RADIO TROUBLE FINDER

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Compiled by the Staff of

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Radio Trouble Finder

CONTRARY to the status of other fields involving electricity and mechanics, the radio enthusiast finds himself so situated that he can be his own service man. It is our contention that the average interested individual who can distinguish symbols upon a wiring diagram and who can differentiate between the parts of a radio receiver can effect simple radio service remedies and solve simple radio service problems. We do not mean to imply that he can become a full-fledged service man. But we feel safe in saying that he can solve many simple problems—effectively and rapidly.

Radio receiver servicing of the simple nature such as we have in mind for the everyday radio enthusiast does not involve extensive technical training nor complex and intricate problems. Equipped with certain knowledge, the everyday radio receiver owner can effect remedies involving common everyday troubles. Certain troubles are common to all radio receivers, from the single-tube regenerative receiver to the complex ten-tube superheterodyne. Likewise the remedy applied to one is satisfactorily applicable to the remainder. Fortunately, these common troubles are easily diagnosed, despite the fact that they are numerous and often cause a similar reaction or final effect. Combining the ear and the eye (testing equipment), plus certain knowledge, the average radio enthusiast will find that he can effect necessary service repairs with surprising rapidity and accuracy. The greatest asset is common sense, because it needs frequent application.

The best example of the lack of common sense is the man who reiterates that the wiring of a receiver is perfect, the products are perfect, the accessories are perfect, the aerial and ground are in good condition, yet the receiver operates poorly. Why?

The basis of servicing is knowledge of a certain nature. The man with a thorough technical background can design a radio receiver or diagnose trouble by consideration of respective electrical constants. But such work never confronts the man who has a receiver that has been operating satisfactorily for a period of time and then goes bad. The problem of design is not involved, since it was originally considered when the receiver was first assembled by the author, the "kit" engineer or the commercial engineer. The technical knowledge required to select equipment to perform a certain function is likewise unnecessary, since it was taken care of in the original design. Hence with the sole exception of the man who wishes to redesign his receiver after a failure, the subject of servicing boils down to the location of the point of trouble by diagnosis and replacement of a defective part by the identical perfect part.

Undoubtedly we will surprise many by insisting that this diagnosis of trouble is not difficult. True, it involves the process of elimination and certain knowledge, but the first is common sense application of the second, hence the important consideration is the knowledge required. The purpose of these pages is to disseminate this knowledge, to give in full the numerous details involved in trouble shooting, to discuss cause and effect, faults and symptoms.

We are certain that many readers of these pages will find, after assimilation of data and application to their receiver, that they can effect changes of beneficial nature, alleviate ailments which appeared beyond solution and maintain receiver performance at the highest level.

HOW OLD IS THE SET?

The first essential of servicing is that it be conducted on a business basis. In our case the association with business is not one of monetary consideration, but rather the application of systematic methods. The receiver owner prior to the servicing of a faulty receiver should ask himself several questions. Two of these questions are:

How old is the set?

How old are the accessories?

(By accessories we mean batteries, tubes, eliminators, aerial, ground and speaker).

It is astonishing to find the illuminating information which comes to light when this cross-examination is completed. One seldom considers such items when a receiver fails, and many important facts which influence receiver performance and life are entirely lost because the interested individual has but one fact in mind, the immediate repair of the failure.

Run down batteries, deactivated tubes in the receiver and in the eliminator, oxidized and corroded aerial connections, oxidized and corroded ground connections and demagnetized speakers are frequent complaints.

These faults are common to innumerable receivers and their extreme simplicity causes neglect. Of the subjects mentioned the demagnetized speaker is the least important because of the design of the output circuits used during the last two or three years and the types of speakers recently developed. We will in later discussions dwell upon the application of special testing units and discussion of the symptoms of each of the previously enumerated faults.

We selected the aforementioned questions as the first of importance because the general symptom of all or any one of the above faults is poor reception. That is to say, signals are received with low intensity, broad tuning, lack of selectivity and a high pitched squeal accompanying reception. These symptoms may be subdivided to expedite isolation of the trouble. The presence of the first may indicate trouble in any portion or every portion of the receiver. The second limits the circuits associated with the radio frequency portion of the receiver. This includes all tuning circuits, including that of the detector and the aerial and ground system. Lack of selectivity may be classified with broad tuning. A high-pitched squeal, on the other hand, accompanying poor reception (low signal intensity) is usually indicative of some sort of trouble in the audio frequency amplifier or its associated batteries or eliminators.

The first consideration when attempting to service a receiver is a general check up of the items mentioned in the preceding paragraph with the detailed consideration of the operating life of the installation, including the accessories. Tubes and batteries have definite operating lives. Oxidization and corrosion cannot be avoided. A few moments thought devoted to the possibility of run-down batteries or deactivated tubes will often expedite repairs. The check-up of the batteries is a very simple matter, requiring the use of a voltmeter. If the B potential source is an eliminator, it is necessary that this voltmeter be of the high resistance type. A check up of the aerial and ground requires a personal investigation, and wherever corrosion of contacts or connections is noted new connections should be made. The tubes may be checked by a dealer, involving but a few cents of expense. If their condition has been determined further worry is unnecessary. The process of elimination is an inherent part of servicing.

THE PROCESS OF ELIMINATION

The sequence of this series will shortly lead to the description of simple yet exceptionally effective testing equipment, but a few subjects must be discussed before the reader is actually prepared to enter into the realm of home servicing.

It is indeed surprising to note how much is gained by a few moments of concentrated thought subsequent to the discovery that the receiver at hand is not functioning perfectly. Radio and golf are two forces which will most readily disturb the most complacent individual and will entirely upset his reasoning power. After all is said and done, ailments in receivers are never mysterious, despite prevalent opinion to the contrary. Every ailment has its cause and consequently displays an effect, hence we must consider cause and effect.

Unfortunately several ailments will manifest the same influence and effect, but the reverse is true with respect to diagnosis by means of elimination. That is to say, troubles do not occur in groups and are invariably limited to one portion of the receiver. The process of elimination necessitates recognition of the function performed by various parts of the receiver. By parts we do not mean the individual components, such as coils, condensers, resistances, etc., but rather the sections such as the radio frequency amplifier, the detector stage and the audio frequency amplifier.

Specific phenomena are associated with these sections, and consideration of the type of ailment evident rather than a haphazard assumption will always prove more beneficial. Let us take, as a concrete example, lack of selectivity, which trouble is a frequent complaint. It is logical that selectivity is a function of the tuning circuits. If this be true we immediately eliminate the entire audio frequency amplifier because it has no connection whatsoever with the tuning system. Analytical interest is therefore focused upon the radio frequency tuning circuits, including the input to the detector stage and also, by virtue of its close association, the aerial and ground system. Assuming satisfactory volume but poor selectivity, and recognizing the fact that the function of the amplifying tubes employed in the radio frequency system is purely that of amplification, we can eliminate the tubes as possible sources of trouble. In this respect the tube never affects selectivity. By virtue of elimination we are now interested in the aerial-ground system and the actual tuning system.

Prior to the examination of the tuning system we are obliged to consider one more factor, namely: receiving conditions in the neighborhood and the degree of selectivity available. If the problem is such that only one station, a local, blankets a portion of the dial and all others are received in a satisfactory manner, reasoning will show without analysis that the receiver is not at fault, because the tuning system does not discriminate between stations, and the average receiver in use today does not possess radio frequency characteristics which would tend to overamplify one particular frequency. A personal investigation of how this interfering station is received by others is now in order. If other receiver owners utilizing other types of receivers are confronted with the same problem it is logical that the receiver is not at fault. By the process of elimination only one item remains, the aerial-ground system. A poor ground or an excessively long aerial are possible reasons for broad tuning, the first because it lowers the electrical efficiency of the aerial system, and the second because it picks up too much energy from the exceptionally strong local station. If the physical length of the aerial cannot be reduced the equivalent reduction may be secured by inserting a .0001 mfd. fixed condenser into the aerial circuit.

Another frequent complaint is general lack of selectivity. This condition differs markedly from that previously cited, but what has been said about the elimination of the audio amplifier and the vacuum tubes in the radio frequency system is again applicable. Once again our attention is focused upon three items: receiving conditions in the neighborhood, the aerial-ground system and the tuning circuits in the receiver. The first we can immediately discount because it is highly improbable that any one locality is so poor that general lack of selectivity results because of the high power of all stations received.

General lack of selectivity is invariably accompanied by low receiver output—that is, satisfactory amplification is not available. Since we have eliminated the audio frequency amplifier and since the operating characteristics of the tubes do not influence selectivity, the possible trouble is limited to two sources, which are apparently causing a loss in signal intensity. The first is the aerial-ground system. In contrast to the preceding comment pertaining to the aerial-ground system, the trouble cannot be due to excessive length because the receiver output is less than the correct amount. However, it is possible that the aerial system is causing the low signal level. A check up is therefore in order to determine the condition of the complete antenna system and to locate, if possible, corroded connections and high resistance short-circuits to ground, all of which cause signal-intensity loss.

The remaining item is the tuning system. Voltage sources associated with the vacuum tubes in the R. F. amplifier will not cause a general lack of selectivity. If the batteries are run down or the voltage applied to the filament, grid and plate of each individual R. F. tube are insufficient the cumulative effect will be low amplification and low receiver output, but no effect upon selectivity. Hence the significant items are the radio frequency transformers and the tuning condensers.

General analysis shows two possible reasons for low signal level and lack of selectivity. One is very prevalent in the present-day multistage receiver—namely, lack of resonance because the various tuned stages are not tuned to the same frequency or wave length when the tuning dial is set to one position. The other cause is an electrical loss at some point in the tuning system. Unfortunately, we cannot at this time give full details about the methods suitable for the determination of lack of resonance, which item will be the subject of another paper. However, with respect to the reasons for electrical losses, we can mention a few. These items, in contrast to the usual source of trouble, are not limited to one single stage, but will be found in the entire tuning system. We refer to the absorption of moisture by the radio frequency transformers and the settlement of lint between the condenser plates. In addition, we have items which are associated with just one stage in the system—namely, a short circuit between the plates of one of the condensers, a short circuit between turns of the transformer windings or a complete short across the plate or grid winding of the radio frequency transformer.

Supplementing this we have shorted by-pass condensers associated with the radio frequency amplifying system. Also a higher resistance leak between the plate and grid windings of the radio frequency transformers. Another possible cause is a grounded tuning condenser, that is both stator and rotor plates grounded.

Inasmuch as our prime subject matter is the process of elimination to illustrate diagnosis, we are not delving too deeply into the actual location of trouble.

INTERPRETATION OF SYMBOLS

In order to satisfactorily service a radio receiver, it is necessary that the individual involved fully comprehend the wiring diagram of the defective system and interpret the symbols designating the components employed in the radio receiver or whatever system is being tested. To do this, it is imperative that the man understand and recognize electrical symbols. To facilitate this comprehension, we show herewith the various symbols employed in present-day wiring diagrams, accompanied by a short description of pertinent details relative to the continuity of the device and certain operating characteristics.

Continuity Tester

Fig. 1

In view of the frequent mention of continuity testing, we show an arrangement whereby the continuity of any devices may be determined, and if the tester is calibrated, it is also possible to determine with a reasonable amount of accuracy, the approximate d. c. resistance of the device being tested. This current-voltage test is preferred to the conventional battery-headset test, in view of the fact that the observation is visual and the possibility of error is less. It is dangerous to depend upon the "click" method of testing, the arrangement employed in the battery-headset system, since the charge and discharge of even small capacity will cause a click, and it is necessary to distinguish between relative intensities of such clicks—a very difficult procedure.

In the system shown, a battery B causes current flow through a resistance R and a milliammeter MA when the test clips are shorted or when the test clip prongs are connected across a certain unit. The resistance R and the battery B are so apportioned that with the test clips shorted the current flow through the circuit is of such magnitude that it is equal to the full scale deflection on the meter MA. This provides for the insertion of an appreciable amount of resistance between the test clips without reducing the current indication to zero, or at least to such a low value that the current indication is difficult to note. By noting the value of battery potential and the current indication when a device is being tested, it is possible to ascertain the approximate d. c. resistance of the unit being tested. For example, if the potential of battery B is 22.5 volts and the full scale reading of MA is 1 milliampere, the value of R must be 22,500

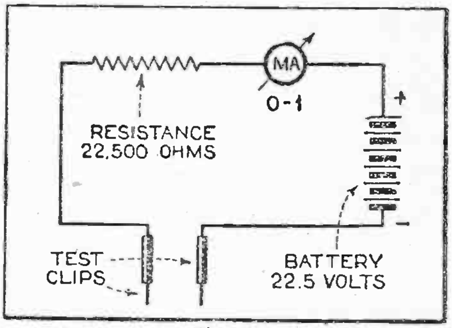

Fig. 1.

ohms in order that the maximum current flow should be 1 milliampere, since

$R = E/I$ and $R = 22{,}500$ when E is 22.5 and I is .001

Considering .1 milliampere, .0001 ampere to be the minimum satisfactory reading upon the meter, sufficient resistance may be inserted between the test clips to make the complete circuit resistance 225,000 ohms. Accordingly, the maximum resistance between the test clips may be 205,000 ohms to give a satisfactory reading on the meter and to permit calibration of the instrument as an "Ohmmeter." This does not mean that the device is limited to the continuity testing of units with 205,000 ohms maximum resistance. Higher values may be employed and continuity or lack of continuity will be observed since the average 1 milliameter will afford a satisfactory deflection on less than .1 milliampere, and this value (.1 mil) permits a total resistance of 225,000 ohms. Hence the continuity tester shown is suitable for all forms of continuity work. Specific application will be discussed as we progress through the interpretation of symbols. In each case, the electrical symbol of the unit mentioned is shown.

Rheostat

Fig. 2

A rheostat is a fixed resistance of either carbon, graphite or wire type, arranged with a sliding contact (wire-wound resistances) arm, which slides over the resistance element. In the case of carbon discs, the pressure between the discs is varied by means of a threaded shaft. As is evident in the symbol, circuit continuity through the resistance element should be continuous and likewise continuity between any part of the resistance element and the contact arm should be continuous. A break in the resistance element will show an "open" when continuity through the resistance element is tested. Lack of contact between the resistance element and the

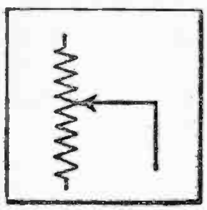

Fig. 3.

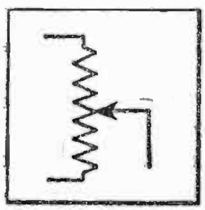

Fig. 2.

contact arm will likewise show an "open" when continuity between the resistance and the contact arm is tested. An imperfect contact between the contact arm and the resistance element will cause a fluctuation in voltage or current in the circuit controlled by the rheostat and will give rise to fluctuating filament brilliancy, or crackling and frying sounds.

Potentiometer

Fig. 3

Potentiometer construction is practically identical to that of a rheostat and similar continuity tests apply. What has been said about the production of crackling and frying sounds when the contact arm does not make perfect contact with the resistor element applies with equal facility to the potentiometer.

Fixed Resistance

Fig. 4

What has been said about variable resistances is likewise applicable to fixed resistances, with the exception that the contact arm is missing. A test with a circuit tester should show complete continuity through the registor element.

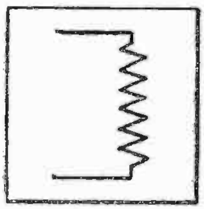

Fig. 4.

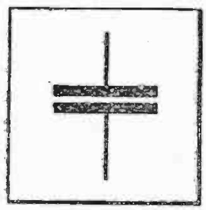

Fig. 5.

Overloading will cause deterioration and burn-out, irrespective of the position of the resistance in the circuit. This latter fact is particularly true of resistances employed in B eliminator voltage divider systems. Once again, overloading may cause frying and crackling sounds because of minute arcs between the turns of the resistance element if it is wire and change in physical structure if the resistance element is of carbon constituency. With respect to the utility of resistance, it is necessary to bear in mind that the size of wire and the structure of carbon units governs the amount of current which may be passed through the element. Current in excess of the rated value will heat the resistance element and cause rapid deterioration, if not a break.

Fixed Condensers

Fig. 5

Fixed condensers designated as shown involve all types of fixed values of capacity, among which are the mica condensers employed as by-pass condensers in radio frequency and audio frequency circuits as isolating condensers in resistance and impedance coupled amplifiers and the various types of filter condensers. Fixed condensers are subject to two principle faults: a rupture of the dielectric due to the application of excessive potential which is the equivalent of a short circuit, and leakage between the active surfaces in the condenser. A ruptured condenser will short whatever circuit is connected to the device and will consequently make that circuit inoperative. A leaky condenser, on the other hand, when connected between two parts of a circuit to isolate the d.c. potential in one part from another part, will cause a leakage of this potential and impair operation of the circuit or device which under normal conditions is supposed to be isolated. A condenser when perfect should offer infinite resistance to d.c. current and consequently when tested for continuity should show an open. It is, however, necessary to distinguish between this type of open and an open between the active plates of the condenser and the contact or lead supposedly connected thereto. Indication of this continuity is evident when a large value of capacity is tested, by a momentary charge indicated upon the continuity tester meter in the form of a deflection which immediately thereafter reaches zero.

Variable Condenser

Fig. 6

The variable condenser is designated as shown and this symbol indicates one unit. These condensers, like the fixed, are subject to rupture of the dielectric, leakage through the dielectric and in some instances a short circuit between the plates. The first and third faults will become evident when the continuity test is made by an indication of continuous current flow of a value equivalent to a short circuit across the test clips. A leaky condenser will, on the other hand, show a much lower value of current and since a perfect condenser would show open, any one of these three conditions makes necessary replacement of the defective unit. A momentary short between the plates will become evident when the continuity test is made and the rotor plates are revolved over the normal arc of motion, by current flow at the moment of the short circuit.

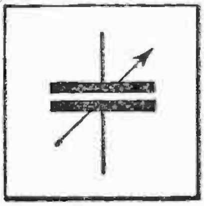

Fig. 6.

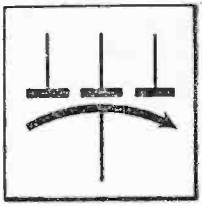

Fig. 7.

Multiple Variable Condensers

Fig. 7

Multiple section variable condensers employing two or more rotors attached to the same shaft are designated as shown, whereas several condensers consisting of individual stators and rotors which are connected to a common operating control, are designated as shown in figure 8. Whatever has been said about variable condensers is applicable to these units. In addition, it is essential that the capacity value for the same position of the rotors be alike for each condenser

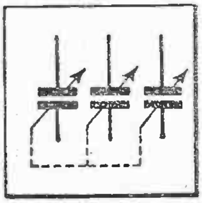

Fig. 8.

