Regenerative and Reflex Receivers

This file contributed by Kim Smith and The Radio Electronique.

RECEIVER, ONE TUBE.-A single vacuum tube may be used as a detector for satisfactory headphone reception up to fair distances. A non-regenerative one-tube receiver with condenser tuning is shown in Fig. 1. The coil and condenser are chosen according to information given under *Coil, Tuning, Sizes Required for.* A similar non-regenerative receiver, but with variometer tuning is shown in Fig. 2. The receivers of Figs. 1 and 2 are both of the single circuit variety, delivering considerable power but having little selectivity.

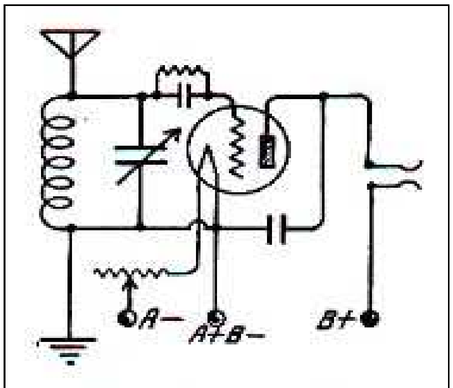


FIG. 1.—One-Tube Single Circuit Receiver.

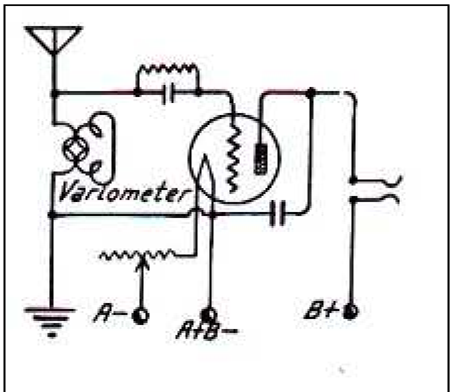


FIG. 2.—One-Tube Varicmeter Tuned Receiver.

Regenerative one-tube receivers are shown in Figs 3 and 4 The antenna circuit is loosely coupled in both of these types, the single circuit arrangement being a too powerful radiator to allow its use with regeneration. The circuit of Fig. 3 uses the usual tickler coil feedback. The receiver of Fig. 4 uses a plate variometer for producing feedback through the internal capacity of the tube. Both of these methods of obtaining regeneration are described under *Regeneration, Methods of Obtaining.*

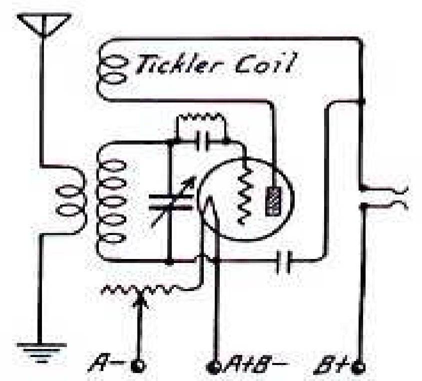


FIG. 3.—One-Tube Receiver with Tickler Coil Regeneration.

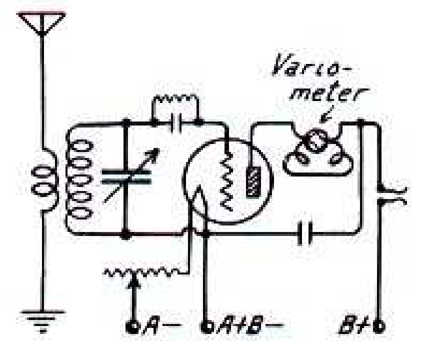
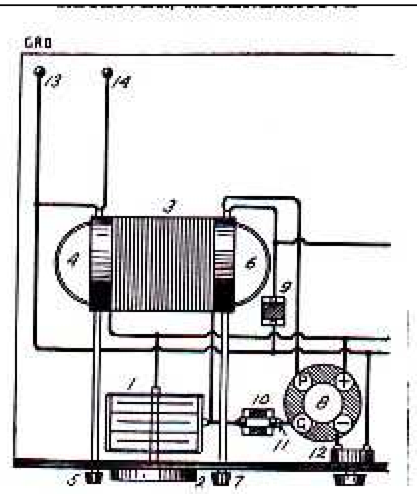


FIG. 4.—One-Tube Receiver with Variometer Regeneration.

RECEIVER, REGENERATIVE.-This type of receiver employs regeneration in the detector stage by using any of the methods described under *Regeneration, Methods of Obtaining.* The most commonly employed system uses a variable tickler winding on a rotor mounted in one end of the coupler. The layout, wiring and specifications for such an outfit are shown. Distance Range: About 200 miles with two audio stages added. Selectivity: Fair. Audio Amplifier: Any amplifier shown under *Receiver*, *Audio Amplifier for*, may be added by connecting to wires at right hand side of diagram. Construction: Easy to build and wire. See *Regeneration, Methods of Obtaining;* also *Coil, Tickler*.



DETECTOR WITH TICKLER REGENERATION

Operation:	Fairly simple, but requires practice for best results. Tuning control by dial 2, regeneration control by knob 7, and selectivity control by knob 5. The controls for regeneration and selectivity both affect the tuning and make logging difficult.
Features:	With skillful use of antenna coupling control and of regeneration control it is possible to make this receiver either an excellent distance getter or quite selective as desired. With optimum antenna coupling and maximum possible regeneration, the range may be as much as three or four hundred miles under favorable conditions.
Parts Required:	See following list. Numbers refer to diagram

1.............	Tuning condenser; capacity to match coupler 3.
2.............	Dial for condenser 1.
3.............	Coupler with variable antenna coil, variable tickler coil, and secondary to tune with condenser 1.
4.............	Antenna coil of coupler 3.
5.............	Control knob for antenna coil 4.
6.............	Tickler coil of coupler 3.
7.............	Control knob for tickler coil 6.
8.............	Socket for detector tube; 5-volt size.
9.............	Fixed condenser for detector plate bypass; .002 mfd. capacity.
10.............	Grid condenser; .00025 mfd. capacity
11.............	Grid leak; 2-megohms resistance.
12.............	Rheostat for detector; 25-ohms resistance.
13.............	Ground terminal post.
14.............	Antenna terminal post.

COIL, TICKLER.-A tickler coil is a coil electrically connected in one circuit and coupled to another circuit so that energy from the circuit in which the coil is connected may be introduced into the circuit to which the coil is coupled. A tickler coil is used as shown in Fig. 1 to secure a feedback of energy from the plate circuit of a tube to its grid circuit for the purpose of causing regeneration. The tickler coil is connected in the plate circuit and coupled to the grid coil of the tube.

Tickler coils may be of either the variable type or the fixed type. The variable type, as in Fig. 1, is mounted so that its magnetic coupling with the main coil may be changed; usually by rotating the tickler coil. The variable coupling might also be changed by sliding the tickler one way or the other.

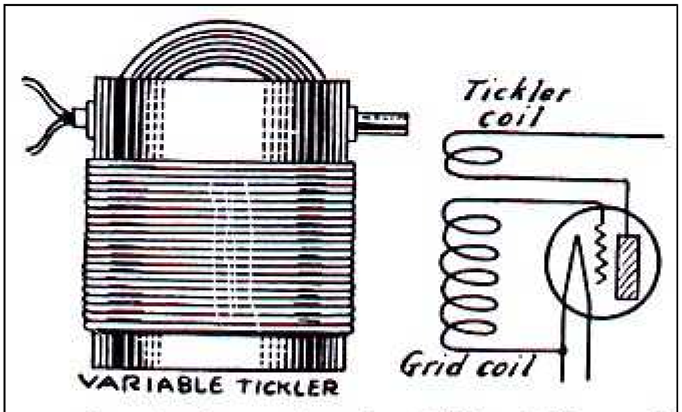


FIG. 1.—Connection of a Tickler Coil.

