ATWATER KENT RADIO

SERVICE MANUAL

The following pages have been prepared with the idea of enabling the Atwater Kent Radio Dealer to more thoroughly understand the product he is engaged in merchandising, and to more readily locate and correct any condition which might interfere with the proper functioning thereof.

ATWATER KENT MANUFACTURING COMPANY
4700 WISSAHICKON AVENUE, PHILADELPHIA

ATWATER KENT RADIO SERVICE MANUAL

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Form No. Ser. D. 27.

INTRODUCTION

1. Purpose of Service Manual

The object of the Service Manual is to assist the retailer of Atwater Kent radio products in giving prompt and efficient service to the consumer-owner. Since in accordance with our Radio Service Policy, service on Atwater Kent radio products is to be handled by Atwater Kent dealers and distributors only, this publication should be considered confidential and except in special cases, is furnished only to regularly appointed outlets of Atwater Kent radio merchandise.

2. Importance of Service

Service has "come into its own" during the past few years and its importance is continually becoming more widely recognized. The value of prompt and courteous service by the dealer cannot be over-emphasized. Service is closely linked with sales—in fact the one depends on the other. The radio dealer who has foresight will build for the future by maintaining a neat and efficient repair department and employing a competent service personnel consistent with the size of his organization. There is no better step toward building good-will for Atwater Kent products in his immediate locality.

3. Dealer Service Procedure

The dealer who has a reasonably well equipped service shop will find that he is in a position to handle the servicing of practically any set which comes to him for repair, since the bulk of repairs will not be of a difficult nature.

In the event that he is unable to perform a certain repair, the set or unit should be returned to his local distributor, who maintains a complete service department similar to that of the factory. The distributor will furnish his dealers with complete instructions for return of material, such as making out of return report blanks and other routine in connection with the handling of service matters.

4. Dealer's Parts Stock

We strongly urge that every dealer carry in stock a supply of such repair parts as may be most commonly required for the more popular types of Atwater Kent sets and speakers. This will eliminate the possibility of a dissatisfied customer, resulting from the delay necessarily involved in ordering a part from the distributor.

Newly appointed dealers should consult their distributor regarding a suitable initial stock to be carried.

Repair parts must be purchased from the distributor. No parts are sold direct from factory to dealer.

5. Repair Charges—Warranty Repairs

The charge on a repair job for the consumer, on a set beyond the warranty, may be based on the consumer price of the repair parts used, plus a charge for the time required, at a definite rate per hour. The time charge will cover the time consumed in testing the set when repaired, and in calling for and delivering the set, if this is done.

Our factory warranty on new products, involves the replacement of parts defective in workmanship or material, and covers a reasonable length of time. Our distributors are notified by bulletin when certain models pass beyond the warranty period, so that in case of doubt, definite information can always be obtained from the distributor, as to whether a warranty adjustment is in order on a certain model.

In many cases the dealer will find it of advantage to adopt a written "Service Agreement" with the consumer, whereby a charge is made for service calls and repair work after a certain length of time. This will protect both dealer and consumer.

6. Service Policy

A complete printed "Service Policy," definitely outlining the factory's plan on service matters, is sent once a year to our distributors, and such information from this as is required by the dealer will be passed on to him by the distributor. A definite understanding between dealer and distributor on all matters pertaining to service will be the means of preventing much conflict and controversy. It cannot be too strongly urged that all instructions from the distributor be carefully followed, so that complete co-operation will exist. Written instructions, such as bulletins, etc., should be kept handy in a loose-leaf note book.

7. Service Literature

The dealer will do well to keep readily available, ALL literature pertaining to service which comes into his place of business. In addition to the bulletins from your distributor, the factory has a special "Dealer Bulletin Service" which contains various suggestions and ideas along service lines.

There are several excellent monthly radio trade publications which are invaluable to the retail dealer, both from a sales and service standpoint. We believe the small price of annual subscription to several of these magazines will be more than repaid by the excellent information and ideas they contain.

Two or three good text books on radio will also not be out of place on the dealer's book shelf. An easily understandable book on the theory of radio and a practical book on general radio service and repairing are suggested.

8. Factory Service Course

One of the best ways in which the recognized Atwater Kent dealer (or his service man) can familiarize himself more completely with the correct methods of servicing Atwater Kent radio products, is to spend a week or two in our factory Service Department. We have mapped out a "Course" of training to be followed in this work, which completely covers the various steps in repairing, assembling, and testing all models of our Sets, Speakers, and Power Units.

The "Service Course" takes from one to three weeks depending on the ability of the individual. There is no charge for the instructions, but the dealer will naturally furnish the transportation and living expenses connected with this visit to Philadelphia. A letter of introduction from the local distributor is required and must be presented at the factory for identification purposes.

Section I

THEORY OF RADIO BROADCAST RECEIVERS

Knowledge of Theory Essential

While the primary purpose of the Service Manual is to instruct the dealer in the testing and repairing of Atwater Kent receiving sets, **we believe that an understanding of the fundamental principles of radio and a knowledge of how our sets function will enable him to perform this work more intelligently.** It is, of course, essential to know what to do to correct troubles, but a knowledge of the theory and functioning of the various units of the set will enable the repairman to locate the trouble more readily. If an unusual condition arises in a set, a repairman without a knowledge of the principles involved, can correct the trouble by "hit-or-miss" methods only. The service man who has this fundamental knowledge can analyze the condition and then determine the remedy.

Fundamental Principles of Electricity Applied to Radio

Radio is based on electricity and a few of the elementary conceptions of its fundamental principles should be understood before going further. Electricity shows many characteristics of a fluid such as water, but unlike water, it apparently has no substance, and its presence can be determined only by the effect. Its force, quantity and other properties, however, can be determined and measured by electrical instruments.

In the pipe line shown in Fig. 1, there is a complete circuit of water which is flowing through the pipes as a result of the force exerted by the pump. The left-hand sketch is a diagram of an electrical circuit in which the electricity is flowing as a result of the force exerted by the batteries. There is a definite amount of water flowing in the pipe line and there is likewise a definite amount of electricity flowing in the electrical circuit.

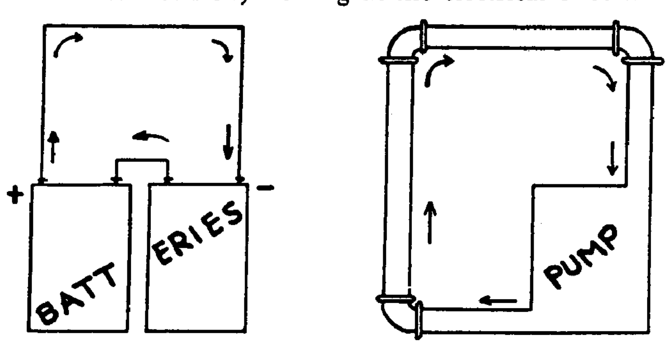

Fig. 1. Comparison of Electric Current with Water.

The quantity of electricity flowing is measured in units called amperes.

