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HOW TO TUNE YOUR RADIO SET

by

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How To Tune Your Radio Set

IN speaking of vacuum tube receiving sets we might compare them to phonographs. They are similar in the respect that both offer to the listener a reproduction of music and the human voice. Both may also be started and turned off at will. Beyond these points there is a vast difference. The phonograph is a machine that requires but little care, starts with a touch of the finger and continues to work without the need of attention until stopped either automatically or by the user. A vacuum tube receiving set, on the other hand, usually causes some annoyance to the average layman. Unlike the phonograph it requires attention and the operator is never sure whether it will keep its party manners throughout a programme. What is more, a certain length of time is necessarily spent in tuning or twirling the knobs, so to speak, before anything desirable is received. For a visitor the fun usually begins with the tuning, the amusement coming eventually with the reception of a concert. Also, the change of phonographic amusement requires but the change of a record while, with a radio receiving set, to attain this same object it is necessary to re-tune and pick up another station.

It has been the attempt of radio engineers and manufacturers to duplicate the simplicity of the phonograph in vacuum tube receiving sets. Some admirable work toward development in this line has been done, but so far no receiver has been placed on the market that can accomplish this feat, and it will evidently be some time before one does appear. The question then arises, what means can be applied to present vacuum tube receiving sets to attain satisfaction of operation?

The satisfactory operation of a vacuum tube set rests on a number of points, such as its design, construction, excellency of material employed in its make up, the circuit used, etc. However, the efficient operation of a good receiver in the hands of an individual rests on his ability to tune it. This is the problem of the average layman who owns a set although he may not realize it. The man of today sits down to his "radio" with the intention of picking something out of the air. To tune, he rotates the knobs and dials at an alarming rate, or slowly moves each one separately from zero to 180 degrees and expects to get unusual results. Others of course have "methods of their own," but the majority are ignorant on the subject of tuning. True, they think they are tuning, but as to what is going on in their receiving sets and as to the correct method of procedure, sad to say, they are completely in the dark.

Now here is the point. They all get results, meaning that they eventually "land" some station. There may be some queer noises attached to whatever is being received, there may be interference or the signals may not be loud. Such conditions are usually attributed to the receiving set itself, not to any lack of adeptness on the part of the operator. Although it may be the fault of the set it is a good guess that in most cases it is not. The reception of signals even though they be fairly loud does not by any means testify that the set is in tune with the station being received. It is for this reason that the how and why of tuning is a vital subject and should be understood by everyone owning a vacuum tube receiving set.

CHARACTER OF RADIO WAVES

It is, in this book, the intention of the author to place before the reader a concise outline of just what should be done to tune different types of vacuum tube receiving sets so that he can get the most out of his own outfit.

The first important step is the thorough understanding of the character of radio waves. In appearance, light, heat, sound and radio waves are similar. They differ only in their characteristics. The way in which a radio concert is brought to you may be explained by the following analogy. Suppose we were to drop a stone in the center of a pool of water. It would be seen that little waves are formed that seem to leave from the point where the stone struck the water, and travel out in all directions, as shown in Fig. 1, until they reach the sides of the pool. This is exactly the way radio waves would look if we could see them.

Now suppose we were to drop a number of stones in the pool, say one stone every half a minute. It would be seen that for each stone dropped into the pool there would be a series of waves, these leaving the point where the stone struck the water, at regular intervals. The total number of waves produced by one stone would be called a wave-train. Therefore if we should drop five stones into the pool there would be five wave-trains that would travel along the water and continue until reaching the sides of the pool.

So it is in radio. In a broadcasting transmitter the electricity is the energy that produces the waves. The great space around the globe is like the pool, in that it

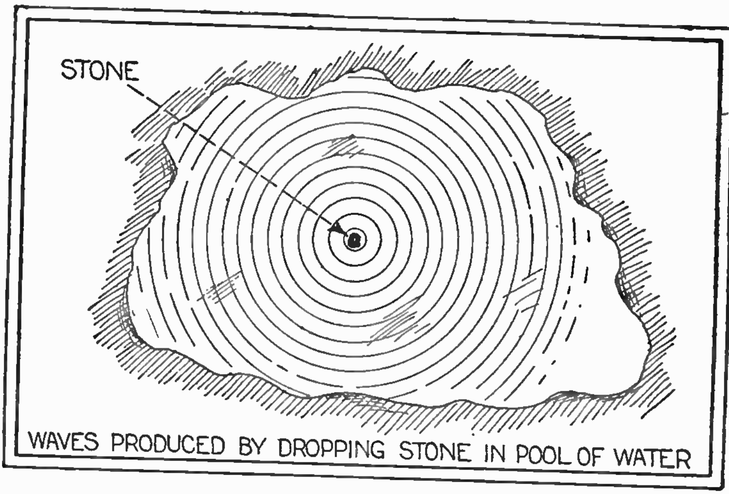

Figure 1

carries these waves along until they eventually die out. Just as in our analogy, radio waves leave the transmitting station and go out in all directions. A man at a broadcasting station speaking into the transmitter would cause it to send out a series of wave-trains. For an example, saying the word "radio" would send out a series of waves or a wave-train just as one stone did in the pool.

Let us go back for a moment to our analogy. Suppose that somewhere near the outskirts of the pool we place a cork as shown in Fig. 2. Again let us drop a stone in the center of this pool. What happens? When the stone hits the water, waves start out in all directions.

When the first wave strikes the cork, it bobs up, and, after the wave passes it goes down, only to bob up with the next wave. It is clear then that each wave imparts a certain amount of its energy to this float, thus making it move. In radio, the transmitted waves, when striking the aerial of a receiving set give some of their energy to it just as the water wave gave some of its energy to the little cork. Although the energy picked up by a radio receiver is very small, it is enough to make the set operative.

Wave Lengths

We have all heard that different radio waves have different lengths but just what is meant by this, and in which way they are measured is not generally known.

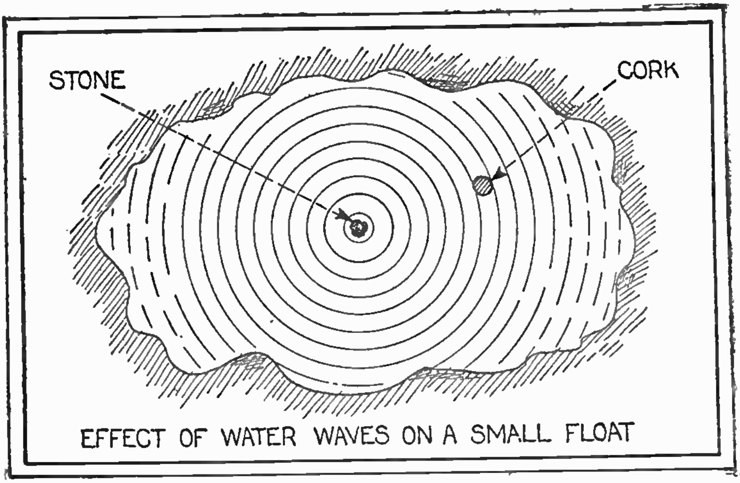

Figure 2

It will be observed that the waves on the pool are a certain distance apart from each other. If closely observed it will be seen that they are all the same distance apart. The distance from the top of one wave to the top of the one following or preceding it is known as the length of the wave, or wavelength. This can be better illustrated by referring to Fig. 3 where the cross-section of a num-

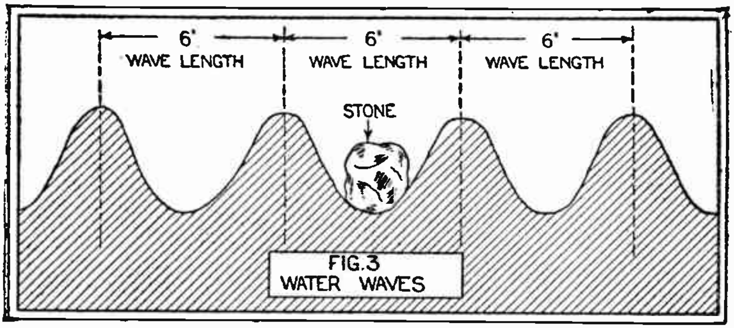

Figure 3

ber of water waves is shown, these having a wavelength of 6 inches. This would be their appearance if we should view them from the surface of the pool. One would likely measure this in inches or feet but in the radio field the metric system is used, and in measuring we would say that the length of a radio wave was 360 meters or 400 meters, etc. It must be remembered that the length between succeeding waves never varies. This factor remains constant unless changed at the transmitting station.