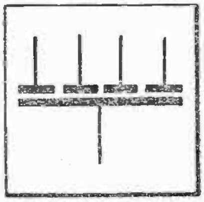

Fig. 9.

when the individual condensers are utilized to tune the various stages in a tuned radio frequency amplifier.

Condenser Block

Fig. 9

The condenser block employed in B eliminators, consisting of several sections with a common ground or a common terminal which makes connection with one of the active surfaces in each condenser unit, is designated as shown. A breakdown or a short circuit or a leak of one of the sections does not impair the operation of a remainder of the section and when this condition occurs, it is necessary to remove the defective section. This is accomplished by disconnecting the lead thereto. All such condensers possess definite voltage ratings, that is d. c. and a. c. operating voltage ratings. The application of excessive potential will puncture the dielectric and render the condensers unfit for further use. In this connection, it is necessary to mention the liquid type of electrolytic condenser which, while of different construction than the linen paper dielectric condenser, is designated in like manner but is self-healing when momentarily punctured by an excessive voltage.

Inductance

Fig. 10

Air core inductances or windings are shown in figure 10. This illustration

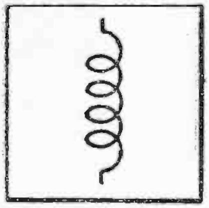

Fig. 11.

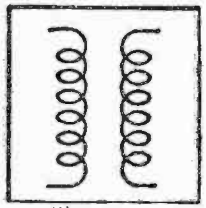

Fig. 10.

may designate a radio frequency choke or the inductance employed in a series or parallel resonant circuit. When indicated as shown, it means that the inductance value of the inductor is fixed and not variable. In view of the fact that the winding under normal conditions should be continuous, a d. c. continuity test should show continuous circuit through the winding. In the case of windings employed in two circuits, the d. c. resistance is very low, consequently the presence of the winding will not indicate high resistance. The possible faults in such units are excessive capacity between the turns, short-circuited turns and an open in the winding.

Radio Frequency Transformers

Fig. 11

Fixed radio frequency transformers and the primary and secondary inductances of tuned radio frequency transformers, are indicated as shown in figure 11, the difference between the two being the number of loops employed to designate the primary winding. If the turn ratio of the two windings is 1:1, the number of loops in the primary and secondary windings is usually the same. If the primary winding has less turns than the secondary, the number of loops employed to designate the primary is less than the number employed to designate the secondary. The fact that the symbol for the primary and secondary winding is similar to the symbol employed to designate an air core inductance, shows that both windings employ an air core. With respect to continuity, what was said about the individual inductor is applicable to the individual inductors constituting the transformer.

Variometer

Fig. 12

Continuously variable inductors are represented by two inductor symbols placed at right angles to each other. These units, like the previously mentioned inductors, are air core windings and are so shown. . . . With respect to continuity, continuous circuit should be available through the windings.

Tapped Inductor

Fig. 13

An inductor arranged with taps, or a slider whereby the amount of inductance may be varied, is designated as illustrated in Fig. 13. Circuit continuity should be available through the winding

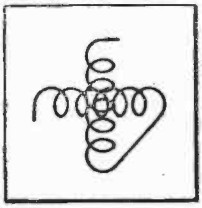

Fig. 13.

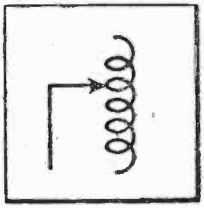

Fig. 12.

and through any part of the winding and the movable lever. Imperfect contact between the lever and the contact terminals, or the wire if the lever is a slider, will give rise to crackling and sputtering sounds in addition to wavering of the signal.

Audio Frequency Inductor

Fig. 14

Windings employed in audio frequency circuits make use of iron or some similar metal as a core and when designated the symbol for air core inductors is employed in conjuction with a number of parallel lines as shown. The presence of these lines indicates the use of a metallic core of some kind. The symbol shown is usually representative of an audio frequency choke employed as a filter choke, as a plate coupling inductor, or as a grid circuit inductor in resistance and impedance audio amplifiers. In view of the fact that the winding should be continuous, circuits should be continuous through the winding. However, audio frequency inductors consist of several thousand turns, hence the d. c. resistance is appreciable. In view of the fact that the core is frequently grounded and the winding is connected into a circuit which is not grounded, it is imperative that contact between any part of the winding and the core be non-existent.

Iron Core Transformer

Fig. 15

The conventional iron core transformer employs a symbol somewhat similar to a radio frequency transformer, but in this case the sign designating the iron core is located between the two windings as shown in figure 15. Whatever has been said about circuit continuity and contact between the winding and the core in the case of the audio frequency transformer. In addition, metallic contact between the primary and secondary windings should likewise be avoided. Possible troubles in such windings involve the application of excessive potential and current flow and consequent burnout. Frayed insulation be-

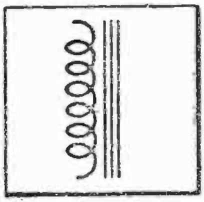

Fig. 14.

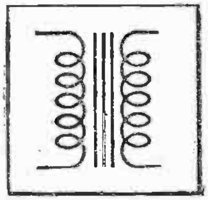

Fig. 15.

tween turns will cause arcing between turns and interference in the form of sputtering or frying sounds. Another condition to be avoided is excessive heat at the terminals when soldering, since this condition is apt to open the connection between the very fine wire employed for the windings and the terminal lug.

Push-Pull Audio Frequency Transformers

Fig. 16

The push-pull audio frequency transformer is very similar to the conventional type of transformer. The difference between the two is found in the physical structure of the push-pull unit. The push-pull transformer is designed for simultaneous operation with two tubes, hence the plate winding is designed for operation with two plates and has a midtap whereby the plate potential is applied to the plates of the tubes. The grid winding is likewise designed for simultaneous operation with two tubes, hence the grid winding has two grid leads and a midtap connection whereby the C bias is applied to the two grids. In some cases the transformer is designed to accommodate two tubes in the output and to operate from a single tube, as shown in the illustration. In other instances the primary winding is designed to operate with two

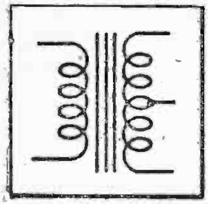

Fig. 16.

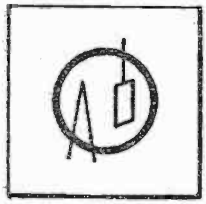

Fig. 17.

tubes and to feed into a single tube or into a speaker. Whatever has been said about circuit continuity for conventional transformers is applicable to the push-pull unit. The effects of overloading mentioned in the discussion of conventional transformers is applicable to push-pull units. In addition it is necessary to add excessive current flow through the primary winding and its effects upon the transformer core. Many new transformers employ alloy cores and the design of these cores is such that the d. c. plate current is definitely limited. Excessive plate current changes the characteristics of the transformers and impairs the operating efficiency. Push-pull transformers designated as "input" transformers employ windings as shown above. Push-pull transformers designated as "output" transformers employ windings which are the reverse of the illustration, that is, the primary has the two plate leads and the midtap. Inter-stage push-pull transformers employ two midtapped windings.

Half-Wave Rectifier

Fig. 17

The half-wave filament type of rectifier tube, typified by the 216B and the 281, is usually designated by means of a filament and a plate contained in a chamber. This is the designation for the conventional two element vacuum tube. Continuity testing of such devices is impossible and the possible faults will be mentioned in another paragraph. With respect to operation, the input a. c. voltage is definitely limited relative to the maximum potential, due to the physical structure of the tube. Excessive potential will cause breakdown of the structure separating the elements. In turn the minimum value is likewise limited in order to secure the rated current and voltage output values. Under the circumstances rectifier tubes cannot be employed in a haphazard manner, and with all transformers. In this connection the frequency of the line supply is of little consequence.

Full-Wave Rectifier Tube, Filament Type

Fig. 18

The full-wave rectifier tube employing a filament is usually designated by means of a filament and two rectangular plates representing the anodes. This tube is typified by the 280. The difference between the half-wave and the full-wave rectifier tubes with respect to results is that the current output of the full-wave tube is equal to approximately twice the current output of the half-wave rectifier. Relative to application, the half-wave transformer cannot be employed with the full-wave rectifier, unless one of the plates in the tube remains inactive since the design of the half-wave transformer plate winding is such that it accommodates but one plate.

Gaseous Rectifier
Fig. 19

The gaseous rectifier is represented by the Raytheon tube and does not employ a filament as the source of electrons. Instead, an inert gas, such as helium, is placed within the chamber and when acted upon by the applied alternating potential, supplied by the power transformer, creates the carriers necessary for current flow between the electrodes.

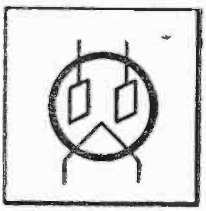

Fig. 18.

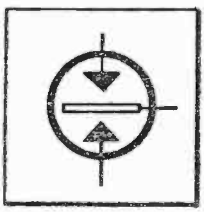

Fig. 19.

The two pyramid-shaped symbols are the anodes and are connected to the two filament terminals of the tube socket. The element between the two anodes is the cathode and is connected to the plate terminal of the tube socket. This tube is made as a full-wave rectifier.

Like the filament type of rectifier, this type has definite voltage limitations. Excessive potential will cause breakdown and insufficient potential will not afford the rated current and voltage output values. These tubes are made in two types, for use in B eliminators to supply B potential and for use in combination A and B eliminators where the current output is approximately 300 to 400 milliamperes and supplies filament current for series filament circuit arrangements.

Dry Rectifiers
Fig. 20

The "dry" rectifier frequently employed in place of the filament type or the gaseous type of rectifier utilizes electro-chemical elements, magnesium and cupric sulphide, to be exact. This type of rectifier employs discs of magnesium and cupric sulphide in contact with each other. The initial flow of current creates an oxide film, which units the electrodes to form a continuous conductor which has a high resistance to current flow from the magnesium to the cupric sulphide and a low resistance to current flow from the cupric sulphide to the magnesium. The magnesium is usually the electro-positive body and the cupric sulphide is usually the electro-negative body. A magnesium disc and a cupric sulphide disc constitutes a unit and a number of units in series are arranged for operation at certain potentials. Once again the operating voltage is limited in order to secure satisfactory operation. These units are arranged for operation as full-wave rectifiers.

Three Element Vacuum Tube
Fig. 21

The three element vacuum tube is undoubtedly well known to the reader, be-

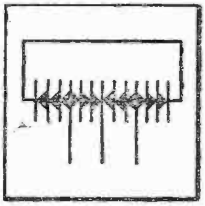

Fig. 20.

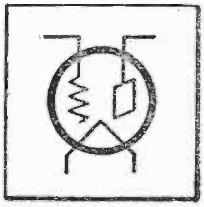

Fig. 21.

ing invariably designated as shown—a grid, a plate and a filament. The zigzag structure represents the grid, the rectangular structure the plate and the two sides of the pyramid structure the filament. However, such tubes are available in two types, although separate distinguishing designations are not shown. One type employes d. c. filament potential, and the other type employes a. c. filament potential. The basic difference between the two type of tubes lies in the structure of the filament. The basic difference between a. c. and d. c. tubes lies in the filament circuit, or rather in the circuit containing the source of electrons. In the conventional a. c. and d. c. tubes, the filament functions as the source of electrons.

Cathode Type Three Element A. C. Tube

Fig. 22

The difference between the conventional three element a. c. tube and the

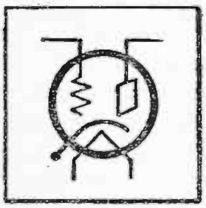

Fig. 22.

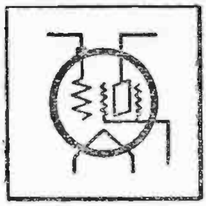

Fig. 23.

cathode type of a. c. tube becomes evident upon analysis of the designation symbols. The symbols for the cathode type of a. c. tube is very similar to that of the conventional three element tube, but the former has one variation, namely, the insertion of the designation indicating the cathode, an element surrounding the filament and heated to incandescence by the filament. Herein lies the difference between the tubes. Whereas in the conventional type of three element tube, the filament is the source of electrons, in the cathode type of a. c. tube the cathode is the source of electrons, and the filament functions as a heater element, whereby the cathode is heated to such temperature that it emits a satisfactory amount of electrons. Under the circumstances, the cathode is the B-return and the exact connection of this return is governed by the circuit wiring.

Screen Grid Tube

Fig. 23

The conventional type of d. c. screen grid tube is very similar in symbol form to the three element tube, with the exception that a screening grid is shown surrounding the plate. Consequently, the d. c. screen grid tube has four elements and five terminals, the control grid, the plate, the screen grid and two terminals for the filament. The utility of the tube is governed by the circuit connection. By this we mean that the circuit utility of the screen grid tube is not limited to one arrangement. When connected in one manner (to be shown later), the tube functions as a screen grid amplifier, and the advantage of a high amplification constant may be secured. When connected in another manner (to be shown later), the tube is utilized as a space charge tube and finds application in audio frequency amplifier circuits.

Cathode Type A. C. Screen Grid Tube

Fig. 24

The cathode type of a. c. screen grid tube bears the same relation to the d. c. screen grid tube as the cathode type a. c. three element tube does to the d. c. type of three element tube. With the exception of the use of the cathode the a. c. screen grid tube is practically identical in structure to the d. c. type of tube and similar in symbol, with the addition of the symbol designating the cathode. In the symbol for the screen grid tube, the small protuberance atop the tube bulb indicates the position of a similar structure atop the tube bulb, and is the connecting terminal for the control grid. This condition is the reverse of the conventional three element tube, where the control grid connects to the grid terminal of the tube socket.

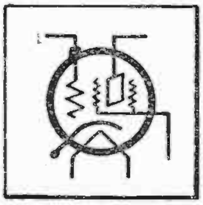

Fig. 24.

Continuity tests are not applicable to vacuum tubes, and electrical condition is usually indicated by the value of electronic emission.

Voltage Regulator Tubes

Figs. 25 and 26

Voltage regulator tubes find application in B battery eliminators to maintain constant potential at certain taps. The principle of operation involves a variable voltage drop across the tube, which reacts upon the associated portion of the voltage divider system network and maintains a constant drop over a predetermined current load range. As such the tubes require a definite amount of current for operation, and this amount of current must be taken into consideration when the eliminator is designed. If the eliminator current output is insufficient, the application of the voltage regulator tube will cause an appreciable drop in output voltage. This tube functions to a certain extent like a large capacity, the average tube being the equivalent of about 20 to 30 mfds. and creates beneficial effects with respect to the elimination of motor boating.

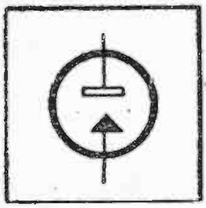

Fig. 25.

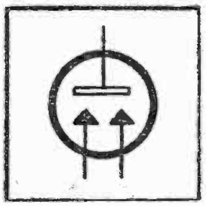

Fig. 26.

Telephone Jacks

Fig. 27

Jacks of various kinds find application where connection is to be made to various circuits by the application of a plug, or where the insertion of a plug into a jack is designed to simultaneously control one or more circuits. An example of this is the jack usually employed to permit connection of the phonograph pickup to the receiver audio amplifier and simultaneous disconnection of other sections of the receiver; also the use of head sets with the various audio stages in the receiver. Continuity testing is possible with all types of jacks, and continuous circuit should be secured between any two contacts arranged to provide a complete circuit. However, this circuit should show an open when contact between the prongs is broken. If the tester shows a complete circuit between two such open contacts, it is an indication of a short between the two contacts through the insulation. Such jacks should be replaced. Leakage through the insulation will cause frying and sputtering sounds.

Head Set

Fig. 28

Closely allied with the jack is the telephone head set, usually consisting of a pair of phones, series connected. Continuity testing is possible with such devices, but in view of the fact that the d. c. resistance of the windings is usually high, the meter indication will be low, showing the presence of a high amount of resistance, about 2,000 ohms for each phone, or about 4,000 ohms for a complete headset. Rupture of the windings is possible by the application of excessive potential and the flow of an excessive amount of current. Noisy operation may be due to electrolysis of the cords and to imperfect contact between connected terminals. Loose diaphragms cause discordant speech and music.

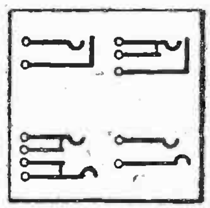

Fig. 27.

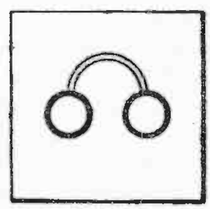

Fig. 28.

Crystal Detector

Fig. 29

The crystal detector, while seldom used in commercial receivers, is still employed in certain experimental circuits. Its function is somewhat similar to the "dry" rectifier, in that it possesses the property of unilateral conductivity, passing current more readily in one direction

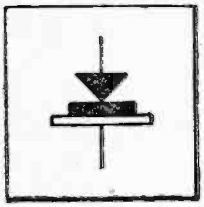

Fig. 29.

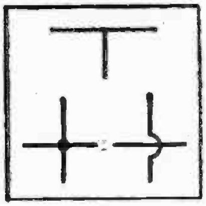

Fig. 30.

than in another. In contrast to the detector of the vacuum tube (three element) the crystal is very much less sensitive, but, on the other hand, does not possess the background noise characteristics found with the vacuum tube.

Wiring

Fig. 30

While wiring is a simple operation, many individuals are confused when checking wiring diagrams by the methods employed to show connection and no connection between crossing leads. The discrimination is a matter of wiring structure; that is to say, that in certain wiring diagrams, connected wires are accompanied by a dot at the point of contact. In such arrangements unconnected wires cross each other without any loop and without a dot. Where con-

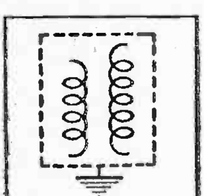

Fig. 31.

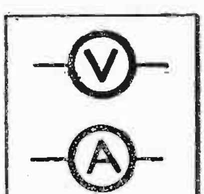

Fig. 32.

nected wires are shown without the dot, unconnected wires cross each other with a loop. Imperfect contacts or imperfect connections give rise to varying effects, among which are varying potential, fluctuating current, scraping and crackling sounds, etc.

