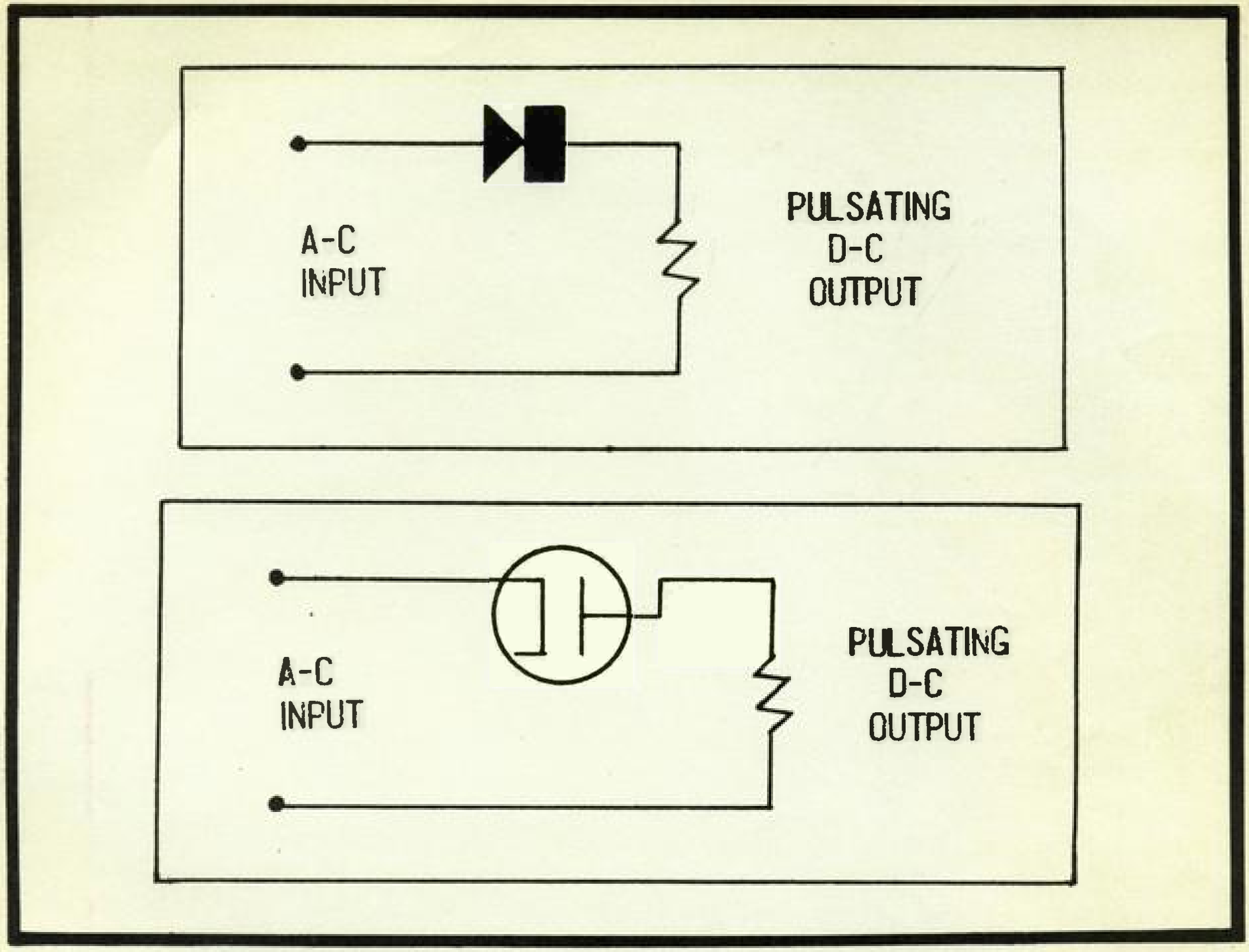

LESSON
23 RA

POWER SUPPLY CIRCUITS FOR RADIO AND TELEVISION SETS

RADIO-TELEVISION TRAINING SCHOOL, INC. · LOS ANGELES · ESTABLISHED 1922

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INTRODUCTION

With the exception of a small quantity of electrical energy which the antenna system absorbs from radio and television waves, all electrical energy as may be needed to operate radio and television receiving sets is furnished by a unit or a section of the set known as the power supply. These power supplies provide:

1. Current for filament and heater elements of tubes and pilot lamps used in radio and television sets.
2. Voltages (d-c) for the plate and screen grid electrodes for vacuum tubes used in radio and television receivers.
3. Grid bias voltages for the respective tubes in the receiver.
4. Field excitation energy for the dynamic-type loudspeaker when used in a receiver.

The circuits used in battery-type power supplies will be introduced first and the manner in which such battery circuits can be used with alternating-current power supplies. Through this lesson the advantages and disadvantages of the various power-supply circuits will be emphasized. In this way you will acquire a better understanding of how to locate defects and make repairs in the power supplies of radio and television receiving sets.

Most power-supply circuits for radio receivers involve voltages under 1,000 volts. Television power-supply circuits may provide voltages as high as 50,000 volts. All voltages above 50 volts may prove to be fatal if allowed to cause a positive contact with the human body. Care should be exercised at all times to avoid a fatal shock and you should, therefore, make it a point to stress safety throughout your work with radio and television power-supply circuits.

TUBES WITH FILAMENT AND HEATER-TYPE CATHODES

The directly-heated-filament type tubes require relatively little electrical heating power. Practically all of the tubes intended for battery operation where power energy drain must be kept as low as possible are of the filament type. These types are sometimes known as the directly-heated type tubes. This is especially true in the case of the portable battery receivers. Examples of the battery-operated filament type tubes are the types 1A7GT, 1F5G, 1H4G and the 1H5G. The voltage applied to the directly-heated filament (cathode) type tubes is seldom a-c (alternating current) since this would cause a variation in the signal being received. This variation may be heard as an objectionable low-frequency hum in the loudspeaker, the frequency of the hum being equal to the power-line frequency of alternation. The voltage drop across the length of the filament of the tube causes a change in the bias voltage because the voltage reverses at the rate of the power-line frequency. The application of an a-c voltage to the filament of tubes is permissable when the tubes are used in the final audio-amplifier stage or power-supply circuits as the signal level is high with respect to the variation in the a-c voltage drop across the terminals of the filament of the tube. The voltages applied to filament-type tubes extend from 1.4 volts to 0.05 amperes to 6.3 volts at 1.0 ampere. The type 1A7GT and the type 6A3 tubes are typical filament-type tubes.