There is one more important point to be considered in wave-trains before taking up the subject of tuning. If we throw different size stones into the pool aforementioned, it will be found that with a small stone the waves produced will not be so far apart, but that there are

more of them than in the case where a larger stone was thrown in. In other words the small stone produces more waves in the same length of time than a larger stone would, but the length between these waves is not as great. This is more clearly illustrated by the water waves shown in Fig. 4 where "A" shows the waves produced by a small stone and "B" the waves produced by a larger stone. In radio we speak of the waves as being vibrations. It is clear then that a radio wave-train has a certain number of vibrations in a certain length of time, the number of these being determined by the length of the wave. From what we have learned of this it is clear that a 200 meter wave would have more vibrations than a wave 360 meters long.

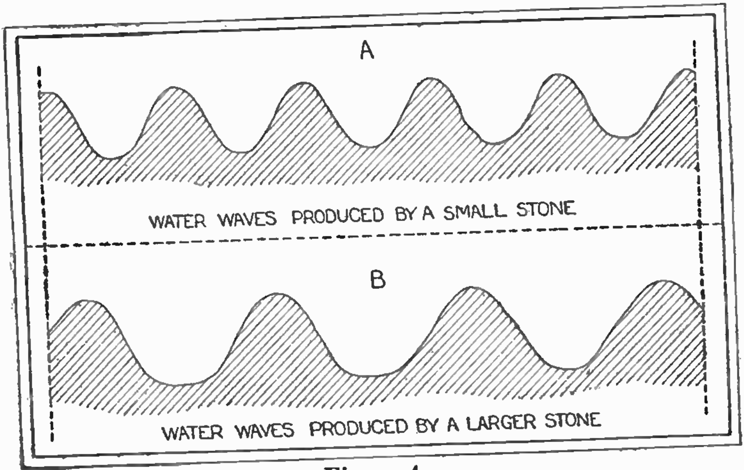

Figure 4

Fundamentals of Tuning

The fundamentals of tuning as we know them are based on the phenomenon known as the sympathetic action of vibrating members, or in other words, the disposition of some object to vibrate in sympathy with some other object in its vicinity which is vibrating by reason of a local energy. This can be better explained as follows.

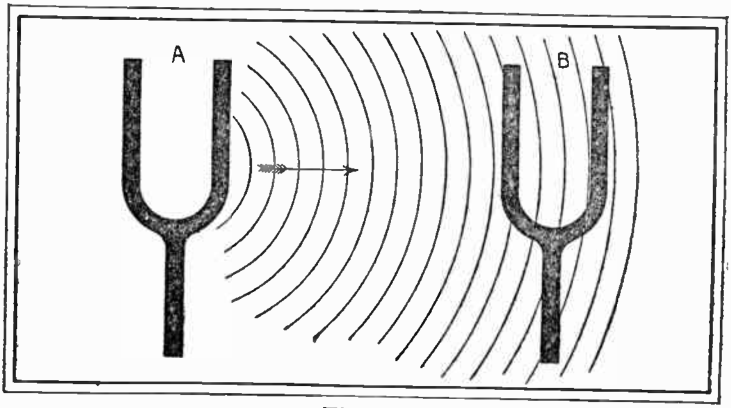

Figure 5

In Fig. 5 there are two tuning forks "A" and "B." If the tuning fork "A" be struck with a hammer it will vibrate and produce a sound wave. The pitch of the sound produced will depend upon the number of vibrations in the wave-train, or it can be just as well said, upon the length of the wave, since we have learned that one is relative to the other. The number of vibrations in turn depends upon the natural period of the tuning fork, meaning its disposition to vibrate at a certain wavelength due to how it is tempered and what it is made of. Now, with fork "A" vibrating should we bring fork "B" within its vicinity, it also will vibrate. If fork "B" has a different natural period of vibration than fork "A" the sympathetic vibrations of fork "B" will be comparatively weak since it is not in resonance or **tune** with fork "A." However, should "B" have the same natural period of vibration as "A," "B" would vibrate strongly when "A" was struck with a hammer. In this instance we would say that fork "B" was **tuned** to the same period of vibration as fork "A."

What applies to sound waves is equally true with radio waves. We have learned that a broadcasting station sends out waves, these waves having a definite length and therefore a definite number of vibrations per second of time. We have also learned that a receiving set collects a certain amount of energy from these waves. A radio receiving set is like the tuning fork in that it vibrates when it is struck by a wave. In radio though, the vibrations are of an electrical character. From what has been said concerning the tuning forks, it is clear that a radio receiving set must be in resonance or in **tune** with the

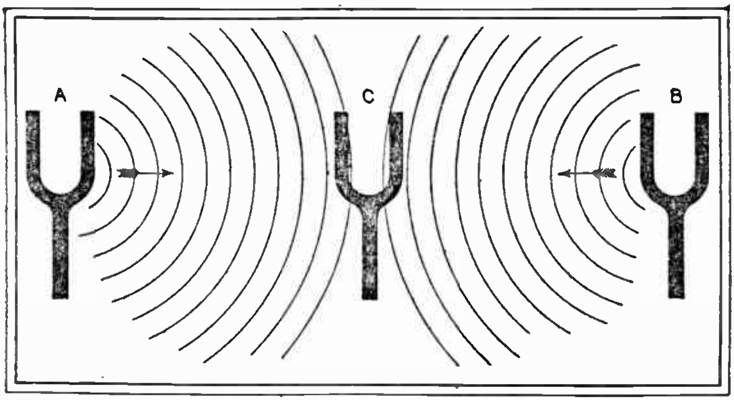

Figure 6

broadcasting station in order to receive the signals loud. If it were not in tune with the sending station the signals received would be very weak, just as in the case of the tuning forks.

To continue our subject, suppose we had three tuning forks, "A," "B," and "C" as shown in Fig. 6. Assume for the moment that all of these tuning forks had the same natural period of vibration. If we were to strike "A" and "B" with a hammer so that they would vibrate and produce sound waves, it is evident that fork "C" would respond to the waves of fork "A" as readily as it would respond to those of fork "B," since it is in resonance with both of them. If we attempted to send intelligible signals by tapping off the code with a hammer, sending a different message from "A" and "B," anything picked up by fork "C" would be an unintelligible mass of dots and dashes all mixed up. Now suppose that the natural period of vibration of fork "A" was changed, that of fork "B" and "C" remaining the same. Repeating the same procedure as above, what would be the result? Our receiving fork "C" would nicely reproduce the signals it picked up from "B," but those from "A" would be excluded, or they would be far too weak to be read through the strong signals from "B."

These phenomena are also apparent between a radio receiving set and one or more transmitting stations. Two stations of the same wavelength would interfere with each other in the receiving set while two stations with different wavelengths would not interfere with each other, the one in which the receiving set was tuned to being the one that would be received the best. This principle was put to use so that a large number of radio transmitting stations could send at the same time without unduly interfering with each other at the receiving end.

Now it stands to reason that our tuning fork with its unchangeable natural period of vibration would not be practical since it will only respond to other forks having the same natural period of vibration as its own. This would be equally true in radio. In such a case a separate receiving set would be required for each wavelength. However, radio receiving sets are so designed that we can vary or change their period of vibration so as to correspond to any number of wavelengths. This is accomplished by the use of one or more variable units in the receiving set, which are controlled by knobs and dials or other suitable means. In operation, such a procedure is referred to as **tuning**. It is in reality the shifting of the wavelength of the receiving set until it is equal to the wavelength of the transmitting station it is desired to receive.

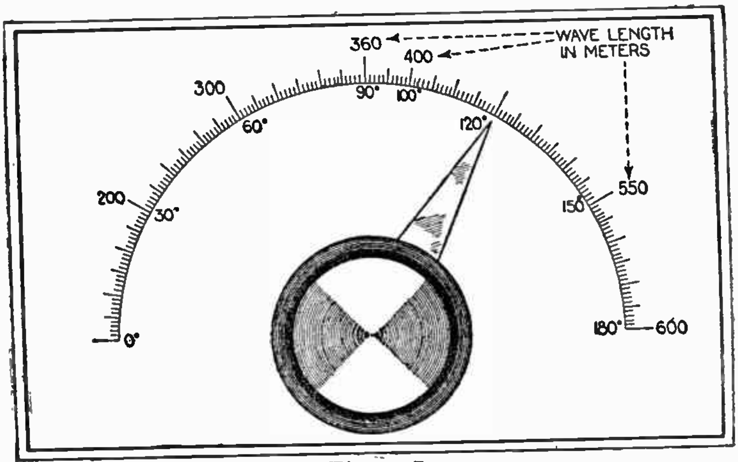

Figure 7

A visual conception of what happens is given in Fig. 7, where a knob with a pointer represents the wavelength control, this being similar to those employed in regular receiving sets. By moving this pointer from zero towards 180 degrees, the wavelength to which the receiver will respond is automatically increased. By rotating the knob until the pointer reached 100 degrees, stations transmitting on 400 meters would be received. By moving it back to 90 degrees 360 meter stations would be heard and so on. This gives to you an idea of tuning in its roughest form.