The water has a certain pressure forcing it through the circuit. The electrical circuit likewise has a definite pressure, which is measured in units called volts. In the water circuit there is a certain amount of resistance due to the friction offered to the water by the sides of the pipe. This resistance is obviously greater in a small pipe than in a large one. The electrical circuit likewise has a resistance depending upon the gauge of the wire, its length and the material of which it is made. Electrical resistance is measured in units called ohms.

In the diagram shown in Fig. 1, the water and electricity flow in one direction only. This type of electrical current and all currents produced by batteries is known as direct current.

Alternating Current

Alternating current may be compared to the sort of water flow illustrated in Fig. 2. Instead of being forced continuously in one direction by a pump, it is pushed first in one direction and then the other by the piston "P." If the rate at which the piston moves back and forth is constant, it corresponds to the frequency of an alternating current, which is generally expressed in "cycles" per second.

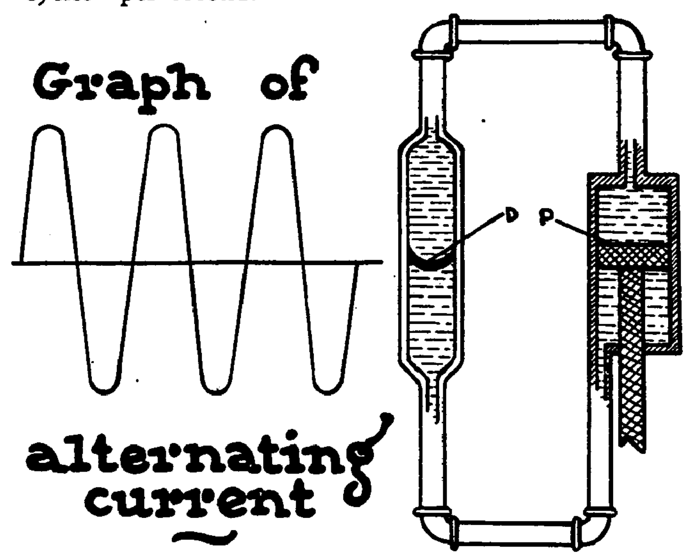

Fig. 2. Alternating Current is Similar to Alternating Water Flow.

The diagram (Fig 2) is a graphical representation of alternating current. The current is built up to a certain voltage in one direction, falls back to zero voltage, builds up an equal voltage in the other direction, and again returns to zero. The two directions are known as positive and negative, and alternating current consists of a series of such alternations in direction, expressed in cycles per second. In the case of "radio" frequency currents, these alternations are very rapid, the frequency ranging approximately from 500,000 to 1,500,000 cycles per second.

Condensers

The action of the flexible diaphragm "D" illustrates the action of a fixed condenser in a circuit of alternating current. The diaphragm would stop a direct flow of water, but allows it to surge back and forth. A condenser likewise acts as an insulator to a circuit of direct current, but not to a circuit of alternating current of high frequency. It will be seen later how this property of a fixed condenser is used in our receiving sets.

A condenser is fundamentally a unit for storing electricity, and its ability to do this is termed capacity, expressed in units called farads. This is a very large unit, however, and the practical unit of capacity is the micro-farad which is one millionth of a farad.

A fixed condenser (one of constant capacity) consists of two or more parallel metallic plates, which are separated from each other by mica, air or another insulator. The capacity of a condenser depends upon the number and size of the metal plates, the distance between them and the insulating material. In the case of our by-pass condenser, which must have a comparatively large capacity, the metallic portion consists of two layers of thin, pure tinfoil, separated by special impregnated linen tissue. The system of layers is then wrapped as shown in Fig. 3. A condenser made with mica insulators, having the capacity of this by-pass condenser, would be very impractical because it would necessarily be very large.

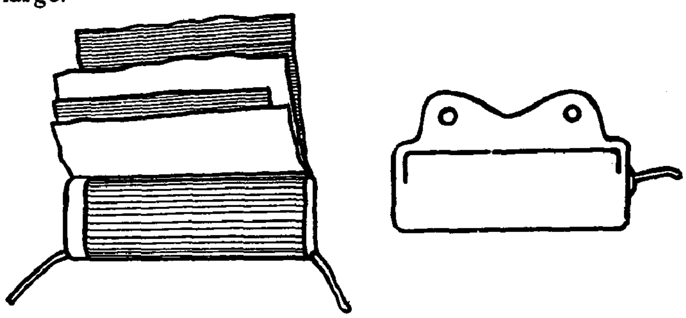

Fig. 3. Construction of Typical Fixed Condenser.

A variable condenser (Fig. 4) is so called because the capacity can be varied. This is accomplished by having two sets of metal plates interleaved with each other and one set revolving on a shaft so that any desired area of the plates can be interleaved. By turning the shaft and revolving one set of plates, the capacity of the condenser is changed to any desired amount within the limits of its total capacity.

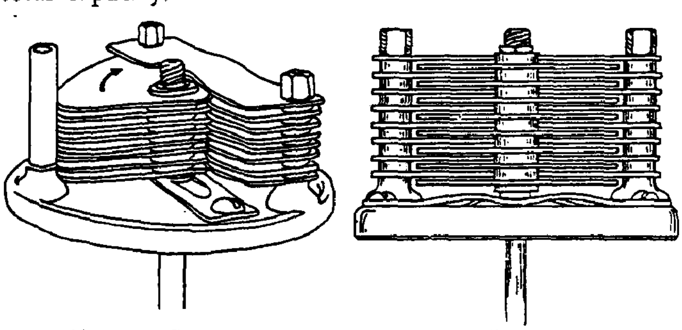

Fig. 4. Construction of Variable Condenser.

Transformers

Transformers are a very important part of a receiving set and when used in connection with a radio tube, serve as a method of amplifying the broadcast signal after it has been picked up. The theory briefly is this: A coil of wire which has an alternating, intermittent, or pulsating current passing through it, sets up a constantly changing electro-magnetic field (lines of force having both electric and magnetic properties). (See Fig. 5.) If another coil of wire is placed in this electro-magnetic field, a current will arise in and flow through this second coil, even though there is no physical connection to the first. This transfer of electric energy takes place by what is called "induction." The voltage "induced" in the second

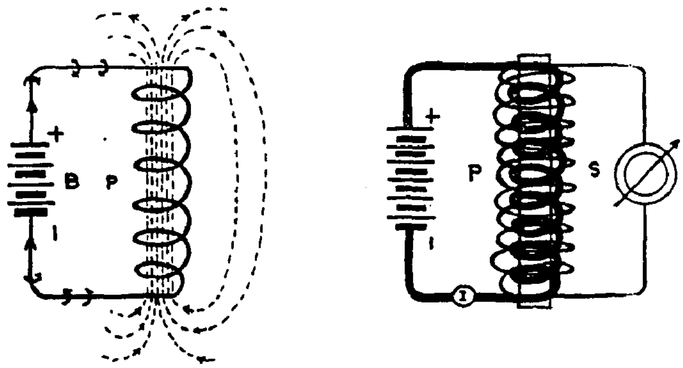

Fig. 5. Electromagnetic Induction—Action of a Transformer.

coil may be made considerably greater than that in the first coil by having a greater number of turns of wire in the second. For ordinary alternating and intermittent current, the two coils of wire (which are called primary and secondary) are wound around a soft iron core, which greatly strengthens the electro-magnetic field and increases the efficiency of the transformer. The two windings are insulated from each other and also from the core.

