CHAPTER FOUR

ASSEMBLY OF RECEIVING SETS

Typical Receiving Stations—Principles of Set Construction—Simple Crystal Detector Set—Simple Tub-Detector Set—Regenerative Detector Set—Radio-Frequency Amplifiers—Rice System of Neutralization—Hazeltine Neutrodyne Amplifiers—Audio-Frequency Amplifiers—Resistance-Coupled Amplification—Impedance-Coupled Amplification—Push-Pull Power Amplifiers—Construction of Popular Receiving Sets—Two-Tube Harkness Reflex Set—Three-Tube Regenerative Set—Three-Tube Super-Regenerative Set—Three-Tube Roberts Reflex Set—Five-Tube Official Browning-Drake Set—Five-Tube Neutrodyne Set—Eight-Tube Superheterodyne Set—Power Supply for Receiving Sets—A-C Filament Tubes—Raytheon "B" Battery Eliminators—Construction of Coils for Receiving Sets—Antenna Couplers—Radio-Frequency Transformers—Browning-Drake Regenaformer—Roberts Reflex Regenerative Transformer—Three-Circuit Tuner—Oscillator Coils for Superheterodynes—Rheostats for Receiving Tubes—Use of Jacks—Increasing Selectivity—Assembly and Construction Hints.

Typical Receiving Stations.—The accompanying illustrations show the essential parts of various types of receiving sets. Almost any type of radio set can be placed in the classes of circuits shown in Figs. 1 to 8.

It is assumed that the reader of this book does not wish to do more than purchase the separate parts of a receiving set and put them together. The construction of some of the very simple units used in radio receiving sets often requires great skill and considerable knowledge of electrical engineering principles. Fortunately such apparatus is now easily obtainable at reasonable prices and there is no necessity for designing and building it. The construction of coils, however, is a simple matter for those so inclined and a special section has been included to cover that subject.

Principles of Set Construction.—The foundation of every type of receiving set is a detector of some kind coupled either directly to an antenna or through some system of amplification. A simple detector is all that is needed to receive signals from nearby stations on a pair of headphones. This type of set is represented by Fig. 1. The receiving range of this simple station may be increased by adding a radio-frequency amplifier as shown by Fig. 2. If it is desired to operate a loud speaker, an audio-frequency amplifier must follow the

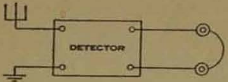


FIG. 1

SIMPLE DETECTOR SET FOR HEADPHONES (LIMITED RANGE)

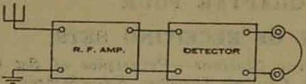


FIG. 2

DETECTOR SET WITH RADIO-FREQUENCY AMPLIFIER (EXCELLENT RECEIVING RANGE)

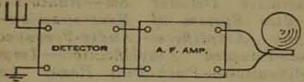


FIG. 3

SIMPLE DETECTOR WITH AUDIO-FREQUENCY AMPLIFIER (LOUD SPEAKER OPERATION)

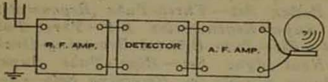


FIG. 4

SET WITH RADIO AND AUDIO-FREQUENCY AMPLIFIER (MAXIMUM RANGE AND LOUD SPEAKER VOLUME)

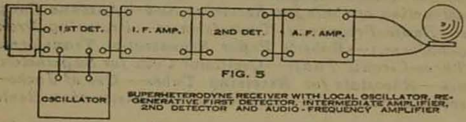


FIG. 5

SUPERHETERODYNE RECEIVER WITH LOCAL OSCILLATOR, REGENERATIVE FIRST DETECTOR, INTERMEDIATE AMPLIFIER, 2ND DETECTOR AND AUDIO-FREQUENCY AMPLIFIER

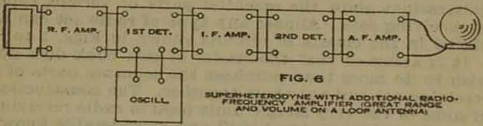


FIG. 6

SUPERHETERODYNE WITH ADDITIONAL RADIO-FREQUENCY AMPLIFIER (GREAT RANGE AND VOLUME ON A LOOP ANTENNA)

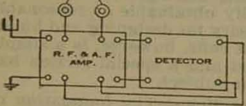


FIG. 7

REFLEX SET WHERE DETECTOR FEEDS BACK TO RADIO-FREQUENCY AMPLIFIER AND AMPLIFIES BOTH R. F. AND A. F. IN ONE STAGE

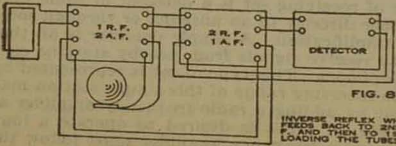


FIG. 8

INVERSE REFLEX WHERE DETECTOR FEEDS BACK TO 2ND STAGE OF R. F. AND THEN TO 1ST STAGE, THUS LOADING THE TUBES MORE EVENLY detector as shown in Figs. 3 and 4. The receiving range of a radio set may be still further increased by using the type of circuit shown in Figs. 5 and 6. The latter types will operate satisfactorily on a loop antenna and are very selective. Some sets use the radio-frequency amplifier as an audio-frequency amplifier at the same time as shown by the diagrams in Figs. 7 and 8. This type is known as a reflex set.

The reader will notice that all of these sets are related in some way. In fact the only difference between the various systems is found in the number and arrangement of amplifiers, for they all employ the original detector. To understand fully the principles of receiving set construction it is only necessary to study the construction of a detector and amplifiers. The constructor may then use any combination of amplifiers he chooses to accomplish a certain result and there is no need to consider the details of every circuit which appeared during the last few years.

There are a few sets which have given remarkable results because of some unusual connection of parts or design of component. The Harkness Reflex, Roberts Reflex, Browning-Drake and Superheterodyne represent this class of receiving sets very well and they will be described in detail. The three-tube regenerative set has been the most popular of all and is recommended to any constructor who desires a simple set for loud speaker operation. This type is also described in detail.

Simple Crystal Detector Set.—Fig. 9 represents a crystal set which is extremely simple to construct and operate, and is useful and serviceable to an extent far out of proportion to its cost. For receiving from broadcasting stations located within fifteen miles when only telephone reception is desired, this circuit is most satisfactory. Only one tuning adjustment is required and

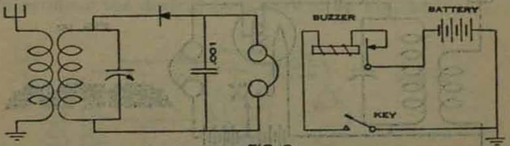


FIG. 9

SIMPLE CRYSTAL DETECTOR SET

TEST BUZZER CIRCUIT FOR SIMPLE CRYSTAL SET

it may be a sliding contact on the inductance coil, a variometer, or a variable condenser connected across the coil. The condenser is the most satisfactory form of tuning and is shown here because this circuit can be the foundation of all succeeding types.

The fixed condenser connected across the telephone receivers is called a "telephone condenser." Its size is not ordinarily of much importance. Its effectiveness may depend upon the make of telephone receivers used, and in some cases the use of such a condenser decreases rather than increases the strength of the signal. Where it is useful at all, a condenser of about 0.001 to 0.002 microfarad (μfd.) will usually be found satisfactory.

The variable condenser should be of the straight-line frequency type because this type eliminates crowding of stations at one particular section of the tuning dial. It is possible to obtain fine adjustment of tuning by connecting a so-called "vernier" condenser in parallel with the tuning condenser. This is a small condenser in which a slight change in capacity is brought about with a substantial change in the setting of the condenser. This same effect can be had with the use of a vernier tuning dial in which a combination of gears allows the shaft of the dial to rotate very slowly while the control knob makes a large number of revolutions.

In order to determine when the crystal detector is adjusted to a sensitive position it is desirable to use a test buzzer. The position of the contact point on the crystal should be adjusted until the loudest sound of the buzzer is heard in the telephone receivers. The circuit for connecting the buzzer with a battery and by a single wire to the ground connection of the receiving set is shown in Fig. 9.

Simple Tube Detector Set.—A more sensitive and more stable detector set results when a vacuum tube is used in place of the crystal detector. This eliminates the need for a test buzzer and increases the receiving range, but requires two sets of batteries. Fig. 10 shows the circuit used in this type of detector. The tube may

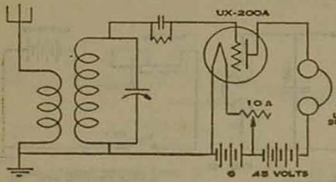


FIG. 10

SIMPLE VACUUM TUBE DETECTOR SET WITH GRID LEAK AND CONDENSER AND SUPERSENSITIVE 200A TUBE

be the dry cell type or the storage battery type, depending on the whims of the builder. Maximum receiving range for this particular type of set will be obtained by the use of the supersensitive detector tube, known as type 200-A. The 200-A supersedes the old type 200 as a sensitive detector. If, however, the 201-A, 199, or 11 and 12 types are used the grid return connection must be made to the positive terminal of the filament instead of the negative terminal as shown in the diagram.

The filament voltage used depends on the type of tube. The 200-A and 201-A tubes require a 6-volt battery, the 199 type a 4.5-volt battery and the 11 and 12 types a 1½-volt battery, *i. e.*, a single dry cell. The "B" battery may be from 22.5 to 45 volts. A grid leak of about 2 to 4 megohms resistance and a grid condenser of about 0.00025 μfd. capacity will be required.

Regenerative Detector Set.—A regenerative detector is similar to the simple tube detector shown in Fig. 10, except for the addition of a coil in the plate circuit which is coupled inductively to the coil in the grid circuit of the tube. The receiving range of this type of detector is very much greater than any other type and it is worth while to add the extra coil, known as a "tickler coil." See Fig. 11.