Types of Variable Tuning Units

As mentioned before, in order to accomplish tuning it is necessary to have one or more variable units. Usually the more variable units employed the better one can tune in one sending station, and tune out another. In Fig. 8

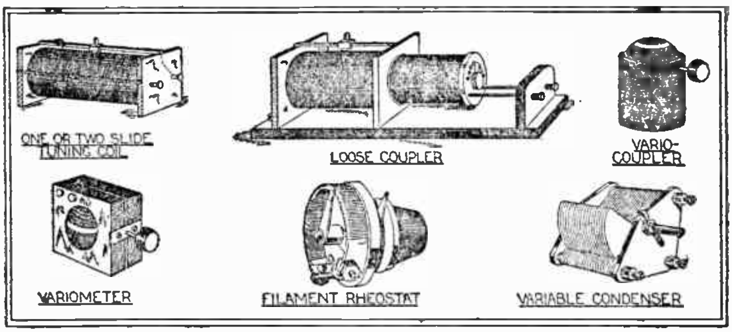

Figure 8

are shown the perspective drawings of those variable units widely used at the present time, some of which may or may not be found in the receiving set you own or contemplate owning.

Each one of these instruments is captioned with its conventional name and will be referred to throughout the book, as they are of greatest importance.

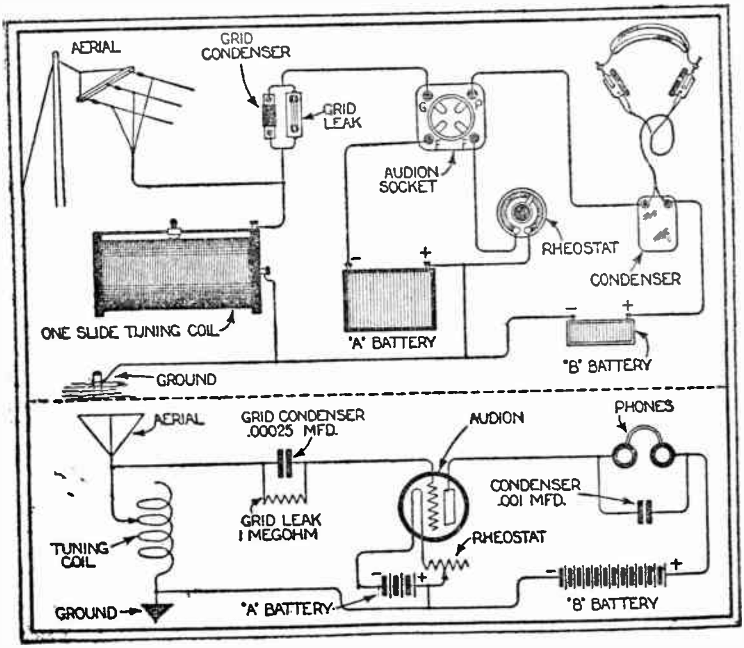

Figure 9—Circuit A

Single Circuit Vacuum Tube Receivers

In Fig. 9 are shown three common types of receiving sets known as the single circuit type. It is so named because there is a direct connection from the aerial and ground to all of the instruments. The tuning of these is comparatively simple. In circuit "A" where a one slide tuning coil is used, it merely remains a case of lighting up the vacuum tube by means of the rheostat provided for this, then moving the slider along the wire on

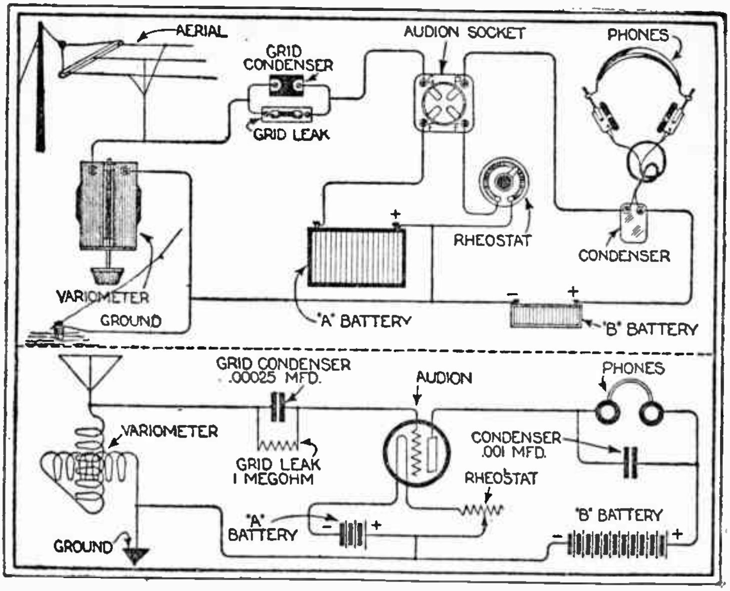

Figure 9—Circuit B

the tuning coil until some station is picked up. Moving the slider varies the wavelength in the same manner as explained before, allowing for a choice of wavelengths. In this case the movement of the slider from one end of the coil to the other represents a constant change of wavelength. The circuit of "B" employing a variometer for tuning, is similar in respect to that of "A" except that the wavelength or natural period of the receiving set is varied by rotating one coil within another, this variation being complete through an arc of 180 degrees. The circuit of "C" employing a two slide tuning coil is more selective than the two aforementioned circuits for the reason that there is another control which allows for a finer variation of the wavelength. This is a desirable addition since the wavelengths of some broadcasting stations differ only in a few meters. The proper manipulation of this lies in the moving of slider 1, until the desired transmitting station is picked up, then moving slider 2 to a point where the signals are loudest. Slider 1 should then be readjusted, upon which a slight increase in volume is obtained.

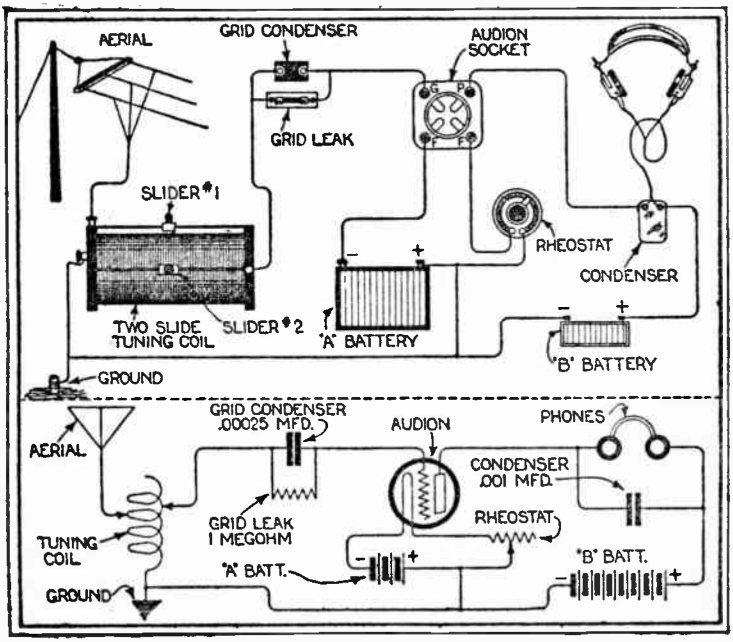

Figure 9—Circuit C

In use of the vacuum tube in the circuits outlined above it will be found that the adjustment of the filament temperature (by means of the filament rheostat) is not critical. As a rule the brilliancy of the filament should be increased to a point above which there is no longer an increase in the signal strength. As to the "B" battery adjustment, there is a certain voltage at which the vacuum tube will work at its best. The correct voltage can only be determined by experiment. It is, however, usually in the vicinity of 22½ volts. "B" batteries can be bought which have a number of connections on them for this particular purpose. After the correct voltage is once found there is no need in again adjusting the "B" battery until the total voltage of the battery starts to drop. This will happen only after continued use.

Increase of Selectivity by Addition of Condensers

When using any of the sets shown in Fig. 9 it may be found impossible to tune out other stations while listening to one in particular. This is due to the fact that these receivers are not as selective as others which contain a multiplicity of controls, meaning that they are unable to cut out interference as readily as their big brothers do. Under such conditions it is advisable to make the addition of a variable condenser (see Fig. 8). This instrument tends to give a still finer variation than would be obtained with a tuning coil or variometer separately. There are two points in the circuit of a receiving set where a variable condenser can be connected. When connected in series with the aerial as in "A" of Fig. 10 it automatically reduces the range of wavelengths the receiver formerly covered. For an example, if your receiving set could tune from 380 to 500 meters the addition of a variable condenser connected in the manner shown would change this range and make it say, 200 to 400 meters. In such a case it would then become possible to **efficiently** receive transmitting stations on 360 meters, where before it was not possible to get **down** to that wavelength. It must also be remembered that at the same time, the addition of this variable condenser allows for a finer adjustment and makes it possible to tune out interfering stations.