Shielding

Fig. 31

Shielded units, or rather the shielding element, is usually designated by a dashed or dotted line surrounding the unit to be shielded and the shield connected to ground. The same symbol is used to indicate a case around an audio coupling unit. Grounding of the shield is necessary, if the desired effect is to be obtained. An imperfect ground connection to the shield or the case will give rise to crackling and sputtering sounds.

Voltmeters

Fig. 32

Electrical measuring devices are usually indicated by a circle, with the utility designation marked within the circle, such as V for voltmeter, A for ammeter and MA for milliammeter. The type of instrument involved is of little consequence. By this we mean whether it is an a. c. or a d. c. instrument. Perfect connection to voltmeters is necessary if accurate, unfluctuating voltage indication is to be obtained. Voltmeters are usually connected across a circuit in order to measure the potential across the circuit. Current meters, on the other hand, are connected in series in order to measure the current flow through the circuit. Perfect connection is therefore imperative in order that the current flow through the circuit be unimpaired. The operating range of all meters is limited, but may be extended by the use of proper resistances.

Phonograph Pickups

Fig. 33

Phonograph pickups of the magnetic type are usually indicated by an arrow passing through an air core inductance. Relative to such devices, we can mention but few points. First, that the moving elements must be in perfect alignment, otherwise the music will be distorted. Second, that the coupling unit attached to the pickup must be of the proper type, if satisfactory frequency transfer (music from record) is to be secured. Continuity through the coils in the pickup is possible, but these are seldom damaged.

Battery

Fig. 34

Batteries are usually indicated by means of a number of parallel heavy and light lines, with plus and minus indications, to show the polarity. It is, however, customary to make the light line positive and the heavy, shorter line negative. This symbol is employed for all types of batteries. The condition of batteries is determined by measuring the voltage under load, since the open circuit voltage (no load upon the battery) is invariably higher than the voltage under load. The magnitude of load or current drain placed upon the battery is governed by the type of battery and its utility.

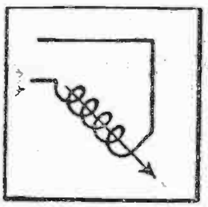

Fig. 33.

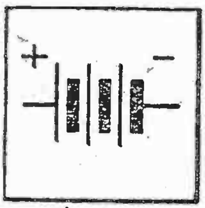

Fig. 34.

Lamp Socket Plug

Fig. 35

The a. c. receiver introduced the lamp socket plug into conventional receiver wiring. Imperfect connection between the plug and the plug receptacle shown in figure 35 is the cause for low line voltage and voltage fluctuation. If subject to vibration, the voltage fluctuation is usually accompanied by sputtering and crackling sounds. Continuity tests should show an open between the two contacts, when the plug is disconnected from all other elements. When connected to a transformer primary, test across these two contacts should show a complete circuit. If continuity is secured when the plug is tested and it is not connected to a circuit or a unit which provides a path for current, that plug is shorted and is defective. If placed into a live plug receptable, it will short circuit the line.

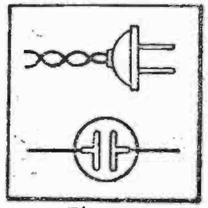

Fig. 35.

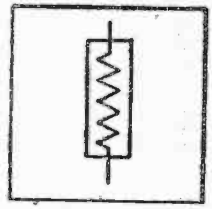

Fig. 36.

Filament Ballast

Fig. 36

Automatic filament ballasts are shown or indicated by a resistance contained within a rectangle. When of this type, they consist of an element which increases in resistance as the applied potential increases and the current flow is increased. This action makes possible automatic filament control. The unit is also used to control line voltage. In this respect and in connection with filament circuits, it is usually designed to be operated with a definite minimum voltage, since, after all is said and done, it possesses a definite minimum resistance.

Lightning Arresters

Fig. 37

Lightning arresters are shown by means of two-non-meeting lines within a rectangle, or sometimes with three pyramid-shaped non-connecting elements. The space between the various elements is very small and the unit is provided to allow an easy path for a lightning

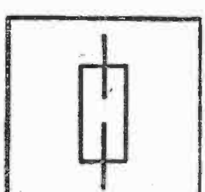

Fig. 37.

discharge in the event that a heavy voltage from such a bolt is induced in the aerial system. The usual arrangement provides for one connection to the aerial and the other to the ground. It is obvious that a short within the lightning arrester will short the aerial, and a high resistance leak in the arrester will impair the operating efficiency of the aerial system.

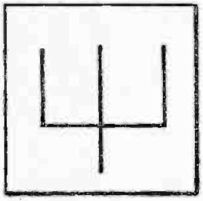

Fig. 38.

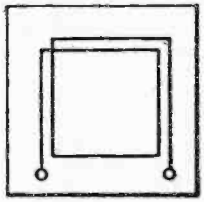

Fig. 39.

Aerials
Fig. 38

Outdoor elevated aerials and indoor aerials of all but the loop type are shown by means of two or three parallel lines, connected at one end. The significant facts about aerials will be discussed in greater detail in the section devoted to aerials and aerial troubles.

Loop Aerials
Fig. 39

Loop aerials are designated by means of a box-shaped structure with two open terminals. They are discussed at greater length in the section devoted to aerials.

Ground
Fig. 40

The ground designation is a series of parallel lines arranged in an inverted pyramid fashion. This subject, like aerials and loops, will be considered at greater length later.

Neon Lamp
Fig. 41

The introduction of television equipment heralded the neon lamp usually symbolized by two rectanguler structures within a circle. This tube consists of a chamber evacuated of all air, and into which has been introduced neon gas. When acted upon by a potential, a glow is caused within the tube by ionization of the molecules of gas. The gas, being free from lag, responds to all frequencies and to all values of potential greater than the ionizing potential. If the applied potential is reduced below this value, the glow ceases.

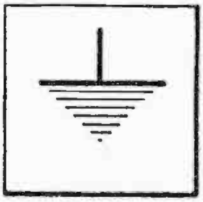

Fig. 40.

Photoelectric Cell
Fig. 42

The conventional type of photoelectric cell usually consist of a chamber, with the inside wall coated with a chemical and a collector ring located within the tube. One portion of the bulb remains uncoated and admits the light rays. The chemical coating possesses the characteristic of emitting electrons when light is impinged upon it, and these electrons are collected by the collector ring. This flow of electrons gives rise to a voltage across whatever circuit or element may be connected across the two elements of the cell. In order to facilitate operation, a polarizing potential is applied.

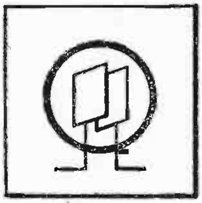

Fig. 41.

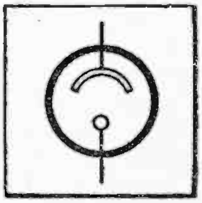

Fig. 42.

TROUBLES IN AERIAL SYSTEMS

Our interest does not lie with the perfect or well-constructed aerial. We are primarily interested in what takes place when an aerial is incorrectly erected or when the construction is such that trouble is present in the aerial system. Unfortunately aerial troubles do not remain in the aerial, but transmit their effects to the remainder of the receiver installation. As such we are obliged to consider these effects.

To expedite comprehension, we will discuss the subject individually and later coördinate the data in a cross index, when considering symptoms and troubles and remedies. Peculiar as it may seem, aerial length is really limited; that is, if satisfactory results are to be secured with conventional radio receivers and in this country of ours. This statement is made, because the design of the modern radio receiver is governed by the status of the air, hence the number of broadcasting stations operating and their power rating influences aerial length. Conventional practice ordains the use of an aerial with an overall length between 100 and 150 feet. We should not say conventional practice, rather conventional design of radio receivers makes this stipulation. Insufficient length reduces signal intensity by minimizing the voltage induced into the aerial system. Excessive length, on the other hand, impairs selectivity by permitting excessive signal voltage, since selectivity is a function of the signal voltage in the circuit. From the above we can deduce that shortening an aerial will increase the selectivity powers of a radio receiver, and that an excessive length may, on the other hand, be the cause of poor or unsatisfactory selectivity.

In connection with the above, it is necessary to consider two additional factors, namely, location, with respect to the receiving conditions in the neighborhood and the type of unsatisfactory reception. If the point of reception is such that only one station interferes and selectivity is poor on this station because of its excessive signal strength, reduction of the aerial size will help. However, if all stations are poorly received, the trouble may not be aerial length. . . . An examination of the tuning system is in order and an examination of the complete antenna system is in order, for short circuits, leaks, etc., instead of for aerial length. Before reducing the length consider the above, since every reduction in length impairs reception of the weak stations, the signals from which may be greatly desired. A simple test for a shortened aerial or a leak to ground may be made with the continuity tester. Disconnect the aerial and the ground terminals from the receiver, as shown by the points X and XI in figure 43, and connect the voltmeter-battery combination across the aerial and ground. If the aerial is grounded or if a leak between the aerial and ground exists anywhere in the circuit, the voltmeter will

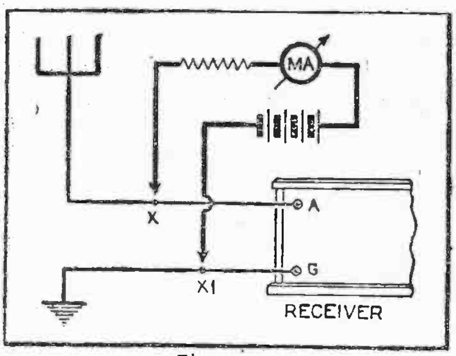

Fig. 43.

show an indication. Full voltage deflection shows a complete short or ground. Partial voltage deflection indicates a leak. It is necessary to remember that reception is possible with a shorted or leaky antenna system if the wires are of sufficient length.

A leak between the aerial and ground will cause general lack of selectivity and low signal strength. In connection with these two factors, we must mention certain conditions which indicate circuit conditions. If the aerial system is at fault for some reason or other and is the cause of poor selectivity, insufficient selecting power will be found on all wavelengths. If, however, lack of selectivity is present on only one or two stations or wavelengths, the aerial cannot be classed as to blame. Instead, it is a matter of local conditions. We must qualify the foregoing to a certain extent.

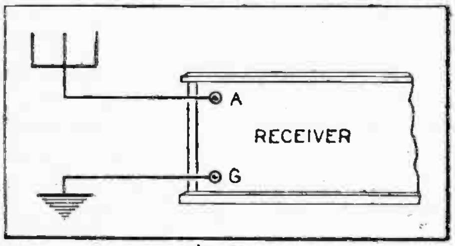

Fig. 44.

In some cases selectivity is lacking over a certain waveband, rather than a certain number of wavelengths. In this case, the aerial system *may* be at fault, but investigation of the tuning system is in order.

To reduce the effective length of an aerial it is not necessary to reduce the physical length. The introduction of a series capacity of say .0001 or .00015 mfd. will do the trick. The arrangement is shown in Figs. *44* and *45*. Shorted aerials may be due to shorted lightning arresters, damaged insulators separating the aerial from the supporting medium, frayed leadin insulation at the point where the leadin enters the house or

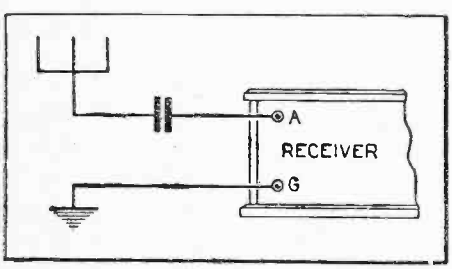

Fig. 45.

home, contact between the leadin and some grounded object, etc. In this connection momentary grounds of any nature will give rise to crackling and sputtering forms of disturbance, hence the aerial system, without any outside influence, is a source of electrical disturbance.

Fading of the signal is a characteristic of aerials which are not rigidly erected, and will sway in the wind. This movement increases the possibility of contact with other aerial systems or grounded objects and increases the possibility of various forms of electrical disturbance.

The location of the aerial governs to a large extent the electrical efficiency and receiver signal strength; the more advantageous the location, the greater the signal strength. Hence, the best location should be sought. The aerial should not be parallel to power lines, unless the distance is appreciable, at least 100 feet or more. Wherever possible it should not be in the shadow of tall structures. By this we mean that a tall structure (in the immediate locality) should not be interposed between the transmitter and the aerial. Lack of signal strength may be due to the position of the leadin wire. Common practice ordains that this wire run down the outside walls of buildings. This is satisfactory providing that the wire is not adjacent to a parallel steel beam. Experiments along this line have shown a signal reduction of as much as 40%. Wherever possible the aerial and the leadin should be removed from large metal masses. Whatever has been said about the effect of aerials upon signal intensity should be borne in mind when distant stations cannot be received, or when receiver sensitivity appears to be low. In this connection, certain localities are poorly situated for radio reception, and this fact may be checked by communication with a neighbor.

Imperfect contact between the leadin and the aerial system will cause crackling, will reduce signal intensity and if this contact is of such nature that it is intermittently made and broken, sputtering sounds will be heard.

The ground displays an effect upon signal intensity and to a certain extent upon receiver selectivity. In this connection, the better the ground, the better the signal strength and selectivity, everything else being normal. Poor grounds or poor ground connections reduce signal strength and decrease selectivity. Imperfect contacts to ground if of such nature that make and break contacts will give rise to crackling and sputtering sounds. This is particularly true in electric receivers.

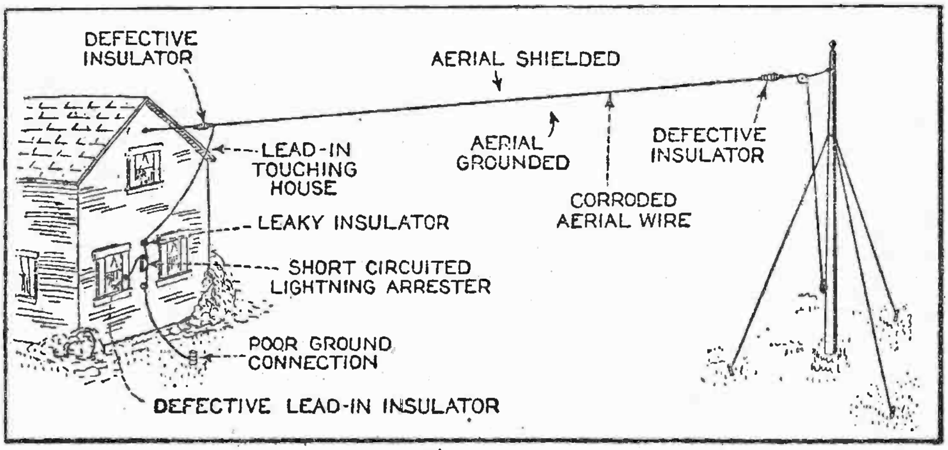

Fig. 46.

The insulation of an indoor aerial is of extreme importance. At this time we refer to the type of aerial used inside the house, exclusive of the loop. Care must be exercised to see that the aerial is well insulated from all ground objects, and that tacks or nails employed to fasten the aerial to the wall or moulding do not come in contact with the aerial wire. The location of this aerial will influence receiver sensitivity and wherever possible location near steel beams or masses of metal should be avoided. Experiment will show the best location with respect to sensitivity and directional properties. The test recommended to determine a good outdoor aerial is applicable to the indoor aerial as well.

The possible defects in an outdoor aerial system are shown in figure 46.

RADIO FREQUENCY AMPLIFIERS

In order to satisfactorily discuss radio frequency amplifiers, it is necessary to differentiate between battery operated units and electric units; that is, radio frequency amplifiers employing batteries as the sources of operating potential and radio frequency amplifiers employing the house supply as the source of operating potential.

Strange as it may seem, the possible troubles in radio frequency amplifiers are not as numerous as one is wont to imagine. In this discussion we will dwell upon the possible troubles. Diagnosis of trouble by the application of set testers will follow later.

It is needless to stress the fact that the radio frequency portion of every radio receiver governs the tuning and the selective powers of the receiver. Under the circumstances, the radio frequency section displays an influence upon the signal strength passed into the detector and into the audio frequency amplifier systems. Generally speaking, radio frequency amplifiers are of two types, tuned transformer and untuned transformer coupled. The tuned transformer coupled is the conventional type known as a tuned radio frequency amplifier, whereas the untuned transformer coupled is the type wherein radio frequency transformers are employed. In some instances, such transformers are utilized in conjunction with a multistage band pass filter.

Recognizing the fact that vacuum tubes are employed in the system, we cannot help but realize that the degree of amplification secured will display an effect upon signal strength, hence in addition to the tuning units we must needs consider the vaccuum tube. Starting with the tuning units, lack of resonance between various stages supposedly tuned to the same wavelength will cause low response and broad tuning, since the cumulative effect of a number of differently tuned circuits is to cover a waveband much wider than is normal. However, if broad tuning is experienced on only one wavelength, the trouble is not in the receiver, but in the locality—the field strength of that interfering station is excessive in that locality.

Low response may be due to other causes as well and, fortunately, it is possible to discriminate between low signal response due to broad tuning and low signal response due to causes to be mentioned. Referring again to broad tuning, a sign of lack of resonance is broad tuning over a certain waveband and satisfactory tuning over another waveband or over a certain portion of the dial.

The difference in signal strength, when the trouble is lack of resonance and when a defect is present in the tuning units is very marked . . . The strength during the latter condition is very much less, and the possible defects are an open secondary winding, a shorted tuning condenser, or a shorted secondary winding. The continuity tester finds application to discover these faults. In addition we must consider an open grid suppressor resistance. An open in the secondary circuit, as mentioned, does not display the effects found when an open is present in the plate or primary circuits, such as an open in the primary winding of the radio frequency transformer. In this case the receiver goes dead, since the tube associated with the open primary does not receive plate potential, hence is inoperative. An open grid circuit will not cause total disability, but an open plate circuit will stop receiver operation. A short by-pass

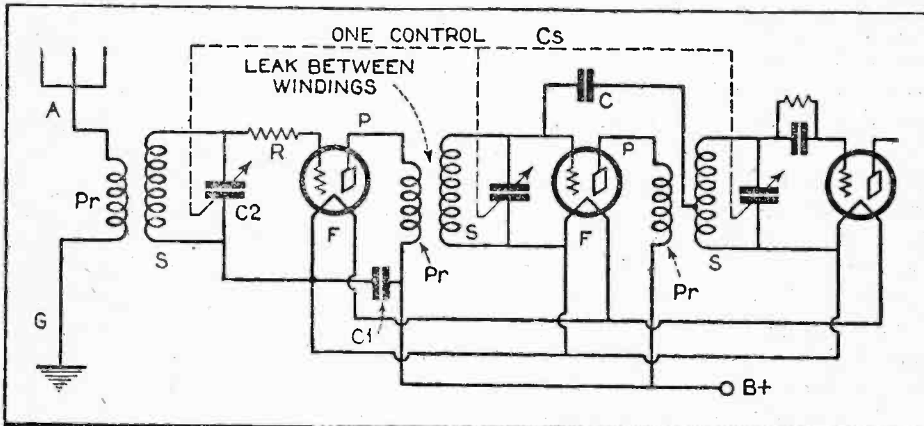

Fig. 47.