The fixed tickler coil shown in Fig. 2 is not movable in relation to its main coil. The effect of the tickler, or its effective coupling, is then controlled by a variable condenser or variable resistance, thus giving a capacitive or resistance control of feedback and regeneration. See *Regeneration, Methods of Obtaining.*

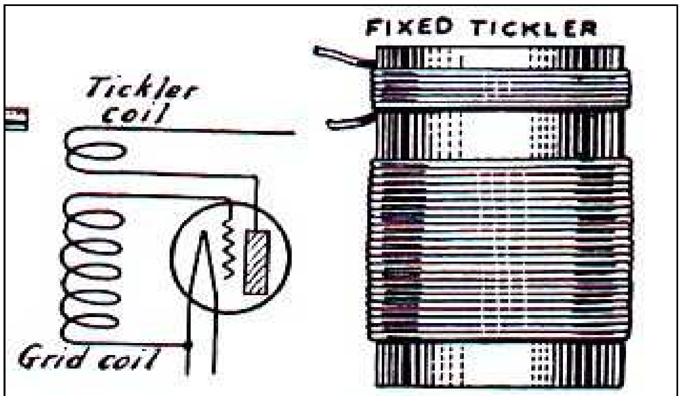


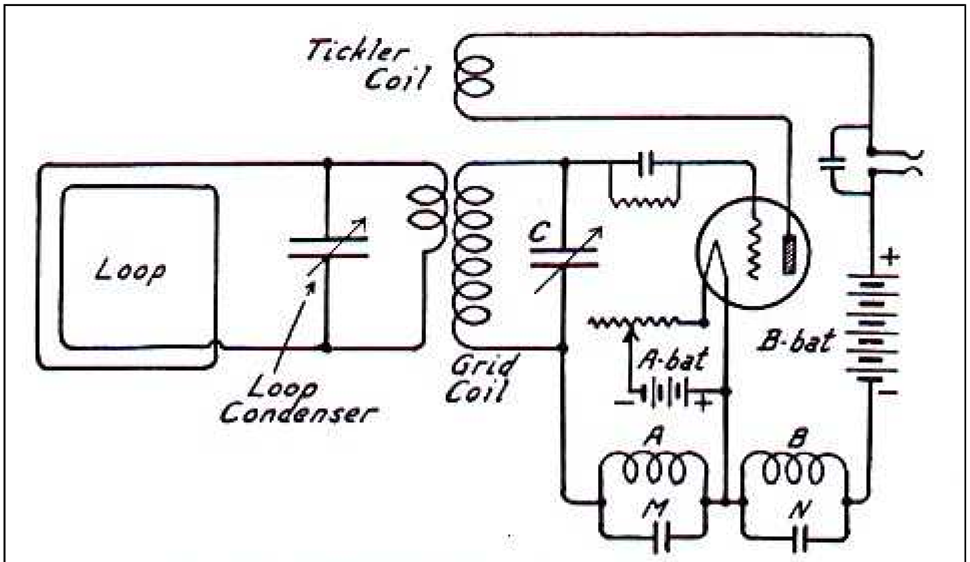
FIG. 2.—Fixed Tickler Coil.

RECEIVER, SUPER-REGENERATIVE.-The super-regenerative receiver is designed to allow maximum regeneration while automatically preventing free oscillation. There are several variations of the principle of super-regeneration, one type being shown in Fig. 1.

Neglecting for the present the coils *A* and *B* and the condensers *M* and *N* at the lower part of the diagram it will be seen that the receiver is of the ordinary regenerative type. Signal energy ls collected by the loop, the loop tuning being accomplished by the variable condenser. The grid coil is tuned with the variable condenser *C*. Feedback of energy from plate circuit to grid circuit is secured by coupling the tickler coil to the grid coil.

With the parts of the circuit so far considered it is possible for the tickler coil to couple with the grid coil closely enough to produce regeneration which will almost instantly build up into oscillation. Maximum amplification will be secured just before regeneration changes into oscillation. In actual operation the receiver allows regeneration to start and to build up to a point that sends great energy into the grid circuit of the tube. While regeneration is continuing to build up, but before it changes into oscillation, the additional circuit in the lower part of the diagram absorbs so much power from the grid circuit that regeneration is completely stopped. The absorption of power is then stopped and regeneration once more starts building up.

Coils A and B together with their condensers M and N allow the tube to act as an oscillator. Coil B is in the plate circuit and coil A is in the grid circuit. The two are coupled together so that continuous oscillations are generated. The frequency of these oscillations is determined by the inductances of the coils and by the capacities of the condensers M and N. The frequency of the oscillations is made of some value above audibility, fifteen thousand to twenty thousand cycles being suitable values.



Circuits of Super-Regenerative Single Tube Receiver.

The oscillation voltages are impressed on the grid of the tube so that the grid voltage is alternately positive and negative. While the grid voltage is negative the regenerative action in the grid and tickler coils builds up rapidly and applies the signal to the grid of the tube with great power. As soon as the oscillator voltage swings to the positive half of a cycle the grid becomes positive and absorbs power. This absorption of power stops the regeneration just before it changes to oscillation. This action keeps on as long as the receiver is in operation.

The super-regenerative receiver is difficult to control, very critical in its adjustments, and because of the peculiar action in the grid circuit it lacks selectivity. It's great advantage is in the extreme amplification possible from single tube. When audio frequency amplification is added it becomes necessary to place a filter circuit between the super-regenerative tube and the first audio frequency tube to prevent the oscillations from coming through and being amplified with great volume.

REGENERATION, ACTION AND PRINCIPLE OF.- Regeneration is the action by which a part of the energy from the plate circuit of a tube is fed back into the grid circuit of the same tube. The plate circuit energy is added to the energy already in the grid circuit.

Fig. 1 shows a tube having one inductance coil in the grid circuit and another inductance coil in the plate circuit. The energy in the plate circuit is several times greater than the energy in the grid circuit. The grid circuit is called the input circuit of the tube and the plate circuit is called the output circuit of the tube. The signal coming to the tube is introduced into the grid circuit and the voltage changes in the signal cause corresponding voltage changes on the grid of the tube. These voltage changes on the grid control the flow of current in the plate circuit.

The strength of the output from the tube is proportional to the strength of the signal input. If the signal voltage impressed on the grid is made stronger by any means, it will be followed by a greater output in the plate circuit. Signal strength may be increased through many causes outside of the receiver. For example, a stronger signal will be received from a nearby or powerful broadcasting station than from a distant or weak broadcasting station.

By means of regeneration the tube itself is made to increase the input voltage. In Fig. 2 the two coils of Fig. 1 have been rearranged so that they are brought close together. The one magnetic field now includes both coils. They are coupled and energy from the plate coil is fed back into the grid coil.

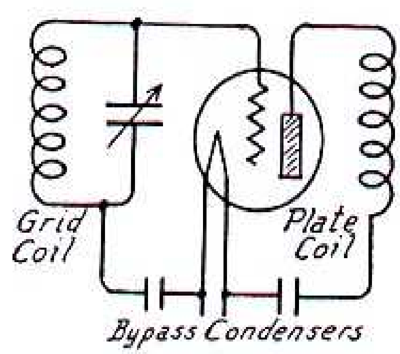


FIG. 1.—Grid and Plate Coils Entering into Regeneration.

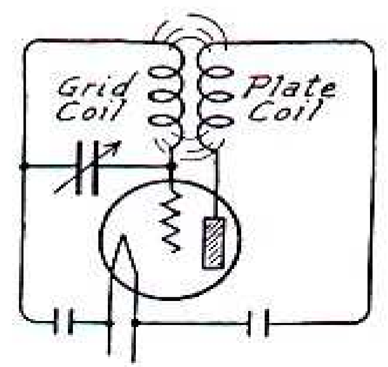


FIG. 2.—Feedback from Plate Circuit to Grid Circuit Causing Regeneration.