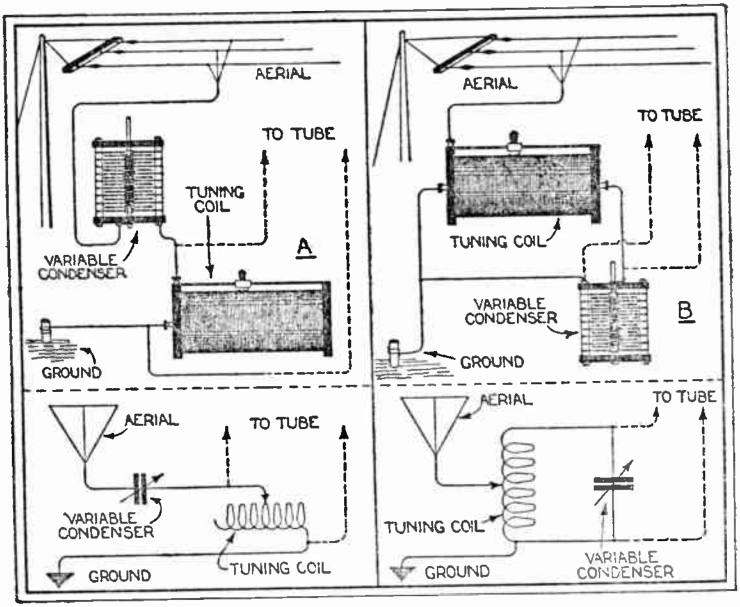

Figure 10

A variable condenser connected across a tuning coil or variometer as in "B" of Fig. 10 tends to boost the entire wavelength range; just the opposite of the former connection. A receiving set that could not reach 400 meters could easily do so with the variable condenser placed in this manner. Finer variation of the wavelength also holds true in this instance.

In tuning receiving sets "A," "B," and "C" of Fig. 9 when employed with a variable condenser, the same procedure should be followed as outlined before, the final adjustments being made with the variable condenser. We could say of this that the tuning coil or variometer was the first and coarse adjustment, while the variable condenser was the final vernier adjustment. These combinations should be experimented with since there are a number of settings of the variable condenser and tuning coil or variometer which will allow reception from one station, but there is one combination of settings that will work better than the rest. As an example, a station might be picked up with the variable condenser set at 50 degrees on the dial and the variometer at, say 100 degrees. By varying both of these units the same station could be picked up again with an entirely different setting of both the dials.

Two Circuit Receivers

With what is known as a two circuit receiver one more step is added to the process of tuning. The increased selectivity in tuning of these combinations over those of the single circuit variety makes up for any inconvenience in the extra operations. A receiving set of this type is shown in Fig. 11, where a loose coupler (see Fig. 8) is employed for tuning. The first or primary circuit consists of the aerial, the primary coil of the loose coupler and the ground connection. The second or secondary circuit consists of the secondary coil of the loose coupler and the rest of the apparatus employed in the receiving set. There are no wires connecting these two circuits together. This is a very interesting application and should be understood by the reader because it is widely used.

Assume that we have a receiver of this type and desire to receive from a station sending on 360 meters. Naturally, the first thing to do is to tune this first circuit to the same wavelength of the transmitter, i. e., 360 meters.

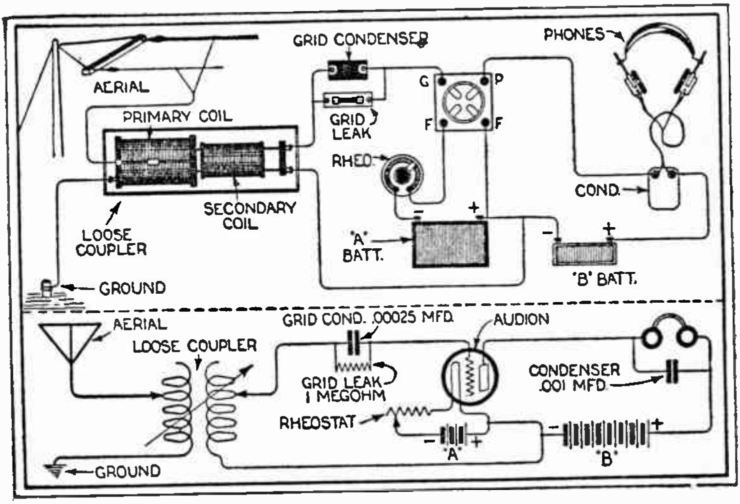

Figure 11

This would be accomplished by moving the slider along the primary coil until the station was heard. As soon as the primary circuit becomes in resonance or tune with the transmitting station it will vibrate electrically. Now these electrical vibrations travel through the space between the primary and secondary coils of the loose coupler, and are in reality, similar to the original radio waves. Therefore upon striking the secondary coil, they will impart a certain amount of energy to it just like the original waves imparted energy to the aerial or primary circuit. It is evident then that the secondary circuit will also vibrate, but in order that it vibrates strongly it must be in tune with the primary circuit. On the secondary coil of the loose coupler there is a switch arm which can make contact with a number of small points. These points connect into different parts of the secondary coil so that by moving the switch arm across them it is possible to "tap in" on different places in the coil, thus cutting in or cutting out turns of wire just as accomplished by moving a slider across the turns of wire on a tuning coil. With the switch arm at the extreme left, but very little wire is connected in the circuit. By moving the arm towards the right from one point to another, more wire is successively cut in to the circuit until reaching the last switch point where all of the wire is connected in the circuit. This switch arm is the means for tuning the secondary circuit.

As to the coupling. The secondary coil of the loose coupler is so designed that it can slide in and out of the primary coil. This movement is referred to as coupling, the position of the secondary determining the degree of coupling. This form of indirect connection or coupling, is of an electrical character. The amount of electrical energy that can be transferred from the primary coil to the secondary coil depends upon the degree of the coupling between the coils, or, in other words, the distance of the secondary coil from the primary coil. This is an important factor in the tuning of a two circuit receiving set. When tight coupling is used (secondary coil some distance within the primary coil) the set works similarly to a single circuit receiver, and is more susceptible to interference. In such a condition the receiver is said to be **broad** in its tuning qualities, meaning that a single station could be heard over a wide band of adjustments of the circuit. By **loosening** the coupling (moving the secondary coil further out from the primary coil) this objection would be overcome and the same station could be tuned out by a slight adjustment of the primary slider and secondary switch arm. In this state a receiver is said to be **sharp** in its tuning qualities.

In tuning this receiver tight coupling should be used to start with. Place the switch arm of the secondary coil on the third or fourth switch point. Move the slider on the primary coil until the desired station is heard. Then move the switch arm of the secondary coil back and forth across the points until a place is found where the signal is loudest. Next **loosen** the coupling, after which re-adjust the primary and secondary circuits by means of their respective controls, until the signal is at its best. Experience will prove that there is a certain degree of coupling that is superior to others, and that it can generally be left at this position for reception from a number of stations. Adjustment is then boiled down to the varying of the primary and secondary coils. As stated before, the adjustment of the vacuum tube requires very little attention.

The selectivity of this receiving set may be increased by the addition of one or two variable condensers connected as shown in Fig. 12. The one connected across the secondary coil of the loose coupler is by far the most important since the adjustment of this circuit by means of the switch arm is very coarse. Usually the entire tuning of the secondary circuit can be accomplished by the variable condenser. This also holds true when a variable condenser is employed in the primary circuit. The function and manipulation of these variable condensers is identical to that described in connection with "A" and "B" of Fig. 10. After a bit of experience with such

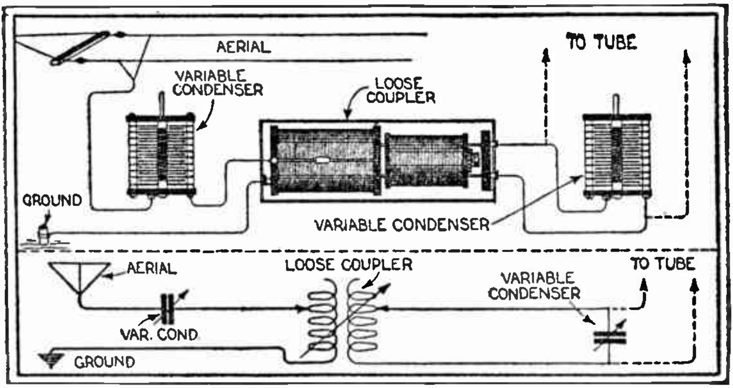

Figure 12

a set, it will be found possible to accomplish most of the tuning by merely adjusting the variable condensers in both primary and secondary circuits.

The arrangement of Fig. 13 is the same as that of Fig. 12, except that a variocoupler (see Fig. 8) is used for tuning instead of a loose coupler. A variable condenser is necessary across the secondary coil since no other means is provided for tuning it. The same method of procedure as outlined above is carried out with this receiving set. In a variocoupler, tight or loose coupling is had when the rotary coil (secondary) is parallel with the plane of the stationary coil (primary).

