprehend without much difficulty any series or series-parallel combination of filaments, since these filaments are nothing more than individual resistances. Perhaps a few words about the electrical circuit of a simple system shall not be amiss. Take as an example the circuit shown in figure 28. It is a simple two stage radio frequency receiver, non-regenerative detector and two stages of audio. If we break up the system and isolate the filament circuit it appears as in figure 29. If we represent each filament as a resistance and include the other resistances the circuit appears as in figure 30.











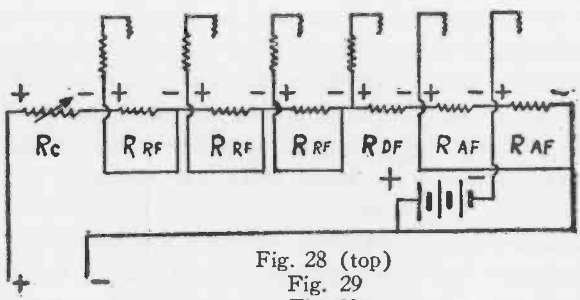


Fig. 28 (top)
Fig. 29
Fig. 30
Fig. 33 (bottom)

Fig. 32
Fig. 31

Referring to figure 29, the bias for the first radio frequency tube is secured by making the grid negative with respect to the filament by the voltage drop developed across R1. This drop is equal to the value of R1 times the filament current. The same is true in the second radio frequency stage, except that the voltage drop is that developed across R2. The grid of the detector is connected to the positive leg of the filament and the potential applied to the grid is therefore of positive polarity. In the case of the audio systems, the voltage applied to the grid of the first audio stage is that developed across R3. In the output stage the polarity is that developed across the resistance R4. It is significant to note the method of wiring necessary to produce the proper polarity of the drop developed across the respective resistances. If we now refer to the electrical circuit in figure 30, we note that the filament is a resistance and therefore produces a drop, the polarity being determined by the point of junction between the filament and the associated grid. This becomes evident when we consider that 1RF in figure 30 is the filament of the first stage radio frequency tube and at the same time is one of the resistances in the series system.

The system shown in figure 29 is quite common in commercial series filament direct current receivers and the bias is that voltage developed across the respective resistances. Assuming correct continuity in the respective grid circuits, the measurement of the grid voltage would necessitate contact between the grid and the filament. It is quite obvious that such connection is not possible when all of the tuning condenser rotors terminate in a common connection, unless some definite precautionary measure is instituted to protect against a short circuit. Two such methods are possible. The first is the use of a blocking condenser in the respective tuned circuits. This form of wiring is shown in figure 31. The bias is applied through the tuning inductance L. The tuning condenser rotor is grounded, but the short circuiting of the filament is precluded by the presence of the blocking condenser C, which unit isolates the grounded rotor from the filaments.

An alternative form of connection is shown in figure 32. The blocking capacity in this instance is located external of the tuning circuit and the bias is applied to the grid through a grid leak of about 2-5 megohms. The blocking capacity C allows the application of the radio frequency voltage to the grid of the tube.

An example of the application of the drop across the filament as a bias is shown in figure 33. Where R_c is the control resistance, R_{rf} are the resistances representative of the filaments of the radio frequency amplifier tubes, R_{df} is the resistance of the detector filament and R_{af} are the resistances representing the audio frequency tube filaments. The grids of the radio frequency amplifiers are returned to the negative ends of the filament through resistances which would be the equivalent of the grid leak GL shown in figure 32. We show it in this fashion because such a tuning system is applicable. The detector tube grid returns to the positive end of the detector filament through the grid leak. These resistances have no bearing upon the actual bias applied to the tube but do manifest a great effect upon the measurement of the bias. With such high values of resistance in the circuit, the voltage measured with an ordinary meter, between the grid and the filament will be very low, in fact negligible. Hence when measuring grid bias in such systems, it is necessary to take into account the presence of the resistance GL or to set a standard of what may be classed as a satisfactory reading. Continuing with the schematic illustrated in figure 33, the first audio frequency tube is NOT returned to the negative side of the associated filament. Instead it is returned to the negative end of the second audio tube filament. The bias applied in this fashion is equal to the sum of the voltage drops across the filaments of the first and second audio frequency tubes. The bias for the second audio stage is secured by means of a biasing battery.

The aforementioned reference to the grid return connection for the first audio stage should not be taken as applicable in absolutely every case, as is evidenced by figure 29. The mention made pertains to figure 33, although it is quite common practice.

It is possible to consider other forms of series filament wiring and circuit connection but we believe that the discussion carried on so far should be sufficient to acquaint the reader with series filament circuits. The difference between the systems shown and the systems employed in commercial receivers involve but few variations.

DISTRIBUTION OF VOLTAGES IN SERIES FILAMENT DIRECT CURRENT RECEIVERS.—A commercial example of the system illustrated in figure 33 is shown in figure 34. The

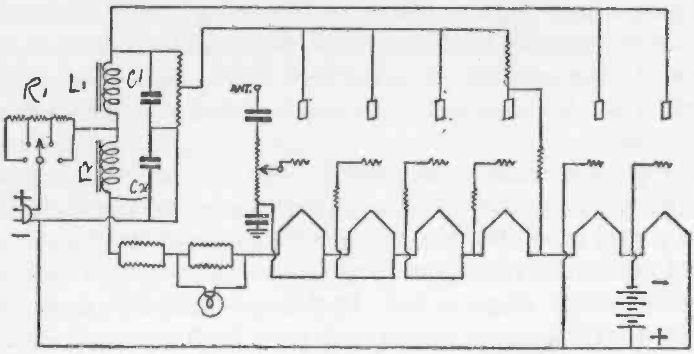


Fig. 34

chokes L1 and L2 offer two paths for the current. L1 in connection with C1 filters the plate current. L2 and C2 filter the filament current. The tapped resistance R1 controls the line voltage input. The two pairs of paralleled resistances in the plus filament circuit limit the filament current. The resistance divider connected across L1 and the negative input lead distributes the plate voltage. The radio frequency and detector bias voltages are secured by means of the voltages drops across the respective filaments. The first audio stage employs the drop across two filaments and the second tube secures its bias from the C battery.

Another commercial example of series filament wiring and B voltage distribution in a direct current receiver is shown in figure 35. Once again the major current is divided into two paths, in fact into four paths. In view of the push-pull first and output audio stages, there is no need for filtering and the input is applied to the plates without any filtering. One choke passes the plate current for the radio frequency and audio frequency tubes and the other passes the filament current. An examination of this schematic shows a combination of series and series-parallel filament wiring. The three radio frequency, detector and first two audio tube filaments are in series. Four tubes are used in the output stage. These filaments are wires in series parallel, two in each series combination and the two series arrangements then paralleled. The complete series-parallel system is connected in series with the remainder of the tubes. The drop across the filaments furnishes the bias for the three radio frequency, detector and first stage audio frequency tubes. As is evident one of the first stage push-pull tubes requires the bias of both filaments and the other secures the bias from a resistance in the negative leg. As to the output tubes, connected in parallel-push-pull, the required bias voltages are secured from batteries.

The correct filament voltage for the output stage tubes is secured by means of the two resistances shown in the series-parallel system. As is evident in the wiring diagram, the plate voltage applied to the output stage tubes is not greater than that applied to the first audio stage tubes. In this connection it might be well to state that one need not expect very high plate voltages, even when the type of tube employed in the audio stages is one which normally employs a fairly high value of plate voltage. It is quite common to employ as low as 70-75 volts upon the plates of a number of 371 tubes in the output stage. In the majority of cases these tubes are connected in parallel push-pull, and are about four in number.

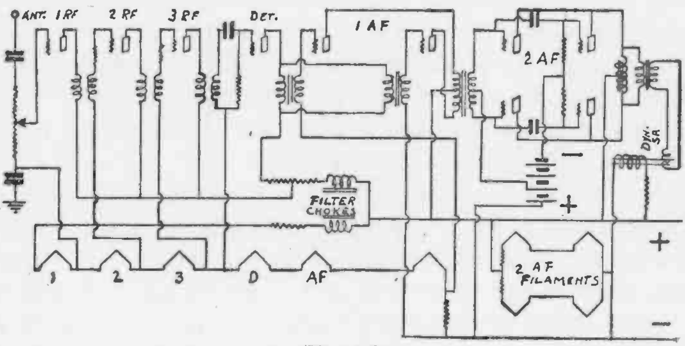


Fig. 35

The schematic illustrated in figure 35 is interesting because of two other peculiarities in the circuit. Perhaps we should say unconventional wiring rather than peculiarities. Examine the first audio stage. The plates are connected in push-pull fashion, whereas the grids are fed by individual transformer windings with the primaries connected in parallel. An unconventional arrangement is employed in the second audio stage. Each half of the push-pull stage employs two tubes with the grids connected as illustrated. One grid in each leg is connected to its associated grid in the same branch through a 2 mfd. condenser. Two bias systems are used, one circuit for each pair of grids in the two branches. The field coil of the dynamic speaker secures its excitation current from the line, being connected across the lines with a series current controlling resistance.

SERIES FILAMENT RECEIVERS WITH A.C. CATHODE TYPE TUBES.—One would imagine that a series filament, direct current receiver would employ the conventional filament type of tube. Figure 36 illustrates a commercial system, wherein the tubes are of the cathode type, the heaters being wired in series and the entire system is planned for direct current operation. With the exception of the series wiring of the heaters, the remainder resembles the normal A.C. system.

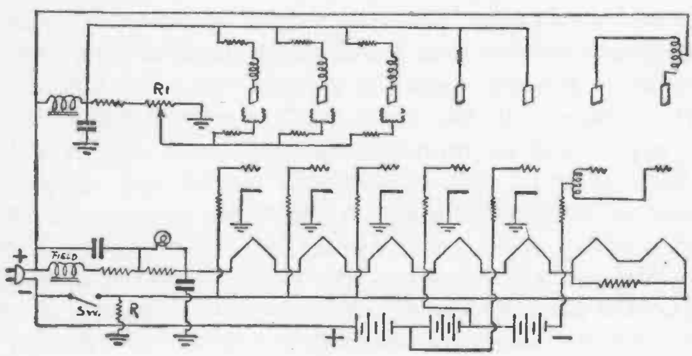


Fig. 36

The grid bias voltages for the detector and two audio stages are secured from batteries. An interesting item is the method of securing the grid bias for the radio frequency amplifiers. As is shown the cathodes are grounded. The divider connected across the plate supply is also grounded. A resistance R is shown connected between the ground and the negative line lead. Thus the plate current of the radio frequency tubes flows through the resistance R in order to reach the negative line and thus complete the whole path. At the same time some bleeder current flows through R. The total current flowing through R produces a drop which is employed as the bias for the radio frequency tube grids. While it is true that the cathodes of the detector and the first audio tubes also terminate at ground, the bias is supplied by the batteries. The volume control is the potentiometer type of resistance R1, whereby it is possible to vary the screen grid voltage. The unfiltered line voltage is applied to the plates of the push-pull output tubes.

THE SHUNT RESISTANCE IN SERIES FILAMENT RECEIVERS.—Thus far we have omitted the resistance employed across some filaments. It functions as a protective resistance so as to overcome the effect of the plate current flow through the filament. Assuming that a voltage is applied to the plate of the output tube in figure 28, and the minus end of this plate voltage source is connected to the negative end of the filament voltage source, the plate current in the output stage must flow through the filament of the output tube and also the filaments of the detector and the first audio tube. Thus the actual current flowing through these filaments is more than the filament current. Just how much more depends entirely upon the system, the tubes and the plate and grid voltages. In the event that the normal filament current is high, say 1.5 and 1.75 amperes, the addition of the plate current, of perhaps 50 or 60 milliamperes will not be very great, but in the event of the low filament current tubes such as the 299 and the 301A, where the normal current is 60 and 250 milliamperes respectively, the additional current of 20, 30 or 50 milliamperes endangers the life of the tube. The protective resistance is inserted in order to carry this excess current or expressed in another manner, the value and function of this resistance is to so apportion the current through the filament that it does not exceed its normal figure. An approximation for the value of this unit when intended for use in this fashion is the application of Ohm's law for resistance wherein E is the normal filament voltage and I is the excess current through the filament. Such resistances are quite popular when the 60 mil tube is used, although they find application with the ordinary type of tube as well.

At the same time, where possible, the use of a shunt resistance enables sufficient increase in total current through the filament circuit to produce the required bias across the bias resistance without recourse to a very high value of resistance.

CHAPTER 4

THE AUTOMATIC VOLUME CONTROL

RECENT advertisements have played up various methods of automatic volume control. Mention has been made of two element detection with linear properties and simultaneous automatic volume control. Still different advertising mentions automatic volume control as a feature without reference to any one particular arrangement.

Perhaps the term "two element" is confusing. It means just what it says although it might be difficult to reconcile the old inefficient two element detector with modern times. Apparently an obsolete device has been resurrected. Such is actually the case, except that modern ingenuity has converted that inefficient device into one which enables performance not even imagined when the two element tube was in its heyday. It should be understood, however, that any reference to automatic volume control does not always mean the two element tube.

As to the two element tube itself, we realize that such tubes are available only as rectifiers in the form of the 280 and 281. Reference to the two element tube as an automatic volume control tube usually means the normal three element tube connected and utilized as a two element tube. Such a change consists of linking (externally) the plate and grid elements or of changing the plate circuit return. How this is done will be shown later in this text.

THE TWO ELEMENT DETECTOR.—We made the statement that the conventional three element tube is employed as a combination two element detector and automatic volume control system. In view of the fact that systems which employ such arrangements are quite numerous and yet not exactly alike, generalization only is possible. However, this data is sufficiently similar to the actual systems to enable correct conception of the action taking place during operation.

One of the paramount virtues of the two element detector is its linear response. By linear response is meant a certain relation between the input and the output signal voltages applied to the tube. To be linear the output voltage must be proportional to the input voltage. Thus an input signal of twice normal magnitude will provide an output signal equal to twice the normal magnitude. This is in contrast to the phenomenon encountered with the square law detector wherein a twofold increase in signal input multiplies the output fourfold.

At the same time we must give credit where credit is due. The two element tube acting as it does, does not amplify, whereas the three element tube used as a square law detector, also amplifies. This, however, introduces no difficulty, since the normal amplification available with the present receiver is sufficient to overcome this deficit in amplification. As a matter of fact another amplifying tube is usually used in connection with the two element detector. At first glance one would imagine that the need for another amplifying tube is an unnecessary expenditure, but upon second thought, the use of the amplifying detector makes necessary another tube to provide the automatic control. Thus six of one and a half-dozen of the other. At this stage one would ask, why change? The reason is found in the fact that the two element tube will handle more input than its three element relative. As to the use of a tuning meter, both systems can use one to advantage. Whereas the three element tube can be used with tuned input systems, the two element tube cannot be used with a tuned input system because it increases the resistance of the tuned circuit with the consequent bad effects. Hence, the input must be of the untuned transformer coupled type, or impedance or resistance. Figure 37 shows this tube operated in conjunction with an untuned transformer. The grid and plate of the 227 tube used as combination two element detector and volume control are joined. If the secondary of the untuned transformer supplies the signal voltage, the complete detector tube circuit resembles an ordinary rectifying system in an eliminator. The resistances R and R1 constitute the load upon the detector tube and can be classified as the voltage divider system. The ordinary eliminator filter is excluded.

Referring to the diagram, a signal voltage causes current to flow through R and R1 producing a voltage drop. This current is due to the presence of the signal upon the combined grid and plate, both elements functioning as a common anode. During the positive

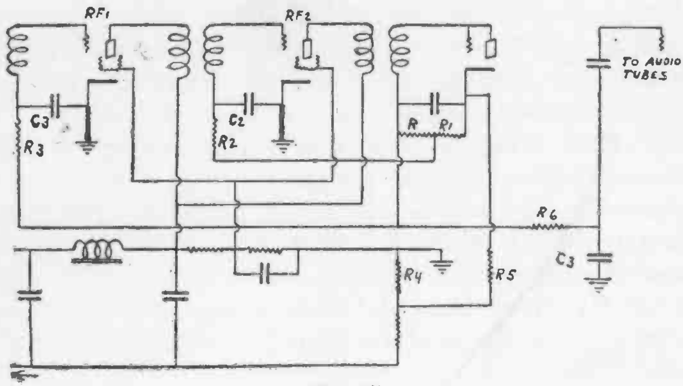


Fig. 37

half of the cycle, current flows between the cathode and anode and as in the normal rectifying system, this current is present in the load. The drop across R1 is then applied to the grid of the tube marked R.F. 2, and the total drop across R and R1 is applied to the grid of the tube marked R.F.1. The grid resistance R2 and R3 are ordinary isolating resistances operating in conjunction with the capacities C2 and C3. At this point one becomes interested in the normal bias without any signal input into the detector-rectifier. This bias is secured from the eliminator voltage divider, across resistance R4, connected between the grounded point upon the divider and the return to the rectifier. Examine the circuit shown in figure 37. You will note that the cathodes of R.F. tubes 1 and 2 return to ground. The path of the plate current according to normal acceptance, is through the cathode to ground and then through the resistance R4. The drop across R4 is then applied through the isolating resistance R5 through R and R1, to R.F. tube 1 through R3 and R.F. tube 2 through R2. The A.F. signal is passed to the audio amplifier through R6. This resistance serves to keep R.F. currents out of the A.F. system. This work is aided by the .0001 bypass condenser C3. Such is the action of the two element detector.

AUDIO FREQUENCY AUTOMATIC VOLUME CONTROL.—Of equal interest are the other forms of automatic volume control. One such system employing a separate tube operates upon the audio frequency signal as applied across the loud speaker. Its control is that of the R.F. plate voltage. The system is that originated by Williamson of Carnegie Institute of Technology. The circuit is simple in operation and the control tube is actually a vacuum tube voltmeter. The circuit is shown in figure 38. An examination of the circuit discloses that the plate voltage for the output tube, the control tube and the radio frequency amplifiers is secured from the same source. However, the plate voltage for the radio frequency and the control tube is less than that applied to the power tube as determined by the control resistance R. The plate voltage for the radio frequency tubes is applied via the choke L located in the plate circuit of the control tube. Any variation of R,

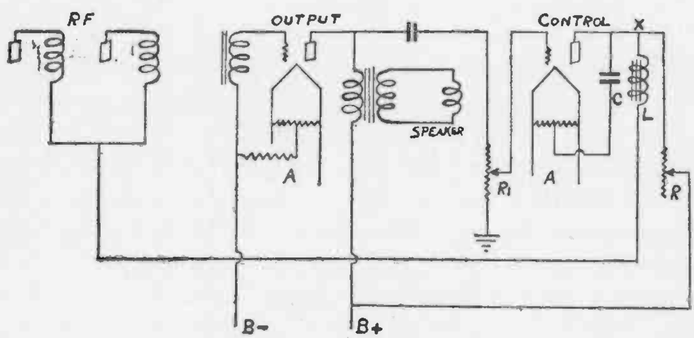


Fig. 38

will naturally change the voltage applied to the control tube and the radio frequency amplifiers. If for some reason the current through R is changed and the voltage drop across that resistance is increased, the voltage effective at point X will be less than prior to the increase in current. Now, if a signal voltage is applied across the output tube primary, this voltage is applied across the grid and filament circuit of the control tube, since both filaments are common. This voltage causes an increase in current in the plate circuit of the control tube and reduces the voltage at the point X. This condition results in a reduction of the voltage applied through L to the plates of the radio frequency tubes. Since a reduction in plate voltage increases the plate resistance, such reduction decreases the amplification available with the tube because it decreases the mutual conductance of the tube or tubes as the case may be.

The output tube and the control tube are of like character, but by adjustment of R1 it is possible to arrange the characteristic

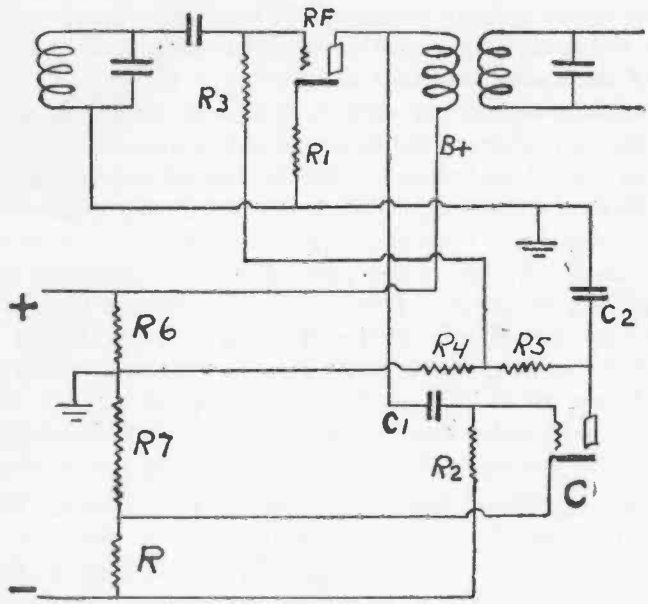


Fig. 39

so that the plate current will increase when a signal is applied to the grid. The adjustment of R1 enables the setting of the control tube for whatever volume is desired. The circuit shows the control tube connected across the output transformer primary. Such wiring is not imperative. It is possible to connect the control tube across the speaker terminals, in which case a separate C battery is required for the control tube with correct connection of the volume control resistance so that the bias may be applied to control tube.

It might be well to make a few additional remarks relative to the R.F. plate voltage reducing action in the control tube plate circuit. According to the diagram, the choke L is in series with the plates of the R.F. tubes and the source of voltage. The same may be said of the resistance R1. Hence, any reduction of voltage by an increased drop across R1 will reduce the voltage effective through L.

R.F. CARRIER VOLTAGE CONTROL CIRCUIT.—Another form of control circuit operates by virtue of the action of the R.F. carrier voltage. Such an arrangement affords a distinct advantage over the audio signal control because it is independent of the intensity of the audio frequencies.

The wiring diagram of such a system is shown in figure 39. This is not as simple as the arrangement shown in figure 38, but close examination will clarify points which do not appear clear in the description. Once again the control tube is a vacuum tube voltmeter, that is, it operates in like manner. The tube marked R.F. in the illustration is the radio frequency amplifier and the tube marked C is the control tube. The resistance R6, R7 and R constitute the eliminator voltage divider. One peculiarity in this system is the arrangement of the ground potentials and the relations between potentials secured from various points along a divider. A resistance after all is nothing but a certain type of conductor and polarity relation exists as much in a resistance as in an ordinary conductor generally classed as connecting wire.

The output of the eliminator is supplied to the plate of the radio frequency amplifier. One such tube is enough to illustrate the action and simplifies the complete circuit because it minimizes the number of connections. This R.F. tube secures one bias by means of the resistance R1 in its cathode circuit connected between the cathode and the ground in the system. Inspection of the eliminator divider system shows a ground at the junction between R6 and R7. Apparently the usual system of grounding the most negative terminal is not used. Since one end of R6 connects the plate of the R.F. tube and the other end returns to ground in the eliminator and to the grounded end of the cathode of R.F., that point is negative with respect to the "high" end of R6.

Now, a point may be negative and positive at the same time. The item of control is the relative point. Thus the junction point between R6 and R7 is negative with respect to another point along R6, yet is positive with respect to any other point along R7. This means that if the junction point between R6 and R7 is ground, ground in this case is at a higher potential than any other point along R7. Now the plate of the control tube C connects to the ground as shown through two resistances R4 and R5. The cathode of control tube C connects to the junction between R7 and R and the bias developed across R is applied to the grid of the control tube through the resistance R2. This circuit is somewhat out of the ordinary. The cathode of the control tube is, because of the connection used, negative with respect to ground. But with the plate of tube C connected to ground this plate is at a higher potential than its cathode and is positive with respect to the cathode of tube C. At the same time it is negative with respect to the cathode of tube R.F.

When a signal is applied to the grid of the radio frequency tube, the radio frequency voltage developed in the plate circuit of that tube is applied to the grid of the control tube C through the condenser C1. This swings the grid of the control tube and current flows in the plate circuit of that tube through the resistance R4 and R5. All audio frequency current is bypassed to ground through the bypass capacity C2 connected between the plate of the control tube and ground, whereas the D.C. current produces a voltage drop across R4 and R5. The direction of the voltage across both resistances of across one resistance is such that it may be applied to the grid of the radio frequency amplifier tube and it will be additive to the normal bias secured via R1. We show a connection from the junction point between R4 and R5 to the grid of the radio frequency tube through the isolating resistance R3. Hence the bias developed across R5 is added to the normal bias across R1.

The bias provided for tube C is of such value that a predetermined signal voltage is required to swing the grid and cause the flow of plate current in the control tube plate circuit, increase the bias applied to the radio frequency tubes thereby reducing the volume output of the receiver.

If so desired, the voltage drop across the resistance R4 and R5 can be distributed to more than one tube and in any proportion depending upon the positions of the taps and the resistance values between taps.

TUNING CONSIDERATIONS.—The application of the automatic volume to the radio receiver introduces a difficulty in tuning unless special measures are taken to enable satisfactory resonance adjustment. Why such a condition should exist becomes quite evident upon analysis of the action of the volume control system. Normally, that is without a volume control arrangement one adjusts for maximum response by noting the adjustment which provides maximum signal output. Such adjustment is not possible with a volume control system because the purpose of the device is to limit the signal output at some level which is not the maximum, thereby providing a certain degree of uniformity with various values of signal input. In other words the volume control circuit is actuated with an input signal voltage of less than the permissible and required to give a fairly strong signal. Were the circuit adjustment such that the volume control system would function only upon very strong signals, it would serve but a very limited purpose in providing a uniform output, with the exception of a low signal output in the event that the signal fades so badly that it is below the minimum signal voltage input limit as decided upon in the design of the receiver.

Under the circumstances, the state of maximum signal intensity extends over a definite range of the tuning control because the control unit tends to decrease receiver sensitivity at the point of maximum response and tends to increase sensitivity as the signal input decreases because the tuning adjustment is partially off resonance. Such a condition is prone to be productive of distortion, particularly if the adjustment of the receiver is set to an off resonant position so that the full side bands are not covered. The visual tuning system overcomes such a difficulty. Essentially it consists of a low range current meter, a milliammeter inserted at a point which would indicate the maximum voltage being applied to the control tube, this state being existent at exact resonance. Just where such a control is located is a matter of design. In one system it is located in the cathode circuit of one of the radio frequency tubes. In this position it indicates the plate current or rather the variation in plate current as the signal input actuates the control tube and therefore the radio frequency tube grid bias. The greater the signal input to the control tube, as one approaches resonance the greater the bias voltage developed by the control tube and applied to the radio frequency tube. This means a greater reduction of the tube plate current. At exact resonance the greatest bias is applied and the plate current is lowest. Since the normal plate current without signal input is greater than that with signal input, such operation of the meter means a "downward" deflection.

Such a meter could be located in the control tube circuit to indicate the plate current of that tube. Considering the magnitudes of the voltages and currents present in such systems, its position in the radio frequency circuit is superior in many ways. Such volume control systems are at all times equipped with a supplementary volume control whereby it is possible to adjust the maximum signal input so that the bias required to produce a normal output is not sufficient to alter the plate current characteristic of the radio frequency amplifier or amplifiers as the case may be, to the extent where the tube or tubes are rectifying, rather than amplifying.

SERVICE CONSIDERATIONS RELATING TO AUTOMATIC VOLUME CONTROL SYSTEMS.—The controlling action of the automatic volume control system hinges upon three items. First is the condition of the tube. Second is the condition of the resistances through which is passed the rectified current present in the volume control tube, and third is the circuit arrangement whereby the signal voltage is passed to the control tube.

As to the tube itself, receivers which employ an automatic volume control tube intended to function as such and without any association with the normal detector will function with this volume control tube removed. Of course the signal will require a manual control if the output is to be changed. The receiver will perform as if it had been never designed for automatic volume control. Such is not true when the automatic volume control tube simultaneously acts as the detector in the receiver. Removing this tube will cause cessation of operation.

A deactivated tube or one with an open plate circuit is the equivalent of no tube, hence in the former instance the volume will be normal without automatic control whereas in the latter the complete receiver will be inoperative.

A gassy tube or a particularly high emission tube will manifest the same effect in both cases. Since the action of the tube is dependent upon its plate current developing a voltage across a resistance, excessive plate current will develop an excessive negative bias and thus tend to decrease the response of the set, making the total output much less than normal. If this bias is sufficient, the radio frequency systems will become totally inoperative.

A tube with an open grid is somewhat the equivalent of a tube with gas or high emission and the same condition will prevail.

As to the respective resistances, short circuits or complete shorting of the resistances in the control circuit will nullify the action of the control tube since the controlling voltage will be low or zero. The same is true if one of the resistances is open, or one of the bypass condensers associated with these control resistances is shorted. Such a condition will not interfere with the operation of the receiver, the major effect being the loss of the automatic volume control.

A defect in the circuit whereby the actuating signal is fed to the control tube may influence the operation of the receiver in such manner that response will be poor. An examination of the various circuits shown in connection with automatic volume controls will bring this to light. Consider figure 39. The condenser C1 supplies the actuating voltage to the control tube. If this is shorted the grid of the control tube is placed at the potential of the radio frequency tube plate; the plate current in the control circuit becomes high and the bias applied to the radio frequency tube is very high. The signal output becomes very weak. If this condenser is grounded on either side the complete receiver will become inoperative. The same is true if the control tube grid leak R2 becomes grounded upon either side.

In the two element system shown in figure 37, an open between the plate and the grid (generally connected to each other) will reduce the controlling action and at the same time will also reduce the signal output because the proper rectifying action does not take place. A short circuit in the bypass condenser connected across the control tube divider elements R and R1 will cause total

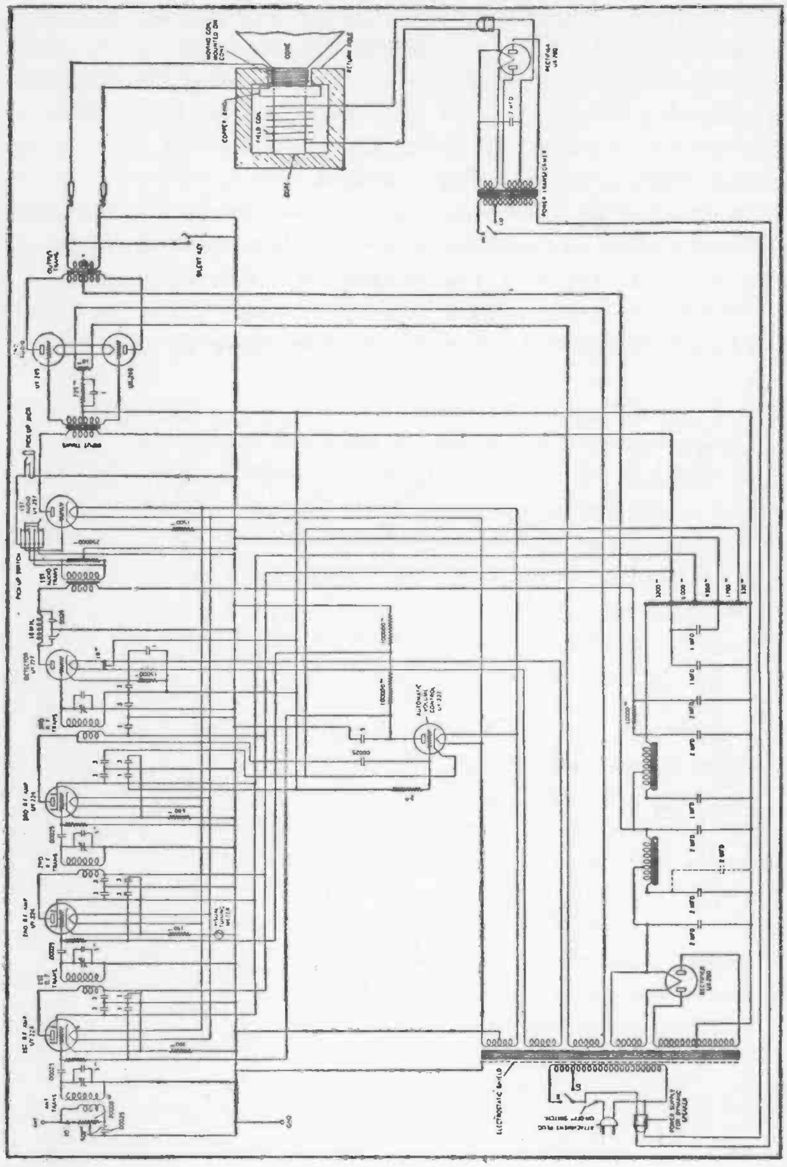


Fig. 40

simply shifting one of the meter connection, of course changing polarity because of the C voltage. However, each of the batteries is independent of the other and may be checked as a separate entity. At no point does the checking voltmeter itself introduce a path for the current so that an erroneous voltage may be observed, the voltage drop across the meter and indicated upon the meter being due to current flow through the internal resistance of the instrument.

Since the grid is one point of contact when measuring C bias voltages and the plate is the point of contact when measuring plate voltages, an open in the grid coil or the plate coil will be indicated. This does not mean that the meter reading designates the point of the open. Not by a long sight. Further testing in the form of continuity is necessary. Once the presence of an open circuit has been located, the rest is routine checking of the individual units in the respective systems.

One need not be very observant to notice that an ordinary voltage test carried out with a high resistance voltmeter can furnish a good deal of information. However, let us proceed.

Figure 43, a duplicate of figure 2 shows the application of a series resistance between the filament and the B— to produce a voltage drop which may be applied to the grid of the tube as the grid bias. The flow of the tube plate current through this resistance produces the grid bias. As far as voltage testing is concerned this circuit is a bit more complex than that shown in figure 42. The common point, B— normally connected to ground can no longer be used as the common point for the grid bias measurement, since the negative bias is developed across the resistance, between the filament and the B—. Thus the filament becomes the common terminal. In this position, the measurement of the plate voltage, i.e., between the filament and the plate of the tube is no longer the voltage of the B battery because of the voltage developed across the bias resistance. This is an important point to remember.

VERY HIGH GRID BIAS AND NO PLATE CURRENT.— Now if it so happens that the bias resistance R in figure 43 is open and a meter is connected between the filament and the grid, the latter, which by virtue of the grid coil may be said to be B—, the circuit normally through the resistance R is completed through the internal resistance of the meter. The tube plate current flowing through the meter will cause a voltage drop, thus indicating a fictitious grid bias. Under normal conditions, the plate current meter would indicate zero plate current because the grid bias resistance is open, and the B— circuit is therefore open. Hence we have the condition where the lack of plate current may be accepted as being due to the excessive bias. Removing the voltmeter being used to check the grid bias creates no change, since the B— filament circuit remains open. The situation is puzzling. Now the actual grid voltage indication is a function of the internal resistance of the meter. In the event that the meter is of the multi-range type, with comparatively low internal resistance because one of the low ranges is being used to check the grid bias, say about 25,000 to 50,000 ohms, an appreciable value of voltage will be indicated upon the meter. If, however, one of the higher ranges is used and the meter resistance approximates 500,000 to 1,000,000 ohms, the meter indication will be zero. This condition offers a means of checking the grid bias, to determine if the high bias indication is actually a high bias or if it is due to the drop across the meter itself. The test is the measurement of the bias with a low and a high range scale or meter.

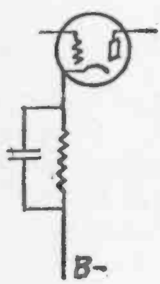


Fig. 44

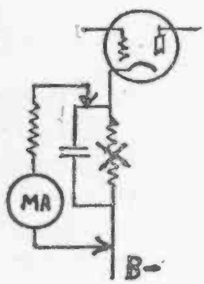


Fig. 45

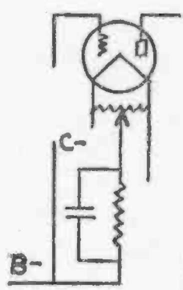


Fig. 46

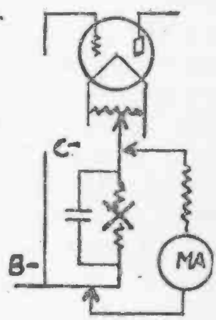


Fig. 47

The systems shown in figures 44 and 45 are much more common, wherein the grid bias resistance is located in the cathode circuit or in the filament center tap-B minus circuit. What has been said in connection with an open bias resistance in figure 43 is applicable to figures 44 and 45. We have taken the liberty in figures 44 and 45 to show only the bias systems. In the former the determining such an open is to connect a suitable bias resistance between either side of the filament and the B minus lead. Such a system will not be electrically balanced and the hum will be pronounced but plate current will be indicated if the trouble is in the grid bias resistor or at the filament center tap.

OPEN PLATE CIRCUITS.—Lack of plate current and lack of grid bias voltage when measured with any type of voltmeter, with normal filament voltage is usually a sign of an open in the plate circuit. The exact location of this open cannot be determined without a continuity test but it is possible to approximate the location of the open by consideration of the voltage data accompanying the receiver in question. By voltage data we refer to the data which usually accompanies a set analyzer such as the grid, plate, and filament or heater voltages.

Much time can be saved by due consideration of this data and recognition of the usual routine of design and manufacture of receivers in this country. There is a definite trend to make abundant use of resistances, which while functioning as voltage resistances also serve as filter resistances. This is particularly true in the case of some of the modern receivers.

The approximate position of the break can be determined by measurement of the plate voltage or current in the respective associated plate circuits. Thus if plate current or plate voltage is lacking at one radio frequency tube plate and plate voltage is practically normal at the remaining radio frequency tube plates, one is safe in assuming that the connections emanating from the original source of voltage; the eliminator, are perfect. The writer has yet to find a system wherein three radio frequency plates were supplied with voltage from two different points of an eliminator voltage divider. Thus the search narrows down to a local part of the system. This work is guided by the response of the receiver. With a three stage radio frequency amplifier as the basis, observation shows that an open plate circuit will not always completely interfere with reception. Reception will be possible, although the signal strength will be reduced. The measure of reduction seems to be influenced by the position of the inoperative tube. The closer this tube to the aerial system the more readily will one secure response, weak as it may be. This statement shall not be construed as being conclusive and we make special mention of this fact because we have found systems wherein an open aerial circuit causes total cessation of operation. This is in contrast to innumerable receivers operating in normal fashion without aerial and ground.

Returning once more to the plate circuits, discovery of an open plate circuit when the remaining tube plates of the system are being furnished with satisfactory plate voltage and the current is normal requires a local examination. One means of determining whether or not the above is true is to link one plate being supplied with normal plate voltage with the plate of the tube not being supplied with plate voltage through a resistance of about 1000 ohms and a plate current meter. Indication of current localizes the trouble between the plate of the tube in the defective circuit and the junction of the voltage supply with the remainder of the circuit. The next step after disconnecting the link circuit previously suggested, is shorting of the radio frequency transformer primary located in the defective circuit. This shorting link should exist between the plate of the tube and the plus terminal of the radio frequency winding rather than directly across the plate winding. The reason is more conclusive evidence, in the event that the plate of that tube remains without plate voltage. If the primary only were shorted and the circuit remained open, the remainder of the system both sides of the plate winding would be open to suspicion. By shorting as stated, the circuit remaining to be investigated is that between the plus end of the plate winding and the junction with the plate voltage supply of the other radio frequency tubes.

In the event that all of the plates in a radio frequency systems are sans voltage, it is useless to check the individual circuits. Much time will be saved by examining and checking the main feeder and the contact between this feeder and the source of voltage, the eliminator.

Quite a few radio frequency amplifier plate circuits are equipped with individual plate circuit resistances. Just what these values are is of no consequence at this moment. A table of electrical values prepared for the supplement to the 1931 edition of the *Trouble Shooter's Manual* shows that an average is impossible The actual values vary over a very large range, depending entirely upon the design of the system. It is necessary to remember that such resistances are located in the respective circuit. It is not practical to state some method of checking to determine the presence of such a resistance because it is quite a difficult matter to measure the voltage across various sections of the voltage divider in view of the fact that the elements of the divider may be located far and wide apart. However, in the event that there is an uneven distribution of plate voltages in the radio frequency system it is safe to assume that the plate circuit of the tube with the lowest plate voltage is equipped with a voltage reducing resistance, and that all of the radio frequency tube plates are fed from the same point in the divider. Once again this is a general statement based upon analysis and with full recognition that there are existent a few exceptions to this rule.

RESISTANCE IN DETECTOR PLATE CIRCUIT.—If we are to judge by the use of filter resistances in many detector plate circuits, which resistance also functions as a voltage reducing unit, there seems to be an advantage in the incorporation of this device. This resistance is located between the B plus side of the coupling element in the detector plate circuit and the source of the voltage fed to the detector. Although it is impossible to state that all detector plate circuits are equipped with such voltage reducing and filter resistances, a sufficient number are so designed to make worthwhile special reference and remarks to check the system to locate this element in the event that the detector plate circuit is under examination.

We also realize that the presence of a wiring diagram will immediately show the elements in the respective circuits, but it is necessary to consider the instance when such a diagram is not available.

BLEEDER CURRENT AND BLEEDER RESISTANCES.—We made mention of the fact that modern receiver design includes one change foreign to old receivers. Although this arrangement is quite popular in the screen grid system it is ofttimes used with the A.C. standard three element tubes. Its presence alters the efficacy of the set analyzer in that a misleading indication is possible during trouble in some other part of the system. Consider figure 49, which is really a duplicate of figure 3. The bias voltage developed across R is a function of more than just the tube plate current. It is also influenced by the bleeder current flowing through R2. R1 is the eliminator voltage divider. The application of the conventional set analyzer will not show the effect of R2 or the current through R2. With R known and the plate current determined it is possible to ascertain how much additional current is passing through R to produce the drop present across R. In the event that the tube plate circuit is open, somewhere between the tube plate and the junction beween R1 and R2 or within the tube, the grid bias voltage will be registered across R. Perhaps not the usual value but at least the drop representing the bleeder current through R2. Thus it is possible to have a grid bias which may be equal to about 50 to 75 per cent of the normal bias and have zero plate current indication upon the plate current meter.

To check for such bleeder current and the presence of such a bleeder resistance it is necessary to remove the tube in question from its socket and check for the C bias. Under normal conditions, as for example in figure 48, or if we can imagine R2 lacking in figure 49, breaking the plate circuit or even the cathode circuit within the tube will interfere with the grid bias. Thus when the tube is removed from the socket it is the equivalent of opening the plate circuit. Removing the tube when the circuit arrangement is as in figure 49, opens the plate circuit but does not interfere with the production of a drop across R. In view of the fact that under no other condition is such a voltage drop possible, it is concrete proof of the presence of a bleeder resistance between the plate circuit and the cathode or the filament center tap.

The usual application of the bleeder resistance in connection with the screen grid tube is shown in figure 50, a duplicate of figure 7A. What was said in connection with the bleeder unit used with the cathode or filament type of conventional A.C. tube is applicable in every respect to the screen grid tube. The only means of determining the presence of the bleeder resistance and the bleeder current is to remove the tube from the test socket, keep the test set insert plugged into the receiver tube socket and measure the grid voltage, that is the voltage between the grid and the cathode. As is evident in figure 50, no amount of testing between the cathode and any point along the plate or screen grid circuit will show the connection between the resistance R2 and the cathode because circuit continuity is completed through several different connections.

Let us now consider another item, namely incorrect grid bias. An open between R2 and R in figure 50 will not interfere with the application of the plate potential or with the application of the screen grid potential. It will not interfere with the grid bias other than to produce less than normal bias. The low bias is occasioned by the fact that only the tube plate current flows through the grid bias resistance. When such a condition exists in a modern receiver circuit, there would be a tendency for a somewhat higher than normal screen grid and plate voltage. About the screen grid voltage we can say very little because it is a variable, but the plate voltage would be a bit higher due to the reduced load.

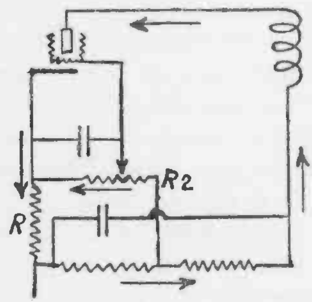


Fig. 50

(We do not show the control grid circuit because it is unnecessary.)

To check for such an open bleeder circuit repeat the test for the presence of the bleeder. The result will be negative if the bleeder circuit is open. Knowing that such a system is used and the fact that a voltage is being applied to the screen grid is evidence of the approximate location of the break, namely between the point at which the screen grid lead makes contact with the resistance and the cathode.

Now it is unsafe to imagine that each and every screen grid receiver makes use of such bleeder combinations. Reference to figure 24 shows another form of circuit. The system employs the screen grid tube but there is no bleeder between the screen grid and the cathode circuit. The screen grid voltage is secured from a potentiometer shunted across the divider. We note a bleeder resistance connected between the radio frequency plate supply circuit and the first and second R.F. stage cathodes. This circuit is the equivalent of that illustrated in figure 49. The fact that the tube in question is a screen grid unit is of no consequence. The screen grid voltage has nothing to do with the link circuit. We do, however, note a difference between figure 24 and 49. The former illustration shows a voltage reducing or filter resistance in the R.F. plate circuit and the bleeder is apparently connected to the junction between the radio frequency coils, and the voltage reducing resistance. This form of connection introduces no complication other than that it makes necessary recognition of another possible element in the average circuit.

OPEN PLATE CIRCUITS AND THE EFFECT UPON OTHER PLATE VOLTAGES.—It has been customary in the past to imagine that an open plate circuit in an A.C. electric system will manifest itself by a great change in the voltages applied to the other tubes in the receiver. Nothing can be more distant from the truth. With perhaps but one exception, an open output tube plate circuit, an open radio frequency plate circuit will have very little if any effect upon the remaining plate voltages. Naturally there will be some effect but the important item is whether or not the change in plate voltage and the variation from normal is sufficiently great to enable one to render the decision that one of the plate circuits is open. Of course checking of the respective circuits will eventually show this condition, but it is doubtful if a voltage 5 or 6 volts in excess of the normal is sufficient variation to create a definite picture in the mind of the man analyzing the voltages in the receiver. We are prone to warn against such decisions. Experiments carried out to determine the effect of an open radio frequency plate circuit in a six tube receiver showed an increase in plate voltage of about 6 to 7 percent. The plate current showed an increase of .5 milliampere from 3.8 milliamperes to 4.2 milliamperes. Such an increase is entirely negligible. Considering the tolerance values allowed in the manufacture of resistances employing a voltage reducing resistance, it is safe to say that no two receivers will show exactly like values of current and voltage. A rapid method of checking for an open plate circuit is to measure the voltage between the grid and plate of the tube in question. Naturally such a test will not show the position of the open. It is possible that the grid circuit may be open in which case the same result will be secured but a test between the grid and ground or B minus will show whether or not the circuit is open or closed. A similar test between the plate and ground will show which circuit is open.

OPEN OUTPUT TUBE PLATE CIRCUIT.—An open in the output tube plate circuit, particularly when the tube requires an appreciable amount of plate current will cause a great change in the current and voltage applied to the plates of the other tubes. Now this great change should not be construed as being anything approximating 50 percent. No such thing. Experiments carried on with a conventional system wherein the plate current drain of the output tubes was about 50 percent of the total current load of the eliminator showed that the actual increase in plate voltage when the output tube plate current load was removed was about 22 percent. Of course this is a good deal more than the previously quoted 7 percent and would in every case create suspicion but one should not expect radical variations. This is particularly true in the modern receivers because of the abundant use of voltage reducing resistances in the respective circuits. As the applied plate voltage increases the drop across the external filter the voltage reducing resistance likewise increases.

OPEN IN THE DETECTOR PLATE CIRCUIT.—An open in the detector plate circuit will have no effect upon the remaining plate voltages. Removing a 1 or 2 mil drain from an eliminator supplying 70 or 75 milliamperes is entirely negligible.

GRID CIRCUIT FILTER ELEMENTS.—The elements contained in the grid circuit, particularly those intended to function as filters are somewhat beyond the scope of the set analyzer. In view of the fact that these filter units, resistances as a rule, do not carry current there is no means of determining their status, with the exception of an open in the element. Whether perfect or shorted, the actual voltages applied to the grid remain as when normal. Hence the only solution is a continuity test. In this case it is necessary to differentiate between radio frequency and audio frequency circuits. Consider the system shown in figure 51. This is a stage of radio frequency amplification, the various tuned circuits constituting a band pass filter. The resistance R is located in the tuned circuit and the resistance R1 provides the grid bias. A voltage check between the grid and the cathode will determine the voltage developed across R1. The presence of R does not manifest itself in the voltage indication, since no current is assumed to flow in the grid circuit. Now the value of this resistance when used as a part of the tuned circuit is always shunted by a capacity C varies between 150 and 600 ohms. Thus it is very small in comparison with the usual resistance of a voltmeter. If this element is open it opens the grid circuit. A continuity test between the grid and ground will show the grid circuit to be open. The same indication will be obtained if the voltage measurement is made between the grid and the cathode or the grid and the plate. In the event of a short circuit across this resistance, there will be no indication of a short as far as voltages are concerned, because the resistance does not carry current. The only possible way of determining the condition of this resistance is to measure the resistance of the circuit between the grid and the ground. The resistance of the average grid coil is very small whereas the resistance of the filter element R is very many times more than that of the coil, hence a satisfactory indication is possible.

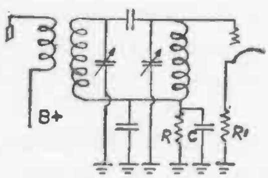


Fig. 51

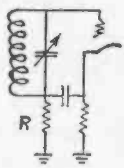


Fig. 52

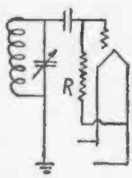


Fig. 53

It is necessary at this time to mention that a resistance test is better than an ordinary continuity test. This becomes evident when we are called upon to check the continuity of other types of filters in grid circuits and the values of grid leaks used in some series filament receivers. The oft repeated indications of "full" and "half" or "quarter" scale readings are not very satisfactory. The resistance R in figure 51 serves two purposes. It acts as a radio frequency filter and at the same time reduces the sharpness of tuning upon the higher wavelengths. In the event of trouble in such a system, a sign of a defective filter or decoupling resistance is very sharp tuning.