If the grid circuit of the tube is tuned to resonance with the frequency of the incoming signal, as is the case in radio frequency amplifiers and in detectors, the inductive reactance and the capacitive reactance in the grid circuit neutralize each other and leave only the resistance of the conductors in the circuit to oppose flow of current. Were it possible to reduce this resistance to zero nothing would remain to oppose the current flow and when oscillating voltages were once introduced into the grid circuit they would continue to flow indefinitely.

It is evident that the same results may be secured by adding just enough energy to that already in the grid circuit so that this additional energy overcomes the loss due to resistance. As an example, supposing the resistance of the grid circuit caused a power loss of five watts and suppose that just enough of the plate circuit energy were fed into the grid circuit to make up for this five-watt loss. Then the signal voltage originally brought into the grid circuit would set up oscillations which would continue on and on without diminishing.

It is possible to feed energy from the plate circuit back to the grid circuit and reinforce the voltages in the grid circuit because the frequency in the plate circuit is exactly the same as the frequency in the grid circuit.

After enough plate circuit energy has been fed back to just overcome the grid circuit resistance still more may be fed back to increase the grid circuit voltages to almost any desired extent. The power fed back from the plate circuit may be made sufficient to maintain oscillations in the grid circuit without the belp of any outside voltage, such as an incoming signal voltage. Under such conditions the tube will maintain oscillations in its circuits as long as the filament batteries and plate batteries hold out. The tube is then oscillating.

As long as the grid circuit absorbs power from the incoming signal we have regeneration with a feedback in use. But just as soon as the feedback energy is great enough to sustain oscillation without outside help we have gone beyond regeneration and have oscillation in the tube. The feedback energy is then able to keep the tube's circuits in continuous oscillation.

It is apparent that regeneration allows an exceedingly weak signal to be built up until it is as effective as a powerful signal. Thus regeneration increases the sensitivity of a receiver many times. Regeneration also increases the selectivity of the receiver as may be seen from Fig. 3. The curve at the left side indicates the response of a receiver to various frequencies when the receiver is tuned to a frequency of 750 kilocycles. When tuned to this frequency the circuits have the least possible reactance at 750 kilocycles. At points below and above this frequency the response of the receiver will not be so powerful because the reactance has not been eliminated by the process of tuning to resonance.

The effect of regeneration is shown at the right in Fig. 3. The frequency of 750 kilocycles is being fed back from plate circuit to grid circuit and the signal at this one frequency is built up to great volume. Since the feedback is occurring only at the tuned frequency other frequencies below and above the resonant points are not increased in strength. Therefore the relative strength of the 750 kilocycle signal with regeneration is several times as great as without regeneration. Any signals attempting to enter the receiver at other frequencies are relatively weaker under the conditions shown at the right in Fig. 3.

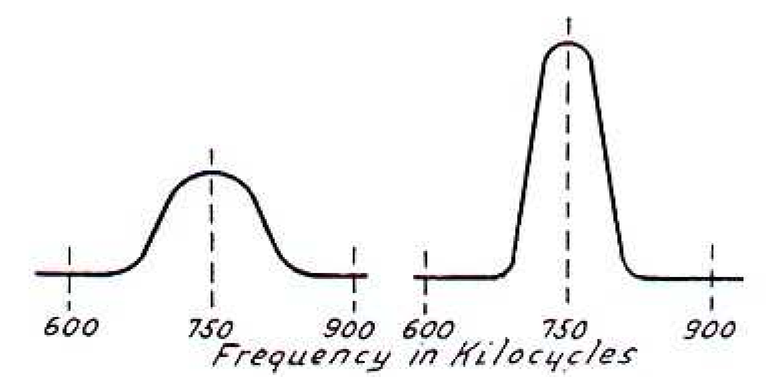


FIG. 3.—Effect of Regeneration on Signal.

The feedback of energy from the plate circuit to the grid circuit may be made through inductive coupling, through capacitive coupling or through resistance coupling. Inductive coupling and capacitive coupling are the types generally used because resistance coupling is not effective at radio frequencies. With the more commonly used methods of obtaining regeneration an inductive coupling between two coils or two parts of one coil is employed. Capacitive coupling through the capacity existing between the plate and the grid inside of the tube is used in a few instances.

There is always a feedback of energy from plate circuit to grid circuit through the capacity between the tube's plate and grid. This capacity feedback is independent of any external means for additional feedback. Since the reactance of any capacity is less at high frequencies than at low frequencies, the capacity feedback at high frequencies will be much greater than at low frequencies because of this change of effective reactance in the tube's internal capacity.

Regeneration and oscillation occur more easily at high frequencies than at low frequencies. Therefore less feedback will always be required to produce regeneration at the high frequencies or low wavelengths. Any control for regeneration provides for increasing the feedback as the frequency is lowered. The lower the frequency or the higher the wavelength the more regeneration will always be needed to produce a given strength of signal in the tube's output.

REGENERATION, METHODS OF OBTAINING- It is plain that the amount of feedback must be under the control of the operator. For strong incoming signals little or no feedback may be required while for very weak signals the maximum allowable feedback and the maximum regeneration must be used. There is always a capacitive feedback through the plate to grid capacity of the tube and the amount of regeneration through this tube capacity varies according to the construction of the tube. The added means for feedback must be controlled so that the feedback energy combined with the energy passing through the tube capacity will equal the desired or needed value.

Regeneration is usually applied only to the detector tube and in the following diagrams showing the various methods of obtaining regeneration the plate of the tube is shown connected to the primary winding of an audio frequency transformer as would be the case with the detector plate. If choke coil coupling or resistance coupling is used in the audio amplifier following the dctector, a choke or a resistance would be substituted for the audio frequency transformer. The part of the detector circuit in which regeneration is obtained would not be altered by this substitution.

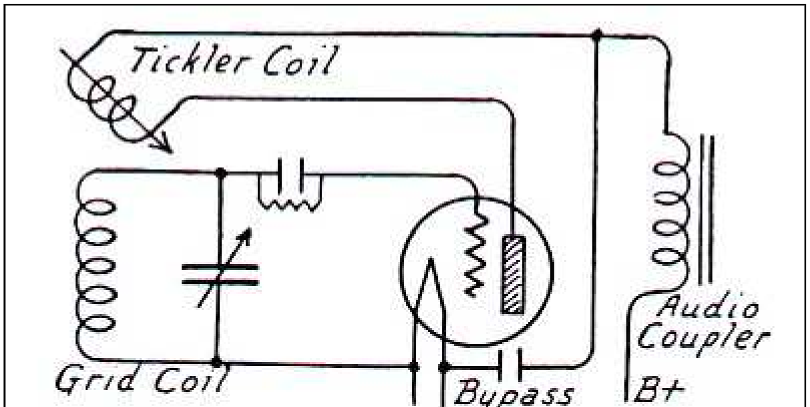


FIG. 1.—Regeneration Obtained with Movable Tickler Coil.

Tickler Coil Control.- Fig. 1 shows regeneration obtained by a tickler coil connected in the plate circuit and coupled to the tuned coil of the grid circuit. The construction of the tickler coil unit is shown in Fig. 2. The tuned winding, which is the secondary of a radio frequency transformer, and the primary winding of this transformer are wound on a stationary form in the usual way. The tickler coil is wound on a form which rotates within the stationary form.

A shaft is attached to the tickler coil form and extends through to a control knob. If the tickler coil is small, consisting of ten turns or less, it must be placed close to the secondary coil. If the tickler is large, containing fifteen to thirty turns, it may be placed farther away from the stationary coil.