The indirectly-heated-cathode type tube employs a cathode which consists of a thin metal sleeve coated with an electron-emitting material. Within this sleeve is placed the heater element which is insulated from the cathode sleeve. It is this heater element that supplies heat to the cathode sleeve. Such heater-type cathodes can be furnished with either d-c or a-c energy. The heater type cathode tube finds considerable use in equipment intended for operation from a-c power lines as well as automobile radio receiving sets. Since the heater element is insulated from the cathode sleeve emitter and the fact that the voltage drop across the heater element is not introduced in the bias circuit, there is less tendency for the introduction of hum or electrical interference which might enter the tube circuit from the heater-element power-supply line. Still another advantage of the heater element type of cathode is the fact that there is less spacing between the cathode and the plate, or between the cathode and the control grid. The cathode is a cylindrical sleeve. The heater elements may be supplied from an a-c voltage ranging from 2.5 volts at 1.0 ampere to 117 volts at 0.09 ampere. The type 57 tube and the type 117P7GT are typical examples of heater-type tubes operating at 2.5 and 117 volts respectively. Pilot lamps found in radio and television receivers operate equally well on either d-c or a-c voltages. The majority of the smaller pilot lamps operate on voltages ranging from 2 volts to 18 volts with respective current requirements ranging from 0.06 to 0.4 amperes. There are also pilot lamps designed and used for 115 to 120 volt operation. These lamps are, of course, connected directly to the power line terminals.

THE SERIES CONNECTION OF FILAMENT AND HEATER-TYPE TUBES

In localities where the power line voltages are between 110 and 120 volts a-c, a low voltage may be applied to the heater element in either one of the following 3 ways:

1. A step-down transformer can be used to reduce the a-c line voltage to low heater- element voltage as shown in Fig. 1.
2. A resistor can be connected in series with the heater element so that as sufficiently high voltage drop can be obtained across the resistor to apply the required voltage to the heater element as shown in Fig. 2.
3. In a locality where d-c rather than a-c power is provided, a low voltage across the tube filament or heater element of a tube can be obtained by connecting a resistor. in series with the filament or heater element. When a receiving set is intended for a-c or d-c operation we will invariably find all of the heaters are connected in a series circuit. This can best be

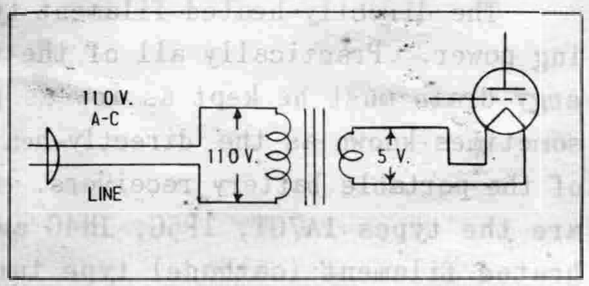

Fig. 1. The high a-c line voltage can be lowered by using a transformer.

illustrated by a receiving set which employs the following types of tubes; 12SK7, 35L6, 35Z5, 12SA7 and 12SQ7 tubes. All of these tubes are of the heater element types employing an indirectly heated cathode.

The manner in which the heater elements are connected in series is shown in Fig. 3. The total voltage drop across the cathode heater of all five for a normal current flow of 0.15 amperes through the heaters of the tubes listed above would be as follows:

TYPE OF TUBE	VOLTAGE DROP ACROSS CATHODE HEATER
12SK7	12.6
35L6	35.0
35Z5	35.0
12SA7	12.6
12SQ7	12.6
12SK7	12.6
TOTAL	120.4

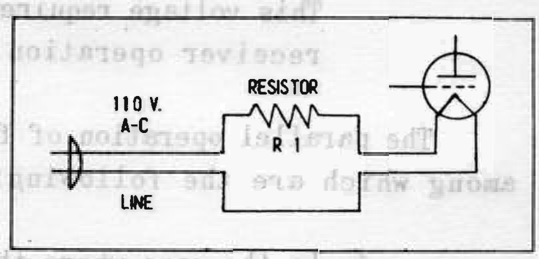

Fig. 2. The high a-c line voltage can be lowered by using a resistor.

Since the line voltage for the a-c lines furnishing power in a home may range from 115 to 120 volts each tube will receive a heater voltage which is very near the manuracturers rating.

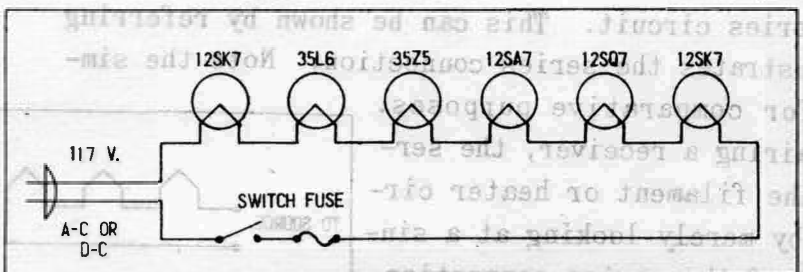

Fig. 3. The heater elements are connected in series.

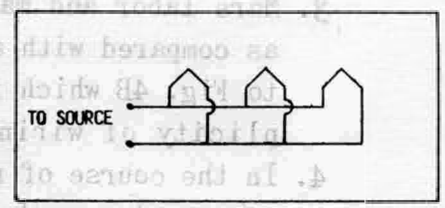

Fig. 4A. Here filament or heater elements are connected in parallel.

THE PARALLEL CONNECTION OF FILAMENT AND HEATER TYPE TUBES

The filament or heaters found in tubes intended for use in radio and television receivers may also be connected in parallel rather than in series such as we have just described. In the case of the parallel connection all the tube filaments or heaters are first connected together and then placed across a battery or an a-c source. The manner of parallel connection is shown in Fig. 4A.

The parallel connection of filament or heaters has some advantages as well as several inherent disadvantages. Among the advantages are the following!

1. Tube filaments or heater connected in parallel are generally operated at a low voltage value. This results in greater efficiency of operation of such tubes.

2. The use of a series resistor is eliminated such as was used in the case of the series connection. En-

ergy flowing through such a resistor is wasted entirely.

3. When one tube burns out the remaining tubes still light or heat thereby making it easier to locate burned out tubes.
4. The parallel operation of filaments or heaters makes it possible to provide filament or heater power in the form of a single 1 1/2 volt battery in the case of the portable radio receiver. For series operation a battery of high voltage would be necessary. This voltage requirement would be objectionable for portable radio receiver operation.

The parallel operation of filament or heater elements does have some disadvantages among which are the following:

1. In the case where the receiver is connected to a-c lines, a means must be utilized to lower the line voltage to a sufficiently low value for use in the parallel operation of such emitters. This generally requires a transformer which makes the receiver muchmore costly.
2. The use of the transformer in an a-c receiver makes the receiver heavier and bulkier as a result of such transformer inclusion.
3. More labor and material is involved in wiring a parallel circuit as compared with a series circuit. This can be shown by referring to Fig. 4B which illustrates the series connection. Note the simplicity of wiring for comparative purposes.
4. In the course of repairing a receiver, the serviceman knows that the filament or heater circuit is functioning by merely looking at a single tube in the case of the series connection. For a parallel connection the serviceman must carefully examine each tube to be certain that they are all working. This latter procedure takes more time in the process of servicing a receiver.