Another type of filter resistance is shown in figure 52. We should say another form of application. In this schematic, the filter resistance is external of the tuned circuit and is of some value between 10,000 and 50,000 ohms. An open in this element will open the grid circuit but a short circuit in the resistance will have no effect upon the grid or any other voltage. Hence the only satisfactory method of test is to check the resistance between the grid and the ground.

The reason for the suggestion to check resistance rather than continuity is shown in figure 53. This circuit shows the use of a 5,000,000 ohm grid leak as the path for the grid bias voltage. The usual continuity tester will show an open when called upon to indicate continuity through a resistance of such a high value, whereas the well designed ohmmeter will indicate the value of resistance present between the grid and the ground. This circuit should not be accepted as the conventional detector stage because the resistor R is not the detector grid leak. Its purpose is to allow the application of the bias to the grid of the tube without interfering with the ground connection of the tuning condenser rotor. (See "Series Filament Receivers" in Chapter 3.)

The circuit shown in figure 52 is duplicated in audio frequency systems, with the exception that the tuning system is replaced with the audio coupling unit located in the grid circuit. (See Regeneration Control.)

CHECKING LOW RESISTANCE WINDINGS.—Quite a few parts of a radio system, particularly in the radio frequency amplifier are of very low resistance and voltage tests cannot be applied because of the very low drop across such units. Parts typical of such low resistance are the plate and grid windings used in the tuned stages. In the event of difficulty, there is no better method of checking to determine a short circuit than to deliberately short circuit the grid or plate coil, the short circuiting wire being connected directly across the terminals of the winding. Such a link will have no effect upon a shorted coil.

SHORTED GRID SUPPRESSORS IN R.F. SYSTEMS.—Examination of a large number of receivers shows that there is a choice between the grid suppressor and the grid filter resistance. In but exceptionally few cases are both used in the same system. Thus if the analyzer indicates an open grid circuit, the first check should be made upon the grid suppressor. For some unknown reason these elements are sources of frequent trouble. A rapid check is not the removal of the unit and measurement of its resistance or a continuity test upon the unit, but the placement of a short circuiting link between the grid of the radio frequency tube and the grid end of the tuning condenser or the coil. If this shorting link completes the circuit it is time to check the resistance. In the event that the shorting link referred to does not complete the circuit, the next test is a shorting link between the grid and the low potential end of the grid coil. If this does not prove fruitful, the next step is between the grid and the ground, with subsequent checkup of the circuit between ground and the low end of the grid tuned winding.

APPLICATION OF SHORT CIRCUITING LINKS.—The short circuiting link is a time saver, but it is necessary to consider the circuit structure before applying such a link. Thus a link between the grid and the ground is possible in figure 52, no matter how low the resistance of the link. In figure 53 however a high resistance link is necessary in order to protect against short circuiting of the filament. Such a link can be a 100,000 ohm resistance which will carry about 10 milliamperes.

SHORTED WINDINGS.—As a general rule, the set analyzer when employed as a voltage tester is a satisfactory method of determining short circuit windings providing that the windings are of high resistance, such as are to be found in audio frequency amplifiers. When so employed the operator is called upon to correlate existing conditions with the voltage readings indicated upon the meter. At no time can the set analyzer solve all troubles. Some very simple methods still provide very lucrative results. Such a thing as tapping the detector tube and noting the speaker response is still a great method of determining if the audio amplifier system is alive. This operation accompanied by a voltage test will furnish a good deal of information.

An examination of any audio amplifier of conventional design will show that only under one condition is it possible to produce a "dead" amplifier and obtain normal voltage and current readings. This condition is a short circuited primary or secondary winding of the audio coupling units if they are transformers or chokes. In the event that the coupling units are resistances, the only possible point at which a short circuit may be completed without altering the plate voltages and plate current is a short circuit across the grid leak. Shorting the plate coupling resistance will show an increase in plate voltage. In this respect the same is true if the transformer or choke in the detector circuit has a resistance of about 1000 to 2000 ohms and the plate current is more than 1 milliampere. Where the plate current is about 3 to 5 milliamperes and the resistance of the element located in the tube plate circuit is 2000 ohms or more, a appreciable increase in plate voltage above normal will be evident.

Returning to the shorted secondary winding, this short circuit need not take place in the coupling unit if that element is shunted by a resistance or a capacity. The short may take place in the resistor or condenser. At this stage one is apt to say that an open in the secondary winding will have the same effect as a short, that is, if that winding is shunted, by a resistance whereby the grid voltage will be applied to the grid. Such is not the case. When a secondary winding is open and that winding is shunted by a resistance, the distributed capacity between the primary and secondary windings is sufficient to act as a coupling medium and signals will be passed through the amplifier, the resistance across the defective secondary winding functioning as the grid lead. It is true that response will be weak, but response will be present nevertheless. Thus it is possible to distinguish between an open and a shorted secondary winding when that element is shunted by a resistance.

When the secondary winding is shunted by a capacity or is alone in the circuit an open in the winding will interfere with the grid bias. To check whether or not the secondary is shorted measure the resistance between the grid and the C— contact. The usual resistance of a high grade secondary winding is about 4000 to 5000 ohms for the standard unit and between 6000 and 8000 ohms total for a push-pull secondary.

USING LOW RANGE A.C. VOLTMETER FOR LOW RESISTANCE CONTINUITY TESTING.—The internal resistance of the multi-range A.C. meter supplied with the conventional set tester when adjusted to the 3 or 4 volt scale is sufficiently low to permit the use of the meter to check low resistances up to about 100 ohms. The lower limit is about 1 ohm, although it is possible to check units of even lower resistance.

CHAPTER 6

AIR DIELECTRIC CONDENSERS

THE most efficient condenser, electrically speaking, is the air dielectric type. This is true irrespective of the shape of the plates or the number of plates employed in order to provide a certain value of capacity.

TYPES OF AIR CONDENSERS.—There are various types of air condensers, the distinction being more in the nature of the physical construction, the capacity and the variation of capacity with respect to the angle of rotation of the rotor.

As to capacity, the usual run of air condensers employed in radio receivers varies between about .000010 mfd. and about .0005 mfd. Of course a complete condenser bank employing a combination of fixed and variable capacities makes possible a much greater range, but the variable unit in that bank seldom exceeds the maximum quoted.

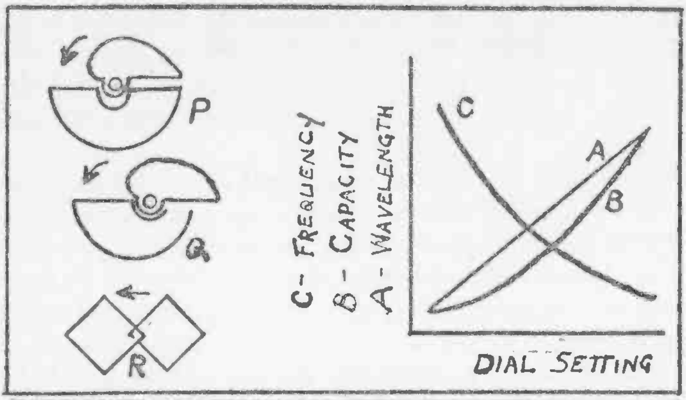
The popular values of variable air dielectric condensers employed in the normal run of broadcast receivers are .00025 mfd., .0005 mfd. and .00035 mfd. In test equipment the usual value is .0005 mfd.

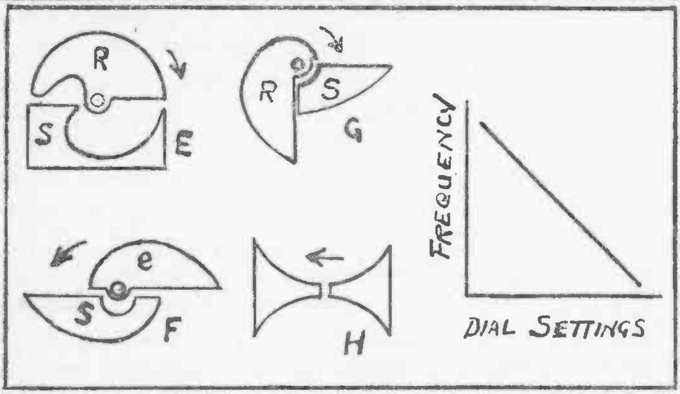
Tuning condensers for the short wave band generally intended for use with a set of coils to cover the complete short wave spectrum are generally made in three values of capacities, namely .0001 mfd., .000125 mfd. and .00015 mfd. In many instances the midget condensers available in sizes between .0001 mfd. and .0001 mfd. are used as tuning capacities, in most cases in series with a larger condenser so that the total capacity of the series combinations is reduced and tuning is accomplished with the larger of the two condensers. As an average of the capacities available from a number of representative condenser manufacturers we quote five types with maximum values of .00015 mfd., .00003 mfd., .00005 mfd., .00007 mfd. and 100 mfds.

MINIMUM SETTING OF AIR DIELECTRIC CONDENSERS.—The minimum capacity setting of any air dielectric condenser is an important matter insofar as the wavelength or frequency band of the tuned circuit is concerned. In this connection it influences the selection of a coil of a predetermined value of inductance. The ideal condition would be a condenser with a zero minimum. Such is not possible and even if one were available, the band covered would not be the value computed from the LC ratio for reasons which are very evident. In the first place the coil, no matter what its dimensions possesses a definite amount of distributed capacity. Second, the leads connecting to the tuned circuit and junctioning the tuned circuit with the remainder of the apparatus have a definite amount of capacity. Third, the input circuit of the tube, if one is used, has a definite grid to filament capacity. Fourth, there is at all times a certain amount of reflected capacity across the grid and filament, or cathode, of the vacuum tube. Hence one should never select an inductance, intended to cover a complete band, based upon the rated minimum of the condenser. For normal broadcast receivers, the optimum minimum value of capacity ranges between 30 and 40 mfds. For short wave receivers this minimum is somewhat reduced but not to a very great extent. The experience of the writer has been that the total minimum with high grade condensers employed in carefully selected systems approximates 20 to 30 mfds.

Theoretically one can compute a wavelength range of about 3:1 with the ordinary condenser. The actual range between 200 and 600 meters, when the systems are designed to operate within this band, is about 2.5:1. For short wave reception this band is reduced to about 2.3:1 or 2.4:1.

The minimum setting of a shielded condenser is at all times greater than that of an unshielded unit. The reason is the capacity between the stator plates and the shield usually connected to the rotor. So much so, that whereas the normal minimum of a .0005 mfd. condenser, unshielded, is about 20 mfds., the same unit when located within an individual shield is about 50 mfds. This is of importance when condensers are employed in testing systems and it is necessary to shield the respective units.





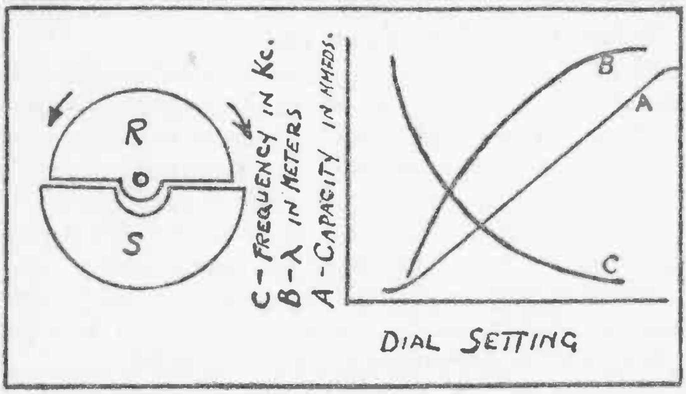


Fig. 54 (top)
Fig. 56 (middle)
Fig. 55 (bottom)

VARIATION OF CAPACITY WITH RESPECT TO ROTATION OF ROTOR PLATES.—It might be well to dwell upon the types of condenser rotors in use today so as to guide the selection of other units in order that a definite manner of tuning be made available.

In figure 54 is shown the usual semi-circular condenser plate. This form of plate affords a straight line capacity variation. In other words the capacity obtained for certain angular rotation of the rotor remains substantially constant between the absolute minimum and maximum settings. This type of condenser crowds the high frequency adjustments for any one spectrum and likewise crowds the low wave adjustments for any one band. When calibrated in capacity, it serves admirably in test circuits for harmonic calibration or one if quarter capacity adjustment is desired. The curves illustrate the form of tuning possible with what may be termed an ordinary inductance.

Figure 55 illustrates one form of rotor, usually referred to as eccentric. The capacity is proportional to the *square of the angle of rotation* and the *variation in wavelength is linear.* The linear variation of wavelength is shown in curve A in figure 55. As is evident two types of eccentric plates furnish like wavelength variations, namely P and Q. The square plates manipulated as shown by the arrow, likewise provide a linear wavelength variation. As is to be seen in curves B and C in figure 55, the frequency curve crowds the stations at the high frequencies whereas the capacity curve increases rapidly towards the higher dial settings.

Figure 56 illustrates several types of straight line frequency condensers wherein the variation in frequency is substantially linear and wavelength and capacity become crowded as the dial setting approaches the maximum. Condenser F employs special stator and rotor plates. Condenser G is a special unit which requires 270° of rotation of the rotor in order to fulfill the complete meshing or unmeshing of the rotor and stator plates. Condenser H is a special sliding mesh type. As far as the tuning curves are concerned we show only the frequency curve. The wavelength and capacity curves resemble curve B in figure 55.

The choice of the condenser has much to do with the manner in which the stations, wavelength or frequency settings will appear upon the dial. In this respect it is best to remember that all condensers do not rotate in the same direction. Some revolve clockwise and other revolve counter-clockwise. Another important point is that all condensers do not occupy the same amount of space when they are completely out of mesh, despite the fact that they appear uniform when completely in mesh. As a general rule, straight line frequency condensers require more space when out of mesh or adjusted to minimum capacity then either the straight line capacity or the straight line wavelength type. At the same time it might be well to mention as a general statement that straight line capacity and straight line wavelength condensers of equal maximum will usually fit into like space.

In connection with the direction of rotation, it is necessary, particularly with drum dials, to select the proper frequency scales, otherwise the high frequency designations will appear when the condenser is in mesh and tuned to the low frequency end of the tuning spectrum; i.e., the tuning scale will be reversed. This applies equally to ordinary dials.

BALANCE AND ALIGNMENT OF GANGED TUNING CONDENSERS.—Great care is being exercised in the manufacture of ganged condensers so that satisfactory uniformity is obtained over the complete scale. But no matter how accurate the manufacture it is possible during handling to destroy the balance, thus necessitating realignment. This is not the easiest of all tasks. Many believe that it can be effected by the simple expedient of connecting a trimmer condenser across the imperfect unit. While it is true that the general run of ganged condensers are equipped with trimmer units, these trimmer units do not always solve the problem. The trimmer condenser is applicable in one case only. Namely when the difference in capacity between any two condensers without the trimmer is uniform over the entire range of the dial. In such event, the addition of the trimmer, adjusted to the correct capacity, will effect balance over the entire dial.

If the variation in tuning which actually represents a difference in capacity is present only upon a part of the scale, application of the trimmer will not alleviate the trouble. It will remedy the difficulty at one point but introduce another problem at some other setting of the condenser. No amount of trimmer adjustment will balance two condensers over the entire scale if they are in balance over a part of the scale. It might be well to qualify this statement by stating that balance may be approached if the two condensers are uniformily out of balance at the low capacity part of the scale. The reason for this is that the addition of the trimmer capacity if it is small will effect balance at the high frequency end and have very little effect at the high capacity end because of the great ratio between the tuning capacity and the trimmer capacity.

When the difficulty is due to misalignment of the plates, or to plate bent out of shape, the best remedy as to simplicity and effectiveness is to realign the plates; to straighten them to their original position. The work is not as difficult as it appears and in the long run does not consume very much time.

Perhaps we have placed the cart before the horse. Before one can align a condenser it is necessary to determine which of the ganged group is out of alignment or balance. Such may be carried out with a very simple tool, which, with very little trouble will also serve to determine whether or not adjustment of the trimmer will alleviate the difficulty. DO NOT TAMPER WITH THE TRIMMER CONDENSERS UNTIL THE COMPLETE CONDENSER SYSTEM HAS BEEN CHECKED. The method of test to be recommended does not allow a definite conclusion because it involves the inductance utilized in connection with the tuning capacity. However a supplementary test will provide the conclusive solution. The checking tool consists of a bakelite rod about 5 inches long and about 3/8 inch in diameter. To one end of this rod is attached a brass semi-circular rotor plate removed from an old variable condenser. A hole of a diameter just slightly less than the diameter of a 4/32 machine screw is drilled into one end of the rod. A 4/32 brass machine screw of suitable length is

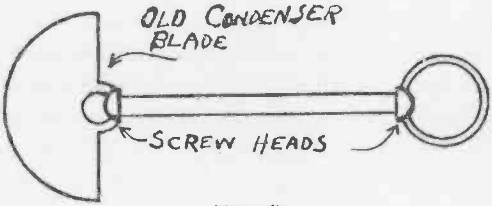


Fig. 57

threaded into this hole. The condenser plate is placed within the slot, upon the head of the screw and soldered into place.

To the other end of the rod is attached a closed loop of wire made from No. 14 BS copper, the diameter of the loop being about 1 inch. The ends of the wire are soldered completing the loop. The loop may be fastened to the rod in the following manner. A brass machine screw is first fastened within the end of the rod by drilling a hole about .5 inch deep lengthwise through the rod. The size of this hole should be slightly smaller than that necessary to allow the insertion of the screw, so that the screw may be threaded firmly into place. The loop of wire is then soldered to the head of this screw. The finished tool appears as shown in figure 57.

To determine if a condenser is out of balance, tune in a station operating upon one of the higher wavelengths. Tune to maximum resonance. Then holding the aligning tool by means of the bakelite handle make electrical contact between the test tool condenser plate and the rotor of the condenser being checked and bring the test tool plate in proximity with the stator plates of the condenser. This operation increases the capacity of the condenser. If the signal intensity decreases, the additional capacity is not required and the condenser may be assumed to be satisfactory. *This may not be the final conclusion.* Proceed to the other condensers and repeat. If the system employs three condensers and two of these show a decrease in signal strength when the tool is applied and the remaining unit shows an increase, the adjustment of the latter is such that its capacity is low.

Now, it is also possible that the coil employed in conjunction with the capacity which apparently is "low," is also "low," due to loosening of the winding or a shorted turn. Before any attempt is made to effect changes, check the condenser alignment at a low wavelength or high frequency. It is possible that one of the outside rotor plates is bent partly out of shape and the low wavelength adjustment will be normal. If such is the case, examination of the condenser is necessary and adjustment of the plate will naturally follow. If the check shows the same discrepancy present on the low wavelength, the next step is to attempt to create resonance by means of the trimmer. This step in preference to checkup of the coil is recommended because removing the coil shield is apt to impair the balance of the complete receiver and the problem will become more difficult. If resonance is secured by readjustment of the trimmer, the decision as to whether or not the coil is defective depends upon the intensity of the signal and the general behavior of the receiver. A shorted turn within a coil is anything but conducive to normal signal strength and selectivity. If these are obtained, the coil may be considered to be perfect.

If however selectivity is not as good as it should be and the signal strength is likewise deficient, the only recourse is to closely examine that particular stage and if everything appears normal, to remove the coil and replace with another. Checking for inductance serves no purpose because the effect of the loop will be to still further reduce the inductance.

If during the original checkup of the condensers, increasing the capacity by means of the test tool shows a greater decrease in signal strength for any one of the condensers than for another, it is safe to assume that that particular condenser is "high" or the coil connected to that condenser is "high." In this respect it is doubtful if any condition subsequent to perfect operation will cause a "high" inductance, because a shorted turn or a loose winding will tend to decrease, rather than to increase the inductance. The only possible means of increasing the inductance is by the use of a magnetic core. Hence one is safe in assuming that the coil was "high" when it left the manufacturer. Another capacity test should be made before testing the coil. Readjust the system to a low wavelength. The same condition should prevail if any of the circuits or the components are "high." If normal resonance obtains, the discrepancy is in the tuning condenser at the high capacity setting. If the "out of resonance" condition exists upon the low wavelength and the tool test shows one circuit to be high, a more accurate check may be made by tuning the system to slightly below accurate resonance. The normal circuits will show an increase in signal strength when the test tool is applied and the imperfect circuit will decrease the signal. The next step is to look over the coil in the supposedly defective stage. If it appears normal try for resonance by reducing the trimmer capacity. If successful and the signal is normal and selectivity is perfect over the entire tuning scale, further examination of the coil is not necessary.

REPLACING GANG CONDENSERS.—A major injury to one of the sections of a gang tuning condenser arrangement, unless the condensers employ individual coupling links, requires replacement of the entire gang. This is more easily said than done. So much so that ofttimes it is better to replace not only the tuning condensers but the coils as well.

REDUCING THE CAPACITY RANGE OF A VARIABLE CONDENSER.—There are several ways of reducing the capacity range of a tuning condenser. The best system is to connect a smaller value of capacity in series with the variable unit. The series unit may be fixed or variable. By employing a variable, several ranges are made available. The form of connection is shown in figure 58A, wherein C is the regular condenser and Cs is the added series unit. The inductance L represents any coil which is to be used in the circuit. If C is a .00025 mfd. condenser and Cs likewise has a maximum of that value, the resultant capacity of the combination when both sets of plates are in mesh is .000125 mfd. By adjusting the setting of Cs any maximum between the minimum of C and .000125 mfd. may be secured. The following

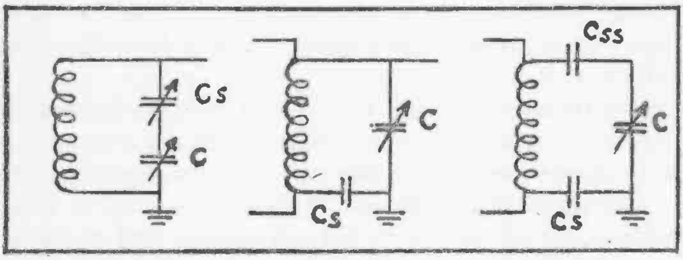


Fig. 58 A   Fig. 58 B   Fig. 58 C

table affords an idea of the approximate range of C when Cs is adjusted to various values.

Fixed Adjustment of Cs	Range of C
.00025 mfd.	.00001 to .000125 mfd.
.0002 mfd.	.00001 to .000111 mfd.
.0001 mfd.	.00001 to .000071 mfd.
.00005 mfd.	.00001 to .000042 mfd.

The reason for the substantially constant minimum is that the ratio between the fixed setting of Cs and the minimum of C is so great that there is practically no change. When calculated on the basis of 10 mmfds. minimum for C and 50 mmfds. adjustment of Cs, the resultant minimum is about 8 mmfds.

A reduction in the capacity range of a tuning condenser may be accomplished as shown in figure 58A by replacing Cs with a small fixed capacity which need not be of the air dielectric type, instead of the solid dielectric type. Such an arrangement definitely fixes the range of the variable unit.

ISOLATING THE TUNING CONDENSER CONNECTED ACROSS AN INDUCTANCE THAT CARRIES DIRECT CURRENT.—In many instances particularly when the screen grid tube is used and the plate circuit is tuned it is advantageous to be able to isolate the tuning condenser so that its rotor may be placed at ground potential. Such a system is shown in figure 58B. The major condenser is C and the series blocking condenser is Cs. If Cs is variable a variable range is provided for C. If Cs is fixed a fixed range is provided for C. Whether or not the maximum capacity range of C remains at its original value depends entirely upon the value of Cs. If it is small the range of C will be reduced. If Cs is large, say one hundred times that of C, then the effect of the series combination will be negligible. C will tune the inductance just as if Cs were absent.

The circuit shown in figure 58B is used in series filament systems where the coil is returned to some point on the finalment system in order to secure the correct bias and the tuning condenser is part of a common ground system. More data pertaining to the operating requirements of such isolating condensers and replacement is to be found in the chapter devoted to "Solid Dielectric Fixed Condensers."

If this coil is located in the plate circuit of a vacuum tube, a short through Cs will interfere with the plate voltage and short circuit the output system of the B eliminator, if one is used. If the circuit shown in figure 58B is a part of the grid circuit and the coil returns to one part of the filament, the short in Cs will short circuit the filament system because of the direct metallic connection between the ground and the part of the filament circuit connected to the low end of the coil.

A short circuit through C will likewise short the voltage applied to the coil because the high end of the coil would return to ground through C. A precautionary measure is the insertion of another capacity identical to Cs as shown in figure 58C. By making Css as large as Cs, very little effect will be noted upon C, providing that the selection of Cs has been such as to have negligible effect upon C.

VARIABLE CONDENSER IN CAPACITY CONTROL REGENERATIVE DETECTOR PLATE CIRCUIT.—It is quite common practice to employ a capacity control regenerative circuit such as that shown in figure 59A. One side of this condenser is at high potential and the other side is at ground potential. A short circuit in this unit will short the tube plate voltage to ground. Protection may be secured without any effect upon the tuning by connecting a series condenser as shown in figure 59B. By making Cs fixed and about one hundred times as great as C, full regeneration control is obtained and greatly increased protection against a short circuit of the plate voltage is also secured. In some cases C is connected between L1 and the grounded filament leg. This does not interfere with the insertion of Cs. As a matter of fact the last named position is preferred because manipulation of the regeneration condenser is not accompanied by any pronounced hand capacity effects. Another position for the regeneration condenser is as shown in figure 59C, the condenser being indicated by C. Here too a short in the condenser will short the plate supply and it is

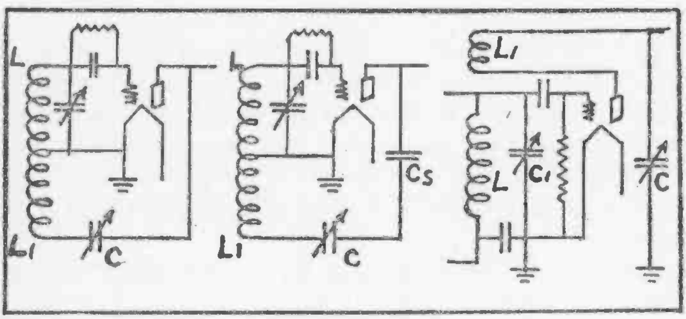


Fig. 59 A Fig. 59 B Fig. 59 C

good practice to preclude damage by connecting a fixed condenser in series with C and the tickler coil return. The value of such an isolating condenser need not exceed .1 mfd.

CAPACITY OF REGENERATION CONTROL CONDENSER.—Such condensers find most frequent application in short wave receivers and the most popular value used is .00025 mfd. This value of capacity seems to cover the entire short wave band from about 15 to 200 meters. Of course the adjustment is variable and satisfactory control is secured by employing regeneration coils such as L1 in figures 59A and 59B and 59C, suitable for the inductance L and the frequency band involved. Referring once more to figure 59C, the circuit arrangement is that present when L is a part of the plate circuit of the previous tube, for example a screen grid tube of either the 222 or 224 type and tuned by the variable condenser C1.

Generally such regeneration control condensers are supplementary controls and are not tied in with the tuning condenser so as to afford automatic regeneration control. The maximum capacity suggested is not necessarily the only possible value. The smaller the capacity the less the possible frequency range over which satisfactory regeneration may be secured. If the tuning inductances are of such nature that only a narrow band is covered with each and the tickler coils are simultaneously changed, a smaller capacity is suitable, say .0001 or .00015 mfd.

VARIABLE CONDENSER IN SHORT WAVE RECEIVER ANTENNA CIRCUIT.—It is quite customary to employ a midget type of variable condenser as the coupling device between the aerial and the first input coil in short wave receivers. As a matter of fact that unit is actually of importance and is of great aid. In operation it is customary to simultaneously vary the capacity of this coupling condenser as the receiver tuned circuits are adjusted to various frequencies, the higher the frequency the lower the capacity of the coupling condenser. A midget variable condenser of about 25 mmfds. is suitable for the wavelength range of from 15 to 200 meters.

VARIABLE CONDENSERS AS TRIMMER CONDENSERS. (Air Dielectric).—While it is not customary to employ air dielectric variable condensers as trimmer condensers they are so used upon several aircraft radio receivers. These units are rated at about .000025 mfd. or about 25 mmfds.

By employing a fairly large minimum, minor variations in capacity do not materially influence the tuning of the receiver, particularly when the system makes use of several ganged sections. It is of course possible to use trimmer condensers with maximum values less than that suggested.

VARIABLE AIR DIELECTRIC CONDENSERS FOR NEUTRALIZING.—One function of the usual run of midget condensers is neutralization of amplifier stages. The exact value depends upon the form of neutralization, primarily upon the number of turns employed in the neutralizing winding, and the type of tube being neutralized, that is, the capacity between the grid and the plate and also upon the number of turns in the normal plate winding. Generally, none of these items are within the control of the man who is called upon to replace a neutralizing con-

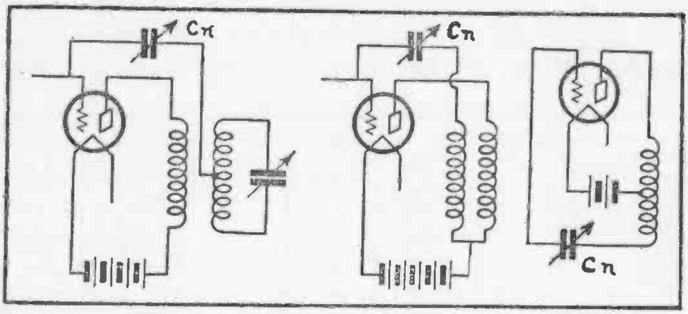


Fig. 60 A Fig. 60 B Fig. 60 C

denser. Hence it might be best to quote the most popular values of capacity employed for the purpose of neutralizing radio frequency amplifiers employed in radio receivers or for that matter in other forms of test equipment. The grid to plate capacity of the tube should be the equivalent of about 20 percent of the total capacity of the condenser, thus allowing suitable variation either side of this adjustment. Based upon a grid-plate capacity of 10 mmfds. for the 226 tube, the maximum setting of a neutralizing capacity need not be more than 50 mmfds.

If for example the neutralizing winding contains about 75 percent of the turns in the plate winding, the maximum value of the neutralizing capacity need not exceed twice the rated grid-plate capacity of the tube. Thus the lower the grid-plate capacity of the tube to be neutralized the lower may be the maximum of the neutralizing condenser.

Three popular forms of neutralizing are shown in figures 60A, 60B, and 60C.

Reference to figures 61A, 61B and 61C shows three systems whereby a defect in the neutralizing condensers will have no damaging effect upon the tube or associated equipment. In 8A an additional fixed capacity Cs of about .005 mfd. is connected in series with the neutralizing condenser Cn. A short in Cn will cause the cessation of operation but will not short circuit the plate voltage. Figures 61B and 61C show substantially the same circuits, the only difference being that 61B is shown in connection with a cathode type of A.C. tube such as the 227 and figure 61C illustrates the application of the system to the filament type of A.C. tube such as the 226. In both cases, the neutralizing system is INDUCTIVELY COUPLED to the plate circuit and any damage in the neutralizing system will not short the plate circuit or jeopardize

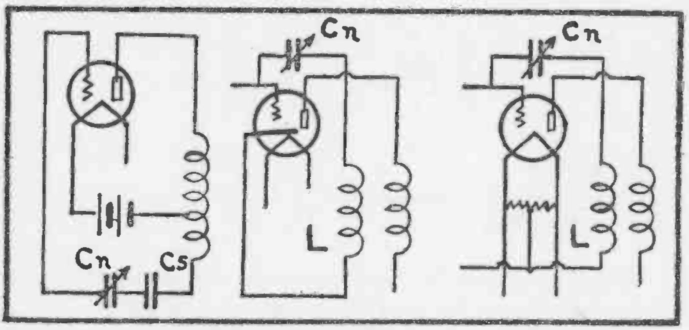


Fig. 61 A Fig. 61 B Fig. 61 C

the tube. The neutralizing system consists of the inductance L and the capacity Cn, the complete circuit being connected between the cathode and the grid.

It is possible to make the best of the opportunity to mention at this time that the series condenser Cs in figure 61A should be a part of every neutralizing system where the condenser is subjected to a high potential. This is particularly true in the case of the solid dielectric neutralizing condensers, such as the mica dielectric equalizers.

SOLID DIELECTRIC VARIABLE CONDENSERS.—These units are generally known as equalizer condensers, employ a mica dielectric, the capacity being varied by decreasing the distance between a stationary and a movable plate. The usual capacity ranges are from about 2 to 35 mmfds. and from about 20 to 80 mmfds. Such condensers are employed as trimmers. They may be employed to replace air dielectric trimmers or vice-versa. The average unit is capable of withstanding an applied potential of several hundred volts.

INCREASING THE RANGE OF VARIABLE CONDENSERS.—According to the electrical laws relating to capacities the capacity of any one unit may be increased by placing another unit in shunt with the first, the final capacity being the sum of the two units.

VARIABLE AIR CONDENSERS IN SERVICE TEST OSCILLATORS.—A very handy value of capacity is .0005 mfd. (500 mmfds.) suitable for tuning over a range of from about 200 to at least 550 meters. This same value of capacity is suitable for service test oscillators intended to cover the popular broadcast receiver intermediate frequencies of 175-180 kc. Whether or not the frequency band will be covered by the condenser depends upon the inductance used.

It might be of interest at this time to mention that the variable capacity in the combination 1400-600 and 180 kc. test oscillator recommended by RCA, employs a variable of .00005 mfd. supplemented by fixed condensers of approximately .00002 mfd. for the 1400 kc. setting, .0004 mfd. for the 600 kc. setting and .00058 mfd. for the 180 kc. setting. A special inductance is used for the 180 kc. frequency.

VARIABLE CONDENSERS IN WAVEMETERS.—Once again the value depends upon the band to be covered with any one inductance. For ordinary measurements, for that matter even for accurate measurements over a band of wavelengths from about 75 to say 20,000 meters with a set of five or six plug in coils, an optimum value of capacity is .001 mfd. For wavemeters intended to cover the normal broadcast band of 200 to 550 meters, a .0005 mfd. variable condenser is satisfactory. Vernier adjustment is beneficial. For definite fixed frequencies, small values of capacity should be used. These range from .000025 mfd. to as high as .0001 mfd. The midget type of condenser is suitable for the small values, unless one wishes to improvise a small capacity range from a large condenser by removing the surplus plates and thus obtain better control. For the very high frequencies where adjustment is critical it is better to remove the majority of plates from a large condenser of say .0001 mfd. and make a final capacity of about .00001 mfd. or .000025 mfd.

LOCATING SHORT CIRCUITS IN VARIABLE AIR CONDENSERS.—A short circuit between the rotor and stator plates will interfere with the operation of the unit but will not manifest a visible sign unless an appreciable voltage is present across the plates of the condenser. A rapid, simple and very effective test is to isolate the condenser under suspicion and test for a short circuit by means of a lamp and a 110 volt circuit. Connect the lamp in series with the source of potential and connect the test circuit across the condenser. Then rotate the rotor plates. Contact between the rotor and stator plates will be indicated by a flash of the lamp.

CHAPTER 7

SOLID DIELECTRIC FIXED CONDENSERS

SOLID dielectric fixed condensers employed in radio and associated fields may be said to be divided into two general groups. These are 1: Linen or wood pulp paper dielectric and 2: Mica dielectric. Now, it should be understood that these classifications are according to structure or physical makeup and not application. As to the latter, it is difficult to attempt to define where classifications based upon application begin and where they end. A resume of designations related to application would appear somewhat like the following:

Filter, bypass, coupling, isolating, buffer, grid, feedback, antenna, ground, etc.

There are to be found certain differences between the condensers selected for any one of these positions. Primarily these differences are twofold. First, capacitance, and second, voltage rating. Of these two the major interest lies in the voltage rating. The capacity of the condenser is a secondary consideration as far as application is concerned. The reason for this is obvious. Incorrect selection of a capacity as to operating voltage rating invariably results in damage to the condenser and possible damage to associated equipment. On the other hand incorrect selection of a condenser as to capacity means nothing more than imperfect operation of the system without damage to any part, and simple methods of remedying the difficulty. Thus it might be well to start this discussion with data pertaining to voltage ratings.

While it is true that the general understanding of fixed condensers is such that all but variable condensers come under one heading we shall consider in this chapter only those condensers which employ paper or mica dielectrics. Fixed condensers of the electrolytic type shall receive special attention.

INTERCHANGING MICA AND PAPER DIELECTRIC FIXED CONDENSERS.—Mica and paper condensers are interchangeable providing that the operating voltage ratings are satisfactory. This statement is applicable to all capacities when they are of high quality. Actually it applies to values between .02 mfd. and about 10 mfd. with a maximum of 2000 volts because condensers rated at voltages in excess of 2000 volts and below .02 mfd. usually are of one type, namely mica.

VOLTAGE RATING OF SOLID DIELECTRIC FIXED CONDENSERS.—The voltage rating of solid dielectric fixed condensers such as the usually quoted filter and bypass units is of importance. Unfortunately it is impossible to list the actual specifications as employed by receiver manufacturers. It is therefore necessary to consider the data set forth by condenser manufacturers. Although condenser rating standardization is not yet a reality, there seems sufficient similarity between rating to allow a definite conclusion. The following data is based upon the facts secured from several prominent condenser manufacturers. At the same time we wish to make a few pertinent statements relative to the needs of condensers employed in certain parts of the receiver.

Condensers of the solid dielectric type are rated in capacity and D.C. operating voltage. Since we can assume that the capacity remains constant, the other item of moment is the voltage rating. The D.C. value is in effect a definite limitation of the effective value of voltage which may be applied to the unit because the peak value of a sine wave is the equivalent of the D.C. rating. Ordinarily it would be possible to say that a condenser rated at 1000 volts D.C. is capable of withstanding a peak voltage of 1000 volts A.C. At this rate the effective value is about 707 volts. Actually, the A.C. rating is not as high. The reason is the variation of A.C. potential encountered in every circuit and to safeguard against the voltages present during a surge, the peak voltage rating is seldom more than about 90 percent of the D.C. rating. According to such rating, the effective value of A.C. applicable to a condenser of a definite D.C. rating is not 70 percent but about 60 to 65 percent. As a matter of fact this rating seems to hold only for condensers rated up to 1000 volts D.C. For higher values, the effective value of A.C. permitted with a condenser rated at a definite value of D.C. is about 50 to 55 percent.

If we consider a conventional B eliminator, the choice of the input filter condenser is determined by the effective or peak value of voltage applied to the anodes of the rectifiers. Assuming 700 volts per anode, the minimum rating of the condenser used as the input filter condenser is 1000 volts D.C.

The other values are determinable by the maximum voltages present in the respective parts of the circuit. However, one must remember that the full load is not applied to the eliminator the moment that the line switch is closed. In the event that the time lag of the filaments in the receiver, particularly that of the tubes in the output system is greater than that of the rectifier tube, the condensers in the filter are subject to voltages in excess of the values present during full load. It is our suggestion that whenever possible the actual D.C. voltage rating should be at least 100 percent more than the maximum voltage encountered during full load.

Particular attention should be paid to the output tank condenser. This unit bears the brunt of the burden when the receiver is turned off. Strange as it may seem, the output tank condenser rather than the input condenser is the one most frequently ruptured.

VOLTAGE RATING OF BYPASS CONDENSERS.—As a general rule the bypass and the blocking condenser are one and the same. We have decided upon a separate heading for bypass condensers because we feel that the correct selection of a bypass condenser as far as voltage rating is concerned, warrants the space. One would be surprised to learn the number of receiver difficulties attributable to defective bypass condensers. We can recall in days gone by the number of audio amplifiers which failed because the blocking condenser used in the impedance coupled system failed to withstand the potentials applied. The bypass condensers in the output system are of particular importance. Once again if the time lag of the tubes in the output system is in excess of the lag of the tubes, the voltage present across some of the voltage divider and voltage reducing resistances may be from 50 to 75 tended for application in a filter is suitable for use as a bypass condenser if the capacity of the condenser is suitable for the position in question. Then again a condenser intended for bypass work is applicable to a filter system if the voltage rating and capacity are suitable. If the voltage rating and capacity are suitable all fixed solid dielectric condensers are interchangeable.

BYPASS CONDENSER IN DETECTOR PLATE CIRCUIT.—Table A, figures 63 and 64 show the normal positions of the bypass condenser C in the detector plate circuit. Figure 64 in Table A illustrates the application of the condenser when the plate circuit contains a radio frequency choke. The arrangement remains the same if the coupling unit in the plate circuit is a resistance instead of a choke or transformer primary.

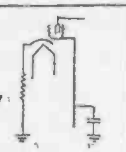
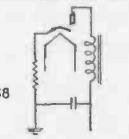
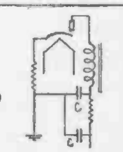
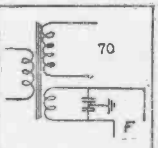
	67 	68 	69 	70 
Type of Dielectric	PAPER	PAPER	PAPER	PAPER
Average Value	.5 mfd.	1. mfd.	1. mfd.	.5 mfd.
Limits	.25 - 1.mfd.	.5 - 2.mfd.	.5 - 1. mfd.	.1 - 1. mfd.
Short Wave Receivers	.05 - .5 mfd	As above.	As above.	As above.
Notes	Voltage rating 200 V minimum. At least 2 x PV	Voltage rating 200 V minimum. At least 2 x PV	Voltage rating 200 V minimum. At least 2 x PV	Voltage rating 200 V minimum.

Table B

BYPASS CONDENSER IN DETECTOR PLATE CIRCUIT EQUIPPED WITH LOW PASS FILTER.—What is meant by a low pass filter is indicated in Table A, figure 65. The inductance L and the capacities C and C1 when combined constitute a low pass filter incorporated into the detector plate circuit to limit the radio frequencies passed to the audio system. When L is of 10 millihenrys the values of C and C1 are .0005 mfd. With an inductance of 5 millihenrys, C and C1 are of .001 mfd. each.

BYPASS CONDENSER IN RADIO FREQUENCY PLATE CIRCUIT.—Early model receivers did not make use of plate circuit bypass capacities. When first introduced, they ranged in capacitance from .006 mfd. to approximately .01 mfd. The specific values employed during the past four or five years are .1; .25; .3; .5 and 1. mfd. As to replacement, we have tried various values between .25 and 1. mfd. and have found that while there is a difference in effect any unit within this range will function in a satisfactory manner. For circuit connection see Table A, figure 66.

BYPASS CONDENSER IN SCREEN GRID CIRCUITS.—See Table B, figure 67.

AUDIO FREQUENCY PLATE CIRCUIT BYPASS CONDENSER.—The bypass condenser finds application in the plate circuit of the audio frequency amplifying tubes, but must be differentiated from the capacities employed in connection with the audio coupling device to produce a certain type of audio frequency response. See Table B, figure 68.

AUDIO FREQUENCY PLATE CIRCUIT FILTER CONDENSER.—Several installations make use of one or more bypass condensers in the audio plate circuit, functioning in conjunction with a combination filter and voltage reducing resistance. See Table B, figure 69.

BYPASS CONDENSER ACROSS A.C. FILAMENT OR A.C. FILAMENT SHUNT RESISTANCE.—Several receivers make use of bypass condensers connected across the filament circuit or across the center tapped filament shunt resistances. Two condensers so used are shown in Table B, figure 70.

CONDENSER ACROSS BATTERIES IN D.C. RECEIVERS.—Quite a few receivers designed to operate with batteries make use of a bypass condenser across the battery taps. Such condensers are really equivalent to bypass units located in the respective plate circuits.

DETECTOR PLATE FILTER RESISTANCE BYPASS CONDENSER.—It is quite customary to find a filter system in the detector plate voltage circuit. Such a filter system consists of a voltage reducing resistance operating in conjunction with a bypass condenser. See Table C, figure 71. In some cases the filter circuit makes use of two resistances and two condensers. See section devoted to "Resistances Located in Plate Circuits."

BYPASS CONDENSER ACROSS R.F. BIAS RESISTANCE.—If each tube has its own bias resistance, each resistance has its own associated bypass capacity. See Table L, figure 108.

BYPASS CONDENSER ACROSS DETECTOR BIAS RESISTANCE.—See Table C, figure 72.

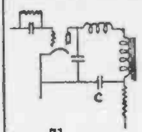
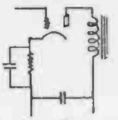
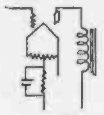
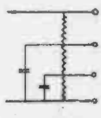
	 71	 72	 73	 74
Type of Dielectric	PAPER	PAPER	PAPER	PAPER
Average Value	.5 mfd.	1. mfd.	1. mfd.	1. mfd.
Limits	.25 - 1. mfd.	.5 - 2.mfd.	.5 - 2. mfd	.5 - 4 mfd
Notes	The tendency is to employ the value quoted as average or the upper limit.	The lower limit in the first audio stage and the upper limit in the detector and other audio.	The lower limit in the first stage and the upper limit in remaining stages.	1. mfd seems standard except across detector where higher value is often used. See text.

Table C

BYPASS CONDENSER ACROSS A.F. BIAS RESISTANCE.—Because of the lower frequencies, the bypass condenser connected across the A.F. grid bias resistance is usually larger than that connected across the R.F. bias resistance. See Table C, figures 72 and 73. The 4 mfd. unit finds application in some single tube power amplifier output stages.

Grid bias bypass condensers are ofttimes omitted across the bias resistance in push-pull stages.

BYPASS CONDENSER ACROSS VOLTAGE DIVIDER SECTIONS.—See Table C, figure 74. As a point of information, difficulty due to excessive audio regeneration (motorboating) may be solved by the use of a 2 mfd. or 4 mfd. capacity across the detector plate voltage tap and the B minus terminal of the divider. If the audio grid bias voltage is secured from the eliminator voltage divider it is a good idea to use a condenser in excess of 1. mfd. In connection with the bypass condenser connected across the eliminator voltage divider we have the following comment to make. It is possible to select a voltage rating which is suitable for operation during such time when the eliminator is in perfect condition. It is also possible to select a voltage rating which is sufficiently high to withstand the potentials present in the event of an open in the load or in the divider. These items become of moment only in the case of eliminators developed to supply normal voltages in excess of 180 to 200 volts, because the average eliminator intended for the 371 or similar tube in most cases makes use of 400 volt condensers. We realize that some installations employ 300 volt condensers in the output of the filter. As it happens the no load voltage output of an eliminator intended for 180 volts and about 60 or 70 mil output is about 300 to 325 volts. If protection is desired against possible breakdown of the bypass condenser connected across the complete eliminator, which actually is the output filter condenser, the minimum rating should be 400 volts for 180 volt output; 600 volts for 250 volt output and as high as 800 to 1000 volts for the 450 volt output.

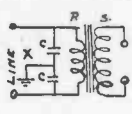
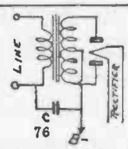
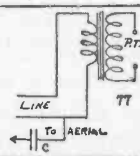
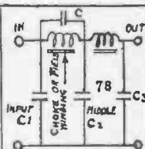
	 75			
Type of Dielectric	PAPER	PAPER	MICA	PAPER - MICA
Average Value	.5 mfd.	.1 mfd.	.00025 mfd.	.2 mfd.
Limits	.1 - 1. mfd.	.05 - .1 mfd	.00025 - .006	.1 - .4 mfd
Notes	Voltage rating at least 300 V for 110 V A.C. line. .1 and .5 most common units	B- assumed to ground. High limit most popular. Used on more recent receivers.	Condenser to Local aerial terminal. Low limit most popular.	Popular values .1, .15, .17, .2, .25, .28, .3, .33. Depends upon L and frequency.

Table D

CONDENSERS IN PRIMARY CIRCUIT OF POWER TRANSFORMER.—A simple capacity filter is often employed across the primary input to the power transformer as shown in Table D, figure 75. This filter consists of two condensers connected in series and shunted across the line, with the midpoint junction "X" grounded. 300 volts D.C. rating should be used for 110 volt A.C. line.

Many modern receiver systems use a condenser connected between one side of the A.C. power mains and the ground as shown in Table D, figure 76.

Another innovation found in the modern A.C. receiver is the use of a fixed capacity between one side of the A.C. power mains and the loop terminal of the receiver or some part of the antenna input circuit, perhaps a tap upon the coil or if the tuning circuits are grounded, to the ground. See Table D, figure 77.

CONDENSER USED IN PARALLEL RESONANT POWER PACK FILTER CIRCUIT.—The modern radio receiving system utilizes better designed filter system in its power pack. One such arrangement makes use of a parallel resonant circuit in one of the filter sections. See Table D, figure 78. Such a circuit does not interfere with the regular structure and consists of a condenser C in shunt with one of the chokes or the speaker field winding. This circuit is resonated to the major hum frequency and serves to reduce this hum better than an ordinary section. Investigation shows that there is a great similarity between all of the values used with the filter choke or the field winding. When replacement is necessary, one can try two values and note results. These values are .15 mfd. and .25 mfd. The difference between the .23 mfd. and the .3 mfd. because of the inherent resistance in the circuit is not very great and a .25 mfd. unit will suffice to cover that range. The .15 mfd. unit should also be tried.

CONDENSER USED IN TAPPED INDUCTOR FILTER SYSTEM.—Another form of special filter circuit is shown in Table E, figure 79. This filter combines the regular filter system and a series circuit in each section. The usual value of capacity employed in the series system, designated as C, is approximately 1 mfd. per unit. This value does not alter the capacitance of the remaining filter condensers.

SOLID DIELECTRIC FILTER CONDENSERS IN A.C. TYPE "B" ELIMINATORS.—There is a certain similarity between B eliminators employed in commercial radio receivers. A common form of filter system is illustrated in Table E, figure 80. Using the rectifier system as the starting point, the condenser nearest the rectifier is usually referred to as the "input" condensers, C1 in figure 80. The condenser connected to the midpoint between the two filter chokes is the "middle" condenser, C2, in figure 80 and the condenser connected across the output of the filter system is naturally known as the "output" condenser, C3, in figure 80. Some receiver manufacturers omit the "input" condenser but most organizations include it as a part of the filter, so much so, that it is safe to assume that it is used. The data contained in the Table are applicable solely to solid dielectric filter condensers and NOT TO THE ELECTROLYTIC TYPE.