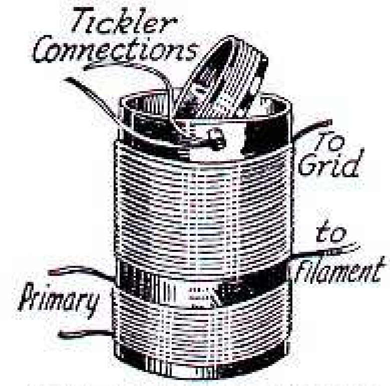


FIG. 2.—Construction of Movable Tickler Coil Used to Obtain Regeneration.

As the tickler is turned to increase its coupling to the stationary coil the effective inductance of the tuned stationary coil is increased. Therefore, the tuning point at which the circuit becomes resonant to a certain frequency will change with changes of tickler adjustment. This is a rather serious disadvantage of this method for obtaining regeneration since a receiver cannot be logged unless a note is made of the tickler coil setting.

The tickler coil adjustment should be such that oscillation may be caused at the lowest frequency or highest wavelength to be received. If oscillation cannot be obtained when the tickler coil is turned to the position of maximum coupling, it will be necessary either to increase the number of turns on the tickler or to move it closer to the stationary coil.

The position of the tickler coil in relation to the fixed coil must be such that increase of coupling between the two will increase the feedback, will increase regeneration and finally cause oscillation. If turning the tickler coil into line with the fixed coil reduces the signal strength by reducing regeneration, the connections to the tickler coil should be reversed or it should be rotated in the opposite direction to increase regeneration.

When the axis of the tickler coil is in line with the axis of the grid coil, there is maximum coupling between the two. If the voltages in the tickler coil and in the grid coil are in phase, the tickler will reinforce the grid coil and there will be maximum regeneration. But if the voltages in the two coils are in *opposite* phase, the tickler coil will oppose the grid coil and the signal strength will be reduced.

Some tickler coils are arranged so that they may be given one-half of a complete revolution, starting with the axes of the two coils in line and ending with them again in line. Other ticklers are arranged for only one-quarter of a revolution, starting with the axes at right angles and ending with them in line.

The greatest range of control will be obtained when the tickler coil is allowed a half revolution. With the tickler coil axis and the grid coil axis in line at one extreme of rotation the voltages will reinforce each other and there will be maximum regeneration. With the tickler turned half way around, so that the two coils are again in line, the voltages will oppose each other, there will be a reversed feedback and minimum signal strength.

If the tickler is allowed only a quarter revolution, it is necessary that the voltages be in phase when the coil axes are in line. Minimum coupling and minimum regeneration will be obtained with the coils at right angles but it will be impossible to make the voltages oppose for a reversed feedback effect.

The feedback from plate circuit to grid circuit is at radio frequency. This radio frequency will not pass through the high impedance of the primary winding in the audio transformer or choke. Therefore, a bypass condenser is connected from the line between tickler and transformer to one of the filament terminals on the tube. This bypass should have at least .001 microfarad capacity.

Fig. 3 shows the method known as reversed feedback. The construction is exactly like that shown in Fig. 2. But now the tickler coil is placed in such a relation to the stationary coil that its energy opposes the energy in the stationary or tuned coil. The constants of the tuned circuit are such that it normally tends to oscillate at the lowest frequency or highest wavelength to he received. This may he accomplished by using a large primary winding on the radio frequency transformer and making the coupling between the primary and secondary of this transformer very close.

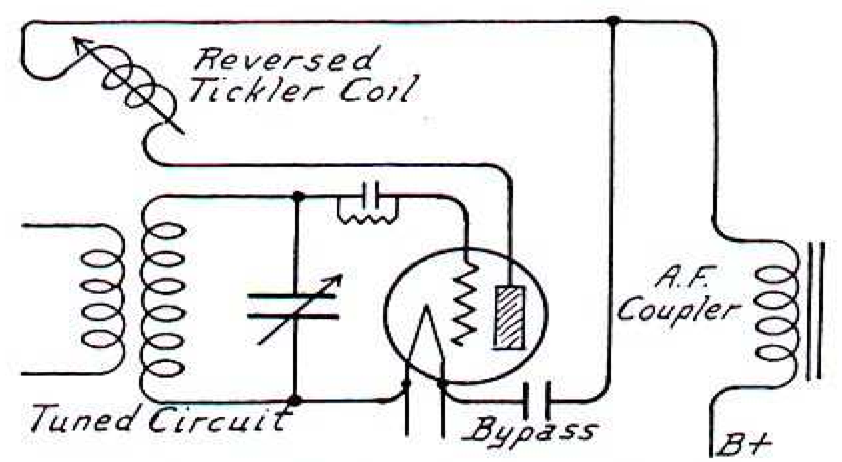


FIG. 3.—Reversed Feedback for Regeneration Control.

When the reversed tickler is in the position for maximum coupling, its feedback effect will be a minimum because it is opposing the voltages in the tuned coil. When the reversed tickler is at right angles to the fixed coil, regeneration will be maximum because then all of the opposing effect of the reversed tickler will have been removed.

If a tickler coil used in the manner of Fig. 1 is rotated to the right to increase regeneration, rotating it to the left will cause it to act as a reversed tickler and the system will then correspond to Fig. 3.

Resistance Control.- Fig. 4 shows control of regeneration by a variable resistance unit placed in the tickler circuit. This unit should have a resistance which is variable up to 50,000 ohms. Units providing still higher resistance will be equally satisfactory. The plate of the tube is connected directly to the primary winding of the audio frequency transformer. The resistance unit is in series with the tickler coil and this tickler circuit connects to one of the filament terminals through a bypass condenser having a capacity not less than .001 microfarad.

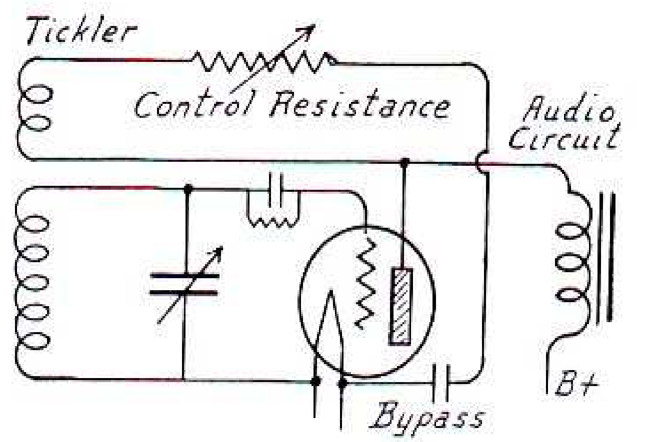


FIG. 4.—Variable Resistance and Fixed Tickler for Regeneration Control.

In the case of Fig. 4 the coupling of the tickler to the tuned coil is not variable. The tickler coil is wound on one end of the form that carries the secondary, this being shown in Fig. 5. The less space between the tickler winding and the tuned winding the fewer tickler turns will be required to obtain satisfactory regeneration. The number of turns and the distance of the tickler winding from the tuned winding should make it possible to obtain oscillation at the lowest frequency or highest wavelength when the control unit is adjusted for lowest resistance. If it is impossible to obtain Oscillation when using the least possible resistance, it will be necessary to increase the number of turns on the tickler winding or to move this tickler winding closer to the tuned winding.

With resistance units giving up to 50,000 ohms the tickler coil may usually be placed so that the nearest turns of tickler and tuned winding are separated by three-sixteenths to one-quarter an inch. From ten to thirty turns will be required on the tickler coil.

Fig. 6 shows the use of a resistance control shunted across the tickler winding. The construction of the tickler and the tuned coil is the same as shown in Fig. 5 and the adjustment of tickler turns and position is the same as for the method of Fig. 4. The resistance of Fig. 6 forms a bypass for the radio frequency energy from the plate circuit. The smaller the amount of resistance used in Fig. 6, the less will be the regeneration obtained. In Fig. 4 the greater the resistance, the less the regeneration. The two methods operate equally well as controls for regeneration.