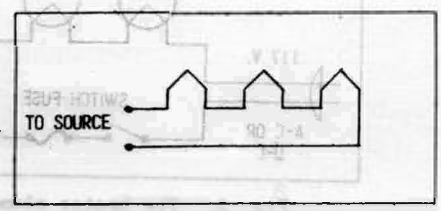

Fig. 4B. **Here the filaments or heaters are connected in series.**

THE USE OF "A", "B" AND "C" POWER SUPPLIES IN RECEIVERS

All types of radio and television receivers/require three types of power supplies for the vacuum tubes contained in such receivers. These types of power supplies may be classified as follows:

1. Power supply to provide energy to the filaments and heaters of the vacuum tubes and filaments of pilot lamps used in such receivers.
2. Power supply to provide the necessary plate voltages for the respective tubes in the receiver.
3. Power supply to provide voltages to the grids of the tubes in radio and television receivers.

In a portable receiver batteries are used to provide the respective power supplies which the receiver requires. The batteries which are used to provide the respective power supplies in such portable receivers are as follows:

"A" BATTERY - This battery is used to furnish the energy for the filament and heater elements in the vacuum tube as well as to provide energy for the pilot lamp or lamps used in d-c receivers.

"B" BATTERY - This battery is used to provide the plate and the screen grid voltages required by the respective vacuum tubes in a radio receiver. As a general rule the "B" battery is principally used in portable receivers.

"C" BATTERY - The "C" battery is used to provide the grid voltage or "C" - bias in a radio receiver. As in the case of the "A" and the "B" batteries we find that the "C" battery is primarily utilized in the portable radio receiver.

A diagram showing the relative location of "A", "B" and "C" batteries in a radio circuit appears in Fig. 5.

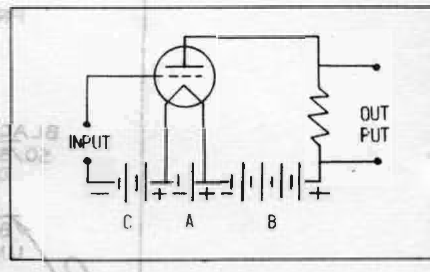

Fig. 5. Where the respective types of batteries are used in a radio circuit.

The advantage of using batteries in obtaining power supply energy is that a steady and pure direct current results. The chief disadvantages of using batteries is that batteries take up a considerable amount of space in a portable receiver and add to the weight of a receiver. Batteries also deteriorate and require frequent replacement which adds to the cost of maintenance of a receiver.

Commercially available "A", "B" and "C" batteries for use in portable receivers give the following voltages:

"A" Battery - 1 1/2, 3, 4 1/2 and 6 volts.
"B" Battery - 22 1/2, 45, 67 1/2, 90 and 144 volts.
"C" Battery - 3, 4 1/2, 7 1/2, 9, 22 1/2, 24 and 37 1/2 volts.

In certain instances the grid voltage or "C-bias" voltage in a portable receiver is obtained by taking a portion of the energy from the "B" battery voltage contained in the receiver.

"A" POWER SUPPLY IN THE A-C OPERATED RECEIVER

When a radio receiver is operated from the a-c house mains, the filament or heater power can be obtained from a transformer. Such a transformer reduces the a-c voltage from the house mains from a voltage in the order of 115 volts to a sufficiently low voltage at which the tube filament or heater is intended to function.

By means of a transformer, it is possible to impress a certain value voltage in one side of the transformer and obtain lower or higher voltage values on the other side of the transformer depending upon the number of turns of wire on the primary and the secondary side of the transformer.

The Radio Manufacturers Association, known by the letters RMA, have found it desirable to have all power transformers color coded. In this way the serviceman knows

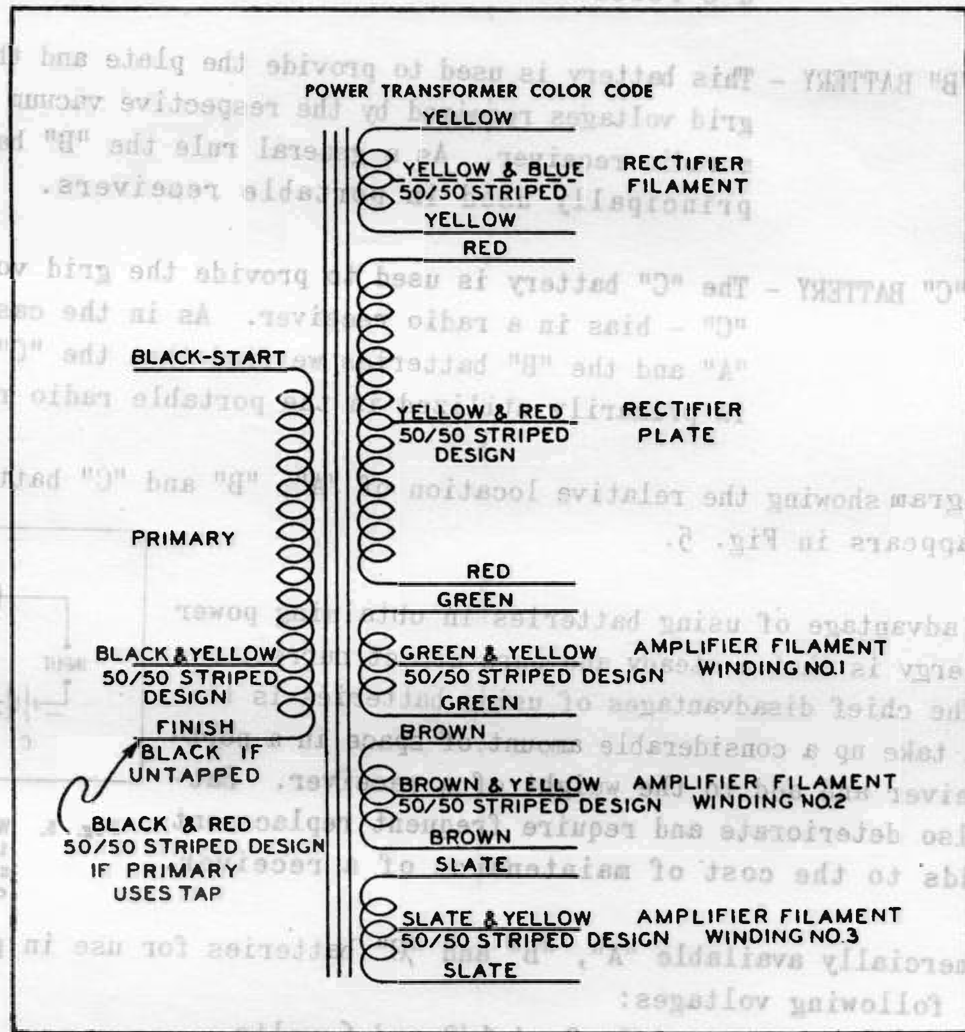

Fig. 6. Color coding for leads in a Power Transformer.

exactly how a power transformer is to be replaced wire by wire. The color coding for a power transformer as you may find in some receivers that utilizes a transformer is shown in Fig. 6.