A two circuit receiver employing two Honeycomb, Spider-web or any type of non-adjustable coil is shown in Fig. 14. In this case a variable condenser is used in conjunction with both primary and secondary coils, as otherwise there would be no means for controlling the circuits aside from the coupling.

In this type of receiver, if the aerial used is a long one, or has more than one wire, the variable condenser should be connected in series with the primary coil as previously

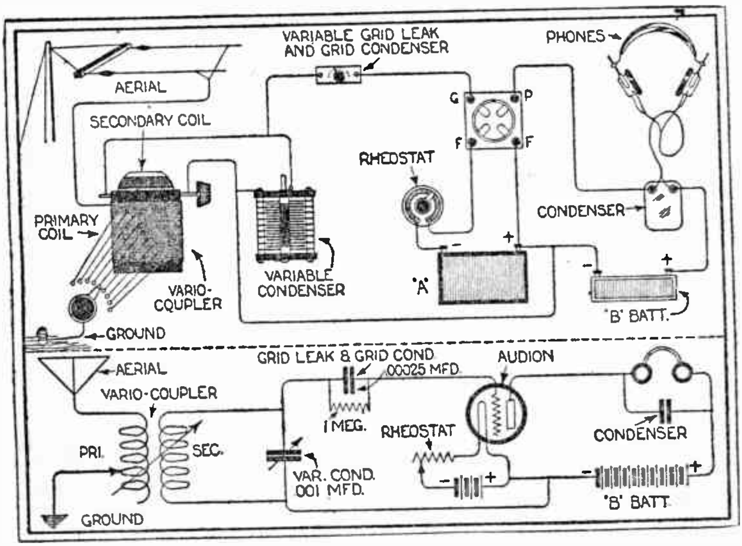

Figure 13

shown in "A" of Fig. 10. If the aerial is small, it should be connected across the primary coil as in "B" of Fig. 10. The other variable condenser should be connected across the secondary coil as shown in Fig. 14, never in series.

In tuning this set close coupling is best used at first as previously mentioned. The variable condensers of both primary and secondary circuits should then be varied until the desired station is picked up. The coupling should then be loosened and the two variable condensers re-adjusted for loudest signals, remembering at all times to try different combinations. After some practice it be-

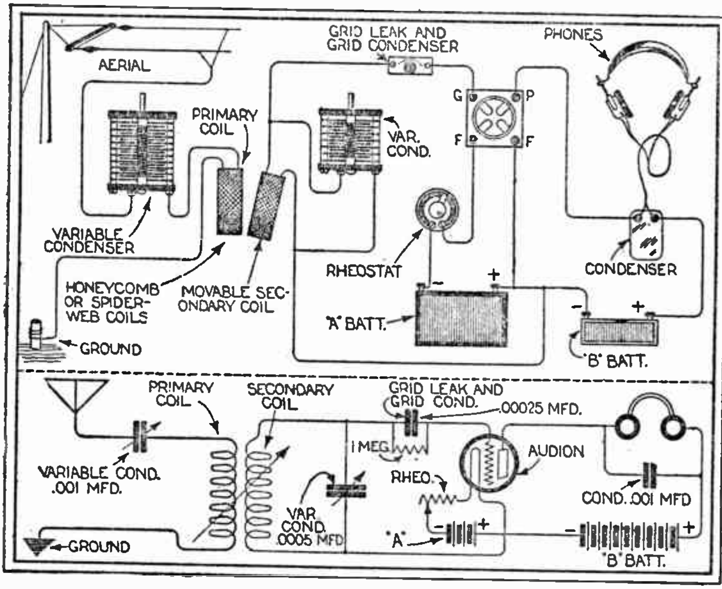

Figure 14

comes an easy matter to tune in a transmitting station and tune out others. It is well to mark down the settings on the variable condenser dials where different stations are picked up, so as to eliminate the necessity of running through the entire process of tuning every time it is desired to hear a particular one. This leaves then but the adjustment of the coupling between the primary and secondary coils. Of course if a knob and dial is provided for coupling adjustment, its corresponding readings can be marked down as well.

Regenerative Receiving Sets

So far only the tuning of so called **straight** vacuum tube sets have been discussed. The tuning of vacuum tube **regenerative** receivers brings in another phase of the subject, important because of its wide use. It is with this type of receiving set that the average person has so much difficulty. When handled properly such sets produce excellent results, in fact, phenomenal results in many cases. Improperly controlled, however, they become a constant annoyance, not only to the operator but to other people in the neighborhood who own receiving sets.

Regenerative receivers are adaptions of the straight vacuum tube receivers with the addition of the principle of **regeneration.** This means that all that has been said concerning the tuning of straight vacuum tube sets applies as well to the tuning of regenerative sets. It is now a matter of grasping the important points of regeneration and combining them with the knowledge gleaned from the tuning of the ordinary vacuum tube receiver.

Although the author has no intention of going into the theory of regeneration, it is necessary that the reader clearly understands what regeneration **is** before any progress can be made.

Regeneration

Referring to Fig. 15; the energy picked up by a receiving set from passing radio waves is impressed upon the "grid" of the vacuum tube which, as seen in the drawing, is connected to the tuning coil. This comparatively small amount of energy, due to the characteristic function of the tube, releases a larger amount of energy (current) in the "plate" circuit of the tube, this current being supplied by the "B" battery. As seen, the plate circuit

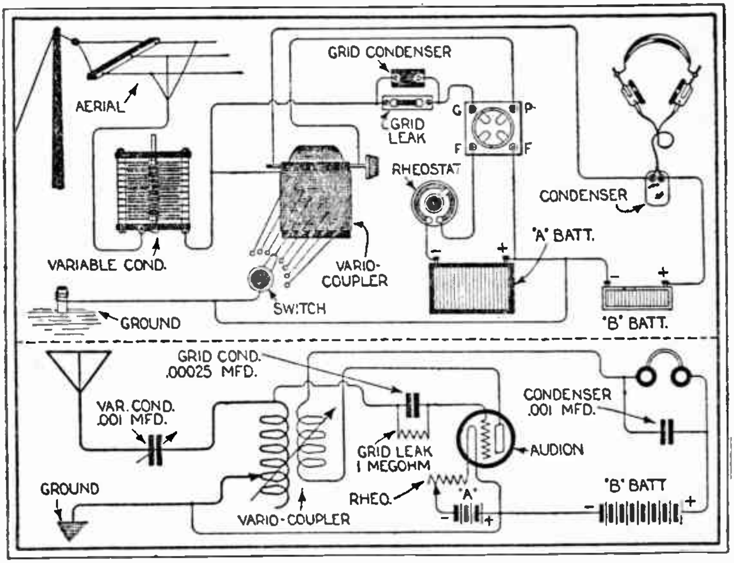

Figure 15

includes the "plate" of the vacuum tube, the head-phones, "B" battery and the filament of the tube, the circuit being completed from the plate to the filament through the small space within the tube itself. It is clear then, that a release of current in the plate circuit will pass through the head-phones. The variation of this current is a reproduction of the original signal, therefore what is heard is a faithful duplication of that sent from the transmitting station.

Now, by the introduction of a coil in the plate circuit which is in relation (coupled) to the tuning coil, regeneration can be obtained. Let us see what happens. A signal is received, which is duly impressed upon the grid of the vacuum tube. Immediately there is a large variation of current in the plate circuit, which is greater than the original current in the grid circuit. In order that this current in the plate circuit can flow, it must pass through the coil that has been introduced. Since this coil is coupled to the tuning coil there will be a transference of energy between the two just as there is between the primary and secondary coil of a two circuit receiver. It is evident then that a good portion of the energy in the plate circuit is fed back into the grid, tending to reinforce the original energy that the receiver is picking up. This naturally increases the total energy on the grid and therefore the plate current will be still further increased and the resultant signals will be much louder, hence the use of the word **regenerate.** The extent of feed-back from the plate to the grid is controlled by the coupling between the feed-back coil and the tuner. The coupling is very critical in most cases and it is this extra control that is of importance. The feed-back coil referred to is usually called a "Tickler" although some manufacturers prefer to term it as the "Regeneration control." In usual cases the secondary or rotor coil of a variocoupler is employed as the tickler, the stationary coil being used as the tuner.