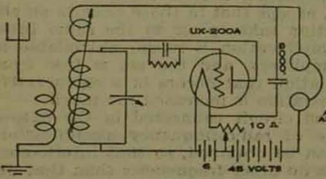


FIG. 11

SIMPLE REGENERATIVE DETECTOR SET WITH VARIABLE DETECTOR FEED-BACK AND THREE-CIRCUIT TUNER

There are other methods of accomplishing regeneration. One method employs a variometer in the plate circuit which causes the proper feed-back through the internal capacity of the tube. Another method uses a condenser connected between the plate and grid circuit to produce the desired feed-back as in Fig. 12.

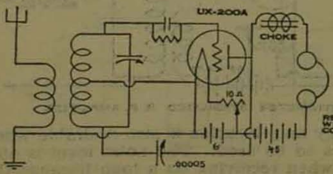


FIG. 12

REGENERATIVE DETECTOR WITH FIXED TICKLER AND CONDENSER FEED-BACK

The most common method uses a coil in the plate circuit so constructed that it rotates within the tube containing the antenna and grid coils. This tickler may be wound directly on the same tube, thus fixing it in position, and regeneration controlled by means of a variable resistance connected across the terminals of the tickler. A resistance of about 25,000 ohms will serve very well.

In all regenerative sets employing a tickler coil it is important to see that the connections to the tickler be so made that the coupling between it and the tuning inductance is in the proper direction. If, therefore, such a set refuses to regenerate, try reversing the tickler coil leads.

The coupler used in a regenerative circuit is commonly called a "three-circuit tuner" or "regenerative transformer." It is easily built and will be described in detail under the heading **"Three-Circuit Tuner."**

Radio-Frequency Amplifiers.—This type of amplifier is employed to increase the strength of the signal before it reaches the detector. It is done by inserting one or more amplifying tubes between the antenna coupler and the detector tuner. It accomplishes the same effect as regeneration does in the circuits shown in Figs. 11 and 12, except that in those circuits amplification and detection takes place in the same tube. The amount of amplification is more controllable in radio-frequency amplifiers, and the set is free from objectionable oscillation that occurs in a regenerative set when the regeneration is increased too much.

By using a tuned circuit connected in the output side of each stage of radio-frequency amplification, great selectivity can be obtained, so that interference from radio stations on other frequencies than that desired can be eliminated. From one to three stages of radio-frequency amplification can be used, the limit depending on the relative strengths of signal and atmospheric disturbances.

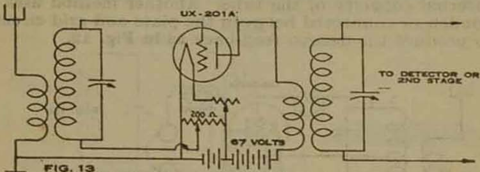


FIG. 13 POTENTIOMETER STABILIZED R. F. AMPLIFIER

Radio-frequency amplification is also desirable when a loop antenna is to be used. The noise level is also greatly reduced when receiving on a loop because the pick-up surface is so small compared with a single-wire antenna of the usual dimensions.

A single-tube radio-frequency amplifier is shown in Fig. 13. This circuit may be added to the detector sets described in the preceding sections with a resulting increase in range. Unless some special precaution is taken to prevent oscillations it will be found that a radio-frequency amplifier is very unstable, breaking into oscillation at some frequencies and not at others. The potentiometer shown in Fig. 13 is used as an oscillation control.

In almost all radio-frequency amplifier circuits there is present some inherent regeneration, even though the circuits be designed as non-regenerative circuits. Regeneration is caused by coupling in some form between the plate and grid circuits of the tube. In the case of radio-frequency amplifiers there may be sufficient capacity coupling between the plate and grid within the tube. In almost every case there is sufficient capacity and inductive coupling between the various parts and wires in the set to cause the unbalancing. The disadvantage of this coupling is that its magnitude is different at different frequencies, and a receiving set which is not in the generating condition at one wave length may by the mere change in the tuning become unstable and generate a local wave which produces beat notes and whistling sounds. If this inherent regeneration is neutralized or balanced, the music or speech received is clearer than otherwise, and the tuning adjustment is made entirely separate from the regeneration or feed-back adjustment, thus simplifying the operation of the set.

There have been many attempts to find a means of balancing other than the variable potentiometer method. Some need adjustment but once and are constant thereafter. The most common form of balanced or neutralized radio-frequency amplifier is known as the "neutrodyne." Two of the common neutrodyne circuits will be discussed.

Rice System of Neutralization.—The Rice system of balancing the internal capacity of the tube makes use of a small capacity connected between the plate and

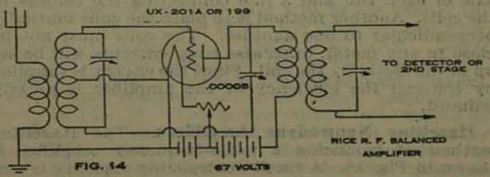


FIG. 14 RICE R. F. BALANCED AMPLIFIER

grid circuits of the tube. The feed-back due to this added capacity balances or neutralizes the feed-back due to the capacity of the tube. When the correct setting of the neutralizing capacity is found it need never be touched unless the tubes are changed, when it is a simple matter to readjust the condenser. The circuit used is shown in Fig. 14. Either the 199 type or 201-A type of tubes may be used in the amplifying circuits. The 199 type has a smaller internal capacity than the other and is therefore easier to balance.

Each stage of a neutralized receiver should be shielded from the next adjacent stages by placing the transformers at the proper angles or by means of metal partitions in the amplifier cabinet.

When a receiver is completely neutralized, changes in voltage in the output circuit have no effect whatever on the input circuit of the tube. For this reason a regenerative detector is often preceded by a single stage of neutralized radio-frequency amplification. The oscillating currents created by the detector can not reach the antenna and cause interference with neighboring receiving sets.

The set using this form of amplification is balanced by first tuning in a signal with all tubes operating. The tube to be neutralized is then turned off and in all probability the signal will still be heard. The balancing condenser is then slowly adjusted until the signal disappears entirely or becomes very much reduced in volume. At this setting the receiver is said to be neutralized or balanced.

The tap on the secondary winding of the antenna coupler is made at the middle turn. The capacity of the small neutralizing condenser is about 0.00005 μfd. All wires should be short and direct and as far apart as possible to eliminate all possible sources of coupling between circuits. The setting of the neutralizing condenser need not be changed unless some change in the circuit is made or the original tube is replaced by one of different internal capacity.

Two or three stages of this type of amplification may be used if care is taken to shield the radio-frequency transformers. Coupling between coils may be reduced by placing them at an angle of about 54.7° between the axis of each coil and a line connecting the centers of the coils. Another method is to place the coils mutually perpendicular to one another. The coils must not be close to any metal, otherwise eddy currents will be set up in the metal by the coil. Since the energy is supplied by the coil the efficiency of the amplifier is greatly reduced.

Hazeltine Neutrodyne Amplifiers.—The Hazeltine method of balancing a radio-frequency amplifier is shown in Fig. 15. A small neutralizing capacity is employed in somewhat the same manner as in the Rice circuit. The connections are not quite alike, however, although the method of balancing is exactly the same. This type of balanced amplifier is very popular on five-tube sets using two stages of radio-frequency amplification, a simple vacuum tube detector and two stages of audio-frequency amplification. The construction of a 5-tube set is shown in a later section. Such a set is called a "neutrodyne" and the small balancing condensers "neutrodons."

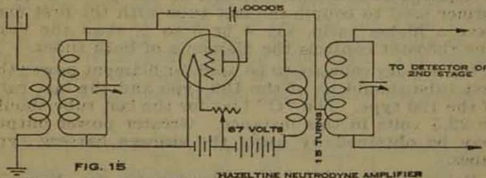


FIG. 15 HAZELTINE NEUTRODYNE AMPLIFIER

Audio-Frequency Amplifiers.—It is possible to amplify the signals heard in the headphones on the simple detector set so as to operate a loud speaker. The device used for this purpose is called an audio-frequency amplifier and is connected in place of the headphones. The loud speaker is connected to the amplifier output terminals. As in the case of radio-frequency amplifiers, the limit of the number of stages of audio-frequency amplification is two or three. This limit is determined by the noise introduced by the amplifier and the probability of singing or howling caused by audio-frequency feed-back. By the judicious use of bypass condensers and the correct placing of apparatus excellent results will be obtained with two or three stages.

Amplifier tubes should be used in such a way that the magnitude of the output voltage is strictly proportional to the magnitude of the input voltage, otherwise the quality of speech or music received may be distorted. In order to obtain maximum amplification with minimum distortion it is usually desirable to use, with amplifier tubes, a "B" battery or other source of plate energy of from 45 volts to 425 volts. The correct grid bias must be used on each tube and, in the case of the extremely high voltages, great care must be used when adjusting the amplifier to avoid fatal shock. Never make any adjustments when full power is turned on. Special tubes must be used at the higher plate voltages.

The most common audio-frequency amplifier is shown in Fig. 16. The power output is sufficient to operate almost any good loud speaker and the quality of reproduction is excellent. The first stage uses the 201-A type of tube coupled to the detector by means of an audio-frequency transformer having a primary winding of fairly high impedance, *i. e.*, a large number of turns. Since, for mechanical reasons, the secondary is usually about the same size for all transformers a low ratio transformer is best for the first stage. The grid bias is obtained from a 4.5-volt "C" battery and the plate voltage from a 90-volt "B" battery or "B" eliminator.

The output tube is a semi-power tube of the 112 type using 135 volts on the plate. A higher "C" bias is required at this plate voltage, as shown. The transformer used to couple the last tube with the first may have a higher ratio, say 4 or 5 to 1, than the first. One rheostat controls the filaments of both tubes.