The selection of the "middle" condenser when used is a matter of experiment although the quoted popular values will serve as a guide.

FILTER CONDENSERS IN TWO SECTION FILTER WITH CHOKE INPUT.—This type of filter system is employed in a few commercial eliminators and is shown in Table F, figure 81. The "input" condenser C1 is omitted. The remaining condensers are as set forth in figure 80. Choke input is not used on 25-40 cycle lines.

FILTER CONDENSER IN THREE SECTION DIRECT CURRENT B ELIMINATOR.—This form of filter resembles that shown in Table E, figure 80. Because of the higher hum frequency the filter condensers are of lower capacity. The average combination is 1, 2 and 2 mfd. (This type of eliminator should not be confused with the systems employed in commercial direct current receivers.) See "B Voltage Distribution in Direct Current Receivers."

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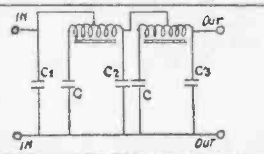

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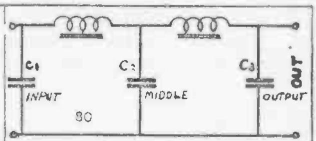


Type of Dielectric	PAPER	Limits for C1, C2 and C3 used in practice	PAPER	Limits for C1,C2 and C3 used in practice
Average Value C1	2. mfd.	1. - 4 mfd.	2. mfd.	1. - 4 mfd.
Average Value C	1. mfd.	1. - 4 mfd.		
Average Value C2	2. mfd.	1. - 4 mfd.	2. mfd.	1. - 4 mfd.
Average Value C3	4. mfd.	2. - 6 mfd.	4. mfd.	2. - 6 mfd.
Notes.	This type of eliminator system is most popular with Strom-Carl. The presence of the special circuit capacities does not influence the value of C1, C2 and C3 with respect to the normal filter.		The above limits as quoted apply more to modern than to the very old type receivers. Analysis shows that 5. mfd. was not uncommon at C1 and as high as 8. mfd. at C3 in old systems.	
For Voltage Rating see text.				

Table E

FILTER CONDENSERS IN SINGLE SECTION B ELIMINATOR FILTER.—A single section filter makes use of two filter condensers and a single choke. It is used in eliminators intended for operation upon 50 or 60 cycle current. It seldom finds application upon 25 and 40 cycle lines. The values of capacity are usually greater than in the two section filter. Such an arrangement may be represented by the first section of two section filter shown in Table E, figure 80. The "input" capacity C1 remains as shown, but the "middle" condenser becomes the output condenser. In such cases, the usual values are either 2 and 4 mfd. or 4 and 4 mfd. respectively. In some instances, power amplifier filters make use of 3 and 3 mfd.

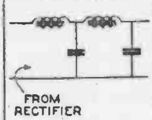
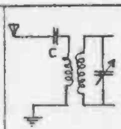
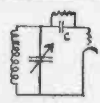
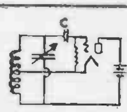
	 81	 82	 83	 84
Type of Dielectric	PAPER	MICA	MICA	MICA
Average Value	Same as in three section filter.	.0001 mfd.	.00025 mfd.	.002 mfd.
Limits	See three section filter	.00005 - .00025	.00025 - .0003	.001 - .0025
Notes	The fact that two condensers are used in the filter does not cause an increase	.0001 and .00025 mfd are the most frequently employed units. The average value is most popular	There seems to be standardization at .00025 mfd.	Any value within the limits is suitable. A .0005 mfd. will do in an emergency.

Table F

BYPASS CONDENSER ACROSS BIAS RESISTANCE IN ELIMINATOR.—As in the case of the conventional voltage divider bypass condenser, the usual value of capacity connected across the C bias resistance located in the eliminator is 1. mfd. Experience shows that higher values of capacity afford somewhat better stability.

VOLTAGE RATING OF GRID BIAS RESISTANCE BYPASS CONDENSERS.—While it is true that the voltage present across the bias resistance is usually low, the minimum voltage rating should not be less than 200 volts D.C. This applies equally well to the condensers connected across bias resistances in the radio frequency, audio frequency or eliminator systems. The fact that a single bias resistance supplies the voltage for more than one tube is of no consequence.

FIXED CONDENSER CONNECTED IN AERIAL CIRCUIT.—Quite a few commercial receivers employ a fixed condenser in the aerial circuit so as to adapt the system to either a long or a short aerial. See Table F, figure 82.

GRID CONDENSER IN DETECTOR CIRCUITS.—The usual value of grid condenser in broadcast and long wave circuits is .00025 mfd. For short wave receivers the value is about .0001 mfd. See Table F, figure 83.

GRID CONDENSER IN SERVICE TEST OSCILLATORS (Self Modulated.).—The grid condenser employed in service test oscillators of the self modulated type is shown in Table F, figure 84. Either value is suitable since the tone may be adjusted by correct selection of the grid leak.

CONDENSERS IN TONE CONTROL SYSTEMS.—One can find a definite similarity between various systems insofar as the

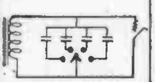
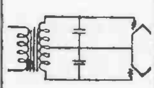
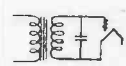
	 85	 86	 87	 88
Type of Dielectric	MICA	MICA	MICA	MICA
Average Value	.0005 - .001	.00025 mfd.	.00025 mfd.	.001 mfd
Limits	.0001 - .002	.0001 - .0005	.0001 - .001	.0005 - .0025
Notes	The switch is of fan blade	Like values of capacity are used in each		
	type. At full it covers all condensers.	half of the push pull stage.		

Table G

specific value of the condenser is concerned. It is necessary when considering tone control arrangements to speak about one system at a time. This discussion is not intended to cover means whereby the amplifying characteristic of an audio system may be continually varied. Instead it is intended as a summary of existing practical systems. See Table G, figures 85, 86, 87 and 88. One system makes use of one or a number of fixed capacities across the secondary of the audio frequency transformer in transformer coupled systems. The higher the value of capacity the lower is the upper cutoff, or the greater is the attenuation of the upper audio register.

CONDENSER USED IN RESISTANCE-CAPACITY TONE CONTROL.—The condenser-resistance series combination in shunt with the secondary of the audio frequency transformer is used in conjunction with conventional audio units and with push-pull units. The series system shunts the complete secondary winding as shown. In the meantime the popular values of capacity employed in such arrangements are between .002 mfd. and .006 mfd. The capacity is fixed and the resistance is variable. In each case a definite maximum value of resistance is employed in conjunction with any one condenser. See Table H, figure 92.

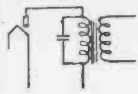
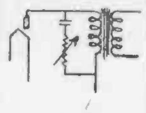
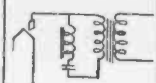
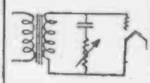
	 89	 90	 91	 92
Type of Dielectric	MICA	MICA	MICA	MICA
Average Value	.006 mfd.	.05 mfd.	.0125 mfd.	.005 mfd.
Limits	.002 - .04 mfd.	.01 - .25 mfd.	.005 - .02 mfd.	.002 - .006 mfd
Notes	Exact value depends upon position. Across interstage units, lower limit. See text.	Exact value depends upon value of R and effect desired. Also transformer. See text.	Exact value depends upon value of L, effect desired and transformer. See text.	Most popular values approximate upper limit. See text Resistances.

Table H

A predetermined tonal characteristic is also produced by fixed condensers connected across the primary side of the audio frequency transformer and in some cases across the primary of the output transformer. One condenser is used across the entire winding. The usual value is found within a range extending from .002 mfd. to about .006 mfd. across the primary of the audio transformer and between .002 and .04 mfd. across the primary winding of the output transformer. See Table H, figure 89.

Some systems are equipped with a series circuit consisting of a fixed condenser and a fixed resistance, connected across the first stage audio frequency transformer primary. The usual value of capacity employed in such circuits approximates .01 to .25 mfd. See Table H, figure 90.

Several receivers make use of resonant circuit consisting of a choke and a fixed condenser in series, across a transformer primary as shown in Table H, figure 91. Since the system is designed to attenuate one frequency, calculation is necessary when the constants are desired. See "Filters."

Tone control is also accomplished in resistance and impedance coupled systems by connecting fixed capacities across either the plate resistance or choke or the grid resistance or choke. Because of the greater impedance of the grid circuit device, the capacity is more effective at that point. The usual value of capacity used in such places is within the .001 mfd. to .004 mfd. range.

SPEAKER FILTERS.—Speaker filters are in reality low pass filters. The wiring diagram of a speaker filter is shown in Table I,

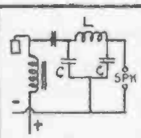
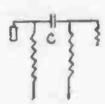
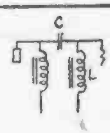
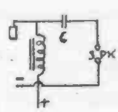
	 93	 94	 95	 96
Type of Dielectric	MICA	MICA	MICA- PAPER	PAPER
Average Value	.01 mfd.	.01 mfd	.25 mfd.	2 mfd.
Limits	Generally .01	.006 - .5 mfd.	.001 - 1. mfd.	1. - 4 mfd.
Notes	The exact value is a function of the choke L and the desired cutoff.	Most common values are from .01 to .1 mfd.	If tuned with L .001 -.15 within audio band. Greater than .15 below audio band When L is 200 H.	Old receivers use 4 mfd. More modern systems use 1. to 2 mfd.

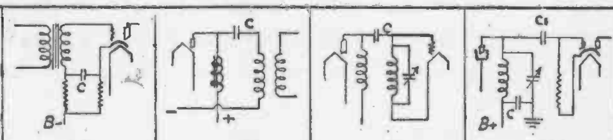
Table I

figure 93. The filter capacity can be made any value, according to the value of the choke but because of the similarity of speakers and output tubes, there is a great similarity between the filter constants. The usual cutoff is 5000 cycles. L is about 10 millihenrys.

CONDENSERS ACROSS SPEAKERS.—Many old type receivers were equipped with condensers connected across the speaker terminals. The range of capacities used with magnetic (cone) speakers extends from .003 mfd. to about .01 mfd. with .005 mfd. to .006 mfd. as the most frequently used units.

OUTPUT COUPLING CONDENSERS.—This unit is the capacity connected between the speaker output circuit and the speaker; popular in many installations operated with magnetic (cone) type of speakers. See Table I, figure 96. As a matter of fact many receiver systems equipped with dynamic speakers are arranged for operation with cone speakers and incorporate a coupling condenser. See "Speakers." Replacement with a 2 mfd. unit will be found satisfactory in all cases.

CONDENSERS USED IN PARALLEL FEED AUDIO SYSTEMS.—Many receivers, old and new, employ parallel feed



	97	98	99	100
Type of Dielectric	PAPER	MICA - PAPER	MICA	MICA
Average Value	1. mfd.	.25 mfd	.000005 mfd.	.05 mfd
Limits	.1 - 1.mfd.	.1 - .5 mfd	.000005 - .00001	.05 - .5 mfd.
Notes	The most popular values are between .5 and 1. mfd.	The exact value depends upon the transformer and the tube. The average is most frequent.	This condenser is usually a part of the R.F. transformer.	In R.F. systems .05 - .1 mfd. In series filament tuned circuits .1 - .5 mfd.

Table J

in the audio amplifying system, thereby keeping the tube plate current out of the coupling device, particularly if it is an alloy core transformer. The wiring arrangement of the capacity in such cases is shown in Table J, figure 98.

CONDENSERS IN GRID FILTER CIRCUITS (A.F.).—The demand for stable operation has created the grid filter circuit shown in Table J, figure 97 and the capacity employed in this isolating circuit is frequently referred to as a bypass condenser.

CONDENSER IN AUDIO PLATE FILTER CIRCUIT.—Filter systems consisting of one or more resistances and one or more condensers are utilized in many plate circuits and an idea of the circuit structure can be had by referring to the associated illustration in Table M, figure 111.

CONDENSER IN GROUND CIRCUIT.—A receiver designed for operation on D.C. lines makes use of a condenser in the ground-minus circuit, thereby precluding shorting of the house mains when the ground lead is attached. Such condensers range in value from .1 mfd. to approximately 6 mfd. The most frequently used values are .1 mfd. and .5 mfd. A few installations, use condensers of from .003 to about .01 mfd.

FIXED CONDENSER USED IN PARALLEL FEED RADIO FREQUENCY AMPLIFIER PLATE CIRCUIT.—A few radio frequency amplifiers are equipped with parallel plate feed. The position of the condenser utilized as an isolating and as a coupling condenser is similar to that shown in Table J, figure 98. As to position it is identical to the audio frequency arrangement indicated. It differs solely in capacitance value. The most frequently employed values are .003 mfd. and .006 mfd. A few instances of .0001 mfd. and .00025 mfd. are known, but for general replacement, the .006 mfd. unit will suffice. It should be understood that these values do not pertain to the special parallel tuned systems utilized in connection with some tuned radio frequency receivers.

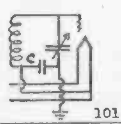
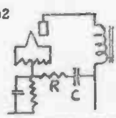
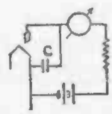
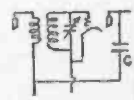
	 101	102 	 103	 104
Type of Dielectric	PAPER	PAPER	PAPER	MICA
Average Value	.25 mfd.	.1. mfd.	4. mfd	.002 mfd.
Limits	.1 - .5 mfd.	.1 - 2. mfd.	2.- 4. mfd	.0005 - .002
Notes	The most popular values range between .25 and	The exact value is a function of R which if made	This capacity is necessary so as to nullify the	This system is used in a few installations.
	.5 mfd.	variable allows a range of C.	effect of the meter. The higher value is used	The upper limit is most popular.

Table K

CONDENSER EMPLOYED AS ISOLATING AND COUPLING UNIT IN SCREEN GRID TUNED PLATE RADIO FREQUENCY SYSTEMS.—The circuit arrangement we refer to is illustrated in Table J, figure 100. The isolating and coupling capacity C1 isolates the grid of the succeeding tube from the plate of the preceding tube. For the broadcast band .005 mfd. to .006 mfd. is suitable. In short wave systems it varies from about .0001 mfd. to .001 mfd.

FIXED COUPLING CONDENSER IN TUNED RADIO FREQUENCY SYSTEMS.—This capacity is connected between the plate end of the plate winding and the grid end of the grid tuning coil. It is shown in Table J, figure 99, and is a part of the radio frequency transformer.

BLOCKING CONDENSER USED IN SCREEN GRID TUNED PLATE OR TUNED GRID CIRCUITS.—This condenser is employed in order to isolate the tuning condensers so that they may be connected to ground, as for example in a gang unit with grounded rotor, wherein some of the sections are used to tune coils which are carrying the tube plate current. The system is shown in Table J, figure 100.

BLOCKING CONDENSER IN D.C. SERIES FILAMENT GRID CIRCUITS.—These condensers are employed in order to isolate the grounded condenser rotor from the inductance being tuned and normally connected to some part of the filament system so as to secure the required grid bias. See Table K, figure 101.

FIXED CONDENSER AS ISOLATING AND COUPLING UNIT IN RESISTANCE-CAPACITY COUPLED AUDIO FREQUENCY AMPLIFIER.—The value of the condenser employed as shown in Table I, figure 94 depends to a large degree upon the other constants in the circuit, particularly upon the type of tube used, the values of the plate and grid resistances and the frequency response characteristic desired. For resistance-capacity combinations see section devoted to "Resistances."

The general recommendation for this condenser used in resistance-capacity coupled audio amplifiers intended for television operation with type 324 screen grid tubes is from .2 mfd. to 1. mfd. With the type 340 tubes, the usual recommendation is from .01 mfd. to about .1 mfd. although it is possible to employ the range cited in connection with the 324 type of tube.

FIXED CONDENSER USED IN IMPEDANCE COUPLED AUDIO AMPLIFIER.—The circuit arrangement is shown in Table I, figure 95. The isolating and coupling capacity C may be utilized to tune the grid choke (also serving as grid leak), constituting a series resonant circuit. Based upon a grid choke of from 150 to 225 henrys, capacity values of from .2 to 1. mfd. will tune the grid choke below the normal audio band, i.e., below 30 cycles. On the other hand capacities between .001 and .15 mfd. will tune these chokes to some frequency between 30 and 200 cycles. A table of resonant frequency is given in the section devoted to "Useful Radio Tables."

As to the frequency response curve at the resonant frequency, the shape of the curve is quite broad because of the resistance inherent in the grid choke.

PLATE BLOCKING CONDENSER USED IN PARALLEL FEED RADIO FREQUENCY TEST OSCILLATORS.—The condenser used to link the plate circuit with the oscillating system is shown in Table M, figure 112. Its value depends in a measure upon the frequency range of the oscillator. These condensers should withstand at least three times the voltage applied to the tube plate.

PLATE CIRCUIT BYPASS CONDENSER IN VACUUM TUBE VOLTMETER.—In order to nullify the effect of the plate current indicating meter, when the range of frequency covered with the device is quite extensive, it is best to use fairly high values of capacity. A 4 mfd. unit is not too high, despite the fact that fairly good results are secured with a 2 mfd. unit. See Table K, figure 103.

FIXED CONDENSER ACROSS C BIAS BATTERIES IN TUBE VOLTMETERS.—A 2 mfd. condenser will serve well in this position. If not available, a 1. mfd. unit will suffice.

FIXED CONDENSER EMPLOYED IN DYNAMIC SPEAKER POWER SUPPLY RECTIFIER.—Some installations make use of a separate full wave rectifier to supply the excitation current for the dynamic speaker field coil. Such rectifiers dispense with the usual form of filter and make use of but a single 2 mfd. condenser. Wherever a complete filter system is used in such rectifiers, the values mentioned in Table E are applicable. The fact that the rectifier may be of the disc type is of no consequence.

SOLID DIELECTRIC FIXED CONDENSERS USED IN NOISE FILTERS.—(See Interference Filters.)

HUM NEUTRALIZING SYSTEM CONDENSER.—A few receivers make use of special hum neutralizing circuits consisting of a capacity and a resistance connected between the B plus end of the audio transformer winding and the filament center tap or cathode. This is shown in Table K, figure 102. For data other than that contained in the table, see Filters.

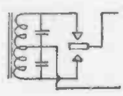
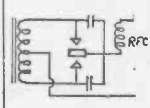
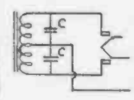
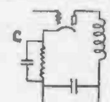
	 105	 106	 107	 108
Type of Dielectric	MICA - PAPER	MICA	MICA-- PAPER	PAPER
Average Value	.1 mfd.	.02 mfd.	.1 mfd.	.5 mfd.
Limits	.05 - .1 mfd.	.01 - .05 mfd.	.05 - .1 mfd.	.1 - 1. mfd.
Voltage Rating	At least 1000 volts D.C. for 350 volt wind-	At least 1000 volts D.C. for 350 volt wind-	At least 1000 volts D.C. up to 600 V A.C.	At least 200 volts D.C. minimum.
	ings.Two times peak voltage.	ings.Two times peak voltage.	r.m.s.	

Table L

FIXED REGENERATION CONDENSER.—A few tuned radio frequency receivers make use of a fixed regenerating condenser connected between the plate of the detector tube and the B plus end of the primary of the radio frequency transformer in the preceding stage. This is shown in Table K, figure 104.

FIXED CONDENSER ACROSS DYNAMIC SPEAKER FIELD WINDING EMPLOYED AS CHOKE IN HIGH VOLTAGE LOW CURRENT RECTIFIER.—This condenser serves to form a parallel resonant circuit with the speaker field winding as the inductance and the combination is the equivalent of the parallel resonant circuit shown in the first section of the filter illustrated in figure 18. The exact value of the condenser depends upon the frequency of the hum in the rectified output and the inductance of the field winding. With a certain similarity in high voltage-low current speaker field coils, this condenser would be of some value between .1 and .35 mfd.

BUFFER CONDENSERS IN ELIMINATORS.—Rectifier power supply systems which utilize the gaseous (Raytheon) rectifier make use of two buffer condensers placed as shown in Table L, figures 105 and 106. Such buffer condensers when employed in conjunction with the filament type of rectifier are shown in Table L, figure 107.

FIXED CONDENSER USED IN SCRATCH OR PEAK FILTERS.—Such a condenser is a part of a series circuit resonated to a certain frequency and usually connected in shunt with the phonograph pickup. The filter is used to remove the scratch frequency. Across the speaker it is employed to reduce the height of a peak at a predetermined frequency. These two systems are shown in Table M, figures 111 and 112 respectively. For design details see "Filters."

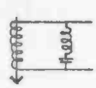
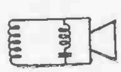
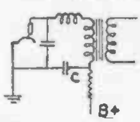
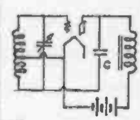
	 109	 110	 111	 112
Type of Dielectric	Mica - Paper	Paper	Paper	Mica - Paper
Average Value	.006 mfd. See Notes	See Notes	1. mfd.	Short Waves .001 Broadcast .005 Intermediate .01
Limits	Depends upon inductance and frequency	Depends upon inductance and frequency	.5 - 2. mfd	Audio .5 See Notes
Notes	See Filter Tables for the values required	See Filter Tables for the constants requir-	The upper limit is preferred. The average	Broadcast Freq. .001 - .01 mfd. Intermediate
	for filters of this type. Resonant to 6000 cy.	ed for various resonant frequencies.	value is most popular.	.005 - .02 mfd. Audio Freq. .1 - 1. mfd.

Table M

CHAPTER 8

ELECTROLYTIC FIXED CONDENSERS

ELECTROLYTIC condensers are of two general classifications, namely "wet" and "dry." The former signifies that a fluid electrolyte is employed. The latter, that the electrolyte is a non-aqueous compound. Albeit the designation "dry," the electrolyte in the unit is a paste. Typical of the "wet" type of electrolytic condenser is the Mershon. Typical of the "dry" type of electrolytic condenser are the various makes of "A" condensers and several high voltage-low capacity electrolytic condensers known under various trade names, such as the Aerovox Hi-Farad.

CHARACTERISTICS OF WET ELECTROLYTIC FIXED CONDENSERS.—One of these characteristics is the self healing property of the unit. The application of a voltage in excess of the rating will cause a flashover or a puncture of the dielectric but it is only momentary. The next cycle of current heals the break and the unit is restored to its original condition. If the excessive voltage is applied for a prolonged period of time damage will result. Another characteristic of this type of condenser is that it is polarized, i.e., has a negative and a positive polarity. This means that its application is limited ONLY TO D.C. or PULSATING CURRENT and the condenser is not suited for continuous operation upon A.C. circuits. The third characteristic is a definite amount of leakage current, small in comparison with the normal interpretation of current but large in contrast to the leakage current through a solid dielectric unit.

The fourth characteristic of the "wet" condenser is an apparent variation in capacity with frequency, decreasing as the applied frequency is increased. A few figures may be of aid. Assuming a capacity of 10 mfds. as measured at 60 cycles, this same condenser will have an apparent capacity of 7.8 mfd. at 480 cycles.

RANGE OF CAPACITIES AVAILABLE IN WET ELECTROLYTIC TYPE OF CONDENSER.—These condensers are available in various forms. At present they are made with single, double, triple and quadruple anodes. The single anode type is a single condenser in a container. The double anode unit is a container with a common negative terminal (the can) and two separate capacities, etc. The single anode units are available in capacities from about 8 mfd. to about 72 mfd. The multi-anode condensers are made in various sizes from 8 mfd. to 18 mfd. per anode.

APPLICATION OF THE WET ELECTROLYTIC CONDENSER.—The container is the negative terminal of the condenser and the anode is the positive terminal. When the container houses several anodes, these may be connected in parallel to constitute a single condenser of a capacity equivalent to the sum of the capacity of the anodes. Thus, four 8 mfd. sections may be connected in shunt to form a single condenser of 32 mfds.

When it is desired to increase the operating voltage, individual condensers may be connected in series. Series connection is not possible between the anodes contained within the same housing. In order to connect electrolytic condensers in series, each condenser must be a separate unit, the anode of one being connected to the container of the other. When so arranged it is best if the voltage applied across each condenser does not rise about 375 volts. A 50,000 ohm resistance rated at about 5 watts should be shunted across each individual condenser unit, between its respective anode and cathode (container).

As to its field of utility, it may be employed wherever a capacity of the equivalent value is required and where the leakage current is not detrimental. This means that it may be employed as a battery bypass unit, as a filter condenser, etc., but *not as an isolating or blocking condenser.* Neither is it suitable as a ground condenser in direct current electric receivers.

The unit is applicable in high voltage systems if the required number of individual sections are connected in series and the proper precautionary measures instituted.

VOLTAGE RATING OF WET ELECTROLYTIC CONDENSERS.—Investigation discloses that the usual peak voltage rating is about 400 to 440 volts D.C. Two such units connected in series and shunted by protective resistances are suitable for application across a 750 volt line. When connected in series the maximum voltage per unit should not exceed 375 volts.

WET ELECTROLYTIC CONDENSER EMPLOYED IN RADIO RECEIVERS.—The wet electrolytic condenser is employed as the filter condenser in quite a few radio receivers. The usual value of capacity represented by each anode in such systems is 8 mfd. See Table N, figure 113.

LEAKAGE CURRENT THROUGH WET ELECTROLYTIC CONDENSERS.—The normal leakage current through a perfect wet electrolytic condenser is about .1 milliampere per microfarad. If the condenser has been idle for a while this current may approximate .25—.5 milliampere, with a gradual decrease to .1 milliampere in about 48 to 72 hours.

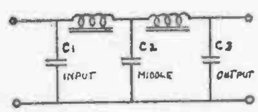
PECULIARITY OF THE WET ELECTROLYTIC CONDENSER.—The electrolyte used in the wet condenser will freeze to a mushy state at about 29° F. and to a dry state after a period of about 5-6 hours at 18° F. In the case of the former, it will remain operative as long as there is moisture in contact between the container and the film. When frozen dry and placed into operation it will be inoperative, but will resume a normal state after about 15 minutes.

THE DRY ELECTROLYTIC CONDENSER.—There are various types of dry electrolytic condensers, primarily segregated according to capacity. Whereas in the wet electrolytic condenser, the electrolyte is a fluid, in the dry unit, it is a non-aqueous composition.

APPLICATION OF 3 TO 12 VOLT DRY ELECTROLYTIC CONDENSERS.—When employed in "A" eliminator filters the usual values are 2000 mfd. per unit, two such units being used in a single section filter. When used in connection with a dry disc low voltage-high current rectifier to supply the excitation current for a dynamic speaker field winding the usual capacity is around 1500-2000 mfds. When used to filter noises from low voltage D.C. generators capacity units as high as 10,000 mfds. may be employed. The filters resemble Table E, figure 80.

APPLICATION OF 25 TO 100 VOLT DRY ELECTROLYTIC CONDENSERS.—These condensers are suitable wherever the voltage range is from 25 to 100 volts. However, it should be understood that because of the character of the condenser, each condenser has its specific voltage rating. Such condensers are suitable for use in C bias eliminators, filters across generators, or wherever the voltage does not exceed 100 volts.

APPLICATION OF HIGH VOLTAGE DRY ELECTROLYTIC CONDENSERS.—These condensers find application in the filter circuits of high voltage low current power pack rectifiers. See Table N, figure 114. These condensers are available in sizes from 1 to about 30 mfds. and when employed in receivers are usually of 2 mfds., 5 mfds., or 8 mfds. Like the wet type of unit more than one condenser or anode may be contained in one housing, the complete unit having a common negative and individual anodes for each of the condensers. Like the wet type of condenser the dry units may be connected in series to enable operation at potentials in excess of the rating of the individual unit. For safe operation it is best not to employ such series combinations at voltages in excess of 450 volts when the condensers are rated at 500 volts peak. A resistance should be connected across each condenser. The value of this resistance may be about 50,000 ohms.



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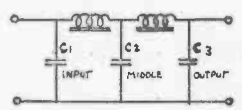

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Type of Electrolyte	WET	Limits for C1, C2 and C3 used in practice	DRY	Limits for C1, C2 and C3 used in practice
Average Value C1	8 mfd.	8 - 15 mfd.	8 mfd.	1 - 8 mfd.
Average Value C2	8 mfd.	8 mfd.	8 mfd.	1 - 8 mfd.
Average Value C3	8 mfd.	8 - 30 mfd.	8 mfd.	1 - 8 mfd.
Notes	Modern systems which employ the wet type of electrolytic condenser invariably use 8 mfd. sections.		The usual values are the average. In some instances 5. mfd. units are used. The lower limit is applied to C1 and the uppor limits to C2 and C3.	
	Some of the old model eliminators employ sections as high as 30 mfd. but they are few in number.			
Voltage Rating	The voltage rating of the conventional wet condensers is about 400 volts peak.		The voltage rating of these units is about 500 volts peak, less when so quoted.	

Table N

LEAKAGE CURRENT OF HIGH VOLTAGE DRY ELECTROLYTIC CONDENSER.—In this respect all of the high voltage electrolytic condensers are in one class and the normal leakage current is about .1 to .5 milliampere per microfarad when the condenser is subjected to a voltage of about 300-350 volts D.C.

LEAKAGE CURRENT OF HIGH CAPACITY-LOW VOLTAGE DRY ELECTROLYTIC CONDENSER.—It is the consensus of opinion of engineers that the normal leakage current of an "A" condenser when tested at about 6 volts D.C. should not exceed between 2 to 3 milliamperes per thousand mfds.

CHAPTER 9

RADIO FREQUENCY CHOKE COILS

THE primary function of a radio frequency choke coil is to retard the flow of radio frequency currents. The designation "radio frequency" is applied in order to show that the device is intended for operation at audio frequencies. As a choke or retard coil, the ordinary radio frequency choke is of little utility in an audio system. As a matter of fact it must be understood that the operation of a radio frequency choke, for that matter any form of choke, is aided or hindered by associated apparatus. Every choke, radio frequency or audio frequency should be used in conjunction with a bypass condenser, unless a special condition exists.

The ideal choke would be one of pure inductance and no capacity, which of course is not available. The closest approximation is one with a low value of capacity and a high value of inductance. Every choke carrying current has a field, hence inductive coupling to other elements is likely and must be nullified whenever possible. In this connection we can state that experiments have shown the tremendous importance of this field in test apparatus and short wave receivers. The best method of nullifying the field surrounding the usual radio frequency choke is to shield it in a separate compartment, for that matter to locate all of the chokes separate from associated equipment.

INDUCTANCE OF R.F. CHOKE USED IN LOW PASS FILTER IN DETECTOR PLATE CIRCUIT.—A very popular arrangement is the installation of a low pass filter in the plate circuit of the detector. Because of the tuned nature of the system the value of inductance employed for the choke is usually much less than that of the average radio frequency choke. The system form. Such a radio frequency choke may be applied to any type of B eliminator providing that the size of wire selected for the winding is capable of carrying the current in the circuit.

RADIO FREQUENCY CHOKES IN NOISE AND INTERFERENCE ELIMINATORS.—See Noise Filters.

D.C. RESISTANCE OF RADIO FREQUENCY CHOKES.—Although it is impossible to quote the D.C. resistance of some of the low inductance chokes, we would be prone to say that a choke rated at 40 millihenrys maximum would not have a resistance of more than perhaps 30 or 40 ohms. The Hammarlund and Samson 85 millihenrys choke has a D.C. resistance of 215 ohms and the 250 millihenrys unit made by these manufacturers has a D.C. resistance of 420 ohms. Investigation of commercial chokes of equivalent inductance shows approximately like values of D.C. resistance.

CHAPTER 10

AUDIO FREQUENCY CHOKES

AUDIO frequency chokes may be divided into three classifications, although there is little physical difference between these units. The first classification is the choke employed in such fashion that its primary purpose is to retard the flow of alternating currents and to prevent sudden variations of direct current. Such is the filter choke in a rectifier eliminator.

The second classification is the use of the choke as a path for the plate voltage and at the same time retard the flow of alternating current. Such is the function of the usual plate filter choke.

The third classification is the use of the choke as a high impedance in the plate circuit of an amplifying tube so that the maximum A.C. voltage is developed across this choke and transferred to the succeeding grid circuit. This function is also found when the choke is used in a parallel plate supply circuit, whereby the tube D.C. plate current is kept out of the transformer primary.

A part of the third classification is the grid choke used in audio amplifiers. In this position the unit serves to present a very high impedance across the grid filament or grid cathode circuit so that the maximum A.C. voltage is impressed across the tube input circuit and at the same time the choke allows the application of the steady grid bias.

USE OF IRON CORE IN AUDIO CHOKES AND THE EFFECT OF DIRECT CURRENT.—The presence of direct current displays a large influence upon the operation of an iron core choke or reactor.

Without attempting to enter upon a technical discussion, audio frequency chokes are usually constructed with magnetic cores. The presence of this core increases the inductance of the winding and by increasing the inductance, increases the reactance and impedance of the complete unit to the flow of alternating currents.

speaker field winding as one of the chokes. The position of this winding as a filter choke is determined by the current requirement. When the current required by the field coil is that to be found flowing through the filter, the field may be used as one of the chokes or it may be added as a separate choke. The usual resistance of such a winding varies between 1000 and 5000 ohms.

SPEAKER FIELD AS COMBINATION CHOKE AND VOLTAGE REDUCING RESISTANCE.—The dynamic speaker field is often used as a combination filter choke and voltage reducing resistance. When so used it replaces one of the voltage reducing resistances in the voltage divider. In some cases, the use of the field as a filter choke combines the function of filter unit and voltage reducing resistance.

A.F. CHOKE AS PLATE FILTER CHOKE IN PUSH-PULL STAGE.—Audio frequency chokes find application as plate filter chokes in push-pull systems as shown in Table P, figure 119. The value of this choke seldom exceeds 40 henrys. An optimum value for use in public address systems is about 15 henrys. Such plate filter chokes are not used in conventional receiver systems. It is also significant to note that such a system is the exception to the rule that a bypass condenser is used in conjunction with filter chokes.

CHOKES USED IN DIRECT CURRENT B ELIMINATORS.—The usual direct current B eliminator filter resembles that shown in Table P, figure 120. Because of the higher frequency to be filtered it is not necessary to employ high values of inductance, bearing in mind that the usual range of filter capacities remains the same. The inductance of such chokes need not exceed 10 to 15 henrys. It is customary however in many receivers to use similar chokes for A.C. and D.C. type eliminators so that the constants given in Table P, figure 120 are applicable.

FILTER CHOKES USED IN "A" BATTERY ELIMINATORS.—The filter choke used in the "A" eliminator is somewhat different than that employed in "B" eliminator systems. In view of the high current and low voltage, it is imperative that the D.C. resistance of the chokes be very low. Accordingly the value of inductance is greatly reduced. To compensate for this condition very high values of filter capacity are employed. The structure of an "A" battery eliminator is shown in Table P, figure 122. For the values of capacity used in "A" eliminators see section devoted to "Application of 3 to 12-Volt Dry Electrolytic Condensers."

PLATE FILTER CHOKE USED IN SINGLE TUBE AUDIO STAGES. The plate choke used in single tube audio frequency amplifiers is shown in Table Q, figure 123. This choke is most frequently employed in public address systems and does not find application in the ordinary run of receivers. The value of inductance varies over quite a range as shown in the table and the choke is employed in conjunction with a bypass condenser, usually of from 1. to 2. mfd.

AUDIO FREQUENCY CHOKE USED AS PARALLEL FEED CHOKE.—The application of the parallel feed choke in audio frequency amplifiers, prominent in public address systems is shown in Table Q, figure 124. The inductance used covers quite a range of values. As a general rule, the higher the inductance, consistent with the ability to carry the current required by the tube, the better the function. Prominent values are 100, 300 and 600 henrys.

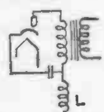
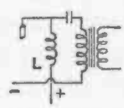
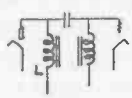
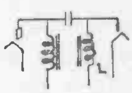
	 123	 124	 125	 126
Type of Core	Standard	Standard Alloy	Standard Alloy	Standard Alloy
Range of Inductance	100 - 600 H	100 - 1000 H	100 - 1000 H	100-1500 H
D.C.Resistance Ohms	500 - 1500	500 - 6000	500 - 6000	1000 - 6000
Notes	The most common value of D.C. resistance is about 1000 ohms	Between 500 and 2000 ohms most frequent. Upper limit with alloy core unit.	Between 500 and 2000 ohms most frequent. Upper limit with alloy core unit.	Between 500 and 2000 ohms most frequent. Upper limit with alloy core unit.

Table Q

AUDIO FREQUENCY CHOKE USED AS PLATE COUPLING UNIT.—The higher the value of the plate load impedance the greater the voltage transfer from the tube to the load. The application of the audio frequency choke as the plate coupling unit is shown in Table Q, figure 125. When used as a separate unit and not housed with the grid choke, the value of L may approximate between 100 and 1000 henrys, the higher the better. A popular value in receivers is 200 henrys; in public address amplifiers, between 600 and 1000 henrys.

AUDIO FREQUENCY CHOKE USED AS GRID LEAK.—Although the schematic in Table Q, figure 126, shows an impedance coupled stage, an audio frequency choke may be employed as the grid leak with a resistance plate load. Since the grid choke is not called upon to carry any current very high values of inductance have been developed for this position, namely 1000 and 1500 henrys. The usual values employed in conventional receivers are as quoted in the table. Quite a few receivers and home constructed amplifiers use 200 henry chokes in this position.

The grid choke may be resonated in a series circuit with the blocking capacity. For resonant values and constants, see Filters.

CHARACTERISTICS OF ALLOY CORE CHOKES.—Whereas magnetic core chokes have been used for a long period it is but recently that alloy cores have been employed. By virtue of high permeability a very high value of inductance is secured. However, such chokes are also beset with certain definite operating requirements. One of these is the limitation of the current flowing through the winding. The action of excessive current is not only to reduce the inductance but to also damage the core material, lowering the permeability and therefore the inductance of the complete winding. Thus it is necessary to safeguard against excessive plate current through windings wound upon alloy cores. Alloy core windings are used where the current is small or negligible. Another peculiarity of such alloy cores is that physical shock such as may be occasioned when the unit is dropped to the floor, will also reduce the effectiveness of the core by damaging the core material.

GROUNDING IRON CORE CHOKES.—Experiment has shown the advantages to be gained by grounding the cores and cases of iron core chokes. This is particularly true when the unit carries appreciable current and therefore produces an extensive field. A great deal of hum in power supply systems is due to induction between the amplifier and the iron core units used in the power pack. Lack of ground connection upon cores and cases is ofttimes the cause for a very aggravating hum.

OUTPUT CHOKES IN AUDIO AMPLIFIERS.—The output choke used in audio amplifiers is common in systems intended for use with cone speakers. At times such chokes are provided in conjunction with output transformers so that either a magnetic speaker (cone) or the dynamic may be used. The range of inductance used in this position covers from 40 to 100 henrys, with 40, 50 and 60 henrys being most common. The absolute lower limit is about 30 henrys although it is possible to design a system wherein the value of the output choke is much less than this lower limit. As to general replacement, a 30 to 50 henry choke will suffice. The D.C. resistance of windings used as output chokes approximates about 300 to 1000 ohms.

CHAPTER 11

AUDIO FREQUENCY AND OUTPUT TRANSFORMERS

TYPES OF AUDIO TRANSFORMERS.—The conventional audio frequency transformer consists of two windings, a primary and a secondary wound upon a magnetic core. As to core material, we have various grades of conventional core materials and various types of alloy core materials. The alloy core enables the attainment of a high primary inductance essential to maximum response at low audio frequencies. At the same time the alloy core introduces the limitation of plate current. Alloy core transformers are not generally applicable unless they have been designed for the location in question. As a general statement, the usual alloy core interstage audio frequency transformer is limited to about 3 to 5 milliamperes of direct current (tube plate current).

Exclusive of the core material, it can be said that there are three types of audio transformers. This reference to type does not mean purpose or the function of the units. It refers to types of windings. The conventional transformer may be said to be that with a single continuous primary and a single continuous secondary, with but two connections to each winding as shown in figure 127. The connections to these windings are as indicated. Reversing the connections to the units alters the frequency characteristic.

The push-pull unit is that wherein the secondary winding is center tapped and the primary is a single continuous winding or both the primary and the second windings are center tapped. The former is usually referred to as an input push-pull unit and the latter as an interstage push-pull unit. Both are shown in figures 128 and 129. The input unit is intended for insertion between a stage with a single tube and the succeeding stage with two tubes connected in push-pull. That shown in figure 129 is intended for use between push-pull stages. However these windings may be used as conventional transformers. The input push-pull unit may be employed as a conventional transformer linking two single tube stages by disregarding the center tap and using the two outside connections.

The interstage push-pull unit may be employed in conventional

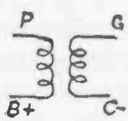


Fig. 127

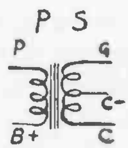


Fig. 128

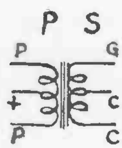


Fig. 129

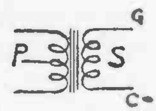


Fig. 130

fashion by disregarding the center taps upon the primary and the center tap upon the secondary, employing the two outside connections across the primary and the secondary. The interstage push-pull unit may also be employed as an input push-pull unit by disregarding the center tap upon the primary and using the two outside connections to the primary. The secondary winding is employed in the normal push-pull manner.

Another type of transformer which finds application in radio receivers is the impedance matching transformer employed in conjunction with phonograph pickups. This transformer resembles figure 127 and its function is to link two circuits, (the pickup) and the receiver input system so that the electrical characteristic (impedance) of one is adapted to that of the other.

Another type of transformer employed in public address systems is the microphone transformer, which resembles the illustration shown in figure 127 and another type is as shown in figure 130. The former may be designated as a single button microphone transformer and the latter as the double button microphone transformer. The split winding is used in the primary circuit. The outside leads connected to the bottoms upon the microphone and the actuating current is sent through the middle connection and the frame of the microphone. The secondary connects to the input circuit of the first amplifying tube.

The output transformer used in connection with radio receivers to link the speaker to the output tube or tubes as the case may be is available in various types. The unit suitable for a single tube output stage and a single speaker resembles the illustration shown in figure 127. The unit used to link a push-pull stage to the speaker looks like that shown in figure 130, the primary circuit connecting to the plates of the output tubes and the plate voltage supply and the secondary winding connecting to the speaker.

In some cases more than one speaker is to be used with the receiving or amplifying system and the number of secondary windings is greater than one, as shown in figure 131. We show a split primary winding because it is customary in such systems to use output tubes connected in push-pull fashion. Another type of output transformer suitable for application when an uncertain number of speakers are to be applied, is shown in figure 132. The secondary is tapped so as to adapt any number of speakers to the amplifier output system in order that best response be secured. As a general statement the output transformers shown in figures 127 and 130 are most common in radio receivers.

The auto-transformer finds application in interstage systems and also in output systems, although in the latter case it is known as an output tapped impedance. The auto-transformer consists of but one winding. A part of this winding is used as the primary and the entire winding is used as the secondary as shown in figure 133. Such units do not find much application in commercial radio

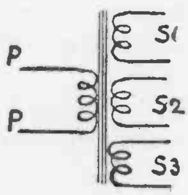


Fig. 131

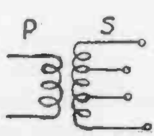


Fig. 132

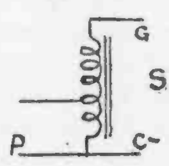
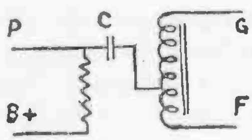


Fig. 133

receivers but have been used quite extensively in home constructed receivers and amplifiers. When designed for home constructed receivers it is customary to arrange the unit in conjunction with a blocking capacity and a resistance. Such a unit arranged for insertion as an interstage audio coupler with the transformer in the grid circuit is shown in figure 134. When assembled in a container, the complete unit has but four terminals just as any ordinary transformer. In the circuit shown, the load in the plate circuit of the preceding tube is the resistance R. The condenser C is the blocking unit. The unit is ofttimes reversed and the transformer is in the plate circuit and the resistance in the grid circuit as shown in figure 135. In some instances, usually power amplifiers the auto-transformer is arranged for push-pull operation as in figure 136. When employed in the output stage as the output coupling device it appears as shown in figure 137. The taps are

Fig. 134



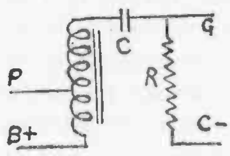
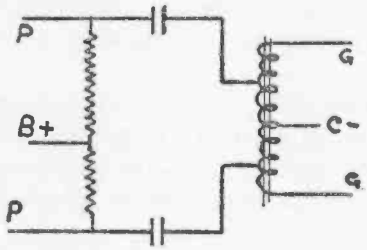


Fig. 135

Fig. 136



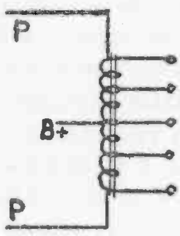


Fig. 137

provided to adapt speakers of different electrical impedance or any number of speakers. Such output impedance units are more frequently used in public address and power amplifiers than in radio receivers.

TURN RATIO OF TRANSFORMERS.—The turn ratio of a transformer is an approximate measure of the voltage amplification possible within the unit.

Generalizing, the lower the ratio of an interstate audio frequency transformer, the better the frequency response. The higher the turn ratio, the inferior the frequency response. At the same time, the lower the turn ratio the higher is the primary impedance and the greater is the voltage take out of the tube over the entire audio frequency range.

Since the detector tube impedance is greater than that of the audio amplifiers the low ratio transformer should be connected between the detector and the first audio stage and the high ratio transformer should be connected between the remaining audio amplifier tubes. The average turn ratio of the conventional type of transformer ranges between 2.5 to 1 and 4 to 1. A very popular value for all positions is 3 to 1. As a general statement the turn ratio of most of the high quality conventional interstage audio frequency transformers is about 2.5 to 1.

The turn ratio in high quality push-pull transformer is about 1.5—1.75 to 1 for each section.

CHARACTERISTICS OF INTERSTAGE AUDIO TRANSFORMERS.—Despite similarity of appearance all interstage audio frequency transformers do not perform in like manner. This condition is aggravated as the turn ratio is increased. The greater the difference in turn ratio between two transformers intended for interstage amplification, the greater the difference in frequency response. There is a great similarity between transformers of low turn ratio, so much so that replacement is possible with any one of the high quality units.

JUDGING BY APPEARANCE.—Judgment cannot be rendered by a visual examination of an audio frequency transformer. Neither the core material, the turn ratio or the frequency characteristic can be decided by a physical examination. Such facts must be determined by actual tests.

APPLICATION OF INTERSTAGE AUDIO FREQUENCY TRANSFORMERS.—The average run of audio frequency transformers, inclusive of the input and interstage push-pull units may be employed in connection with all low mu tubes.

PARALLEL PLATE FEED AND TUNED PRIMARIES.—It is quite a common practice when using high permeability cores to arrange a parallel plate feed system such as is shown in figure 138. The choke L carries the tube plate current and A.C. only flows through the transformer primary. For the value of the choke L, see "Audio Frequency Chokes." The same system is used to resonate the primary to some low frequency so as to secure greater response upon the lower audio register below 200 cycles. The blocking capacity C is resonated with the primary of the transformer.

RELATION BETWEEN TRANSFORMER PRIMARY AND TUBE IMPEDANCE.—The consensus of opinion is that the primary impedance of the interstage transformer at some optimum frequency, preferably 60 cycles should be several times that of the tube plate impedance. A satisfactory minimum is about five to six times the tube plate impedance.

SHUNTING PRIMARY OR SECONDARY WINDING OF TRANSFORMERS.—Condensers, resistances and even series combinations of inductance, and capacity and resistance and capacity are frequently connected in shunt with transformer primary or secondary windings. These units are added in order to alter the characteristic of the transformer, therefore the tonal quality of the output signal. Unless special resonated circuits are used, the effect of a shunt condenser or resistance is to lower the intensity of the high notes, in other words to attenuate the high notes. For values of capacity used in this fashion and for values of resistance used in this fashion see "Solid Dielectric Fixed Condensers" and "Resistances."

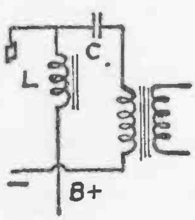


Fig. 138

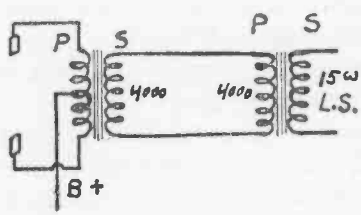


Fig. 139

OUTPUT TRANSFORMERS.—Output transformers are of varied type. Whenever used they are selected to fill a certain need. Generalization is possible as far as the output tubes are concerned but specialization is necessary as far as the load upon the secondary winding is concerned. Experiments have shown that best quality of reproduction consistent with maximum power output is secured from the output tube or tubes as the case may be when the load impedance is equal to twice the tube impedance. In this respect there is a little latitude. Empirical determinations show that there is very little difference when the load impedance is from 1.75 to about 2.5 times the tube impedance. In view of the fact that quite a few output tubes have practically like values of output impedance at the rated maximum plate potentials, a transformer suited to adapt a speaker to a 350 type tube is suitable for use with the 345 and the 371 tube.

Based upon the impedance relation the reverse should also be true, but it is necessary to take into consideration the values of plate current encountered with such tubes. If the output transformer is capable of passing the current, that transformer is interchangeable among the tubes stated. For further information about tube impedances, see "Vacuum Tubes."

Any one transformer designed to adapt a speaker to an output tube system is not necessarily satisfactory for another type of speaker to be used with the same tube system, unless the electrical characteristics (impedance) of the two speakers is the same. Thus a transformer intended for use with a 20 ohm speaker is not satisfactory for use with a 200 ohm unit, despite the fact that the same tube is used in the output stage.

As a general rule, all magnetic type speakers are rated at 4000 ohms and an output transformer rated at 4000 ohms input and output is suitable for practically any cone speaker when it is fed from a single 350, 345 or 371 tube. These tubes, when employed in a single tube output system require a 4000 ohm load. The 310 requires a 10,000 ohm load.