R—Open or shorted grid suppressor resistances. C—Open or shorted neutralizing condenser. CS—Tuning condenser out of synchrom—lack of resonance. B+—Insufficient or excessive plate potential. P—Open or shorted plate circuit. C1—Shorted plate bypass condensers. F—Insufficient or excessive filament potential. A-G—Grounded aerial. C2—Shorted or open tuning condensers. PV—Open or shorted primaries. S—Open or shorted secondaries.

condenser so located that it shorts the plate potential will invariably cause the same effect. What has been said about open primary and secondary circuits is applicable to the tuned as well as the untuned types of radio frequency transformers.

Open circuit in the grid and plate circuits are not limited to the radio frequency coupling units, but may be found in the leads supplying the operating potentials and the reaction will be the same. In other words, if the lead connecting the filament side of the transformer secondary and the grid bias resistance or the source of grid potential is open, it is the equivalent of an open secondary, with respect to effect, although the continuity tester will show the position of the break to be different. The same is true with respect to a break in the plate supply lead.

The principles underlying the operation of the vaccuum tube state that if the grid potential is positive and of sufficient magnitude, the plate current in the tube will reach such value that the tube will be inoperative. This brings up the subject of leaks between the primary and secondary windings of radio frequency transformers and shorted grid condensers in tuned plate circuits. These conditions are illustrated in figure 47. *Once again the continuity tester finds application to determine a short or leak between the primary and secondary windings and a short or leak in the grid condenser.*

Excessive regeneration or oscillation in radio frequency amplifiers is a frequent complaint. The possible reasons are numerous. First is the application of excessive plate potential. Second, is coupling between the various radio frequency transformers. Third, is the omission of by-pass condensers in the plate circuits of the radio frequency amplifiers. Fourth, is a defective or shorted grid suppressor resistance. Fifth, is incorrect or insufficient neutralization, due to wrong adjustment of the neutralizing condenser or an open in the neutralizing condenser circuit. Lack of ground or aerial.

Sputtering and crackling sounds find origin in the radio frequency amplifier and the causes include loose connections, corroded contacts, dirty terminals, defective batteries, defective by-pass, condensers, etc. . . . In this connection we must mention that such disturbances when carried in by the aerial will pass through the radio frequency amplifier and be passed to the detector and audio systems. Isolation of the location of the fault may be made by removing the aerial and noting the effect and by removing the various radio frequency amplifier tubes and noting the effect.

Low signal level and sensitivity may be due to defective tubes, deactivated filaments, incorrect polarity of grid bias, insufficient plate potential and insufficient filament potential, and incorrect connection of the transformers.

DETECTOR SYSTEMS

Detector systems *(Fig. 48-48A)* are quite interesting. Detector sensitivity is a function of the tube and operating potentials and circuit conditions. In the grid leak and condenser system, we find

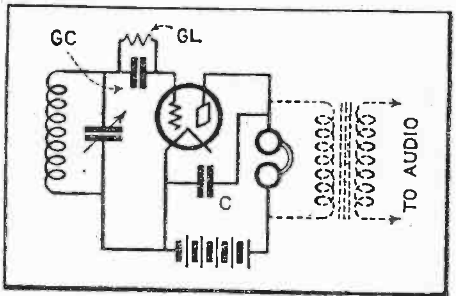

Fig. 48.
GL—Grid leak. GC—Grid condenser. C—Bypass condenser.

that the value of the grid leak plays a very important role in connection with the sensitivity and the ease of regeneration if the detector circuit is regenerative. . . . The higher the value of the grid leak, the greater the sensitivity and, conversely, the lower the value of the grid leak the less the sensitivity. The value of the grid condenser may be left at .00025 mfd. without detailed consideration of the effect. General receiver operation does not require detailed analysis of this value.

The by-pass condenser in the plate circuit likewise influences sensitivity of the system and has a great effect upon regeneration. In many instances, particularly with resistance coupling, or when low ratio audio frequency transformers are employed, the plate circuit by-pass condenser is imperative in order that satisfactory regeneration be secured.

The value of plate potential is likewise of importance, influencing sensitivity and operation. If too low, sensitivity is poor. The same is true of the filament potential.

Defective batteries will cause very bad effects when associated with detector tubes, and reception will be very noisy. The same is true of the grid leak. Particular care must be exercised to choose good grid leaks if background noises are to be avoided. During the operation of the detector, a certain amount of grid current flows through this resistance and unless the unit is capable of passing this current, normal

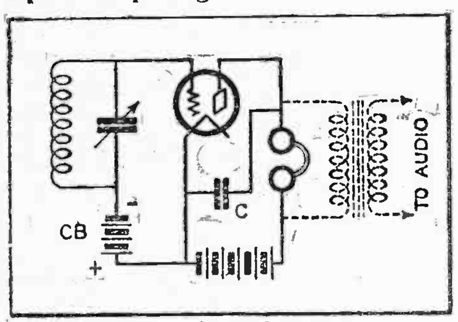

Fig. 48A
CB—C battery. C—Bypass condenser.

reception will be accompanied by a hissing or frying sound. The grid bias applied to grid-leak condenser detectors is critical and constitutes the difference between satisfactory and unsatisfactory sensitivity.

The grid bias system of detection is finding favor because of the ability to handle greater input than the grid leak and condenser arrangement. However, it is less sensitive. Here, too, the value of the grid bias plays a very important rôle, as does the polarity of the bias. Incorrect polarity will cause a marked reduction in receiver sensitivity and signal output, also an effect upon the quality of the audio output.

With respect to faults in detector systems, a short by-pass condenser will greatly decrease detector sensitivity, if not stop operation. An open in the grid circuit will cause a hum, sometimes a howl, and an open in the plate circuit will likewise cause a hum. An open in the grid leak will cause intermittent operation, with a wavering of signal intensity and distorted signals. Fluctuating operating potentials will likewise cause a wavering of signal intensity.

Imperfect contacts anywhere in the system, at the socket terminals, prongs, in the rheostat, grid coil, grid condenser or the tuning condenser will cause very disagreeable crackling and sputtering noises.

Excessive coupling between the plate and grid coils will cause disagreeable regeneration. Coupling between the grid or plate wires and a nearby power circuit will cause a bad hum in the receiver. Coupling between the detector system and the radio frequency amplifier parts will cause excessive regeneration and uncontrollable oscillation, greatly interfering with reception and impairing the quality of the music and speech being received.

AUDIO FREQUENCY AMPLIFIERS

The problems associated with audio frequency amplifiers (*Fig. 49, 50, 51 and 52*) are much more numerous because of the character of work involved. Here we are confronted with frequencies within the audio range, or within the response range of the average ear. Hence any disturbances, with a frequency within this band, is amplified in the system and made audible.

that promiscuous application of plate potential is to be avoided and that some of the "static" may be due to conditions in the audio system.

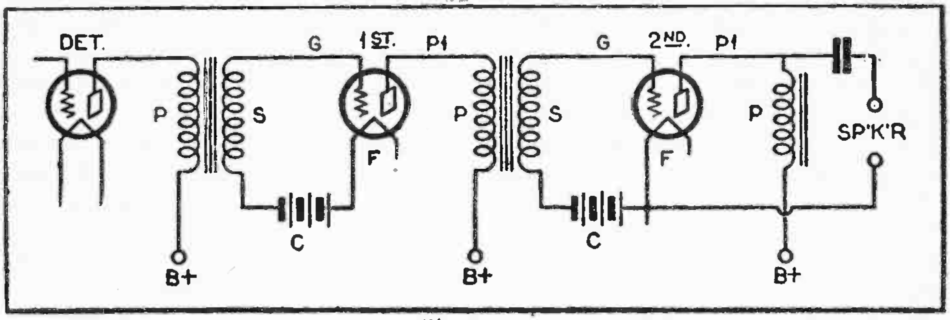

Fig. 49.

P1—Open or partially shorted plate circuit units. S—Open or shorted secondaries. P1—Noisy primaries. C—No-insufficient or excessive C bias. C—Wrong polarity of C bias. F—Open filament circuit. F—Insufficient or excessive filament potential. B—Insufficient or excessive plate potential. P1—Open plate circuits. P-S—Reversed primary and secondary connections. P-S—Leak between primary and secondary windings and core. B+—Reversed B battery. C—Open grid circuits. 1st-2nd—Defective or deactivated vacuum tubes.

Regardless of the type of audio frequency amplifier involved, of which there are three, transformer, resistance and tuned double impedance, the same items associated with trouble are applicable. We made mention that excessive current flow through a resistance or through the winding of an audio fre-

It is not our purpose to recommend a system of audio frequency amplification. As far as we are involved the reader may employ any system he desires and sees fit. What we are interested in is the possible fault in the system. Hum is a frequent complaint and its source is oftimes the audio frequency

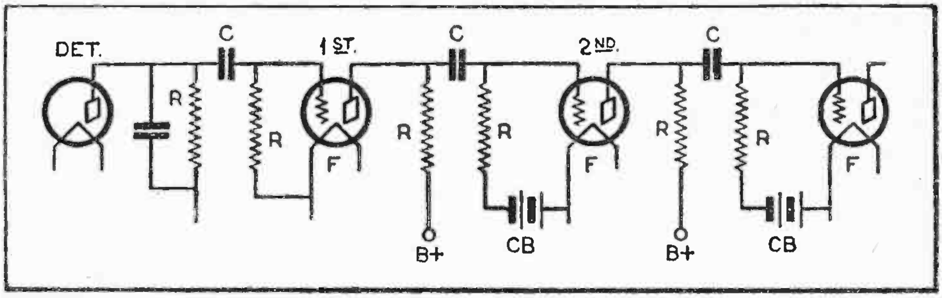

Fig. 50.

C—Leaking or shorted isolating capacity. R—Defective-noisy-open-shorted resistances. IF—Excessive or insufficient filament potential. CB—Incorrect, insufficient-excessive or no C bias. 1st-2nd—Defective or deactivated tubes. B —Wrong polarity, insufficient or evcessive plate potential.

quency transformer may cause deterioration of the element, and during that process gives rise to sputtering and crackling sounds. This condition is found in audio frequency amplifiers and every precaution must be exercised to eliminate it or prevent it. This means

amplifier. An open grid circuit will cause a hum. An open detector plate circuit, equivalent to the input circuit of the audio amplifier, will give rise to a hum. Induction from a power supply unit into the audio amplifier coupling units will give rise to a hum independent of reception of the signal.

With respect to distortion, the possible sources are many. First is the tube itself. A defective tube will cause this effect. Incorrect grid bias potential will do likewise. Incorrect polarity of the grid bias potential will cause distortion. Insufficient plate voltage will also produce this effect. The same is true of insufficient filament potential. In this connection, the action of the filament voltage of vaccuum tubes employed as audio amplifiers produces effects distinctly different from the effects found in radio frequency amplifiers.

The exact pitch of this signal is governed by the electrical constants of the chokes or transformers in the circuits.

Referring to transformer coupled audio amplifiers, certain forms of distortion and certain effects upon signal strength may be attributed to incorrect connection of the audio coupling transformers. That is to say, the connection of the transformers to the vaccuum tubes is not according to the transformer designations. Lack of signal strength may be due to insufficient operating voltages and to deactivated tubes or defective tubes.

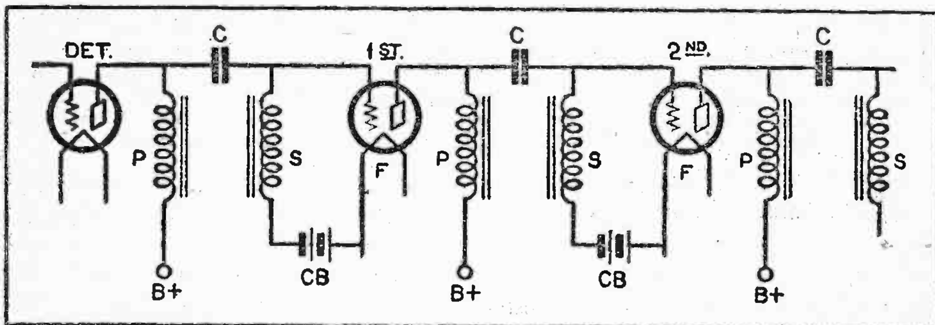

Fig. 51.

C—Leaky or shorted coupling capacity. P—Defective or open plate choke. S—Defective or open grid choke. F—Excessive or insufficient filament potential. B —Excessive or insufficient plate potential. CB—Incorrect polarity-insufficient or excessive or no C bias. 1st-2nd—Defective or deactivated tubes.

A certain form of distortion is due to excessive regeneration in the system. This result may be due to coupling between the various stages in the system and is found in resistance coupled audio amplifiers as well as in transformer and impedance coupled units, since in many cases the coupling exists between leads rather than between the audio coupling units. Distortion due to this condition manifests itself by great exaggeration of certain frequencies or the cutoff of some of the high frequencies. The loss of high frequencies does not affect the power in a signal, but does impair articulation when speech is involved. If the degree of regeneration reaches a certain value, continuous oscillation will be generated in the system and a definite whistle or howl will be encountered.

The type of tube employed in the audio frequency amplifier is governed by the electrical structure of the amplifier and the suitability of the tube in question to the coupling units in use. By this we mean that a high mu tube, because of its electrical design, is not suited for use with a transformer. The same applies to the screen grid tube. The type of volume control employed in audio systems must be selected with care if distortion is to be avoided. Certain circuit arrangements are conducive to distortion of the signal being passed through the amplifier while the volume is being adjusted. It is common practice to control volume in the audio frequency amplifier by employing a variable resistance across one of the transformer secondaries. This method is satisfactory in battery or eliminator operated receivers, providing that the volume control resistance is of a certain type. If it is of the potentiometer type with the movable lever connected to the grid of

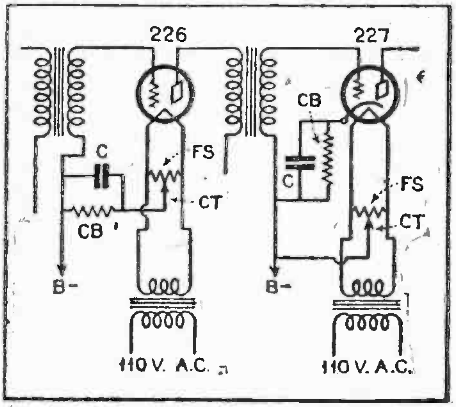

Fig. 52.
F.S.—Incorrect adjustment or open in filament shunt resistance. CB—Open or incorrect grid bias voltage resistance. C—Open or shorted bypass condenser. CT—Open center tap.

the tube, everything will be satisfactory. If, however, it is of the regular rheostat type, then every adjustment of the volume control will change the operating characteristic of the transformer connected to that volume control resistance.

Much greater care must be exercised in a. c. audio frequency amplifiers because of the characteristic of the filament voltage supply. The hum in the power supply line may be passed through the average well-designed audio frequency amplifier, hence if any of this hum finds its way into the audio system it will be amplified and be passed on to the speaker.

Closely allied with the a. c. audio amplifier is the B power supply system. If this system is not of excellent design, much trouble will be experienced. Hum may be passed to the plates of the audio amplifier as a component of the d. c. potential secured from the power supply. Another possible fault is excessive regeneration due to the condition existing in the power supply unit. If the bypass condensers connected across the voltage divider resistance are not of the proper type or properly connected a section of the voltage divider resistance network will function like a coupling resistance in the plate circuits of several audio tubes and increase regeneration by means of coupling through this resistance.

A-ELIMINATORS AND THEIR FAULTS

Despite the popularity of the a. c. tube and the a. c. receiver, the A battery eliminator (*Fig. 53*) is still a very popular device and many thousand units are in use. In this device a rectifying medium is employed to rectify the alternating input voltage and to supply a pulsating d. c. output. This pulsating voltage is then filtered and smoothed out so that the output is d. c. with very little a. c. component.

Under the circumstances, these devices possess certain characteristics. Due to the structure of the rectifying system, the voltage output is not constant. Not that it fluctuates when adjustment for any one voltage is made, but that the voltage output is a function of the current drain imposed upon the eliminator. Hence this unit has a definite voltage regulation curve. . . . As it happens the characteristic of the device is such that the output voltage decreases as the current load is increased, and, conversely, the output voltage increases as the current drain is decreased.

According to the above, the unit cannot be employed in a haphazard manner. By this we mean that whatever adjustment is provided for the purpose, the output voltage of the device must be adjusted for the correct amount of current drain. If the drain is insufficient, the voltage applied to the filaments of the tubes will be in excess of the rated value and there will be danger of a burnout. If, on the other hand, the current drain is greater than that provided by the adjustment, the voltage applied to the filaments will be less than the rated value and the results obtained will be of the type occasioned by insufficient filament potential.

Another significant fact associated with the A eliminator is that its maximum voltage and current values are definitely limited. If the current drain is in excess of the rated value, the operation of the entire unit will be impaired. One of the most frequent faults due to such load is excessive hum in the output. The reason for this is that the rectifier is being overloaded and hence cannot perform the rectifying action in the proper manner. Another possible reason for the hum is that when the current drain is excessive, the current flow through the filter chokes will be in excess of the rated value; harmonics will be generated in the choke coils and the filtering action will be seriously impaired.

The design of the A eliminator calls for the use of very high values of filter capacity and low values of filter inductance. The use of 3,000 to 5,000 mfd. of capacity is quite frequent. The usual value of inductance employed in the filter system is approximately .1 to .3 henrys. As it happens, these filter condensers are of the chemical type and unless of excellent design will deteriorate after a while, and impair the filtering action, so that the final effect is excessive hum in the output d. c. voltage and excessive hum in the receiver output. One of the effects of deterioration is the reduction in the capacity of the condensers. Such defective condensers may be the cause for sputtering and frying sounds, which are passed into the receiver via the filament system. Such conditions are quite frequent and are puzzling because of the excellent performance of the complete eliminator for a certain period.

A defect in the rectifying unit will cause a marked reduction in the current and voltage output, the voltage drop per 10 milliampere drain being abnormal. Such a defective element will likewise give rise to various electrical disturbances, such as crackling and sputtering sounds.