In case dry cells are to be used for filament power the first tube should be of the 199 type and the last tube of the 120 type. The "C" bias for the last tube should be 22.5 volts in this instance. Greater power output may be obtained by using the storage battery type tubes.

Four 1-microfarad bypass condensers are shown in Fig. 16. They may not be absolutely necessary for satisfactory operation but very often their use means good quality when without them the amplifier is practically useless. Such condensers confine the audio-frequency alternating currents to the circuit proper by providing a path of low impedance around the batteries. If the resistance of the "B" power supply be high, as is often the case when "B" batteries have been used for any length of time, and the audio-frequency currents are allowed to flow through them, an alternating voltage drop exists across the battery terminals common to both tubes causing a regenerative effect which produces howling or singing in the loud speaker.

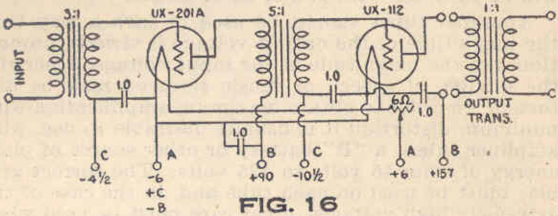


FIG. 16

A 201-A type tube may be used in the last stage instead of the 112 but it is liable to become overloaded and cause distortion long before sufficient volume is obtained from the loud speaker. The power handling capacity of the 112 is about two and one-half times as great as that of the 201-A at 135 volts "B" supply. Still more power output may be had by using the 171 type power tube, with its power output of seven times that of the 201-A at 135 volts and thirteen times at 180 volts. The 210 tube has less power output at 180 volts than the 171 tube, but at a plate voltage of 425 the output is thirty times that of the 201-A at 135 volts.

Resistance-Coupled Amplification.—Another popular type of amplifier is shown in Fig. 17. Here a resistance-coupled amplifier using two tubes is used in place of the one shown in Fig. 16. In this case the first tube is of the high-mu or 240 type with an amplification factor of 30. The last tube may be the usual power tube such as the 112 type. The amplification of the signal is accomplished by the tube itself. The voltage drop across the resistance in the plate circuit of the detector is applied through the blocking condenser to

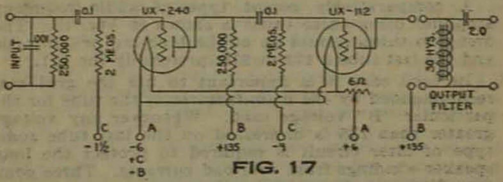


FIG. 17

the grid of the high-mu tube. The amplification of the transformer is lacking, but is compensated for by the high amplification of the 240 tube.

The 201-A type of tube may be used successfully but three stages of resistance-coupling must be used to obtain the same degree of amplification possible with transformers or the high-mu tubes. The 171 type of tube is excellent for the last stage of a three-stage audio-frequency amplifier. In the two-stage type it is better to use the 112 or 210.

Impedance-Coupled Amplification.—An impedance-coupled amplifier is shown in Fig. 18. This is similar to the resistance-coupled type except that choke coils are used in the plate circuits instead of resistances. The chokes must have an inductance of about 30 henries. Either resistances or chokes can be used in the

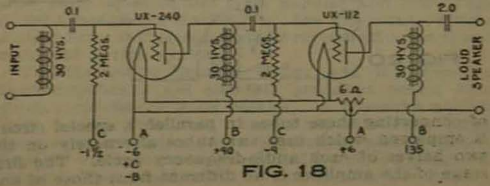


FIG. 18

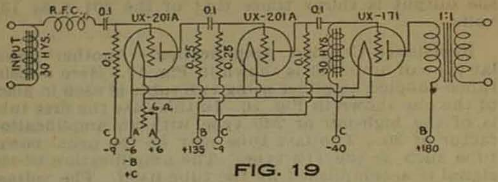


FIG. 19

grid circuits, though resistances are commonly employed for this purpose.

A comparatively recent type of audio-frequency amplifier using three tubes is shown in Fig. 19. The first two tubes should be of the high-mu or 240 type and the last tube a 171 or 210, preferably the 171.

In each case it is important to use the grid bias recommended by the manufacturer of the tube for the particular "B" voltage used. Whenever any voltage greater than 135 is impressed on the last tube some type of filter circuit is required to protect the loud speaker windings from overload currents. Three common filters are shown in the diagrams.

When it is desired to obtain increased power output without resorting to the use of power tubes the load can be divided between two tubes connected in parallel.

Push-Pull Power Amplifiers.—In Fig. 20 two tubes are used in the final stage of the amplifier, but instead

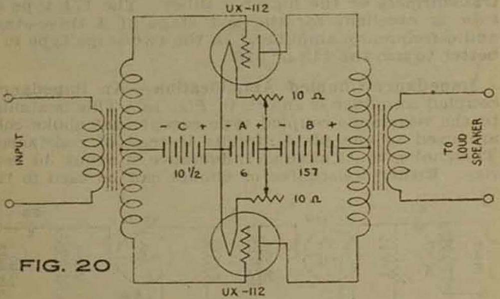


FIG. 20

of connecting these tubes in parallel, a special circuit is employed which uses two tubes alternately on the two halves of each audio-frequency cycle. The first stage of the amplifier is no different from those of any ordinary audio-frequency amplifier. This type of amplifier is called a "push-pull" power amplifier.

In principle, this push-pull circuit uses one tube during one-half of the cycle and the other tube during the other half of the cycle. Each tube is effective while the terminal of the secondary transformer winding to which its grid is connected is at a positive potential with respect to the middle of the winding. During the other half of the cycle, when this terminal is negative with respect to the center tap, this tube is not operating, but use is made of the other tube whose grid is connected to the transformer terminal, which is momentarily at a positive potential.

Ordinary receiving tubes can be used in this circuit, although louder signals can be secured if special power tubes are used. Transformers built especially for use in the push-pull amplifier have been placed on the market although they are not generally available. Ordinary audio-frequency transformers may be used if two, with primaries and secondaries connected in series, are used for the input circuit and two similarly connected transformers are used in the output circuit. The connection between the two windings is used as the center tap. It is important that the transformers connected together in this manner be identical. The volume from the output side of this amplifier may be increased somewhat if the secondary winding of a low ratio transformer is connected in series with the secondaries of the final pair of transformers and the loud speaker is connected directly to the primary terminals of the same transformer. Where special push-pull transformers with center taps are used this additional connection is not necessary.

Construction of Popular Receiving Sets.—During the last few years many receiving sets appeared under different names. A few proved to be very popular and will be described in detail in the following sections. The crystal set and single-tube set were discussed at the beginning of this chapter. The next logical type to consider would be a two-tube type in which the crystal could be used. The two-tube Harkness Reflex was chosen because the results obtained were better than one might expect from such a simple set. The three-tube class contains the most popular and one of the oldest types on the market, *i. e.*, the Three-tube Regenerative Set. A three-tube super-regenerative set is also described in this section.

The three-tube Roberts Reflex and the five-tube Browning-Drake are also old standbys which have given consistently good results. A five-tube neutrodyne is also presented. In the six-tube class might come another neutrodyne or any tuned-radio-frequency receiver using three stages of radio-frequency amplification. The construction of this type is the same as the five-tube neutrodyne and is therefore not given. A seven-tube superheterodyne might be discussed next but the eight-tube type has been more popular because it gives greater amplification. The difference between the two lies in the number of stages of radio-frequency amplification.

Two-Tube Harkness Reflex Set.—When receiving tubes were priced at $5.00 and $6.00 each, attempts were made to have each tube do the maximum possible work. The Harkness Reflex circuit employs one tube as a combined radio and audio-frequency amplifier, a crystal detector and a second tube as an audio-frequency amplifier only. This set will operate a loud speaker with fair volume and the receiving range is good. The circuit is drawn in Fig. 21. It is so designed as to be non-oscillating and to function with high selectivity. The following parts will be required:—

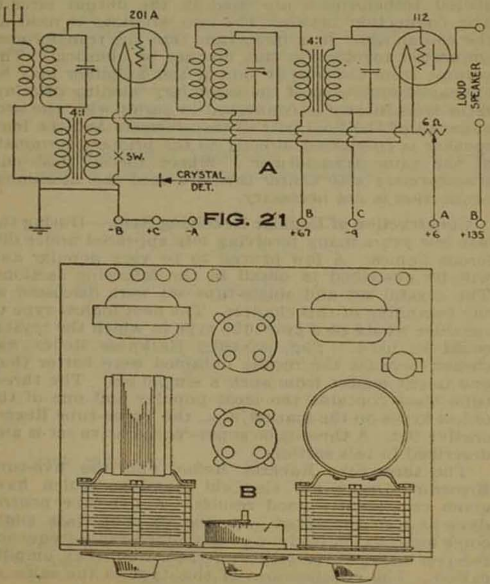


FIG. 21

Two Harkness Radio-Frequency Transformers. (See later section for construction.)

Two Straight-Line Frequency Variable Condensers. 0.00035 μfd. capacity.

Two high grade audio-frequency transformers. Ratio 4 or 5 to 1.

One 0.0006 μfd. mica fixed condenser.

One 6 or 10-ohm rheostat. Two push-type tube sockets.

One sensitive crystal detector.

One type 201-A radio-frequency amplifying tube.

One last-stage audio-frequency amplifying tube, type 201-A or 112.

Storage battery, "B" supply, phones or loud speaker, two vernier dials, binding posts, 7″x10″ panel, 10″x10″ base, antenna about 100′ long and ground.

A suggested panel and base arrangement is given in Fig. 21B.