It is however possible to arrange a supplementary transformer which will adapt a speaker of a certain impedance to an output system of higher or lower impedance. Thus if an output transformer is designed to feed into a 4000 ohm load and the speaker available has an impedance of 15 ohms, a supplementary transformer designed to operate from a 4000 ohm load and feed into a 15 ohm load can be used as shown in figure 139. This is independent of the tubes used in the output system. For additional information about speakers and transformers, see "Speakers." When arranging such circuits, the 4000 ohm secondary of the output transformer must be connected to the 4000 ohm primary of the supplementary transformer. Of course the values involved need not be 4000 ohms. As a matter of fact special transformers are frequently employed in public address systems to link two circuits of different impedance.

Incorrect impedance relations in the output system result in a loss of power and distortion. This is particularly true if the load impedance applied to an output transformer is less than the impedance of the output winding of that output transformer. In the event that the load impedance is higher than the impedance of the secondary winding, a loss of power will ensue with a possible reduction in the intensity of the low notes. However such a condition will not result in the generation of harmonics in the output tube.

CURRENT IN TRANSFORMER SECONDARY WINDING.—With the sole exception of the output transformer current never flows through the secondary windings of audio transformers. That is, the circuit adjustment should be such that current does not flow through the secondary winding. The presence of grid current alters the frequency characteristic and in general impairs the operation of the transformer.

ELIMINATING MAGNETIZING EFFECT UPON CORE.—The advantage of uniform distribution of current in both halves of a center tapped primary of an audio frequency transformer is that by virtue of the opposite directions of these two currents, the

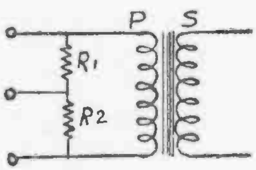


Fig. 140

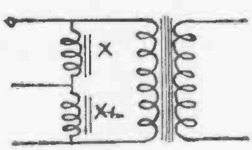


Fig. 141

total magnetizing effect upon the core of the transformer is zero. If however the two currents are not equal, there is a magnetizing effect upon the core. Such an effect exists whenever the transformer primary is a single continuous winding with but two connections or when a center tapped winding is used as a single winding.

OBTAINING A CENTER TAP UPON A PRIMARY WINDING WHEN THE WINDING IS NOT EQUIPPED WITH A CENTER TAP.—Oftentimes it is desirable to secure a center tap upon a transformer primary when the winding is not equipped with a center tap. Two methods suitable to obtain such a tap are shown in figures 140 and 141. In figure 140, resistances are used. In figure 141 chokes are used. The former method is suitable when the current flowing to the plates of the tube is comparatively small. An optimum value for R1 is about 50 times the input impedance of the transformer. The same applies to R2. At this rate it is impractical to use such resistances in conjunction with high quality interstage transformers because the input impedance is very high. The system is best suited to transformers of comparatively low input impedance.

The system shown in figure 141 is more readily adaptable because the reactance value of the chokes X and X1 need not be more than 10 times the input impedance of the transformer. In fact 5 times the input impedance is even satisfactory. However, the cost of such reactances is at times greater than the cost of a transformer with the center tap, so that no economy is effected in this direction. Once more the system is best suited to the transformer with a comparatively low input impedance so that the inductance values of X and X1 need not be very great.

CHAPTER 12

VACUUM TUBES

A GREAT deal of time and space can be devoted to a detailed discussion of vacuum tubes. In fact the subject cannot be covered thoroughly in two volumes such as this. However our interest lies in practical data and we shall limit ourselves to such information.

THE BEST METHOD OF TESTING A TUBE.—Recognizing the many factors present in tube design, the most satisfactory method of testing a vacuum tube or comparing a number of tubes of like design and intended for like application is the old reliable grid swing test. This test indicates the mutual conductance of a tube or the plate current change per volt change upon the grid. Expressed in the simplest manner, the grid bias is changed one volt and the plate current change noted. The greater the change in plate current per volt change upon the grid the higher the mutual conductance of the tube. This is the best measure of performance when similar tubes are being compared. Such a test is possible with the ordinary set analyzer. If the plate current changes (1 milliampere) .001 ampere for a 1 volt change upon the grid, the mutual conductance is .001 mho or 1000 micromhos.

Of course such a test is not applicable to the two element rectifier tube. The best test for this type of tube is the emission measurement. When testing screen grid tubes, the plate current meter is in the plate circuit and so located that it measures the current in the plate circuit and not the sum of the plate and screen grid currents.

RELATION BETWEEN TUBE CONSTANTS.—Although the three important constants of a vacuum tube, namely amplification constant, plate resistance and mutual conductance do not vary in a definite manner, there is to be found a certain relation between these factors. For example plate resistance increases with amplification constant. If the amplification constant of one tube is higher than that of another of like design, the plate resistance will also be higher. The mutual conductance is a function of the amplification constant and the plate resistance, being expressible as equal to amplification constant divided by plate resistance. The answer is in mhos. If the amplification constant remains fixed and the plate resistance decreases the mutual conductance will decrease.

The amplification constant of a vacuum tube may be said to be substantially uniform over the normal range of voltages. It shows a decline with high values of grid bias and low values of plate voltage, and a gradual decline at high values of plate voltage.

The plate resistance of a tube decreases with increase in plate voltage and decrease in grid bias. It increases with an increase in grid bias and a decrease in plate voltage.

The mutual conductance therefore increases with an increase in plate voltage or a decrease in grid bias, and decreases with a decrease in plate voltage and an increase in grid bias.

Operating tubes in parallel reduces the plate resistance in proportion to the number in parallel. Plate resistances in parallel act like resistances in parallel. Connecting tubes in push-pull causes a plate resistance variation as if the resistances were in series. Thus two tubes in push-pull have four times the resistance of two like tubes connected in parallel. Four tubes connected in parallel push-pull have the same total plate resistance as a single tube.

APPLICATION OF VACUUM TUBES.—Low mu tubes are suitable for use in any position in a receiver or amplifier with the possible exception of the output stage. Although power tubes are low mu tubes they are distinguished from the ordinary conception of a low mu tube such as the 326, the 327, the 301A, etc., by designation as a power tube.

Power tubes are suitable for any position in a power amplifier if the correct plate voltage and grid voltage and signal voltage is available.

High mu tubes rated at from 20 to 400 as the amplification constant are suitable for use as radio frequency amplifiers and detectors. They may be used in audio amplifiers with the following reservations. The high mu tube, rated at an amplification constant between 20 and 40 and a plate resistance of about 30,000 to 50,000 is suitable for use in either resistance or impedance coupled audio amplifiers providing that the value of resistance in the external plate circuit is at least 100,000 ohms and the value of impedance when a reactive load is used is equal to at least 300 to 500 henrys. High mu tubes are suitable for use as detectors. The very high mu tube, typified by the screen grid tube is suitable in the audio frequency amplifier if the plate load is purely resistive.

High mu tubes are not suited for use in oscillators or amplifier output stages.

Power tubes are not interchangeable unless the proper plate voltage, grid voltage and signal voltage are available. The power output of a power tube varies as the square of the input signal voltage. This is in contrast to the manner of operation of the conventional radio frequency or audio frequency voltage amplifier. Doubling the input voltage in a voltage amplifier increases the output voltage two times. Doubling the input signal voltage to a power amplifier increases the power output four times. In turn if the input signal voltage to a power amplifier is half of the rated signal voltage, the power output is one quarter of the rated value.

LIMITATIONS INTRODUCED BY GRID BIAS.—The grid bias voltage limits the input signal voltage to a peak value slightly less than the grid bias. This is so because the shape of the wave encountered in practice may be more peaked than a sine wave. Thus the effective voltage (signal) permissible across the input circuit of any amplifier tube is the grid bias divided by 1.5. Excessive as well as insufficient grid bias in an amplifying system will cause distortion. The vacuum tube is a voltage operated device and as such does not require current in the grid circuit. The only exception to this statement is the grid-leak and condenser form of rectification, wherein grid current, little as it may be, is present. *Grid current should not be permitted in any amplifying stage. It produces distortion.*

APPLICATION OF TUBES IN DIRECT CURRENT RECEIVERS.—Tubes used in series filament direct current receivers are not limited to the direct current type. A.C. type cathode-heater tubes may be employed in a direct current system, the respective heaters being connected in series. The bias voltage is secured by means of resistances in the respective cathode circuits. In this respect the ordinary filament type of A.C. tube such as the 326 also finds application in series filament systems.

GAS CONTENT IN POWER TUBES.—Gas is frequently present in tubes which employ the oxide coated filament, such as is the case in power tubes. Excessive voltage will liberate more of this gas and thus injure the tube and make it unfit for further use. The presence of such gas ofttimes causes a blue glow. This does not necessarily mean that the tube is defective. The manner of operation should be classed as the criterion. If the glow increases in brightness as the tube is in operation and if the intensity of the glow seems to waver in harmony with the signal passing through the tube, that tube is unfit for use. It may be possible to remedy the condition by reducing the applied plate voltage.

The usual effect is a high plate current. An abnormal value of plate current will cause excessive bias when the bias voltage is secured by means of the plate current flow through the bias resistance.

UNIFORMITY OF TUBES USED IN PUSH-PULL OR PARALLEL SYSTEMS.—Tubes employed in push-pull or parallel should be of like characteristic. A good method of matching tubes is to secure tubes which have like values of mutual conductance and if possible tubes with like values of plate resistance. If these two conditions are achieved, the similarity of amplification constant is automatically taken care of.

OVERHEATING OF TUBES IN PUSH-PULL OR PARALLEL COMBINATIONS.—Overheating of one tube in a two tube push-pull or parallel combination is a sign of a defective condition in the tube that remains cool. The tube that is overheating is being subject to an overload.

NON-UNIFORM PLATE CURRENT IN PUSH-PULL STAGE.—The fact that one tube draws more current than the other in a push-pull system does not signify that the former is defective. In the majority of cases the tube with the minimum plate current is the defective tube.

CHANGING THE GRID BIAS.—Never operate a power tube without the grid bias. If it is necessary to interrupt the grid bias voltage circuit in order to make some change, open the plate supply. Operation with normal plate voltage and no grid bias will cause a heavy plate current, sufficient at times to cause an injury to the tube if not to the associated apparatus located in the plate circuit.

RANGE OF OPERATING POTENTIALS AND CURRENT IN COMMERCIAL RECEIVERS.—The accompanying table shows the range of plate voltage, filament voltage, grid voltage and plate current encountered in commercial receivers. As is evident the greatest variation is to be found in the applied filament voltages. Also in the plate voltage applied to the 371 type of tube. The low plate voltages applied to the 371 type of output tube is encountered in direct current series filament receivers.

Tube	*Plate Voltage*	*Grid Voltage*	*Filament Voltage*	*Plate Current*
				1. – 3.5 ma.
'24	50–180	0. –5 .	1.5–2.5	.5– 3.8 ma.
'26	75–175	0. –27.5	1.2–1.5	2.4– 8. ma.
'27	13–270	0. –25.	1.9–2.6	.2–13. ma.
'71	65–180	12. –45.	4. –5.	12. –20. ma.
'45	145–255	12. –50.	2.1–2.5	18. –33. ma.
'10	365–410	20. –35.	6.4–7.5	20. –23. ma.
'50	320–445	55. –80.	6.4–7.5	37. –50. ma.

As is evident in the table one cannot take for granted that a peculiar state at least different from the conventional as determined by reference to tube manufacturers' literature is a sign of a defect in the system.

LACK OF EMISSION AND ITS EFFECTS UPON OTHER VOLTAGES.—Lack of electronic emission in a vacuum tube used in a receiver will naturally interfere with reception. When a set analyzer is applied, the measured plate voltage will not necessarily be very high unless the tube is the output power tube. At the same time the plate current will be very low or zero and the same is true of the grid bias. A good method of determining whether or not the tube is good is to apply the grid swing test or to replace with a known tube.

EXCEEDING VOLTAGE LIMITS.—While it is not good practice to exceed the tube manufacturer's voltage ratings it is possible to boost voltages if the grid bias voltage is likewise increased. Such increase can safely be made to about 15 or 20 percent above the rated plate voltage.

DETERMINING DISTORTION IN AMPLIFYING SYSTEMS.—The simplest method of determining whether or not the amplifying tube is performing in correct manner is to insert a current meter into the plate circuit and note the action of the meter pointer during operation. The meter pointer should remain steady during the passage of the signal. A fluctuation of about 2 to 3 percent of the total plate current is permissible. It might be well to mention that this form of test is not very suitable for tubes with high resistance plate loads. The ideal position for the meter is the output stage, although it may be employed in the plate circuits of the preceding audio amplifier tubes. Such meters are of little value in radio frequency amplifiers.

TUBES FOR VACUUM TUBE VOLTMETERS.—Experiments show that the tubes suitable for use in tube voltmeters are the 299, the 112A and the 371 or 371A. These tubes are operated at high values of grid bias and low values of effective plate voltage. For further details see "Practical Testing Systems," written by this author.

OUTPUT TUBES IN PUSH-PULL AND PARALLEL.—Output tubes connected in push-pull do not provide the fanciful increase in output power imagined by many. Investigation shows that the output power from two tubes employed in push-pull fashion is about 150 percent more than would be possible from one of the tubes. Thus two tubes rated at 4.65 watts each (350 type) when used in push-pull furnish about 11 to 12 watts output. Paralleling tubes does not double the output despite the theoretical calculation to that effect. Experimental measurements show that the increase in output is seldom more than 40 percent over that of but one tube. However, the plate resistance is halved, which in itself is an advantage.

LOCATING TUBES IN SOCKETS.—It is at times difficult to place the correct tubes in the sockets when the tubes required for the sockets are known but not designated. In the event that the receiver employs the 326, the 327, the 345, or the 371 type of tube and the 380, the following procedure will prevent burnout of the filaments. First locate the correct position of the rectifier tube. Since the tube filament requires 5 volts at 2 amperes this filament will not glow in normal fashion in any other socket but the rectifier socket. Being a four prong tube it can be inserted only in the four prong sockets. When correct glow of the filament is noted the socket has been located. If it so happens that the receiver employs the 345 type of tube and not the 371, the 380 rectifier filament will not even light in the other sockets. If the rectifier socket has been located, mark the socket but do not place the tube into the socket. The next step is to locate the socket for the 371 tube, assuming that it is used. This tube requires 5 volts and has four prongs. Hence insertion is limited to the remaining four prong sockets. The tube filament will not glow in the sockets intended for the 326 tube. Hence it is not a difficult matter to locate the position of the 371 tube socket. If the output tube or tubes are of the 345 type, this tube will not glow in the socket intended for the 326 tubes. Then mark the sockets for the 345 tube. If the radio frequency tubes are of the 326 type, the remaining four prong sockets are for this tube. This decision is made after the 345 or the 371 tube sockets have been located.

Sockets intended for use with the 324 type of tube are easily identified because the control grid clip is located nearby. Sockets intended for the 327 are easily located.

REJUVENATION OF TUBES.—Oxide coated filaments cannot be rejuvenated, despite some experimental comment to the contrary. Rejuvenation is most feasible with thoriated tungsten filaments. See "Useful Radio Tables" for correct emission.

RELATION BETWEEN TUBE IMPEDANCE AND LOAD IMPEDANCE.—Approximately 90 percent of the signal voltage in the tube is transferred to a resistance load when the value of the resistive plate load is about 10 times the tube impedance. About 95 percent of the signal voltage in the tube is transferred to a reactance load, when the value of the reactive load is about 5 times the tube impedance. Minimum distortion consistent with maximum power is secured from the output tube when the load impedance is equal to twice the tube output impedance.

TUBES SUITABLE AS OSCILLATORS.—Low mu tubes with fairly high values of mutual conductance serve best as oscillators in superheterodyne receivers and test signal generators. Such tubes are the 327, the 112.

LOW POWER RECTIFIERS.—A low power rectifier tube is the 326 with the grid and plate joined. The A.C. anode voltage should not exceed 110 to 150 volts. Such rectifiers find application in A.C. operated signal generators of low power wherein the hum in the rectifier power supply modulates the carrier generated in the oscillator tube. The rectifier also supplies the plate voltage for the oscillator tube, a 327.

GRID BIAS VOLUME CONTROL.—Grid bias form of volume control is used in many radio frequency amplifiers. The system is satisfactory providing that the adjustment of the bias is not increased to the point where the tube acts more like a detector than an amplifier. For additional data see "Volume Controls."

OVERLOADING RADIO FREQUENCY AMPLIFIERS.—It is possible to overload radio frequency amplifier tubes. Such a condition is frequent in multi-stage screen grid radio frequency amplifiers, particularly in the third stage of a three stage system. Whenever possible the bias applied to this tube should be slightly higher than that applied to the other tubes and the plate voltage should be correspondingly higher.

BALLAST TUBES.—The 876 is a ballast tube intended for use in the primary circuit of the power transformer. It has a current rating of 1.7 amperes and a voltage drop of from 40 to 60 volts. It is used on 50-60 cycle lines. The transformer primary must be specially designed to accommodate the tube.

The 886 is a ballast tube intended for 40 cycle lines. It is rated at 2.05 amperes and a voltage drop of from 40 to 60 volts. The transformer primary must be specially designed to accommodate the tube.

CHOICE OF POWER TUBES.—When the signal voltage is not in excess of 10 volts peak the most satisfactory output tube is the 112. When the signal voltage is in excess of 10 volts or greater than 16 volts peak and the available plate voltage is limited to 180 volts the 371 is the best tube. When the signal voltage is in excess of 30 volts and the plate voltage available is as high as 250 volts, the 345 is the best tube. Where the signal voltage is in excess of 50 volts and the available plate voltage is as high as 400 to 450 volts, the best tube is the 350.

USE OF OUTPUT COUPLING DEVICE WITH POWER TUBES.—As a general rule an output coupling device should be used with all output tubes. Such a device is necessary with any dynamic speaker and should be used with all magnetic (cone) speakers when the output tube plate current is in excess of 5 to 8 milliamperes.

CHOICE OF RADIO FREQUENCY OR AUDIO FREQUENCY AMPLIFICATION TO INCREASE POWER OUTPUT.—The addition of a stage of radio frequency amplification will produce greater total output than the addition of a stage of audio frequency amplification, assuming that the amplification per stage is the same in both cases.

HUM IN A.C. TUBES.—It is very possible that a tube which checks perfect in every respect will hum badly. The only solution is replacement with another tube.

CHANGING POWER TUBES.—It is not possible to change power tubes in the output stage of the audio amplifier without due regard for the plate current output of the eliminator. The following table gives the normal plate current for the various types of power tubes now in use.

Tube	*Plate Voltage*	*Grid Bias*	*Plate Current*
'45	180	–33	26 milliamperes
	250	–55	32 milliamperes
'71	90	–16	10 milliamperes
	135	–27	16 milliamperes
	180	–40	20 milliamperes
'10	250	–18	10 milliamperes
	350	–27	16 milliamperes
	425	–35	18 milliamperes
'50	450	–84	55 milliamperes

HIGH MU TUBES.—High mu tubes are not suited for use with transformers but may be used with resistance and impedance coupled systems.

LOW MU TUBES.—Low mu tubes such as the 326, the 327, the 301A, etc., are suitable for use with all forms of amplifying units.

CHAPTER 13

SOCKETS

SOCKET CONNECTIONS.—The illustration in figure 142 shows the terminals upon the five prong socket utilized in connection with the type 327 tube. The letters H, H designate the heater connections, C is the cathode, G is the grid and P is the plate. The five prong socket used with the A.C. screen grid tube is shown in figure 143. H and H are the heaters. C is the cathode. G is the screen grid and P is the plate. The control grid of the screen grid tube is located atop the tube. The conventional four prong tube socket suitable for use with the 301A, the 326, the 199, the 340, the 371, the 345, the 310 and the 350 is shown in figure 144. F and F are the filament terminals, G is the grid and P is the plate. The socket used with the 380 full wave rectifier is identical to that shown in figure 144. The grid terminal is used for one of the anodes and the plate for the other anode. The socket for the 381 and the Raytheon rectifier is as shown in figure 145. F and F are used for

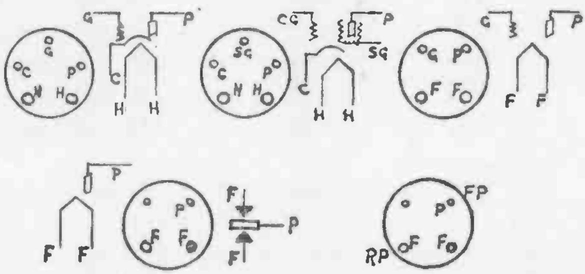


Fig. 142 Fig. 143 Fig. 144
Fig. 145 Fig. 146

the filaments of the 381 and P is the plate. The grid prong is not used. In the case of the Raytheon tube, the leads from the transformer connect to the filament terminals and the cathode is the plate prong. Figure 146 shows the connections to the conventional neon tube as used for television at the present time. The socket is of the four prong variety. The front plate connects to the plate terminal of the socket and the rear plate connects to the left hand filament terminal.

LEAKAGE THROUGH SOCKETS.—Leakage is possible between the terminals of a socket, particularly if the socket base is covered with a layer of moisture or lint or some other such foreign deposit.

OPEN CIRCUITS IN SOCKETS.—A large number of open circuits have been traced to imperfect contact between the tube prong and the socket contacts. In this respect a good deal of the complaints relative to intermittent reception are due to poor contact between the heater or filaments and the socket contacts. The best means of checking the condition of socket contacts is by means of prongs fashioned from an old tube base. One wide prong is attached to a long brass tube and permanently fastened into a bakelite handle. One narrow prong is arranged in like fashion. These prongs are used to make connection to the different circuits through the socket.

CHAPTER 14

VOLUME CONTROLS

FILAMENT CURRENT FORM OF VOLUME CONTROL.—It was customary in days gone by to employ filament current form of volume control. Such systems were partially satisfactory when located in the radio frequency system and operated in conjunction with the old type thoriated tungsten tubes. Such systems now are obsolete. The same applies to the detector tube. *Under no condition should the control of volume be secured by reducing the filament current in the audio system.* This form of operation in old receivers should be replaced by one of the several described in this section.

GRID BIAS FORM OF VOLUME CONTROL.—Grid bias form of volume control is possible in the radio frequency amplifier, the volume being reduced by increasing the bias. The system is satisfactory just so long as the bias is not increased to the point where the amplifier tube is functioning as a detector. The result is rectification in the radio frequency amplifier with consequent distortion. Such form of volume control should be used in conjunction with another control located in the input system of the radio frequency amplifier, both being simultaneously controlled so that the bias adjustment need not be carried to the point where rectification occurs. As a matter of fact if the location of the receiver is such that the supplementary volume control affords satisfactory variation of signal strength, it is a good idea to entirely disconnect the bias control, after suitable adjustment of the bias.

The usual form of grid bias volume control consists of a fixed and variable resistance located in the cathode-ground circuit. The fixed resistance governs the minimum or normal bias and the variable unit enables the increased bias for volume control. In some cases the circuit is relatively simple as in figure 148. In other cases it is somewhat more detailed as shown in figure 149. The variable bias resistance also shorts the antenna system as the volume is decreased, thus decreasing the pickup as well as increasing the bias. Such an arrangement makes unnecessary an excessive increase in bias.

VOLUME CONTROL IN THE AERIAL CIRCUIT.—A satisfactory volume control in the aerial circuit is shown in figure 150. This system is applicable when the input circuit contains a radio frequency transformer. R is a 10 to 50 ohm fixed resistance. R1 is a potentiometer of 15,000 to 25,000 ohms. R2 is a 200 ohm resistance and C is a .00025 mfd. condenser.

A fixed potentiometer resistance located in the aerial circuit as shown in figure 151 is simple and practical, although it is not of the best. Some value between 2000 and 10,000 ohms will suffice.

The system shown in figure 151 can be improved in the manner shown in figure 152. The resistance in the aerial circuit is replaced by a radio frequency choke of say 200 turns of No. 30 wire upon a form 1 inch in diameter. A tap is taken off at the 100th turn. The resistance R is a 5000 ohm potentiometer.

Such forms of volume control are naturally applicable when the receiver is capable of housing the system. In the majority of commercial receivers, however, it is necessary to abide with the system incorporated in the receiver.

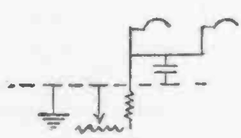


Fig. 148

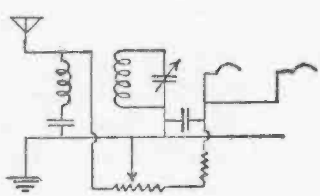


Fig. 149

ARRANGING FOR LOCAL RECEPTION.—At times it may be necessary to arrange for local and distant reception, primarily to reduce the pickup for local reception. The best method of accomplishing this effect is to arrange a simple switch whereby a small antenna condenser of about .00005 mfd. is connected into the aerial circuit. This condenser can be permanently placed in series with the aerial lead for local reception and short circuited for distance reception. Another possible means is to short circuit the aerial coil or the aerial system for local reception. Another method of adjusting a receiver for local reception is to arrange a switch whereby a .01 or a .02 mfd. condenser is connected across the aerial and ground terminals. This condenser is removed from the circuit by some suitable means when distant reception is desired. All of these innovations do not disturb the connections within the receiver.

COMMERCIAL ARRANGEMENTS FOR LOCAL AND DISTANCE RECEPTION.—Commercial methods of arranging for local and distance reception vary. In some instances the pri-

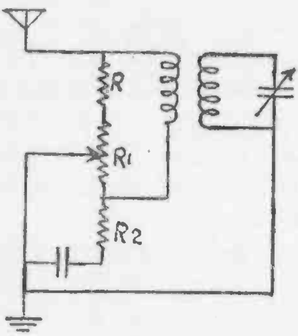


Fig. 150

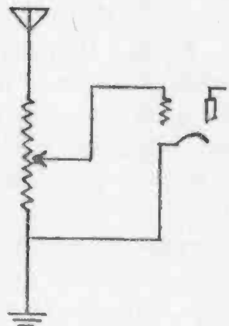


Fig. 151

mary winding of one of the radio frequency transformers is tapped and the number of turns in the winding is reduced or short circuited for local reception. In another instance a resistance is inserted into one of the tuned grid circuits. This resistance is present for local reception and short circuited for distance reception. In another case the aerial is disconnected for local reception and connected to the local terminal which is one junction of a fixed condenser connected to one side of the power line.

VOLUME CONTROL BY MEANS OF VARIABLE RESISTANCE CONNECTED ACROSS TUNED GRID WINDING.—This form of volume control is not very satisfactory and is not in general use today. When applied the resistance is usually rated at around 200,000 ohms maximum.

VOLUME CONTROL BY MEANS OF SCREEN GRID

VOLTAGE.—Quite a few receivers make use of a variable screen grid voltage as the volume control, amplification decreasing with decreasing screen grid voltage. In the majority of cases two screen grids are connected to the control unit, that is two tubes are controlled in this manner. The range of voltage extends from about 20 to perhaps 75 volts. The lower limit is a variable depending upon the design of the receiver. Such a system is shown in connection with bleeder resistances in screen grid circuits described in the section devoted to Circuit Continuity in Radio Receivers.

VOLUME CONTROL IN ELECTRIC PICKUP CIRCUITS. —See Phonograph Pickups.

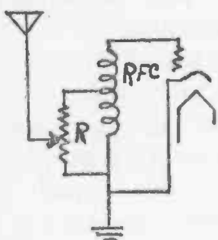


Fig. 152

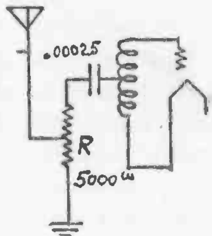


Fig. 153

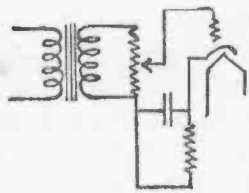


Fig. 154

VOLUME CONTROL IN AUDIO AMPLIFIERS.—The usual volume control system employed in the audio amplifier is associated with the coupling unit, usually the transformer. If the coupling unit is a resistance-capacity combination, the control is associated with the grid leak. However, in connection with transformers, the form of control is some means whereby the signal voltage applied to the transformer primary or to the grid of the tube is varied. Without much ado, let it be said that no simple method of volume control related to the variation of the signal voltage passed into the transformer primary is a satisfactory method. Be the system a potentiometer across the primary, a variable resistance across the primary or a series resistance, none of these methods are satisfactory.

The item of importance associated with volume control in the audio system is not the actual control of volume, which may be accomplished in many ways, but the effect of the control upon the frequency characteristic of the coupling unit. Any and every simple form of control located in the primary circuit of the transformer interferes with the frequency response either at the low or the high if not both ends of the frequency scale.

As to control systems allied with the secondary of the transformer, only one system is suitable. This is the use of a high resistance potentiometer connected across the secondary winding. This system at its most inefficient condition has very little effect upon the low notes, which are so much desired but so seldom secured. As far as the high notes are concerned, the attenuation is not very great. The system referred to is shown in figure 154. The value of the potentiometer may be between 200,000 and 500,000 ohms. The lower limit has a tendency to reduce the slight bump upon the high frequencies present in modern high quality units and thus maintain a uniform characteristic regardless of the adjustment of the control. At the same time, the use of a potentiometer approximating the lower limit tends to slightly reduce the amplification available with the transformer but this reduction is so slight that it is not discernible without measuring apparatus. The use of the high resistance potentiometer affords slightly greater amplification but the bump previously referred to remains in the system.

Under no condition should the control across the secondary take the form of a simple high resistance of the rheostat type.

If the coupling unit in the grid circuit is a grid leak, volume control may be effected by replacing the fixed leak with a potentiometer of about 250,000 ohms, employing the entire resistance as the grid leak and connecting the potentiometer lever to the grid of the tube. The other end of the potentiometer resistance goes to C minus.

VOLUME CONTROL IN SHORT WAVE REGENERATIVE DETECTOR CIRCUITS.—The requisites for a good system are smoothness of operation, silent operation and minimum effect upon the tuning system. An ideal arrangement is shown in figure 163. The regeneration control is very smooth and the effect upon tuning is entirely negligible. The value of R is about 5000 to 7500 ohms and C is a .0001 to .0002 mfd. fixed condenser. This system is better than the B voltage control by means of a variable resistance in the detector plate battery lead.

AUTOMATIC VOLUME CONTROL.—See Section 1, Chapter 4, "The Automatic Volume Control."

CHAPTER 15

RESISTANCES

A GREAT deal can be written about resistances. Unfortunately space does not permit a full and detailed resume. We shall consider nothing but the pertinent items pertaining to such units.

CURRENT CARRYING CAPACITY OF RESISTANCES.—First and foremost is the current carrying capacity of resistances. The reason for burnout of a resistance is the flow of excess current through the unit. The only other reason is deterioration with age. The second is naturally allied with the first but we shall assume that such deterioration is not very great during the normal life of a receiver or amplifier unless the current flow through the resistance is the maximum permitted rating.

The maximum current carrying capacity rating of a resistance as determined by the current rating of the wire does not necessarily mean that the resistance in question will carry the rated amount of current for an indefinite period. Heat is developed when electric current flows through a resistance and this heat is a contributory cause for the premature demise of resistance units. No resistance should be taxed to carry the maximum current permitted by its rating unless every condition has been fulfilled to rapidly dissipate the heat developed during the operation.

The amount of current which may be passed through a resistance is definitely limited. If the circulation of air around the resistance is not free, the amount of current which may be passed through the resistance is less than its rating in open air. So much so that if the resistance is confined in a closed space as is the case in radio receivers, a 50 percent increase in current rating should be allowed. It is necessary when working with resistances which carry current to realize that the heat developed is proportional to the square of the current. The same applies to the wattage rating of the unit. Thus if the current through a resistance is doubled, the wattage rating increases four times. Bearing in mind that a resistance burns out because the current in the circuit is excessive, the replacement unit should be of a higher current carrying capacity.

TEMPERATURE CHARACTERISTIC OF RESISTANCE MATERIALS.—All resistances are made from some sort of material. This substance may be copper, an alloy of iron, nickel and chromium or some other metals. Resistances are also made from carbon, graphite or some such compound. No matter what the substance its resistance varies with temperature. This variation is known as the temperature coefficient. For practically all metals it is positive, i.e., the ohmic value of the unit increases with temperature. For all carbon materials the temperature coefficient is negative, i.e., the ohmic value decreases with temperature. For certain special types of wire wound resistance positive temperature coefficient is so low that the variation in ohmic value over a large range of temperatures is said to be zero. Such resistances are, however, not generally employed in radio receivers or associated equipment. The positive temperature of some of the alloy resistance wires is sufficiently low to be suitable for general application.

In connection with the selection of carbon resistances which are to be used under very high temperatures, it is necessary to remember that its resistance value decreases with an increase in temperature above the standard of 20° C. This means that the original value must be higher than that actually required. Such is the case with resistances used in automobile ignition systems to suppress electrical radiation and interference with the radio receiver in the automobile.

ACCURACY OF RESISTANCES.—As a rule, the degree of accuracy employed during the manufacture of resistances intended for use in radio receivers approximates about plus or minus 5 percent. In many cases the tolerance is even greater, approximating 10 percent. This means that a resistance rated at 1000 ohms may be found when measured to have a resistance of from 900 to 1100 ohms, depending upon the accuracy employed in manufacture. As the rated resistance increases the magnitude of the tolerance also increases. In other words a resistance normally rated at 100,000 ohms may have a resistance of from 90,000 to 110,000 ohms.

RELATION BETWEEN TYPE OF RESISTANCE AND CURRENT CARRYING CAPACITY.—As a rule, the resistances used in radio receivers are segregated according to types and current carrying capacity. Carbon, special composition, Lavite and metallized resistances are used where the current flow is small. Wire wound resistances covered or uncovered are used where the current flow is great. Based upon the general manufacture the highest wire wound resistance used in receivers is about 100,000 ohms. Metallized resistances are seldom rated higher than about 2 or 3 watts. Carbon type resistances used in receivers are generally rated at 5 watts or less, unless they are of special character. Wire wound resistances are usually rated higher than 3 watts.

APPLICATION OF RESISTANCES WITH RESPECT TO ACCURACY.—There is no doubt about a decided advantage in using highly accurate resistances. However, the structure of a radio receiver is such that a certain latitude of operation is possible, therefore a certain tolerance in accuracy. This tolerance is at times much more than the tolerance employed in the manufacture of the device, so that it is possible to effect replacement with units which are not identical duplicates of the defective unit removed.

Such positions are the grid circuit of tuned stage, as grid suppressors, grid filters or grid isolating resistances, grid leaks employed in detector circuits and as a path for the grid bias voltage in special tuned radio frequency systems wherein the tuned stage is isolated from the C bias circuit, in fact wherever the function of the resistance is other than to produce a definite voltage drop related to one of the operating potentials. A tolerance as high as from 25 to 50 percent is possible with low values of resistance and about 15 to 20 percent with high values of resistance.

It might be well to mention that a plus tolerance is to be preferred to a minus tolerance. In other words if a grid suppressor in the radio frequency system is rated at 800 ohms and another of exactly similar value is not available, it is better to employ a 900 ohm unit rather than a 700 ohm unit, unless a test proves that excessive regeneration will not develop with the 700 ohm unit in the circuit.

A fair degree of accuracy is required when the resistance is used to produce the correct operating voltage as for example, voltage reducing resistances in the divider, plate circuit or filament circuit. Generally identical replacement is not possible, because of the tolerance in manufacture, hence it is best if the resistance of the unit is less than the rated, rather than more than the rated. The reason for this statement is that the application of a reasonably higher plate voltage will seldom cause any trouble, whereas the application of a plate voltage less than that required is apt to decrease sensitivity and even cause distortion. In the case of grid bias resistances, it is better to use a "high" value rather than a "low" value. A reasonable increase in grid bias will not cause any trouble, whereas a low bias is apt to cause distortion, overloading, etc. Of course our reference to reasonable, means an increase of about 5 to 10 percent in voltage.

WATTAGE RATING OF RESISTANCES.—The wattage rating of a resistance refers to the entire resistance and not to a part of the complete unit. In other words if the complete resistor is rated at 1000 ohms and 10 watts, which is the equivalent of 100 milliamperes of current and a voltage of 100 volts, it means that the entire resistance of 1000 ohms is rated at 10 watts. If a part of that resistor is to be used, say 500 ohms, the wattage rating no longer is 10 watts. The unit will allow the passage of 100 milliamperes of current but the permissible voltage is only 50 volts in order that the current flow be limited to 100 milliamperes and the wattage rating of the unit is 5 watts.

APPLICATION OF RESISTANCES IN SERIES AND PARALLEL.—See "Reference Data."

RESISTANCES AS GRID SUPPRESSORS.—The range of fixed resistances employed as grid suppressors in radio frequency amplifiers extends from about 50 to 2000 ohms. The most popular values are 400, 600 and 800 ohms. See Table R, figure 155.

FILTER AND DECOUPLING RESISTANCE IN BAND PASS FILTER.—A fixed resistance is often included in band pass filters so as to reduce side band suppression at the high frequencies. See Table R, figure 156.

RESISTANCE AS GRID FILTER IN TUNED RADIO FREQUENCY AMPLIFIER.—See Table R, figure 157.

RESISTANCE AS GRID FILTER IN AUDIO FREQUENCY AMPLIFIER.—Such regeneration control resistances are to be found in many commercial radio receivers and in practically all well designed public address systems. See Table R, figure 158.

RESISTANCES ACROSS A.C. FILAMENTS AND HEATERS.—These resistances are used to provide the electrical center tap in the filament or heater circuits. See Table S, figure 162. When a single resistor is used across a number of filaments connected in parallel, the total resistance is less than that used across a single filament. Thus the resistance used and suitable across two or more 326 type filaments connected in parallel ranges between 6 and 10 ohms total. The resistance required across a single unit ranges between 10 and 20 ohms total. Similar values apply to the heaters used in the 327 type of tube. The same is true of the 345 type of tube. As to the 371 and the 350 type tubes, the resistance approximates between 20 and 40 ohms total. At least these

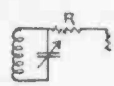
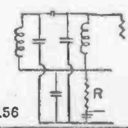
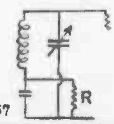
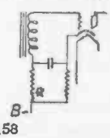
	 155	 156	 157	 158
Type	Fixed Wire, Carbon or Metallized	Fixed Wire, Carbon or Metallized	Fixed Wire, Carbon or Metallized	Fixed Wire, Carbon or Metallized
Average Value Ohms	600	500 - 1000	10000 - 30000	100,000
Limits	50 - 2000	250 - 1500	10000 - 50000	25,000 - .25meg
Power Rating	1 - 2 watts	1 - 2 watts	1 - 2 watts	2 - 3 watts
Notes	400, 600 and 800 ohm units common	500 and 1500 ohm units common.	20000 to 50000 ohms most common	Upper limit with .1 meg minimum most common.

Table R

are the common values. Its minimum value should be influenced by the fact that the current flow through this resistor should be small in comparison with that through the tube filaments or heaters.

RESISTANCES EMPLOYED AS PLATE COUPLING UNITS IN DETECTOR AND AUDIO SYSTEMS.—An examination of a large number of receiving systems shows that the usual value of resistance employed as the plate load upon the detector or one of the amplifier tubes varies between 40,000 and 100,000 ohms. See Table S, figure 159.

RESISTANCES USED AS GRID BIAS RESISTORS FOR OUTPUT TUBES.—See section devoted to "Useful Radio Tables."

RESISTANCE USED WITH CONDENSER IN TONE CONTROL.—The series combination of resistance and capacity is a popular form of tone control, being connected across the audio transformer secondary, or across the output transformer primary. See Table S, figure 160 for the formation of the circuit. The time constant of this combination with C in farads and R in ohms usually approximates between .002 and .004 when R is set at maximum. Some popular combinations are .002 mfd. and 1,000,000 ohms; .005 and 500,000 ohms; .25 and 15,000 ohms, etc. The combination of high capacity and low resistance is used across the primary of the transformer.

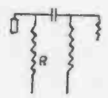
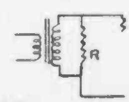
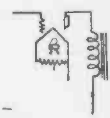
	 159	 160	 161	 162
Type	Fixed	Variable	Fixed	Fixed Center Variable Center
Average Value Ohms	100,000	.0015 - 1. meg See Notes	.1 - .25 meg.	20
Notes	Several receivers use 40,000-	.002 mfd and 1 megohm max.	Most popular value is upper	326 tubes 6 - 20 327 tubes 6 - 20 371 tubes 20 - 40
	50,000 ohms in detector plate circuit. Some	.005 mfd and .5 megohm max.	limit. 500,000 ohms used in many instances.	350 tubes 20 - 40 345 tubes 6 - 20
	audio stages use 250,000 ohms	.25 mfd and 20,000 ohms max.	.5 and 1.-2. meg. across PP secondary half.	Upper limit for '6-7-5s often 10

Table S

RESISTANCE USED AS GRID LEAK IN SELF MODULATED TEST OSCILLATORS.—The usual values of grid leaks employed in test oscillators range from 50,000 ohms to several megohms. The lower limit is employed in conjunction with grid condensers of from .001 mfd. to .002 mfd. The higher values are used with .00025 mfd. and .0005 mfd. grid condensers.

RESISTANCES USED FOR GRID BIAS IN RADIO FREQUENCY AMPLIFIERS.—See "Useful Radio Tables."

RESISTANCE USED ACROSS AUDIO FREQUENCY TRANSFORMER SECONDARIES.—These fixed resistances are used as shown in Table S, figure 161.

RESISTANCE USED AS GRID LEAK IN AUDIO AMPLIFIERS.—The value of the grid leak used in a resistance coupled audio amplifier is allied with the value of the blocking capacity. Generally the value of the leak is at least 2.5 times the value of the plate coupling resistance. If possible, the value of the leak should be between 500,000 and 1,000,000 ohms. Such values are used in some receivers, particularly when the audio amplifier uses but a single stage of resistance-capacity coupling. The power rating of the resistance used in the plate circuit depends upon the plate current. In the grid circuit we must provide for satisfactory current carrying capacity despite the fact that the normal current is zero. A resistance of 1 megohm rated at 2 watts will carry about 1.5 milliamperes entirely sufficient to take care of grid current. If the grid leak is of less than .25 megohm a 1 watt rating will be entirely sufficient.

RESISTANCES USED IN RESISTANCE-CAPACITY COUPLED AUDIO AMPLIFIER INTENDED FOR USE WITH RECTIFIED POWER SUPPLY.—The following combination is intended for use with conventional tubes and correct C bias adjustment. The amplifier consists of three stages. In the first stage the plate coupling resistance is 1. megohm and the grid leak .25 megohm. In the second stage the plate coupling resistance is .25 megohm and the grid leak is .1 megohm. In the third stage the plate coupling resistance is .25 megohm and the grid leak is .1 megohm. *If the original values used in the amplifier work satisfactorily there is no need for the changes suggested.*

DETERMINING THE POWER RATING OF RESISTANCES.—See "Useful Radio Tables."

RESISTANCE USED AS PLATE FILTER IN CONJUNCTION WITH A CONDENSER.—The selection of such a resistance depends upon several factors. An idea of the position of the resistance can be secured by referring to Table C, figure 71. The resistance in the plate circuit lead is the plate filter unit. The unit functions as a voltage reducing resistance. It also acts as a filter in conjunction with the bypass condenser. Combining these two functions, the minimum value of the resistance should be about 10 times the impedance of its associated capacity, calculated at the lowest frequency in the circuit. If it is possible to employ a higher value, so much the better, As to replacement, it is impossible to give average values, since one purpose of the unit is to produce the correct voltage upon the plate of the tube. Such data is contained for practically all commercial radio receivers in the supplement to the 1931 edition of the *Trouble Shooter's Manual,* written by the author of this book.

RESISTANCES USED IN ELIMINATOR VOLTAGE DIVIDERS.—The only standardization possible is the mention of a suitable total value for use with rectifiers of various types. The proper voltages are then secured by tapping the divider at the correct points. A total resistance of 12,000 ohms is suitable for use with the 380 and the Raytheon BH tubes assuming an anode voltage of between 350 and 400 volts. Such a resistance may be divided into four sections of 3000, 3000, 2000 and 4000 ohms. A total divider resistance of 20,000 ohms is suitable for use with a single 381 tube in a half wave rectifier or a pair of 381 tubes as a full wave rectifier. Assuming that the plate voltage for the output tubes is secured from within the filter system so that the output tube plate current or currents as the case may be do not flow through the divider, the maximum current through the divider in the case of the 380 or the Raytheon is about 50 or 60 milliamperes and through the single 381 divider about 50 milliamperes. Through the divider intended for use with a pair of 381 tubes in full wave connection, the maximum current will not exceed 75 milliamperes.

RELATION BETWEEN GRID LEAK AND BLOCKING CAPACITY IN RESISTANCE COUPLED AUDIO AMPLIFIERS.—Based upon a plate coupling resistance of .1 megohm, the following values of grid leak resistance are suitable for use with the following values of blocking capacity in order to secure substantially uniform response to as low as 50 cycles. These values are due to Sylvan Harris, Proceeding of the Institute of Radio Engineers, December, 1926.

Blocking Capacity	*Grid Leak*
.1 mfd.	.1 megohm
.06 mfd.	.2 megohm
.025 mfd.	.5 megohm
.012 mfd.	1. megohm
.006 mfd.	2. megohm

It is interesting to note that while these values are based upon theoretical computations and practical experiments, they are not followed faithfully in practice. In other words many amplifiers deviate from the above values. As an example, .2 and .5 and even 1. mfd. condensers are used with .1 and .25 megohm grid leaks.

RESISTANCE USED FOR LINE VOLTAGE REDUCTION.—See Chapter 16 and "Useful Radio Tables."

RESISTANCES USED ACROSS FILTER CONDENSERS CONNECTED IN SERIES.—Figure 62 shows the use of resistances across filter condensers connected in series. The purpose of the resistance is to evenly distribute the voltage across these condensers independent of the leakage resistance of the individual condensers. Two factors enter into the choice of the correct resistance. The first is the leakage resistance of the condensers. The usual leakage resistance is high, being more than 100 megohms per mircrofarad for paper dielectric units and about 250,000 ohms per microfarad for electrolytic units. The second is the voltage desired across the condensers as determined by the voltage rating. This item is influenced by the voltage to be applied across the series combination. Thus if two condensers are rated at 600 volts each and are to be used across a 900 volt line, the actual voltage across each unit may be arranged to be 450 volts. By connecting a 100,000 ohm resistance across each condenser the total resistance is 200,000 ohms. The current through these resistances will be 4.5 milliamperes. Then the voltage across each resistance will be $.0045 \times 100{,}000$ or 450 volts. Each of these resistances should be rated at 3 watts or more so as to allow a safety factor. The actual wattage rating as determined by the current and the resistance is 2 watts.

RESISTANCES USED TO PRODUCE BIAS IN SERIES FILAMENT CIRCUIT.—We refer to the resistances located in the respective filament circuits so as to produce the bias required for the associated tube. The value of this resistance is a function of the bias required and the current in the filament circuit. Ordinary Ohm's law for resistance with voltage and current known, is applied. The voltage is the bias required and the current is the filament current.

RESISTANCE USED TO CONTROL FILAMENT CURRENT.—The type of filament current whether A.C. or D.C. is of no consequence. The function of the resistance is to produce a voltage drop so that the correct voltage is applied across the tube filaments. If the available voltage is called E and the required voltage across the filament is E_1 and the filament current is I, then the resistance required to produce a voltage drop E_2 is

$$\frac{E - E_1}{I}$$

A table of resistances necessary to produce certain voltage drops at various values of filament current is given in the section, "Useful Radio Tables."

RESISTANCE CONNECTED IN SHUNT WITH FILAMENT IN D.C. SERIES FILAMENT RECEIVERS.—It is customary to employ a protective resistance across low current tubes used in old style series filament receivers. These resistances tend to nullify the cumulative plate currents which, because of the location of the tubes and the return connections flow through some of the filaments, thus adding to the total current through the filament circuit. The value of this resistance is governed by the excess current. Ohm's law for resistance with the tube filament voltage as E and the excess current as I is applicable.

LOCATION OF FILAMENT CONTROL RESISTANCE IN A.C. CIRCUIT.—Since the purpose of the filament shunt resistance is to provide the electrical center tap, the resistance utilized to reduce the filament current must be located between the transformer and the filament shunt resistance. If the filament shunt resistance is of the variable center tap type, the filament current control resistance may be a single unit connected into either leg of the filament circuit. If, however, the filament shunt resistance is of the fixed center tap type and the tubes in question are of the 326 type, the filament current control resistance should be split into two sections, each section being equal to one half of the required total. This system is true when the electrical center for the filament circuit is provided by the center tap upon the filament transformer. The only exception is the use of the cathode-heater type of A.C. tube. When this type of tube is used, the filament control resistance may be a single unit in either leg.

RESISTANCE IN PLATE CIRCUIT OF RADIO FREQUENCY AMPLIFIERS.—A resistance is oftentimes located in the plate circuit of radio frequency amplifier tubes in modern receivers. This resistance serves to isolate the respective radio frequency plate circuits and also to control the voltage applied. The fact that such resistances are used should be remembered when hunting for trouble.

RESISTANCES AS DETECTOR GRID LEAKS.—The value of the grid leak used in broadcast receivers varies between 1 megohm and 3 megohms. The most popular value is 2 megohms. In short wave receivers, the value varies between 7 megohms and 10 megohms.

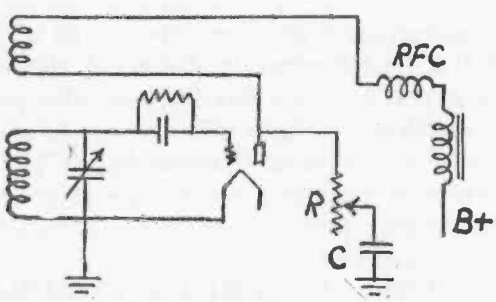


Fig. 163

CHAPTER 16

FACTS ABOUT POWER SUPPLY DEVICES

VOLTAGE REGULATION OF A.C. ELIMINATORS.—A.C. eliminators do not supply constant values of potential regardless of current. The value of current drawn from the eliminator has a great bearing upon the available output voltage. It is for this reason that all A.C. eliminators bear certain definite voltage and current specifications. The general action of the device is that if the output voltage is increased, the output current decreases. Conversely if the load current is decreased the output voltage increases. The extent to which this decrease takes place is a matter of design and is neither uniform with respect to a number of different eliminators nor with the current load. The characteristic is usually determined by noting the voltage drop per unit current increase starting with a load current approximately equal to about 25 percent of the maximum.