In most instances a receiver will not have more than two filament or heater windings for the following purposes:

1. One low voltage winding for the rectifier filament.
2. One low voltage winding for the remaining tube filaments or heaters in the receiver.

It must be kept in mind that a power transformer which supplies the filament and heater power together with the high voltage for the rectifier can only be used on alternating current circuits. Should a transformer be connected to a direct current source, it would be damaged. Once the high voltage supplied to the rectifier by the transformer has been rectified such voltage is filtered and can then be used for the plate and grid voltages in a receiver.

Before explaining how rectification can be obtained in an alternating current circuit, it would be well to briefly review the relationship which exists between the turns and the voltages on the primary and the secondary windings of a power transformer. Such relationship can best be explained by solving a problem at this time.

PROBLEM: Determine the number of turns on the three secondary windings of the power transformer shown in Fig. 7 when the primary applied voltage is 120 volts and there are 1,000 turns of wire on the primary winding. The desired secondary voltages are shown on the diagram presented in Fig. 7.

SOLUTION: For winding No. 1, the ratio of the primary to the secondary voltage is equal to $\frac{120}{5}$ or $\frac{24}{1}$.

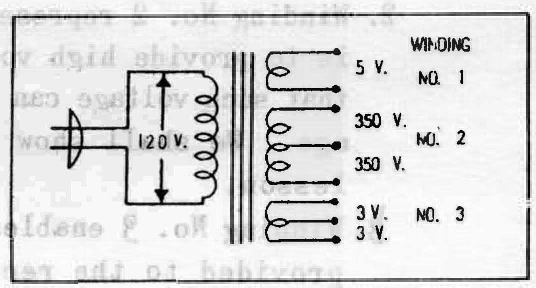

Fig. 7. A power transformer showing voltages appearing at the respective windings.

Since the primary winding has 1,000 turns, winding No. 1 will have $\frac{1000}{24}$ or 41.8 turns. The manufacturer will generally wind 42 turns on this winding rather than a fraction of a turn more or less.

In the case of winding No. 2 we require a total of 700 volts on this winding which is center-tapped so that there will be 350 volts on either side of the center-tap. The voltage ratio between primary and secondary winding No. 2 is equal to $\frac{120}{700}$ or $\frac{6}{35}$. Thus the total number of turns on secondary winding No. 2 will be $\frac{35}{6}$ times 1,000 or 5,833. This means that there will be $\frac{5,833}{2}$ or 2,917 turns on either side of the center tap.

The number of turns on winding No. 3 is solved in very much the same way that we solved for the number of turns for winding No. 2. The voltage ratio between primary and secondary will be $\frac{120}{6}$ or $\frac{20}{1}$. Thus we will have $\frac{1000}{20}$ or 50 turns on winding No. 3. This means that there will be some 25 turns on either side of the center tap of this winding.

The solution of the above problem was based on the following relation:

$$\frac{\text{PRIMARY VOLTAGE}}{\text{SECONDARY VOLTAGE}} = \frac{\text{PRIMARY TURNS}}{\text{SECONDARY TURNS}}$$

The above relation can be stated in another way by saying that the voltage ratio is equal to the turns ratio for the primary and the secondary windings. The voltage ratio would be equal to the primary voltage divided by the secondary voltage. The turns ratio would be equal to the primary turns divided by the secondary turns.

The purpose of the three windings shown on the secondary of the transformer in Fig. 7 are as follows:

1. Winding No. 1 is intended to furnish the electrical energy for the respective filament or heaters for the vacuum tubes in the receiver with the exception of the rectifier tube.
2. Winding No. 2 represents the high voltage winding and its purpose is to provide high voltage to the plates of the rectifier tube so that such voltage can be changed from an a-c voltage to a d-c voltage. We shall show how this is accomplished presently in this lesson.
3. Winding No. 3 enables filament or heater electrical energy to be provided to the rectifier tube used in the receiver.

In all receivers where we find two filament or heater windings, one is intended for use of the rectifier tube filament or heater and the other winding is used for the remaining tube filament or heaters in the circuit. One filament or heater winding for both the rectifier tube as well as the other tubes in the circuit could not be used for numerous reasons such as the following:

1. The filament or heater constitutes the positive high voltage terminal in the rectifier circuit. Using the ordinary filament or heater winding for the rectifier as well as the other tubes in the circuit would actually place a high voltage short on the receiver tubes.
2. Two separate windings provide necessary isolation and separation between the rectifier circuit and the filament and heater elements in the remaining tubes in the circuit.

HOW PLATE AND SCREEN D-C VOLTAGES MAY BE OBTAINED FROM AN A-C SOURCE

Since the distribution of alternating current is more economical and practical, we find most homes in the country supplied with alternating current power. It becomes desirable to utilize such d-c energy in providing the necessary d-c voltages for the plate and screen grid elements in a radio or television receiver. This is conventiently done by means of the process of rectifying the a-c energy into d-c energy. Among the various ways in which this can be done are the following:

1. The use of a vacuum tube known as a rectifier which enables a-c voltage to be converted into d-c voltage.
2. The use of certain substances known as semiconductors which when placed in contact with metal surfaces enable the rectification of a-c energy into d-c energy to be realized. Among the semiconductors in contact with metal surfaces which we shall discuss in this lesson are those known as copper-oxide rectifiers and selenium rectifiers.

A vacuum tube which is invariably used for purposes of rectification contains two elements, the plate and the cathode, and is known as a diode. When connected in a circuit such as is shown in Fig. 8, the diode enables the a-c input electrical energy to be converted into pulsating direct current.

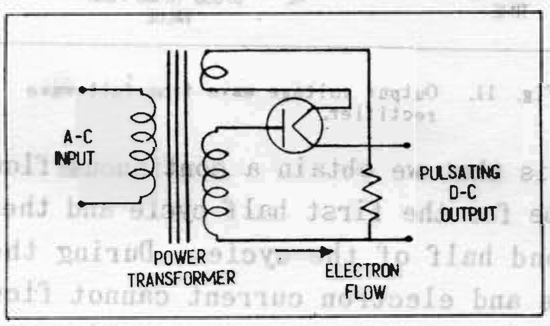

Fig. 8. How a diode tube can be used to convert a-c into d-c energy.

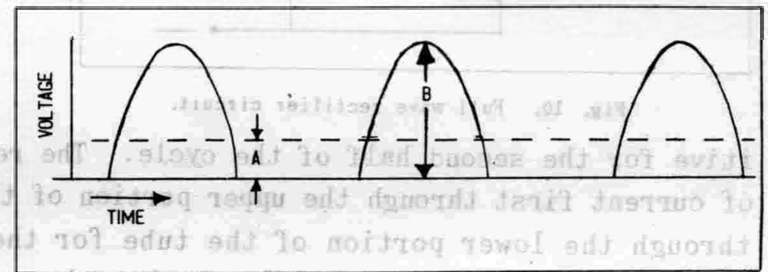

Fig. 9. Output voltage wave for a half wave diode rectifier.