Three-Tube Regenerative Set.—One of the most popular three-tube sets has been the regenerative detector followed by two stages of audio-frequency amplification. This set has been nicknamed the "squealer," "blooper" and other degrading titles because in the hands of careless operators it has spoiled the reception of thousands within its range. Yet, no matter what can be said against it, it is still popular, equalling the performance of very expensive sets with a fraction of the upkeep cost. On local programs it can operate a loud speaker with more than comfortable volume and under favorable conditions distant stations are easily received. No better set can be found for the beginner although care must be used when tuning because it radiates strongly when in the oscillating condition. With the addition of a stage of balanced radio-frequency amplification radiation can be prevented and anyone can operate it with a clear conscience. Such a set is described under the heading **Browning-Drake Set.**

The circuit diagram is shown in Fig. 22. The antenna coupler is called a "three-circuit tuner" and its construction described in a later paragraph. The detector may be the 201-A or 200-A type of tube. The 200-A is more sensitive on weak signals but on strong signals no difference will be noticed in the performance. The first audio stage uses a 201-A and the last stage the 112 type. Dry-cell tubes such as the 199 type may be used satisfactorily with the 120 in the last stage. The power supply may be a "B" battery or "B" eliminator. If the latter is used make sure that the correct bias is applied to the grid of the last tube.

A good panel and base arrangement is given in Fig. 22. The center dial controls the tuning condenser; the knob on the left controls the tickler setting and the

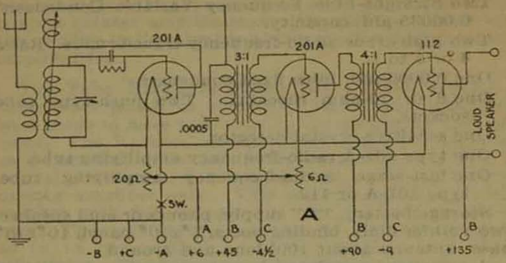
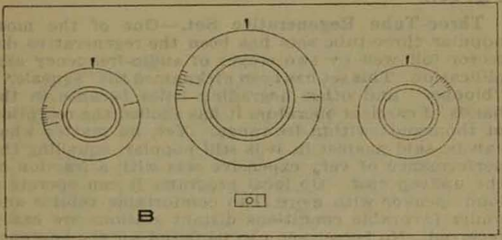
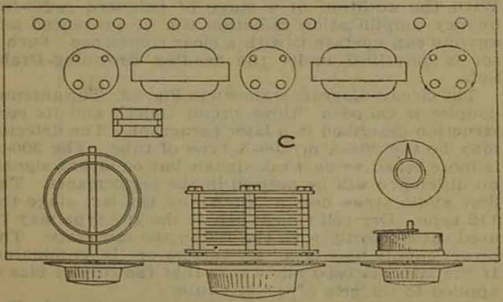

201A
3:1
201A
4:1
112
.0005
LOUD SPEAKER
20Ω
6Ω
SW.
A
A B C
B C
B
-B +C -A +6 +45 -4½
+90 -9
+135

FIG. 22


B


C

one on the right is the detector rheostat used as a volume control.

An antenna of about fifty to seventy feet in length and a good ground connection are required. The set is placed in operation by turning on the power and setting the tickler to just below the oscillating point. If the tickler is turned too far, a click or faint "plop" will be heard in the loud speaker indicating oscillation. In this condition the set is a good radiator of radio-frequency power and the power is being supplied by the "B" batteries connected to the set. Therefore, do not operate the set in an oscillating state but turn the tickler back until just below this point. Slowly rotate the tuning dial until a station is heard. The signal can be made clear and loud by properly adjusting the detector rheostat and the tickler coil. If the condenser is turned while the set is oscillating, a whistle will be heard every time a station is picked up. This is caused by the beating of the local oscillations with the carrier wave of the broadcasting station and is an indication of the exact dial setting of the station.

The following apparatus is required when building the set shown in Fig. 22:

Three-circuit tuner.

- Straight-line-frequency variable condenser, capacity depends on tuner but either 0.0005 or 0.00035 μfd. may be used.
- Vernier dial for condenser.
- Grid leak of about 2 to 4 megohms resistance and grid condenser of 0.00025 μfd. capacity.
- Detector tube, either 201-A, or 200-A for storage battery operation. Type 199 for dry cell operation.
- Detector rheostat, 20 ohms resistance for 201-A or 200-A tube and 30 ohms for 199 type.
- Low-ratio audio-frequency amplifying transformer for first stage following detector.
- By-pass condenser in plate circuit of detector, about 0.0005 to 0.001 μfd.
- Type 201-A tube for first audio-frequency amplifying stage.
- Second-stage audio-frequency amplifying transformer, ratio about 4 or 5 to 1.
- Type 112 semi-power tube for last stage.
- (Output filter if more than 135 volts is supplied to plate of last tube.)
- Rheostat or special filament control resistance for last two tubes, about 6 ohms will control two tubes. A fixed resistance will serve very well.
- "A" battery, 6-volt for 201-A or 200-A tubes. For 199 tubes three dry cells.
- In this case use the 199 type for the first audio stage and the 120 for the last stage, with a 20-ohm rheostat for the last two tubes.

"B" battery or "B" eliminator with 45-volt tap for detector, 90-volt tap for first audio tube and 135-volt tap for last tube.

"C" battery with 4½-volt tap for first audio tube and 9-volt tap for last tube. This bias will depend on the tube used and the plate voltage applied.

Loud speaker, binding posts, connecting wire, and three push-type sockets. Use well insulated and heavy wire for connections, say, about No. 20 rubber covered.

If the 200-A tube is used as a detector the grid-return connection should be made to the negative filament terminal instead of the positive terminal as shown in the drawing. In wiring the set keep the grid and plate leads well separated from all others. Connections should be short and direct, well soldered, neat. A good practice is to place all direct-current carrying wires below the base.

Should the set refuse to oscillate after the power is applied, reverse the connections to the tickler coil. The detector rheostat will also serve as an oscillation control.

Three-Tube Super-Regenerative Set.—Super-regeneration is a method of reception by which regeneration can be carried much farther than in straight regeneration. This gives very loud signals, even when receiving on a small indoor antenna from distant stations. The method is not as free from circuit noises as some other methods.

In this method, the feed-back coupling is increased beyond the point where oscillation would take place in straight regeneration. This is done only momentarily, however, the feed-back being made to alternate repeatedly above and below the value required for self-generation. During the time that it is above the value the current in the tube builds up rapidly and to a much larger amount than with straight regeneration, and during the intervals when it is below this value the current dies down.

Super-regeneration is accomplished by introducing in the ordinary regenerative circuits anything which periodically varies the feed-back above and below the point required for self-generation. The voltage which the tickler coil feeds back into the grid circuit depends upon the direct voltage existing in the plate circuit. Super-regeneration may therefore be brought about by introducing some form of alternating current generator in series with the "B" battery, as at G in Fig. 23. When the voltage in this generator is in the same direction as the voltage from the battery, the feed-back increases beyond the point of self-generation and the current builds up to a very large value; when the voltage reverses the current dies out.

The same effect can be accomplished by varying the resistance in the tuned circuit (L C) connected to the grid. If the tickler coil is adjusted so as to be almost on the point for self-regeneration, a reduction in the resistance of the tuned circuit will start the current building up to a very large value. If the resistance is then increased again, the current will die out.

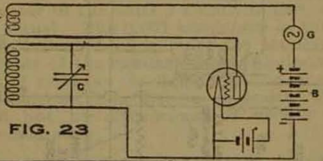


FIG. 23

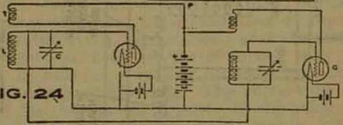


FIG. 24

The actual means that are used to produce super-regeneration consist of auxiliary vacuum tubes. For example, instead of using a rheostat with a contact sliding back and forth to produce a variable resistance, the grid and filament of the tube are shunted by a connection to the grid and filament of another tube (G, Fig. 24) which is generating at some frequency lower than the received radio-frequency. During one-half of the cycle of current generated by the auxiliary tube G it draws current from the tuned circuit L C, thus having the same effect as increasing the resistance of L C. The resistance thus rises and falls periodically at the frequency of the current generated by the auxiliary tube G.

Signals may be received by inserting a phone at the point P in the plate circuit and something less than 5 volts negative on the grid. Still louder signals may be received by connecting an ordinary amplifier tube to the system. The way this is done is shown in Fig. 25. Tube 1 is the super-regenerative amplifier tube, tube 2 is the generator, and tube 3 is the audio-frequency amplifier. The generator tube (2) employs capacitive coupling instead of inductive coupling as in Fig. 24, and the plate voltage is supplied to this tube through a filter to keep out the generated current. The amplifier tube (3) is connected through any good audio-frequency transformer in the ordinary way. All three tubes may be the 201-A type, or small power tubes may be used with plate voltages as high as the tubes will stand. Power tubes are preferable. All tubes

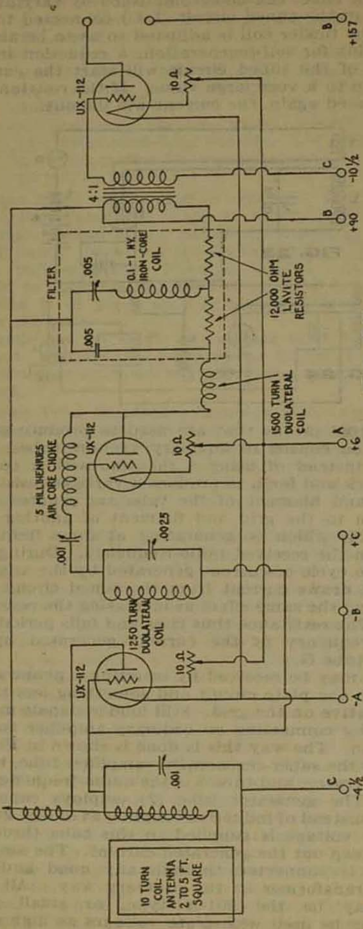


FIG. 25

Super-Regenerative Set

must be of the same type, but need not be matched. The various coils, condensers, batteries and other parts are the standard types used in radio apparatus. The condensers marked 0.0025 and 0.005 are set once for all for a frequency of about 15,000 cycles per second.