VOLTAGE REGULATION OF D.C. ELIMINATORS.—The D.C. eliminator does not possess a voltage regulation characteristic other than that imposed by the D.C. resistance of the chokes in the filter. The current output of a D.C. eliminator is governed by the current rating of the socket outlet (the power circuit connected thereto) and the current carrying capacity of the chokes. Theoretically if the D.C. resistance of the filter chokes is negligible, any required value of current may be drawn from the eliminator (providing that the chokes will carry that amount of current) and the divider resistances are properly arranged.

SECURING IMPROVED VOLTAGE REGULATION.—Improved voltage regulation can be secured from an A.C. eliminator when the D.C. resistance of the filter chokes is low and the eliminator is operated at a load current close to the maximum as specified by the tube manufacturer. An additional condition, but not absolutely essential is that the input filter condenser (when using tube rectifiers) be removed. This will drop the voltage output, increase the operating life of the tube to a certain extent and increase the hum. If corrective measures are made to compensate for the decreased voltage and increased hum, better voltage regulation will be secured. The current consumption can be increased by increasing the bleeder current. This will of course necessitate readjustment of the other voltage divider sections in order to secure the original voltages.

FUSED PRIMARY CIRCUITS.—The primary circuit of the eliminator should be fused in order to protect the line and possible injury to the primary in the event of a short circuit in the load connected to the eliminator or in the eliminator itself. A half ampere fuse will be satisfactory when the eliminator is of the A.C.

Fig. 164

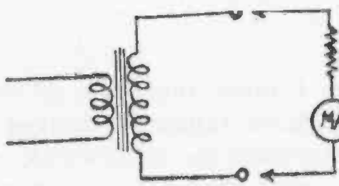


Fig. 165

type and is a separate "B" unit employed with a battery operated receiver. A three ampere fuse will be found satisfactory when the eliminator is of the D.C. type and is used to supply A. B and C potentials. If the unit supplies "A" voltage only and is of the A.C. type used in conjunction with a D.C. filament type of receiver, a five ampere fuse will be satisfactory. The average current in the primary circuit of an A.C. receiver is about .8–1. ampere, hence a 2 ampere fuse will be sufficient. If the receiver is of the type equipped with a large power amplifier and phonograph motor and turntable, the power consumption in the primary may be as high as 350 watts and a five ampere fuse is required. Cartridge or plug fuses are applicable with equal facility. See figure 164.

An emergency fuse can be improvised by fastening some fuse wire between the contacts of a male plug such as is connected to the average lamp cord. A female plug is first inserted into the fuse socket. Then the male plug is inserted. A handy size of fuse wire is 1 ampere. By arranging several lengths of fuse wire between the terminals, the current carrying capacity increases in proportion to the number of lengths of wire. Thus three lengths of 1 ampere wire will pass 3 amperes. The length of the wire for each loop is equal to the distance between the screws within the plug.

LINE VOLTAGE CONTROL RESISTANCES.—When the line voltage is constant but of higher than the required value a fixed resistance can be employed to reduce the input voltage to the correct value. Three specifications must be known before the required resistance can be determined. First the actual line voltage E, second, the required voltage E_1, and third the current consumption I (in amperes) of the power transformer under full load. Then the required value of resistance is

$$\frac{E - E_1}{I}$$

Table No. 1 gives the value of fixed resistance required to drop the stipulated values of voltage at certain popular values of current consumed by eliminators, complete power packs and sundry other such devices. The fractional answers are to the nearest decimal equivalents. If a fixed resistance of the stated value is not available a variable unit with a maximum 50 percent greater than the required value may be employed. Another item must be considered in conjunction with the value of the resistance. This is the power rating of the resistance. The wattage rating for each resistance accompanies the ohmic value.

DAMAGED POWER TRANSFORMER PRIMARY.—If some of the turns of the primary of a power transformer are short circuited, the transformation ratio within the transformer is increased and all output voltages will be high. Since the voltage output is to a very large extent governed by the turn ratio, the voltages vary in proportion and an emergency repair may be made by decreasing the input voltage by means of a resistance in the primary circuit. The value of this resistance must be such as to decrease the input voltage to the same extent that the output voltage exceeds the rated value. Suppose that the output voltage with the defective power transformer primary is 6 volts instead of 5. This is an increase of 20 percent and with a constant line voltage represents a change of about 20 percent in the turn ratio. To restore the electrical balance of turn ratio and voltages to normal, one can reduce the line voltage 20 percent or from 120 to approximately 96 volts. Of course such a repair is only temporary. Damaged windings should be repaired. A new winding is required if the major portion of the primary is shorted.

OPEN CIRCUIT IN TAPPED POWER TRANSFORMER PRIMARY.—An emergency repair is possible when an open occurs between the taps of a tapped power transformer primary, providing that the open is NOT in the main portion of the winding. If the open is between the 110 and the 115 volt taps or between the 115 and the 120 volt tap, short that part of the winding by soldering a lead between the respective tap terminals and reduce the line voltage to compensate for the fact that a certain number of turns have been removed. The method of determining the extent of line voltage reduction is like that quoted under the heading "Damaged Power Transformer Primaries." It is of course necessary to know the rated output voltage when the transformer is perfect and the output voltages when the defective part of the primary is shorted. A complete new winding is required if the main section of the primary is open.

LOOSE LAMINATIONS OR WINDING.—Loose laminations or windings will vibrate when the transformer is in operation and give rise to annoying sounds, particularly a hum. Such a condition may be corrected by wedging a piece of wood or heavy cardboard between the loose winding and the laminations. If it is impossible to tighten the laminations by means of the mounting screws frequently provided, success may be achieved by winding a few turns of No. 14 wire around the loose portion of the laminations. Draw these wires taut and twist to keep in place.

OPEN CONTACTS WITHIN POWER TRANSFORMER OR CHOKE CANS.—Before giving up all hope of repairing transformer windings or choke windings which show all indications of an open and the windings cannot be examined because they are within a can, heat the connecting tips with a soldering iron until the solder within the can at the contact is thought to flow. Then shift the position of the unit so that if the lead is broken at the contact, the circuit can perhaps be closed by the flowing solder. It is worth a trial before the unit is broken open.

OPEN HALF OR FULL WAVE PLATE VOLTAGE WINDING.—The repair of an open in one half of a full wave plate voltage winding is not very practical and the only suggestion we can make is to employ the transformer as a half wave transformer using the perfect portion of the winding. If the transformer is a part of a conventional B eliminator, remove the plate lead from the defective half of the plate voltage winding or open the circuit between this contact on the transformer and the part of the rectifier connected to it. The midtap winding remains as before. Such an arrangement will necessitate changes in the voltage divider in order that the correct voltages be available at the taps of the divider.

"HIGH" POWER TRANSFORMER OUTPUT VOLTAGES.—Several reasons may be quoted for "high" power transformer output voltages among which are high line voltage, shorted turns in the primary and insufficient load upon the output windings. Last but not least is the unused winding if such is to be found upon the transformer. If the plate winding of a transformer designed to supply filament and plate voltages is not used, the filament voltages will be high because the normal current drain of the plate winding is not used as a load upon the transformer.

SPLIT WINDING USED AS WHOLE WINDING.—It is possible to use a split (full wave) winding in a half wave rectifier by employing only one half of that complete winding, providing that the required voltage is that available from one half of the winding and the current consumption is within the rating of the transformer. It is further possible to employ a split winding as a complete winding in a half wave rectifying system when the required voltage is equal to the sum of the voltages available from each half of the winding. In such cases simply disregard the center tap.

The same is true of filament windings. Half of a split winding can be used when the required filament potential is equal to that available from each separate half of a split winding. Either winding may be used.

MEASURING VOLTAGE OF HIGH VOLTAGE WINDING.—It is often necessary to measure the output voltage of a high voltage transformer winding and a high range A.C. voltmeter is not available. It is possible to approximate the voltage in the circuit (effective voltage) by applying the unknown voltage to a known resistance and measuring the current flow. Use a standard A.C. milliammeter with a maximum range of 25 milliamperes, a resistance of 100,000 ohms for voltages between 1000 and 2000 volts; a 50,000 ohm resistance for voltages between 500 and 1000 volts, a 15,000 ohm resistance for voltages between 100 and 500 volts. Connect the meter in series with the resistance as shown in figure 165. Ohm's law for voltage or $E = I \times R$ where E and I are in effective values.

VOLTAGE WINDINGS IN SERIES.—When the voltage requirement is in excess of that available from one winding another winding may be connected in series with the first, providing that both are able to supply the required current. Another requisite when both windings are upon the same transformer is that the windings be checked to assure a series connection. Incorrect connection will cause bucking and no voltage will be available. When two like windings are connected in series the voltage is approximately doubled but the current output, if both windings have the same output remains as that of one. The primaries must be in parallel. See figure 165A.

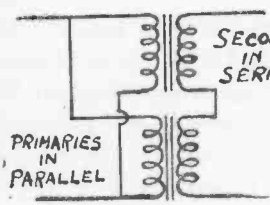


Fig. 165 A

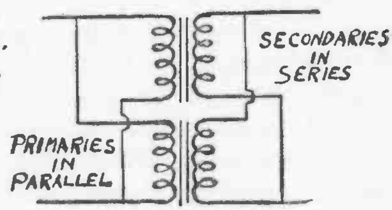


Fig. 166

VOLTAGE WINDINGS IN PARALLEL.—When the current requirement is in excess of that available from one winding another of like rating can be connected in parallel with the first and the current output will be approximately doubled whereas the voltage remains as that of either one. The primaries must be in parallel. See figure 166.

SHORTED WINDINGS UPON POWER TRANSFORMERS.—A shorted secondary winding will reduce the voltage available from a power transformer and cause overheating. Burnout of the primary is a hazard if shorted winding is the only one upon the transformer or if it is a high voltage winding.

EXCESSIVE HEATING OF POWER TRANSFORMERS.—A power transformer will overheat if the design is poor; if the regulation of a transformer winding is not like that of an eliminator. Decreasing the load current increases the voltage output, but since the voltage output of a transformer is a function of the turn ratio and the number of turns are fixed, the maximum voltage available from a winding at no load is a fraction greater than the rated voltage under load. The exact difference is a matter of design. The current which may be drawn from a transformer winding is limited. Increasing the current load decreases the voltage, gradually as the full load is reached and more rapidly as the overload is increased.

CENTER TAP UPON FILAMENT WINDINGS.—If the center tap upon a filament winding is incorrect or open at the terminal, the equivalent center tap may be secured by connecting either a fixed center tap or a variable center tap resistance in shunt with that winding and utilizing the center tap upon this resistance as the center tap of the winding. The filament winding for a rectifier tube used as a half wave rectifier or for two rectifier tubes used as full wave rectifiers need not have a center tap. Satisfactory operation may be secured by connecting the positive output lead to the filter, to either one of the filament leads.

INCREASING FILTER CAPACITIES.—The required filter capacity need not consist of one condenser with the required capacity values. It is possible to improvise a four mfd. section by using smaller values of capacity connected in parallel, as for example a 3 and a 1 mfd., four 1 mfd. units or two 2 mfd. units, etc. One requirement must be fulfilled. All of the condensers should have like voltage rating because the same value of voltage is applied to all. If like rated (voltage) condensers are not available, the lowest voltage rating of a condenser in the paralleled bank should be equal to the rating required by the design of the eliminator.

PROTECTING FILTER CONDENSERS.—It is possible to protect a filter condenser against possible breakdown during a momentary surge or when the load is removed by shunting the capacity with a resistance of such value that it is low enough in comparison with the D.C. resistance of the condenser yet high enough not to cause undue leakage across the circuit. The usual range of such units is from 50,000 to about 100,000 ohms.

HUM DUE TO POOR FILTER CONDENSER.—A
may be due to a poor contact or connection in a filter cc
The presence of a resistance due to the poor contact may c
generation of a voltage across this resistance which is then
to the voltage divider. Replacement of the condenser is the only solution. Discovery of such defective condensers is seldom possible by means of the regular routine tests. The presence of this fictitious resistance does not alter the operating voltages and the defect becomes present only when the eliminator is placed into operation. To locate the defective unit it is necessary to alternately remove and replace each filter condenser with one known to be perfect. If the filter capacities are enbloc, it is necessary to test for this fault by replacing the entire block.

As a point of information, bad joints are not limited to within the condenser case but may be external of the case. Cleaning and resoldering of the joints frequently clears the trouble.

EFFECTS OF OPEN FILTER CONDENSERS.—If an eliminator has been so designed that an input filter condenser is used, an open in this capacity will cause a great increase in hum accompanied by an appreciable reduction in output voltage.

An open middle filter capacity will have an increasing effect upon hum but will have very little effect upon output voltage.

An open output capacity will have little effect upon output voltage, causing a slight reduction in voltage, but will cause poor quality of response on loud signals, and have a tendency to cause low frequency oscillation.

LOCATING OPEN FILTER CONDENSERS.—A fairly rapid and satisfactory method of locating open filter condensers is to set the receiver or eliminator into operation and connect (if access is possible) a known filter capacity across the junctions of the units within the eliminator. If the defective condition present is due to an open filter condenser, the temporary unit connected during the test will show an improvement and at the same time indicate the unit that is open.

HUM DUE TO UNGROUNDED POWER TRANSFORMER CORES.—Grounding the core and the case of a power transformer frequently reduces the hum to a large extent.

FILTER CHOKES IN PARALLEL.—Filter chokes may be the filter. They average about 3 in number with a maximum for a single resistance or section of about 25,000 ohms. When the replacement problem arises it is possible to determine the required resistance by connecting a 25,000 variable resistance in place of the defective or burned out unit and adjusting until the correct voltage values are secured. Then measure the resistance with an ohmmeter and replace defective unit with the equivalent resistance. This resistance need not carry more than 50 mils equivalent to about 62.5 watts. The general arrangement of power supply devices is such that the main current for the output tubes does not flow through the voltage divider and the remaining tube and bleeder current seldom run higher than 50 mils. See Chapter 2.

CHECKING TOTAL CURRENT DRAIN IN ELIMINATOR WITH RAYTHEON TUBE.—The circuit arrangement shown in figure 168 is plugged into the rectifier socket and the tube is then plugged into the test socket. The meter will indicate the total direct current flow. The meter should have a maximum range of about 150 milliamperes D.C. The test circuit consists of a four prong socket and a four prong tube plug made from an old socket. A conventional four prong tube plug may be used. The test meter is inserted between the plate terminal of the plug and the plate terminal of the test socket. The filament terminals upon the test socket are connected to the filament terminals upon the plug.

INCREASING THE VOLTAGE OUTPUT AT AN ELIMINATOR TAP.—Since the voltage output and any tap is a function of the drop across the resistance connected between that and the tap at the next higher voltage, reducing the value of this resistance will reduce the voltage drop and thus increase the voltage output. A variable resistance of about 25,000 ohms may be connected across the resistance which must be changed. The supplementary unit is then varied until the correct output voltage is secured. See figure 169. The wattage rating of R1 need not exceed 50 watts. If the adjustment is to be permanent, measure the portion of R1 in use by means of an ohmmeter or the voltmeter-ammeter method and replace with a fixed unit of equivalent value.

DECREASING THE VOLTAGE OUTPUT AT AN ELIMINATOR TAP.—In view of the fact that it is quite bothersome to tamper with the constants of the divider, the series resistance is the most feasible system. The value of this resistance depends upon the voltage to be dropped and the current flow through the circuit. A resistance-current and voltage drop table is given elsewhere. As a general rule, the higher the current, the lower can be the value of the resistance required to produce a definite voltage drop. The lower the current the higher is the value of resistance required to produce a constant drop. When applying a series resistance it is necessary to know the current flowing in the circuit, the voltage available and the voltage required. If the voltage available is E and the voltage required is E_1, the resistance required to produce the correct voltage drop E_2 is

$$\frac{E-E_1}{I}$$

where I is the current in the circuit.

OPEN C BIAS RESISTANCE IN ELIMINATOR.—Quite a few receivers make use of C bias resistances located in the eliminator voltage divider. By virtue of the location of these units in the complete system, an open C bias resistance opens the eliminator load.

REMOVING DEFECTIVE FILTER CONDENSER.—A defective filter condenser can be cut out of a pack without interfering with the remaining unit. In the event that the punctured unit is the output tank condenser in a two section filter and no other unit is available, two methods of operation are possible. The first, is to change the connection of the middle condenser so that the two filter chokes are in series and the middle unit replaces the output unit. The alternative is short circuiting the second choke, and operating with but a single section filter. A distinct aid in such a case would be a parallel resonating condenser across the choke in operation. A value between .1 and .3 mfd. will be found suitable for use in 60 cycle full wave rectifiers. For half wave rectifiers the value of this capacity should be doubled.

BALLAST UNITS.—There is a distinct difference between a ballast unit and a line voltage control. The former is usually of the nature whereby line voltage variations have little effect upon the power transformer output voltages. Such units require a transformer of special design. Line voltage control or reducing resistance serve to adapt a transformer of fixed line voltage input to a line which has a normal voltage in excess of transformer rating.

In the event of failure of the ballast unit, it is possible to operate the transformer by reducing the line voltage by means of a resistance to the value required by the power transformer. As a general rule, such transformers are designed for operation at voltages approximating 65, 80 and 90 volts. If the current requirement is not known one can assume about 1 ampere input. By using a variable resistance of about 100 ohms rated at about 200 or 300 watts, it is possible to adjust the system for satisfactory operation by measur-

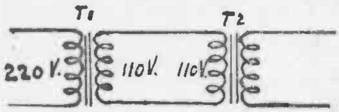


Fig. 170

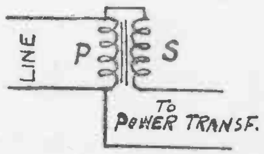


Fig. 169 A

ing the output voltages with a resistance load. In many instances the special transformers have a 110 volt tap upon the primary winding to be used in the event that the ballast element becomes defective or damaged.

OPERATING A 110-VOLT SYSTEM UPON A 220-VOLT LINE.—It is possible to operate a 110 volt A.C. power transformer upon a 220-volt line by connecting a 220-110 volt step down transformer T_1 between the power transformer T_2 in the receiver or amplifier and the line. The power rating of the supplementary power transformer should be at least equal to that required by the power transformer in the receiver or amplifier. The connection is shown in figure 170. The 110-volt output winding of the supplementary transformer is connected to the 110-volt winding of the power transformer. If the power requirement of the amplifier or receiver power transformer is about 1-2 amperes at 110 volts, the output of the supplementary 220-110 volt transformer should be 110 volts at 1 or 2 amperes as required by the power transformer.

OPEN VOLTAGE DIVIDER SECTION.—An open voltage divider section will cause an increase in all plate voltages which are secured from the eliminator. If the bleeder resistance in unit is open plate voltage will be applied to the tubes in the receiver but because of the reduced load, the voltages will be higher than normal. If one of the divider sections other than the bleeder unit is open plate voltage will be high for some tubes and lacking in others.

SHORTED VOLTAGE DIVIDER SECTION.—A short circuit across a voltage divider section increases the load upon the eliminator and therefore reduces the plate voltage. If the bleeder unit is shorted all plate voltages will be low and the tube normally supplied with the lowest plate voltage will be at B— potential. If some section other than the bleeder is shorted plate voltages will be low and the shorted section will interfere with the voltage applied to the tubes connected to that section, reducing the plate voltage to the lowest voltage associated with that section.

OPERATING RECTIFIERS UNDER MAXIMUM RATING.—The usual 380 or 381 type of tube will operate in a satisfactory manner for more than 1000 hours if it is operated below the maximum rating. Excessive heating of the plates or other forms of overloads will materially shorten the life of the tube.

LINE BOOSTER.—A line booster whereby the voltage fed into a power transformer may be increased above the normal value is of extensive utility. It enables the application of a voltage in excess of the line voltage and substantially normal voltage when the line voltage is somewhat below normal. The wiring of the system is shown in figure 169A. The booster transformer is an ordinary bell ringing single phase unit rated at about 50 to 60 watts and 15 volts.

OPERATING THE 380 TYPE FULL WAVE RECTIFIER AS A HALF WAVE RECTIFIER.—A few sets use the 380 type tube in this fashion. The two anodes are joined and the tube is used as a half wave rectifier with a half wave winding. The output current is approximately that which would be secured with the conventional full wave arrangement.

D.C. POWER SUPPLY SYSTEM.—The usual D.C. battery eliminator consists of the conventional choke-condenser combinations, except that it is possible to employ lower inductances for the filter chokes because the hum frequency present in such systems is very much higher than that found in A.C. systems. The exact frequencies depend upon the generator employed in the power house.

OPEN FILTER CONDENSER IN D.C. POWER SUPPLY SYSTEM.—In contrast to the effect of an open input filter section in an A.C. power supply system, an open input filter condenser in a D.C. system will have no effect upon the output voltage. There is a possibility of an increase of hum. As to the output condenser, its most pronounced effect will be less stability as far as receiver performance is concerned.

SHORTED D.C. VOLTAGE DIVIDER.—A shorted voltage divider will naturally short circuit the filter system and through that circuit, short the line. Such circuits are fused.

POWER PACKS IN D.C. RECEIVERS.—Although it is not true in every case, the majority of modern D.C. series filament systems employ two sets of filter chokes. One choke is used to filter the "A" supply and another choke is used to filter the "B" supply. In some instances more than one choke may be found in each of these systems.

OPEN FILTER CONDENSER IN A.C. TYPE "A" POWER PACK.—An open filter condenser will greatly increase the hum.

DEFECTIVE FILTER CONDENSER IN A.C. TYPE "A" POWER PACK.—The dry electrolytic condenser used in A.C. type "A" power packs need not fail entirely in order to be defective. Gradual deterioration manifest by abnormal leakage current will cause a reduction in the capacity of the unit. The result will be increased hum and a reduction of the output voltage. The only possible means of determining whether or not such a unit is defective is to make a leakage current and capacity test. Of course a much simpler means is replacement. Troubles of this nature have been encountered with some of the old type "A" condensers. The period of use is indeterminate. Failure has been recorded after approximately three months. The modern units are however much more satisfactory.

TAPPED POWER WINDINGS UPON "A" ELIMINATOR TRANSFORMERS.—Quite a few "A" eliminators are equipped with tapped power transformer secondaries so that the voltage output may be adjusted according to the available and required voltage. In some instances a resistance form of control is used between the winding and the rectifier. Such "A" eliminator windings may be separate transformers or one of the secondary windings upon the regular power transformer.

CHAPTER 17

AUTOMOBILE RADIO

In view of the fact that the purpose of this chapter is to consider the repair problems of automobile radio equipment rather than the design problems, we shall not attempt to enter upon a discussion relative to design.

Consideration of every detail relating to the present day automobile shows that there is only one logical position for the radio receiver, namely beneath the cowl, between the instrument board and the motor. When so located direct rather than remote control is possible, thus eliminating all of the possible troubles which invariably develop in remote control systems. This statement should not be taken as disparaging, since it is only logical that direct control is more satisfactory than remote control.

With respect to the complete receiver it is impossible to state the exact arrangement in any one system. It is possible that the complete receiver is divided into two parts, the radio frequency amplifier-detector unit and the audio amplifier. Such design offers much greater leeway in the installation, because it enables placement of the audio amplifier in the most convenient position.

THE ANTENNA SYSTEM.—The importance of having a good antenna system in an automobile cannot be stressed too much. At best it is poor because of the very low effective height. Experiments carried out by the writer during the past six years during which period various types of aerials have been employed in connection with various types of receivers have shown that two types of aerials are most satisfactory. The first is the capacity aerial, with a large plate or screen as the upper plate and the chassis of the machine as the other plate. Another type of aerial found satisfactory was the vertical loop located inside the car and outside of the car. In connection with aerials we take the opportunity to abstract from an excellent article describing automobile radio equipment published in *Radio Engineering,* August, 1930. The author is Arthur V. Nichol, Asst. Chief Engineer of the Automobile Radio Corporation.

"The importance of the antenna system design cannot be too highly stressed. Extensive tests upon various types, sizes and constructions have definitely pointed to the large superiority of the large area screen antenna over all others, with the horizontally coiled loop a second choice. The effective height is woefully low which means that a receiver of high gain is required. The capacity of the antenna should therefore be made as high as possible. In cars using poultry wire as a support for the deck material, this netting may be insulated and makes an excellent aerial.

"Many automobile manufacturers are insulating this poultry wire from the car by a spacer built into the roof construction. A lead wire is brought down the right front post to facilitate installation. Measurements of these antenna show, for sedan models a capacity of about .002 mfd. and a resistance of about 1.5 ohms at 1000 kc. This capacity compares favorably with that of the good broadcast antenna, but the effective height is about .4 meter. In cars having a slat roof, the antenna may consist of copper window screen tacked against the underside of the bows and concealed by the head lining. In factory installations this copper screen is placed between the slats and the deck material. The characteristics of this type are much the same as those of the poultry wire antenna, but as they are necessarily smaller in area they show no improvement in reception.

"In roadsters and touring cars a flexible wire is woven into a horizontal loop supported by cloth which is stitched to the pads which support the top material at each side. A lining of the same material as the top is stretched beneath to conceal it from view. In such an installation, the top may be folded back and the lead wire brought down the rear of the top and along the body sill to the cowl. The set may be operated with the top up or the top down, although better reception is secured with the top up. This antenna is about 75 percent as efficient as the screen, but because of the smaller masses of metal about it, its effective height is greater than that of the screen. These two factors tend to offset one another, and a very successful installation can therefore be made even in a roadster. A touring car antenna often is superior to that possible in a sedan.

"Many unusual types have been tried, such as using a capacity to ground, the use of insulated bumpers, trunk racks and so forth. Probably one of the most interesting was an insulated plate fastened beneath each running board. Shielded leads were run from these plates to the receiver. The idea was that spark radiation from the ignition system would be picked up equally by these two plates and being in phase across the antenna would cancel out. The signal however being slightly out of phase would induce a potential in the secondary. It was far from successful from an elimination standpoint but was rather a good antenna. However, it was directional and therefore discarded.

"Wire, tinsel tapes or small loops mounted inside the car do not prove satisfactory because of the shielding effect of the metal parts of the body. These antennae necessitate receivers of too high a gain to be practical and their advantage from an installation angle is slight.

"We find therefore that the best antenna is one which combines the highest possible capacity with the greatest effective height, or in other words maximum spacing from metal parts of the body."

The foregoing description of general antenna construction in automobiles of varied type should prove valuable to the man who is confronted with service upon one of these car receivers.

In connection with loop aerials mounted within the body of a sedan, the writer had the opportunity of employing one such system for a period of about nine months. The receiver was of the superheterodyne type, consisting of oscillator, modulator, two stages of intermediate frequency amplification, second detector and one stage of audio frequency amplification. This equipment in addition to supplementary apparatus was employed during a survey of field strength throughout metropolitan New York. While it is true that the apparatus proved cumbersome to handle, the reception secured with an upright box loop approximately 30 inches square was superior to anything possible with external horizontal aerials. Such equipment may be of interest to the man who is called upon to locate a particularly annoying source of electrical interference.

While upon the subject we must state in due justice to other experimenters that the receiver used possessed a very high gain and that the receiver was operated with the motor shut down. At the same time, no effort was made to minimize electrical interference from the motor.

ELIMINATING INTERFERENCE FROM MOTOR IGNITION SYSTEMS.—The item of moment in connection with automobile radio receiver equipment is the elimination of the radiated interference caused by the normal motor ignition system. We employ the word "normal" to distinguish between the unfiltered and the filtered (if we may call it that) ignition system. In operation the various wires located in the ignition system are miniature antennae. The frequency of these oscillations may be said to be determined by the distributed capacity and inductance of the system. At the same time the system is akin to a spark transmitter where the radiated signals cause shock excitation of receiver antenna irrespective of the frequency adjustment of the receiver system. However experiments carried on with short wave receivers showed that the most prominent frequency range of the ignition system lies between 70,000 and about 5,000 kc.

Several successful methods of combating this form of interference have been placed into effect. One of these is shown in the section devoted to the elimination of spark plug interference in the chapter devoted to Electrical Interference and Its Elimination. A very popular form of minimization of this type of interference is the insertion of a 25,000 to 50,000 ohm fixed resistance in each spark plug lead, directly at the plug. When selecting such resistances it is necessary to remember that the heat developed at this point will have a tendency to age the resistances and thus reduce their actual ohmic value. Thus it might be well to start with a resistor (for each plug) which is several times the actual resistance required, bearing in mind that the carbon type of resistance has a negative temperature coefficient and decreases in resistance as the temperature is increased.

Another important position in the ignition system is the distributor, and a suppressor of about 25,000 to 50,000 ohms should be located in the lead from the rotary arm of the distributor to the ignition coil. Also refer to "Electrical Interference and Filters."

CHAPTER 18

ELECTRICAL INTERFERENCE AND FILTERS

LINE VOLTAGE FLUCTUATION AND ELECTRICAL INTERFERENCE.—The fact that voltage fluctuations are present in a system is by no means new information, but it might be of interest to men associated with such work that voltage fluctuation has been found to accompany "click" type of interference. Recent tests made in various parts of New York City in connection with A.C. electric receivers have brought to light the fact that wherever voltage fluctuation is appreciable, this form of trouble is invariably accompanied by electrical interference.

The rate of the voltage fluctuation plays a very important role. If it is gradual, from a higher to a lower level, it is frequently accompanied by a gradual decrease in receiver sensitivity and sometimes by actual fading of the signal. On the other hand, if it is rapid and instantaneous, the effect upon the receiver with respect to receiver sensitivity is negligible, yet the "click" form of disturbance prevails during each voltage variation period.

Perhaps it is thought that the fluctuation in voltage must be radical in order that the audible disturbance be present. We have found a 5-volt fluctuation to be sufficient to cause a very strong click when the receiver is adjusted to a high sensitivity level. Such action raises a point of discussion. Interruption of an electric circuit or a neighboring circuit securing its power from the same source, causes the propagation of an electrical impulse along the power lines, which appears as a single signal pulse of "click" nature; sometimes as a rough "buzz," in case the interruption is unsteady for short periods as for example, a defective lamp, switch or socket.

A few voltage records made with a graphic voltmeter are shown in figures 171 and 172. Each fluctuation of the line voltage causes a movement of the voltmeter pointer and a tracing upon the chart.

The installation indicated in the graph shown in figure 171 is known to be quiet and free from radical fluctuations. Note that 5- or 6-volt fluctuations occur but very infrequently. The normal width of the voltage curve is about 1 volt with an average plus or minus of 1 volt.

The change at 8:17 P.M. caused no variation in receiver sensitivity whereas the drop at 9:52 P.M. caused a sudden drop in sensitivity. Another such drop occured at 11:06 P.M. Such observations showed that a drop of five volts in line voltage is sufficient to show a change in receiver sensitivity.

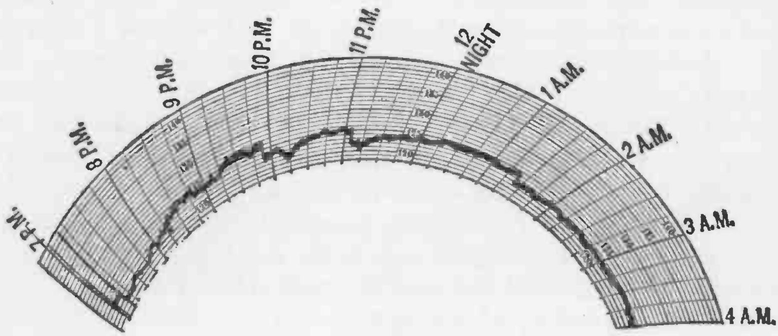


Fig. 171

A very atrocious condition is shown in figure 172. At this location between the hours of 8 A.M. and 2:30 A.M., reception is continually harassed by clicks, sometimes as many as 5 per minute, rendering radio reception very unpleasant. Contrast the normal width of the voltage line in figure 171 with that in figure 172. Instantaneous 5-volt fluctuations are quite common in figure 172 and each such variation is accompanied by a bad click. The maximum instantaneous fluctuation at this point was 8 volts. Every sudden dip and rise in voltage was accompanied by a click.

It is now necessary in due justice to the power companies to make specific mention that every click heard in a radio receiver installation is not attributable to line interference. The average console receiver when in operation vibrates to an appreciable extent, thus setting into motion all loose contacts. Arcing between high voltage and grounded leads across low resistance paths is also prevalent. Defective detector tubes, momentarily overloaded rectifiers, etc., and external sources must also be considered.

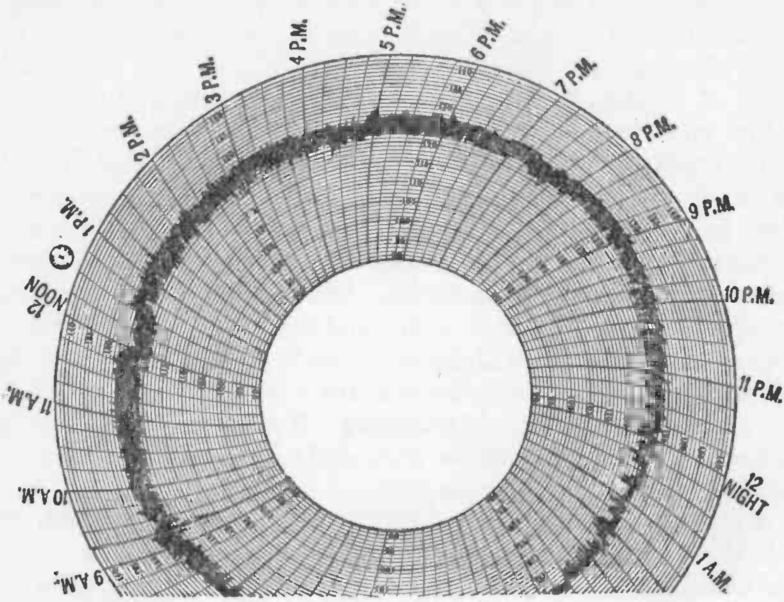


Fig. 172

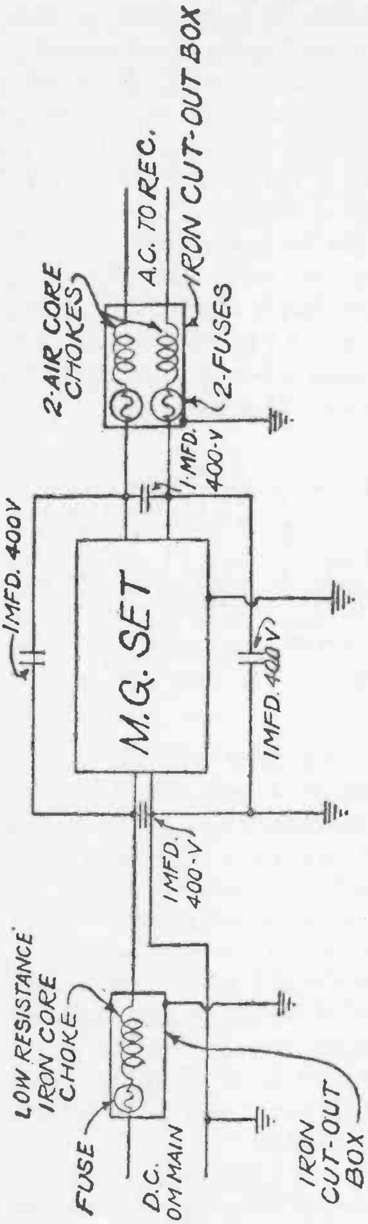
Electrical interference finds its way into the electric radio receiver by two paths, first through the power supply, (i.e., power pack) and second, through the antenna and ground system. That is to say, a device which causes radio interference may radiate into the ether just as a broadcasting station radiates its signal, or it may send the interfering signal out over the power line to which the device is connected. The disturbance may be anything from an ordinary A.C. hum to hissing or crackling, depending on the piece of faulty equipment causing it. Sometimes it is possible to tune the interference in or out at will with the tuning condensers. More often, this is not the case since the majority of such disturbances are well spread out over the broad cast range. Radiated interference must generally be cured at its source by preventing radiation, whereas interference from the power line can generally be eliminated by an interference filter inserted in the power line between the radio receiver and the A.C. mains.

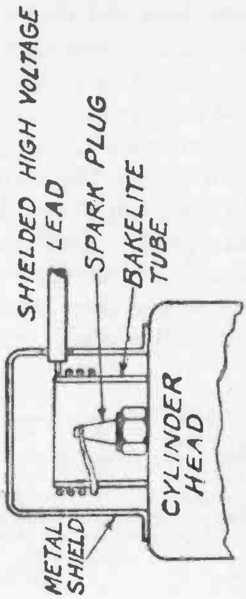
FILTER FOR MOTOR-GENERATORS.—A motor-generator frequently sets up radio frequency disturbances which are conducted along the power line and radiated directly to the radio receiver. Generally, such disturbances can be eliminated by carefully cleaning and adjusting the brushes and brush holders. In cases of trouble, it is always advisable to take apart the brush holder and clean all contacting surfaces of brushes, brush holder and pigtails. The frame of the motor or generator should always be solidly grounded. In some makes of small motor-generator sets, there is a conductive connection between the armature winding of motor and generator. In any case, it is advisable to test for ground before grounding any conductor. Thus a small motor-generator set operating from the D.C. mains and supplying A.C. for receivers may show that one side of the A.C. line is a few volts from ground due to electrical inter-connection of the armatures and the fact that one side of the D.C. line is grounded. If such is not the case, one side of the A.C. line should be grounded. Figure 174 shows a common type of motor-generator filter.

FILTERS FOR RELAY CONTACTS AND SPARK PLUGS.—In the case of relay contacts or switch buzzer contacts or the like, the disturbance can be prevented by shunting the contacts with condenser and a resistance as in figure 175. This prevents the formation of the disturance. With respect to spark plugs, the wave-length or frequency of the disturbance can be changed by adding a shielded choke coil in series with the shielded spark plug lead at the spark plug. This coil may consist of a few turns of No. 16 wire wound on a 1½" form with a small tin can mounted over it. See figure 176. In many cases a 25,000-50,000 ohm carbon resistor can be used to replace the choke coil, in which case the shielding may be omitted.

This scheme prevents the formation of the high frequency currents. Some or all of these schemes may have to be employed in order to eliminate the disturbance sufficiently for the particular installation. Referring to figure 174 the air-core chokes are 50 turns No. 14-18 S.C.C. wire wound on a Bakelite form 2-2½" O.D. The iron core choke should be of .5 or 1 henry and of very low D.C. resistance.

FILTERS FOR DOORBELLS, BUZZERS AND MISCELLANEOUS DEVICES.—The design of a filter for the elimination





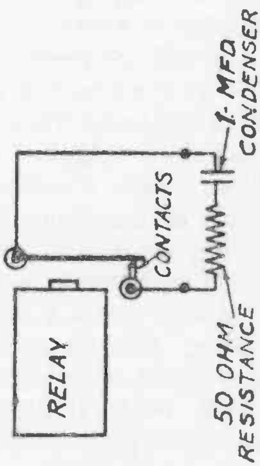


Fig. 174 (top)

Fig. 175 (left)

Fig. 176 (right)

of radio frequency radiation is a matter of experiment, particularly as far as the exact selection of the condensers is concerned. One thing is standard and that is the imperative need for shielding of the filter system. Each such filter system should be located within some shield or can be properly grounded. Examples of filters suitable for low power circuits are given in figure 177A, 177B and 177C.

The inductances L and L1 are of like value and consist of a coil of about 100 or 150 turns of No. 18 annunciator wire. If the current through the circuit is very low, these coils may be of the honeycomb variety. Ordinary annunciator wire of No. 18 B. & S. gage is capable of passing 3 amperes. As to the form of coil used, it may be a single layer winding upon a 3-inch form or it may be a multilayer coil wound upon a spool. If nothing else is possible,

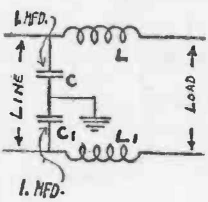


Fig. 177A

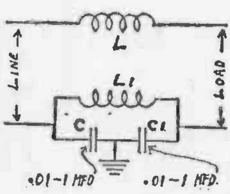


Fig. 177B

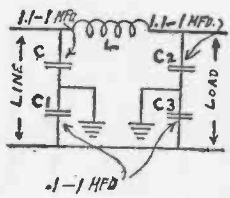


Fig. 177C

a random winding upon any sort of a form will do. As to the exact number of turns, the inductance of such a coil is not very critical. A table of current carrying capacities of copper wires as prescribed by the Board of Fire Underwriters, is given in the chapter devoted to Useful Tables. The figures associated with the various condensers, designate the range of capacities suitable for use in the filter system illustrated. In connection with such filters, it is necessary to remember that the location of an inductance in a line carrying an appreciable amount of current, means the insertion of a resistance, hence in order that the voltage drop be minimum, the size of wire selected should be such as to cause the minimum voltage drop. Because of this requirement, pure resistances of an equivalent impedance value, cannot be used.

FILTER FOR INPUT CIRCUIT OF A.C. RECEIVER POWER SUPPLY.—This filter is intended for location in the line connecting the primary winding of the power transformer to the house power system. The filters shown in figures 177A and 177C are suitable for this use.

FILTERS FOR MOTORS OR GENERATORS.—The systems shown in figures 178A to 178A inclusive are suitable for use in connection with motors and generators. The inductances should be wound with wire sufficiently heavy to carry the current and introduce very little resistance. A coil of about 100 turns wound upon a winding form about 2 inches in diameter will be found satisfactory. If desired, chokes may be wound upon wax impregnated spools. A typical spool would be 1 inch in diameter, 1 inch wide and with sides which would enable a winding depth of about 1½ inches. A typical choke would employ sufficient number 18 D.C.C. wire to fill this space. Chokes connected between the line and a motor may consist of about 50 or 60 turns of No. 14 D.C.C. wire wound upon a form about 3 inches in diameter. For actual wire sizes based upon current flow, see "Useful Radio Tables."

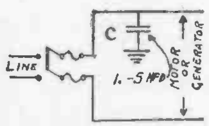


Fig. 178 A

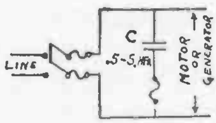


Fig. 178 B

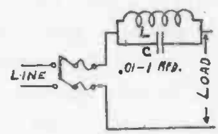


Fig. 178 C

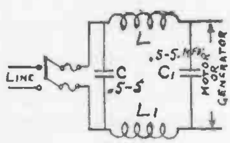


Fig. 178 D

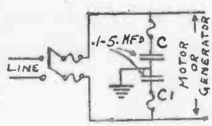


Fig. 178 E

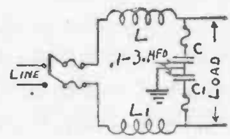


Fig. 178 F

CHAPTER 19

STORAGE BATTERIES

TESTING BATTERIES.—It is customary to test the condition of certain types of batteries which find application in radio receivers by measuring the voltage of the battery. The usual load under such conditions is that of the measuring instrument, which is seldom greater than about 5 to 10 milliamperes. Such voltage tests are not applicable to storage batteries. While it is true that the specific gravity test is very satisfactory, a better test is the measurement of voltage while the battery is under load. Whether or not such a test can be made because of the equipment required depends entirely upon the number of times the man interested may be called upon to make the test. As an item of interest, storage batteries when delivered to a battery station are tested under a load of from 50 to 100 amperes and the voltage is measured during the application of this load. While it is possible to secure a bar of copper of the proper resistance to produce a load within this range and also carry this load, it is best if such battery test meters are purchased as complete units. If such a unit is not available the next best test is the hydrometer.

AMPERE HOUR RATING.—The ampere hour capacity of a cell is generally understood to be a fixed quantity. Thus if a battery is rated at 100 ampere hours, it is customary to assume that the complete battery will deliver current at any rate to equal this rating during a definite period. Thus one would imagine that the battery would deliver 100 amperes for 1 hour, 50 amperes for 2 hours, 10 amperes for 10 hours, 5 amperes for 20 hours, etc. Such is not the case. The ampere hour rating, whatever it may be, is the discharge capacity at a definite rate of discharge. If the rate of discharge is increased, the discharge capacity is decreased and if the rate of discharge is decreased below the normal rating the discharge capacity is increased. Thus if the normal rate is 5 amperes per hour, and the total discharge capacity is 100 ampere hours, that battery may be suitable for operation over a period of 20 hours. If the actual rate of discharge is increased to 10 amperes, the period of operation will be less than 10 hours. If, however, the rate of discharge is decreased to 2 amperes, the normal period of operation prior to the need for recharging will be more than 50 hours.

CHARGING.—A battery after it has been discharged must again be charged. During charge the charging source must be of D.C. character and the positive terminal of the charging source must be connected to the positive pole of the battery and the negative terminal of the charging source must be connected to the negative terminal of the battery.

For best performance and greatest battery life the charging process should be tapered. In other words, the initial charge applied to a discharged battery may be high, but the charging rate should decrease as the state of charge of the battery increases. Excessive gassing of a cell should be avoided. Operation of the battery during the period of gassing is apt to be accompanied by noise. It is necessary to remember that the voltage per cell is appreciably higher than normal right after charge, the voltage of a 6-volt battery in some cases being as high as 6.5 to 7. volts.

TEMPERATURE.—High temperatures, in excess of 110° F. are injurious to the battery and prolonged operation at such temperatures will greatly shorten the life of the wood separators employed within the cell and replacement of these separators will be necessary long before the battery completes its normal operating life. Low temperatures on the other hand decrease the discharge voltage and the discharge capacity. Low temperatures have a greater effect upon discharged or partially discharged, than upon fully charged batteries. This is of particular interest in the case of the batteries employed in automobiles. The average car owner is not very careful of the state of the car battery. He asks for a rental when the battery refuses to actuate the starter. By this time, the state of discharge is such that the receiver tube filaments glow dim and the receiver is inoperative or performs in a poor manner. Poor maintenance results in damaged cells. Damaged cells in turn cause voltage fluctuations. Voltage fluctuations in turn cause electrical interference in the receiver—just a vicious circle.

CHAPTER 20

SPEAKERS

SEVERAL problems relative to the replacement of speakers have come to the fore since the advent of the dynamic. The presence of the field coil and the voice coil in the dynamic reproducer and the definite relations which must exist when such speakers are employed are in direct contrast to the conditions present when the cone speaker is employed.

We are accustomed to connecting a speaker to the output system of a radio receiver without regard to what takes place in the power pack filter; without concern as to the possible interruption of service unless all of the components of the reproducer system are correctly arranged. The advent of the dynamic introduced the field coil and the voice coil, two elements unknown in the old type of speaker. When working with a cone speaker we have two leads and no interest with what is inside. With the dynamic we have four leads, sometimes five leads, which must be plugged into a certain receptacle specially provided in the receiver. If the speaker is independent we have an additional plug which must be connected to the line supply and two leads for connection to the output of the radio receiver.

What is the relation between the dynamic supplied with the receiver and an external speaker of similar type? . . . What is the relation between the field and voice coils of the same speaker? . . . Are they so interlocked that they cannot be used independently? . . . Must the field winding be employed to replace a dynamic—a dynamic supplied with the receiver and plugged into the receiver power pack—a dynamic which is not an integral part of the receiver? . . . The answers to these few problems encompass practically all of the difficulties prevalent at the present time. . . .

THE FIELD COIL AND THE VOICE COIL.—It is necessary to explain the relation between the field coil and the voice coil. We shall not attempt a dissertation upon dynamic speakers. Perhaps this short explanation will solve the enigma. The voice coil and the field coil of a dynamic speaker are definitely different windings. The voice coil cannot be operated without the field coil, but the field coil winding can be employed independently of the voice coil. If for some reason the voice coil of a speaker is not to be used, the field winding can be employed as a choke for any purpose within the current and voltage rating of the winding. The voice coil can be disconnected from the speaker transformer with-

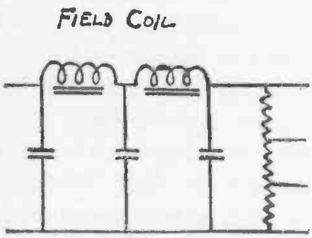


Fig. 179

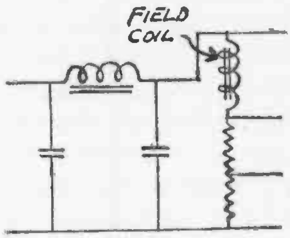


Fig. 180

out interfering with the action of the field winding as a choke. When the two are to be separated, the voice coil can remain intact in a speaker not connected to the output of a receiver without interfering with the operation of the field winding when that winding is employed as a choke. . . Let us continue.

THE FIELD COIL AS A CHOKE.—Many receivers are so arranged that the field coil of the dynamic speaker furnished with the installation forms a part of the power pack filter system; wherein the field coil functions as one of the chokes. If such a speaker is to be replaced, several conditions must be fulfilled. We shall assume that the contemplated speaker is suited for operation with the receiver. In the event that a new dynamic is equipped with its own source of current for its field winding, the field winding of the old speaker must remain connected to the power pack of the receiver when the voice coil is disconnected from the receiver. See figure 179. In the event that the old speaker is an encumbrance, the field winding which is a part of the filter system can be removed from the filter system, but a choke of the correct electrical constants, equivalent to the constants of the field winding which has been removed, should be inserted in its stead. A fixed resistance equal to the D.C. resistance value of the old field coil cannot be used to replace the field winding in the filter. If, however, the field coil is used as a voltage divider resistance as in figure 180 it can be replaced by a fixed resistance of identical D.C. ohmic value without interfering with the distribution of output voltages or the filtering action of the elements within the power pack.