Audio Frequency Transformers

Our audio transformer No. 7661 (See Fig. 6) consists of a soft iron core made of a number of soft iron wires, a primary winding of about 6,000 turns of wire and a secondary of 15,000 turns of wire (gauge 40). The ratio of the number of turns of secondary to primary is 2.5 to 1, which is likewise the ratio of output to input. The first stage transformer (No. 8060) has a ration of about 4 to 1. (Fig. 7).

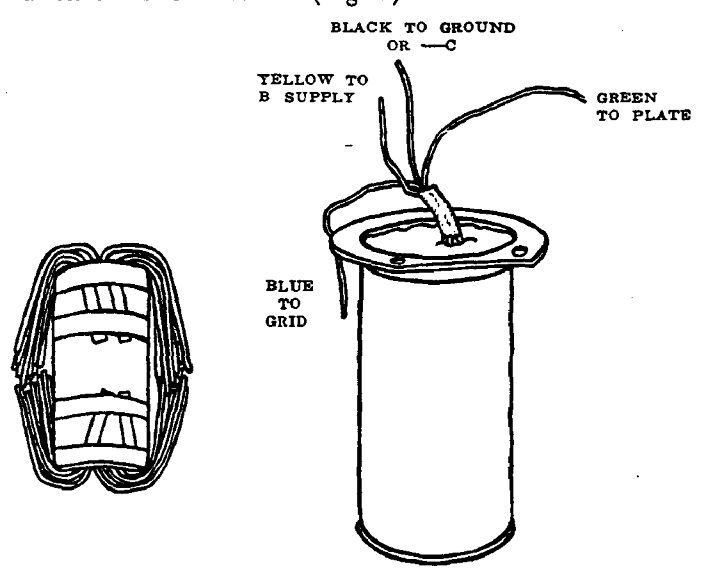

Fig. 6. An Atwater Kent Audio Frequency Transformer (2d stage).

The iron core of a transformer builds up an electro-magnetic field which varies the same as the current in the windings. However, an iron core cannot respond efficiently to currents which vary at a rate of over 500,000 cycles per second, which is the case of radio frequency current, and radio frequency transformers are, therefore, usually made without a solid core, and are termed "air-core" R. F. transformers.

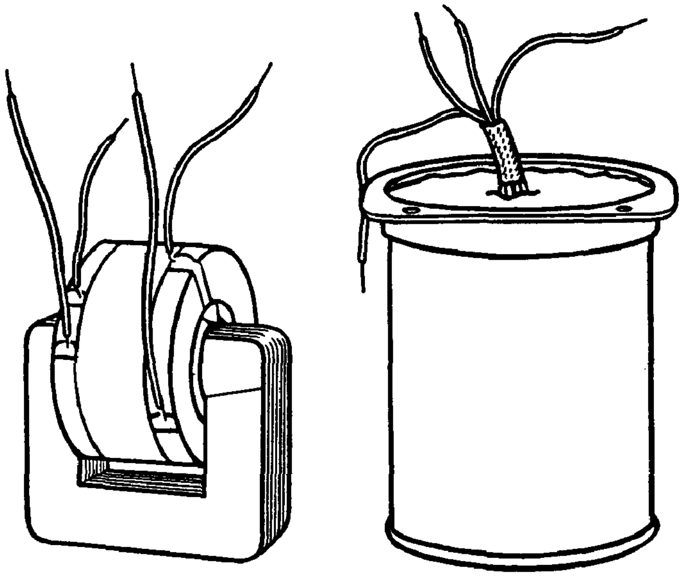

FIG. 7. ANOTHER TYPE OF ATWATER KENT AUDIO TRANSFORMER (1st stage).

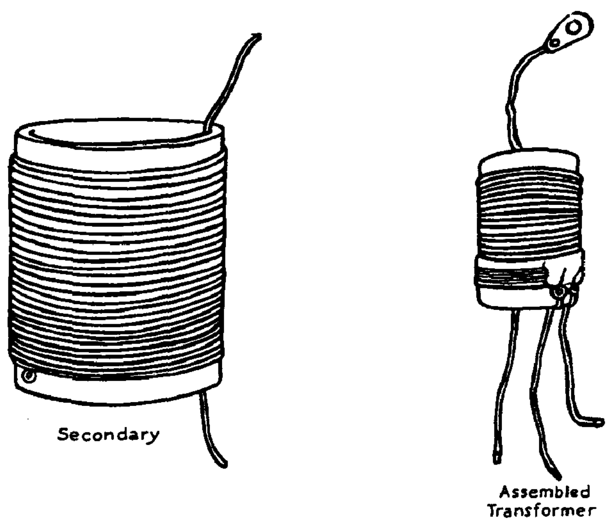

FIG. 8. TWO TYPES OF ATWATER KENT RADIO FREQUENCY TRANSFORMERS.

Fig. 8 shows the types of transformers used in our sets to amplify the radio frequency signals. As can be seen, these transformers do not have an iron core.

Radio Tubes—Construction

The radio tube is undoubtedly one of the most important units used in radio reception. We are all more or less familiar with the external appearance of common radio tubes, and in Fig. 9, we see how the tube is constructed internally. Most of the present-day tubes are vacuum tubes, but some of special type are filled with a rare gas which is chemically and electrically inactive. The filament of a vacuum tube is made of tungsten, thoriated tungsten or other metals coated with a chemical, which, when heated, emits electrons (negatively charged particles) in a vacuum. Tungsten, when it contains thorium, emits a greater number of electrons at a given temperature than plain tungsten, and consequently requires less current. The plate is made of thin metal,

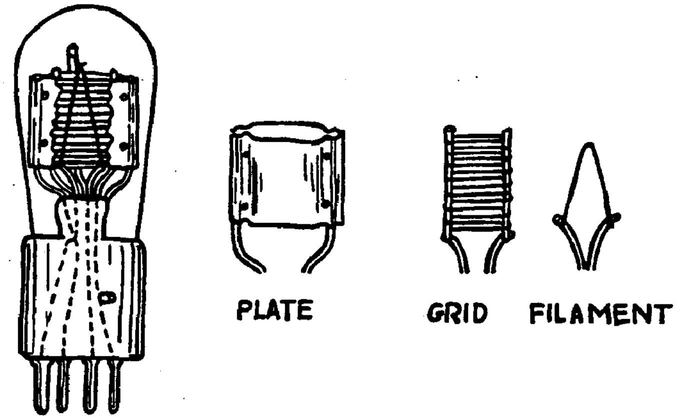

FIG. 9. CONSTRUCTION OF A TYPICAL RADIO TUBE.

stamped in the form shown in the illustration. The grid is of fine wire, so placed that it forms a sort of lattice work between the filament and the plate.