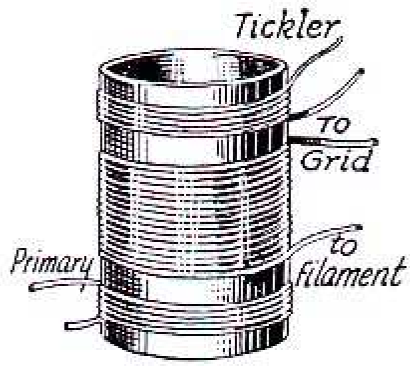


Fig. 5.—Construction of Fixed Tickler Coil for Regeneration.

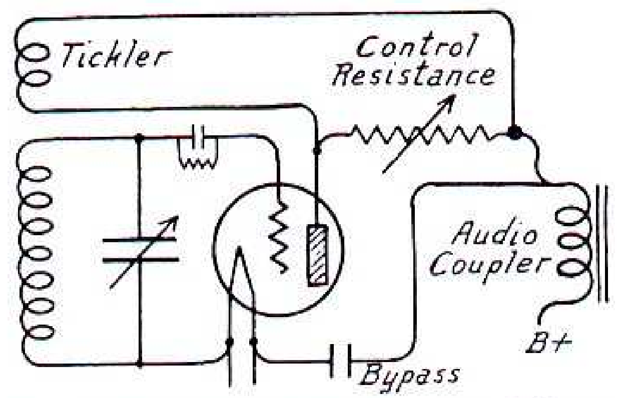


Fig. 6.—Fixed Tickler Control with Shunt Resistance.

Condenser Control.- In Fig. 7 the regeneration is controlled by a variable condenser used as a bypass for the radio frequency energy in the plate circuit. The tickler coil should be mounted so that its coupling with the tuned coil may be varied. The method of Fig. 2 makes a satisfactory mounting, but any other adjustable coil mounting may be used. The variable condenser should have a capacity of .001 microfarad, the old style forty-three plate units being just right. If a smaller variable condenser is used, it will be necessary to increase the number of turns on the tickler coil.

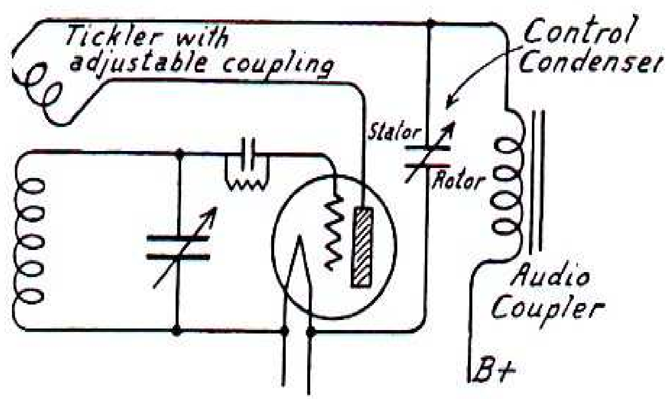


Fig. 7.—Variable Bypass Condenser for Regeneration Control.

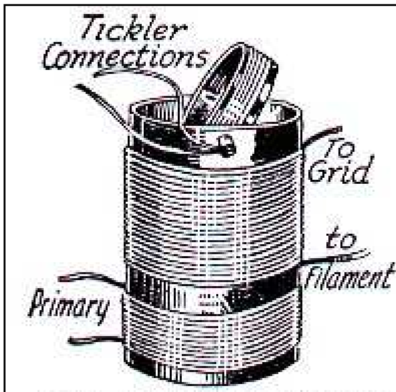


Fig. 2.—Construction of Movable Tickler Coil Used to Obtain Regeneration.

The connections are made exactly as shown in Fig.7. The plate of the tube is connected to the tickler and the other side of the tickler is connected to the stator plates of the control condenser and to the primary of the audio transformer. The rotor of the condenser is connected to either filament terminal of the tube.

When making the preliminary adjustment for the system of Fig. 7, the condenser should be turned to maximum capacity with its plates fully in mesh. Connections to the tickler should then be reversed and tried both ways. The connections are left in the way that produces maximum regeneration or oscillation. With the condenser still at maximum capacity the tickler is coupled closer and closer to the fixed coil until oscillation takes place. Oscillation may then be prevented and regeneration controlled by varying the condenser. The less the condenser capacity, the less will be the regeneration and the greater the condenser capacity, the more regeneration will be obtained. If it is impossible to obtain sufficient regeneration at the lower frequencies or higher wavelengths, it will be necessary to increase the coupling or the number of turns on the tickler coil

The regeneration control of Fig. 8 is very similar to that of Fig. 7 and all of the constructional details given for Fig. 7 apply equally well to Fig. 8. The only difference between the two methods is in the connections between plate, tickler and condenser.

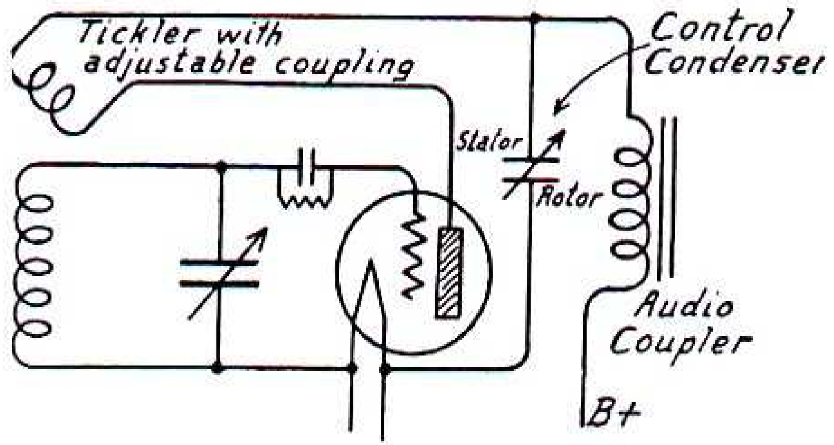


FIG. 7.—Variable Bypass Condenser for Regeneration Control.

Fig. 9 shows still another method of controlling regeneration with a variable condenser. Here the tickler winding forms part of the tuned coil winding. The tickler winding should have a number of turns equal to about one-fourth the number of turns in the tuned portion of the coil. For broadcast reception this method of Fig. 9 is not as satisfactory as the methods of Figs. 7 or 8.

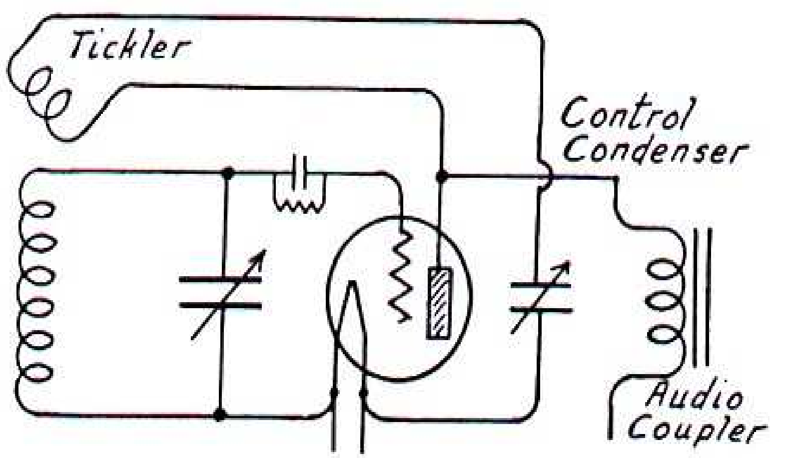


FIG. 8.—Regeneration Control with Condenser in Series with Tickler.