Operation is as follows: Signals are tuned in by varying the 0.001 condenser in the tube 1 circuit. The 0.001 condenser in the tube 2 circuit is then adjusted for loudest signal. The 0.001 condenser in tube 1 circuit is then adjusted once more for loudest signal. Both directions of the connection to the filament battery should be tried, as the signals will be much better with one connection than with the opposite. The operator should not be discouraged if results are not obtained immediately.

The super-regenerative method may be used in a great variety of forms. The functions of super-regenerative amplification, generation, and detection may each be performed in separate tubes; they may be combined in various ways, or all functions may even be combined in a single tube. The three-tube arrangement is by far the easiest to tune. In the other arrangements the various tuning adjustments affect one another.

The frequency generated in the set for periodically varying the feed-back, called the "variation frequency," is 15,000, so as to be inaudible and not disturb the sounds received. It is best to keep the variation frequency as low as possible, because the lower this frequency the more time there is for the incoming current to build up. The sensitiveness of the method is proportional to the ratio of the wave frequency to the variation frequency. For this reason it is very well adapted to short waves.

It is highly desirable to use this circuit only on a loop antenna. It generates and radiates sufficient power to cause disturbance to radio reception by others. Fortunately, it produces signals of ample strength on a small coil antenna.

The following notes apply to Fig. 25:

Variocoupler must have at least 50 turns on secondary.

Either honeycomb or duolateral coils may be used for the 1250 and 1500-turn coils.

These coils should be kept well apart.

"B" battery of less than 200 volts may be used but results will not be as good.

The 12,000 ohm resistors are non-inductive; this, however, is not necessary. Grid leaks of proper value will function equally well. These resistors need not be variable and a tolerance of several thousand ohms is permissible.

The 5-millihenry air-core choke can be either closely wound or spread out, but is preferably of the former type.

The same number of turns are used for a 2-foot loop as for a 5-foot loop. Because of the variable value of inductance in standard variocouplers it is necessary to try connecting the loop both in series and in parallel with the primary of the coupler as shown in Fig. 25. Adopt the connection which permits tuning within the range of the 0.001 variable condenser. If this is impossible with either connection, then reduce the number of turns on coil antenna until the desired result is obtained.

It is immaterial whether the grid tap "A" be as shown or tapped into the filament rheostat. Generally speaking, run plate voltage as high as tubes will allow.

Three-Tube Roberts Reflex Set.—The circuit diagram of the Roberts Reflex set is shown in Fig. 26. As will be seen the first tube serves both as a radio-frequency amplifier and as the first stage audio-frequency amplifier. The detector is regenerative and the last stage of audio-frequency amplification is of the single power tube type, although a push-pull stage can be used satisfactorily. This set is operated exactly as the Browning-Drake.

The panel and base connections are shown in Fig. 26. The following apparatus will be required when building the Roberts Reflex Set:

- Antenna coupler.
- Radio-frequency transformer with tapped primary and variable tickler coils.
- Reflex audio-frequency transformer, ratio about 4 to 1.
- Input and output audio-frequency transformers.
- Two straight-line frequency variable condensers, 0.0005 μfd. capacity.
- Two bypass condensers, 0.0025 and 0.005 μfd. capacity.
- Grid leak of about 4 megohms and grid condenser of 0.00025 ufd. capacity.
- Neutralizing condenser of about 0.00005 μfd. capacity.
- Three 10-ohm rheostats or automatic filament control resistances.
- Two separate "C" batteries, 4½-volt and 9-volt.
- Three 201-A type tubes or 199, depending on the filament supply.
- Binding posts, loud speaker, panel, base and connecting wire.

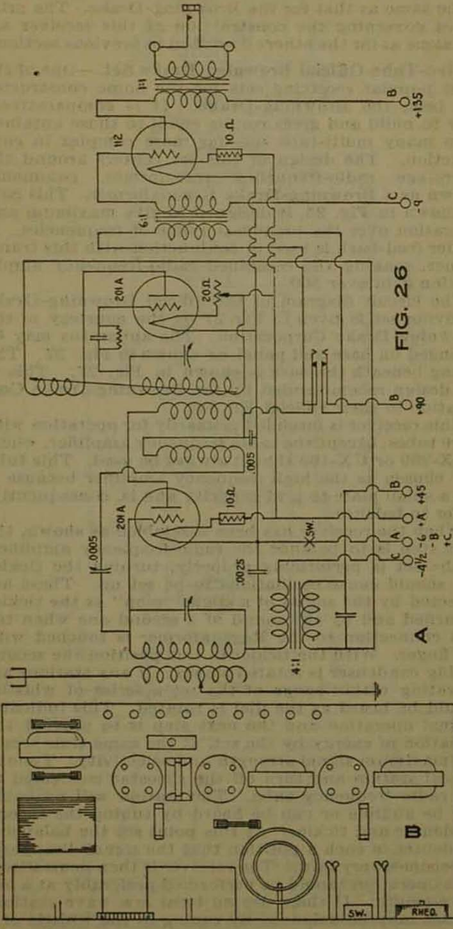


FIG. 26

Roberts Reflex Set

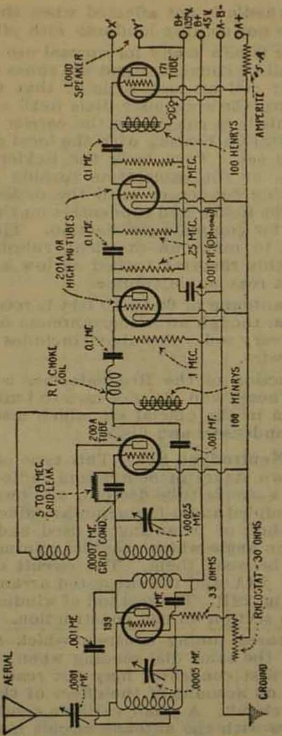
The method of neutralizing the Roberts Reflex Set is the same as that for the Browning-Drake. The principles governing the construction of this receiver are the same as for the others described in previous sections.

Five-Tube Official Browning-Drake Set.—One of the most popular receiving sets for the home constructor has been the Browning-Drake. It is comparatively easy to build and gives results equal to those obtained from many multi-tube sets far more complex in construction. The design of this set centers around the interstage radio-frequency transformer, commonly known as a Browning-Drake Regenaformer. This coil, as shown in Fig. 35, is designed to give maximum amplification over the broadcast range of frequencies. A tickler feed-back is used in conjunction with this transformer, making the combined radio-frequency amplification gain over 500.

The circuit diagram of the official Browning-Drake receiving set is given in Fig. 27 by the courtesy of the Browning-Drake Corporation. The apparatus may be arranged on base and panel as shown in Fig. 27. The wiring beneath the base is shown in Fig. 27. This is the design recommended by the Browning-Drake Corporation in their Official Kit Set.

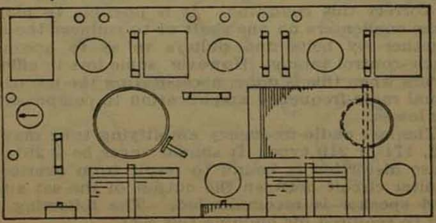
This receiver is intended primarily for operation with large tubes, except the radio frequency amplifier, where a CX-299 or UX-199 should always be used. This tube was chosen as the high frequency amplifier because it has a small plate to grid capacity and is, consequently, easier to balance.

When the receiver has been assembled as shown, the next step is to balance the radio-frequency amplifier. If the set is performing properly, turning the tickler coil should cause oscillations to be set up. These are detected by the sound of a slight "plop" as the tickler is turned and by the sound of a second one when the grid connection to the Regenaformer is touched with the finger. With the tickler in this position the second tuning condenser is rotated slowly. If any stations are operating within range of the set a series of whistles should be heard as the dial is rotated. This indicates normal operation and the next step is to prevent the radiation of energy by the set, at the same time securing maximum signal strength and selectivity. Tune in a local station and turn off the rheostat connected to the radio frequency tube. The station will probably still be audible or can be heard by tuning the second condenser and tickler. At this point set the balancing condenser in such a position that the signal disappears or becomes very faint. The receiver is then neutralized. This operation should be performed preferably at a low wave-length. If there are no local low wave stations the set may be balanced by tuning in the whistle of a distant one. Set the balancing condenser so that the



Circuit Diagram of the Official Browning-Drake

FIG. 27



pitch of the whistle is not affected when the first dial is turned. Do not confuse loudness with pitch.

The receiver is now ready for normal use. The batteries should all be connected and the tubes turned on. Set the tickler coil at such a point that the circuit oscillates. Turn the condenser dials until a whistle is heard; this whistle is caused by the carrier wave of a broadcasting station beating with the local oscillations caused by the set. Turn back the tickler until the whistle ceases, at the same time turning the radio-frequency tuning condenser until the desired volume is obtained. The tickler and condensers may need slight readjustment for complete satisfaction. The rheostat will be found to make an excellent volume control. Always keep this rheostat turned as low as possible, consistent with reasonable volume.

An outside antenna of 60 to 70 feet is recommended for best results, though an indoor antenna of about 20 feet will serve very well. The above includes the length of the lead-in wire.

The construction of the Regenaformer is described in Fig. 35. Those who do not care to build the coils may buy them in the official kit which also contains the variable condensers and dials.