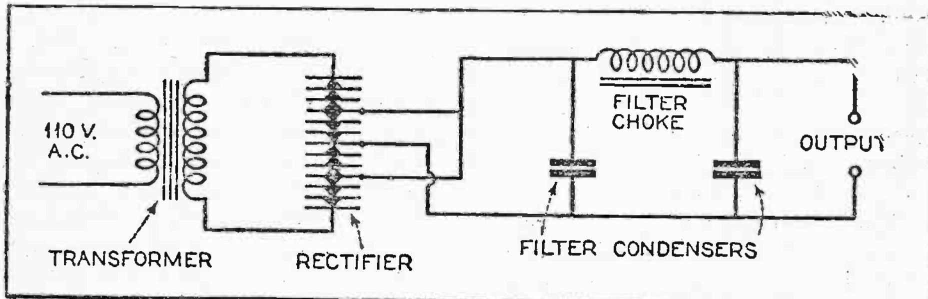

Fig. 53.

B BATTERY ELIMINATORS AND THEIR FAULTS

B battery eliminators find application in all types of receivers and millions of these units are in use. In structure all are practically alike, the greater difference being found in the type of rectifying element employed and the electrical connection of these elements. In connection with the types of rectifying devices, we tabulated the three popular types in the section devoted to the symbols designating the various units employed in radio receivers.

It is difficult to choose between the various types of rectifying elements and to select the most popular. The filament type of rectifier is employed in two ways, as a half-wave rectifier and as a full-wave rectifier (*Fig. 54*). The difference between these two is very similar to the difference in structure between the conventional audio frequency amplifying system and the push-pull arrangement. Mind you, we are discussing circuit arrangements and not operation. The advantage gained by the use of the full-wave arrangement is twofold. First, the current output is approximately twice the current output of a single tube employed as a half-wave rectifier and, second, the a. c. component found in the pulsating d. c. output of the rectifying system is of 120 cycles, which makes filtering much simpler. Whereas in the half-wave rectifier, employing but a single tube with a single filament and a single plate, one half of the complete a. c. cycle is employed, the full-wave arrangement employing a single tube with a single filament and two plates or two tubes, each with a filament and a plate, makes use of both halves of each a. c. cycle, hence the frequency at which the filter condensers are charged is twice the input frequency or 120 cycles for a 60-cycle input.

Before progressing further in B eliminators, let us make specific mention of the utility of these devices with respect to the frequency of the operating line supply. This is the frequency of the house power supply and not the frequency of charge, the subject just concluded. The transformer supplying the a. c. potentials to the rectifying units or elements is designed for operation at a certain frequency or over a certain band of frequencies. The limiting factor is the design of the primary winding of the power transformer. Under the circumstances, it is imperative that the transformer be employed over the band of frequencies specified. It is imperative to remember that a B eliminator designed for a. c. operation cannot be connected to a d. c. line. If it is the primary winding of the transformer will go up in smoke. In connection with the rectifying units, the frequency of operation is of little consequence, operation at 25, 40, 50 or 60 cycles being satisfactory.

As we stated in the section devoted to symbols, the gaseous type of rectifier tube is designed for operation in full-wave systems and the same is true of the "dry" disc rectifier. However, the dry disc rectifier may be arranged in a half-wave rectifying circuit, but it is not common practice. Now, in connection with the operation of all B eliminators, the voltage regulation as mentioned in connection with the A eliminator holds true. These units, like the filament supply devices, afford an output voltage which is a function of the current drain or current load. In this case it is the plate current rather than the filament

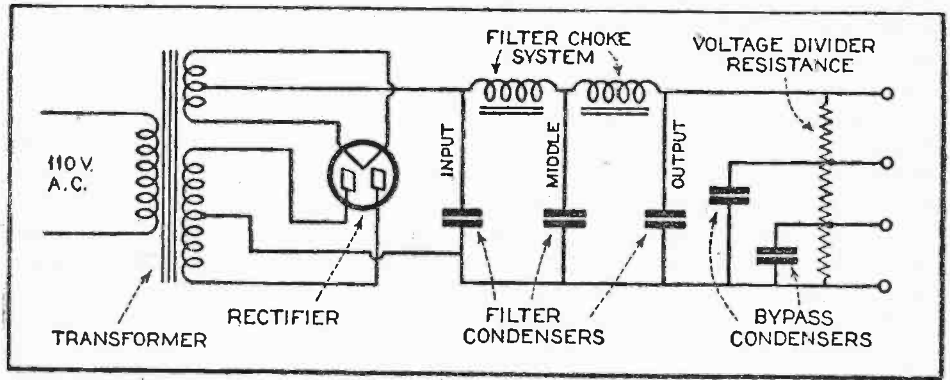

Fig. 54.

current. The usual fluctuation of voltage with variation in current drain in a well-designed B eliminator is about 1.85 to 2 volts per milliampere drain.

Just as in the A unit, it is necessary that the drain imposed upon the eliminator be of the correct value, in order that the specified output voltages be available. If this current drain is insufficient, the output voltage will be higher than normal with the results occasioned by excessive plate potential. In the case of radio-frequency amplifiers excessive plate potential is a frequent cause for uncontrollable regeneration and trouble due to constant oscillation.

The rectifiers employed in B battery eliminators fail after a period of use and one of the factors controlling the life of the rectifying device or element is the value of a. c. potential applied to the rectifier by the power transformer. The average life of a filament type of rectifying tube is about 1,000 to 1,200 hours. The same is true of the gaseous type of rectifier. Longer operating life is claimed for the dry disc rectifier. In connection with the failure of the filament type of rectifier typified by the 280 and the 281, is deactivation of the filament or lessened electronic emission. In the case of the gaseous rectifier it is dissipation of the gas within the tube, or the lowering of the pressure of the gas, which in turn means that the amount of carriers provided by the gas is insufficient for satisfactory output current and voltage. In the case of the dry rectifier, the film is exhausted. However, other defects may and frequently do develop.

Defective rectifying tubes or elements will cause an aggravated condition of a. c. component in the d. c. output because the rectifying action has been greatly impaired. This condition includes deactivation of the tube filament and lowering of the gas pressure in the gaseous type of rectifying tube. Defective rectifying tubes are frequent sources of electrical disturbance similar to the types mentioned in connection with the rectifiers associated with A eliminators.

With respect to the filtering system, the B unit differs from the A unit not so much in structure, but in electrical values and the types of condensers employed. The filter chokes employed in B units are usually rated between 20 and 30 henrys and the condensers between 2 and 10 mfds. Excessive current flows, through the filter choke or chokes as the case may be, will produce the effects mentioned in the chapter devoted to A eliminators, namely, excessive hum and low output voltage.

Possible troubles in B eliminators includes punctured filter condensers, open circuits and shorted resistances. Punctured filter condensers will cause discontinuance of operation, since a punctured condenser is the equivalent of a shorted condenser and a short across any portion of the system preceding the voltage divider will preclude voltage across the voltage divider network. Such a short will also cause excessive current flow and if permitted to exist for a long period will ruin the rectifying tube or element. If the punctured filter condenser is located adjacent to the rectifying system and is connected across the rectifying system output, it will ruin the rectifier in a few minutes.

An open between the filter condensers and another part of the system will cause excessive hum, because the filtering is not as good as it should be. The same is true if one of the by-pass condensers connected across the voltage divider network is open. If one of these condensers is shorted, voltage will not be available across the section of the resistance network by-passed by this capacity. An open circuit in the filter choke will result in no voltage across the resistance network. The difference between an open filter choke and a shorted filter condenser is very evident in the filament type of rectifying system, and can be easily determined by a measurement of the d. c. voltage output out of the rectifying system. The presence of a shorted filter condenser will cause heating of the rectifying tube and very

operated from any one winding. In other words, each winding possesses a definite wattage rating which is the pro-

STANDARD TIME WDZ KILOCYCLES

IMPROVEMENTS WARRANT REPLACING OLD RADIOS

The excellence of the new season's radios augurs 1934-35 as the best radio year since predepression days. Improvements have been made sufficiently important to warrant the replacement of existing receivers. Once again the factories have resumed the production of quality models.

Practically all lines include one or more types of all-wave sets, some manufacturers offering nothing else. Receivers tuning from 20,000 kilocycles through the broadcast band without a break are quite common, and many makers are producing export sets good down as far as 150 kilocycles in the hope that long-wave weather reports and the occasional reception of foreign long-wave broadcasts will stimulate demand.

Extended-band broadcast sets, including one or more police and amateur bands, are to be found in a number of table and console offerings. But by far the most common type of receiver is the "jump band" type, tuning in the broadcast range and then skipping down to the more popular foreign channels, omitting the relatively (to the average listener) unimportant intervening services.

It seems apparent that all-wave sets are destined to stay with us. Technically, they are much improved over early efforts, which were nothing to write home about. Dead-spots are almost a thing of the past, due to the growing popularity of separate band coils and trick grounding systems; sensitivity is up and noise, which includes spurious code interference, has been largely eliminated by proper antenna coil design and tuned radio frequency stages.

Then, too, worth-while strides have been made toward the simplification of all-wave tuning. Converters have been resurrected and, embodying modern improvements, really work quite satisfactorily. Also, the growing interest in short-wave reception has induced a number of companies to put out straight short-wave receivers for the new crop of dyed-in-the-wool fans. Some of these have all the professional gadgets such as single-signal crystals, bandspread controls and logging dials.

Noise-reducing antennas are a distinct advantage when operating an all-wave or short-wave receiver in the majority of locations. Now it appears sure that certain factories will sell them as stock equipment within the next few months. Many new sets incorporate automatic switching and antenna coil systems which take care of both broadcast and short-wave sensitivity when using a doublet.

Console cabinets are larger, with most designers leaning toward the practically legless types carrying the speaker baffle right down near the floor, which often improves tone amazingly. The usual crop of conservative lowboys and highboys is to be seen, old standbys but all dolled up in demimodernistic dress.

Even the radio-phonograph combination is definitely staging a comeback, again indicating the anticipation of a quality market. Recording companies are more up on their toes than for a number of years and new disc recordings by leading radio and stage celebrities will do much to stimulate the combination market.

With improvements in the new models, and the increased demand for them, prices are slowly but surely stiffening, and it seems reasonable to expect advances from 10 to 20 percent over current prices by the first of the year.

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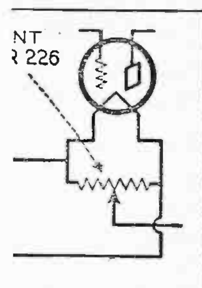

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The number of secondary or output windings of an a. c. filament transformer is governed by the precalculated utility of the transformer. Just as the number of windings are predetermined, so are the number of tubes of like filament potential requirements which may be

former supplying 5 volts and rated at 10 watts. Since current is equal to wattage divided by voltage, the maximum amount of current load in this case is 10 divided by 5, or 2 amperes, which is the equivalent of the current consumed by 8 171 A tubes.

The application of excessive current drain will cause a reduction in the output, which means that if a transformer has been designed to supply operating potential for the filament of four 226 tubes and 6 such tubes are connected across this winding, the voltage applied to the various filaments will be less than that required for normal operation. This fact should be considered when tests show that the operation voltage is less than the rated value specified by the tube manufacturers and when the input voltage to the transformer is satisfactory.

In connection with the above, it is necessary to mention that variations in input voltage will cause corresponding variations in the output voltage of such transformers. In other words, if the input potential is less than the value calculated in the design of the transformer, the output voltage will consequently be less than the rated value. Furthermore, low filament voltages may be due to excessive resistance in the form of a filament control resistance in the filament circuit when the number of tubes connected to the transformer winding is not in excess of the rated value and when the input voltage corresponds with the requirements set forth by the transformer manufacturer.

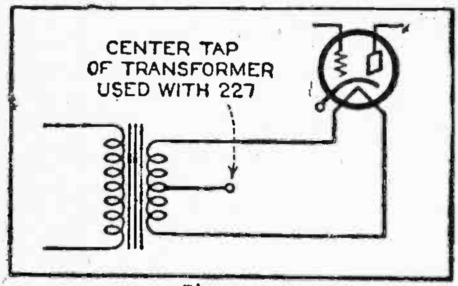


Fig. 56.

It is necessary to realize when employing a. c. transformers that the current and voltage in the circuit are alternating, consequently wires located near the transformer or near the filament circuit wires connected to the transformer will lie within the magnetic field surrounding the filament wires, created by the current flow through these wires. Principles of electricity state that under such conditions a corresponding voltage of alternating character will be induced in these wires. If this be the case and these wires are connected to the grid or plate circuits, the frequency of this voltage will be made audible by the speaker because this induced alternating voltage will be passed into the grid and plate circuits. Hence, the filament transformer and the filament winding in an a. c. installation may be the probable cause for hum in the receiver.

In connection with filament transformers it is necessary to make some mention about the filament shunt resistances employed in a. c. circuits. These filament shunt resistances are frequently employed in place of the center tap upon the filament winding. An idea of what is being said is shown in the accompanying illustrations *(Figs. 55* and *56)*. The use of such resistance obviates the necessity of employing the transformer employed in place of the center tap upon center tap and the utility of either the ance is governed by the type of tube being employed. As it happens, the 226 tube necessitates the use of variable center tapped filament shunt resistances, whereas the 227 permits the use of the transformer center tap.

TESTING DEVICES ESSENTIAL TO RADIO REPAIR

The combination tube and receiver tester usually known as the set analyzer is one of the most essential pieces of apparatus to the man who is interested in receiver trouble-shooting and repair. This device is an arrangement of meters, sockets and insert plugs whereby the voltages present in a radio receiver may be measured without rupturing or cutting leads in the wiring. It also permits the observation of tube efficiency and operating characteristics, without complicated calculations and intricate testing arrangements.

The suggested unit is shown in schematic form in *Figs. 57* and *58*. Bearing in mind that the receiver tester requires some means of connecting the testing equipment to the receiver, we show the constructional details of a four- and five-prong insert plug. These insert plugs are linking mediums between the receiver sockets and the testing device, the inserts being plugged into the receiver socket and the tube in the receiver socket being placed into the tester socket. The associated apparatus such as the voltmeters and current indicating devices are connected into the circuit between the receiver and the tester, thereby being directly in the tube circuits. The construction of the inserts is very simple and provides a means of utilizing burned-out tubes. The plug part of the insert consists of the base of the damaged tube, and in order to provide access to four- and five-prong sockets in receivers, it is necessary to wire a four- and a five-prong insert.

The glass portion is removed from the base of the damaged tube. The glass within the base is removed with a screwdriver and a pair of pliers. The wire connected to each tube prong, within the prong, is removed by heating the prong and withdrawing the wire. This is followed by attaching the tester cables, four to the four-prong insert and five to the five-prong insert. If possible these cables should be color-coded to facilitate recognition later when making connection to these cables. The wires should be about twelve inches long and one end is connected to or rather soldered to the insert plug prong. The other ends of the wire remain unconnected. A handle is required for each plug insert and this is in the form of a short round rod, with a hole drilled through the middle, lengthwise through the rod. The diameter of the hole should be great enough to pass the four wires for the four-prong insert and the five wires for the five-prong insert. Such handles may be made from a three inch section of an ordinary broom handle. The handle is wedged into the base and fastened with sealing wax.

The binding posts associated with the wiring diagram of the set analyzer permit connection of either prong insert to the receiver; also the utilization of the set analyzer as a tube tester, with operating voltages secured from a receiver or from an external source of potential.

All filament voltages are measured with the three range a. c. voltmeter indicated on the diagram. This arrangement is preferred to separate a. c. and d. c. filament voltmeters because it permits economy and eliminates the necessity for multiplicity of switches. The a. c. instrument is satisfactory on d. c. circuits, the difference in voltage reading being about 2 or 3%, a value entirely negligible. The three-point switch associated with this meter makes possible the use of any one of the three ranges. The 0 to 150 volt range is suitable for the measurement of a. c. line voltages. A separate d. c. voltmeter is provided for the measurement of B and C voltages. This meter is not a permanent fixture

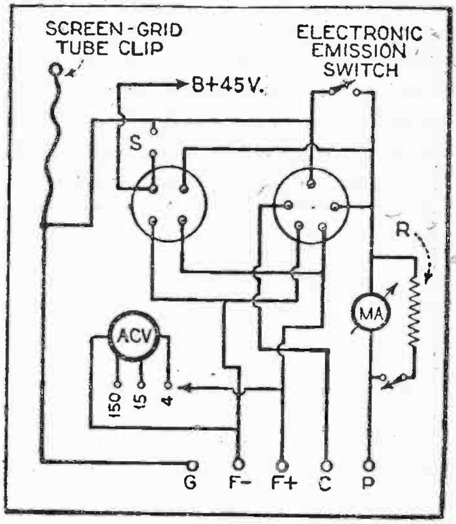


Fig. 57.
S—Is closed when testing regular tubes and open when testing screen grid tubes—the B 45 lead is for the screen grid.

of the unit, but is a separate unit, thus permitting connection in any manner without need for switches. The tester sockets are a four and five prong respectively. The plate current meter MA is a Weston, model 301 d. c., 0 to 20 milliamperes. The internal resistance of this meter is 1.5 ohms and in order to increase its range to 200 milliamperes, the value required when making electronic emission tests, this meter is shunted by a resistance R, which when connected across the meter by its associated switch increases the range to 200 milliamperes. The value of this resistance is .111 ohm. The a. c. filament voltmeter is a Weston model 476, three-range switchboard type of meter. The switch associated with the four-prong socket is used when determining electronic emission. The flexible cable associated with this socket is employed

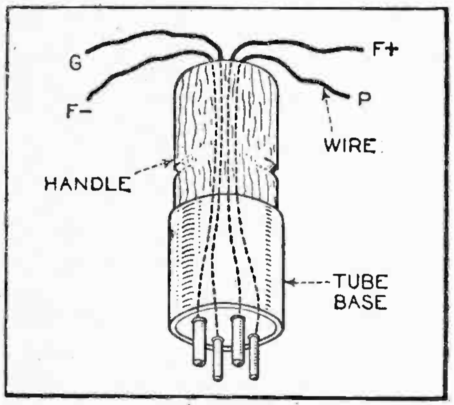


Fig. 58.

when testing screen grid tubes. The electronic emission switch when closed short the grid and plate contacts.