As connected the diode tube permits electron current to take place within the tube only when the plate of the diode tube is positive. When the plate becomes negative, the current flow through the tube ceases. Since an a-c voltage impressed on the tube contains both positive and negative half cycles of energy we find that current only flows through the tube during the positive half cycles. For this reason the diode tube with a single plate is known as a half wave rectifier. The output voltage for this half wave rectifier is shown in Fig. 9.

The average value of this rectified voltage is equal to 0.319 times the peak value of the half sine wave. Thus if the sine wave had an amplitude of 100 volts as is illustrated at B in Fig. 9, the average value, as shown by the letter A, of d-c voltage would be 100 times 0.319 or 31.9 volts.

It is sometimes desirable to improve the wave form resulting from a rectifier circuit. This can be accomplished by using a full wave rectifier circuit such as shown in Fig. 10.

Here we see that the diode tube has one cathode and two separate plates. Among the types of rectifiers falling into the full wave catagory are those employing the type 25Z6 and the type 117Z6 of the cathode heater type and the type 5Y3 and the type 80 for the cathode filament type. The transformer shown in Fig. 10 is provided with a center

In this way the plate No. 1 of the tube is positive during one half of a cycle while the plate No. 2 of the same rectifier tube is positive during the other half of the cycle. Thus electron current first flows to the No. 1 plate for the first half of the cycle while such plate is positive and then flows to the No. 2 plate while this plate is positive for the second half of the cycle.

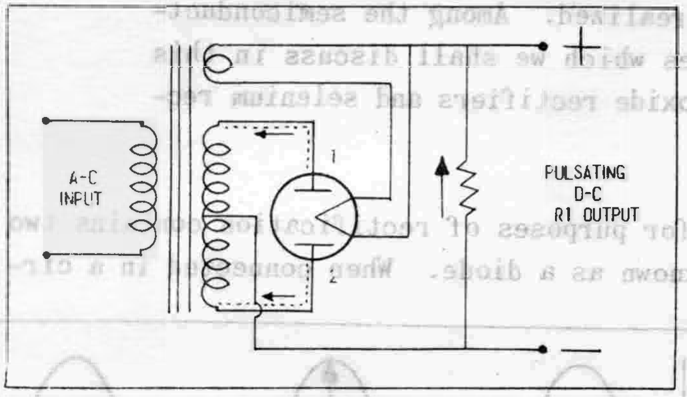

Fig. 10. **Full wave rectifier circuit.**

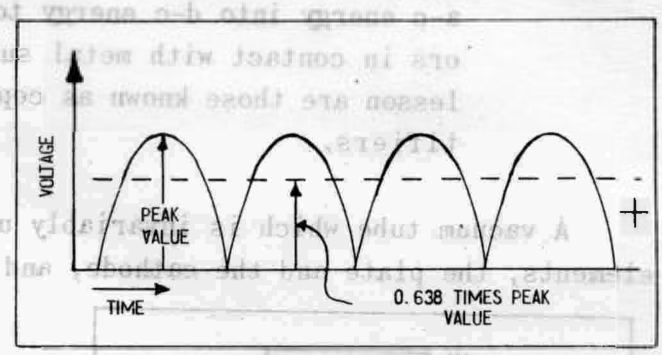

Fig. 11. **Output voltage wave from full wave rectifier.**

The result is that we obtain a continuous flow of current first through the upper portion of the tube for the first half cycle and then through the lower portion of the tube for the second half of the cycle. During the first half of the cycle the No. 2 plate is negative and electron current cannot flow through it. During the second half of the cycle the No. 1 plate becomes negative and electron current will not flow through such plate. The resulting electron current flow through the full wave rectifier is represented in Fig. 11.

The average value of d-c voltage or current is now equal to exactly twice the value we obtained for the half wave rectifier. This value is equal to 0.638 times the amplitude of the half sine wave shown in Fig. 11. Thus if the amplitude of the half sine wave is 100 volts, the average value of d-c voltage becomes 100 times 0.638 or 63.8 volts. The full wave rectifier is preferred over the half wave rectifier and is invariably found in receiver circuits. We shall presently show how the pulsating current is converted into a smooth d-c current so that it can be utilized for the plates and the screen grid elements in tubes in receiver circuits.

COPPER-OXIDE AND SELENIUM RECTIFIERS

Instead of utilizing the diode rectifier tube, as shown in Fig. 12B, we sometimes find that the copper-oxide or selenium rectifier is used, as shown in Fig. 12A. The copper-oxide rectifier functions on the principle that when a thin film of cupreous oxide is formed upon a metallic copper surface the resistance that such a thin film offers is relatively small for currents flowing in one direction and rather high for currents flowing in the opposite direction. The rectifying action obtained from such a rectifier is quite stable. Over long periods of operation the resistance in the conducting direction of the rectifier increases slightly but does not materially alter the rectifying characteristics of the rectifier.

In recent years the selenium rectifier has placed the copper-oxide rectifier in many applications. Selenium rectifiers make use of the rectifying properties which result when a thin film of selenium is formed on a metallic surface such as iron. Although the stability of selenium rectifiers is equal to those ohtained with copper-

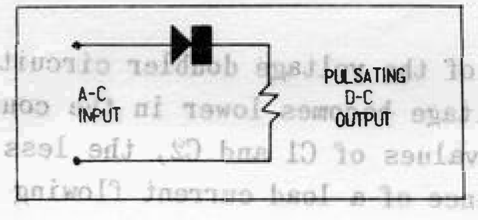

Fig. 12A. This is a diagram of a semiconductor, such as a copper-oxide rectifier or selenium.

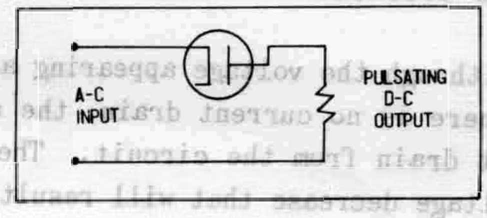

Fig. 12B. This is a diagram of a vacuum tube rectifier.

oxide rectifiers we find that the resistance in the forward direction or the direction in which current flow is desired to take place is less. As a result of this lesser resistance in the forward direction we find that the selenium rectifier enables higher efficiency than the copper-oxide rectifier. The current carrying capacity for the selenium rectifier is also greater than is generally the case for the copper-oxide rectifier.

Although the copper-oxide or selenium rectifier are somewhat more expensive than the vacuum tube rectifier the former type rectifiers have the advantage of being less bulkier, thereby permitting a receiver size to be made smaller. Copper-oxide and selenium rectifiers can also be expected to last longer than the vacuum tube. Copper-oxide and selenium rectifiers have been known to be in operation as long as 10 years giving continuous and dependable service during such time. The vacuum tube could not be expected to provide such long life. Some manufacturers utilize copper-oxide and selenium rectifiers in receivers.

VOLTAGE DOUBLER CIRCUITS

The transformer shown in the half and the full wave rectifier circuits was used so that a sufficiently high d-c rectified voltage would result. Had the rectifier tube been used merely in conjunction with the line voltage of 110 volts, the resulting d-c voltage would have been of some value lower than 110 volts. In order that a power transformer can be omitted and a high enough d-c voltage still obtained, a circuit known as the voltage doubler is utilized. Such a circuit is shown in Fig. 13.