Five-Tube Neutrodyne Set.—This type of receiving set employs two stages of neutralized radio-frequency amplification, a simple tube detector and two stages of transformer-coupled audio-frequency amplification. The Hazeltine method of balancing is used and the coils are placed at an angle which provides minimum inductive coupling between them. The circuit diagram is shown in Fig. 28A and the suggested arrangement of apparatus in Fig. 28B. The method of winding the coils is given in the section on coil construction.

There are three tuning controls which are set at approximately the same dial reading when tuning in a station. The first condenser may not read quite like the other two on account of the effect of the antenna on the tuning circuit. A small variable condenser connected in series with the antenna circuit may be used to correct this condition. It is possible to place all three condensers on one shaft or to connect the shafts together by belts and pulleys so as to accomplish single-control tuning. However, some loss in efficiency occurs when this is done, necessitating the use of additional radio-frequency amplification to compensate for the losses.

The last audio-frequency amplifying tube may be a 112, 171 or 210 type. It should never be a 201-A because distortion is bound to result from overloading. A filter circuit between the output of the set and the loud speaker is recommended. The following parts will be required for building this set:

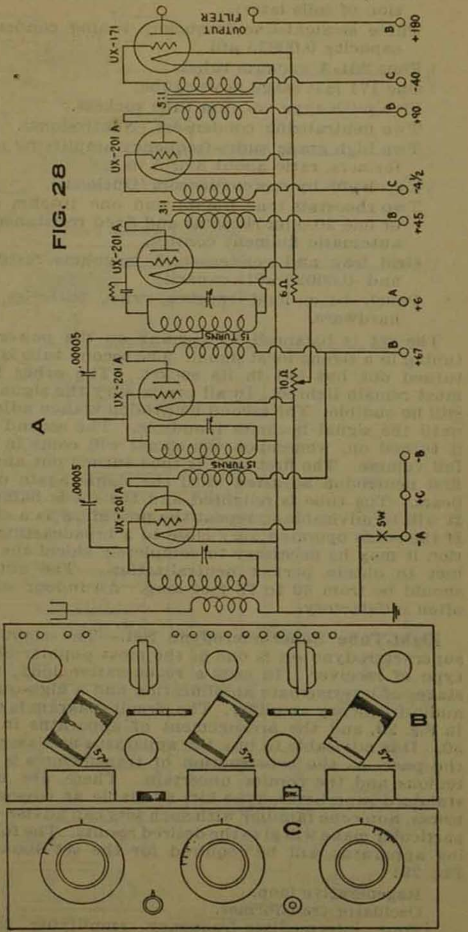

A
B
C
UX-171
UX-201 A
OUTPUT FILTER
15 TURNS
.00005
5:1
3:1
6 Ω
10 Ω
SW
B +180
C -40
B +90
C -4½
B +45
A +6
B +67
-B
+C
-A

FIG. 28

Three radio-frequency transformers (see construction of coils later).

Three straight-line frequency tuning condensers, capacity 0.00035 μfd.

Four 201-A vacuum tubes.

One 171 last stage power tube.

Five push-type vacuum tube sockets.

Two neutralizing condensers (Neutrodons).

Two high grade audio-frequency amplifying transformers, ratio about 3 or 5 to 1.

Two 1-μfd. bypass condensers (Optional).

Two rheostats (one 6-ohm and one 10-ohm size), or one 20-ohm rheostat and fixed resistances for automatic filament control.

Grid leak and condenser, 3 megohms resistance and 0.00025-μfd. capacity.

Panel, base, loud speaker, wire, batteries, and hardware.

The set is balanced by turning on the power and tuning in a strong local signal. The second tube is then turned out but left in its socket. The other tubes must remain lighted. In all probability the signal will still be audible. The second neutrodon is then adjusted until the signal becomes inaudible. The second tube is turned on, whereupon the signal will come in with full volume. The first tube is then turned out and the first neutrodon adjusted until the signal again disappears. The tube is relighted and the set is balanced. It will be advisable to repeat the procedure as a check. If the set is operated very close to a broadcasting station it may be necessary to completely shield the cabinet to obtain perfect neutralization. The antenna should be from 50 to 75 feet long. An indoor wire is often satisfactory.

Eight-Tube Superheterodyne Set.—The eight-tube superheterodyne set is one of the most popular of this type of receiver. It uses a regenerative loop, three stages of intermediate amplification and a high-quality audio-frequency amplifier. The circuit diagram is given in Fig. 29, and the arrangement of apparatus in Fig. 30. It is advisable to buy the apparatus and assemble the parts as the construction of transformers is very tedious and the results uncertain. There are many standard superheterodyne kits available at reasonable prices. Someone familiar with such sets can advise what particular make will give the desired results. The following apparatus will be required for the set shown in Fig. 29:

Regenerative loop.

Oscillator transformer.

Four intermediate-frequency amplifying transformers.

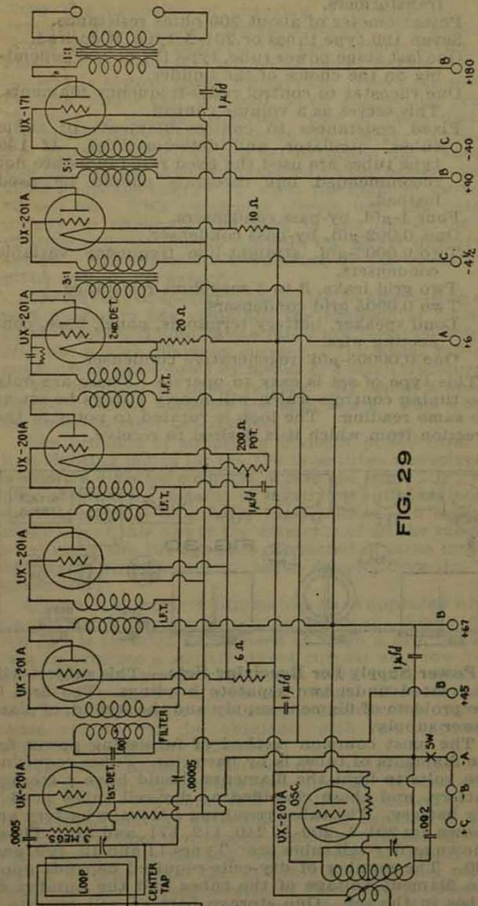


FIG. 29

Superheterodyne

First and second-stage audio-frequency amplifying transformers.
Potentiometer of about 200 ohms resistance.
Seven 199 type tubes or 201-A type, if desired.
One last stage power tube, type 171 or 120 depending on the choice of the builder.
One rheostat to control radio-frequency filaments. This serves as a volume control.
Fixed resistances to control filaments of audio tubes, oscillator and detector-tubes. If 199 type tubes are used the fixed resistances are not recommended but rheostats should be used instead.
Four 1-μfd. by-pass condensers.
One 0.002-μfd. by-pass condenser.
Two 0.0005-μfd. straight-line frequency variable condensers.
Two grid leaks, 3 to 5 megohms resistance.
Two 0.0005 grid condensers.
Loud speaker, battery terminals, panel, base, connecting wire.
One 0.00005-μfd. regenerative condenser.

This type of set is easy to operate. There are only two tuning controls which will nearly always be set at the same reading. The loop is rotated to point in the direction from which it is desired to receive.

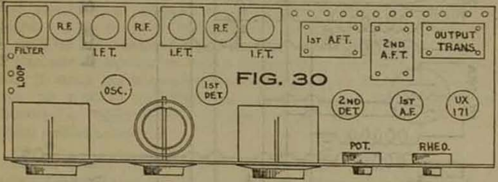


FIG. 30

Power Supply For Receiving Sets.—This subject will be treated under two separate headings. The first is the problem of filament supply and the second, of plate power supply.

The most common method of furnishing power for the filaments of tubes is by batteries. Tubes requiring five volts to light the filaments should have a storage battery, and those classified as dry-cell tubes need a dry battery. The tubes requiring a storage battery are known as: 201-A, 200-A, 240, 112, 171, and 210. Those known as dry-cell tubes are: Types 11 and 12, 199, and 120. The number of dry-cells required depends upon the filament voltage of the tubes and the number of tubes in the set. One storage battery will operate a large number of tubes and is sufficient for nearly all of the existing receiving sets.

The objection to the use of a storage battery arises from the necessity of charging it periodically. To remedy this condition "trickle chargers" have appeared which are always connected to the battery, giving it a slow charge when it is not being used. In this way the battery is always ready for service. There are several circuits which can be used when connecting trickle chargers to storage batteries. One of them uses an automatic relay which turns on the charger as soon as the filament switch of the set is turned off. Another has the charger always connected to the battery and a third turns the charger on when the filament switch is turned on. This particular circuit uses the battery merely to eliminate the hum in the output of the charger and the charger supplies the power directly to the set. Directions for connecting up the circuits are given with each charger.

The advent of special tubes suited to alternating current operation has simplified the problem of filament power supply. These have a fairly low terminal voltage and use a high filament current. The usual 110-volt supply is stepped down by means of a small transformer to the required filament voltage. By using a special circuit filament batteries are eliminated. This will be discussed in more detail later.

The problem of supplying filament power from the a.-c. lighting mains for the 199 type tubes was solved in a slightly different manner. There are some "B" battery eliminators capable of supplying sufficient power for this purpose at a fairly high voltage. In order to make use of this power the filaments of all the tubes in a set using the 199 type are connected in series instead of parallel and the current taken directly from the "B" eliminator.

Several "A" battery eliminators have appeared which do not use a storage battery in any way. The a.-c. of the line is rectified and passed through a filtering system to produce a strictly direct current at a low voltage. The apparatus required is very bulky and the power consumption is necessarily high. The a.-c. tubes will probably render such eliminators obsolete, for the same results can be obtained with less expensive apparatus and more efficiently.