In connection with the plate current meter shunt, this resistance is a section of a .5 ohm rheostat capable of satisfactorily passing .5 ampere, adjusted to the correct resistance value by means of the following procedure. The meter without the shunt but in series with a 2250 ohm resistance is connected across a 22.5 volt battery. These two units find application in the continuity tester shown in *Fig. 1.* The current flowing through the circuit mentioned will be 10 milliamperes. The shunt resistance switch is now closed and the .5 ohm rheostat is manipulated until the plate current meter reading is 1 milliampere or one tenth of the original reading. This position or setting of the rheostat is equivalent to a resistance of .11 ohms and is left in this position. If possible the position of the lever should be permanently secured in that position by sealing wax or solder. With the resistance in the circuit, the range of the meter is increased. Each indication of 1 milliampere flow means a current flow of 10 milliamperes through the circuit. The effect of the shunt resistance is to by-pass some of the current around the meter.

The grid and plate voltmeter is not an inherent part of the set and tube tester. Instead it consists of a 0-2 d. c. milliammeter with two external series resistance. One R is rated at 250,000 ohms and the other R is rated at 400,000 ohms. The first resistance permits measurement of voltages between 0 and 500 volts and the second permits measurement of voltages from 0 to 800 volts. The interpretation of voltage by current indications is possible because it requires a definite amount of voltage to force a certain amount of current through a resistance. The resistance is known and the current flow is evident upon the meter. The determination of the magnitude of applied voltage is simple. The arrangement of the voltmeter system is shown in *Figure* 59. The two-point switch permits either range. This meter is connected across whatever circuit is to be measured. Being a separate system it obviates the necessity of switches whereby various connections are made and polarity changed. With the 250,000 ohm resistance in the circuit each milliampere indication is the equivalent of an applied potential of 250 volts and each tenth of a milliampere current flow is the equivalent of an applied potential of 25 volts.

The application of the device is simple. Let us employ it as a set analyzer. The correct plug insert is attached to the binding posts. The screen-grid lead is adjusted if a screen grid tube is used, to be left alone if the conventional type of tube is involved. The electronic emission switch remains open. The plate current meter switch remains open. The tube is removed from the receiver socket and the plug insert placed into the receiver socket instead. The tube previously in the receiver socket is then inserted into the tester socket. The plate current is then noted. If no indication is noted, the conditions mentioned elsewhere must be considered. The filament voltage is measured by means of the filament voltmeter. The plate voltage is determined by connecting the two test prongs connected to the voltmeter system. The grid voltage is measured by means of this voltmeter. If the type of tube involved is of such design that the plate current consumption is in excess of 20 milliamperes, as for example the 210, 245 and the 250, it will be necessary to close the plate milliammeter shunt resistance switch. This is done in order to extend the operating range.

As a tube tester to determine electronic emission, the operating voltages are connected to the binding posts provided. The tube is inserted into the correct socket. The plate current meter shunt resistance switch is closed and the grid-plate switch located adjacent to the four-prong socket is likewise closed. The plate current meter will now indicate the electronic emission. The plate voltage is measured with the plate voltmeter; the filament voltage, with the filament voltmeter.

B-ELIMINATOR TESTERS

B-eliminiators are frequent sources of trouble and require servicing. Unfortunately, however, manufactured B eliminators do not provide easy accessibility, hence the service man is frequently obliged to use his own ingenuity to reach certain parts of the eliminator unit. Since most of the B eliminators utilize gaseous or filament type of rectifier tubes, it will be best if we concern ourselves with testing equipment suitable for these units. The drawing shown here in *Figure* 60 illustrates a system whereby all a. c. voltages in B eliminators of the above types may be determined. The tester utilizes two a. c. voltmeters, one for indicating the applied a. c. filament voltage (filament type rectifier tube) and the other for indicating the applied a. c. filament potentials for all types of rectifiers. Jacks are arranged across the various circuits and the voltmeters are plugged in as required.

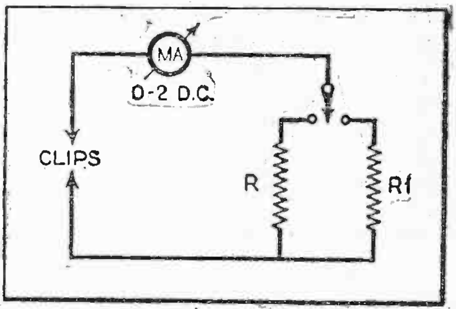


Fig. 59.
Improvised high resistance voltmeter.

These voltmeters need not be parts of the tester. Instruments employed with other testers may be connected to plugs and inserted into the jacks provided. The method of testing calls for the insertion of the four-prong insert into the B-eliminator socket and insertion of the various voltmeters to read available voltages. The eliminator rectifying tube is not utilized, since this tube is tested on some other device. One arrangement employing the filament type of rectifier tube (half-wave) cannot be tested with this system and this is the arrangement wherein one end of the plate winding connects to the center tap of the filament winding and the other end of the plate winding is "positive." The same plug insert is suitable for all rectifier tube sockets; that is, for the type used with filament rectifiers and for the type used with gaseous rectifiers, such as the Raytheon and QRS. The plug insert is shifted from one socket to the other when testing two-tube full-wave filament type B-eliminators.

Referring to the above illustration, all the jacks are single, open circuit, and the designations are as follows: 1 and 2 are used to measure the a. c. plate voltage applied to the anodes of the gaseous rec-

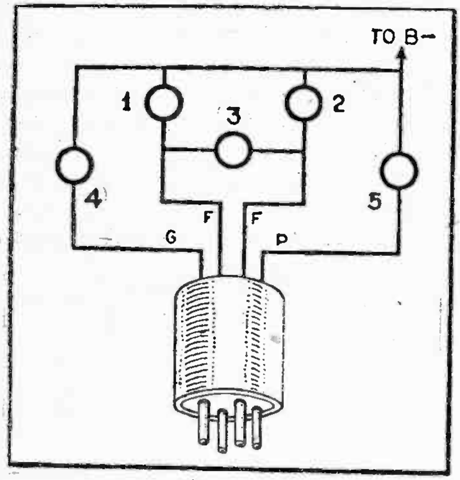


Fig. 60.

tifier tubes. 3 is used when measuring the filament voltage of filament type rectifiers. 5 is used when measuring the a. c. plate voltage for half-wave rectifiers, such as the 216B and the 281. 4 and 5 are used when measuring the a. c. voltages applied to the anodes of a single tube full-wave rectifier such as the 280 or the 213.

The B minus lead shown in the drawing should be connected to the B minus terminal of the eliminator. If, however, the eliminator is equipped to furnish C bias voltages, this B minus connection should be made to the most negative C bias terminal.

The high range a. c. voltmeter should be capable of indicating a potential of at least 750 volts and the jacks and plugs employed should be capable of withstanding this potential. The eliminator input potential should be "off" when voltmeter plug is inserted.

R. F. OSCILLATOR

Re-neutralization of radio-frequency receivers is a frequent problem hence we cannot complete a trouble finder book without showing a modulated radio frequency oscillator suitable for the generation of a modulated signal necessary for neutralization of a receiver. This oscillator is a very simple device. (See *Circuit* 61.) The system is an ordinary tickler feedback. L1 is the grid coil and L2 is the tickler coil. C is the tuning condenser and C1 is the grid condenser. C2 is the plate battery by-pass condenser.

The oscillator is of conventional design utilizing a 119 tube dry cell, a supply and a single 45 volt block of B battery. The entire unit is contained within a shielded compartment, the shield being open at the coil end, so the energy can be radiated from the coil. The switch Sw1 controls the generation of a pure radio-frequency signal or a modulated radio-frequency signal. When in position A the output is pure R. F. When in position B, the output is modulated radio-frequency. The grid leak GL is of 5 megohms resistance, and will produce a modulating frequency of about

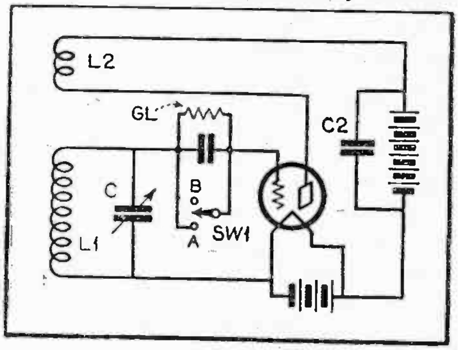


Fig. 61.

800 cycles. The frequency is controlled by means of the condenser C, a variable condenser of about .0005 mfd. L1 and L2 are wound upon the same form with a separation of about ⅛" between the two windings. L1 consists of 50 turns of No. 22 d. s. c. wire on the 3" form and L2 consists of 36 turns of No. 22 d. s. c. on the same form

VOLTAGE AND CONTINUITY TESTS

Very little need be said about voltage and continuity tests, although an explanation of the construction of the continuity tester is necessary. Relative to the

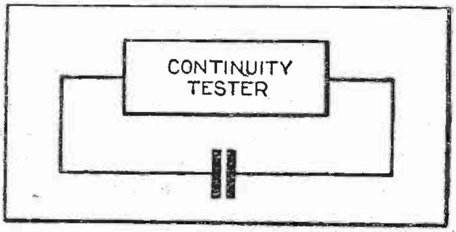


Fig. 62.

voltage tests, the voltmeter improvised for utility with the set analyzer is satisfactory where the voltage is not in excess of 100 volts. It is of course understood that the improvised high resistance voltmeter is suitable for d. c. measurements only. For the measurement of d. c. voltage in excess of 100 volts and where the current drain is not of consequence, the a. c. filament voltmeter, the 0-150 range is suitable. However, wherever the current consumption must be small, as for example when measuring the output voltage of B eliminators, the high resistance voltmeter (milliammeter-resistance unit) must be used. The fact that the current meter is a 0-2 instead of a 0-1 milliampere instrument is of

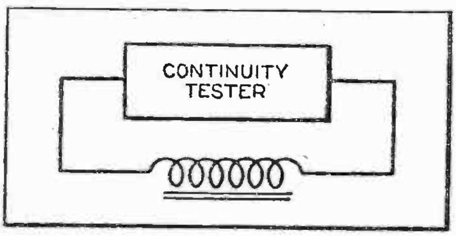


Fig. 63.

little consequence, since the drain of 2 milliamperes at maximum is negligible and will not influence the operation of a power device.

With respect to the continuity tester, it is a very simple device, since its function is that of an arrangement showing that the continuity of a device is perfect. It consists of a 0-1 d. c. milliammeter in series with a 22,500 ohm resistance and a 22.5 volt battery. The resistance of

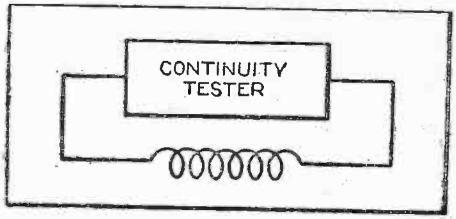


Fig. 64.

22,500 ohms is made up of two units, the 2,250 ohm unit mentioned in connection with the adjustment of the plate current meter shunt resistance and an additional 20,000 ohm resistance unit. The complete tester terminates in two test prongs as shown in *Fig. 1.* With the two prongs shorted the maximum

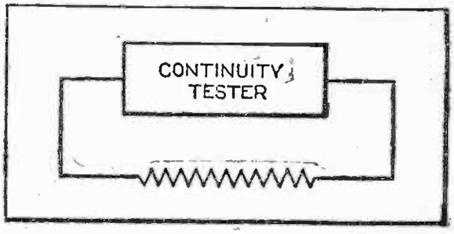


Fig. 65.

current deflection is 1 milliampere. Any resistance connected across the two test prongs will show a reduced reading, if circuit continuity is perfect through the resistance. Such a resistance is represented by the primary winding of a transformer, a part of a voltage divider resistance network, secondary of a radio-frequency transformer, etc. The associated illustrations show the application of the continuity tester. See *Figs. 62, 63, 64, 65.*

LOCATING TROUBLES

Generally speaking, troubles in radio receivers are singular with respect to numbers, with the exception of the case when the failure of one part causes the failure of another. An example of this is the rupture of a filter condenser, which in turn is very effective in damaging the rectifying tube or element in an eliminator.

To expedite matters we shall consider various observed conditions, isolate the possible troubles and mention the tests for these troubles. In connection with this work it is necessary to mention that the receiver owner, or rather the man who does the repair, should have in his possession the wiring diagram of the receiver or amplifier in question. A typical installation will be shown. We will first concern ourselves with battery receivers.

TUBE OR TUBES DO NOT LIGHT

Possible Trouble	Form of Test
1. Burned - out tube	Continuity test
2. Corroded battery terminal or cable contact	Continuity test
3. Open filament switch	Continuity test
4. Open in filament circuit	Continuity test
5. A battery discharged	Hydrometer test
6. Imperfect contact between tube and socket contacts	Examination
7. Burned - out filament rheostat or ballast	Continuity test

TUBES LIGHT BUT NO RECEPTION

1. A battery connections reversed	Examination and voltmeter test
2. B battery connections reversed	Examination and voltmeter test
3. Open circuit in plate supply lead from battery to receiver	Continuity test
4. Open in tube plate circuits	Set analyzer and continuity test
5. Defective tube	Set analyzer
6. C battery connections reversed in audio system	Examination and voltmeter test
7. Aerial disconnected	Examination
8. Ground disconnected	Examination
9. Shorted by-pass condensers in plate circuits	Continuity test
10. Run-down B battery	Voltmeter test
11. Open speaker or disconnected speaker	Continuity and examination
12. Defective grid leak	Continuity and examination

WEAK RECEPTION

1. Poor aerial	Examination
2. Shielded aerial	Examination
3. No ground	Examination
4. No aerial	Examination
5. Open grid circuits	Set analyzer
6. Low filament voltage	Set analyzer
7. Low plate voltage	Set analyzer
8. Incorrect grid voltage	Set analyzer
9. Defective tubes	Set analyzer
10. Lack of resonance in tuned stages	Resonance test
11. Open neutralizing system or shorted neutralizing condenser	Continuity test
12. Open grid suppressor	Continuity test
13. Poor contact between tube and socket	Examination
14. Grounded grid	Continuity test
15. Shorted tuning condenser	Continuity test
16. Defective radio frequency transformer	Examination

NOISE

1. Loose connections and contacts	Examination
2. Aerial striking grounded object	Examination and continuity
3. Momentary short in tuning condensers	Continuity test
4. Leaky plate circuit by-pass condensers	Continuity test
5. Defective A or B battery	Voltage and hydrometer test
6. Defective audio coupling units	Phone test
7. Defective speaker	Examination

FLUCTUATING SIGNALS

1. Natural fading of signals	
2. Swinging aerial	Examination
3. Intermittent grounding of aerial or lead-in	Continuity test
4. Run-down batteries	Voltage and hydrometer test
5. Imperfect contacts	Examination
6. Corroded connections	Continuity test

DISTORTION

1. Coupling between stages	Examination of parts position
2. Heterodyne between stations	
3. Lack of by-pass condensers	Examination
4. Shorted grid suppressor	Continuity test
5. Open neutralizing system	Continuity test
6. Defective tube	Set analyzer
7. Incorrect C bias	Voltage test
8. Defective speaker	Examination
9. Run-down batteries	Voltage and hydrometer test
10. No C battery	Examination

HUM AND WHISTLE

1. Heterodyne between stations	
2. Low B batteries and run-down A battery	Voltage and hydrometer test
3. Low detector B voltage	Voltage test
4. Open grid circuit (detector and audio)	Continuity test
5. Microphonic tube	Tap test
6. Speaker to close to set	Examination

OSCILLATION

1. No aerial	Examination
2. No ground	Examination
3. Incorrect R. F. Tubes	Examination
4. Open neutralizing system	Continuity test
5. Shorted grid suppressors	Continuity test
6. Excessive plate potential (R. F.)	Voltage test
7. Excessive grid bias (R. F.)	Voltage test
8. Open by-pass condensers (Plate R. F.)	Continuity test

A. C. SETS

Many of the troubles found in battery operated receivers are also found in a. c. receivers, but the use of A and B eliminators and a. c. filament transformers complicates the possible troubles. Hence we shall consider such receivers as individual items and forget that we made a list of the possible troubles in battery operated receivers.