In Fig. 13 is shown a type 25Z5 tube, used for the voltage doubler circuit. This heater is connected to the a-c line through a resistor marked R1. Often times, other heaters from the remaining tubes in the receiver are connected in series with the heater of type 25Z5 tube and the resistor shown in Fig. 13.

When the upper a-c terminal marked 1 is positive, electron current flows to the plate 1 of the tube. This plate current charges capacitor C2 to the peak line voltage. During the next cycle, electron current flows to the plate 2 which results in capacitor

C1 being charged to the peak line voltage. Since the two capacitors are in series we find that the total voltage across the two capacitors is approximately twice the line voltage value. Hence, we have the name "voltage doubler" signifying that the line voltage is doubled.

Although the voltage appearing at the output of the voltage doubler circuit is high when there is no current drain, the available voltage becomes lower in the course of a current drain from the circuit. The larger the values of C1 and C2, the less will be the voltage decrease that will result in the presence of a load current flowing from the

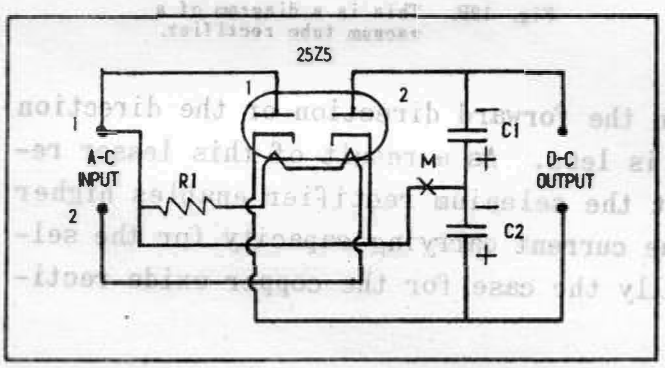

Fig. 13. A voltage doubler circuit.

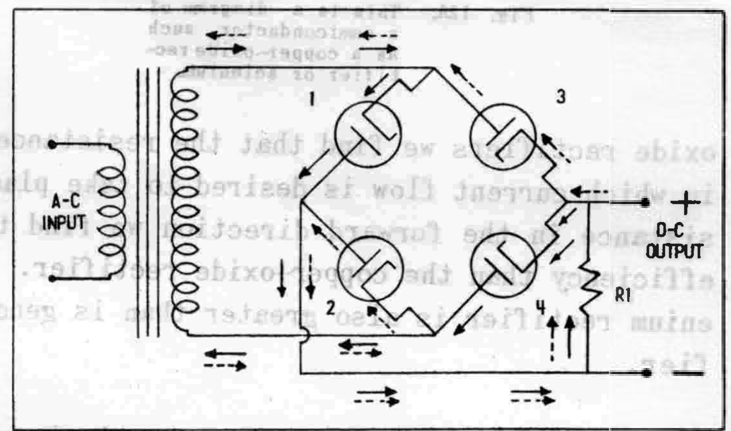

Fig. 14. A bridge rectifier circuit.

circuit. The value of capacitors C1 and C2 are generally 20 to 40 microfarads each in actual practice. In some circuits where the values of the capacitors C1 and C2 are made higher than 40 microfarads, it is desirable to introduce a resistor in series at the point marked M, in Fig. 13, so that excessive emission currents from the tube can be eliminated. Such high emission current flows since, with large capacitors, the charging time for the capacitors is very small and the charging current reaches a high peak value rapidly. The insertion of the resistor reduces this high value of peak charging current although it does increase the charging time for the capacitor.

BRIDGE RECTIFIERS

Bridge rectifiers enable full wave rectification to take place. The arrangement for a bridge rectifier is shown in Fig. 14.

The name of bridge rectifier is given to the circuit arrangement shown in Fig. 14. because the 4 tubes utilized in the circuit are connected in the form of a bridge circuit. The bridge rectifier enables twice as much voltage to be realized at the rectifier output as can be obtained with full wave center-tapped transformer using a single diode with separate plates.

In Fig. 14 we see that when the upper terminal of the secondary winding is positive that current flows through tubes 3 and 2. During this portion of the cycle tubes 1 and 4 are blocked and no current flows through these tubes. When the upper terminal of the secondary winding becomes negative then current flows through tubes 1 and 4. During this half cycle, tubes 3 and 2 are blocked and no current flows through these two latter tubes. The resulting action with a bridge type rectifier circuit is one where full wave rectification takes place with twice as much voltage as could be realized with the center-tapped transformer used previously. In the bridge rectifier circuit shown in Fig. 14 there is no center-tapped winding and as a consequence, the circuit makes full use of of the secondary winding during each half of the cycle.

Instead of 4 diode tubes, the bridge rectifier could utilize 4 copper-oxide or 4 selenium rectifier elements. The operation of such rectifying elements would be similar to the operation of the diode tubes just described. The disadvantage of the bridge type rectifier lies in the fact that 4 tubes or 4 copper-oxide or 4 selenium elements must be used. In the case of filament type diode tubes, 3 separate filament or heater windings are needed. One winding for tubes 3 and 4, one winding for tube 1 and another winding for tube 2.

FILTER CIRCUITS USED IN POWER SUPPLIES

Although the output voltages from the half wave and full wave rectifier shown in Fig. 9 and Fig. 11 may be entirely staisfactory for such uses as charging batteries and for the operation of relay devices, such voltages cannot be used for the screen andplate voltages in radio and television receivers. In order that such output voltage can be made suitable for such purposes, it is essential that such output voltages be fed into a filter circuit so that the resulting voltage will be practically pure d-c with very little ripple super-imposed on the voltage output. The super-imposed ripple reveals itself in the form of objectionable hum in the radio receiver and for this reason must be made as low as possible.

Filter circuits used in power supplies fall in the following classification:

1. Capacitor-input type filter shown in Fig. 15.
2. Choke-input type filter shown in Fig. 15.
3. R-C type filter shown in Fig. 15.

A study of Fig. 15 shows that the first two types of filters consist of inductances and capacitances, while the third type of filter is composed of resistance and capacitance. Each of these types of filters has certain desirable features which makes the filters useful in such applications as the following:

1. CAPACITOR INPUT FILTER - This type of power supply filter is used in most types of radio and television receivers. In the case of the television receiver where a high voltage and an average voltage are simultaneously supplied by two power supplies in a television receiver, we find that the average voltage supply is equipped with a capacitor input type filter. This filter is desirable since it enables a high voltage to be maintained by the power supply.

2. CHOKE INPUT FILTER - This type of filter is used where large current drains take place in the load circuit. Less voltage fluctuation due to changes in load current takes place in a power supply utilizing choke-input type filtering. With less voltage fluctuation the voltage regulation of the power supply is said to be better. Although the choke-input is not generally used in radio or television receivers, it finds considerable use in equipment where good voltage regulation and heavy current drains are present.