The most common method of supplying the "B" power to receiving sets has been through "B" batteries. Up to about 135 volts this is fairly satisfactory but beyond this voltage batteries are very expensive. Sets using more than five tubes consume a great deal of "B" power so a method was devised to supply the power directly from the 110-volt a.-c. lighting mains found in nearly every section of the country. The devices which accomplish this are called "B" eliminators and vary with respect to voltage and power rating. These are very satisfactory and when the proper eliminator has been selected will be more economical than ordinary batteries. The most popular type for three, four and five-tube sets has been the "Raytheon Eliminator," which will be described in detail.

A-C. Filament Tubes.—The following types of tubes are suited to a.-c. filament operation: 210 at 7.5 volts, 171 at 5.0 volts, 112 at 5.0 volts, 226 at 1.5 volts and 227 at 2.5 volts. The latter tube is interesting in that it has a five-prong base. In addition to the usual filament, plate and grid connections there is a fifth to a thimble surrounding the filament. In the 227 type the filament is used to heat the thimble and the thimble gives off the electrons necessary for operation. This tube is designed for use as a detector. In addition to the requirement for correct voltage it is necessary to have a potentiometer or other resistance with center tap connected across the filament terminals of the socket. The grid return and negative "B" connections are made to this tap. The circuit diagram in Fig. 31 shows a typical filament wiring system using the new a-c. tubes..

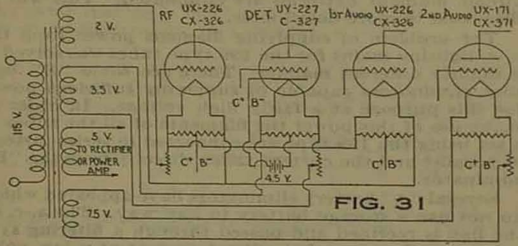
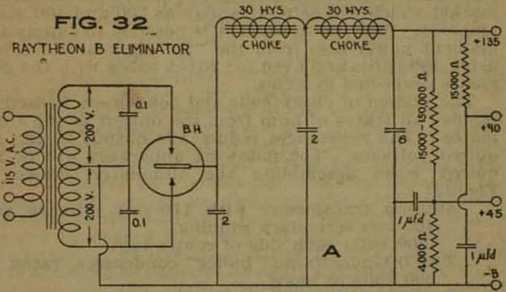


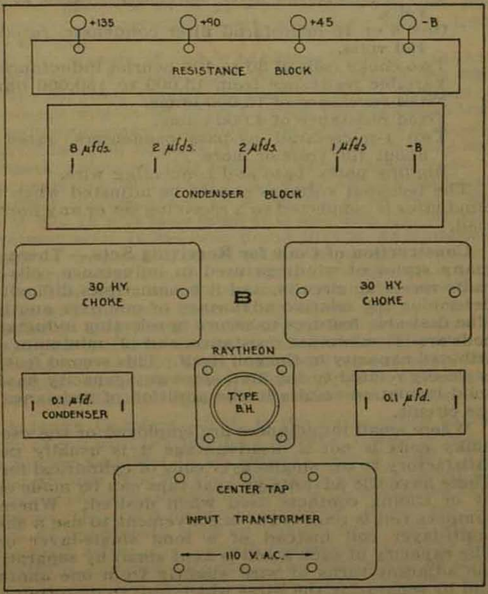
FIG. 31

Raytheon "B" Battery Eliminators.—This type of eliminator is satisfactory for supplying voltages up to about 180 for most receiving sets. If more than 180 volts are required the Raytheon tube should be replaced by thermionic rectifiers. The Raytheon depends upon the conductivity of a gas for its rectifying properties. The circuit diagram for a good eliminator is shown in Fig. 32. Referring to this diagram, it will be seen that the rectifying tube has two points and a plate sealed in a gas filled bulb. Current will flow from the points to the plate but not in the reverse direction. As no filament is required for its operation, the Raytheon tube will not be subject to damage from filament breakage or burn-out. This type of rectifying tube is supplied in several sizes. One size will deliver 60 milli-

FIG. 32

RAYTHEON B ELIMINATOR





amperes at 150 volts and another 85 milliamperes at 200 volts. Tubes of this type have been placed on the market which will deliver as high as 300 and 400 milliamperes. With these tubes it is possible to supply the filament power also from the "B" eliminator for sets using 199 tubes and even for 201-A tubes with the filaments connected in series.

The system of choke coils and condensers is used to remove all traces of hum from the output of the eliminator. The resistances reduce the output to the required voltages. The following apparatus will be required when assembling the eliminator shown in Fig. 32:

Step-up transformer with 110-volt primary and 400-volt secondary windings.
(200 volts each side of center tap)
Two 0.1-microfarad "buffer" condensers, rated at 200 volts or more.
One Raytheon tube or similar rectifier.
Two 2-microfarad filter condensers, rated at 180 volts.
One 8 or 10-microfarad filter condenser, rated at 180 volts.
Two choke coils of 30 to 100 henries inductance.
Variable resistance from 15,000 to 150,000 ohms.
Fixed resistance of 15,000 ohms.
Fixed resistance of 4,000 ohms.
Two 1-microfarad by-pass condensers, rated at about 100 volts or more.
Binding posts, base and connecting wire.

The terminal voltages should be adjusted when the eliminator is connected to a receiving set or any normal load.

Construction of Coils for Receiving Sets.—There are many styles of windings used in inductance coils for radio receiving circuits, and it is sometimes difficult to determine the relative advantage of one over another. The desirable features to secure in selecting inductance coils are (1) minimum resistance, and (2) minimum distributed capacity in the coil itself. This second feature is closely related to the first, since any capacity having solid insulation results in the addition of resistance to the circuit.

Where small inductances are employed or the use of bulky coils is not a disadvantage it is usually most satisfactory to use single-layer coils of cylindrical form. These have the advantages that taps can be made easily or sliding contacts used when desired. Where a compact coil is required it is convenient to use a short multi-layer coil instead of a long single-layer one. The capacity of such a coil is kept small by separating the adjacent turns of wire slightly from one another and by separating the wires which lead to its terminals. Various manufacturers separate adjacent turns by a number of ingenious schemes of windings by which the layers of wire are made to cross each other at an angle, leaving air spaces between the adjacent turns of a given layer. Some of the winding methods also result in a self-supporting coil which avoids the presence of an undesirably large mass of insulating material in its field. That the advantage of spaced winding and small coil capacity is not fully appreciated is indicated by the fact that some coils which are wound in this way are then mounted on blocks of solid insulating material through which the two terminal wires pass with very little spacing between them. These two terminal wires act like plates of a condenser, and the capacity between them has as its dielectric the solid insulating material of the mounting block. Thus the advantage gained by spaced winding is at least partly lost by a poor method of mounting; therefore in selecting coils it is desirable to consider not only the method of winding but also the method of mounting. Both should result in the use of as little solid insulating material as possible, and the turns of wire forming the coil, and especially the terminal wires, should be spaced from one another.

If this feature of design has been followed it is then worth while to investigate the resistance of the wire conductor itself, though ordinarily it is not essential to use large wire in an effort to keep the resistance low. A radio-frequency resistance of several ohms is usually unavoidable on account of the method of winding and mounting the coil; this makes it unimportant to go to the expense of the use of large wire, which would only decrease the resistance by a fraction of an ohm. No. 16 or No. 18 wire is as large as is desirable for ordinary receiving sets. It has been found that in the broadcast range of frequencies there is not much gain in using wire larger than No. 24. Within this range the single-layer solenoid is as efficient as any and considerably easier to build than more complicated types. For receiving on long waves where large inductances must be employed the coils should be of the "honeycomb" or "duolateral" wound type. At short waves below the broadcast range the most efficient type is the single-layer solenoid with spaced turns and No. 18 wire.

Antenna Couplers.—This is the name given to the type of coil used in coupling a detector circuit or radio-frequency amplifier to an antenna (not a loop). The most popular type for the usual broadcast receiving set is the single-layer solenoid wound on an insulating tube between 2½ and 3 inches in diameter. There are two sizes of condensers used in tuning most sets in the broadcast range, *i. e.*, 0.0005 microfarad capacity and 0.00035 microfarad capacity. The circuit will be more selective and the received signals more powerful with the use of the 0.00035 condenser. The other size uses less wire with a resulting decrease in circuit resistance. The usual construction is as shown in Fig. 33. The coil in the antenna circuit contains about 8 to 10 turns of No. 18 or No. 20 wire. The wire may be d.c.c., d.s.c., enamel or single covered wire.

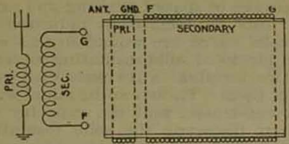


FIG. 33
ANTENNA COUPLER
3" DIAM.
SECONDARY #24 D.C.C.

CONDENSER	TURNS
0.0005	55
0.00035	65

PRIMARY
8 TO 10 TURNS #20 D.C.C.

Radio-Frequency Transformers.—The coils used to couple the stages of a radio-frequency amplifier are called radio-frequency transformers. The construction is somewhat the same as for the antenna coupler. The secondary is exactly the same but the primary may be wound in a slot at one end of the coil as shown in Fig. 34. The resistance of this coil is not very important because the primary is connected in series with the plate resistance of a vacuum tube, which may be as high as 18,000 to 20,000 ohms, depending on the plate voltage of the tube. Therefore the only requirement is that the wire be capable of carrying the plate current without burning out. Small wire is best because it occupies little space in the slot. The object in designing the coil in this way is to obtain maximum inductive coupling and minimum capacity coupling between the primary and secondary circuits.