Internal Action of the Tube

The diagram on the right (Fig. 10) is a schematic symbol representing a vacuum tube. The diagram on

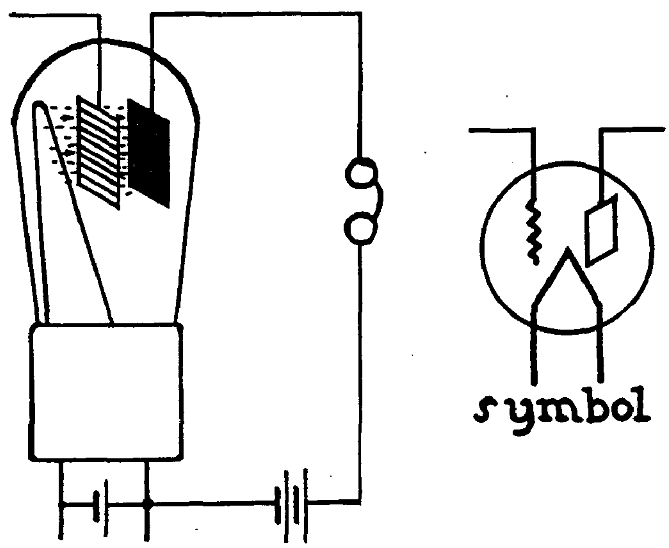

FIG 10. PATH OF FLOW OF ELECTRONS IN VACUUM TUBE.

the left is also more or less schematic, so as to show more clearly just how the tube functions. The two ends of the filament wire are attached to the "A" or storage battery, which heats the wire so as to create the desired amount of electronic emission. These electrons would ordinarily fly off in all directions, but the plate of the tube being connected to the positive side of a "B" battery, has a high positive potential, and the electrons are attracted by, and flow to the plate. The grid is placed between the filament and the plate, and when the potential on the grid is comparatively positive it assists in causing the electrons to flow to the plate. When the grid is negative it repels the electrons on their way to the plate and when sufficiently negative, may stop the flow.

The negative side of the "B" batteries is connected to the filament and as mentioned before, the positive side is connected to the plate. In the particular illustration shown there is also a 'phone unit placed in the circuit. When a stream of electrons flows between the filament and plate, the "B" battery circuit is completed across this gap and a current passes through the 'phone unit. However, as previously stated, the potential on the grid determines the intensity of the electron stream between the filament and plate, consequently as the potential on the grid varies, the current in the plate circuit and therefore in the 'phone unit also varies. The incoming broadcast signal is the factor which causes the potential of the grid to vary. Thus the current in the broadcast transmitter, varied by a voice or sound in a microphone at the broadcasting station and radiated in the form of high frequency alternating current, eventually controls the current which flows through the speaker unit at the receiving set and similar sounds are consequently reproduced. As a small voltage impressed on the grid controls a large current in the plate circuit, the tube may be used as a means of amplifying radio signals.

Action of Tube as Detector

The radio frequency currents which pass into the set from the antenna are of extremely high frequency, between 500,000 and 1,500,000 cycles per second. If a speaker unit were installed directly in this circuit with the current varying with such rapidity, it would be mechanically impossible for the diaphragm to respond to the variations in current. If it did respond, the pitch of the sound waves created would be so high that the sound would not be audible to the human ear.

It is, therefore, necessary to convert the radio frequency current to an audio frequency current which will operate a speaker unit and produce sound waves audible to the human ear. This is accomplished by the detector tube, which through the action of the grid condenser and grid leak, rectifies the radio frequency current. The potential on the grid of this tube is affected not only by the alternations of the radio frequency signal, but also by the charge which is stored up by the grid condenser. The current produced in the plate circuit of this tube has the same characteristics as the radio frequency current, but at a lower frequency.

Principles of Radio Wave Transmission

Some of the fundamentals of electricity and the units used in a radio set have now been discussed, and the question that arises in the minds of many is, "How does the radio frequency current generated by the broadcasting station reach the receiving set?"

Electrical energy in the form of a radio frequency wave which has been modulated by a voice or music, is radiated in all directions by the broadcasting antenna.

An analogous mechanical phenomenon will illustrate what takes place. When a tuning fork is made to vibrate, waves are sent out and any tuning fork within range having the same period of vibration will be affected and start to vibrate also. The tuning fork "A" (Fig. 11) is caused to vibrate by striking it, and the tuning fork "B," which has exactly the same period of vibration as the tuning fork "A," also starts to vibrate. The tuning fork "C," however, has a different period of vibration and is therefore not affected.

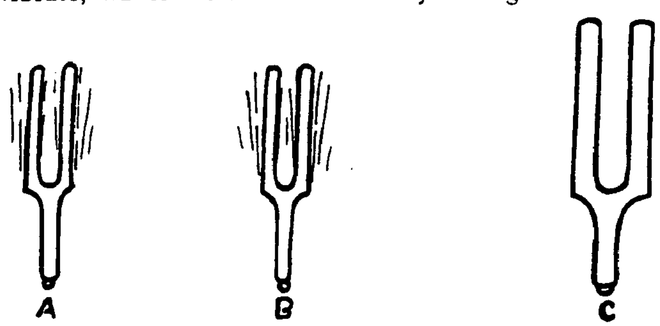

FIG. 11. TRANSFER OF MECHANICAL VIBRATIONS BETWEEN UNITS HAVING SAME FREQUENCY OF VIBRATION.

Purpose of the Antenna

A similar action takes place in the broadcasting and reception of radio. The radio frequency wave radiated by the broadcasting antenna sets up a corresponding radio frequency current in the antenna of a receiving set when it is tuned to the same frequency. The frequency of the wave is expressed in kilocycles or wave length, and since the tuning devices in the receiving set enable us to change the period of vibration or frequency of the set, we are able to receive waves from any broadcasting station within range. The radio frequency current in the broadcasting antenna is of such high frequency that a wave of electrical energy is radiated from it, and if the receiving antenna has the same period of vibration, it responds to this wave in such a way that a radio frequency current is set up in the antenna circuit. The purpose of the receiving antenna is therefore to convert the waves of electrical energy that are in the air to radio frequency current in the receiving set.

The alternating currents set up in the antenna circuit are of extremely high frequency, ranging between 500,000 and 1,500,000 cycles per second. As mentioned before, it is impossible to convert alternating current of such high frequency directly into sound waves, and it is therefore necessary to convert this current to a pulsating current of audio frequency. We have already explained how this is accomplished by the action of the detector tube.

Necessary Elements of Receiving Set

From the various points discussed so far, we can see that the simplest receiving set would consist of an antenna, to convert the electrical energy to radio frequency current; a tuning device, to bring the set to resonance with the desired wave; a detector, to convert the radio frequency current to an audio frequency current; and a 'phone unit to convert the audio frequency current to sound. It is highly desirable to amplify the signals received so that the sound waves produced will be of considerable strength.