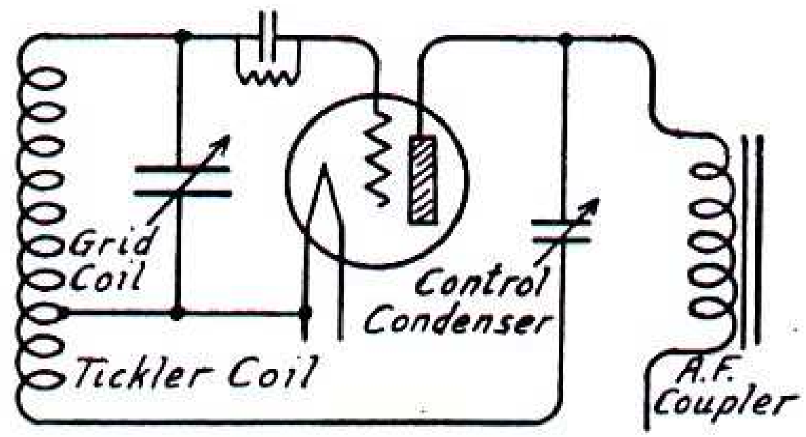


FIG. 9.—Condenser Control of Close Coupled Tickler.

Link Circuit Control.- Fig. 10 shows regeneration obtained through a link circuit coupled at one end to the plate circuit and at the other end of the grid circuit. It is necessary to insert an additional air-core coil between the plate of the tube and the audio frequency transformer. This coil has two windings, both of the same number of turns, and closely coupled by winding them end to end or one over the other. Twenty turns on each winding will usually be about right. If the coupling between these two windings is to be varied to control regeneration, this unit may be made of a split variometer.

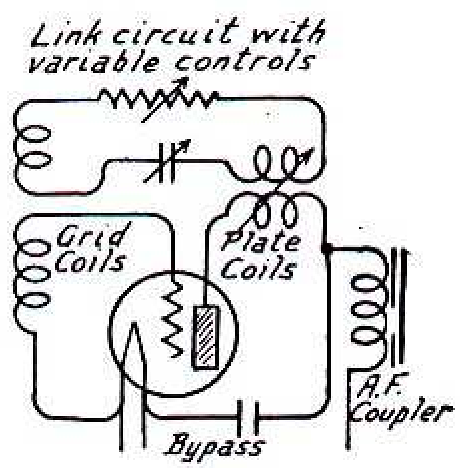


FIG. 10.—Link Circuit Control of Regeneration.

The tickler coil proper, which is coupled to the tuned coil of the grid circuit, is fixed in position as shown in Fig. 5. It should consist of ten or more turns. The number of turns on the tickler and its closeness of coupling to the tuned coil are such as to allow oscillation at the lowest frequencies or highest wavelengths to be received.

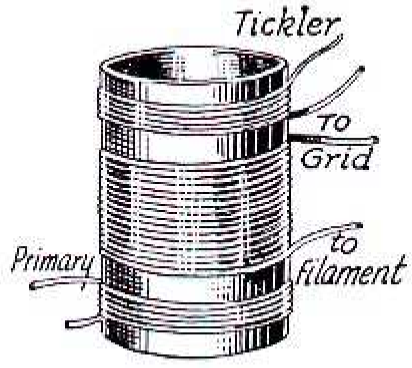


Fig. 5—Construction of Fixed Tickler Coil for Regeneration.

Three different methods of control are shown in Fig. 10, although only one of them would be employed at any one time. As already mentioned it is possible to control regeneration by varying the coupling between the coil in the plate circuit and the coil in the link circuit. With variable coupling neither the variable resistance nor the variable condenser would be used.

If the variable condenser is placed in the link circuit of Fig. 10, neither the resistance nor the variable coupling would be used. The resistance would likewise be used without either the variable condenser or the variable coupling.

Control of Plate Circuit.- Fig. 11 shows regeneration control by limiting the energy passing into the grid circuit to a value low enough so that the total energy in the grid and plate circuits of the tube, even with the feedback through the tube capacity, is not sufficient to allow oscillation. A variable resistance, which may be adjusted from about 10,000 to 100,000 ohms, is connected between the *B* battery or plate voltage supply unit and the primary of the radio frequency transformer. Increasing the resistance lessens the regeneration while lessening the resistance increases the regeneration. Since this method acts to change the direct current voltage applied to the plate circuit of the preceding tube it must not be allowed to interfere with passage of radio frequency currents through its circuit. Therefore, the resistance is bypassed with a one microfarad condenser through which the radio frequency currents pass unhindered.

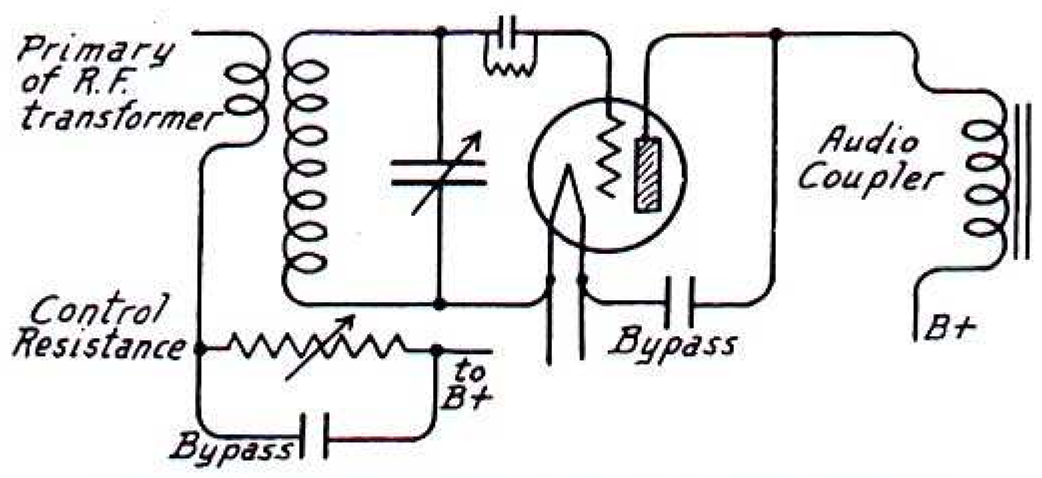


FIG. 11.—Regeneration Control with Plate Circuit Resistance.

Fig. 12 shows another method of regeneration control applied to the plate circuit of one or more radio frequency tubes. The primary of the radio frequency transformer is divided into two parts, one part being stationary and the other being rotated. Rotation of the movable part of the primary winding allows it either to assist the stationary part, to oppose the stationary part, or to have any intermediate effect. With the movable part of the primary opposing the stationary part regeneration is cut to a minimum. With the two parts acting together regeneration is maximum.

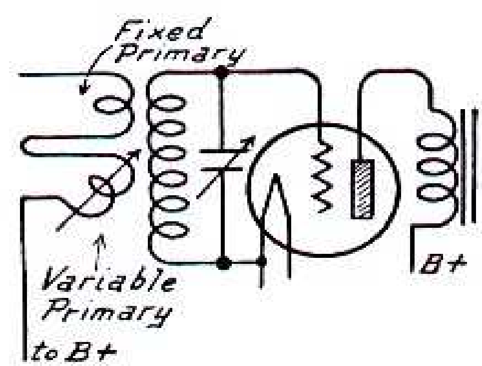


FIG. 12.—Regeneration Control with Variable Split Primary Winding.

The split primary winding of Fig. 12 has been used for automatic control of regeneration by attaching the movable part of the winding to the shaft of the tuning condenser. More regeneration is always required for low frequencies than for high frequencies, consequently the connection is made so that the two parts of the primary act together for maximum regeneration at low frequencies or high wavelengths.

Inefficient Methods.- The control methods shown in Figs. 1 to 12 allow efficient operation of the receiver since they introduce the least possible added resistance and loss into the grid circuits. The methods to be shown immediately following are classed as inefficient since they add considerable resistance directly or indirectly to the grid circuit. This causes a loss of signal strength and broadens the tuning of the receiver.