CHANGING SPEAKERS.—When changing speakers it is necessary to consider the output unit employed in the receiver. When a speaker is supplied with a receiver, the transformer contained within the speaker properly coordinates the electrical characteristics of the output tube or tubes as the case may be, with the characteristic of the speaker. When another speaker is to be used, the same relation of characteristics must be obtained, hence the first important requisite is that the new speaker be suited for the receiver. Suppose that the new speaker is a cone. Further, that it is suited to the receiver. How can such a unit be employed in place of the dynamic? We must assume that the old dynamic was furnished with the receiver. In this case, however, we will say that the speaker is equipped with its own source of field current, a rectifier. Also that the output transformer is located within the speaker system. Since the speaker has its own field supply, it is unnecessary to worry about the field coil. However, the output transformer is in the speaker. How can we arrange an output unit for the cone. Two methods are available. First, the removal of the output transformer from the dynamic speaker and utilization of its primary winding. The secondary is of no use, since it is "matched" with the dynamic voice coil, hence it is disconnected from the voice coil and remains open. The cone is then connected across the primary winding and the plates of the push-pull tubes as in figure 181. In some cases it is very inconvenient to separate the primary and the secondary windings of the output transformer because the secondary winding is an integral part of the voice coil. An entirely new transformer will then be necessary. This transformer should be of the type designed to match the cone to the output stage as in figure 182.

In the event that the output stage consists of but one tube and the primary of the dynamic transformer is available for use the speaker is connected across the plate and B-terminals with a series condenser as shown in figure 183. It is understood that the voice coil of the dynamic will be disconnected from the transformer secondary. If the output stage consists of but one tube and the primary and secondary windings, the latter connected to the voice coil, cannot be divorced, a separate coupling transformer will be necessary as in figure 184. If a choke-condenser output is preferred, the conventional output transformer is replaced by a choke-condenser combination.

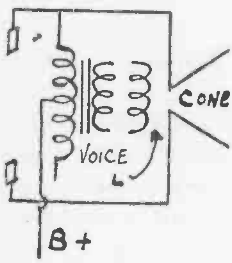


Fig. 181

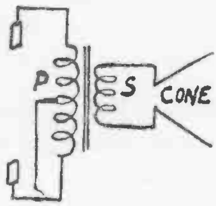


Fig. 182

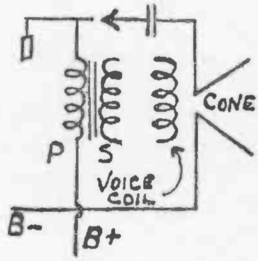


Fig. 183

If the receiver is equipped with a choke-condenser output system which was used in conjunction with a cone speaker and a new reproducer is a dynamic equipped with a transformer designed for operation with the tube employed in the output stage, the choke-condenser combination need not be removed in order that the dynamic be correctly coordinated with the output stage. Assuming that the dynamic is equipped with its own source of field current, the primary winding can be connected in place of the cone after the latter has been removed from the output circuit of the receiver. Such an arrangement is shown in figure 185.

A few words relative to the types of field windings will not be amiss. All dynamics are not designed for operation with the same value of field current. Some operate at 6 volts, some at 8 volts, some at 90, some at 110, some at 250 volts and others as high as 475 volts. Because of this variation in design, dynamic speakers not equipped with separate sources of field current must be selected with care.

In the event that the dynamic is equipped with its own rectifier and is designed for 110 volt A.C. input, the type of rectifier employed is of no consequence and the actual voltage applied to the field coil is likewise of no consequence since the winding is designed for operation with the rectifier furnished.

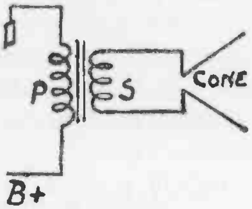


Fig. 184

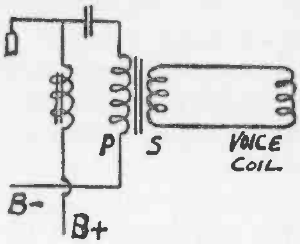


Fig. 185

Relative to the designations P.S. in the aforementioned illustrations the former designate the primary winding of the transformer and the latter the secondary winding. The severed connections between S and the voice coil indicate that the circuit is interrupted at two points.

SOME FACTS ABOUT DYNAMIC SPEAKERS.—The dynamic speaker appears to be a much more rugged device than the old type of moving armature (cone) unit, but it, too, is subject to faults. Neglecting the possibility of a separation between the voice coil and the diaphragm, burnout of the voice coil is still possible. To guard against such a condition do not operate the amplifier feeding into the voice coil unless the field power supply is on. Further, do not attempt to align these parts while the unit is in operation.

As a precautionary measure, in the event that the speaker and the amplifier are operated from two different sources, reduce the sound output or amplification before turning the set "off." This method of operation is applicable at all times because it lengthens the life of the output filter condenser in the B eliminator.

The sensitivity of the speaker depends to a large extent upon the current through the field winding, since the motion of the voice coil depends upon the magnetic flux produced in the "pot" magnet by the current through the field winding. Any and all values of current are not suitable for the field winding.

When testing for continuity through a voice winding assumed to be open do not apply a 45-volt battery and watch for the spark.

Low impedance winding will not carry the current due to the application of such a high plate voltage and will burn out. Overheating of this winding should be avoided because it might blister the compound placed upon the winding and thus interfere with its motion within the small confine provided for the voice coil as it surrounds the magnet.

Rattling sounds may be due to loose mounting screws. Weakness may be due to low field current. Since the magnet used is an electromagnet, functioning only when the current is "on" through the field winding, it is needless to consider the replacement of the magnet. The permanent magnet in the old type of cone speaker was subject to demagnetization, but not so in the dynamic speaker.

The baffle prevents the escape of propelled air around the edge of the diaphragm, thus providing better low frequency response.

Foreign particles find their way into the space between the voice coil and the magnet and interfere with the free motion of the coil.

Elements which radiate heat, such as transformers and rectifying tubes, should not be placed near the speaker diaphragm. Excessive heat will warp some part of the vibrating surface and thus change the uniformity of tension, altering the quality of reproduction.

Speakers should not be placed in inclosed chambers. The form of the housing may be partially covered, an opening left for the diaphragm, but the rear should be open in order to allow a free circulation of air. Unless such a condition exists cavity resonance will be present, resulting in an "overhang" of a tone and interference with other tones.

Dynamic speakers should not be placed into cabinets made of light wood. Vibration of the sides or walls of the cabinet is possible and distortion will be inevitable. That "barrel" or "booming" sound is due to cavity resonance and may be minimized if not eliminated by either drilling the back or removing the back of the cabinet. When the cabinet is placed too close to the wall removal of the back is not of such great advantage. A separation of six or eight inches between the rear of the cabinet and the wall will be found advantageous.

The general characteristic of the average dynamic is that a definite amount of power must be fed into the unit to secure good reproduction. Low "gain" will not produce the best results.

CHAPTER 21

ELECTRIC PHONOGRAPH PICKUPS

THE application of the phonograph pickup to radio receivers and its use with public address amplifiers is no longer a new innovation. An examination of practically every modern radio receiver installation shows provision for the use of a phonograph pickup. Hence a few pertinent facts about such units will not be amiss.

All electrical pickups are not of like character or design, character and design in this case referring to the electrical considerations, rather than the physical appearance. While it is true that they look alike, they do not perform in like manner. Because of this condition, all pickups are not equally suited for all radio receivers or all power amplifiers. This fact may be proved by a simple aural test, during which time several different makes of pickups are connected to the same amplifier or receiver. This may be said to be true even when the respective units are being operated under ideal conditions. We therefore make the general recommendation that electric phonograph pickups intended for operation with any one receiver or power amplifier be of the make suggested by the receiver or power amplifier manufacturer.

RECORDING CHARACTERISTICS.—As a general statement, each pickup is associated with two electrical items of importance. The first is the impedance and the second is the frequency characteristic. In a measure the second is influenced by the first because of the effect of the associated equipment upon the impedance characteristic. For the moment we shall neglect the first factor and consider the frequency response.

We shall assume that the method of applying any one pickup to a system is that which is best suited to the pickup. Generally speaking the frequency response characteristic of a pickup is governed to a large measure by the systems employed during the original recording of the speech or music upon the phonograph disc. This is somewhat beyond the radio field but nevertheless is important. One would naturally imagine that the sound energy pickup by the microphone, either condenser or carbon button is amplified, passed to the cutting tool and recorded as grooves which are true reproductions of the amplitudes of the waves in the original sound.

Such is not the case. Assuming ideal amplification, the record is not a true reproduction of the original sound. Due to the forms of recording and the relative intensities of different frequencies it is necessary to limit the magnitude of energy of these waves so that the frequencies present in the range are satisfactorily recorded within the grooves cut in the record without breaking through the sidewalls between the grooves. A break in the sidewalls present between the grooves renders a record unfit for use. In view of the greater amplitude of the low frequency oscillations it is necessary to set a definite amplitude limit which will include the low and the high frequencies. This limit must of necessity, for the reason set forth, take place upon some low frequency. This means that the low frequencies are attenuated to a variable extent as the frequency is increased, thus changing the amplitudes of the frequencies present, with the greatest decrease upon the low frequencies.

Provision must therefore be made when reproducing to raise the amplitude of the low frequencies to the original level, so that the final reproduction via the speaker will be the same as the original impinged upon the microphone in the studio. Figure 186 (solid lines) shows a typical frequency characteristic of a commercial recorder. Note how the low frequencies between 50 and 300 cycles are attenuated with respect to the higher frequencies.

The characteristic of the phonograph pickup device must be such as to compensate for this rising characteristic. In other words the pickup must be more responsive to the lower frequencies between 50 and 300 cycles than to higher frequencies. An idea of what is necessary is shown by dotted line curve in figure 186.

Extensive analysis is unnecessary, considering the characteristic of the cutter, to realize that if the desired characteristic is not obtained or if the method of connecting the pickup to the receiver impairs the correct characteristic, reproduction will be poor insofar as loss of depth and power are concerned.

the receiver. The exact method depends upon the design of the pickup unit. Electric pickups classified as "low impedance" units invariably require a transformer or some other means of matching the pickup to some suitable part of the receiver.

Four popular methods of this type are shown in figures 187, 188, 189 and 190A. In figure 187 the pickup is connected across a part of the first stage audio frequency transformer primary. The entire

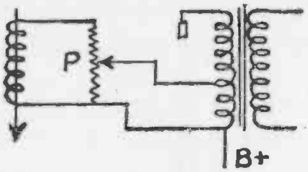


Fig. 187

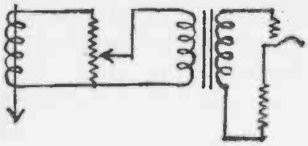


Fig. 188

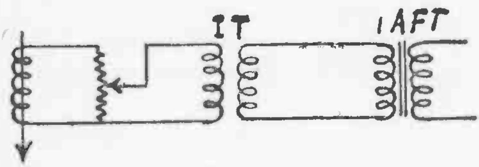
primary is used in the detector plate circuit, but only a part of the primary is used to link the amplifier with the pickup. The control of volume is accomplished by means of a low resistance potentiometer connected across the pickup. It is necessary to specify that such low resistance units ranging from 60 to about 500 ohms are suitable with low impedance pickups and are not suited for use with medium or high impedance units.

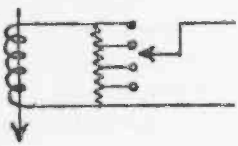
Figure 188 shows a means of employing any type of pickup unit, and for that matter shows a system extensively employed in radio receivers. The pickup may be of the low or high impedance type, since the proper impedance matching transformer may be secured. In the illustration shown, the transformer adapts the pickup so that it is connected across the input circuit of the detector tube. The control of volume is accomplished by means of the potentiometer connected across the pickup unit.

Figure 189 illustrates the use of an impedance matching transformer to link the pickup unit with the first audio stage transformer. The pickup and volume control units are connected across the primary of the impedance matching transformer. The secondary of this unit is connected across the primary of the first stage audio unit. Of course the proper switches are included to disconnect the primary of the transformer from the battery supply of the system.

Figures 190A and 190B show two alternate methods of controlling volume. The former is somewhat similar to that shown in figure 187, except that the control resistance is tapped and the control of volume is accomplished by setting the switch to any one of the taps. Figure 190B shows the use of a tapped auto-transformer, whereby an increase or decrease of volume may be secured.

In very many cases, the pickup unit connects across the grid-cathode circuit of the detector tube without any special provision for volume control; control being accomplished in the audio frequency part of the receiver.





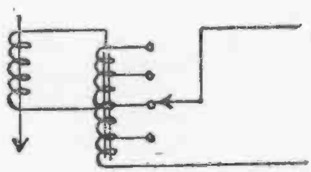


Fig. 189 (top)

Fig. 190 A

Fig. 190 B

Electric pickup units manufactured for general application are equipped with simple potentiometer type volume control units. The approximate resistance of such potentiometers is about 25,000 ohms. These units are suitable for application unless specification has been made to the contrary, directly across the primary of the audio frequency transformer in the first audio stage.

If a special effort is to be made to secure the best performance, an impedance matching transformer should be used in connection with the pickup. When selecting such a transformer it is necessary to specify the location of the matching unit, i.e., whether it is to feed into the primary of the audio frequency transformer or into the grid circuit of a vacuum tube.

In connection with volume control units allied with electric pickups it is significant to note that the resistances are not of the rheostat type. Control units which tend to reduce the resistance across the pickup during the time that the volume is being decreased tend to impair the quality of reproduction.

TROUBLES IN PICKUPS.—Troubles occur in pickup devices as well as in other parts of the installation. In some respects the difficulties are similar to those encountered with other units which contain a coil of wire. In addition several new items present themselves. As a point of interest in order to clarify miscomprehension, pickup devices do not require steady D.C. operating potentials. When the device is connected across the primary of the audio frequency transformer its winding should be isolated with respect to the tube plate current.

Pickup troubles in general are attributable directly to the use or to its mounting. Classified, these troubles would be as follows:

Distortion	Worn out needle. Excessive tension upon tone arm. Excessive tension upon armature. Loose needle. Loose elements. Defective damping (rubber pads).
"Dead" Unit	Frozen armature. Armature out of alignment. Opening winding. Opening connecting cable. Shorted winding. Shorted connecting cable. Open transformer primary.
Sputtering	Loose needle. Loose armature. Loose connections.
Unsteady Reproduction	Non-uniform speed of motor Excessive weight upon disc.

CHAPTER 22

EXCESSIVE REGENERATION REMEDIES

INCORRECT operating potentials have a tendency to cause excessive regeneration, but such troubles are present with normal voltages.

REGENERATION IN RADIO FREQUENCY AMPLIFIERS.—Regeneration in the radio frequency amplifier is frequently due to imperfect bypassing. This does not necessarily mean that the condenser is open or that a bypass condenser is lacking. Time and again have we encountered bypass condensers which were internally defective so that the actual bypassing effect was very low and replacement was necessary. In other cases, we have experienced that the usual value of bypass capacity was insufficient. In this connection we recall frequent additions to condensers rated at .1 mfd. Theoretically a .1 mfd. bypass condenser should be sufficient in the average tuned radio frequency system but if experience is a more practical guide, we are prone to say that the minimum capacity should be .25 mfd.

GRID SUPPRESSORS.—One form of regeneration control is the use of grid suppressors. These units are located between the grid of the radio frequency tube and the high end of the coupling unit in that stage. We refrain from mentioning the grid coil, because grid suppressors have been found necessary in systems equipped with grid leaks and tuned plate circuits. In cases of this type, the suppressor is located between the grid of the tube and the point of junction between the grid leak and the blocking or coupling capacity.

The grid suppressor finds application in screen grid as well as the conventional tuned circuits. Screen grid tubes are subject to excessive regeneration despite the low internal grid-plate capacity.

The exact value of resistance required for the suppressor is a matter of experiment. The usual range found in radio frequency systems extends from about 200 to 2000 ohms. The 600, 800 and 1000 ohm units are most popular. An optimum value for experiment is about 600 ohms. The optimum location in a three-stage system is the second stage. If another unit is necessary place it in the input stage.

Referring once more to bypass condensers, it is possible to greatly minimize regeneration by employing a separate bypass capacity for each and every circuit in the system. Thus if the amplifier is of the screen grid type and a single voltage plate reducing resistance is used for several stages, it might be well to bypass each screen grid and plate circuit. A .25 mfd. unit will be found suitable.

SCREEN GRID VOLTAGE REDUCING RESISTANCE.—At times regeneration in a screen grid system is most pronounced when the volume control, located in the screen grid circuit and employed to vary the screen grid voltage, is adjusted to full volume, that is maximum screen grid voltage. A remedy is to reduce the screen grid voltage applied to the first stage radio frequency amplifier. This may be accomplished by inserting a 2000 to 5000 ohm fixed resistance in the screen grid circuit of the first radio stage between the volume control and the screen grid of the tube. This

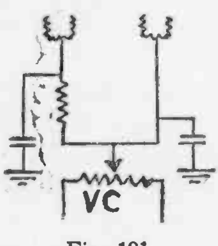


Fig. 191

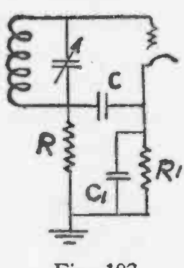


Fig. 192

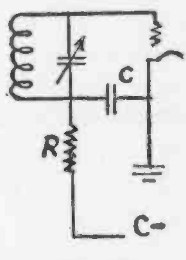


Fig. 193

will make necessary shifting of the bypass condenser so that it bypasses the supplementary voltage reducing resistance. This resistor need not be rated at higher than 10 milliamperes and the bypass capacity need not be more than .25 mfd. See figure 191 for the location of the resistance R. VC is the volume control unit. C is the bypass capacity.

GRID FILTER RESISTANCE (R.F.)—The grid filter unit serves its purpose well. It is a fixed resistance located between the low potential end of the grid tuning system and the ground or C minus contact. This is shown in figure 192. R is the grid filter unit, a resistance of some value between 50,000 and 100,000 ohms. The capacity C is of .25 mfd. In the event that the C bias for the radio frequency tube is secured from the eliminator, the circuit shown in figure 193 is applicable.

NEUTRALIZING SYSTEMS.—This mention of neutralizing systems does not pertain to those already incorporated but rather to the occasion when one is necessary. One method is shown in figure 194. It consists of tapping the grid coil at about the 16th turn from the filament end of the usual coil tuned with a capacity of .00025 or .00035 mfd. The neutralizing condenser should be a variable unit with a maximum of about 30 mmfds.

A second method is shown in figure 195. Wind a coil, a dupli-

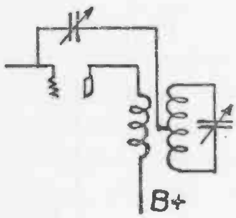


Fig. 194

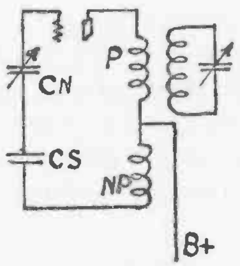


Fig. 195

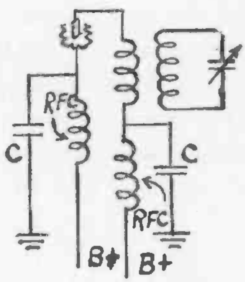


Fig. 196

cate of the primary winding used in the radio frequency transformer and connect both windings in series with the midtap connected to the plate voltage supply. Place the neutralizing winding NP in inductive relation with the secondary and primary. If the neutralizing winding is wound upon the form used for the regular primary winding, the position is automatically taken care of and no further changes are necessary. Connect the free end of the neutralizing winding to the series capacity Cs a .01 mfd. condenser and then join this condenser with the neutralizing capacity Cn as shown. The latter condenser has a maximum capacity of about 30 mmfds. The purpose of the series condenser Cs is to protect the tube in the event of a short circuit in Cn.

RADIO FREQUENCY CHOKES.—The radio frequency choke finds application in tuned radio frequency amplifiers irrespective of the type of design, whether for long, short or broadcast waves. Such a choke is suitable for application in each plate voltage lead between the coupling unit and the plate voltage supply source, with the bypass capacity connected between ground and the high potential end of the choke. Such chokes find application in each screen grid lead as shown in figure 196. A suitable unit ranges in inductance from 50 to about 200 millihenrys. The condenser C may be a .25 mfd. unit. Although figure 196 illustrates the screen grid tube, the plate of that tube can be imagined as being the plate of a conventional three element tube.

GRID FILTERS (A.F.)—The grid filter resistance finds frequent application in audio frequency circuits. Its location is as shown in figure 197. The value of R varies between 50,000 and 250,000 ohms. C is a condenser of 1. to 2. mfd. The winding shown is assumed to be the secondary of a transformer. Regeneration is ofttimes encountered in an impedance coupled system or the occasion may arise when it is necessary to alter the height of the peak in tuned impedance system. A grid resistance finds application in such systems and the circuit is arranged as shown in figure 198.

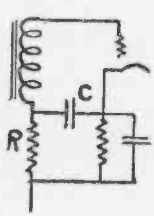


Fig. 197

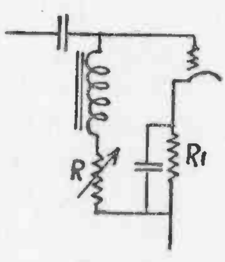


Fig. 198

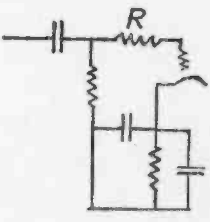


Fig. 199

The value of R is about 25,000 ohms maximum for grid chokes up to about 500 henrys. For chokes higher than this values, R should have a maximum value of about 50,000 ohms. It is interesting to note that the usual bypass capacity is not used in this case, the only condenser in use being the unit connected across the grid bias resistance R1.

Several other types of grid suppressor systems are shown in figures 199, 200 and 201, R in each case being the grid suppressor or filter resistance. In each of these systems the value of R approximates between 100,000 and 250,000 ohms. In figure 199, the suppressor unit is being used in a resistance coupled stage. In figure 200, the unit R is used as a grid filter operating in conjunction with C. In figure 201, R is a grid suppressor in each grid lead of a push-pull system. A common filter resistance is shown in figure 202. R is about 50,000 ohms.

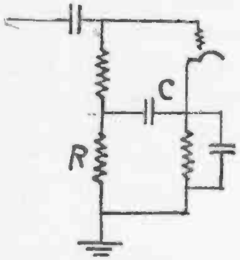


Fig. 200

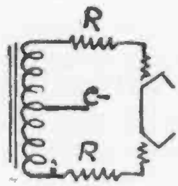


Fig. 201

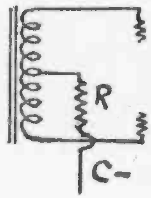


Fig. 202

PLATE FILTER RESISTANCES.—Plate filter resistances are nothing more than combination voltage reducing resistors functioning in conjunction with a by pass capacity.

AUDIO FREQUENCY PLATE FILTER CHOKES.—Filter chokes are used in many audio frequency circuits being located in the plate voltage supply circuits. When used in single stage or single tube circuits, the choke is usually associated with a bypass capacity as shown in figure 123, where L designates the chokes in the plate circuit. The bypass capacities are marked C. The inductance values of such chokes range from about 50 to 300 henrys depending upon the position in the circuit.

The filter choke employed in a push-pull plate circuit is not operated in conjunction with a capacity and its value approximates between 8 and 50 henrys.

GRID CHOKES IN RESISTANCE COUPLED AUDIO AMPLIFERS.—Resistance coupled audio amplifiers are known to be subject to difficulties due to excessive regeneration when operated with eliminator source of plate potential. One possible means of remedying the trouble in a three stage system is to employ grid chokes as the grid impedances instead of grid leaks of the resistance type. A grid choke should be used each alternate stage.

GROUNDED CASES.—Grounding the cases of the audio frequency transformers, unless special mention is made to the contrary by the transformer manufacturers is often the sole solution to the problem of excessive regeneration encountered in an audio amplifier system. As a matter of fact unless special mention is made to the contrary, all the metal cases should be grounded.

BYPASSING IN AUDIO AMPLIFIERS.—A defective bypass condenser or insufficient bypass capacity connected across a C bias resistance may be the cause of excessive regeneration.

BYPASSING IN ELIMINATORS.—Imperfect or insufficient bypassing of the voltage divider elements within a power pack voltage divided will ofttimes cause much trouble, due to excessive regeneration. Check the bypass condensers, particularly the values of capacity connected cross the C bias resistances located in the eliminator.

RELOCATING SPEAKERS.—Coupling between the speaker and the amplifier equipment or the speaker leads and the wiring within the amplifier will cause excessive regeneration.

COUPLING BETWEEN INPUT AND OUTPUT CIRCUITS.—Coupling between the input and the output circuits will have no effect upon the operating voltages and may be existent with normal voltages. Such coupling will cause excessive regeneration and only an investigation of the alignment of the units within the system will bring such defects to light.

LOSSER METHODS OF SUPPRESSING REGENERATION IN RADIO FREQUENCY AMPLIFIERS.—A simple yet effective method of suppressing excessive regeneration in a radio frequency amplifier is to locate a metal band or ring, about one-half or one-quarter inch in width and not wholly complete around some part of the radio frequency transformer or within the transformer. The eddy currents induced in this band will introduce sufficient loss in the system to effect stability. A copper disc equal in diameter to the inside diameter of the radio frequency transformer when located within the transformer or near it will also introduce sufficient loss to produce stability. The thickness of the disc need not exceed about .032 inch. At times a free ended coil, with lead connected to ground and located near the tuned radio frequency transformer secondary will produce stability. All of these lesser methods have a tendency to reduce total amplification and to broaden tuning, but they are effective and that is the primary consideration.

CHAPTER 23

DEFECTS WHICH DO NOT INFLUENCE OPERATING VOLTAGES

THERE are to be found quite a number of defects in a radio receiver which will interfere with the normal operation of the complete system, yet will not cause any variation of the operating potentials or interruption of the electrical continuity. In view of the extensive variations in the design of a radio receiver it is impossible to list each of these defects according to the type of receiver in question. We shall therefore quote the complete list, hoping that reference to this list will exclude all of the items not associated with the type of receiver being employed.

Inasmuch as the location of a defect in a radio receiver which is indicated by some interruption of operating potential circuit continuity is a matter of routine testing, it is unnecessary to dwell further upon the subject other than to state that the routine continuity test is in order, accompanied by the resistance test for resistors and the short circuit test for ruptured bypass condensers.

We shall make an effort to arrange the possible defects which will not influence operating voltages according to the possible symptoms. Fortunately these symptoms are very much alike and do not comprise a very extensive list. Again we wish to state that we are considering troubles which do not cause any change in operating potentials or a change of such small magnitude that it is apt to pass unnoticed.

WEAK OR NO RESPONSE.—In view of the very low resistance of the primaries of radio frequency transformers, short circuited windings will have no effect upon the plate voltage or the plate current. In this connection the short circuit is not to ground or to the secondary winding but directly across the coil or between turns. As to the secondaries of such radio frequency transformers it is necessary to mention a short circuit and an open circuit. The former applies in all cases whereas the latter applies when the design of the radio frequency system is such that the bias applied to the tube is not passed through the coil but through a separate grid leak furnished for that purpose. The blocking capacity used in such systems when "open" will impair operation of the system without any effect upon the operating potentials.

As a general statement, trouble of any nature, short circuit or open circuit located in the pre-selector type of band pass filter system located ahead of the first radio frequency tube will have no effect upon the operating voltages unless the trouble is in the last coil through which the bias is applied to the first radio frequency amplifier tube.

Quite a few receivers make use of what may be termed capacity coupled tuned grid radio frequency amplifier systems. In such systems, the load in the plate circuit of the radio frequency amplifier is a radio frequency choke. A condenser of about .001 to .006 mfd. links the plate of the preceding radio frequency tube with the tuned grid circuit of the succeeding tube. An open in this condenser will cause trouble without any effect upon the operating potentials, since the plate and grid circuits remain intact.

Short circuited tuning condensers are the equivalent of short circuited tuning inductances and will in the normal system impair operation without any effect upon the grid bias. The same is true if the tuning condenser is open or if the blocking condenser utilized to isolate the tuning capacity from the grid coil is open.

Under normal conditions we would be prone to state that an open aerial coil will cause cessation of operation but this is not always true, particularly if the design of the receiver is such that the volume control system simultaneously short circuits the aerial coil and increases the grid bias. However a short circuited aerial winding will greatly reduce the signal input without any effect upon the grid bias when the volume control is also connected across the aerial coil.

It has been customary to say that an open aerial will reduce signal intensity, but this is true only when the receiver has been operated with an aerial for all reception. A very large number of receivers are so designed that the aerial is deliberately disconnected for local reception. The same may be said of ground connections, but as a general statement we list the open ground as one cause for poor response without any effect upon operating voltages.

The grid leak employed in many radio frequency amplifier systems does not carry current and as such will have no effect upon the grid bias unless it is open. Any degree of reduction of the ohmic value of this unit from the normal to zero will influence response but not the operating voltage. Hence a defect which causes a marked reduction of the resistance of this resistor will reduce the signal response without any change in operating potential.

A defect in the neutralizing system wherein the neutralizing condenser is connected in series with a protective condenser, will, if the neutralizing condenser becomes shorted impair operation without any effect upon the operating potentials. In order to clarify this system we refer to the section devoted to "Neutralizing Systems."

Shorted grid leaks or open grid condensers in grid condenser-leak systems of detection will impair operation without any effect upon the operating potential. Such defects may be of varied nature. If the grid leak is connected across the grid condenser, a short circuit within the condenser or an open within the condenser will have the same effect. If however the grid leak is NOT connected across the grid condenser but junctions between the grid of the tube and the B minus or the positive leg of the filament, an open circuit or a short circuit will stop operation of the system without any effect upon the bias voltage and the tube plate current. As to the grid leak used in such fashion any reduction in resistance will reduce the signal response with no response when the ohmic value is zero or between 0 and 25,000 ohms in the conventional detector system.

Passing from the radio frequency amplifier into the audio frequency system we find great similarity. Short circuited primaries or secondaries of transformers, short circuit plate or grid resistances or chokes will have like effects, namely reduction of signal output without any effect upon the operating potentials. In the grid circuits of transformers which are shunted by resistances across the complete windings, an open circuit in the secondary winding will have no effect upon the bias unless the application of the shunt resistance is such that it is not in contact with the C bias voltage circuit. Of course such an arrangement is not possible in a conventional stage, that is, not push-pull, hence such a transformer secondary may be open without any effect upon the bias. This reference to a shunt resistance does not include the resistance employed in series with a condenser in a tone control system.

A short circuit in a unit used in shunt across the transformer primary or secondary winding is the equivalent of a complete short circuit in the winding, thus it is necessary to consider all of the elements in the circuits.

Parallel plate feed systems in audio amplifier make use of a blocking and a coupling capacity. An open circuit in this condenser will impair operation without any effect upon the plate voltage. At this time it might be well to mention that a short circuit within this condenser will also impair operation but it will not cause total cessation of operation and at the same time will influence the plate voltage because the primary of the transformer is then shunted across the plate voltage system.

Defects in the secondary circuit of output transformer of either short circuit or open circuit nature will have no effect upon the plate voltages or the grid voltages. This comment does not include the field coil of the dynamic speaker when it is a part of the power pack filter system. In connection with output transformers we wish to state that one side of the secondary winding is oftentimes grounded and a ground with the high side of the secondary winding short circuits the complete output system.

An open circuit in the output condenser in a single or push-pull tube system will interrupt operation without any effect upon the operating voltage. The same may be true in some instances when this condenser is short circuited internally or externally with the exception of the short circuit due to grounding.

Short circuited output condensers in push-pull systems will have no effect upon performance unless the short circuit is due to grounding of the condenser.

Defects in speakers unless they carry the plate current have no effect upon operating voltages.

It is necessary at this time to make special mention of the two element combination detector and automatic volume control system. In contrast to the conventional tube stage, the tube used at this point may be defective as far as emission is concerned without any effect upon the voltages in the system. The reasons for this are the following: First, the plate voltage employed for this tube is the signal voltage. Second, the steady normal "no-signal" bias voltages for the other tubes are secured from independent sources. Thus an open in the radio frequency transformer connected to this tube or an open in the plate circuit will have no effect upon the operating voltages. The passage of a signal is necessary to show the presence of a defect in the system.

For further comment upon defects in automatic volume control systems, see Chapter 4.

Referring once more to the radio frequency amplifier, it is not necessary to stress that imperfect alignment of the tuning condensers will cause poor response. At the same time we wish to comment upon difficulties in the tuning systems due to short circuits in the trimmer condensers.

With the new interest in the superheterodyne receiver it is necessary to make comment upon the oscillator system employed in such receivers. First and foremost is the fact that all tubes are not necessarily good oscillators. Thus poor response may be due to a poor oscillator tube without any effect upon the grid and plate voltages associated with the tube. The tube may be good in every respect, yet be a very feeble oscillator at the normal voltages recommended for the system.

In this connection it is necessary to think about the coupling between the oscillator and the mixer tube. Be the form of coupling of inductive or conductive nature, any defect in the coupling system such as a short circuited coupling coil or an open coil or resistance if they are not directly in the potential circuits will impair performance without any visible effect upon the operating voltages.

As to troubles in the oscillator system, an open grid coil will, in a tickler feed back type oscillator with the grid leak connected between the grid and B minus interfere with the operation of the system without any effect upon the voltages. This is particularly true in the case of several modern oscillator systems wherein the grid tuned system is isolated from the grid and the bias voltage is applied through a special leak. The same condition will prevail if the grid coil is short circuited, its high end being grounded or the high end of the tuning condenser system is grounded. An example of such an oscillator system is found in the RCA-Victor 80 series, the Westinghouse, Graybar and General Electric receivers of like type.

DISTORTION.—As a general rule one usually associates the problem of distortion with the audio frequency amplifier. Prior to the discussion of impedance relations in the output systems, distortion was usually associated with incorrect bias voltages and grid current. Now that we have very high gain radio frequency amplifiers, efforts made to provide various types of frequency response characteristics in audio systems, dynamic speakers and sundry other such items, we have a fairly large number of items which are associated with the subject of distortion, and strange as it may seem we have a large number which have no effect upon operating potentials.

Grid current in the radio frequency amplier is generally of such small value that it is not measurable upon the usual run of testing equipment, yet the effects of grid current due to nothing more than excessive amplification and signal voltage applied to grids which are biased with normal potentials cause distortion of marked degree. Such distortion is very pronounced when the grid bias form of radio frequency volume control is carried to extreme and the radio frequency amplifier tubes no longer perform as amplifiers, the high bias changing the operation to detectors. Thus the high bias is normal yet the effect is bad. The solution seems a mystery, yet is simple, being nothing more than a reduction of input signal voltage so that the maximum bias need not be applied in order to secure satisfactory output for local reception.

Another significant item in connection with radio frequency amplifiers of modern times is the decoupling resistance used in some band pass filter stages. The function of this unit is to reduce the tendency towards side band suppression at resonance. If short circuited, regeneration is increased and side band suppression occurs. The result is distortion and the usual position of the unit is such that it carries no current, hence when short circuited it does not alter any of the operating potentials. The same is true if a part of the unit is shorted or its resistance decreases because of a minor defect.

Incorrect alignment of the tuned stages will result in distortion, generally in a reduction of response upon the lower register, greatest response being secured upon the higher sidebands. Such defects have nothing to do with regeneration or the operating voltages. In fact, the actual action is the reverse of that present when regeneration is excessive. As a general rule, regeneration is minimum when the circuits are out of balance. Distortion due to regeneration is manifest as cutting of the sidebands, i.e., little loss in power but a decided loss in articulation. Incorrect alignment causes a decided loss in power but articulation remains fair. This can be tested upon any receiver by merely detuning. As to reasons for excessive regeneration see section devoted to "Excessive Regeneration Remedies."

Distortion may be due to heterodyning, i.e., the frequency separation of two stations is less than 6000 cycles. We have selected this maximum because a heterodyne signal of higher than this frequency is usually attenuated sufficiently to be negligible, in fact inaudible in most installations. The possible remedy at the receiver is slight detuning to a frequency "away" from the interfering station. This is apt to slightly impair the quality but it may help remove the interference.

Passing from the radio frequency system to the detector we cannot help but comment upon overloading of the detector tube. It is trite but must be included in every discussion relating to distortion. At the same time a common reason for distortion is an open radio frequency bypass condenser in the plate circuit. Neither of these conditions will show any change in operating potentials during the time that the distortion is present.

Entering the audio frequency amplifier we must quote overloading with normal operating potentials. As it is possible to operate an audio amplifier during the time that the set analyzer is applied, a check upon overloading is the observation of plate current and plate voltage. If the degree of overloading is sufficient, as is the case in the output stage, the plate current will fluctuate with a reduction in plate voltage accompanying each radical increase of plate current. It is however possible that overloading of the first stage will cause distortion without any radical change in plate voltage.

Comparing the modern audio amplifier with the system of yesteryear shows that the perfect system of old was the equivalent of the imperfect system of today. In other words a defective audio transformer of today, wherein some of the primary turns are shorted was the equivalent of the perfect transformer or lower primary impedance of days gone by. Distortion in a modern system may be due to a short circuited section somewhere within the primary winding or a short circuited element connected across the primary winding. The same may be said to be true in connection with the secondary winding. A defect in the shunt condenser or resistance connected across the transformer secondary will cause distortion.

In connection with resistance-capacity coupled systems, a defect in the grid leak so that its ohmic resistance is very low will cause a pronounced loss of high notes, thus distortion accompanied by a decided drop in signal output.

Excessive regeneration in the audio system so that the system is operating just below the point of oscillation causes such a change in the frequency response characteristics of the audio coupling units that the quality is very poor. Such a condition may be created by a short circuit across the grid filter or grid suppressor resistances, or extreme reduction of the ohmic value of these units, coupling between stages, etc.

Excessive regeneration resulting in the generation of a high audio frequency signal, say between 5000 to 6000 cycles will interfere with the quality. Oscillation at an inaudible frequency is just as bad because its final effect is distortion. The presence of sufficient regeneration to cause the generation of sustained oscillations is evidenced by grid current without signal voltage, assuming correct polarity of bias. The average set analyzer does not make provision for a grid current test, hence a special test must be made.

As far as impedance relation is concerned, the point of greatest interest is the output tube. Now, in this stage, we can take for granted that the original arrangement as provided by the manufacturer was such that the correct impedance relation existed. This impedance relation involves not only the plate or primary winding upon the output transformer but also the secondary winding and last but by far not the least, the load connected to the secondary winding, namely the speaker. Any variation from the original number of turns influences the impedance. Thus it is imperative that the number of turns present in the respective windings remain intact. This condition increases in importance as the impedance of the speaker winding decreases. In other words it is of greater importance in a low impedance than in a high impedance system. The greatest amount of trouble is experienced in connection with the voice coil upon dynamic speakers. The position of this part of the installation has no bearing upon operating voltages yet short circuiting of some of the turns of a low impedance voice coil will cause distortion. The motion of the voice coil within the air-gap is frequently accompanied by scraping of the voice coil against the pole pieces, that is, when the voice coil is not exactly centered. The result is injury to the insulation. If the voice coil impedance is in excess of 200 ohms, it is possible to remove a few of these shorted turns without impairing the balance of the system, but if the impedance of the voice coil is very low, replacement is necessary, unless the coil can be repaired by sweating some insulating medium like collodion or shellac between the shorted turns.

A bad case of distortion is often due to a cracked diaphragm, imperfectly stretched diaphragm, a torn diaphragm or loose screws, nuts and bolts. When the diaphragm is cracked, torn or imperfectly stretched, the original impulse sets different parts of the complete diaphragm into vibration and these vibrations do not cease in accordance with the actuating impulse. The result is that some part of the diaphragm vibrates at a frequency other than that applied and a distinct hangover is audible, a very annoying form of distortion. The same is true of loose nuts, screws, washers, etc. These are set into vibration and produce sounds foreign to the frequencies passed to the speaker system.

In connection with the magnetic type of speaker, short circuits in the speaker winding reduce the impedance of the unit and create distortion upon the lower audio register. At times the distortion is accompanied by a general reduction of intensity, due to short circuiting of one of the coils.

Distortion due to some acoustical condition is treated in the chapter devoted to "General Acoustic Problems."

HUM.—The subject of hum is of interest because its presence is very much undesired and very annoying. At the same time its cause is one of the most difficult of all troubles to locate. It is related to distortion because it represents an audible sound encompassing a small band of frequencies, the extent of which depends upon the nature and cause of the hum. When present it combines with the normal signal, accentuating or attenuating the normal sounds within the same band, depending upon the phase relation between the instantaneous signal and hum voltages.

Its causes are numerous and its relation to operating voltages is a matter dependent upon the nature of the hum and the cause. One bad case is the pronounced hum when the receiver is tuned to one or more local stations. The exact cause has not been conclusively determined but a remedy, effective in very many cases is the use of a capacity filter across the primary of the power pack transformer. (See "Line Interference Filters" for values.)

A peculiar cause for hum, without any effect upon the operating voltages is the instantaneous polarity of the line supply. Reversing the plug connection to the line frequently decreases the hum to a very great extent.

An open "middle" condenser in a two section filter will cause a bad hum without any effect upon the output voltage. For further details relative to hum due to defects in rectifier systems, see "Some Facts About Power Supply Devices." Lest we forget, we wish to comment upon the parallel resonating condenser so popular in power pack filter systems. This condenser is employed in order to produce maximum attenuation of the major hum frequency. If for some reason this condenser is open, the hum will increase appreciably without any effect upon the operating potentials.

Induction between the power supply units and the detector or audio amplifier wiring or even the speaker wiring will cause a bad hum. Such induction need not involve the power transformer. The filter chokes have fairly strong fields and are frequent offenders. Grounding of the cases and cores alleviates this trouble. A defect of this type has no effect upon the operating potentials.

Pickup by encased, ungrounded audio frequency transformers is possible, particularly when these units are adjacent to lines carrying A.C. The relative position of the transformers when more than one transformer is used in the power supply system may introduce hum. Since these units are fixed, the possible remedies are very limited in number. Grounding and shielding have been found effective.

Coupling to the input leads to the power amplifier is often the cause for the trouble. Coupling to the detector control grid lead is also a possible cause.

Imperfect or insufficient value of bypass capacity across the detector grid bias resistance produces a bad case of hum. The same may be said of the grid bias resistance bypass condensers in the audio stage. Operating voltages remain normal.

Imperfect or imperfectly connected plate filter bypass condenser units will cause hum without any effect upon the operating voltages. Defective or unbalanced hum neutralizing systems will cause hum.

Imperfect rectification in speaker power supply systems will cause a bad hum. Of course such a condition can be checked by a special voltage test, but the difficulty does not cause any effect upon the voltages in the receiver, hence it is included in this list. Induction into the speaker cable is oftentimes a cause for a bad hum.

Imperfect filter condensers in the speaker power supply system will cause a bad hum without any effect upon the voltages applied to the tubes in the receiver. Two popular methods of overcoming hum in speaker systems, exclusive of that due to induction are mentioned in connection with simple repairs.

SINGING CONDENSERS, CHOKES AND TRANSFORMERS.—Quite a few cases of this type are reported daily. The sounds produced are due to poor physical construction of the respective units. In the case of the condensers the trouble is due to loose dielectric or active materials. These parts are set into vibration by the voltage applied and produce audible sounds, being most prevalent in the audio system, in the output stage or associated with the speaker. The remedy is replacement.

As to chokes a very frequent offender is the input choke in a choke input power pack filter system. This choke carries an appreciable amount of A.C. and loose laminations or a loose winding or core will be set into vibration and produce an audible sound of fair intensity. The repair is a matter of how easily one may find access to the innards of the unit. Any means of rigidly fastening the laminations, core or winding will solve the trouble. When access is difficult, a possible remedy is to switch the positions of the chokes in the system, replacing the imperfect choke with one assumed to be perfect and using the defective unit in the second section. If the trouble still persists, and repair of the unit is not practicable, replacement is necessary.

Loose windings or laminations in transformers used in the audio or power systems will produce audible sounds. Tightening of the core or winding is the only remedy. Whether or not this remedy can be effected is a matter of the existing conditions. If the winding and the core are accessible, it is possible to fasten the loose parts by wedging a piece of cardboard or wood between the laminations, winding or core. It may be possible to pour additional impregnating compound into the container and thus solidify the entire assembly.

In connection with hum in modern systems we cannot fail to mention an unbalanced state in the hum neutralizing systems. Such combinations when used in the amplifier proper consist of a resistance and a capacity (fixed). Considering the values of the units employed and their position in the circuit, only one of several possible defects will manifest an effect upon the operating voltages in the output stage. This defect is grounding of the resistance or a short circuit within the condenser. In view of the fact that the simultaneous occurrence of both of these defects at one time is highly improbable, we consider such troubles as singular. All of the other defects possible in connection with this circuit will cause hum but no effect upon the operating potentials.

In connection with the hum bucking systems employed in the voice coil circuits, any defect will interrupt operation or cause a bad hum but will not influence the operating potential. These two hum balancing systems are shown in the chapter devoted to Practical Repairing.

CRACKLING—SIZZLING AND FRYING SOUNDS.—A great deal of ground is covered within this heading. In view of the separate chapter devoted to various forms of electrical interference, this section shall consider items associated with the respective units employed in the receiver and not those which would be listed under external sources of electrical interference.

The first and foremost is imperfect contact between parts of the system which are held at different potential. Examples of the above are grounded circuits and ungrounded shields. Poor ground contacts to cores, cases and shields, momentary short circuits between turns upon voltage divider sections, C bias resistances, etc.

Momentary flashover across lint and other forms of deposit between the terminals of high voltage condensers, filter chokes, transformers, jacks, etc. The mention of jacks is quite important, particularly in connection with high voltage output circuits. We recall a peculiar case when every loud passage was accompanied by a burst of crackling and sputtering sounds, which would cease when the intensity of the audio signal would decrease. A thorough investigation disclosed nothing which could be assumed to be at fault. At the last moment during such a state, the operator noted arcing between the contacts of the speaker plug. The trouble was relieved by using terminals instead of a jack and plug combination.

In another case a great deal of aggravation was caused by a sputtering sound which persisted during the time that the receiver-amplifier was in operation. Everything was checked. It was observed that the trouble ceased when the ground wire was removed. This circuit was checked. At one point the bare ground wire crossed the pipe to which it was grounded at another point. Each time that this wire was brought into contact with the pipe and the ground wire was connected to the set, a sputtering sound was heard. The wire was taped at this point and the trouble ceased.

In another instance no amount of amplifier analysis illuminated upon the cause for a sputtering sound. However it was noted that the trouble was present only during the time that a signal was being passed through the amplifier. Thus the trouble was assumed to be due to vibration of the amplifier panel. A further search revealed a momentary rubbing contact between two lead sheathed cables. This contact was made permanent by soldering and the trouble ceased. Another time a rubbing contact between a lead sheathed grounded cable and the iron panel caused a great deal of grief until located.

Thus it is necessary to check all parts which are in contact to make certain that the contact is perfect, even if both parts of the contact are supposed to be at the same potential. Although it is true that every part used in a radio receiver or amplifier is subject to a defect, the items which cause the greatest amount of grief because of sputtering and frying sounds, are switches, rheostats, potentiometers, jacks, plugs, socket contacts, meter connections, etc.

Electrolysis in audio transformers is a frequent source of trouble. Moisture present in the unit in conjunction with the difference of potential between the core and the primary winding causes electrolysis and gradual eating away of the primary turns nearest the core. During this period the transformer is noisy and eventually burns out.

Intermittent grounding of aerials or contact between different aerials gives rise to sputtering sounds without any effect upon the operating voltages.

Old condensers equipped with pig-tail contacts which are not wholly perfect cause sputtering sounds. Deposits of lint and moisture between the plates of variable condensers cause grief during the time that the units are being manipulated. Momentary short circuits across the plates of a variable condenser create a sputtering sound. This form of trouble is usually accompanied by interruption of the received program.

Oxidization of rheostat, potentiometer and like device resistance sections causes poor contact between the switch blade and the resistance element. Such poor contacts are accompanied by disturbing sounds.

When the battery is spoken of as a source of disturbance, one assumes that it is run-down or has completed its normal span of life. Such is not the case, although it is true in the majority of cases. Perfect batteries, at least batteries which indicate normal output voltage may be noisy and must be checked. Storage batteries which have been charged to the point where the electrolyte "gases" profusely are frequent sources of noise when used to supply "A," "B" or "C" voltage.

We can spend much time upon noisy fixed condensers and resistances. Since there is no visible manifestation of a noisy fixed condenser unless the noise is due to momentary arcing within the unit, during which time the operating voltage is affected, the best means of location is to disconnect the unit under suspicion.

In the case of resistances, the trouble may or may not be visible, depending upon the nature of the trouble. If it is due primarily to overloading, that is excessive current flow through the unit, wire wound resistances glow red at spots and minute arcs between the turns are clearly visible, providing that the resistance is of such design that the wire is visible. As a matter of fact experiments carried out upon vitreous enameled units showed that overloading showed up at the weakest spot upon the enamel coating and burned through. In the case of metalized or carbon resistances contained in glass capsules, overloading is accompanied by discolorization of the glass because of carbonization. Such resistances are very noisy during this period. The final result is burnout of the resistor.

Resistances need not be overloaded in order to become noisy. The only solution is replacement. In connection with resistances we wish to state that no unit used within a receiver is above suspicion. It is necessary by a simple process of elimination to determine the relative position of the origin of the noise, and then to check every unit used within that part of the receiver or amplifier.

As a point of information, resistances being subject to an overload vary in resistance and will cause a variation in the current or voltage associated with that circuit during the process of disintegration.

Vacuum tubes too may be noisy. The greater the amplification the greater the noise. However the magnitude of the tube noise present in a conventional receiver or a power amplifier arrangement when the tubes are classed as perfect is not sufficient to cause any trouble. Just as it is possible to experience peculiar sounds because of poor circuit external of the tube just so it is possible to experience various forms of interference because of faulty tube structure.