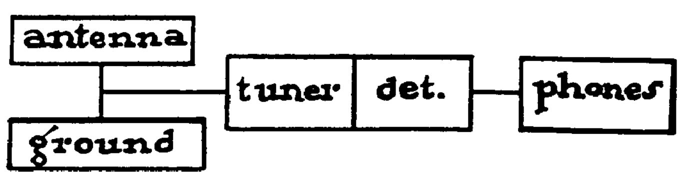

FIG. 12. FUNDAMENTAL UNITS OF A RECEIVING SET.

Circuit and Construction of Model 20 Compact Set

The Model 20 Compact three-dial receiving set has two stages of radio frequency amplification, a detector and two stages of audio frequency amplification. In explaining what takes place in each stage, schematic diagrams will be referred to using the symbols shown in Fig. 13.

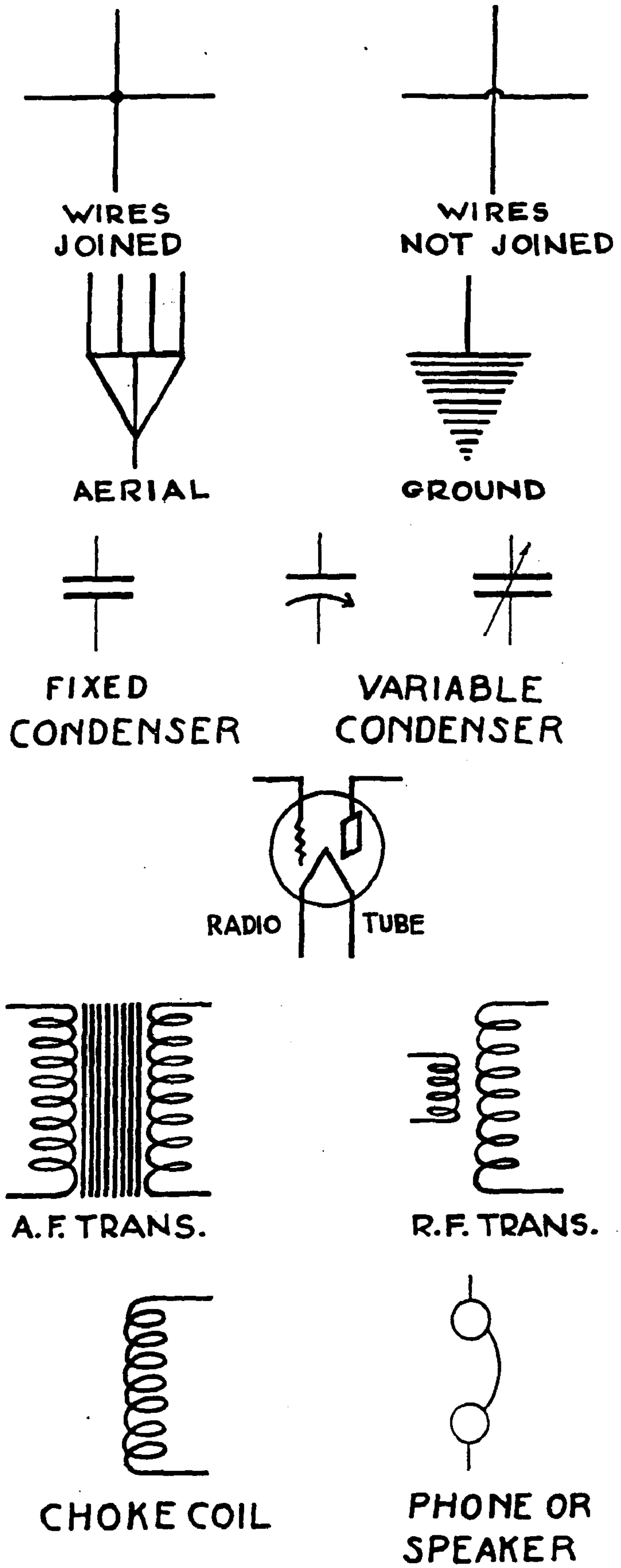

FIG. 13. SYMBOLS USED IN SCHEMATIC RADIO DIAGRAMS.

Referring to Fig. 14, the antenna circuit, which consists of aerial, primary of the first radio frequency transformer and ground, converts the waves of electrical energy in the air to radio frequency current. The aerial wire and the primary winding of the transformer give this circuit a certain amount of inductance. In general, and up to a certain limit, a long aerial and considerable inductance in the coil winding will pick up the greatest amount of energy. Too much inductance, however, lessens the selectivity and since it is impractical to shorten or lengthen the aerial wire to regulate this, we change the number of turns in the primary winding of the first coil by means of the tapped switch and thus accomplish the same thing. Placing the switch blade on the first tap (Fig. 14), puts fewer turns of wire in the circuit and increases the selectivity at a slight sacrifice in volume. Using the third tap, which uses all the turns of wire of the primary winding, increases the volume considerably, at a sacrifice of selectivity. The center tap is a medium between the first and third.

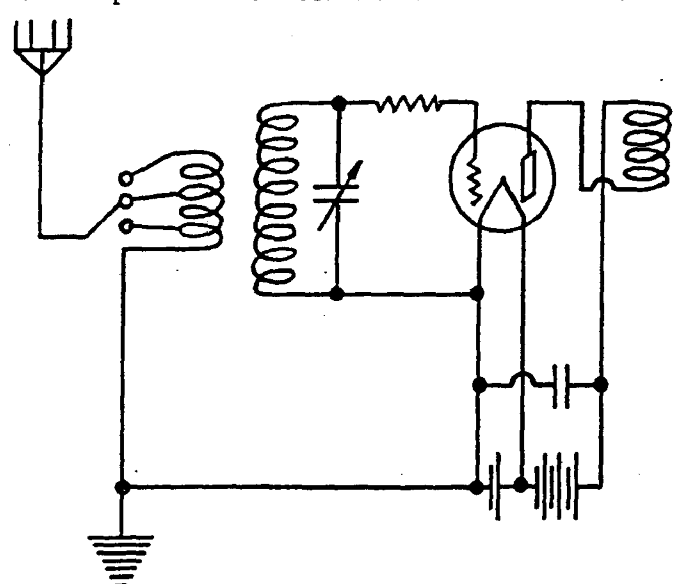

FIG. 14. ANTENNA CIRCUIT AND FIRST STAGE OF R. F. AMPLIFICATION—MODEL 20 COMPACT.

Detector Circuit—Action of Grid Leak and Condenser

After passing through the three radio frequency circuits, the signal which is still a radio frequency current as it was originally set up in the antenna circuit, but considerably amplified by the R. F. transformers, is impressed upon the grid of the detector tube (Fig. 15). The function of this tube as explained under tube action, is to rectify the radio frequency current to a pulsating current of audio frequency, and which has the same characteristics as the original current. This tube may be the same type as those used for amplifiers and the fact that it rectifies the current, instead of merely amplifying it, is due to the action of the grid condenser and grid leak. The grid condenser collects a charge and the accumulated charge is impressed upon the grid of the tube. The grid leak prevents this charge from becoming too great by allowing it to leak off slowly to the filament circuit.