Fig. 13 shows the use of a variable resistance unit in the oscillatory portion of the tube's grid circuit. This resistance may be a rheostat or a potentiometer used as a rheostat. The amount of resistance needed to control regeneration and prevent oscillation depends on the size and construction of the coil and condenser, also on the wiring in the grid circuit. Resistances as low as ten to twenty ohms may be sufficient or it may be necessary to use two or three hundred ohms.

Fig. 13 also shows the use of a variable resistance between the ground connection and the antenna coil, this method being applied to the first tube of the receiver. This resistance should have a maximum value of 200 to 400 ohms. A potentiometer or any variable resistance reaching this value will be satisfactory. Increasing the amount of the resistance will reduce regeneration while reducing the resistance will increase regeneration and produce oscillation.

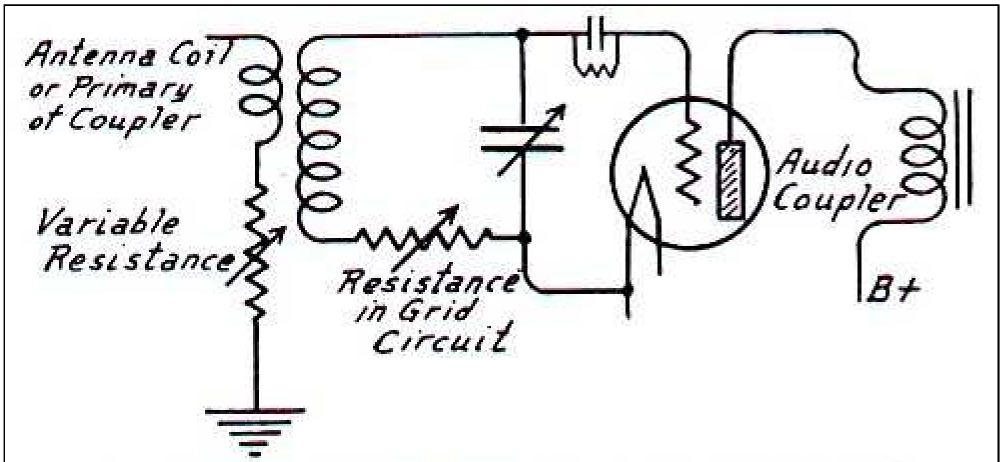


FIG. 13.—Resistances in Primary Circuit and in Grid Circuit.

Fig. 14 shows the use of a variable grid leak for controlling regeneration. This grid leak should be constructed so that its resistance may he reduced below 100,000 ohms or one-tenth of a megohm. Reducing the resistance of the grid leak lessens regeneration while increasing this resistance will increase regeneration and produce oscillation

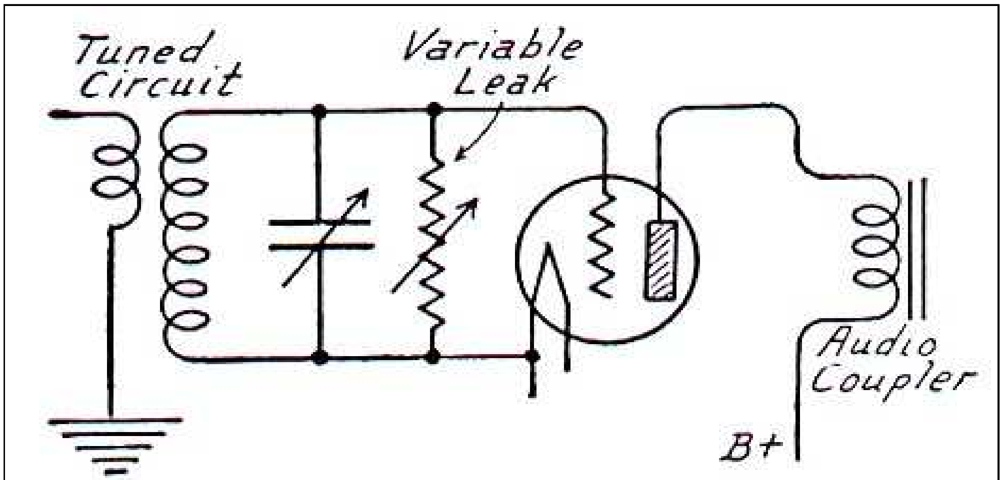


FIG. 14.—Variable Grid Leak Controlling Regeneration.

In Fig. 15 a potentiometer is used in the grid return circuit. Turning the potentiometer arm to the side connected to the negative filament terminal places a negative grid bias on the tube, increases regeneration and increases the tendency to oscillate Turning the potentiometer arm toward the positive side provides a positive grid bias and allows the grid circuit to consume power. This reduces regeneration. This use of a potentiometer broadens the tuning and distorts the signal. It also weakens the incoming signal

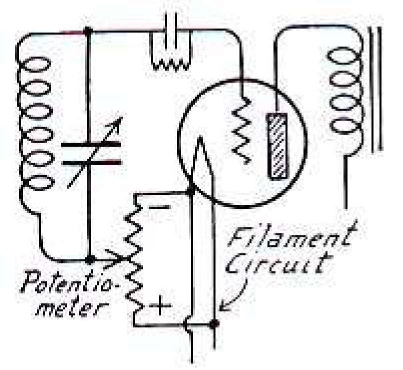


FIG. 15.—Potentiometer in Grid Return to Control Regeneration.

Fig. 16 shows the use of an absorption circuit for controlling regeneration. The absorption circuit consists of a coil and a variable condenser. The coil is loosely coupled to the tuned coil in the grid circuit. The absorption coil may be mounted on the grid coil form as in Fig. 5. The coupling of the grid coil to the absorption coil should be close enough so that oscillation may be prevented at the highest frequencies to be received The absorption coil's inductance and the capacity of its tuning condenser must be of such values that they tune to the highest frequency or lowest wavelength to be received.

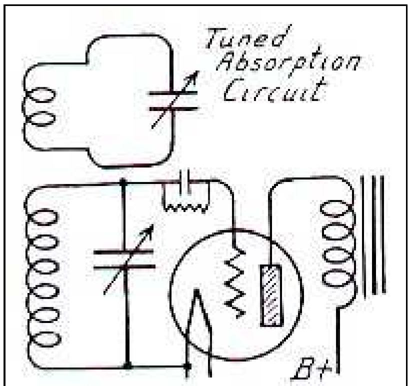


FIG. 16.—Absorption Circuit Control of Regeneration.

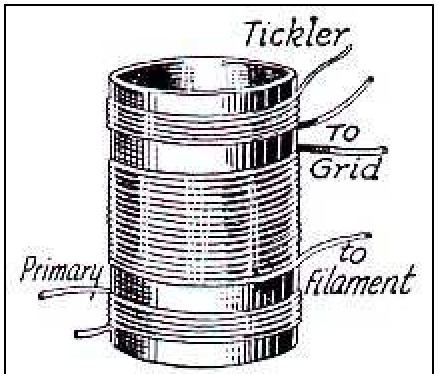


FIG. 5.—Construction of Fixed Tickler Coil for Regeneration.

As the regeneration control condenser is tuned more and more closely to the frequency being received, the power absorbed from the grid circuit will increase and regeneration will be reduced.

Variometer Controls.- Fig. 17 shows one of the first methods used for regeneration control in broadcast receivers. This is known as the tuned plate method. A variometer is inserted in the plate circuit between the plate terminal of the tube and the audio frequency transformer.

As the inductance of the variometer is increased, the voltages across it are increased proportionately. The feedback is obtained through the capacity between the plate and the grid in the tube. This capacity is indicated in broken lines.