Crackling and sputtering sounds are ofttimes encountered in connection with "A" battery eliminators of the A.C. rectifier type. What with the use of the electrolytic type of condenser in some of the high voltage low current eliminators, similar troubles are experienced with such devices. In the case of the low voltage high current unit, the increase in leakage current does not produce a very noticeable effect upon the output voltage, hence the noise is noticed but without any effect upon the output voltage. The noise, a sputtering sound is attributable to an ever increasing defect in the electrolytic filter condensers. After a prolonged period, the hum commences to increase accompanied by a gradual reduction in the output voltage.

Sputtering may be experienced in connection with the dry disc type rectifier. In the majority of cases, this condition is accompanied by a reduction of the output voltage and current, since the difficulty is within the rectifier element.

Sputtering is oftentimes experienced in connection with poor filter condensers of the solid dielectric type. Peculiar as it may seem experience has shown that a flashover within a condenser (not of the wet electrolytic type) is possible without permanently injuring the unit. We have had the good fortune to observe two such instances. A power amplifier filter pack broke down completely after about 30 minutes of sputtering sounds. In another case, replacement of a filter condenser relieved the trouble. This same condenser was again placed into operation, sputtered for a while and then broke down. An examination made in order to check for the possibility of poor connections showed perfect contact at the joints but a rupture of the dielectric. No sign was visible to explain the periodic sputtering sounds prior to the rupture. Many reasons can be advanced for this phenomenon. They are of no importance at this time. The paramount subject is replacement during the sputtering period rather than waiting until the unit breaks down and thus jeopardizes the life of other units in the system.

For the causes of sputtering sounds associated with phonograph pickups, see Chapter 18.

GENERAL ACOUSTIC PROBLEMS.—Rooms which are bare of furniture or contain furniture of the unstuffed variety will have a tendency to accentuate the high notes. Rooms equipped with a great deal of absorbing material, such as heavily stuffed furniture, heavy rugs and carpets, numerous drapes and hangings will have a tendency to reduce the apparent intensity of the high notes. If the walls are bare without hangings reflection and reverberation are possible, thus producing overlapping, having a tendency to interfere with the proper comprehension of speech sounds. When speakers are located within confined quarters as in console cabinets, free circulation of air should be possible. This means that the back of the cabinet should be open and that the cabinet should not be placed flush with the wall, so that the wall would have a tendency to function as the back of the cabinet.

CHAPTER 24

FILTERS

This chapter is not intended as a discourse upon the design of filter systems. The contents have been selected with a view of providing practical constants for simple filters other than radio frequency band pass units. We omit the latter classification because the correct arrangement of a radio frequency band pass filter is a matter of thorough design.

FILTERS FOR ELIMINATOR POWER PACKS.—See Chapter 7 for values of capacity used in filter systems and see Chapter 10 for values of inductance used in filter systems.

RADIO FREQUENCY LOW PASS FILTERS FOR DETECTOR PLATE CIRCUITS.—See Chapter 7 for values of capacity used in such filters and see Chapter 9 for values of inductance used in such filters.

PLATE CIRCUIT FILTER SYSTEMS.—See Chapter 7 for values of capacity used in conjunction with resistance or choke type plate filters. See Chapter 15 for values of resistance employed in resistance-capacity plate filters. See Chapter 10 for values of inductance used in audio frequency inductance-capacity plate filters. See Chapter 9 for values of inductance used in radio frequency plate filters.

SCRATCH FILTERS.—See Table M figure 111 for wiring diagram of conventional scratch filter of the series resonant type used in conjunction with phonograph pickups. See "Resonating Capacity Table For Audio Frequencies" for the value of capacity required to resonate an inductance to the scratch frequency.

SERIES RESONANT PEAK FILTERS.—See Table M figure 112 for the circuit diagram of a series resonant peak filters arranged across the speaker coil. See "Resonating Capacity Table For Audio Frequencies" for the value of the capacity required to resonate an inductance to audio frequencies. The values given do not include the impedance of the filter. In the event that a certain impedance is desired so as to reduce the current through the speaker winding by a predetermined amount, consider the D.C. resistance of the inductance as a part of this impedance and add sufficient series resistance to total the required impedance. The relation between the speaker impedance and the filter impedance for a certain division of current is as in ordinary parallel resistances. Suppose that the required current through the speaker is one quarter of that originally flowing in the circuit. The impedance of the filter at the resonant frequency should be equal to one third of the impedance of the speaker winding at the prescribed frequency.

The series resonant filter is suitable for application across the primary winding of an audio frequency transformer.

EQUALIZER CIRCUIT.—The usual form of simple equalizer system is an ordinary parallel resonant circuit consisting of the inductance and capacity in shunt connection. See "Resonating Capacity Table For Audio Frequencies."

WAVE TRAPS.—The value of inductance necessary to resonate to a certain radio or intermediate frequency with various values of capacity is contained in "Capacity-Inductance Table For 10 to 20,000 Meter Wavelengths." The inductance value is the maximum required to resonate at the wavelength.

For values of capacity or inductance used in resonant radio frequency or intermediate circuits see "Table of Frequency and Oscillation Constants (LC)." The value of L is in microhenrys and C is in microfarads. To solve for capacity, divide the LC constant for the required frequency by the inductance of the coil to be used. The answer will be the required capacity in microfarads. To solve for inductance required to resonate with a condenser of known capacity at some frequency shown upon this table, divide the LC constant by the value of capacity in microfarads. The answer will be the required inductance in microhenrys.

LOW PASS AUDIO FILTERS IN OUTPUT CIRCUIT.—The data to follow is purely of practical nature and is based upon the simplest possible design. The circuit is shown in Table I, figure 93, being designated by L and CC. Decide upon a cutoff frequency and with a known inductance determine the value of capacity which will result in resonance. Double this value for each condenser C shown in the circuit.

PARALLEL RESONANT CIRCUIT IN POWER PACK FILTER.—Maximum attenuation is desired upon the major hum frequency. This value is twice the line frequency in a full wave rectifier and the line frequency in a half wave rectifier. With the inductance of the choke to be resonated a known value refer to "Resonating Capacity Table For Power Pack Filter Chokes" for the required value of capacity.

HUM NEUTRALIZING CIRCUITS.—A suitable combination of resistance and capacity used as shown in Table K, figure 102, is a variable resistance of about 500-10,000 ohms and some value of capacity between .2 and 1. mfd. A recommended value for the capacity is .5 mfd. and a variable resistance of about 5000 ohms maximum. For a complete résumé of such hum neutralizing system as described by the inventor B. F. Meissner see Proceedings of the Institute of Radio Engineers, January, 1930, or *Radio News,* March and April, 1930.

CHAPTER 25

HEADPHONES AND ELECTROSTATIC SPEAKERS

HEADPHONES.—The use of headphones in connection with radio receivers in order to aid the deaf so that they can hear broadcast radio programs is becoming quite popular. Figure 203 shows the method of connecting a pair of headphones across the output system of a receiver equipped with a single tube output stage. The application of the headphones does not interfere with the normal operation of the receiver and it is unnecessary to interrupt any connections. The constants for the circuits are designated. The 1. meg. units should be rated at 2 watts each. The .5 meg. variable should be rated at 2 watts, minimum.

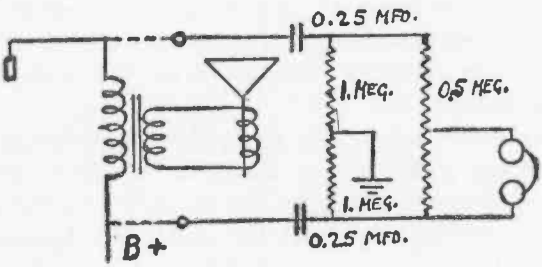


Fig. 203

The method of connecting headphones to a push-pull tube output system is as shown in figure 203. The output is connected across the transformer primary. The dotted lines in each case illustrate the connection to be added.

TROUBLES.—In connection with headphones, continued use of the iron diaphragm type is apt to bend the diaphragm causing it to touch the pole pieces during the passage of loud signals. This condition can be corrected by reversing the diaphragm.

The headphone is a small speaker and since it employs a winding and a magnet, it is subject to the normal run of electrical troubles. Incorrect polarity of direct current passed through the winding will weaken the magnets. Excessive current, for example more than about 6 or 7 milliamperes endangers the winding, particularly the inside turns which are not exposed to the air and therefore cannot successfully dissipate the heat generated.

The leads are subject to open and short circuits. The leads are subject to an open circuit at the junction between the cord tip and the cord. A method of repairing broken headphone cords is described in the chapter devoted to "Tests and Kinks."

ELECTROSTATIC SPEAKERS.—In contrast to the conventional speaker the electrostatic or condenser type of speaker requires a polarizing voltage. This is usually secured from a separate rectifier or by suitable isolation of one part of the voltage divider system. By virtue of the action of a condenser when subjected to a D.C. potential, current flows around the speaker circuit only during the first few moments subsequent to the application of the charging potential. In other words, the electrostatic speaker does not consume current during the time that it is polarized. Thus the rectifier employed to produce the polarizing voltage is not a heavy or even a medium duty rectifier. Its current output is small. The voltage output is a matter determined by the type and design of the speaker being used.

For satisfactory operation the polarizing voltage should not deviate from the rated value. However, excessive voltage should be minimized because injury to the insulating surface is possible. While it is possible to operate the condenser speaker without a polarizing voltage the response is far from what it should be, in fact is badly distorted. The output is much less than that secured when correct polarization is present and character of the sound is very poor, a great amount of distortion being present.

The Kyle speaker, most popular in this country is built up in sections and a complete condenser speaker may employ a few or a large number of sections connected in parallel. Since the sections are connected in parallel, the voltage relation present between the sections is as in any parallel combination of condensers. All of the sections are subject to the same potentials.

In the event of damage to any one section, it can be removed and another section substituted in its place. The greater the number of sections connected in parallel (electrically) the greater the sound radiating surface. However, connecting units in parallel does not enable the application of a voltage in excess of that permissible to a smaller number of sections connected in parallel.

In contrast to the usual dynamic speaker circuit, the condenser speaker circuit is of high impedance and precautions must be exercised to minimize all possible introduction of noise into the system. Thus coupling must be avoided and all parts used in the system must be of such character as to be free from structural variations which would tend to cause a variation of the potentials in the circuit.

As to the structure of the usual condenser type of speaker, it makes use of one movable plate. The push-pull type of speaker employs two stationary plates and one movable plate. The conventional speaker employs a single stationary plate and a single movable plate. Either type of speaker is applicable irrespective of the type of output system employed.

The output coupling capacity employed in conjunction with the Kyle condenser speaker seldom exceeds about .5 mfd. although a 1. mfd is shown in some cases.

CHAPTER 26

EMERGENCY MEASURES

FILTER CONDENSER BREAKDOWN.—In the event of condenser breakdown in a power pack, particularly the filter condenser, you can operate the system by removing the plus or minus lead from the punctured condenser. The entire condenser need not be removed. Filtering will not be as perfect, neither will the output voltage be normal, but operation is possible until such time when a new filter condenser may be installed.

DAMAGED FILTER CHOKE.—In the event of a short circuit in a filter choke and the eliminator filter system makes use of two chokes, operation of the eliminator is possible by completely shorting the choke. Of course, if the short is between some part of the choke and the low potential side of the eliminator, or vice versa, in the event that the chokes are in the negative lead, operation is impossible unless the short is removed because it shorts the output of the rectifier.

In the event of an open in one of two chokes used in the eliminator, a short across the open will be satisfactory for the time, replacement to follow later. This short should be across the two terminals of the choke.

DAMAGED OUTPUT CHOKE.—In the event of a breakdown or burnout of the output choke in a choke-condenser output system, the choke may be replaced by a resistance of approximately 4,000 ohms in all tubes other than the 210, in which case a 10,000 ohm resistance will be necessary. The resistance must be capable of passing the plate current. Of course, the signal output will be materially impaired but any sort of reception is better than none.

OPEN AUDIO PRIMARY.—An open audio transformer primary may be replaced until such time when a new transformer can be installed by a choke and condenser combination, the choke replacing the transformer primary and the condenser connected between the plate end of the choke and the grid end of the transformer secondary, which of course, is still in the receiver. As an emergency unit, any choke from 30 to 100 henrys and any condenser from .01 to .1 mfd. will be satisfactory. The same remedy is applicable if the primary winding is shorted.

DAMAGED AUDIO SECONDARY WINDING.—A receiver which has become inoperative because of a defect in the secondary of an interstage audio frequency transformer of the conventional type can be placed into operation by disconnecting the defective secondary from the tube circuit and replacing the secondary winding with a .1 to a .25 megohm grid leak and connecting a .01 fixed condenser between the plate terminal of the primary and the grid of the succeeding tube.

If the secondary winding of a push-pull transformer becomes defective an emergency repair is the use of a .1 or a .25 megohm grid leak between the grid and C minus of each tube and the use of a .01 mfd. condenser between the one plate end of the primary and one grid of the succeeding tube and another .01 mfd. condenser between the other plate end of the primary and the grid of the other tube.

DEFECTIVE BYPASS CONDENSERS.—The isolation of a defect is a very good accomplishment but it is even more important that the receiver work when the defective part has been removed and cannot be replaced at once. Bypass condensers are frequently sources of trouble. When located in the plate or grid circuit of an A.C. receiver, operation of the receiver will be possible after the defective unit has been removed from the circuit. While a new unit is essential in order to restore normal operation, reception will be possible without the bypass condenser. There are, however, a few exceptions to the above and certain limitations which must be mentioned.

Certain D.C. operated receivers and series filament receivers employ a fixed capacity in the tuned circuit. If this is injured, replacement of some kind is imperative. However, as an emergency measure, it is possible to employ a smaller or a larger value than that originally installed. If the value is too small, the consequence will be a reduction in the tuning range of that particular circuit.

If the bypass condenser is located in the plate circuit of a detector tube, operation is possible without it, but if another is to be installed the value should not be in excess of .001 mfd. We are referring to the bypass condenser usually employed to bypass the radio frequency component in the plate circuit.

If the bypass condenser is located in the plate circuit of an R.F. tube operation is possible without it. Perhaps the receiver will not be as stable, but it will work nevertheless. If another is to be installed, any value greater than .005 mfd. will do until the correct unit is available.

If the bypass condenser across a grid bias resistance is defective, it will be necessary to incorporate another. Any value in excess of .1 will be found satisfactory until the correct unit is installed.

Resistances, like capacities, are frequent sources of trouble. If a resistance across an audio transformer secondary develops a defect, a temporary substitute of 50,000 ohms will be satisfactory. In some instances it will be possible to operate the amplifier without the resistance.

GRID LEAKS.—Grid leaks must be replaced when used in the detector circuit. However, it is not imperative that the replacement unit be the identical of that removed. Any value greater than 1 megohm will be satisfactory until the correct one is installed.

Grid suppressor resistances need not always be replaced. However, if a 400 ohm resistance is available, it can be employed to replace the defective unit. In many cases the recommended value will not be sufficient to create stable operation over the entire tuning scale, hence total operation of the receiver will not cease.

DEFECTIVE TUNING STAGE.—In the event that a tuning stage is defective in a multi-stage radio frequency amplifier, it is possible to remove the entire stage, in effect only, by bridging from the preceding plate to the plate of the defective stage. This, of course, only when the defect is not in the tube. In the event that the tube is defective (series filament receivers excluded), such as an open filament, the tube may be removed from the socket and the plate terminal of the empty socket connected to the plate of the preceding socket.

DEFECTIVE "A" CONDENSERS.—Emergency measures mean a great deal to the man who is confronted with a problem which entails defective equipment of a nature which cannot be replaced at the moment. One such problem is failure of the "A" condenser or "A" condensers, as the case may be, in an "A" eliminator. Many such devices are still in use, and the man who is fortunate and possesses an old 6 volt storage battery which is not in use, can very effectively use the battery. Many large sound installations secure filament potential for the high powered amplifying tube from a motor generator. The output of this generator or for that fact any other unfiltered D.C. generator, contains an audio frequency voltage, the commutator ripple. This is very effectively removed by floating a number of storage batteries of the proper voltage across the line. Such a system is suggested in connection with the "A" eliminator. When the "A" condenser fails and another is not available for immediate replacement and the eliminator is designed to furnish 6 volts, an old 6 volt storage battery connected as if for charging with the plus of the eliminator to the plus of the battery, the minus to the minus, will enable operation until a replacement unit may be secured. One precaution must be exercised. A switch must be provided in one of the battery leads so that the battery circuit may be open when the eliminator is turned off. This switch may be located in either battery lead. One can readily understand that a 4 volt battery is required for a 4 volt eliminator, although a 6 volt battery tapped across two cells, if this is possible, is suitable for use with a 4 volt "A" eliminator.

DEFECTIVE RESISTANCES.—Resistor replacement is also a problem. When the electrical value of the unit which has failed is known, replacement is comparatively simple, providing of course, that the new unit is of the correct physical dimensions. For the man who must cope with a defective resistance of unknown value, even if a replacement unit ordered by means of part number will be secured at a future date, we suggest the following: A variable resistance may be substituted for the defective part and adjusted until either the correct voltages are obtained, if they are known, or until proper reception is secured. However, one such resistance is not suitable for all positions. Judging by the resistance values employed in commercial receivers, voltage reducing resistances in the eliminator voltage divider may be temporarily replaced by means of a 50 watt 0 to 25,000 ohm variable unit. A defective resistance normally employed as a voltage reducing unit in the detector plate circuit, may be replaced by means of a 10 watt 0 to 50,000 ohm resistance. In the event that the detector circuit is of the grid bias type, this resistor should have a maximum range of 100,000 ohms and need not be greater than 5 watts. Defective resistances employed in the R.F. or A.F. plate circuits as voltage reducing resistances may be temporarily replaced with an 0 to 25,000 ohm unit rated at 15 watts.

"C" BIAS RESISTANCES IN AMPLIFIERS.—"C" bias resistances can be replaced, temporarily of course, with a variable unit rated at from 0 to 3,000 ohms and 50 watts for audio (output stage) systems. The same unit is suitable for the normal run of audio stages. In the majority of instances the aforementioned value of "C" bias resistance can also be utilized in the R.F. system in which case the wattage rating need not exceed 10 or 15 watts. If, however, variable grid bias is used as a volume control, the replacement unit should have a range of from 0 to approximately 50,000 ohms.

DAMAGED PUSH-PULL TUBE.—Although it is not very good practice to operate a push-pull output stage with but one tube, satisfactory performance is possible in an emergency. However, it is necessary to remove the defective tube and to adjust the plate voltage to the correct value. A simpler method is to measure the plate voltage prior to adjustment and if it is not greatly in excess of the rated value, increase the grid bias to correspond to the plate voltage applied. Never operate a single tube in a push-pull stage without correcting the plate or the plate and grid bias voltages.

DAMAGED GRID CONDENSERS.—Two solutions are possible when the detector grid condenser is damaged and a duplicate is not available. The first is to short the grid condenser and change the detector system to grid bias or plate current rectification. The second is to remove the detector plate circuit bypass condenser if it is .001 mfd. or less and use it as the grid condenser.

DAMAGED VOLUME CONTROL.—If the volume control is damaged so that control is not possible, adjust or remove the unit in such fashion that circuit continuity is completed. Then insert a condenser into the antenna system or partially short the antenna coil. This adjustment should be such as to afford satisfactory volume upon the local stations, as few as they may be, replacement of the correct unit being carried out when it is available. If the control is in the grid bias circuit of the radio frequency stage, short the variable unit. The fixed resistor will furnish the normal minimum bias.

DAMAGED OUTPUT TRANSFORMER.—The remedy in this case depends upon what is available and the type of speaker system in use. A bell ringing transformer with a 6 or 8 volt output can be used to replace an output transformer intended for use with dynamic speakers with a voice coil impedance lower than 20 ohms. Of course the quality will not be excellent but the receiver will be operative. A single tranformer is applicable when the output stage is a single tube. Therefore a push-pull output stage should be altered to a single tube output stage. For further data see "Speakers."

DAMAGED C BIAS RESISTANCE IN ELIMINATOR.—A possible solution to the difficulty encountered when a C bias resistance located in the eliminator becomes damaged is the use of the voltage divider bleeder resistance, providing that it is of the uncovered wire type. If of this type it is possible to arrange a 1000 or 2000 ohm section for use as the C bias resistance for various types of tubes. The removal of the bleeder resistance will naturally increase the voltages but if the increase is not excessive, no damage will result. With the exception of the bias resistance required for a pair of 345 tubes or a pair of 350 tubes, the average bleeder unit will carry the required amount of current.

DAMAGED VOLTAGE DIVIDER SECTION.—In the event of damage to one of the voltage divider sections it is possible to employ the bleeder unit or a part of the bleeder unit connected between the detector voltage tap and the B minus, providing that the voltage divider structure is of the simple bridge type. Another possible solution if the resistances are of the open type is to remove the defective section and to rearrange new taps, not necessarily altering the position of the taps provided but making new temporary connections with sections of the remaining parts of the divider. This means a reduction in the various plate and grid voltages, but the operation has been found successful in numerous instances.

VISUAL BALANCING.—The occasion frequently arises when it is necessary to rebalance a radio receiver so that the various stages are resonant to the same wave length at the common setting. While the work of balancing is fairly simple, it is necessary to use a means of accurately noting when maximum resonance has been obtained. The usual method of checking by listening to the signal from the loud speaker is very inaccurate because the average ear is insensitive to small changes in signal intensity. A much better, yet inexpensive system is available.

A 0–2 D.C. milliammeter is inserted into the detector plate circuit, between the tube plate and the plate end of the first audio coupling unit. Without signal input this meter will show a steady deflection, the normal tube plate current. When a signal is tuned in, the plate current reading will change in accordance with the intensity of the radio frequency carrier wave. Since the intensity of this wave is independent of the voice or music frequencies imposed upon it at the broadcasting station, the meter indication will be steady and will not follow the audio frequency fluctuations.

The type of detector circuit will govern the action of the plate current. In a grid leak and condenser system the meter indication will decrease when the signal is applied. In the grid bias system the meter indication will increase when the signal is applied.

This method of indication permits adjustment of condenser (tuning) setting while the signal is being passed through the amplifier, the correct adjustment for resonance being indicated by maximum increase or decrease in detector plate current, according to the detector system being used.

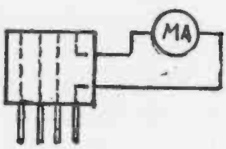


Fig. 205

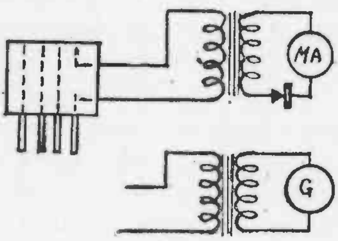


Fig. 206

The recommendation of a 0–2 D.C. milliammeter is based upon the fact that such a meter affords a wide scale and will show small variations. However, it is limited to use in systems where the plate current when normal is not in excess of 2 milliamperes. In the event that the normal plate current is in excess of this value, a 30 ohm rheostat can be connected in shunt with the meter to increase its range.

Figure 205 illustrates the use of a simple plate circuit break-in adaptor whereby the meter may be inserted into the detector plate system, or for that matter into any plate system. As is customary, the adaptor is a combination socket and insert. The tube is removed from the receiver, the insert is plugged into the receiver tube socket and the tube is inserted into the adaptor socket. The leads between the adaptor and the meter should be sufficiently long to enable ready placement of the meter without fear of breakage. It might be well to connect a small bypass condenser across the meter terminals.

The same system is applicable during neutralizing, except that the minimum movement is desired. It is best, however, to arrange the indicator device in the output stage. In order to experience the minimum amount of difficulty, apply the break-in adaptor as shown in figure 206. Instead of the current meter, connect the primary of a small bell ringing transformer. The secondary is connected to a thermocouple galvanometer. Either socket in a push-pull stage will be found satisfactory. The system is unorthodox, but it works.

CHAPTER 27

SIMPLE TESTS AND HINTS

CONTINUITY TESTING.—A suggestion for a continuity tester is a battery of say 4.5 volts or, if possible, a small B battery block of 22.5 volts and a high resistance voltmeter of say 50 volts maximum. This arrangement enables continuity testing of devices which are of such low current capacity that low resistance voltmeters cannot be used during the continuity test. A meter rated at from 600 to 1000 ohms per volt is best. This makes it possible to test such elements as grid suppressers which have very low power rating.

APPLICATION OF CONTINUITY TESTER.—The application of the continuity tester is a very simple item and is free of all technical complexities. The voltmeter is in shunt with the battery when the test clips are short circuited. If some form of resistance, such as a transformer winding, a plate coupling resistance or a radio frequency choke, is connected across the test clip terminals (with the test clips open) the voltmeter is in shunt with the series of combination of the battery and the device under test. If the circuit through the device being tested is perfect, current will flow through the unit and an indication will be secured on the voltmeter. However, the magnitude of the indication upon the voltmeter is governed by the resistance placed into the circuit, represented by the D.C. resistance of the unit under test. The higher the resistance of the unit placed under test, the less the indication upon the voltmeter. In this respect, however, the important consideration is continuity, rather the magnitude of indication, although items understood to possess very low values of D.C. resistance should not reduce the voltage indication to a marked degree.

As to actual testing, all coils or inductances or resistances should show continuity. In the case of resistances, particularly when the ohmic value is high, the voltmeter indication will be low, whereas when the resistance is low, the voltmeter indication will be practically normal, that is, almost the actual battery voltage as indicated when the two test clips are shorted.

Solid dielectric condensers should indicate an "open." Circuit continuity through a condenser is indicative of a shorted or imperfect condenser. Very frequently when testing large values of capacity such as a 2 or 3 mfd. filter condenser, a momentary indication will be obtained when the testing voltage is applied. This is quite natural and is the initial charge applied to the condenser, but the deflection should not be constant during the application of the testing potential.

The continuity tester is well suited for determining momentary shorts in tuning condensers. The tester should be applied and the condenser rotor manipulated the full arc of the dial. When testing condensers, particularly tuning condensers, it is imperative that the condenser under test be disconnected from all circuits unless its position in the receiver is such that circuit through other units connected to the condenser is impossible. This, however, is seldom the case, hence each condenser should be disconnected from the receiver. The removal of one lead from the condenser to the receiver proper or coil is sufficient.

CONNECTIONS BETWEEN POINTS.—When testing connections or contacts between points, connect the continuity tester across the contacts or across the points. When testing leads connect the tester across the full length of the lead. This is particularly applicable to connecting cables, loud speaker leads and similar connections.

A very satisfactory test of an aerial system may be made with the continuity tester shown. Under normal conditions, the aerial should not be grounded in any manner other than the ground through the aerial coil within the receiver. A good test for an external ground is to remove the aerial-ground leads from the receiver and to connect them across the test clips. If the aerial is grounded, current will flow through the circuit and the meter will indicate a certain voltage. Whatever its value, it indicates a grounded aerial.

RAPID TESTING OF LARGE SOLID DIELECTRIC CONDENSERS.—The following method offers a simple means of approximating the capacity of solid dielectric filter condensers within the range used in commercial power packs. The apparatus required is an ordinary plug, a 25 watt 110 volt lamp and 110 volt A.C. line. Select a 1 or 2 mfd. condenser as a standard. Connect the condenser in series with the lamp and connect the combination across a 110 volt line. Note the glow of the lamp. Then connect the condensers to be tested in place of the standard and note the glow of the lamp. If the lamp glows dimmer than with the standard the capacity of the condenser being tested is less than the standard. If it glows more brightly than the standard, the capacity of the condenser being tested is more than that of the standard. By arranging various combinations of standards it is possible to approximate a fairly large range of unknown capacities.

TESTING HIGH VOLTAGE TYPE ELECTROLYTIC CONDENSERS.—To test the Mershon condenser apply a D.C. voltage of about 350 volts across the anode and the container. A D.C. milliammeter should be in the circuit. The range need not be in excess of 160 milliamperes. A protective lamp of the flashlight type rated at about 100 milliamperes should be connected in series with the meter to protect against overload in the event of a short circuit in the condenser. Apply the voltage for 5 minutes. After this period a good condenser will show a leakage current of less than .5 milliampere per microfarad.

TESTING HIGH VOLTAGE TYPE DRY ELECTROLYTIC CONDENSERS.—Apply the rated voltage. The normal leakage current for a good condenser should not exceed .1 to .5 milliampere per microfarad.

TESTING LOW VOLTAGE DRY ELECTROLYTIC CONDENSERS.—Apply a D.C. voltage of from 3 to 4 volts D.C. The normal leakage current should not exceed about 5 milliamperes per 1000 microfarads.

TESTING LOW CAPACITY SOLID DIELECTRIC CONDENSERS.—The best method of test is with a high resistance D.C. voltmeter and a voltage of about 100 volts. A perfect condenser will show a momentary current by a momentary deflection upon the voltmeter. After a few seconds the meter pointer should return to zero. If it continues to indicate a certain voltage less than that of the battery, the condenser is leaky and defective. Precaution must be exercised to insulate the operator from the test prongs, otherwise leakage through the body of the operator will cause a deflection upon the meter and this may be erroneously interpreted as a leak through the condenser. A voltage indication equal to the battery voltage signifies a short circuit in the condenser. To protect against erroneous external short circuits, the condenser under test should be placed upon an insulating surface.

Whenever possible test condensers with a voltmeter so as to protect the instrument against damage in the event of a short circuit in the condenser. If a current meter is used a protecting lamp or a protecting fuse should be incorporated. An alternative is a routine test for short circuit before the meter test is applied.

Use a high resistance voltmeter for all testing in order to be able to detect high resistance leaks.

TESTING FOR GROUNDED WINDINGS.—To test for a grounded winding apply a high voltage in series with a high resistance voltmeter of proper range between one end of the winding and ground, case or core as the condition requires. Good condition is indicated by zero deflection upon the meter. A voltage deflection is a sign of a leak between the winding and the core, case or ground. The limit of voltage applicable for such a test is that employed in practice. As a rule, 500 volts D.C. is not excessive for all audio transformers, chokes, etc. Power transformers may be tested at 1000 volts. However, a high resistance voltmeter of about 1000 ohms per volt will show leaks with test voltages as low as 200 to 250 volts.

TESTING FOR IMPERFECT CONTINUITY.—Arrange a test circuit so that the correct current flows through the winding. The source of voltage should be constant so that under normal conditions the current indication is constant. Apply the current for a few minutes so that the normal temperature is reached. Then shake or gently tap the unit under test. If the continuity is perfect the current indication will remain steady.

TESTING FOR NOISY RESISTANCES.—There is no sure yet simple test for detecting noisy resistances. The most effective and simplest method is replacement. A good point of application is the detector circuit as the detector grid leak or as the plate coupling unit in the detector or audio stage.

TEST LAMPS.—Several simple means of arranging illumination within the receiver during testing are possible. One of these is the use of a small 1.5, 2 or 5 volt flashlight screwed into a suitable socket to which have been soldered two leads. These leads terminate in lugs which slip over the filament or heater prongs of one of the tubes in the receiver. The tube is placed into its correct socket and the receiver power supply furnishes the light for the test operations.

Another method is to arrange a small pilot light as a test light, within a suitable socket. Two leads fastened to this socket are then soldered to the base of a burned-out pilot light from which the glass bulb and its contents have been removed. This plug is screwed into the receiver pilot light socket. The connecting cable should be twisted or parallel lamp cord and about 4 or 5 feet long in order to enable application in console type receivers.

A test lamp may be arranged by using a regular 25 watt 110 volt light, a connecting cable about 15 or 20 feet long and the regular lamp socket. The connecting cable is soldered to this socket. The other end of the cable terminates in a male attachment plug. A part of this test lamp is a double outlet plug. One outlet is used for the receiver power line plug and the other outlet is used for the test lamp. By making the test lamp small in size greater freedom of operation is secured.

SMALL VALUES OF CAPACITY.—Several receivers make use of a small value of coupling capacity between the primary and secondary windings of a tuned radio frequency transformer. The value of this capacity ranges from about 1 to 5 micromicrofarads. In fact this condenser is used in many band pass filters. Such small capacities may be formed by twisting two short pieces of insulated wire. The length of the wire need not exceed 1 inch. One end of each wire constitutes the terminals of the condenser. If desired the two lengths of wire may be placed adjacent without twisting and the capacity varied by changing the separation between the two wires.

SCREEN GRID TUBE CONTROL GRID CLIPS.—A very satisfactory control grid clip suitable for use with screen grid tube may be fashioned from a Fahnstock clip. Bend the spring back until it fits over the control grid terminal.

PHONE CORD TIPS.—Phone cord tips can be fashioned by winding bare tinned No. 22 wire around the stranded wire and continuing the winding around a part of the outside insulation. Roll tightly and apply a thin, even coat of solder.

LOOSE COIL WINDINGS.—Loose windings or turns may be kept in place by a coating of collodion.

CHANGING THE RANGE OF TWO RANGE INSTRUMENTS.—A rapid method of changing the range of a two range meter is to fasten a single pole double throw switch to the meter, make all connections and change the range by manipulating the switch, one range being connected to one terminal, the other range to the remaining terminal and the connecting lead being connected to the blade. The common lead makes contact with the plus or minus common terminal upon the instrument.

CHECKING GANG CONDENSERS.—A rapid means of checking the alignment of ganged condensers is to arrange three midget type variable condensers of about 30 mfds. upon a small panel. Each of these units has its own pair of connecting leads. Assuming that the midget condensers are uniform, attach a small panel type dial to each of these units. Arrange a reference point upon the panel. Set each condenser to about half of the total capacity, with uniformity between the test condensers. Then connect a condenser across each of the ganged variable condensers. Manipulate the ganged unit and note the adjustment of the midgets for maximum response or balance.

TEST PRONGS.—Test prongs can be made from No. 8 or No. 10 B&S copper wire.

MAGNETIZED SCREW DRIVER.—A steel screw driver can be magnetized by winding one or two layers of No. 18 annunciator lamp cord around the shaft and passing about 2 or 3 amperes of direct current through the winding for several hours. The higher the grade of steel the longer will it retain its magnetism.

REPAIRING A CRACKED OR TORN DIAPHRAGM.—While it is not very good practice to repair a cracked or torn speaker diaphragm, such repair may be made by smoothing the surface and applying a heavy coating of rubber cement.

EXTENSION CORDS.—Whenever possible extension cords should be of the twisted variety rather than parallel. This is of particular interest when the purpose of the cord is to connect a magnetic speaker to a receiver located at a distance. For wires of equal length, capacity effects are much more pronounced with the parallel cable.

IONAL EFFECTS OF AERIALS.—Single wire e inverted L type display directional effects, being ponsive in the direction opposite to the free end, in other words most responsive in the direction of the end connected to the lead-in. The shorter the length of the lead-in the greater is this directional effect, hence it is very pronounced in inside aerials of the "around-the-moulding" or "under-the-carpet" type.

LIGHT BULBS AS RESISTANCES.—The ordinary light bulb makes a good emergency resistance. However, it is necessary to consider the temperature of operation. If the rated current is to flow through the bulb filament, the resistance as determined by Ohm's law is applicable. If the current through the lamp is less than the rating as denoted by the wattage of the lamp, Ohm's law no longer holds. Because of the negative temperature coefficient of carbon filament lamps, the resistance when cold is much greater than the resistance of the filament when hot. The reverse is true in the case of the tungsten filament lamp. The resistance of the filament when cold is much less than the resistance of the filament when hot. The following approximate values for hot and cold tungsten filaments should be of aid. This table was compiled by W. H. Wenstrom, *Radio Broadcast*, September, 1929.

Tungsten Lamps	*Resistance Cold*	*Resistance Hot*
10 Watt 115 Volts	140	1280
15 Watt 115 Volts	45	525
50 Watt 115 Volts	23	260
100 Watt 115 Volts	11	135
150 Watt 115 Volts	8	90
25 Watt 32 Volts	5	40
50 Watt 32 Volts	3	20
Carbon Filament		
15 Watt 6 CP 110 Volts	1250	730
50 Watt 16 CP 110 Volts	415	234
100 Watt 110 Volts	260	122

The resistance cold was determined by measurement with small currents.

PROLONGING THE LIFE OF THE SOLDERING IRON.—Excessive heating of a soldering iron pits the soldering tip. A handy method of keeping the iron at a satisfactory temperature without overheating is to arrange a 50 or a 75 watt lamp in series with the iron and a switch whereby the lamp can be short circuited during the time that maximum temperature is required. The presence of the lamp in the circuit will limit the current flow through the iron to a temperature which will keep the iron warm. The lamp is short circuited a minute or two before the iron is to be used. The correct lamp depends upon the normal wattage rating of the iron. A 50 watt lamp is satisfactory for soldering irons rated at from 100 to 200 watts. A 75 watt lamp is satisfactory for soldering irons rated at 250 to 300 watts. The switch should be of the knife blade type capable of carrying 5 amperes.

LOCATING THE SOLDERING IRON.—Soldering irons when heated but not in use should be placed in a horizontal position. Do not place the iron in a vertical position with the tip down. The heat developed within the coil and the iron will heat the handle and make the unit unwieldy.

AN EMERGENCY SOCKET WRENCH.—An emergency socket wrench can be made when a nut of equivalent size and a narrow block of wood are available. Hammer the nut into the wood until it is flush with the edge of the wood. Then remove the nut. The impression cast within the wood will serve as a socket wrench.

IMPROVING DRY DISC RECTIFIER UNITS.—It is possible to improve the performance of the dry disc type of rectifier by tightening the discs. Operate the unit at an overload for a short period. When heated, disconnect from the circuit and tighten the locknut upon the bolt. Do not employ too much pressure. Allow to cool. Cooling the complete unit will still further tighten the pressure upon the disc because of the contraction of the bolt.

FISHHOOK FOR PULLING WIRES.—A very handy fishhook can be made by bending the end of a piece of busbar wire into a half ellipse. This hook is quite handy for pulling drum dial cables and other flexible wires around pulleys and turns. The tool may be bent into various shapes to accommodate existing conditions.

LOCATING THE WINDINGS UPON A POWER TRANSFORMER.—It is possible to locate the primary, plate and filament windings upon a power transformer which does not carry the required designations, by proceeding in the following manner. First locate the plate winding. Arrange a battery of about 5 or 6 volts and a 5 volt tube. If desired, a filament control rheostat may be used in series with the battery and the tube filament so as to limit the filament current to the correct value. The tube circuit terminates in two prongs or loose wires. Connect these two leads across one of the windings upon the transformer. If it is the primary winding the tube will glow. If it is the filament winding, the tube will glow with practically normal brilliancy. If it is the plate winding the tube will not glow. Thus we locate the plate winding. This is marked with a tab. Now we must locate the filament windings and the primary winding. The reactance of the primary winding is much more than that of the filament windings. Arrange a continuity tester with the 110 volt A.C. line as the source of voltage and a 25 watt lamp as the indicator. Connect this continuity tester in series with one of the unknown windings. If it is one of the filament windings, the lamp will glow with practically normal brilliancy. If it is the primary winding the lamp will glow dull or not at all. Thus we locate the primary winding.

It now is necessary to determine the voltage of the various filament windings. Connect the primary winding to the 110 volt A.C. line. Connect a 381, 350 or 310 filament across one of the windings. If it is a 7.5 volt winding the tube filament will light with normal brilliancy. If it is a 5 volt winding, the filament will glow but with low intensity. The filament will not glow if the voltage output is 1.5 or 2.5 volts. Thus we locate the 5 or 7.5 volt winding. These are marked with tabs. Now connect a 327 or a 345 tube filament or heater across the remaining unknown filament windings. The tube filament or heater will glow with normal brilliancy if the voltage output is correct but if the winding supplies 1.5 volts the tube will glow very dim, if at all. Thus we can locate the 1.5 or 2.5 volt winding or windings as the case may be.

SOLDERING FLUX.—Powdered rosin in alcohol makes a good soldering flux. Keep the rosin paste in a semi-fluid condition by adding alcohol.

ALTERING TONE QUALITY.—One branch of radio service work is to effect changes upon a receiver as desired by the owner. Demands to alter the tonal output of a receiver are quite numerous. The methods possible are likewise numerous. We have shown a number of simple methods of varying the tone quality of a radio receiver by the use of bypass condensers across the primary or secondary windings of audio frequency transformers, the use of series resonant circuits and resistance-capacity combinations.

What with the demand for variable tone control, some of these systems must be inserted in such fashion that a variable control is possible external of the receiver. This may be accomplished by the use of combination socket-adaptor units. If the control unit is to be connected across the secondary winding of a single tube stage, one lead is fastened to the grid prong of the socket-adaptor unit and the other terminals at B minus or ground, providing that the stage does not employ a filter resistor. If the stage employs two tubes in push-pull, two adaptors are required, one adaptor unit being placed in one socket and the other adaptor in the other socket. The tone control unit is joined between the grid terminals of these adaptors. The tubes are inserted into the adaptor sockets and the tone control unit is then connected across the grid circuit. The same arrangement can be used across a push-pull output system, with the tone control unit connected between the plate terminals of the adaptors.

These tone control systems may be simple or complex, the design of the system being independent of the application of the device via the adaptor systems suggested.

CHAPTER 28

REFERENCE DATA

RESISTANCES.—When resistances are connected in series, the total resistance is the sum of the individual resistances connected in series. All resistances in a series system are called upon to carry the current in the circuit. If two resistances have been connected in series because a higher value of resistance is required, the current carrying capacity of all of the units in the series combination should be sufficiently high to carry the current in the system. Resistances of non-uniform current carrying capacity may be connected in series providing that the lowest current carrying capacity in the combination is sufficient to safely carry the current present in the circuit.

Connecting resistances in series does not increase the wattage rating of the combination. It increases the total resistance and the possible voltage which may be applied to cause the passage of a certain amount of current as limited by the lowest wattage rating of the resistances in the series combination.

Any number of resistances may be connected in series to produce a final value. It is, however, more practical and economical in the long run to secure one resistance of equivalent ohmic value. It conserves space and minimizes the possible points of trouble.

If twice as much current is to flow through one resistance of a certain value than through another resistance of like ohmic value, the wattage rating of the first must be four times that of the second. If the ratio of currents is 3, the wattage rating of the first must be 9 times that of the second, etc.

RESISTANCES IN PARALLEL.—Placing resistances in parallel reduces the total resistance. If the ohmic value of the units in parallel is not uniform, the final resistance will be less than that of the smallest value in the parallel combination. If the units connected in parallel are of like value, the final resistance of the combination is equal to the value of one of the units divided by the number of units connected in parallel. If five 10,000 ohm resistors are connected in parallel, the final resistance is 2000 ohms.

Connecting resistors in parallel increases the current which may be passed through the parallel combination so that the permissible current is more than that allowed by the individual units. The amount of current which may be passed through the combination is the sum of the current permissible through the units connected in parallel. Thus if two 10 ohm units rated at 10 amperes each are connected in parallel, the final resistance is 5 ohms and the permissible total current through the circuit is 20 amperes. This current will divide between the branches, inversely to the resistance of each branch. If the resistances are equal the current division is equal.

For the solution of resistances in parallel see "Useful Radio Tables."

CONDENSERS IN SERIES.—When condensers are connected in series the final capacity is less than the smallest value of capacity in the series combination. If the capacities of the condensers in the series combination are alike, the final capacity of the series combination is equal to the capacity of one of the units divided by the number connected in series. Five 1. mfd. units in series provide a final capacity of .2 mfd.

Condensers connected in series are not subject to like voltages unless special precautions as illustrated in figure 62 are applied. When condensers are connected in series the voltage applicable across the series combination is limited to the sum of the peak voltage ratings of the individual condensers in the combination, providing that the correct precautionary measures are instituted to arrange for uniform division of voltages.

Condensers connected in series should be of like capacity and if possible of like leakage resistance.

For the solution of series combinations of unequal capacities see "Useful Radio Tables."

CONDENSERS IN PARALLEL.—Condensers in parallel add like resistances in series. The total capacity of a number of condensers connected in parallel is the sum of the individual capacities in the parallel combination.

Condensers connected in parallel are subject to like values of potential and the lowest voltage rating in the parallel combination should be sufficiently high to accommodate the voltage applied. If the voltage rating is satisfactory any number of condensers may be connected in parallel. It is, however, better to replace a parallel bank with a single condenser of equal capacity, thus conserving space, making the system more efficient, introducing economy and minimizing points of possible defects. Condensers connected in parallel need not be of like capacity rating.

INDUCTANCES.—The inductance of a coil in practically all cases varies as the square of the number of turns. If the number of turns is doubled, the inductance increases four times. If the number of turns is halved, the inductance becomes one-quarter of the original value. If the number of turns is increased to three times the original value the inductance increases to nine times the original value. If the number of turns is reduced to one-third of the original values, the inductance is decreased to one-ninth of the original value.

INDUCTANCES IN SERIES.—If inductances are connected in series and there is no inductive coupling between them, the final inductance is the sum of the individual inductances in the series combination. Inductances like everything else wound with wire have definite current carrying capacity ratings. If two inductances are connected in series the minimum current carrying capacity should be equal to the current in the circuit.

INDUCTANCES IN PARALLEL.—Inductances connected in parallel behave like resistances connected in parallel. The total inductance of a parallel combination is less than that of the smallest value in the combination, assuming that there is no inductive coupling between the windings. If two like values of inductance are connected in parallel, the final inductance is equal to half the inductance of either winding in the combination.

ELECTRIC FIELD BETWEEN TURNS OF AN INDUCTANCE.—An electric field is present between the turns of an inductance and the manner of insulation between turns and between layers must be such as to withstand the potential present across the inductance.

MAGNETIC FIELD OF AN INDUCTANCE.—Every winding carrying electric current has a magnetic field. Coils of large diameter have more extensive fields than coils of small diameter. If interaction is to be eliminated, shielding is necessary between all windings.

DIRECT CURRENT RESISTANCE.—D.C. resistance is the opposition offered by a conductor or a non-conductor to the flow of continuous current. All substances are possessed of this property it being greatest in non-conductors. All wires and coils no matter how few or how many the number of turns offer opposition to the flow of direct current. This opposition is a function of the atomic structure of the material.

REACTANCE.—Reactance is the opposition offered by an electrical device to the flow of alternating current, the value expressed in ohms being governed by the structure of the device and the frequency of the current.

CAPACITY REACTANCE.—Capacity reactance is the opposition offered by a condenser to the flow of alternating current.

CAPACITY IMPEDANCE.—The impedance of a condenser expresses the total hindrance offered by that condenser to the flow of alternating current and involves every item associated with the condenser capable of offering any opposition. As a rule the capacity reactance (X_c) is the common term used.

VARIATION OF CAPACITY REACTANCE.—The reactance of a condenser decreases with an increase in frequency or an increase in capacity. The reverse conditions increase the reactance of a condenser. If the capacity is constant, capacity reactance varies inversely with frequency. If the frequency is constant, the reactance varies inversely with capacity.

INDUCTIVE REACTANCE.—The reactance of an inductance is the opposition offered to the flow of alternating current based upon the formation and structure of the winding and the frequency of the current.

INDUCTIVE IMPEDANCE.—The impedance of a winding or an inductance is the total hindrance offered by that winding to the flow of alternating current, taking into consideration every element associated with that inductance, such as D.C. resistance, frequency, etc.

VARIATION OF INDUCTIVE REACTANCE.—The reactance of a coil increases with frequency and with the inductance or the number of turns. The reactance decreases with a decrease in frequency. If the inductance is constant, the inductive reactance is proportional to frequency. If the frequency is constant, inductive reactance (X_L) varies in proportion to the inductance.

OHM'S LAW.—Ohm's law is applicable to all D.C. circuits and in the same form is applicable to all A.C. circuits which are purely resistive or at resonance. When applied to direct current circuits, the voltage E is the product of the current I times the resistance R. The voltage being expressed in volts, the current in amperes and the resistance in ohms. When the current is constant the voltage is proportional to the resistance. When the voltage is constant the current varies inversely with the resistance. When the resistance is constant, the current is proportional to the voltage.

In A.C. circuits, R is replaced by Z, the total impedance, at which time Ohm's law is applicable to the A.C. system. The voltage and the current must be expressed in like units and like manner, such as effective, average or peak values of voltage and current.

WATTAGE RATING.—The wattage rating of a unit is equal to the current I times the voltage E, or to the current squared (I^2) multiplied by the resistance R. As a general rule wattage and power are synonymous. With the wattage rating known, the current I is equal to the watts W, divided by the voltage E. With the watts rating known, and the resistance known, the maximum current through the element is equal to the square root of (W divided by R).

RECIPROCAL.—The reciprocal of a number is 1 divided by that number. Thus .001 is the reciprocal of 1000 because 1 divided by 1000 equals .001.

CONDUCTANCE.—Conductance is the reciprocal of resistance and is expressed in mho, which when spelled backwards is the term "ohm." The conductance of a resistance of 10 ohms is 1 divided by 10 or .1 mho.