The grid leak is connected to either the positive or negative filament circuit, but experiments by our laboratory have shown that the detector circuit offers least resistance to weak signals when the grid leak is connected to a slightly negative potential. To accomplish this, a fixed resistance of about 450 ohms is installed directly across the positive and negative filament circuit, and the grid leak is connected to the two-fifths point, nearest the negative side.

The radio frequency current impressed on the grid of the detector tube is, by the above process, rectified to an audio frequency current in the plate circuit of this tube,

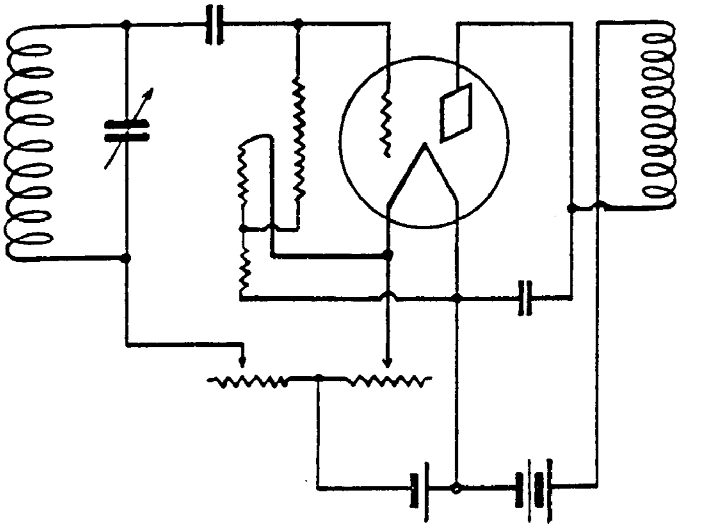

Fig. 15. Detector Circuit.

and if a 'phone unit were connected in series with this circuit, the broadcast signal would be converted to sound. However, for purposes of loud-speaker reproduction, it is desirable to amplify this signal to greater strength, and accordingly the primary winding of an audio frequency transformer is placed in this circuit instead. This plate circuit is completed through the "B" battery to the filament circuit.

Purpose of "'Phone Condenser"

There is a small component of radio frequency current which is passed to the plate circuit of the detector tube from the grid circuit. If this current were allowed to pass through the "B" batteries and audio transformer with the audio frequency current, it would cause some distortion. A small fixed condenser called a 'phone condenser is therefore connected between the plate and the filament of the detector, which shunts this radio frequency current across the audio transformer and "B" batteries. No direct current from the batteries and none of the audio frequency current can go through this condenser.

Action of Audio Frequency Transformers

The pulsating current in the primary circuit is induced and amplified in the secondary circuit and is again impressed upon the grid of the next tube (Fig 16). It is amplified to the plate circuit of this tube, in which circuit is placed the primary of the second audio frequency transformer. The signal is then induced and amplified in the secondary of this transformer and is again sent into the grid circuit of the next and last tube. The sound unit of the radio speaker is installed in the

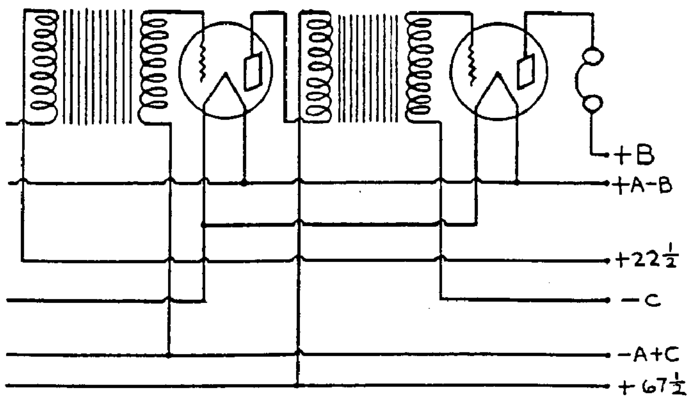

Fig. 16. Audio Frequency Circuit.

output or plate circuit of this second audio frequency amplifier tube, and the variations in current cause the diaphragm to vibrate and send out sound waves which have the same characteristics as the wave of the pulsating current sent through the sound unit. The characteristics of this electrical current were determined by the sounds sent into the microphone at the broadcasting station. The theory and construction of speaker units is described in Section X of this Manual.

Use of "C" Battery

One lead from the secondary of the first audio transformer is connected to the grid of the following tube and the other lead, called the grid return, is connected to the filament of the same tube. The grid return of the second audio transformer, however, is connected to the filament of the last tube through a "C" battery, this grid return being connected to the negative side of the battery. As explained under tube action, the potential on the grid of the tube determines the flow of "B" battery current across the plate and filament, the flow being less when the grid is comparatively negative. By placing a negative potential supplied by the "C" battery on the grid, considerable "B" battery current is saved, and amplification without distortion obtained.

Power Tubes

Power tubes are tubes especially designed to handle the considerable volume of signal reaching the last stage of audio amplification and at the same time give improved tone quality. They require additional "B" battery voltage on the plate, and also a fairly high negative voltage on the grid, to prevent the tube from becoming overloaded, which would cause distortion. The "C" battery is connected so as to operate on the last tube only, so that the desired negative voltage may be used on the grid of this tube without affecting the first audio tube, which would not function properly if used with the negative grid voltage required by a power tube.

Grid Resistances and By-pass Condenser

Two units which have not as yet been discussed and which are essential to the operation of the set are the grid resistance unit and by-pass condenser. A grid resistance is connected in the grid circuit of each of the radio frequency amplifier tubes and is one of the means used to keep these tubes stabilized.

The by-pass condenser is shunted across the "B" power supply of the radio frequency tubes and allows the plate circuits of these tubes to be completed directly to the negative filament circuit. This likewise assists in stabilizing the set and preventing distortion.

Filament Connection of Tubes

There are two fundamental methods of connecting several electrical units in the same circuit, namely **series** and **parallel** (see Fig. 17). Each method has its own particular advantages and is used accordingly. In the case of a parallel connection of units, each unit can receive the voltage of the source of current and can be operated and controlled independently of the others. For this reason the tubes in our sets, in fact in most radio sets, are connected in parallel (see Fig. 19).

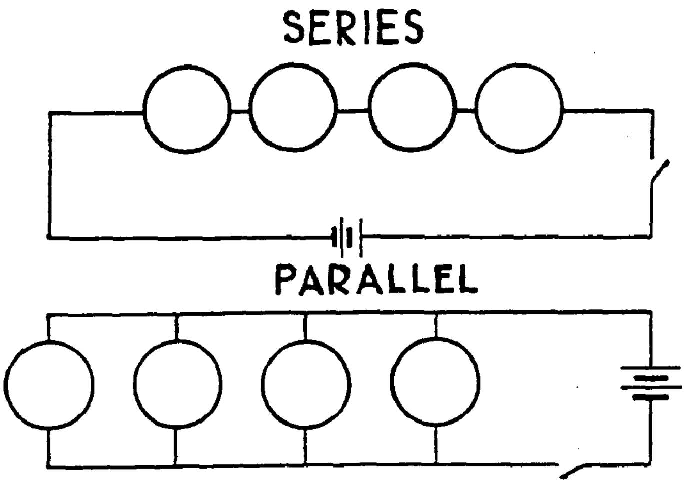

Fig. 17. The Two Fundamental Methods of Connecting Several Electrical Units Together.