The secondary should be wound with No. 24 wire and the primary with about 20 turns of No. 26 wire wound in a slot at one end of the secondary winding. This end of the secondary should be connected to the filament or grid bias, and the other end of the secondary to the grid of the tube.

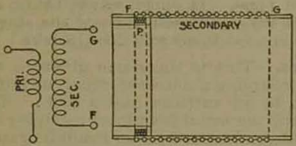


FIG. 34
RADIO FREQUENCY TRANSFORMER
3" DIAM.
SECONDARY #24 D.C.C.

CONDENSER	TURNS
0.0005	55-60
0.00035	65-70

PRIMARY
SLOT WOUND
20 TURNS #26 D.C.C.

Browning-Drake Regenaformer.—This type of coil was designed for use with the official Browning-Drake receiving set. The construction is like that of the radio-frequency transformer except for the addition of a tickler coil at the grid end of the secondary. A small diameter tickler is best because it will have less tuning effect on the circuit. The turns on the tickler are also wound in a slot, using as small wire as possible consistent with current carrying capacity and mechanical strength. No. 26 enamel wire for the primary and No. 22 or 24 for the secondary will do. The tickler requires about 20 to 30 turns of No. 26 enamel wire. Construction details are given in Fig. 35.

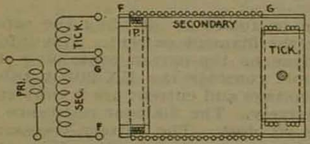


FIG. 35
BROWNING – DRAKE
REGENERAFORMER 3" DIAM.
SECONDARY SPACE WOUND #24

CONDENSER	TURNS
0.0005	55-60
0.00035	65-70

PRIMARY SLOT WOUND
20 TURNS #26 D.C.C.
TICKLER - ROTOR
20 TURNS #26 D.C.C.

Roberts Reflex Regenerative Transformer.—This transformer is exactly like the Browning-Drake coils except that the primary winding consists of 40 turns of wire with center tap for the neutralizing condenser connection and 90-volt "B" battery.

Three-Circuit Tuner.—The three-circuit tuner performs somewhat the same service as the Browning-Drake Regenaformer. Instead of coupling two radio-frequency stages, however, it is used to couple an antenna to the regenerative detector. Its primary winding must have a low resistance to be efficient. The secondary and tickler are the same as in the Browning-Drake coils. This type of tuner is shown in Fig. 36.

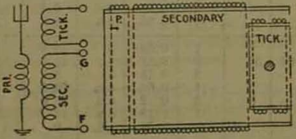


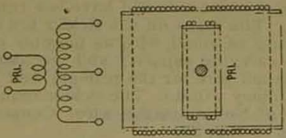
FIG. 36
THREE - CIRCUIT TUNER
3" DIAM.
SECONDARY #24 D.C.C.

CONDENSER	TURNS
0.0005	55
0.00035	65

PRIMARY
8-10 TURNS #26 D.C.C.
TICKLER - ROTOR
20 TURNS #26 D.C.C.

Oscillator Coils for Superheterodynes.—The oscillator coil is used to control the frequency of the local generator in a superheterodyne circuit. This coil consists of two windings—a primary and center-tapped secondary. The dimensions are given in Fig. 37. The wire can be No. 24 enamel, d.c.c. or d.s.c. Tuning is done with a straight-line frequency variable condenser.

Rheostats for Receiving Tubes.—The proper rheostat to use in a given circuit is not always known but can be calculated if the type of tube and the voltage of the battery are known. The resistance of the fila-



OSCILLATOR COILS
3" DIAM.
SECONDARY

CONDENSER	TURNS
0.0005	55
0.00035	65

PRIMARY
ROTOR 6 TURNS

FIG. 37

ment of a tube can be found by dividing the rated terminal voltage by the filament current. This information is always given on the carton containing the tube. As an example consider the UX-201-A tube. The rated filament voltage and current are 5 volts and 0.25 amperes respectively. The filament resistance is therefore 5÷0.25 or 20 ohms. The battery necessary to operate this tube has a voltage of 6 volts. Now, the total resistance which must be in the circuit to give the rated current of 0.25 ampere is given by: 6÷0.25 or 24 ohms. Since the resistance of the tube is 20 ohms an external resistance of 4 ohms must be used. The voltage of the battery is not always constant and the rated filament temperature is not always desired. If the filament rheostat is to serve as a volume control there must be sufficient resistance to reduce the current to almost zero. Therefore a variable rheostat of 10 to 20 ohms is recommended for a single 201-A tube.

Type	Va	Vf	If	Rf	No. of Tubes	Total Current	No. of Cells	Resist. Required	Size Rheostat
WD-11...	1.5	1.1	0.25	4.4	1	0.25	2	1.6	6
&					2	0.50	4	0.8	6
WX-12...					3	0.75	6	0.5	16
	6.0				3	0.25	s.b.	10.8	12
UV-199. .	3 to				1	0.06	3	25.0	30
&	4.5	3.3	0.06	55	2	0.12	3	12.5	20
UX-199. .					3	0.18	3	8.3	12
	6.0				1	0.06	s.b.	50.0	60
	6.0				2	0.12	s.b.	25.0	30
	6.0				3	0.18	s.b.	16.7	20
	6.0				2	0.06	s.b.	0	6
UX-120..	4.5	3.3	0.125	26.4	1	0.125	3	9.6	20
UX-200A	6.0	5.0	0.25	20	1	0.25	s.b.	4.0	10
UX-201A	6.0	5.0	0.25	20	1	0.25	s.b.	4.0	10
					2	0.50	s.b.	2.0	6
					3	0.75	s.b.	1.0	6
UX-112..	6.0	5.0	0.50	10	1	0.50	s.b.	2.0	6
UX-171..	6.0	5.0	0.50	10	1	0.50	s.b.	2.0	6
UX-210..	8.0	7.5	1.25	6	1	1.25	s.b. a-c.	4	2
UX-200..	6.0	5.0	1.0	5	1	1.0	s.b.	1.0	6

Use of Jacks.—A jack is a device which permits rapid connection of headphones or loud speaker to certain parts of a receiving set. If the headphones only are needed for reception on a powerful set they should be inserted in the detector circuit and not the final output circuit. There are several types of telephone jack. One type disconnects the rest of the circuit as soon as the plug is inserted and is called a double-circuit jack. Another type, known as a single-circuit jack allows the plug to be inserted without changing the circuit in any way. A third type is a filament control jack and automatically lights the tubes in the circuit in which the plug is placed. The use of the three types is shown by Fig. 38.

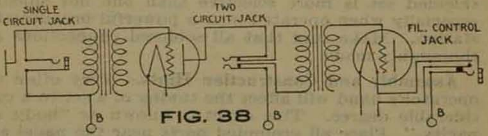


FIG. 38

Jacks are not employed as widely as in former days. A set is usually built either strictly for headphone operation or loud speaker operation. The volume control on high powered sets does not require a jack in the detector circuit in order to give less volume than the full output. Automatic filament control is not necessary in most cases and only serves to complicate the wiring of the set. A single-circuit jack is often placed in the output circuit in order to permit rapid change in connection of loud speakers where more than one are used in various parts of the building. However, the use of pin jacks which accommodate the cord tips directly is very common.

Increasing Selectivity.—The selectivity of a set is governed by the amount of resistance in the tuned circuits. A short antenna is more selective than a long one. Keep the antenna away from grounded conductors such as trees, and metal work on buildings. The insertion of a small condenser in series with the antenna often increases the selectivity. The use of a loop antenna provides maximum selectivity as far as the antenna circuit is concerned.

A selective coil has a large number of turns well spaced and well insulated. Rubber or fiber tubes are excellent foundations for coils. If possible wind the coils on a form and apply collodion to hold the turns in place and then remove the form. Do not mount the coils near metal panels or shields or end plates of condensers. Use large size wire in the tuned circuits.

The variable condenser should be well made with as little insulation as possible. Use as large a condenser as possible for minimum resistance. The sizes given in this chapter are satisfactory.

Be sure that the radio-frequency amplifying tubes are in good condition. The selectivity of a set depends upon the input resistance of these tubes to some extent. Sockets must be made of good insulating material such as Bakelite, hard rubber and the like.

By reducing the number of turns in the primary windings of antenna couplers and radio-frequency transformers the selectivity can often be improved. Separate the primary winding of the antenna coupler a greater distance from the secondary coil. The use of regeneration greatly increases selectivity. A well shielded set is more selective than one not shielded especially when operated near a powerful broadcasting station. Make sure that all soldered connections are thoroughly made.

Assembly and Construction Hints.—Very often the operator's hand will affect the tuning of a set to a considerable degree. This effect is known as "body capacity." Place all grounded parts near the panel and all high potential parts away from it to remove this trouble. If possible, ground the rotors of the tuning condensers and all shafts connected to dials on the panel. The use of metal dials in addition to the ground connection just mentioned will help to stabilize the set. If this condition cannot be remedied by any other method, shielding will be necessary. The shield should extend along the front panel and be well grounded.

Vernier dials will permit very fine adjustment of the tuning controls and are recommended for use with straight-line frequency condensers. These condensers are so called because the graph of the relation between frequency and dial readings is a straight line. When wiring a set keep all grid and plate leads well separated. Make sure that all connections are correct the first time and the set is bound to operate as it should. Short and direct wires without fancy bends and angles improve the efficiency of the set.

Use the best apparatus you can afford, making sure that the manufacturer is well known and has a good reputation. Poor apparatus is more expensive in the long run. Do not buy unknown brands of storage batteries, "B" batteries or tubes if a set with long life is desired. A fancy antenna is not always necessary for good operation. However, be sure that an approved lightning arrestor is connected to the antenna and is always in good operating condition.