3. R-C FILTERS - The resistance-capacitance (R-C) type filter is used where little current drain takes place in the circuit. In Fig. 15 we see that the inductance is replaced by a resistor in the case of the resistance-capacitance type filter. Radio receivers utilize the R-C type filter in the output of the detector circuit. The high voltage power supply circuit in a television receiver makes use of the R-C type filter since little current drain takes place in this particular circuit.

In principle of operation all types of filters behave similarly. The unfiltered energy entering a filter circuit encounters the action of a capacitor and a coil or the action of a capacitor and a resistor. The alternating current has a tendency to enter the capacitor circuit rather than the coil or the resistor since the impedance or resistance of the capacitor circuit is less than the resistance of either the coil or the resistor. The choke coil or the resistor offers a high impedance or resistance path to the flow of a-c energy but permits the d-c current to flow through the choke coil or the resistor without hinderance. Thus we have a device that permits the d-c energy to flow through without hinderance while the a-c energy is made to flow through the capacitor and return back to the source. In this way the voltage fluctuations are materially reduced and the output waves initially shown in Fig. 9 and 11 are altered as shown in Fig. 16 after such voltages have passed through the filter.

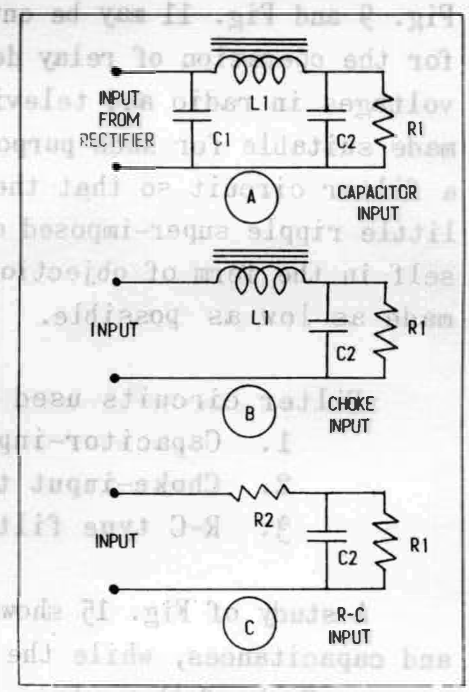

Fig. 15. Filter circuits used in power supplies.

The size of the capacitors used in a filter circuit may vary from 100 micromicrofarads for the R-C filter used in the diode output circuit to about 40 mfd. for filters used in the capacitor-input type. The size of inductances may range from about 4 to 20 henrys in filters used in radio receivers and in filter circuits used in the low voltage power supply of a television receiver. In the case of the high voltage power supply circuit of a television ceiver where a choke coil is utilized we find that the value of this choke may be as high as 1,500 henrys. As a matter of interest the low voltage power supply in a television receiver furnishes power to the plates and grids of the ordinary tubes used in such receivers while the high voltage power supply in a television set is used to provide a high voltage source to the picture tube in such sets. The value of resistors used in R-C type filters may vary over exceedingly wide limits. In general we will find such

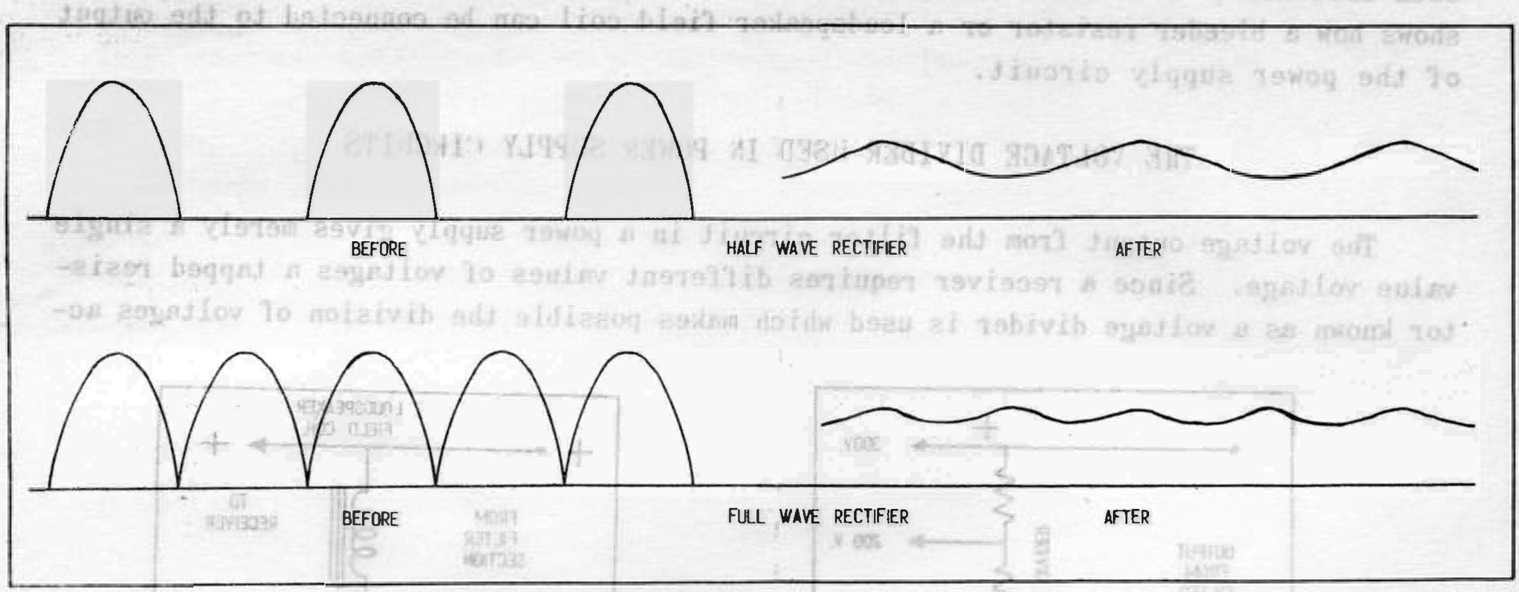

Fig. 16. Comparison of rectified wave before and after filtering.

resistance value to be in the range from 1,000 ohms to 50,000 ohms.

THE USE OF BLEEDER RESISTORS IN A POWER SUPPLY CIRCUIT

Across the output of the filter section we generally place a resistor which is called a bleeder resistor. The purpose and the order of importance of the bleeder resistor is as follows:

1. To place a continuous load on the power supply so that when the set is first turned on, the power supply voltage will not reach an unusually high value where it may damage the receiving tubes and the plate and screen by-pass capacitors. When the receiver is first turned on the set draws little or no plate and screen current until such time as the filament or heaters have warmed up. With such little current drain on the receiver until such time as the heaters have warmed up, the voltage output may become dangerously high. The bleeder assures a continuous load on the power supply and prevents this voltage from becoming too high.
2. The bleeder resistor also enables better voltage regulation to take place in the receiver, thereby assuring better operating performance.
3. When the receiver is shut off, the bleeder resistor enables the capacitors to discharge through such bleeder resistor. Servicemen have been killed where capacitors were touched thatcontained considerable residual charges. In servicing a receiver, it is important to bear in mind that the bleeder resistor may be open and accordingly the serviceman should always exercise care in suchrepair work.