Arrangement of Rheostats

A variable resistance, or rheostat, is connected in series with one of the main filament battery leads to the radio frequency tubes, which permits the control of the filament current supplied to these tubes independently of the other tubes. Another rheostat is connected in series with the detector tube to control it separately.

The audio frequency tubes require a definite voltage to operate at maximum volume. A lower voltage will reduce the volume, but while this is sometimes desirable,

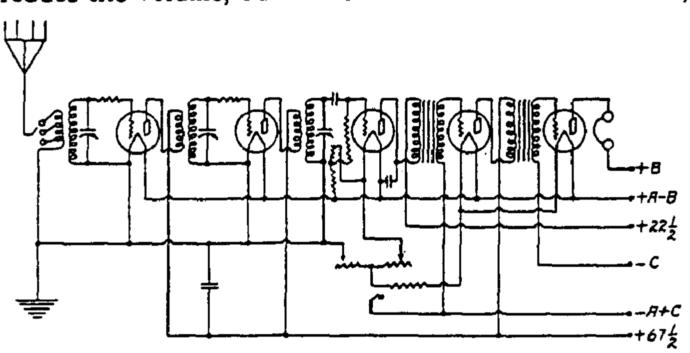

Fig. 18. Schematic Wiring Diagram of Model 20 Compact Set.

it also impairs the tone quality. A higher voltage does not improve the tone or the volume and our sets are therefore equipped with a fixed resistance rather than a rheostat for these audio tubes. The volume of the set is readily controlled by the radio frequency rheostat.

Plate Voltage on Different Tubes

The plate of each tube is connected through the primary of the transformer following it, to the positive side of the "B" batteries. Tubes functioning in different circuits of the set required different plate voltages and the plates are therefore connected to different terminals of the source of "B" voltage (batteries or "B" power unit). The plates of the radio frequency tubes and the first audio tube are connected to positive 67½ volts, the detector to 22½ volts, and the last audio tube to plus 90 or a higher voltage, according to the type of tube used.

Model 30—Circuit and Operation

The general circuit of the Model 30 set (Fig 19) is very similar to that of the Model 20 Compact No. 7960,

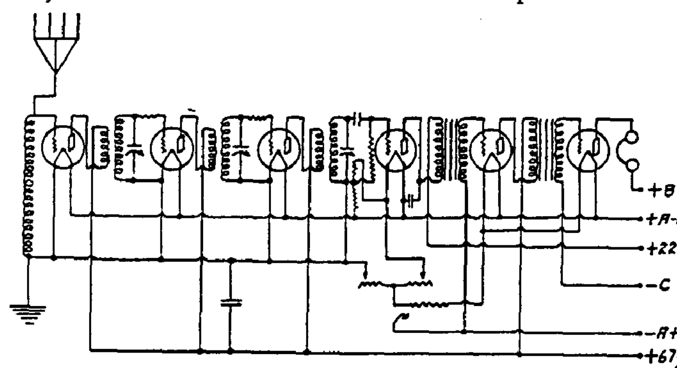

Fig. 19. Schematic Wiring Diagram of Model 30 Set.

but being operated by one dial, certain additions are necessary. The radio frequency transformers are substantially the same as those in the three-dial sets and have approximately the same inductance. However, these transformers are not taken indiscriminately and installed on sets, but each set of coils is selected after their inductances and other characteristics have been determined by special apparatus. A set of variable condensers is likewise carefully selected to be used with these transformers.

"Synchronizing" the Condensers

The variable condensers are controlled simultaneously by having the rotor shafts driven by belts, which are connected to a common pulley, which is turned by the single or center dial (Fig. 20). As the dial is turned, the capacities of the three variable condensers are changed uniformly, and the respective circuits which they tune are all brought into resonance with the same frequency of current. Because these condensers and transformers have all been accurately matched, this condition holds good over the entire wave length band.

Condensers, so adjusted that one movement will tune all their circuits, are termed "synchronized." The method used in the Atwater Kent single-dial sets is licensed under Hogan Patent Number 1014002.

On the three-dial sets it was observed that as the condensers were tuned for various wave-lengths, the dial settings of the three condensers were approximately the same. By the system of matching already explained, the slight difference in setting is overcome, and synchronism is established.

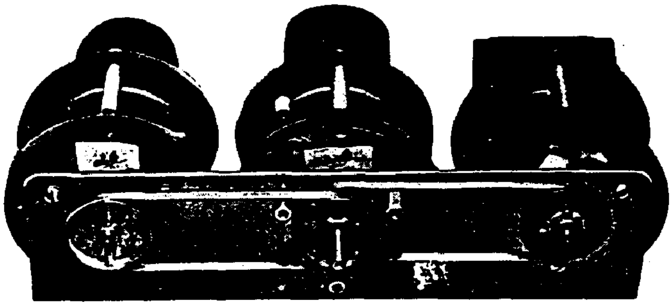

FIG. 20. METHOD OF CONNECTING VARIABLE CONDENSERS BY BELTS.

Eliminating the Antenna Tuning Device

It was also observed in the case of the three-dial receivers that the setting of the first dial varied according to the length of the aerial used, while the other two dial settings were unaffected. Since we cannot tune the aerial circuit independently in a one-dial receiver, we must overcome this condition in some other way. An additional tube, which is installed in the antenna circuit, takes care of this.

This tube has very little value in amplifying the signals, being used simply to transfer all signals from the antenna circuit to a position where any desired one can be selected and amplified to maximum by the synchronized tuning control before it reaches the detector. It also eliminates the effect of the antenna circuit on the tuning of the succeeding circuits by the dial.

Model 35

The Model 35 set is considerably different from the Model 30 in the mechanical design, which requires certain changes in the electrical design. The circuit, however, is identical with that of the Model 30, with the exception of the detector rheostat. (Fig. 21.) In the other sets, the radio frequency tubes are controlled by one rheostat, the detector tube by another, and the audio exception of the detector rheostat. (Fig. 21.) In the set, the radio frequency tubes are controlled by a rheostat, and the detector and audio frequency tubes are controlled by a fixed resistance.

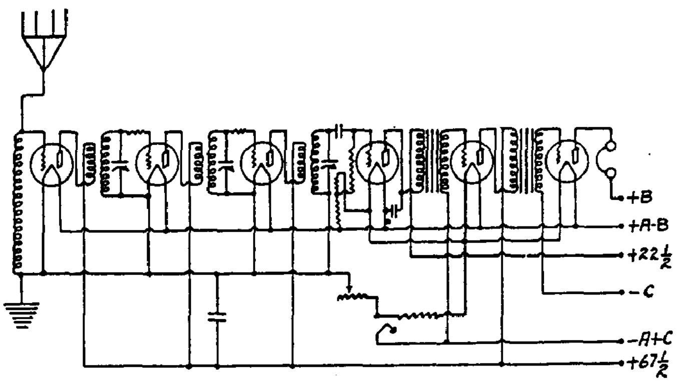

FIG. 21. SCHEMATIC WIRING DIAGRAM OF MODEL 35 SET.