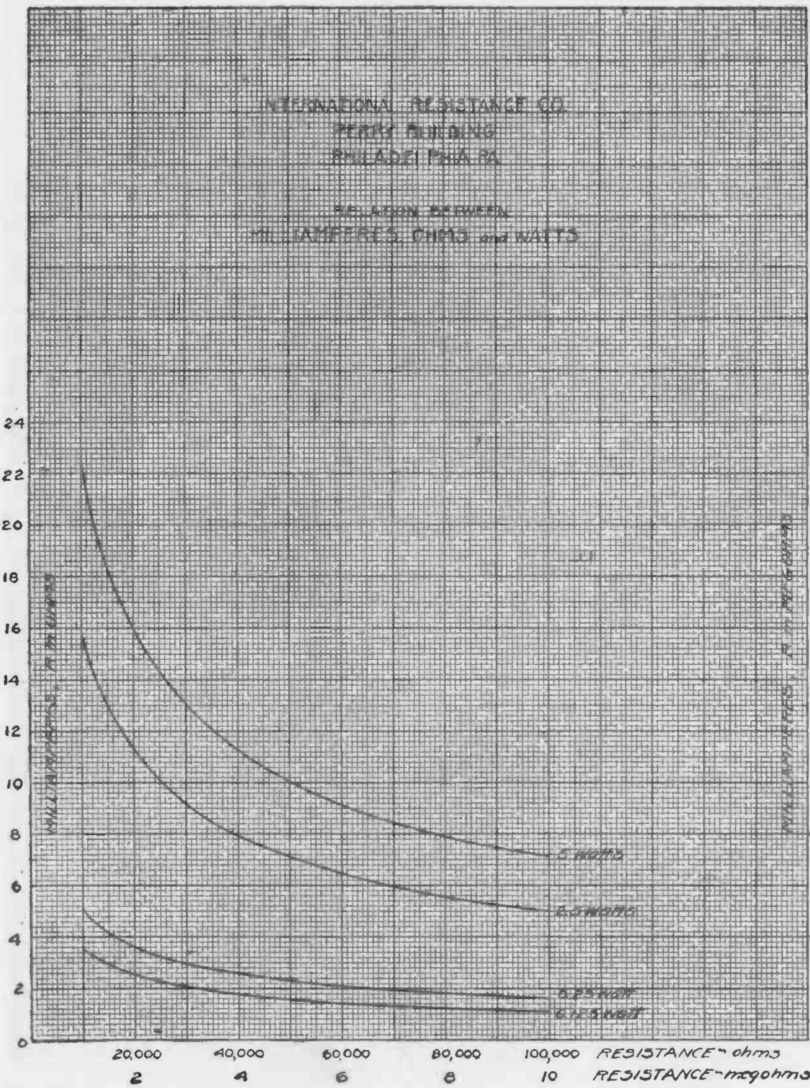
CHAPTER 29

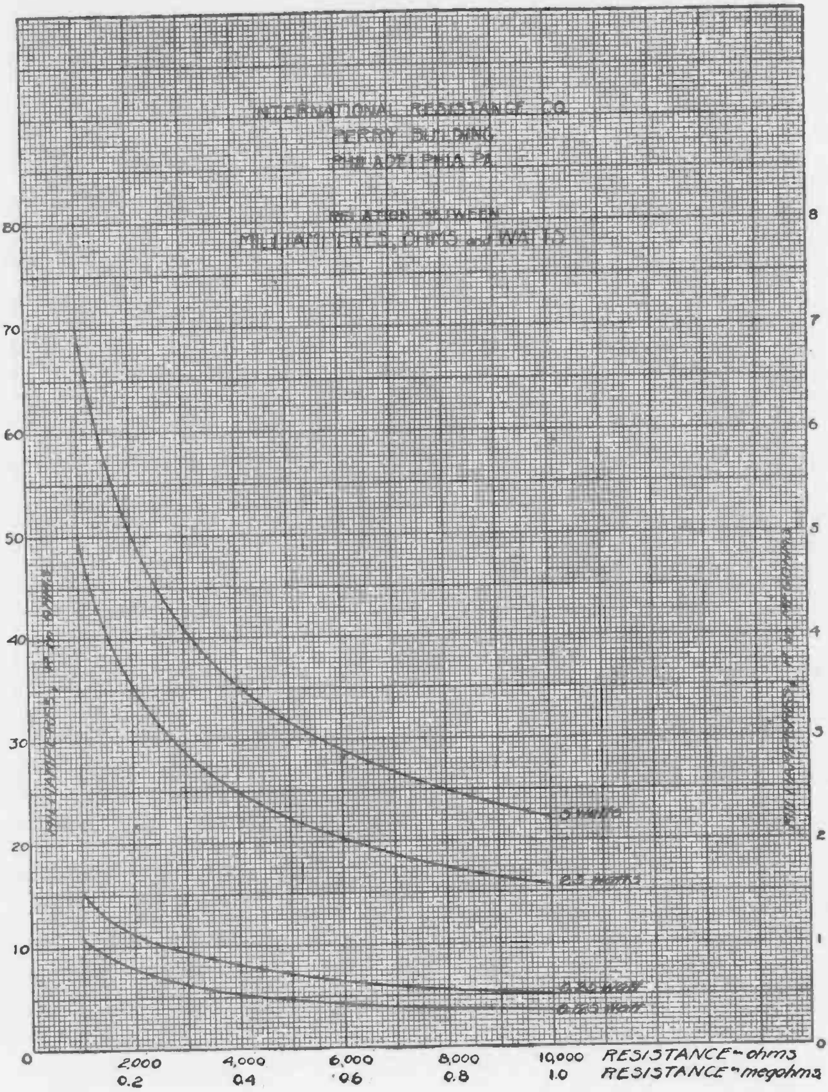
USEFUL RADIO TABLES

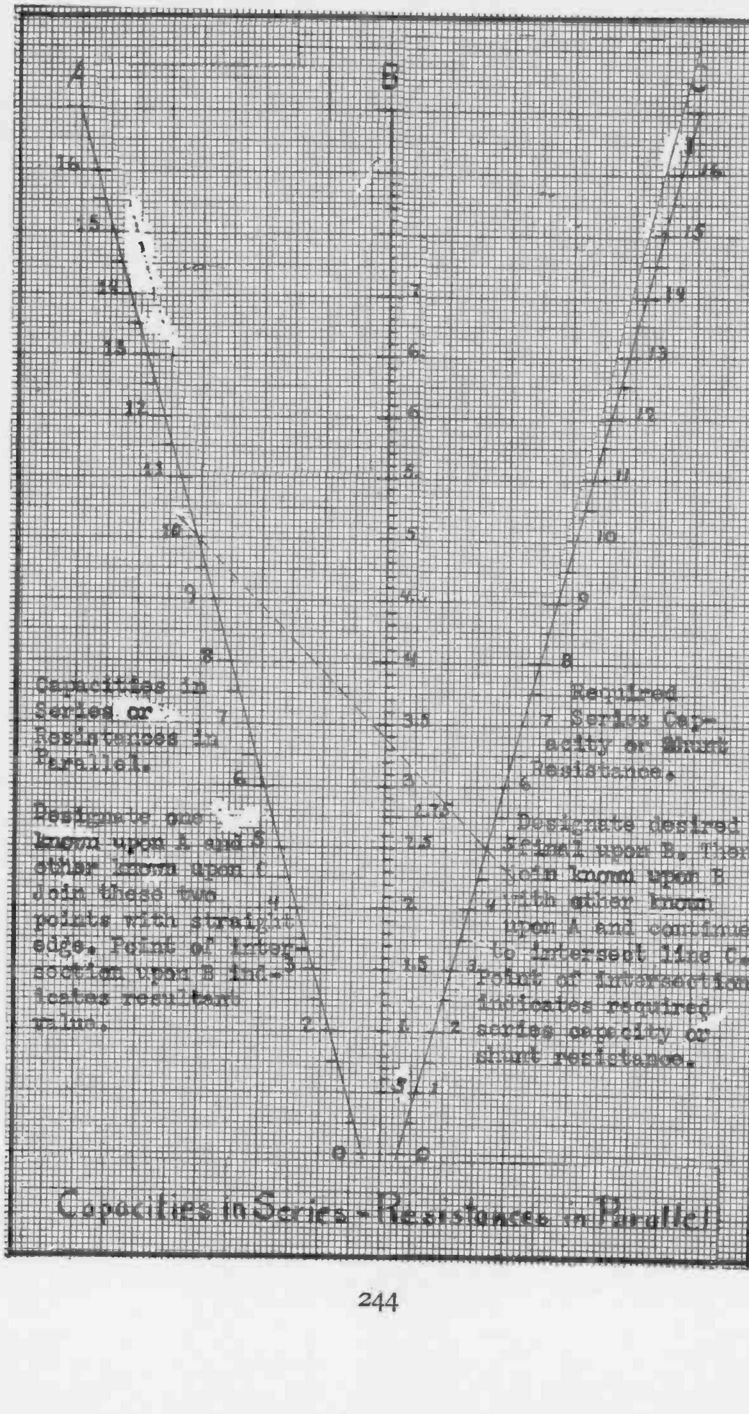
Table of Frequency and Oscillation Constant (LC)

Frequency	L C	Frequency	L C	Frequency	L C	Frequency	L C	Frequency	L C	Frequency	L C
300,000,000	.0000003	1,364,000	.01362	454,500	.1225	256,400	.3853	178,600	.7946	101,700	2.450
150,000,000	.0000011	1,333,000	.01425	447,800	.1263	254,200	.3921	177,500	.8037	100,000	2.533
100,000,000	.0000025	1,304,000	.01489	441,200	.1302	252,100	.3988	176,500	.8134	96,770	2.705
75,000,000	.0000045	1,277,000	.01555	434,800	.1341	250,000	.4052	175,400	.8231	93,750	2.833
60,000,000	.0000070	1,250,000	.01622	428,600	.1378	247,900	.4121	174,400	.8329	90,910	3.066
50,000,000	.0000101	1,225,000	.01690	422,500	.1419	245,900	.4190	173,400	.8422	88,240	3.255
42,860,000	.0000138	1,200,000	.01760	416,700	.1459	243,900	.4260	172,400	.8520	85,910	3.448
37,500,000	.0000180	1,177,000	.01831	411,000	.1501	241,900	.4326	171,400	.8620	83,330	3.648
33,333,000	.0000228	1,154,000	.01903	405,400	.1540	240,000	.4397	170,500	.8720	81,080	3.854
30,000,000	.0000282	1,132,000	.01977	400,000	.1583	238,100	.4469	169,400	.8821	78,950	4.065
20,000,000	.0000634	1,111,000	.02052	394,800	.1626	236,200	.4541	168,500	.8916	76,920	4.277
15,000,000	.0001126	1,091,000	.02129	389,600	.1668	234,400	.4610	167,600	.9018	75,000	4.503
12,000,000	.0001760	1,071,000	.02207	384,600	.1712	232,600	.4683	166,700	.9120	73,170	4.733
10,000,000	.0002533	1,034,500	.02366	379,800	.1756	230,800	.4757	165,700	.9223	71,430	4.966
8,571,000	.0003448	1,017,000	.02450	375,000	.180	229,000	.4831	164,800	.9327	69,770	5.204
7,500,000	.0004503	1,000,000	.02533	370,400	.1847	227,300	.4906	163,900	.9425	68,180	5.446
6,667,000	.0005700	967,700	.02705	365,900	.1893	225,600	.4978	163,000	.9530	66,670	5.700
6,000,000	.0007039	937,500	.02883	361,400	.1941	223,900	.5053	162,200	.9634	65,220	5.960
5,454,000	.0008519	909,100	.03066	357,100	.1985	222,200	.5130	161,300	.9741	63,830	6.219
5,000,000	.001014	882,400	.03255	352,900	.2034	220,600	.5208	160,400	.9841	62,500	6.485
4,615,000	.001188	857,100	.03448	348,800	.2082	218,900	.5281	159,600	.9948	61,220	6.759
4,286,000	.001378	833,300	.03648	344,800	.2132	217,400	.5359	158,700	1.006	60,000	7.039
4,000,000	.001583	810,800	.03854	340,900	.2179	215,800	.5438	157,900	1.016	58,820	7.327
3,750,000	.001801	789,500	.04065	337,100	.2229	214,300	.5518	157,100	1.027	57,690	7.606
3,529,000	.002034	769,200	.04277	333,300	.2289	212,800	.5598	156,300	1.038	56,600	7.905
3,333,000	.002280	750,000	.04503	329,700	.2332	211,300	.5674	155,400	1.049	55,560	8.208
3,158,000	.002541	731,700	.04733	326,100	.2381	209,800	.5755	154,600	1.060	54,550	8.519
3,000,000	.002816	714,300	.04966	322,600	.2434	208,300	.5837	153,800	1.071	53,570	8.836
2,857,000	.003105	697,700	.05204	319,100	.2487	206,900	.5919	153,100	1.081	52,630	9.139
2,727,000	.003404	681,800	.05446	315,900	.2541	205,500	.5998	152,300	1.092	51,720	9.467
2,609,000	.003721	666,700	.05700	312,500	.2595	204,100	.6081	151,500	1.104	50,850	9.801
2,500,000	.004052	652,200	.05960	309,300	.2647	202,700	.6165	150,800	1.115	50,000	10.14
2,400,000	.004397	638,300	.06219	306,100	.2704	201,300	.6250	150,000	1.126	49,180	10.47
2,308,000	.004757	625,000	.06485	303,100	.2759	200,000	.6335	146,300	1.183	48,550	10.82
2,222,000	.005130	612,200	.06759	300,000	.2816	198,700	.6416	142,900	1.241	47,620	11.17
2,144,000	.005518	600,000	.07039	297,000	.2870	197,400	.6502	139,500	1.301	46,870	11.54
2,069,000	.005919	588,200	.07327	294,100	.2927	196,100	.6590	136,400	1.362	46,150	11.88
2,000,000	.006335	576,900	.07606	291,300	.2986	194,800	.6677	133,300	1.425	45,450	12.25
1,935,000	.006760	566,000	.07905	288,400	.3045	193,600	.6760	130,400	1.489	44,780	12.63
1,875,000	.007204	555,600	.08208	285,700	.3105	192,300	.6849	127,700	1.555	44,120	13.02
1,818,000	.007662	545,400	.08519	283,600	.3161	191,100	.6938	125,000	1.622	43,480	13.41
1,765,000	.008134	535,700	.08836	280,400	.3222	189,900	.7028	122,500	1.690	42,860	13.78
1,714,000	.008620	526,300	.09139	277,800	.3283	188,700	.7118	119,000	1.760	42,250	14.19
1,667,000	.009120	517,200	.09467	275,700	.3345	187,500	.7204	117,700	1.831	41,670	14.59
1,622,000	.009634	508,500	.09801	272,200	.3404	186,300	.7295	115,400	1.903	41,100	15.01
1,579,000	.01016	500,000	.1014	270,300	.3467	185,200	.7387	113,200	1.977	40,540	15.40
1,538,000	.01071	491,800	.1047	267,900	.3531	184,100	.7480	111,100	2.052	40,000	15.83
1,500,000	.01126	483,900	.1082	265,500	.3595	182,900	.7573	109,100	2.129	39,470	16.26
1,463,000	.01183	476,200	.1117	263,100	.3660	181,800	.7662	107,100	2.207	38,960	16.68
1,429,000	.01241	468,700	.1154	260,900	.3721	180,700	.7756	105,300	2.287	38,460	17.14
1,395,000	.01301	461,500	.1188	258,600	.3787	179,600	.7852	103,500	2.366	37,980	17.56

L in Microhenrys. C in Microfarads. $LC = (159.155 \div F \text{ in kc})^2$


INTERNATIONAL RESISTANCE CO.
MILLIAMPERES, OHMS and WATTS
5 watts
2.5 watts
0.25 watt
0.125 watt
20,000
40,000
60,000
80,000
100,000
RESISTANCE – ohms
2
4
6
8
10
RESISTANCE – megohms


INTERNATIONAL RESISTANCE CO.
PERRY BUILDING
PHILADELPHIA PA.
RELATION BETWEEN
MILLIAMPERES, OHMS and WATTS
80
70
60
50
40
30
20
10
0
8
7
6
5
4
3
2
1
0
2,000
4,000
6,000
8,000
10,000
RESISTANCE - ohms
0.2
0.4
0.6
0.8
1.0
RESISTANCE - megohms


A
B
C
Capacities in
Series or
Resistances in
Parallel.
Designate one
known upon A and
other known upon C
Join these two
points with straight
edge. Point of inter-
section upon B ind-
icates resultant
value.
Required
Series Cap-
acity or Shunt
Resistance.
Designate desired
final upon B. Then
join known upon B
with other known
upon A and continue
to intersect line C.
Point of intersection
indicates required
series capacity or
shunt resistance.
Capacities in Series - Resistances in Parallel

In Meters	CAPACITANCE IN MICROFARADS							
	.0001	.0002	.0003	.0004	.0005	.0006	.0007	.0008
10	.282	.141	.094	.0704	.0563	.0469	.0402	.0352
15	.633	.317	.211	.158	.127	.1056	.0900	.0790
20	1.126	.563	.375	.281	.225	188	.161	.141
30	2.53	1.27	.845	.633	.507	422	.362	.317
40	4.50	2.25	1.50	1.126	.901	.751	.644	.563
50	7.04	3.52	2.35	1.76	1.41	1.173	1.005	.880
60	10.14	5.07	3.38	2.53	2.03	1.69	1.45	1.27
70	13.8	6.89	4.60	3.45	2.76	2.30	1.97	1.72
80	18.0	9.00	6.00	4.51	3.60	3.00	2.57	2.25
90	22.8	11.4	7.60	5.70	4.56	3.80	3.26	2.85
100	28.2	14.1	9.38	7.04	5.63	4.69	4.02	3.52
150	63.3	31.7	21.1	15.8	12.7	10.6	9.00	7.90
200	112.6	56.3	37.5	28.1	22.5	18.8	16.1	14.1
300	253.4	126.7	84.5	63.3	50.7	42.2	36.2	31.7
350	345.	172.	115.	86.2	69.0	57.4	49.3	43.1
400	450.	225.	150.	112.	90.1	75.1	64.4	56.3
440	545.	272.	182.	136.	109.	90.8	77.9	68.1
500	704.	352.	235.	176.	141.	117.	101.	88.0
600	1014.	507.	338.	253.	203.	169.	145.	127.
700	1379.	689.	460.	345.	276.	230.	197.	172.
800	1802.	900.	600.	451.	360.	300.	257.	225.
900	2281.	1140.	760.	570.	456.	380.	326.	285.
1000	2816.	1408.	939.	704.	563.	469.	402.	352.
1100	3407.	1704.	1136.	852.	681.	568.	487.	426.
1200	4054.	2027.	1351.	1013.	810.	675.	579.	507.
1300	4758.	2379.	1586.	1190.	952.	793.	680.	595.
1400	5518.	2759.	1839.	1380.	1104.	920.	788.	690.
1500	6334.	3167.	2111.	1584.	1267.	1056.	905.	792.
1600	7207.	3604.	2402.	1802.	1441.	1201.	1030.	901.
1700	8136.	4068.	2712.	2034.	1627.	1356.	1162.	1017.
1800	9122.	4561.	3040.	2280.	1824.	1520.	1303.	1140.
1900	10163.	5081.	3388.	2541.	2033.	1694.	1452.	1270.
2000	11262.	5631.	3754.	2815.	2252.	1877.	1609.	1408.
2100	12416.	6208.	4139.	3104.	2483.	2069.	1774.	1552.
2200	13626.	6813.	4542.	3406.	2725.	2271.	1947.	1703.
2300	14894.	7447.	4965.	3723.	2979.	2482.	2128.	1862.
2400	16216.	8108.	5405.	4054.	3243.	2703.	2316.	2027.
2500	17595.	8797.	5865.	4399.	3519.	2933.	2514.	2199.
2600	19032.	9516.	6344.	4758.	3806.	3172.	2719.	2379.
2700	20524.	10262.	6841.	5131.	4105.	3421.	2932.	2565.
2800	22072.	11036.	7357.	5518.	4414.	3679.	3153.	2759.
2900	23677.	11838.	7892.	5919.	4735.	3946.	3382.	2959.
3000	25340.	12670.	8447.	6335.	5068.	4223.	3620.	3167.
3500	34487.	17243.	11446.	8622.	6897.	5748.	4927.	4311.
4000	45045.	22522	15015.	11261.	9009.	7507.	6435.	5631.
4500	57008.	28504.	19003.	14252.	11402.	9501.	8144.	7126.
5000	70383.	35191.	23461.	17596.	14077.	11731.	10055.	8798.
5500	85166.	42583.	28389.	21292.	17033.	14194.	12167.	10647.
6000	101360.	50680.	33787.	25340.	20272.	16893.	14480.	12670.
6500	118940.	59470.	39647.	29735.	23788.	19823.	16991.	14867.
7000	137950.	68975.	45983.	34487.	27590.	22991.	19707.	17244.
7500	158360.	79180.	52787.	39590.	31672.	26393.	22623.	19795.
8000	180180.	90090.	60060.	45045.	36036.	30030.	25740.	22522.
8500	203410.	101705.	67803.	50852.	40682.	33902.	29058.	25426.
9000	228030.	114015.	76010.	57007.	45606.	38005.	32576.	28504.
9500	254090.	127045.	84696.	63512.	50818.	42348.	36298.	31761.
10000	281510.	140755.	93836.	70377.	56302.	46918.	40215.	35188.
11000	340660.	170330.	113553.	85165.	68132.	56776.	48665.	42582.
12000	405400.	202700.	135133.	101350.	81080.	57566.	57914.	50675.
13000	475800.	237900.	158600.	118950.	95160.	79300.	67971.	59475.
14000	551820.	275910.	183940.	137955.	110364.	91970.	78831.	68977.
15000	633450.	316725.	211150.	158362.	126690.	105575.	90493.	79181.
16000	720720.	360360.	240240.	180180.	144144.	120120.	102960.	90090.
17000	813650.	406825.	271216.	203412.	162730.	135608.	116235.	101706.
18000	912160.	456080.	304053.	228040.	183432.	152026.	130308.	114020.
19000	1016300.	508150.	338766.	254075.	203260	169384.	145185.	127037.
20000	1126200	563100	375400	281550	225240	187700.	160885.	140775.

Courtesy Samson Elec. Co. **Figures in vertical columns: Inductance in MICRO-HENRYS**

Meters	Kilocycles	Meters	Kilocycles	Meters	Kilocycles	Meters	Kilocycles
10	29980	720	416.4	1430	209.7	2140	140.1
20	14990	730	410.7	1440	208.2	2150	139.5
30	9994	740	405.2	1450	206.8	2160	138.8
40	7496	750	399.8	1460	205.4	2170	138.1
50	5996	760	394.5	1470	204.0	2180	137.5
60	4997	770	389.4	1480	202.6	2190	136.9
70	4283	780	384.4	1490	201.2	2200	136.3
80	3748	790	379.5	1500	199.9	2210	135.7
90	3331	800	374.8	1510	198.6	2220	135,1
100	2998	810	370.2	1520	197.2	2230	134.4
110	2726	820	365.6	1530	196.0	2240	133.8
120	2499	830	361.2	1540	194.7	2250	133.3
130	2306	840	356.9	1550	193.4	2260	132.7
140	2142	850	362.7	1560	192.2	2270	132.1
150	1999	860	348.6	1570	191.0	2280	131.5
160	1874	870	344.6	1580	189.9	2290	130.9
170	1764	880	340.7	1590	188.6	2300	130.4
180	1666	890	336.9	1600	187.4	2310	129.8
190	1578	900	333.1	1610	186.2	2320	129.2
200	1499	910	329.5	1620	185.1	2330	128.7
210	1428	920	325.9	1630	183.9	2340	128.1
220	1363	930	322.4	1640	182.8	2350	127.6
230	1304	940	319.0	1650	181.7	2360	127.0
240	1249	950	315.6	1660	180.6	2370	126.5
250	1199	960	312.3	1670	179.5	2380	126.0
260	1153	970	309.1	1680	178.5	2390	125.4
270	1110	980	305.9	1690	177.4	2400	124.9
280	1071	990	302.8	1700	176.4	2410	124.4
290	1034	1000	299.8	1710	175.3	2420	123.9
300	999.4	1010	296.9	1720	174.3	2430	123.4
310	967.2	1020	293.9	1730	173.3	2440	122.9
320	936.9	1030	291.1	1740	172.3	2450	122.4
330	908.6	1040	288.3	1750	171.3	2460	121.9
340	881.8	1050	285.5	1760	170.4	2470	121.4
350	856.6	1060	282.8	1770	169.4	2480	120.9
360	832.8	1070	280.2	1780	168.4	2490	120.4
370	810.3	1080	277.6	1790	167.5	2500	119.9
380	789.0	1090	275.1	1800	166.6	2510	119.5
390	768.8	1100	272.6	1810	165.6	2520	119.0
400	749.6	1110	270.1	1820	164.7	2530	118.5
410	731.3	1120	267.7	1830	163.8	2540	118.0
420	713.9	1130	265.3	1840	162.9	2550	117.6
430	697.3	1140	263.0	1850	162.1	2560	117.1
440	681.4	1150	260.7	1860	161.2	2570	116.7
450	666.3	1160	258.5	1870	160.3	2580	116.2
460	651.8	1170	256.3	1880	159.5	2590	115.8
470	637.9	1180	254.1	1890	158.6	2600	115.3
480	624.6	1190	252.0	1900	157.8	2610	114.9
490	611.9	1200	249.9	1910	157.0	2620	114.4
500	599.6	1210	247.8	1920	156.2	2630	114.0
510	587.9	1220	245.8	1930	155.3	2640	113.6
520	576.6	1230	243.8	1940	154.5	2650	113.1
530	565.7	1240	241.8	1950	153.8	2660	112.7
540	555.2	1250	239.9	1960	153.0	2670	112.3
550	545.1	1260	238.0	1970	152.2	2680	111.9
560	535.4	1270	236.1	1980	151.4	2690	111.5
570	526.0	1280	234.2	1990	150.7	2700	111.0
580	516.9	1290	232.4	2000	149.9	2710	110.6
590	508.2	1300	230.6	2010	149.2	2720	110.2
600	499.7	1310	228.9	2020	148.4	2730	109.8
610	491.5	1320	227.1	2030	147.7	2740	109.4
620	483.6	1330	225.4	2040	147.0	2750	109.0
630	475.9	1340	223.7	2050	146.3	2760	108.6
640	468.5	1350	222.1	2060	145.5	2770	108.2
650	461.3	1360	220.4	2070	144.8	2780	107.8
660	454.3	1370	218.8	2080	144.1	2790	107.5
670	447.5	1380	217.3	2090	143.5	2800	107.1
680	440.9	1390	215.7	2100	142.3	2810	106.7
690	434.5	1400	214.2	2110	142.1	2820	106.3
700	428.3	1410	212.6	2120	141.4	2830	105.9
710	422.3	1420	211.1	2130	140.8	2840	105.6

Table Showing Current Carrying Capacity and Allowable Voltage That Can be Applied to Resistors of 3, 10, 25 and 50 Watts Capacity:

Watts →	3	3	10	10	25	25	50	50
Resistance ↙	Amperes	Volts	Amperes	Volts	Amperes	Volts	Amperes	Volts
1	1.730	1.73	3.163	3.163	5.000	5.000	7.070	7.070
1.5	1.410	2.115	2.572	3.858	4.083	6.124	5.773	8.659
2	1.224	2.448	2.235	4.470	3.420	6.840	5.000	10.000
2.5	1.097	2.742	2.000	5.100	3.154	7.885	4.474	11.185
3	1.000	3.000	1.835	5.505	2.939	8.817	4.083	12.249
3.5	.970	3.395	1.689	5.911	2.672	9.342	3.778	13.223
4	.866	3.44	1.579	6.316	2.500	10.000	3.420	13.680
5	.774	3.87	1.414	7.070	2.236	11.160	3.154	15.770
7.5	.632	4.74	1.154	8.655	1.826	13.695	2.581	19.357
10	.547	5.470	1.000	10.000	1.598	15.980	2.236	22.360
15	.447	6.705	.816	12.240	1.298	19.470	1.829	27.435
20	.389	7.78	.708	14.160	1.119	22.380	1.598	31.960
25	.346	8.65	.632	15.800	1.000	25.000	1.414	35.350
30	.316	9.48	.577	17.310	.912	27.360	1.298	38.940
35	.292	10.220	.534	18.690	.844	29.540	1.197	41.895
40	.274	10.960	.500	20.000	.791	31.640	1.119	44.760
50	.245	12.250	.447	22.350	.700	35.000	1.000	50.000
75	.200	15.000	.365	27.375	.574	43.050	.818	61.350
100	.173	17.300	.316	31.600	.500	50.000	.700	70.000
150	.141	21.150	.258	38.700	.432	64.800	.577	86.550
200	.122	24.400	.223	44.600	.353	70.600	.500	100.000
250	.109	27.250	.200	50.000	.316	79.000	.447	111.750
300	.100	30.000	.182	54.600	.294	87.800	.432	129.600
350	.097	33.950	.169	59.150	.269	94.150	.378	132.300
400	.086	34.400	.158	63.200	.250	100.000	.353	141.200
500	.077	38.500	.141	70.500	.224	112.000	.316	158.000
750	.063	46.650	.115	86.250	.186	139.500	.257	192.650
1000	.054	54.000	.100	100.000	.158	158.000	.220	220.000
1500	.044	66.000	.081	121.500	.129	193.500	.182	273.000
2000	.038	76.000	.070	140.000	.112	224.000	.159	318.000
2500	.034	85.500	.063	157.000	.100	250.000	.141	352.500
3000	.031	93.000	.057	171.000	.091	273.000	.129	387.000
3500	.030	105.000	.053	185.500	.085	297.500	.119	416.500
4000	.027	108.000	.050	200.000	.079	316.000	.111	444.000
5000	.024	120.000	.044	220.000	.071	355.000	.100	500.000
7500	.020	150.000	.036	270.000	.058	445.000	.081	607.500
10000	.017	170.000	.031	310.000	.050	500.000	.070	700.000
15000	.014	210.000	.025	375.000	.043	645.000	.057	855.000
20000	.012	240.000	.022	440.000	.035	700.000	.050	1000.000
25000	.011	265.000	.020	500.000	.031	775.000	.044	1100.000
30000	.010	300.000	.017	510.000	.029	870.000	.043	1290.000
35000	.009	315.000	.015	525.000	.026	910.000	.037	1290.500
40000	.008	320.000	.014	560.000	.025	1000.000	.035	1400.000
50000	.007	350.000	.013	650.000	.022	1100.000	.031	1550.000
75000	.006	450.000	.011	825.000	.018	1350.000	.025	1875.000
100000	.005	540.000	.010	1000.000	.015	1500.000	.022	2200.000

Courtesy ELECTRAD INC.

RESONATING CAPACITY TABLE FOR POWER PACK FILTER CHOKES

Frequency	*Inductance* 9h	10h	12h	14h	16h	18h	20h	22h
50 cy	1.12	1.01	.844	.725	.633	.563	.505	.46
80	.44	.395	.33	.282	.247	.219	.197	.179
100	.28	.253	.21	.18	.158	.14	.126	.115
110	.231	.208	.173	.149	.13	.115	.104	.095
120	.194	.175	.146	.125	.11	.097	.087	.08

	24h	*26h*	*28h*	*30h*	*32h*	*34h*	*36h*	*38h*	*40h*
50 cy	.422	.39	.362	.338	.316	.298	.282	.266	.253
80	.164	.152	.141	.132	.123	.116	.11	.104	.099
100	.105	.097	.09	.084	.079	.074	.07	.066	.063
110	.087	.08	.075	.069	.065	.061	.058	.055	.052
120	.073	.067	.063	.058	.055	.051	.048	.046	.043

INDUCTANCE OF DUOLATERAL COILS
(Pacent)

Number	*Approx. Inductance*	*Distributed Capacity*
25	.039 millihry.	30 mfds.
35	.07	33
50	.15	31
75	.32	26
100	.56	24
150	1.3	17
200	2.3	16
250	3.7	15
300	5.4	17
400	9.6	13
500	15.2	13
600	21.5	14
750	34.5	14
1000	62.	13
1250	102.	11
1500	155.	13

(This data was secured from the Pacent Bulletin)

CURRENT SQUARED TABLE

The occasion frequently arises when it is necessary to calculate wattage rating of resistances which operation involves the squares of decimal values. The following table affords squares of various values of current between 1.5 milliampere (.0015 ampere) and 6000 milliamperes (6 amperes).

I In Amperes	I^2	*I* In Amperes	I^2	*I* In Amperes	I^2
.0015	.00000225	.032	.001024	.3	.09
.002	.000004	.034	.001156	.4	.16
.0025	.00000625	.036	.001296	.5	.25
.003	.000009	.038	.001444	.6	.36
.0035	.00001225	.040	.0016	.7	.49
.004	.000016	.044	.001936	.8	.64
.0045	.00002025	.048	.002304	.9	.81
.005	.000025	.052	.002704	1.	1.00
.0055	.00003025	.054	.002916	1.25	1.5625
.006	.000036	.058	.003364	1.5	2.25
.007	.000049	.062	.003844	1.75	3.0625
.008	.000064	.065	.004225	2.	4.00
.009	.000081	.070	.0049	2.25	5.0625
.010	.0001	.075	.005625	2.5	6.25
.011	.000121	.080	.0064	2.75	7.5625
.012	.000144	.085	.007225	3.	9.00
.014	.000196	.090	.0081	3.25	10.5625
.016	.000256	.095	.009025	3.5	12.25
.018	.000324	.100	.01	3.75	14.0625
.020	.0004	.125	.015625	4.	16.00
.022	.000484	.150	.0225	4.25	18.0625
.024	.000576	.175	.030625	4.5	20.25
.026	.000676	.200	.04	4.75	22.5625
.028	.000784	.225	.050625	5.	25.00
.030	.0009	.25	.0625	6.	36.00

TRANSMISSION UNIT TABLE

This table shows the equivalent T.U. gain or loss of a gain or loss in power. If P is the input and P′ is the output power the power ratio in transmission units is

$$10 \log_{10} \frac{P'}{P}$$

Suppose that the power ratio is 3.16. According to the table the gain is 5 T.U. Suppose that power ratio is .339. Then the loss is equal to 4.7 T.U. This table is taken from The General Radio Experimenter, October 1927.

No. of	*Power Ratio*		*No. of*	*Power Ratio*		*No. of*	*Power Ratio*	
T.U.	*Gain*	*Loss*	*T.U.*	*Gain*	*Loss*	*T.U.*	*Gain*	*Loss*
0.1	1.023	.977	3.6	2.29	.437	7.1	5.13	.195
0.2	1.047	.955	3.7	2.34	.427	7.2	5.25	.191
0.3	1.072	.933	3.8	2.40	.417	7.3	5.37	.186
0.4	1.096	.912	3.9	2.45	.407	7.4	5.50	.182
0.5	1.122	.891	4.0	2.51	.398	7.5	5.62	.178
0.6	1.148	.871	4.1	2.57	.389	7.6	5.75	.174
0.7	1.175	.851	4.2	2.63	.380	7.7	5.89	.170
0.8	1.202	.832	4.3	2.69	.372	7.8	6.03	.166
0.9	1.230	.813	4.4	2.75	.363	7.9	6.17	.162
1.0	1.259	.794	4.5	2.82	.355	8.0	6.31	.158
1.1	1.288	.776	4.6	2.88	.347	8.1	6.45	.155
1.2	1.318	.759	4.7	2.95	.339	8.2	6.61	.151
1.3	1.349	.741	4.8	3.02	.331	8.3	6.76	.148
1.4	1.380	.724	4.9	3.09	.324	8.4	6.92	.144
1.5	1.413	.708	5.0	3.16	.316	8.5	7.08	.141
1.6	1.445	.692	5.1	3.24	.309	8.6	7.24	.138
1.7	1.479	.676	5.2	3.31	.302	8.7	7.41	.135
1.3	1.514	.661	5.3	3.39	.295	8.8	7.59	.132
1.9	1.549	.645	5.4	3.47	.288	8.9	7.76	.129
2.0	1.585	.631	5.5	3.55	.282	9.0	7.94	.126
2.1	1.622	.617	5.6	3.63	.275	9.1	8.13	.123
2.2	1.660	.603	5.7	3.72	.269	9.2	8.32	.120
2.3	1.698	.589	5.8	3.80	.263	9.3	8.51	.118
2.4	1.738	.575	5.9	3.89	.257	9.4	8.71	.115
2.5	1.778	.562	6.0	3.98	.251	9.5	8.91	.112
2.6	1.820	.550	6.1	4.07	.245	9.6	9.12	.110
2.7	1.862	.537	6.2	4.17	.240	9.7	9.33	.107
2.8	1.906	.525	6.3	4.27	.234	9.8	9.55	.105
2.9	1.950	.513	6.4	4.37	.229	9.9	9.77	.102
3.0	1.995	.501	6.5	4.47	.224	10.0	10.00	.100
3.1	2.04	.490	6.6	4.57	.219	20.0	100	.01
3.2	2.09	.479	6.7	4.68	.214	30.0	1,000	.001
3.3	2.14	.468	6.8	4.79	.209	40.0	10,000	.0001
3.4	2.19	.457	6.9	4.90	.204	50.0	100,000	.00001
3.5	2.24	.447	7.0	5.01	.200	60.0	1,000,000	.000001

VOLTAGE MULTIPLIER TABLE FOR MICROAMMETERS AND MILLIAMMETERS

MICROAMMETER SCALE

Voltage Range Desired	*100 ua*	*200 ua*	*300 ua*	*500ua*
1	10,000	5,000	3,333	2,000
1.5	15,000	7,500	5,000	3,000
2	20,000	10,000	6,667	4,000
3	30,000	15,000	10,000	6,000
5	50,000	25,000	16,667	10,000
7.5	75,000	37,500	25,000	15,000
10	100,000	50,000	33,333	20,000
15	150,000	75,000	50,000	30,000
30	300,000	150,000	100,000	60,000
50	500,000	250,000	166,667	100,000
100	1,000,000	500,000	333,333	200,000
150	1,500,000	750,000	500,000	300,000
300	3,000,000	1,500,000	1,000,000	600,000
500	5,000,000	2,500,000	1,666,667	1,000,000
1,000	10,000,000	5,000,000	3,333,333	2,000,000

MILLIAMMETER SCALE

	1 M.A.	*1.5 M.A.*	*2 M.A.*	*3 M.A.*	*5 M.A.*
1	1,000	667	500	333	200
1.5	1,500	1,000	750	500	300
2	2,000	1,333	1,000	667	400
3	3,000	2,000	1,500	1,000	600
5	5,000	3,333	2,500	1,667	1,000
7.5	7,500	5,000	3,750	2,500	1,500
10	10,000	6,667	5,000	3,333	2,000
15	15,000	10,000	7,500	5,000	3,000
30	30,000	20,000	15,000	10,000	6,000
50	50,000	33,333	25,000	16,667	10,000
100	100,000	66,667	50,000	33,333	20,000
150	150,000	100,000	75,000	50,000	30,000
300	300,000	200,000	150,000	100,000	30,000
500	500,000	333,333	250,000	166,667	100,000
1,000	1,000,000	666,666	500,000	333,333	200,000

OUTPUT TUBE GRID BIAS RESISTANCE TABLE

Number and Type of Power Tube		*Plate Voltage*	*Bias Resistance*	*Maximum Power Rating*
1	171	180	2000 ohms	3 watts
2	171	180	1000	3
3	171	180	666	3
4	171	180	500	5
1	171	135	1560	3
2	171	135	780	3
4	171	135	390	3
1	210	250	1800	3
2	210	250	900	3
4	210	250	450	3
1	210	350	1560	3
2	210	350	780	3
4	210	350	390	3
1	210	425	1944	3
2	210	425	972	3
4	210	425	486	5
1	245	180	1328	3
2	245	180	664	5
4	245	180	332	5
1	245	250	1600	5
2	245	250	800	5
4	245	250	400	10
1	250	450	1530	10
2	250	450	765	25
4	250	450	383	30-40

Model 375 Portable D.C. Galvanometer

Current per scale division: Approximately 22 micro amperes. Resistance of Galvanometer about 30 ohms. Scale: 30 divisions each side of zero.

Model 301 D.C. Voltmeter

Approximate resistance:—62 ohms per volt. Available with 1,000 ohm per volt rating.

Model 301 D.C. Ammeter

Ammeters up to 50 amperes inclusive have a drop of 50 M. V. + 5%.

Model 301 D.C. Milliammeter

Milliamperes	*Total Resistance in Ohms*
1	27
1.5	18
2	18
5	12
10	8.5
15	3.2
20	1.5
25	1.2
30	1.2
50	2.0
100	1.0
150	.66
200	.50
300	.33
500	.20
800	.12

Model 476 A.C. Voltmeter

Range Volts	*Approximate Ohms per Volt*
1.5	3
2	4
3	6
5	10
10	14
15	14
25	26
50	52
150	105
250	166
300	166
150/8/4	67/10/10

Model 476 A.C. Ammeter

Range Amperes	*Total resistance in ohms*
1	.2030
2	.05
3	.024
5	.010
10	.0058
20	.00162
30	.00070
50	.00057

Model 476 A.C. Milliammeter

Range Milliamperes	*Total resistance in ohms*
15	2000
25	520
50	120
100	21
250	4
500	1.1

Model 506 Panel A.C. Voltmeter

Resistance of voltmeters 125 ohms per volt.

Model 506 D.C. Milliammeters

Range Milliamperes	*Approximate resistance in ohms*
1.5	18
5	8.5
10	3.2
15	1.5
25	2
50	1
100	.5
200	.25
300	.16
500	.1

WESTON ELECTRICAL INSTRUMENT COMPANY—Cont.

Model 517 A.C. Panel Voltmeter

Range volts	*Approximate ohms per volt*
1.5	3
2	4
3	6
5	10
10	14
15	14
25	26
50	52
130	105
150	105
250	166
300	166

Model 517 A.C. Ammeter

Range Amperes	*Resistance in ohms*
1	.2030
2	.05
3	.024
5	.010
10	.0058
20	.00162
30	.00070
50	.00057

Model 528 A.C. Ammeter

Range Amperes	*Approximate total resistance in ohms*
1	.2040
3	.0249
5	.0108
10	.0067
15	.0030
20	.0025
30	.0016
50	.0014

Model 528 A.C. Milliammeter

Ranger Milliamperes	*Approximate total resistance in ohms*
15	2000
25	520
50	120
100	21
250	4
500	1.1

*Supplied with pin tipped 30" flexible cables for plugging into connection jacks on instrument.

JEWELL ELECTRICAL INSTRUMENT COMPANY

Model 68 High Frequency Vacuum Couple Milliammeter

Range	*Scale Div.*	*Approx. Res.*
10	50	65 ohms
25	50	16
50	50	6
100	50	2

Standard Type

150	75	2 ohms
250	50	1.5
500	50	.8

Model 68 Ammeter

1.	50	.3
1.5	75	.2
2.	40	.15
2.5	50	.12
3.	60	.08
5.	50	.05
10.	50	.018
15.	75	.012
20.	40	.009

Model 68 Galvanometer

100	50	4.5

Model 78 A.C. Voltmeter

1.5	75	10.5
3.	60	21.
5.	50	50.
10.	50	160.
15.	75	750.
20.	40	1000.
25.	50	1250.
30.	60	1500.
50.	50	4000.
75.	75	6000.
100.	50	8000.
150.	75	15000.
300.*	60	30000.
500.*	50	50000.
750.*	75	75000.
1000.*	50	100000.

*Supplied with external resistors.

Model 88 D.C. Milliammeter

Range	*Scale Div.*	*Approx. Res.*
1	50	30.
1.5	75	30.
2	40	25.
3	60	20.
5	50	12.
10	50	7.0
15	75	5.0
25	50	3.0
50	50	1.5
75	75	1.0
100	50	.75
150	75	.50
200	40	.37
250	50	.3
300	60	.25
500	50	.15

Model 78 A.C. Voltmeter Double Range

3-15	75	48/240

Model 78 A.C. Milliammeter

25	50	250 ohms
50	50	120
75	75	35
100	50	15
150	75	6
200	40	3
300	60	1.5
500	50	.7

Model 78 A.C. Ammeter

1.	50	.2
1.5	60	.15
2.	40	.06
2.5	50	.05
3.	60	.022
5.	50	.007
10.	50	.004
15.	75	.002
20.	40	.001
30.	60	.001
40.	40	.001

JEWELL ELECTRICAL INSTRUMENT COMPANY—Cont.

Model 88 D.C. Voltmeter

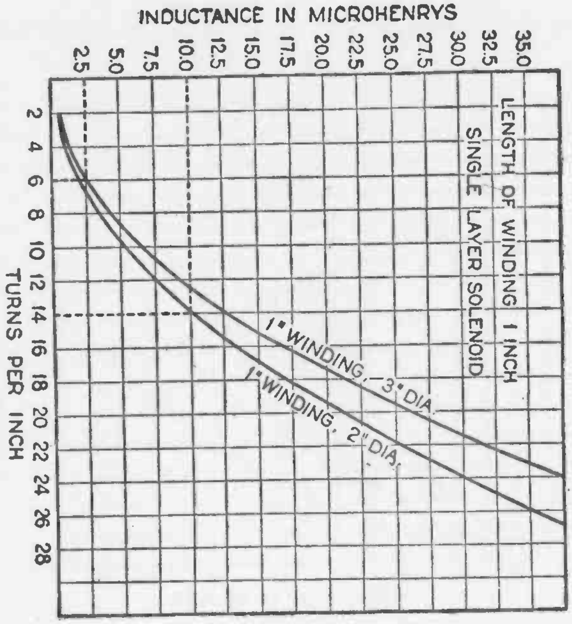
Range	*Scale Div.*	*Approx. Res.*
3	60	300
5	50	500
8	40	800
10	50	1000
15	75	1500
20	40	2000
25	50	2500
30	60	3000
50	50	5000
75	75	7500
100	60	10000
150	75	15000
300	60	30000
500	50	50000
750	75	75000
1000	50	100000
1500	75	150000

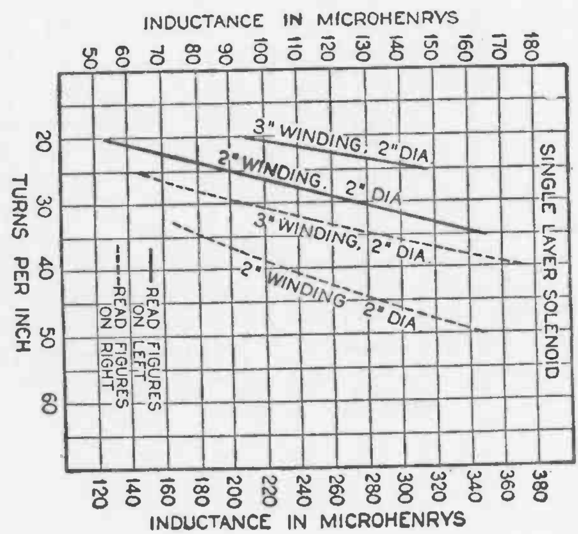
Model 88 D.C. Microammeter

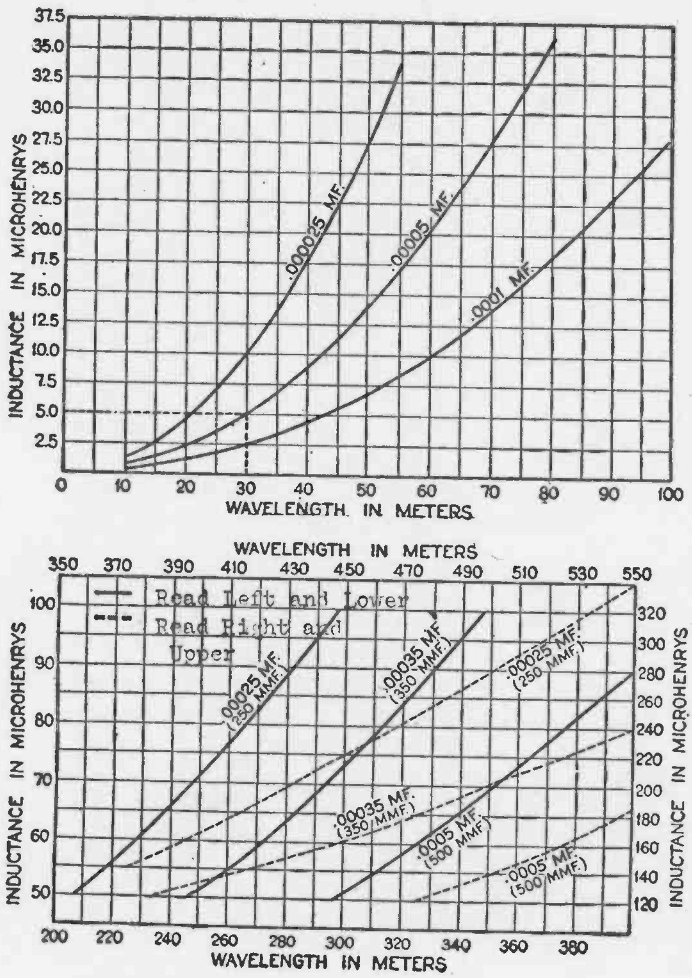
Range	*Scale Div.*	*Approx. Res.*
200	40	140
300	60	140
500	50	140

Model 88 D.C. Ammeter

1.0	50	.075
1.5	75	.050
2.0	40	.037
3.	60	.025
5.	50	.015
10.	50	.075


INDUCTANCE IN MICROHENRYS
2.5
5.0
7.5
10.0
12.5
15.0
17.5
20.0
22.5
25.0
27.5
30.0
32.5
35.0
LENGTH OF WINDING 1 INCH
SINGLE LAYER SOLENOID
1" WINDING, 3" DIA.
1" WINDING, 2" DIA.
2 4 6 8 10 12 14 16 18 20 22 24 26 28
TURNS PER INCH


INDUCTANCE IN MICROHENRYS
50
60
70
80
90
100
110
120
130
140
150
160
170
180
SINGLE LAYER SOLENOID
3" WINDING, 2" DIA
2" WINDING, 2" DIA
3" WINDING, 2" DIA
2" WINDING 2" DIA
READ FIGURES ON LEFT
READ FIGURES ON RIGHT
20 30 40 50 60
TURNS PER INCH
120
140
160
180
200
220
240
260
280
300
320
340
360
380
INDUCTANCE IN MICROHENRYS


INDUCTANCE IN MICROHENRYS
37.5
35.0
32.5
30.0
27.5
25.0
22.5
20.0
17.5
15.0
12.5
10.0
7.5
5.0
2.5
.000025 MF.
.00005 MF.
.0001 MF.
0
10
20
30
40
50
60
70
80
90
100
WAVELENGTH IN METERS
WAVELENGTH IN METERS
350
370
390
410
430
450
470
490
510
530
550
Read Left and Lower
Read Right and Upper
.00025 MF. (250 MMF.)
.00035 MF. (350 MMF.)
.00025 MF. (250 MMF.)
.00035 MF. (350 MMF.)
.0005 MF. (500 MMF.)
.0005 MF. (500 MMF.)
INDUCTANCE IN MICROHENRYS
100
90
80
70
60
50
INDUCTANCE IN MICROHENRYS
320
300
280
260
240
220
200
180
160
140
120
200
220
240
260
280
300
320
340
360
380
WAVELENGTH IN METERS