Fig. 16 gives an illustration of the effect of tightening the coupling between the tickler and tuning coil. The white portion designates the amount and extent of regeneration that can be had. Assuming that a left to right movement of the knob and pointer tightens the coupling, it will be seen that the regenerative amplifica-

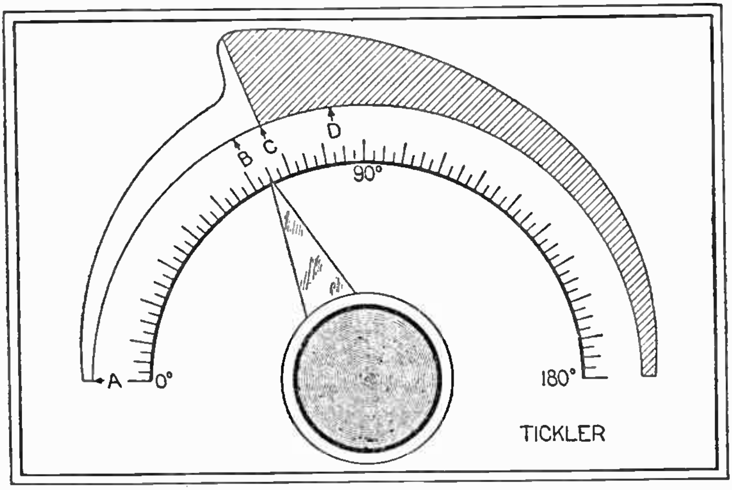

Figure 16

tion from A to B is a gradual increase, but that it reaches no great proportions. From B to C however the amplification increases rapidly. Above C the tube ceases its function as a pure regenerator and in reality becomes a miniature transmitter. This is represented by the shaded portion. When the pointer is moved past the point C a clicking or plucking noise is heard in the headphones. It is just below the point C that the greatest amplification is obtained and this is the point to be sought for.

A Single Circuit Regenerative Receiver

Fig. 17 shows a standard type of single circuit regenerative receiver employing a tickler coil for obtaining regeneration. The main tuning instruments are seen to be a variable condenser and a variocoupler. The secondary (rotary coil) of the variocoupler is used as the tickler in this instance, the primary acting as the tuning coil.

In operating a receiver of this type, the filament of the vacuum tube should be turned up until it burns brightly, or, in the case where a WD-11 or VT 1 tube is employed, until the filament burns a cherry red. Move the tickler coil knob from zero towards 180 degrees until the aforementioned "click" is heard. If this does not manifest the tube filament brilliancy should be slightly increased. If the circuit still persists to remain silent, the leads to the tickler coil should be reversed. The presence of the click assures us that the circuit is work-

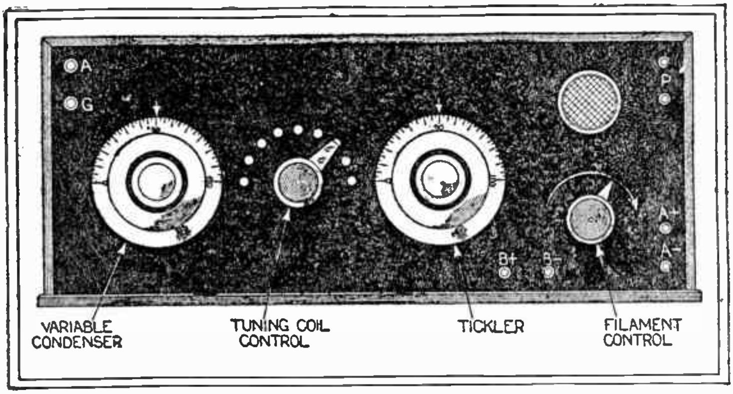

Figure 17

ing properly. Now place the tickler back to the zero setting. The desired station is now tuned in in the usual manner, by means of the variable condenser and the coil switch. When picked up the tickler knob is turned, upon which the signal volume will be materially increased. The presence of the critical point is denoted by a squealing noise. Reverse the movement of the tickler knob until this disappears, then readjust the variable condenser. This last operation will probably require another adjustment of the tickler in order to obtain quiet operation. In usual practice it is feasible to adjust the variable condenser and the tickler at the same time, using both hands. When receiving with a regenerative set the presence of a radiophone transmitting station is in the usual case denoted by a high pitched whistle. When the receiver is properly tuned or adjusted so to speak, the voice or music will come through clear, the whistle having vanished. If difficulty is had in separating the voice or music from the whistle even when loose tickler coupling is employed, the filament of the vacuum tube should be turned down slightly by means of the rheostat. As mentioned before, the switch arm can be placed on the switch point that proves the most satisfactory and thereafter left that way. It is only when large changes of wavelength are desired that it should require further adjustment.

Tickler coils are employed in a number of different types of receiving sets such as the two circuit variety which has already been outlined. Sufficient information has been given to enable one to efficiently tune any type of receiver employing a tickler, for, as said before, the individual circuits are tuned in the same manner whether a tickler be used or not. The point to remember is, that with any regenerative receiver, the desired station should be tuned in first, with the tickler knob set at a low value (loosely coupled). After the station has been tuned in, increase the tickler setting (tighten the coupling) until greatest amplification is obtained without distortion. After completing this procedure is the time to take care of the fine adjustments. As mentioned before, this consists of a slight readjustment of both the main tuning control and the tickler. These two adjustments should be done simultaneously, using both hands. Small alternate backward and forward motions of both tuning and tickler dials will produce the best point of reception. Remember that this last operation is critical, so great care should be taken. Also remember that every time the receiver tends to squeal or howl, the tickler dial setting should be moved back until a point is again reached where the disturbance disappears.

Three Circuit Regenerative Receiver

A three circuit regenerative receiving set employing two variometers and a variocoupler for tuning is shown in Fig. 18. This set is especially adapted to the reception of radiophone stations because of its extreme selectivity. A variometer is introduced in the grid circuit to allow for fine tuning. With the addition of this variable element it is unnecessary to use a variable condenser across the secondary coil of the variocoupler since there is now means for controlling it.

Tuning this receiver remains about the same as a similar set employing a tickler coil. In this case, however, we have more of a control over the plate circuit, which can now be **tuned** by means of the plate variometer. Theoretically, this receiver will be at its most efficient point of operation on a certain wavelength when the plate circuit, by means of the plate variometer, is brought in resonance or tune with the grid or secondary circuit. Just as we tune a secondary circuit to a primary circuit, so, in this receiver, do we tune the plate circuit to the grid circuit.

Referring again to Fig. 18; in the preliminary tuning of this set the plate variometer dial should be placed at zero setting and the grid variometer dial somewhere within the vicinity of 60 degrees. With comparatively tight coupling as shown in the illustration, start tuning the primary in the usual manner. In this set there are two switch arms. One of these arms when moved, adds

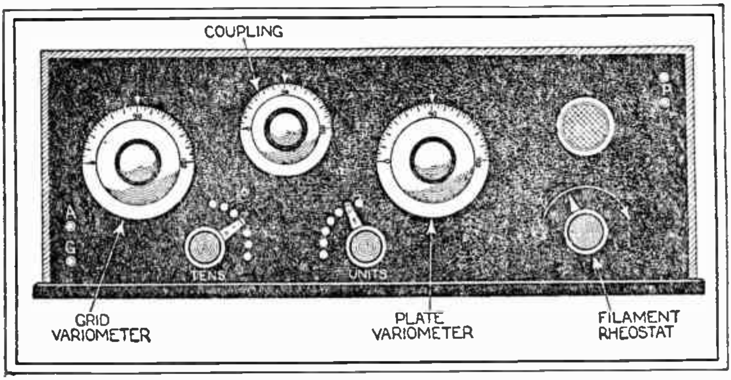

Figure 18

or subtracts ten turns of wire at a time in the circuit, while the other controls but one turn at a time. These switches are marked "Units" and "Tens" in accordance with their type. Start adjusting the "Tens" switch, moving it over the contact points until the station that you desire to listen to is heard. The units switch is then moved in order to get a still finer adjustment. To further increase the volume the plate variometer is moved from zero towards 180 degrees until a point is reached just below where squealing manifests. The final adjustments are accomplished by simultaneously moving both the grid and plate variometer controls back and forth and mentally checking the apparent intensity of the signals until a point on the scale of both dials is found where the station is heard best. In rotating these two dials, always keep them below the point where there is squealing. If undue interference should be experienced, the coupling of the variocoupler should be loosened and the settings of both variometers changed. In practical work it may not be found necessary to bother with the adjustment of either the primary coil or the coupling, accomplishing all the tuning with the two variometers.

In all systems employing regeneration the main point to keep in mind is that the greatest amplification can be obtained just below the point where the set starts to squeal, and that when tuning, one should always endeavor to keep below that point.

Capacity Feedback

There are a number of circuits today using capacity (condenser) feedback. Those developed by Mr. Reinartz are probably the most effective in their operation. The layout and circuit of Fig. 19 is one of his recent developments and is the type most widely used. A variocoupler is employed as the tuning unit, the rotor of which is connected in series with the stationary coil as in a variometer. No tickler coil or variometer is used, the regeneration being obtained by the variable condenser V.C.