TUBES DO NOT LIGHT

Possible Trouble	Form of Test
1. Power transformer not connected to line	Examination
Defective A rectifier tube or rectifier element	Examination
2. Open in power plug cord	Continuity test
Open filter in A Eliminator	Continuity test if possible
3. Open power transfomer primary	Continuity test
Shorted filter condenser in A eliminator	Continuity test

ONE OR SEVERAL TUBES DO NOT LIGHT

1. Defective tube or tubes	Continuity test
2. Open in filament transformer secondary	Continuity test
3. Open in filament circuit wiring	Continuity test
4. Shorted filament transformer secondary	Continuity test
5. Tube does not make contact with socket	Examination

TUBES LIGHT BUT NO RECEPTION

1. Defective A or B supply	
2. Defective rectifier in A or B supply	Voltage and set tester
3. Open filter system in A and B supply	Continuity test
4. Open voltage divider system in B supply	Continuity test
5. Shorted speaker choke	Continuity test
6. Open in tube plate circuits	Continuity test
7. Aerial disconnected	Examination
8. Ground disconnected	Examination
9. Shorted by-pass condenser in plate circuits	Continuity test
10. Shorted condenser in B power pack	Voltage test
11. Excessive bias	Voltage test
12. Defective tube	Set analyzer

WEAK RECEPTION

1. Poor aerial	Examination
2. Poor ground	Examination
3. No aerial	Examination
4. No ground	Examination
5. Open grid circuit (R. F.)	Set analyzer
6. Low filament voltage	Voltage test
7. Low plate voltage	Voltage test
8. Incorrect grid voltage	Voltage test
9. Defective tube or tubes	Set analyzer
10. Lack of resonance in tuned stages	Resonance test
11. Open neutralizing system	Continuity test
12. Open grid suppressor	Continuity test
13. Poor contact between tube and socket	Examination
14. Shorted tuning condenser	Continuity test
15. Defective radio frequency transformer	Examination
16. Partially shorted plate choke	Continuity test
17. Defective audio transformer	Continuity test
18. Defective filament shunt resistances	Continuity test
19. Defective by-pass condensers in R. F. circuit	Continuity test

CONTINUOUS HUM

1. Defective A or B supply	
2. Low line voltage	Voltage test
3. Defective tube	Set analyzer
4. Open filament shunt resistance	Continuity test
5. Shorted filter choke	Continuity test
6. Shorted by-pass condenser	Continuity test
7. Open detector or audio grid circuit	Continuity test
8. Lack of by-pass condensers	Examination

FLUCTUATING SIGNAL INTENSITY

1. Natural fading of signals	
2. Swinging aerial	Examination
3. Intermittent grounding of aerial	Examination and continuity
4. Defective power supply	
5. Line voltage variation	Voltage test
6. Imperfect contacts	Examination
7. Open grid circuit	Continuity test

OVERHEATING OF POWER DEVICE

1. Shorted output winding	Continuity test
2. Overloading of windings	Voltage test and examination
3. Shorted filament winding	Continuity test

EXCESSIVE HUM OR NOISE

1. Loose contacts	Examination and continuity
2. Induction from power system	
3. Aerial striking grounded object	Continuity test
4. Overloaded audio coupling resistance	
5. Defective audio units	Replacement
6. Poor contact between tube and socket	Examination
7. Defective grid leak	Replacement

MOST FREQUENT DEFECTS

Defect	Symptom
1. Incorrect, insufficient or excessive grid bias	Distortion, hum
2. Biasing resistance burned out	Distortion, hum
3. Loose volume control elements	Noise
4. Punctured filter condenser in B eliminator	Rectifier overheats, no plate potential, set dead
5. Burned-out radio frequency transformer primary	Set dead, very weak
6. Defective by-pass condensers	Set weak, noisy
7. Open detector plate lead	No reception, hum
8. Audio system defective including choke or resistance	Reception weak, hum
9. Oscillation in R. F. system	Neutralizing condenser open, grid suppressor open
10. Deactivated rectifier tubes	Low plate voltage, hum
11. Worn-out rectifier elements	Low voltage, hum
12. Burned-out filaments	Excessive potential from transformer, excessive line potential
13. Defective grid leak	Noise, intermittant reception, inoperative
14. Burned-out audio transformer primary	Set audio system inoperative
15. Transformer (audio) secondary open	Distortion, set weak

MOST FREQUENT DEFECTS (Continued)

16. Power transformer primary burned out	Set dead, no operating voltages
17. Tuning condensers not matched	Broad tuning, weak
18. Shorted by-pass condensers	Set dead, weak
19. Open B eliminator voltage divider system	Incorrect operating plate voltages
20. Tuning condenser shorted	Set weak, noisy
21. Tuning condensers out of synchrony	Set tunes broadly, weak
22. Loose filament control elements	Fluctuating signals, noise
23. Loose connections	Fluctuating signals, noise

B-POWER DEVICES

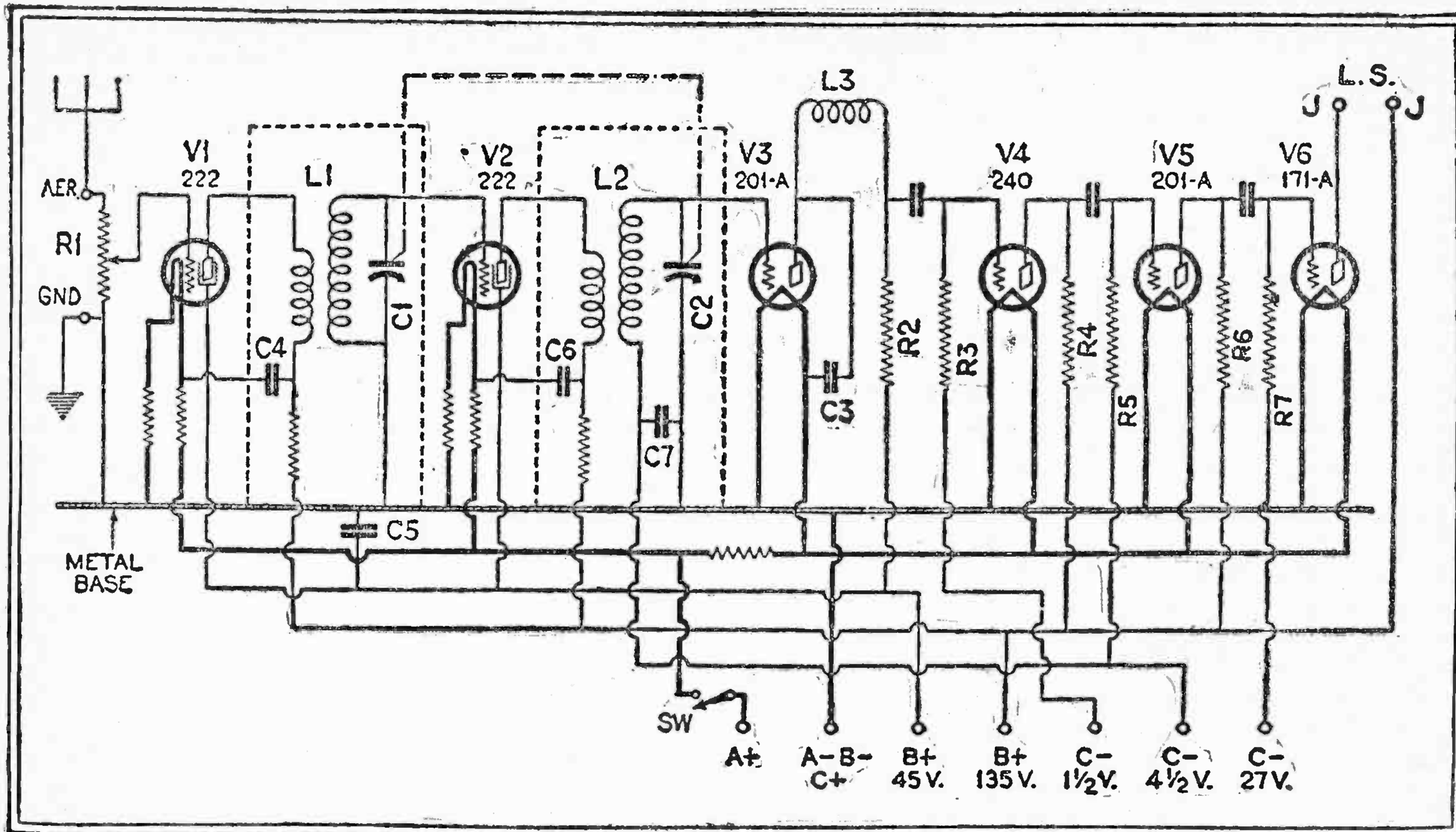
Possible Trouble	Form of Test
1. Defective rectifier tube or element	Set analyzer
2. Open filter chokes	Continuity test
3. Open filter condenser connections	Continuity test
4. Open by-pass condenser connections	Continuity test
5. Open voltage-divider system	Continuity test
6. Shorted filter condenser	Voltage and continuity test
7. Shorted filter chokes	Continuity test
8. Loose connections	Voltage and continuity test
9. Burned-out primary winding.	Continuity test
10. Burned-out secondary winding	Continuity test

A-POWER DEVICES

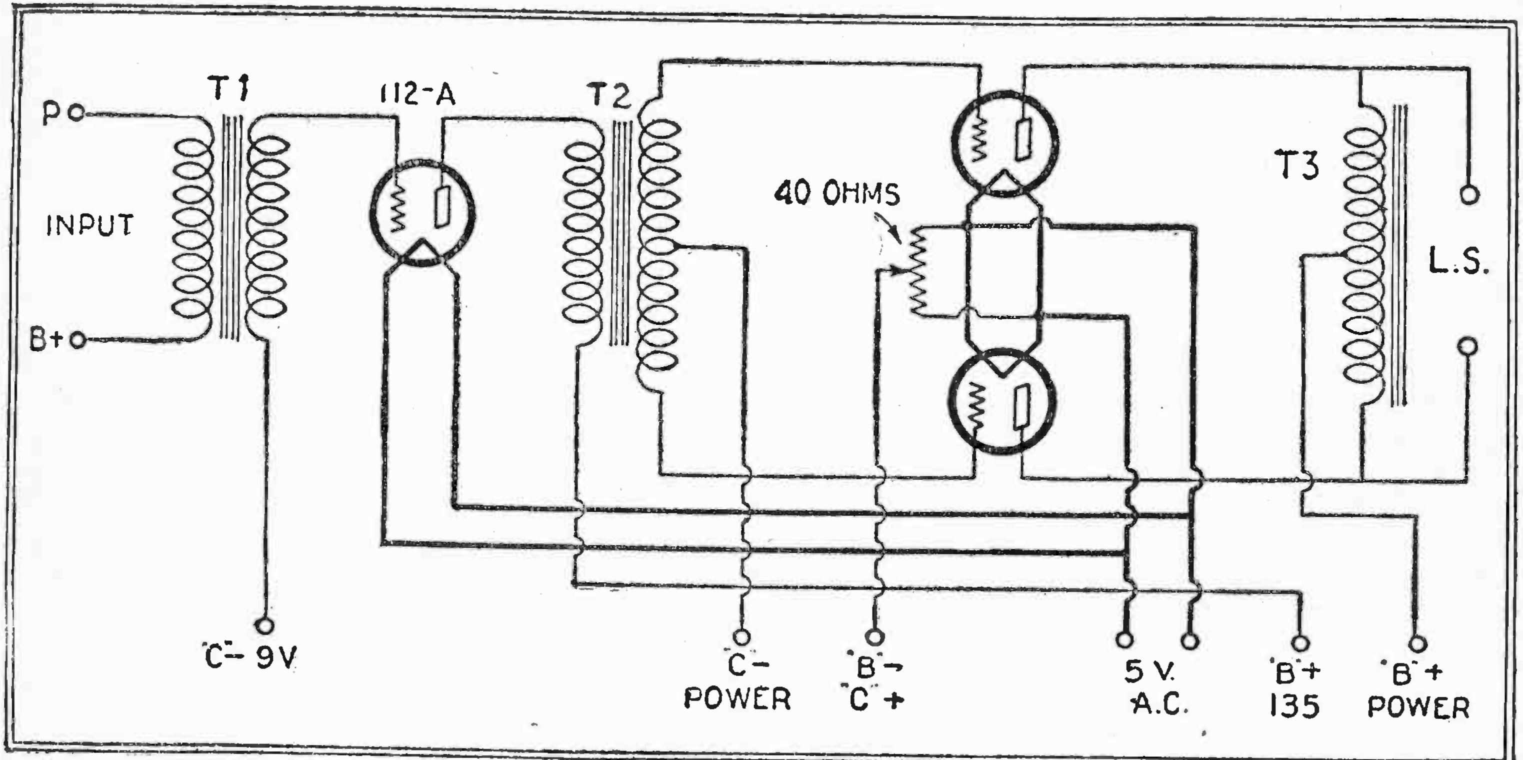
Possible Trouble	Form of Test
1. Defective rectifier tube or element	Set tester
2. Open filter choke	Continuity test
3. Open filter condenser	Continuity test
4. Open voltage control resistance	Continuity test
5. Defective filter condenser	Continuity test
6. Shorted filter choke	Continuity test
7. Shorted filter condenser	Continuity test
8. Loose connections	Voltage and continuity test
9. Burned-out primary winding	Continuity test
10. Burned-out secondary winding	Continuity test

			DETECTOR		AMPLIFIER				
TUBE	FILAMENT TERMINAL VOLTS	FILAMENT CURRENT (AMPS)	"B" VOLTS	PLATE CURRENT (MA)	PLATE VOLTS	GRID BIAS VOLTS		PLATE CURRENT (MA.)	MAXIMUM UNDISTORTED OUTPUT (MILLIWATTS)
CX-12 UX-12	1.1	.25	22.5 TO 45 V.	1.5	90.0	4.5		2.5	7
					135.0	10.5		3.5	35
CX-299 UX-199	3.3	.063	22.5 TO 45 V.	1.5	45.0	1.5		1.0	
					67.5	3.0		1.7	
					90.0	4.5		2.5	7
CX-220 UX-120	3.3	.132			90.0	16.5		3.2	
					135.0	22.5		6.5	110
CX-322 UX-222	3.3	.132	SCREEN-GRID VOLTAGE +45		90.0	1.5		1.5	
					135.0	1.5		1.5	
					135.0	3.0		1.0	
CX-300A UX-200A	5.0	.25	45	1.5					
CX-301A UX-201A	5.0	.25	45	1.5	45.0	1.5		.9	
					67.5	3.0		1.7	
					90.0	4.5		2.5	15
					135.0	9.0		3.0	55
CX-340 UX-240	5.0	.25	135	.3	135.0	3.0		.2	*
			180	.4	180.0	4.5		.2	*
CX-326 UX-226	1.5	1.05			90.0	6.0		3.5	20
					135.0	9.0		6.0	70
					180.0	13.5		7.5	160
C-327 UX-227	2.5	1.75	45	2.0	90.0	6.0		3.0	
					135.0	9.0		5.0	
					180.0	13.5		6.0	
C-324 UX-224	2.5	1.75	SCREEN-GRID VOLTAGE +75		180.0	1.5		4.0	
CX-112A UX-112A	5.0	25				D.C.	A.C.		
					90.0	4.5	7.0	5.5	30
					135.0	9.0	11.5	7.0	120
					157.5	10.5	13.0	10.0	195
					180.0	13.5	16.0	10.0	300
CX-371A UX-171A	5.0	.25			90.0	16.5	19.0	10.0	130
					135.0	27.0	29.5	16.0	330
					157.5	33.0	35.5	18.0	500
					180.0	40.5	43.0	20.0	700
CX-310 UX-210	7.5	1.25			250	18.0	22.0	12.0	340
					350	27.0	31.0	16.0	925
					425	35.0	39.0	20.0	1540
CX-345 UX-245	2.5	1.5			180	34.5		26.0	750
					250	51.5		32.0	1600
CX-350 UX-250	7.5	1.25			250	45.0		28.0	900
					300	54.0		35.0	1500
					350	63.0		45.0	2350
					400	70.0		55.0	3250
					450	84.0		55.0	4650
CX-380 UX-280	5.0	2.0	FULL WAVE RECTIFIER. MAX. A.C. INPUT VOLTAGE PER ANODE - 300 VOLTS A.C. R.M.S. MAX. D.C. LOAD CURRENT 125 MA.						
CX-381 UX-281	7.5	1.25	HALF WAVE RECTIFIER. MAX. A.C. INPUT VOLTAGE 700 VOLTS A.C. R.M.S. MAX. D.C. LOAD CURRENT 85 MA.						

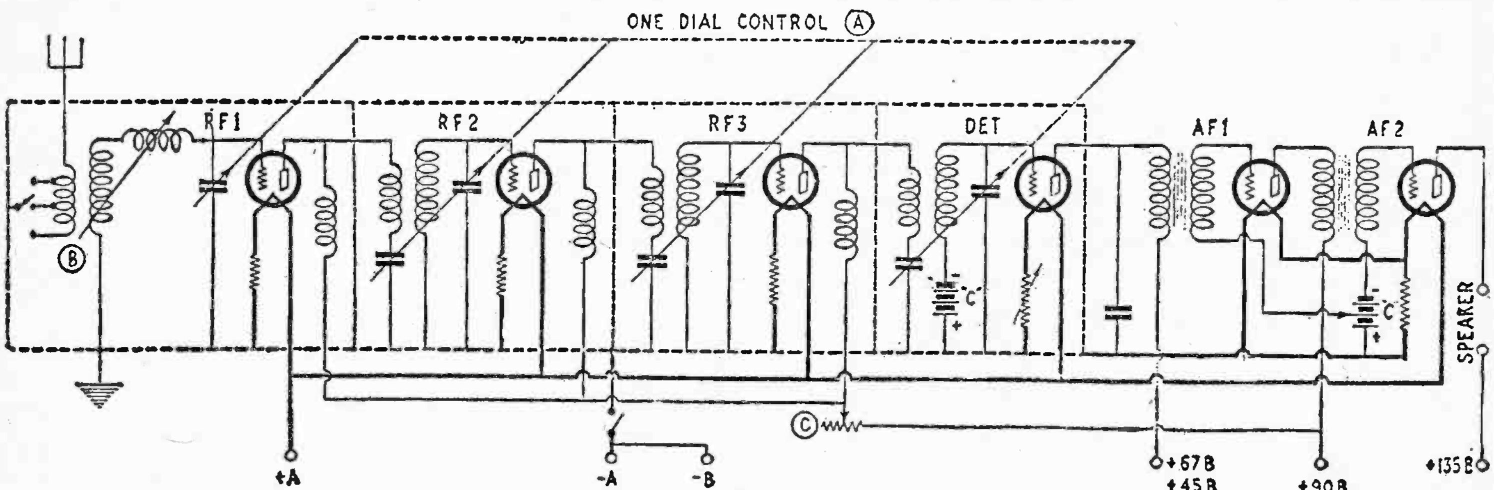
* WHEN USED IN RESISTANCE COUPLED AMPLIFIER WITH .25 MEGOHM PLATE RESISTOR.



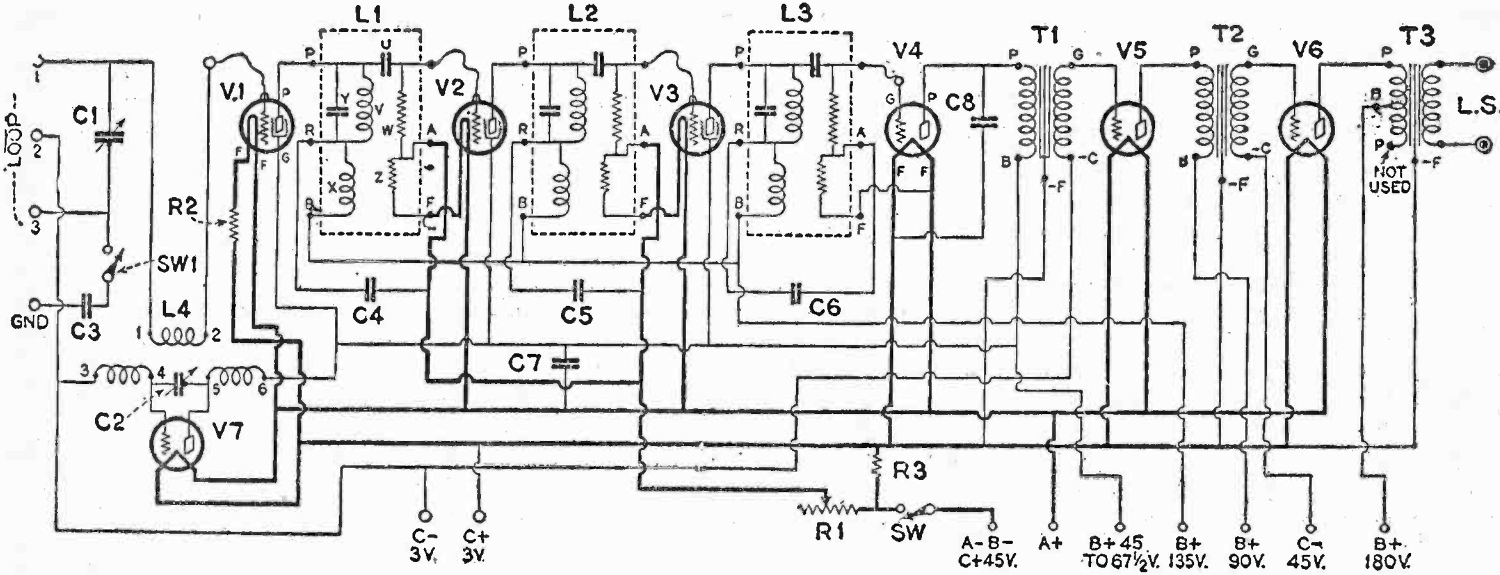
Two r.f. amplifiers, one detector and the three resistance-co upled audio-frequency amplifiers comprise the 6-tube receiver whose circuit is given here. The first r.f. tube is employed also as a coupling medium between the antenna and the first tuned r.f. stage. The r.f. tubes are of the screen-grid type.