Model 32

The Model 32 set has an additional stage of radio frequency amplification which necessitates a fundamental change in the type of radio frequency transformer used. In the Model 20, 30 and 35 sets, which have three radio frequency transformers, the transformers are mounted at right angles to each other, to prevent an electrical coupling between them. However, the Model 32 set has an additional radio frequency transformer, and since there are only three mutually perpendicular planes, we must use a different method to prevent a coupling between these transformers.

The circuit and functioning of this set is identical with that discussed for the Model 30, except for the additional stage of radio frequency amplification, which requires an additional transformer, tube socket and variable condenser. This stage of R. F. amplification increases the selectivity, sensitivity and volume of the set. The extra condenser is tuned by a third belt, also connected with the main or single control dial shaft. There are therefore three belts controlled by the tuning dial of the Model 32.

Model 33

The Model 33 set is a six-tube outfit, combining some features of both the Model 20 Compact and the Model 30 sets. It has three stages of radio frequency amplification, controlled by a single dial similar to the Model 30. However, instead of the untuned antenna circuit, an inductance or antenna coil is connected between the antenna and ground and provided with two taps connected to binding posts, so that part or all of the coil can be placed in the circuit, depending on the length of the antenna used. In addition to this, one of the rotary plates of the first variable condenser is controlled by a separate small knob at the left side of the panel, so that perfect resonance is obtainable in the antenna circuit regardless of the length of antenna. This set is therefore more selective than the Model 30, and easier to tune than the Model 20 Compact, at the same time being more efficient than either. A schematic diagram of the Model 33 will be found in Section VI of this Manual.

A.C. Type Receivers

During the summer of 1927 a new type of tube was developed, the outstanding characteristic of which was the fact that it was designed to operate with alternating current on the filament instead of direct. The producing of these tubes meant that it was possible to design a set to operate direct from the A. C. electric socket without batteries, since the only necessary step was to reduce the voltage of the A. C. line to the correct value for the tube filaments, which is easily accomplished by means of a "step-down" transformer. The B voltage requirements of these tubes being practically the same as those of the previous type D. C. tubes, the incorporation of a B power unit in the set along with the step-down transformer results in a completely light-socket-operated set.

The theory of function of the A. C. tubes is very similar to that of the D. C. tubes, and will not be discussed here. In general performance they compare very favorably with the D. C. tubes. The filament voltage requirements are slightly different, however, an A. C. voltage of 1½ being required for the amplifier tubes and 2½ volts for the detector tube. The power tube used is a regular D. C. type requiring the standard 5 volts, since by the use of a center-tapped resistance across its filament terminals, the effect of the A. C. fluctuations is effectively balanced out in this particular circuit.

The A. C. detector tube differs from the D. C. tubes in having an extra element known as the "cathode." This necessitates a five-prong socket for this tube. The cathode is a cylinder of special metal surrounding the filament, and performs the same function as the filament in a D. C. tube. The filament in the A. C. tube is used only to warm the cathode so it can function. Owing to the material and construction of the cathode, a period of about 30 seconds after the set is turned on, is required before it warms sufficiently to function and allow signals to come through the set.

Power Units In the A.C. Receivers

The power units used in Atwater Kent A. C. receiving sets furnish direct current "B" supply for the plate circuits, direct current "C" supply for the grid circuits, and alternating current of the proper values for the filaments of the A. C. tubes. Every power unit consists of the following essential parts:

(1) **A power transformer** to change the voltage of the 110 volt A. C. line to the required higher and lower values. This transformer has a primary, a high-voltage center-tapped secondary winding, a low voltage secondary winding for the filament supply of the rectifier tube, and three other low voltage secondary windings for the filament supply of the receiving tubes.

(2) **A double-wave filament-type rectifying tube** that converts the high voltage A. C. to pulsating D. C. The tube has two separate plate electrodes which are connected to opposite ends of the high-voltage winding. The center tap of this winding is connected to ground, which is equivalent to —B. When the outside circuit between the filament of the rectifying tube (equivalent to +B) and the center tap of the high voltage winding is completed through the filter and the plate circuits of the radio set, electrons flow from the filament to whichever plate is positive. As the rectifier plates are alternatively positive, electrons flow from the filament almost continually. This flow of electrons constitutes a steady flow of pulsating direct current.

(3) **A filter section** consisting of audio frequency chokes and high-capacity fixed condensers, serving to smooth out the pulsating direct current delivered by the rectifying tube and make it pure and noiseless in action.

(4) **Resistances** of the correct value to reduce the high rectified voltage to the values required by the first A. F. and detector plate circuits. By-pass condensers are connected to these resistances.

(5) **A grid bias resistance** connected between the ground and the second A. F. filament circuit, and another bias resistance connected between the ground and the R. F.—first A. F. filament circuit. The plate currents flow through these resistances and cause a voltage drop across them, the filament end of each resistance being positive with respect to the ground end. By connecting the grid return leads of the amplifying tubes to ground, the grids are maintained at a negative voltage with respect to the filaments.

(6) **Three separate "step-down" filament windings** or secondaries on the power transformer. These reduce the 110 volt A. C. supply to the voltages required by the filaments of the tubes, about 1½ volts for the R. F. and first A. F. filaments, 2½ volts for the detector filament, and about 5 volts for the second A. F. filament.

Connections between the filament circuits and the set are made to a center tap on resistances of low value shunted across each filament supply winding. The purpose of these center-tapped resistances is to provide a neutral voltage point which does not vary in value. The voltage on either side of the filaments is alternating (A. C.), and if the grid-return leads were connected to either side of the filament circuits, this A. C. voltage would be impressed on the grids of the tubes, causing a loud hum in reception. The center tap on each shunt filament resistance is like the pivotal or center point on a see-saw, it does not move up or down, but remains steady.

(7) **A speaker or output choke.** One end of this choke is connected to the rectified and filtered high voltage supply and the other end is connected (through the set cable) to the plate of the second A. F. tube. The choke offers but little resistance to direct current, but it has a high effective resistance or impedance to audio frequency variations, tending to make audio frequency variations of the plate current flow through the speaker, which is coupled to the plate of the second A. F. tube through a fixed condenser (the speaker filter condenser). The return lead from the speaker is connected to the center tap of the second A. F. filament shunt resistance. With this arrangement no direct current flows through the speaker, but only the audio frequency or A. C. component of the plate current.

(8) **A panel assembly** which contains the terminals for connection to the cable card of the receiving set. On all power units except that used with the early Model 36 sets, the grid biasing resistance and the plate circuit and filament shunt resistances also are mounted on this panel.

(9) **A line voltage regulating resistance** is used on some of the recent models. This resistance is connected in series with one side of the 110 volt supply line, and it serves to maintain a constant voltage across the primary of the power transformer, automatically compensating for line voltage variations and fluctuations. The resistance of this regulator increases if the line voltage increases above normal, and the resistance decreases if the line voltage goes below normal. This device is mounted on the left-hand side of the power unit container.