The loudspeaker field coil is sometimes used in place of the bleeder resistor. In such instances, the result is similar to the use of the bleeder resistor. Fig. 18A shows how a bleeder resistor or a loudspeaker field coil can be connected to the output of the power supply circuit.

THE VOLTAGE DIVIDER USED IN POWER SUPPLY CIRCUITS

The voltage output from the filter circuit in a power supply gives merely a single value voltage. Since a receiver requires different values of voltages a tapped resistor known as a voltage divider is used which makes possible the division of voltages according to the voltage value required for the tube in the receiver. The respective values of voltages depends upon the value of the resistances in the respective sections of the voltage divider. A typical voltage divider is shown in Fig. 17.

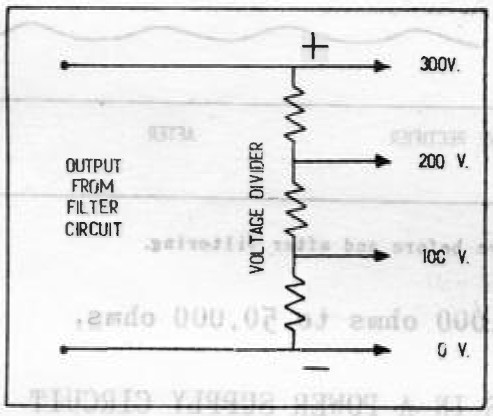

Fig. 17. A three section voltage divider.

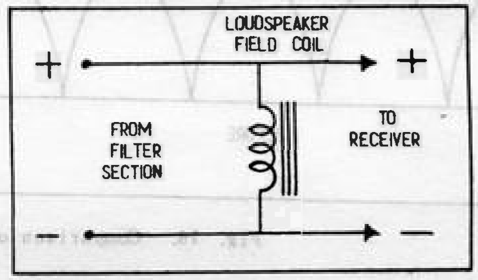

Fig. 18A. The high resistance of the loudspeaker field coil is used as a bleeder resistor.

A study of Fig. 17 shows that the total voltage from the power supply filter is 300 volts. Two taps are shown on the voltage divider one for the 100 volt terminal and a second tap for 200 volts. The 100 volt tap would be located 1/3 of the way up from the bottom while the 200 volt tap would be located 2/3's of the way up from the bottom for load circuits requiring low amounts of current.

The voltage divider can also be regarded as a bleeder resistor since it forms a complete path across the output of the filter circuit. Since each section of the voltage divider is generally connected to a different part of the radio circuit, it is desirable to connect by-pass capacitors between each tap and ground. In this way the respective stages are isolated from each other insofar as interference between stages might be involved. The value of such capacitors should range from 2 to about 8 microfarads in value. The actual value that will be found in an existing receiver depends considerably upon the type of set and the degree of interaction that might be present without such capacitors.

HOW THE LOUDSPEAKER FIELD CAN BE EXCITED BY THE POWER SUPPLY

The dynamic loudspeaker has so many advantages that it is used in practically all types of receivers. There are two basic types of dyanmic loudspeakers which may be listed as follows:

1. The permanent magnet (PM) type of loudspeaker which obtains its excitation through the use of a permanent magnet.
2. The electrodynamic loudspeaker which obtains its excitation from an electromagnet.

The PM loudspeaker has the advantage of being light in weight than the electrodynamic speaker as well as simpler in construction and less expensive. It also has the advantage of requiring no d-c energy for field excitation. The principal disadvantage

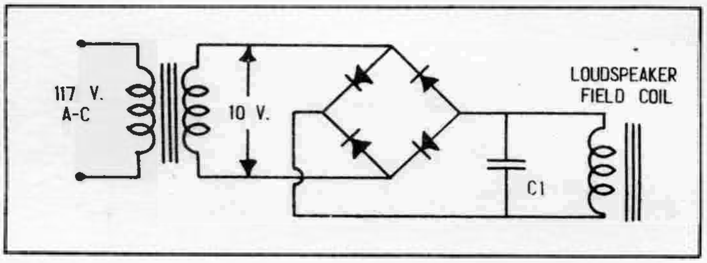

Fig. 18B. A voltage step-down transformer and a selenium rectifier connected in a full wave bridge rectifier circuit is employed here to excite the field of the loudspeaker.

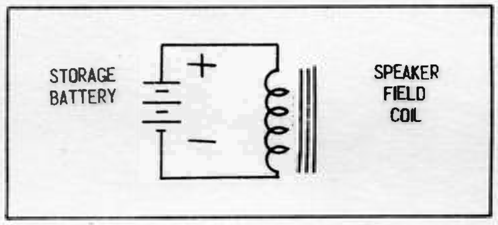

Fig. 18C. The d-c voltage from a storage battery can be applied directly to the loudspeaker field coil without filtering.

of the PM loudspeaker is that it is not adaptable where the application calls for large acoustic power output. It is in the latter instances that the electrodynamic loudspeaker finds greater usuage.

There are a number of ways in which the electrodynamic loudspeaker may be excited. A number of methods of exciting such electrodynamic loudspeakers is illustrated in Figures 18A, 18B, 18C and 18D.

Fig. 18A shows how a loudspeaker field can be connected so that it will act as a bleeder in a power supply circuit. Current flowing through the loudspeaker field coil from the power supply enables this loudspeaker field to be excited. Fig. 18B and 18C the manner in which the loudspeaker field is separately excited by separate power supplies is shown. The battery excitation shown in Fig. 18C, in particular, is used on sound trucks where the field coil is wound with heavy wire. In Fig. 18D we see that the loudspeaker field is used as the second choke coil in the power supply circuit. In such an application the loudspeaker field is always connected after the choke coil in the power supply filter, where the hum level is lowest.

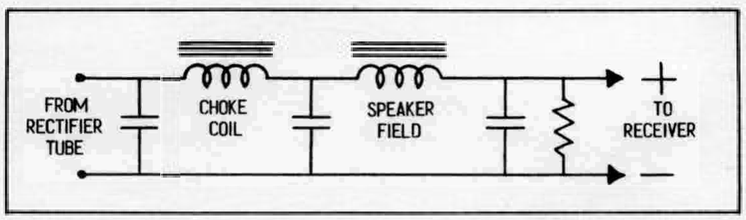

Fig. 18D. Here the field coil of a loudspeaker is connected in series with the regular filter choke coil to not only give additional filtering action but also to excite the field coil of the loudspeaker.

The present discussion in this lesson is intended to introduce you to the broad subject of power supplies. There is considerable similarity in power supplies used for the low voltage supply in a television receiver.

-END OF LESSON-

EXAMINATION QUESTIONS ON FOLLOWING PAGE

Dear Student:

The voltage doubler shown in Fig. 13 of this lesson is incorrect. The diagram shown below is correct.