The manner in which regeneration is obtained is better understood by the following. A condenser connected in a circuit, allows the passage of the radio frequency currents which are traveling through it, when a signal is being received. A condenser of a certain capacity will allow radio frequency currents of a certain wavelength (frequency) to pass more freely than others. It is clear then, that if a variable condenser is connected from the plate to the grid of the vacuum tube, it will feed the

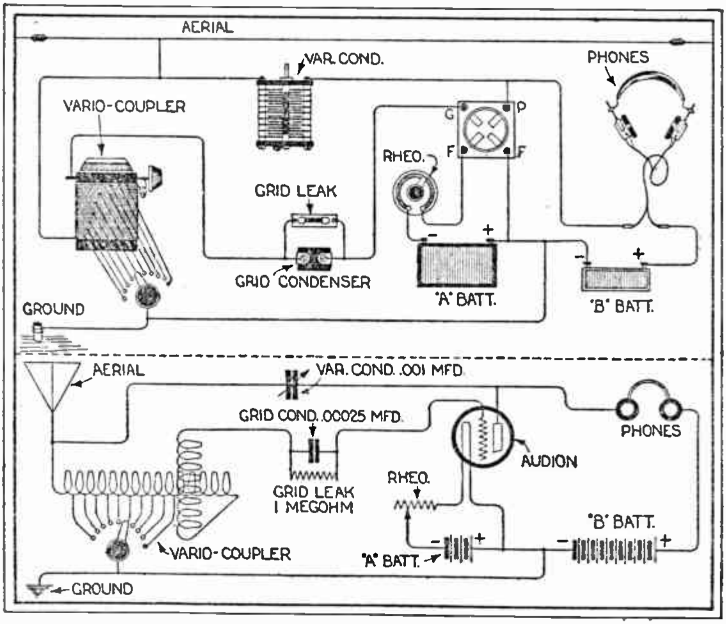

Figure 19

magnified radio frequency currents in the plate circuit back to the grid circuit and thus produce regeneration. Being a variable condenser, it can be so adjusted that not enough of the current will pass to cause the set to become unstable and squeal, but still a sufficient amount to give maximum regeneration or amplification. This condenser might well be termed an electrical valve.

In tuning this type of receiver, as in former types, it is not necessary to adjust the switch arm after the approximate wavelength has once been found. For an example, it might be found that 360 meter stations were received best with the switch arm on the third switch point and 400 meter stations on the fifth switch point. Thus the operation is boiled down to two controls, namely, the rotor of the variocoupler and the variable condenser. It will be found that the tuning of this receiver is identical to that described in connection with Fig. 17, wherein tickler feedback regeneration was employed. As mentioned before, it is best to manipulate both controls at the same time, remembering throughout the adjustments, to always keep below the point where the receiver starts to squeal. If squealing should persist during operation, the brilliancy of the vacuum tube filament should be decreased slightly by means of the filament rheostat.

The Flewelling Receiver

The Flewelling Receiver has gained popular favor, due to the enormous amplification that can be obtained with but one vacuum tube and a handful of apparatus. Long-distance reception is also possible, provided the set is operated correctly. The average person, however, finds great difficulty in getting this type of receiver to function in a reliable manner. There is little wonder in this since the Flewelling set is not only very critical in its adjustment, but has the characteristics of a spoiled child. The greatest of care is required when making adjustments and, for this reason, it is not the receiver for an impatient person. One of the characteristics of this receiver is the continual presence of a high-pitched squeal in the headphones or loud-speaker. If this squeal should cease, the receiver would no longer operate properly. Although the squeal is bothersome, one can become used to it in time. In some instances it may be found possible,

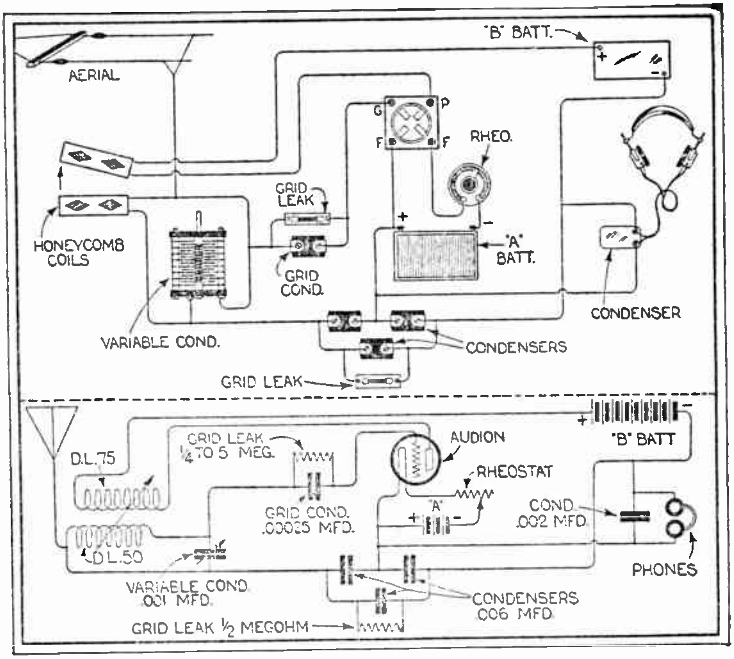

Figure 20

by critical adjustment of the grid leak, to raise its pitch to such a high point that its reality seems but a product of the imagination. The presence and control of this squeal is produced and varied by an adjustable grid leak. When preparing the Flewelling Receiver for operation, this is the first adjustment to be made. In Fig. 20 is shown the layout and connections of the Flewelling Receiver. As seen, there are four variable units, viz., the variable condenser, the Vernier variable condenser, tickler coil and the adjustable grid leak. In the preliminary adjustment, light the filament of the vacuum tube by means of the filament rheostat, then place the tickler coil in close proximity to the tuning-coil (tight coupling). The adjustable grid leak should then be varied until the aforementioned high-pitched squeal is heard. It will be found that this adjustment is very critical. If the squeal is not immediately produced, try varying the tickler coil and the variable condenser, doing so for every adjustment of the grid leak. Some nearby station should now be picked up for means of test. Proceed to do so in the following manner: Move the dial of the variable condenser from zero toward 180 degrees, until the whistle of a broadcasting station is heard. This will probably be accompanied by a loud, rushing noise in the headphones. If so, the coupling of the tickler coil should be loosened and followed by a readjustment of the variable condenser, until the particular station is heard clearly. As the pitch of the squeal has much to do with the reliable operation of the Flewelling Receiver, it is necessary to experiment in order to find what pitch gives the most satisfactory results without being of annoyance to the listener. This, as mentioned before, is accomplished by varying the adjustable grid leak. When this is once determined, it is not necessary ever to touch the grid leak again. Thereafter, the tuning-in of a station is accomplished: First, by the simultaneous variation of both the variable condenser and tickler coil, until the station is heard; then, with the variable condenser left at that point, the station can be brought through clearly and loudly by a fine adjustment of the tickler coil and the Vernier condenser. This last adjustment is also very critical and should be done with the greatest care. Best results are usually obtained with loose coupling between the tickler and tuning coil. The loud, rushing noise that is heard in the headphones is another characteristic of the Flewelling set and denotes the reaching of a point of resonance or "balance."

Use of Audio Frequency Amplifiers

Practically all of the widely used variations of vacuum tube receiving sets have been reviewed but these have not been mentioned in conjunction with audio frequency amplifiers. Since the addition of one or more stages of audio frequency amplification does not change the method of tuning, it is not necessary to dwell on them. It is well to mention though that since the magnet windings of the head-phones are not usually the same as the primary winding of the first audio frequency transformer, when the latter is substituted in place of the former, which is done when the phones are taken out of the receiver circuit and plugged into the amplifier, the receiver will require retuning. This is true in most cases, so, when you plug into the amplifier try readjusting your receiver to determine if this substitution has made any difference. If it has not there is no need to think of it again.

Radio Frequency Amplification

Where audio frequency amplifiers are used to increase the volume of signals, radio frequency amplifiers are used to increase the receiving range of a set. Also, unlike the audio frequency amplifier, they are connected in the circuit before the detector tube used in the receiving set. The common types of radio frequency amplifiers have transformers that are similar in appearance to those of the audio frequency type, although of slightly different construction.

A popular type of receiving set having two stages of radio frequency amplification is shown in Fig. 21. This set has but two controls, one for tuning and one for the "stabilization" of the receiver. The tuning control is a variable condenser and the "stabilizer" is an instrument known as a "Potentiometer" which is similar in appearance to a filament rheostat, but having a much higher resistance. Although an aerial and ground may be used with this set, it is usual and more convenient to use a "loop aerial." This consists of a square frame with a number of turns of wire wound on it.