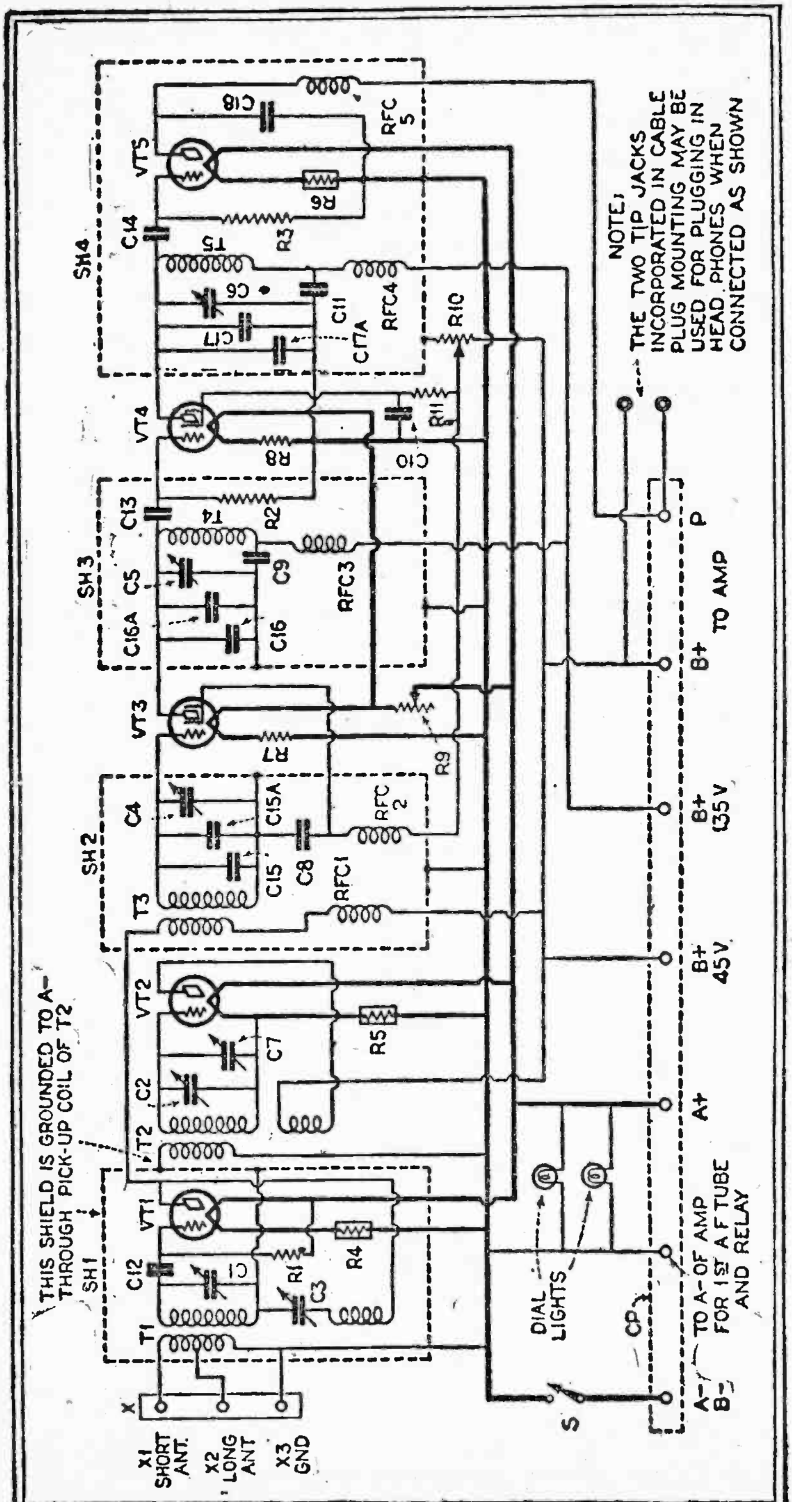
Here is the circuit diagram for a two-stage audio-frequency amplifier. The first stage, as indicated, is a straight stage of amplification employing a 112A tube for signal-handling capacity. It is followed by a pair of 171A tubes arranged in push-pull. In the operation of this amplifier it is highly important that the correct values of B and C voltages be applied.



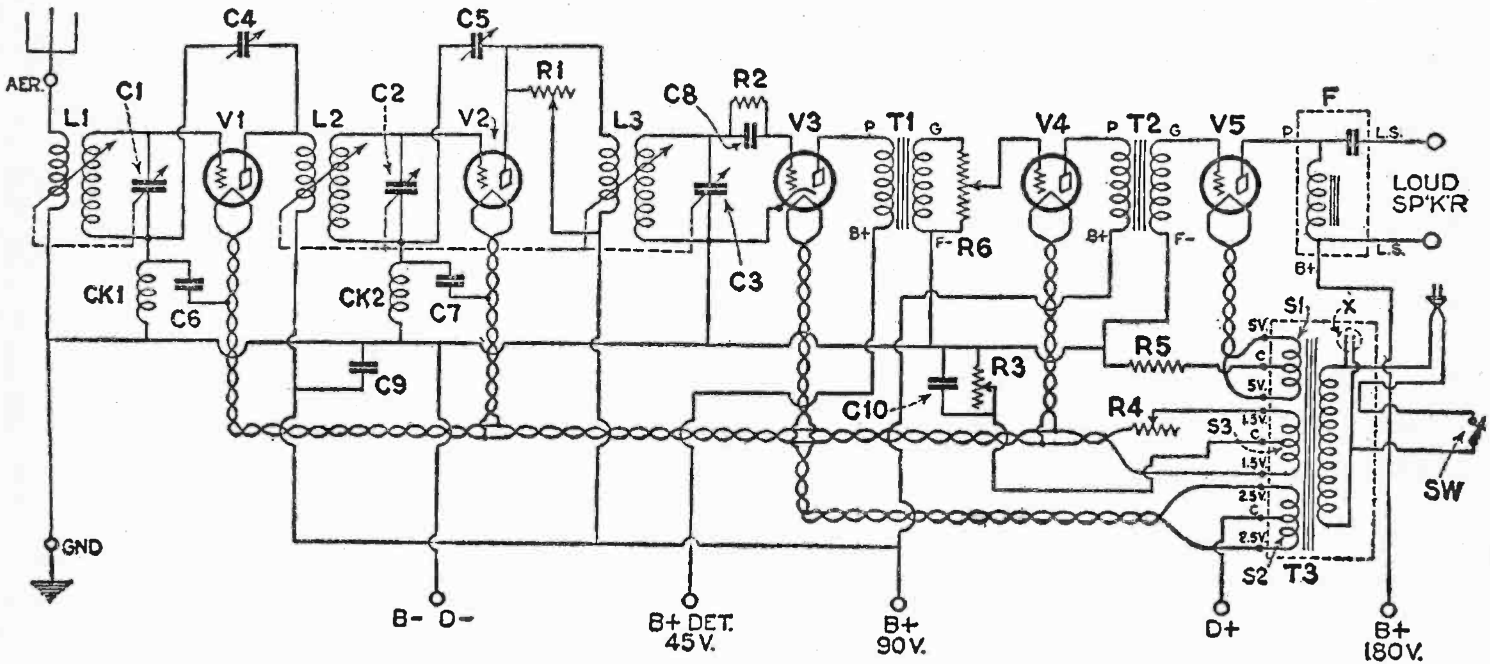
The intelligent use of compartment shielding is only one of the outstanding features of the 6-tube receiver whose circuit is shown above. Notice that in the radio-frequency amplifier circuits the plates obtain their plate potential through an r.f. choke, the regular plate coil being conected, through a variable condenser to the ground. In this single-control circuit, the constant-capacity-balance scheme of neutralization is one that makes of it a highly desirable receiver.



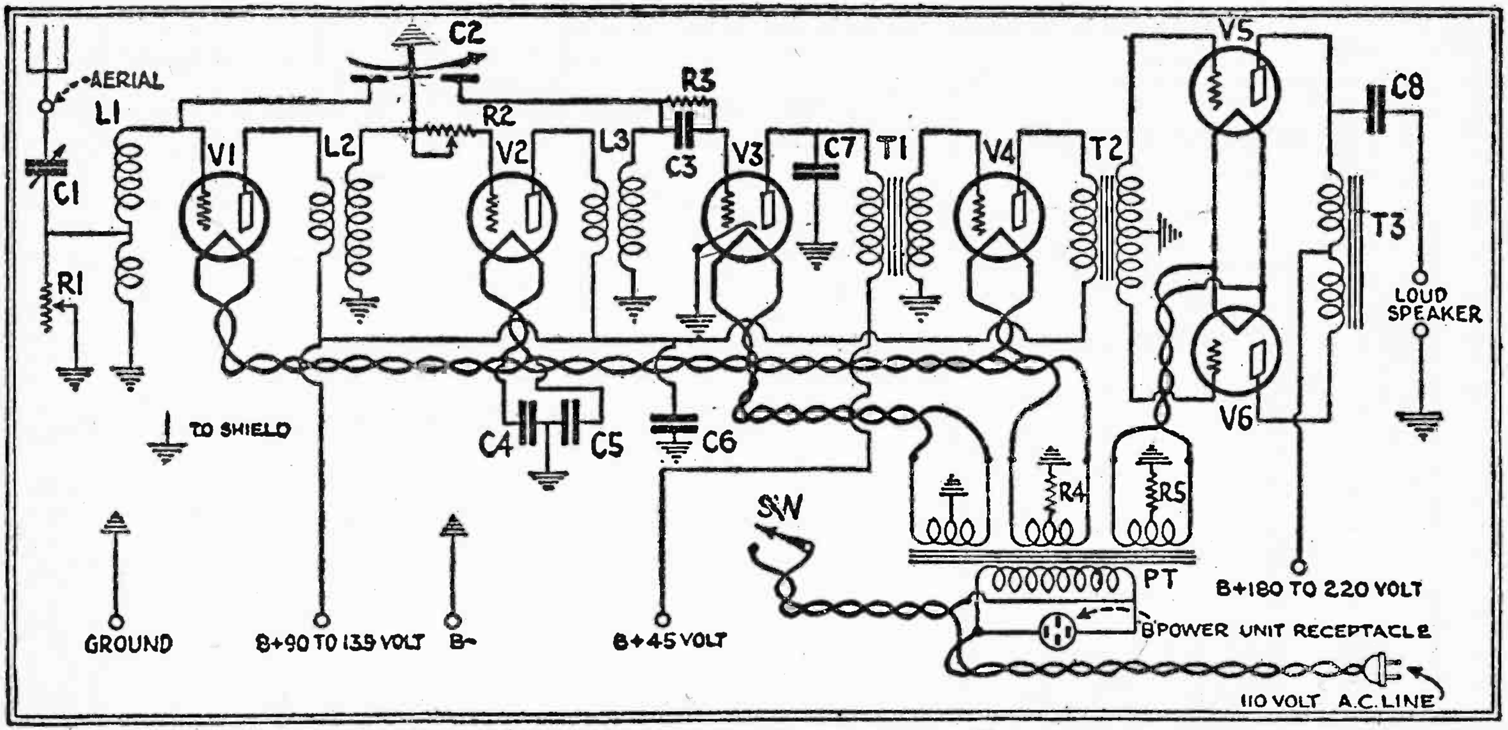
Here is given the complete schematic circuit diagram of a shield-grid super-heterodyne, such as is employed in the Tyrman Seven. The shield-grid tubes are used in the intermediate amplifier stages, while the regular -01A tubes are used in the oscillator and second detector stages. In the first audio stage may be used a 112A tube while in the power output stage it is well to employ a 171A tube with the B and C voltages as indicated.



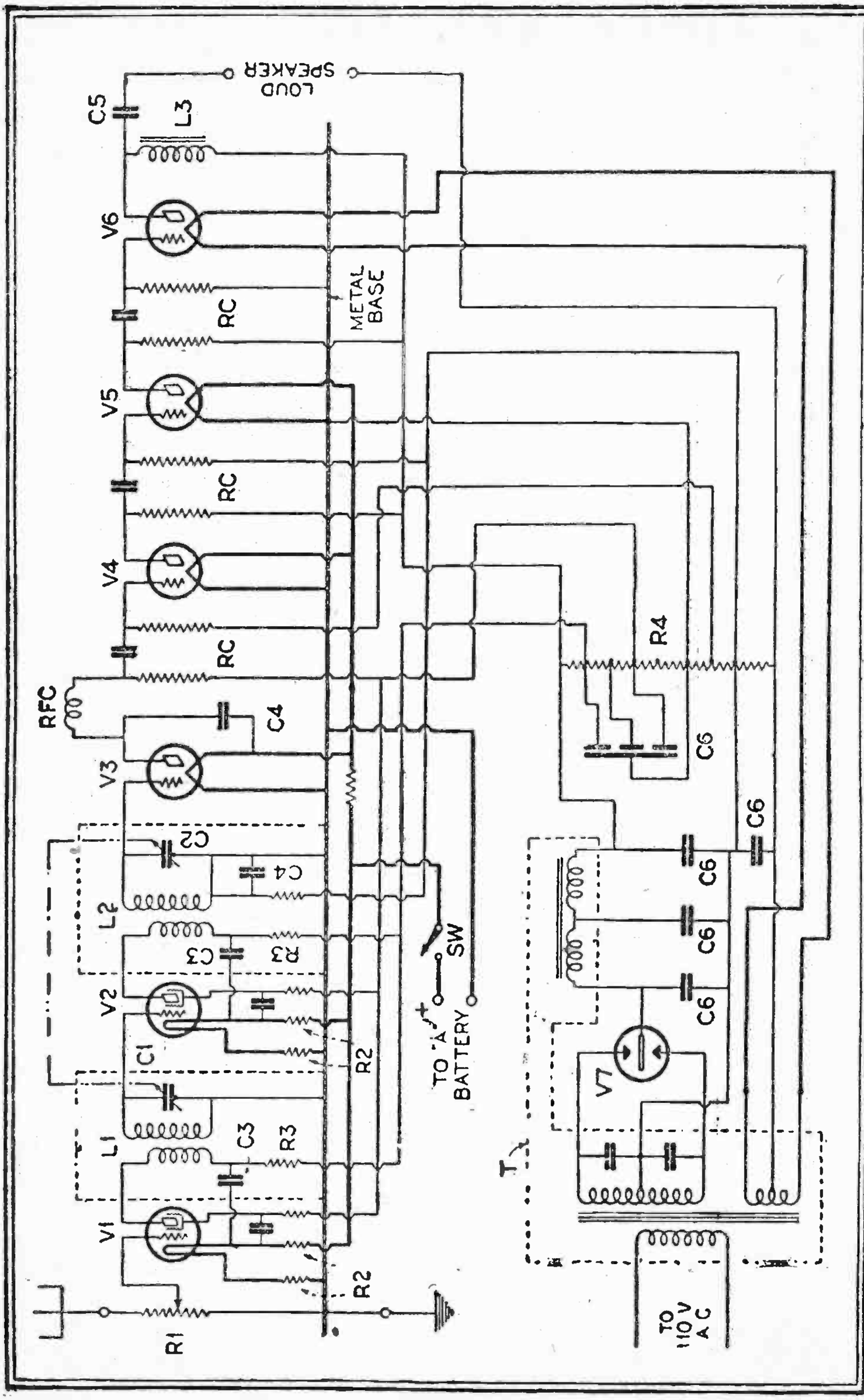
This is the circuit diagram for Taylor's Band-Isolator rece iver, which during the past year gained wide popularity. The Taylor Band-Isolator makes use of air-core tuning coils actua lly tuned to resonate at the adjusted frequency by means of a group of paralleled condensers, as shown.



An a. c. operated Karas Equamatic circuit is shown here. Automatically variable coupling between primary and secondary coils is maintained by the manual adjustment of the tuning condensers. Only the a.c. filament supply is shown, the B and C potentials being obtained externally from a suitable B-C supply device.

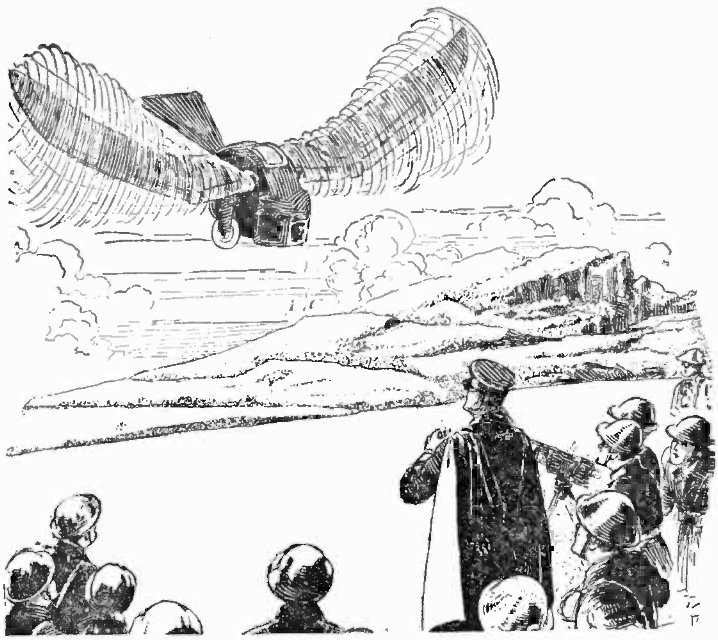


Still another type of a.c. operated receiver circuit. Here, both the a.c. filament and heater-cathode type of a.c. tubes are used. The tuner section is single-control. Note that, above, the conections of the circuit which return to ground are actually grounded to the chassis of the receiver.



Above, the circuit diagram of a receiver with power supply shows the use of the gaseous type of rectifier employed in the power supply.

NOTES AND CLIPPINGS



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