The tuning of this variety of receiver is very simple. The respective rheostats of all the tubes are turned on and raised to a point where the tube filaments burn at their normal brilliancy. This, of course, depends upon the type of tubes used, as mentioned before. The next step is to point either end of the loop aerial towards the station you desire to receive from. Then rotate the variable condenser dial until the station is heard. The position of the loop should then be more accurately checked by revolving it and noting the comparative signal strengths. It will be noted when tuning a receiver of this type that it often becomes inoperative. This is denoted by a "clacking" noise in the head-phones or loudspeaker. When in this state the receiver is unstable and fails to receive in the usual manner. It is in such a case that the "stabilizer" becomes effective. When such instances occur, the stabilizer knob should be turned slightly forward or slightly backward until normal operation is again obtained. At other times reception is accompanied by squealing noises. As before, it should be turned slightly in one direction or another until the objection is

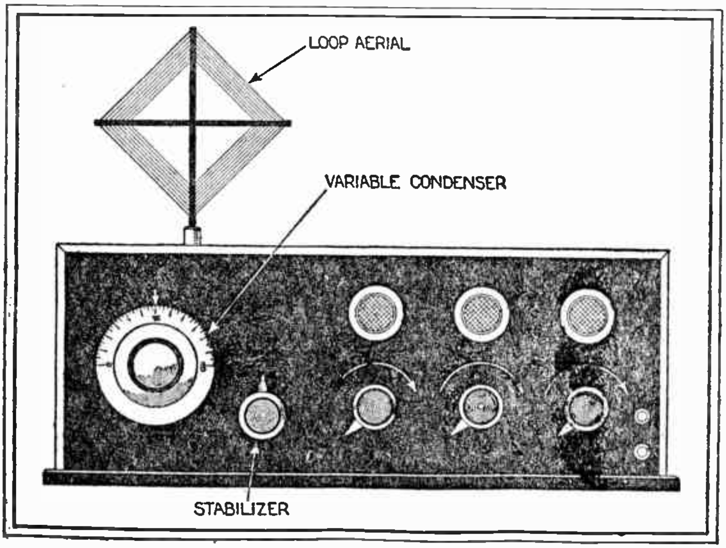

Figure 21

overcome. Since the movement of this instrument is not of great extent, its correct adjustment in relation to the receiver takes but a second. Remember, that when employing a loop aerial, one of its ends should point towards the station you wish to receive from. It should be, at least, in the general direction of the desired station or no signals will be heard. In localities surrounded by large steel structures or other similar forms of conductors, the directional qualities of a loop aerial are usually destroyed and it may be found that its position is not of importance, or that its position in relation to a certain station is somewhat off line. This is due to the fact that steel structures, and the like, will reflect and refract radio waves in the same manner that a mirror and a prism will reflect and refract light waves.

The Neutrodyne Receiver

There has lately been developed a set, which is a combined radio frequency amplifier and receiver. It is a decided improvement over the type of radio frequency amplifier and receiver already described, in that no stabilizer is required and that more amplification can be obtained per stage than was heretofore possible. The secret of its perfect operation is the addition of a few small semi-fixed condensers in a certain portion of the circuit, which **neutralize** the tendency of the amplifier to become unstable and squeal all over the place. The unstable action of the ordinary radio frequency amplifier limited its operation to a certain point. With the Neutrodyne Receiver it is possible to go beyond this limit and, therefore, obtain greater amplification. One of these receivers is shown in Fig. 22. It has two stages of radio frequency amplification and two stages of audio frequency amplification. The radio frequency transformers in this set look somewhat like variocouplers only they have no movable parts. In function they are similar to the ordinary type of radio frequency amplifying transformer. As seen, there are three knobs and dials provided for control, the controlling units themselves being variable condensers. The condenser on the extreme left is used for tuning the main circuit, while the other two condensers tune the respective circuits of the radio frequency amplifiers. In operating this set the following procedure should be adhered to. Place all of the dials at approximately the same setting. Start by adjusting dial No. 3, until a station is picked up. Vary it until the loudest signals are obtained; then adjust dial No. 2 in the same manner. The tuning is completed by the adjustment of dial No. 1.

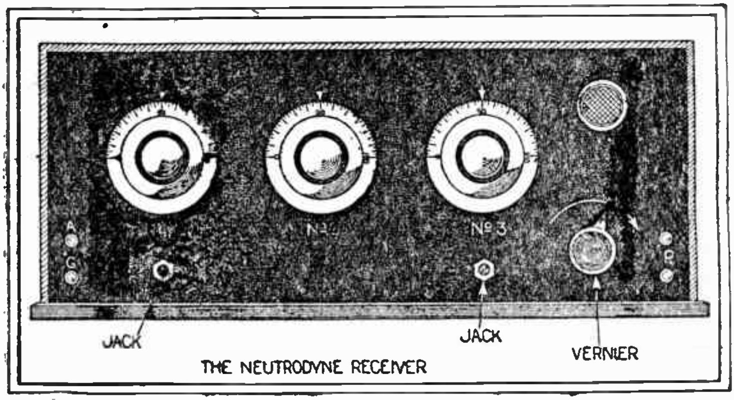

Figure 22

If, after placing all the dials at approximately the same setting, prior to tuning, no station can be picked up by adjusting dial No. 3, all of the dials should be shifted to another setting and the above outlined procedure again gone through. In any case, continue the changing of the dial-settings, until it is possible to pick up a desired station by adjusting dial No. 3.

After a few try-outs, the approximate primary positions of all the dials can be determined for each particular band of wavelengths. For an example, it may be found that for reception on a wavelength of 360 meters that all of the dials will be at approximately 50 degrees. Thus, whenever one wished to receive a station on this wavelength, all of the dials would be placed at this setting, and when heard, the particular station tuned in by readjustment of all the dials, starting, of course, with the one on the extreme right.

It is clear, then, that for best reception each circuit must be tuned to the one next to it. This is similar to the method employed in the three-circuit regenerative receiver, where the plate circuit is tuned to the grid circuit for best results. Care should be taken in tuning the Neutrodyne Receiver, for, if any of the circuits are off-tune, the volume of the received signal will be cut considerably. Since the amount of amplification that can be had from each of these amplifiers depends upon the tuning of it, it is easily understood that if, say, the first amplifier were off-tune in relation to the main tuning circuit, it would not pass as much to the second amplifier as it should. Therefore, the second amplifier would not deliver as much energy as it could if all circuits were in tune.

Referring again to Fig. 22, the small knob, with a pointer marked "Vernier," is the control for the rheostat that lights the filament of the detector vacuum tube. This should be varied during operation, until a point is found where reception is best. No filament control is provided for the amplifying vacuum tubes, since the adjustment of temperature or brilliancy of their filaments is not critical. The set is so wired that, when the headphone or loud-speaker plug is placed into either of the jacks, the tube filaments automatically light, and, of course, are extinguished when the plug is removed.

In Conclusion

In closing the author wishes to say that the greatest part of success in tuning lies in patience and practice. The exact way of tuning each type of vacuum tube receiving set cannot be handed out in a cut-and-dried form. Every set has its own characteristics, that the owner can learn only by experience. After a number of nights at home with the set, one gets the "feel" of it, and after a bit of practice it takes but the wink of an eye to tune in a station **right** the first time. A knowledge of what lies behind the panel, and what it is doing, is a long step towards the mastering of the art of tuning.

It is hoped that the reader now has a clearer vision of what takes place between a transmitter and a receiver, and better understands the requirements of a radio receiving set. It is an impossibility to discuss every type of radio receiver. The author has, however, explained the operation of the basic types. Other receivers are adaptions of these, so the reader should have no difficulty in applying the principles of tuning, as outlined in this book, to any type of receiver in existence today.

Probably the most appropriate word really descriptive of tuning is "balance." Balancing a receiving circuit to a transmitter is an actuality, as well as the balancing of the secondary circuit of a receiver to its primary circuit. So long as you realize the necessity for balance, the better are your chances for tuning to proficiency.

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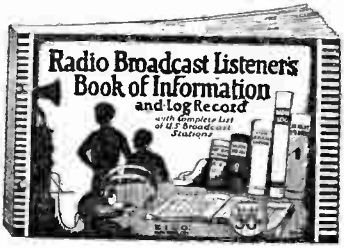

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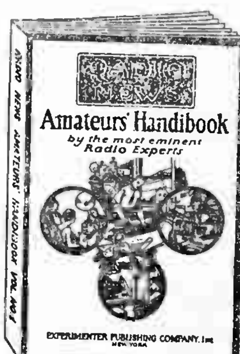

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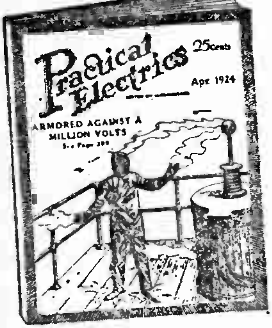

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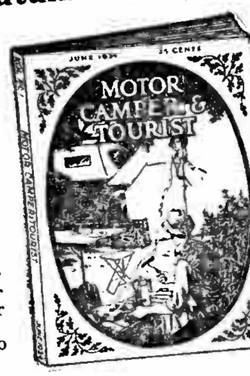

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