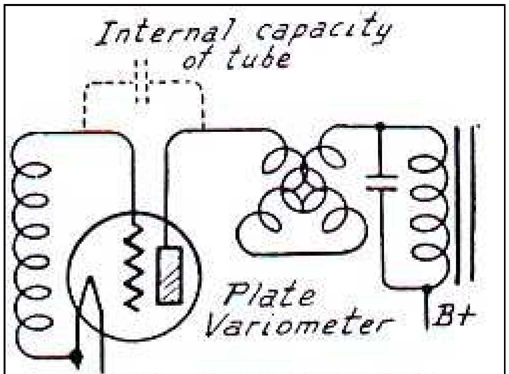


FIG. 17.—Regeneration with Plate Variometer.

As the variometer's inductance is increased, the feedback through the tube capacity increases so that additional energy is sent back into the grid circuit. Reducing the variometer's inductance reduces the regeneration.

Fig. 18 shows the use of a plate variometer connected and operated in the same way as the variometer in Fig. 17. The grid circuit also contains a variometer whose inductance is used for tuning the grid circuit to the frequency being received.

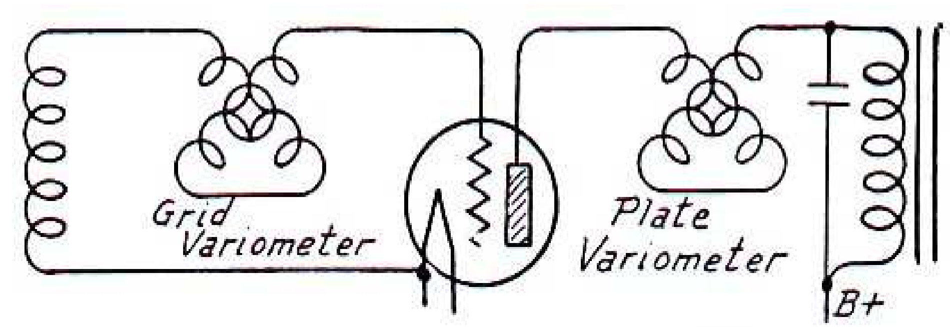


FIG. 18.—Variometers in Both Grid Circuit and Plate Circuit.

Automatic Control of Regeneration.- Inasmuch as it is desirable to increase the amount of regeneration with decrease of the frequency being received, the regeneration control may be attached to the tuning control so that both move together. Tuning is usually done with a variable condenser whose capacity is increased for the reception of higher wavelengths or lower frequencies. If regeneration is controlled with a condenser, this control condenser may be connected to the tuning condenser so that the feedback is increased as tbe capacity of the tuning condenser is increased. The types of control shown in Figs. 7, 8, 9, 10, 12 and 16 are well adapted to automatic regeneration.

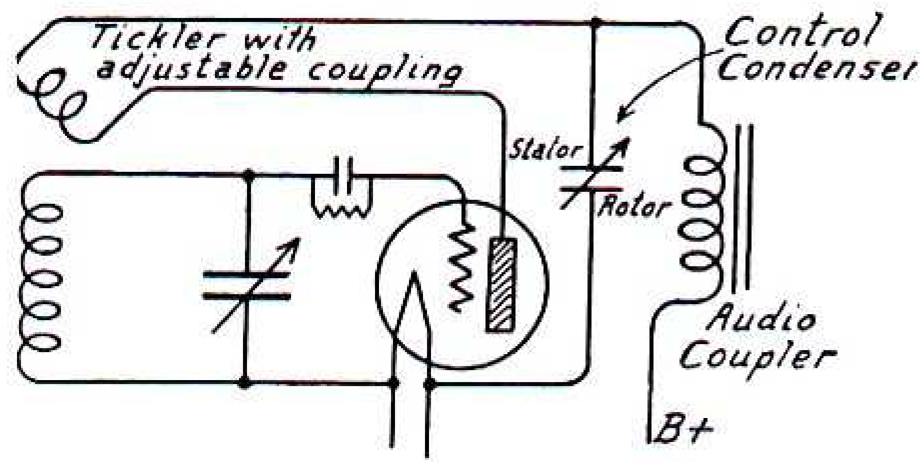


FIG. 7.—Variable Bypass Condenser for Regeneration Control.

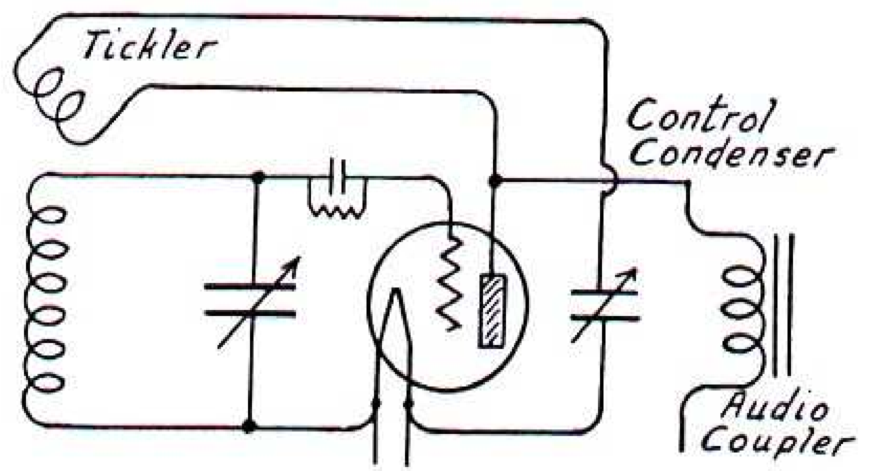


FIG. 8.—Regeneration Control with Condenser in Series with Tickler.

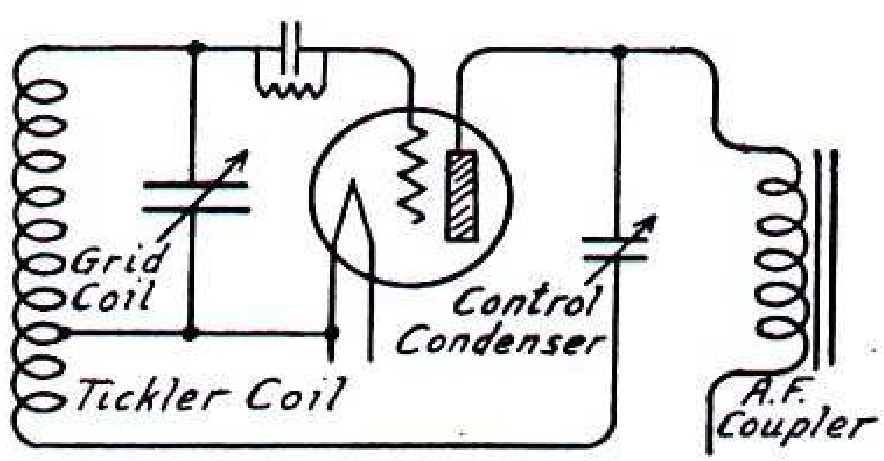


FIG. 9.—Condenser Control of Close Coupled Tickler.

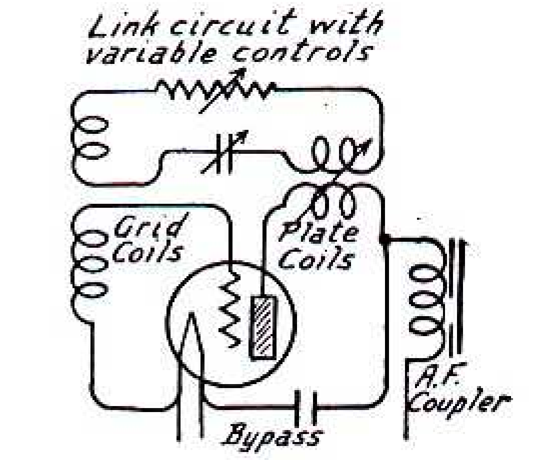


FIG. 10.—Link Circuit Control of Regeneration.

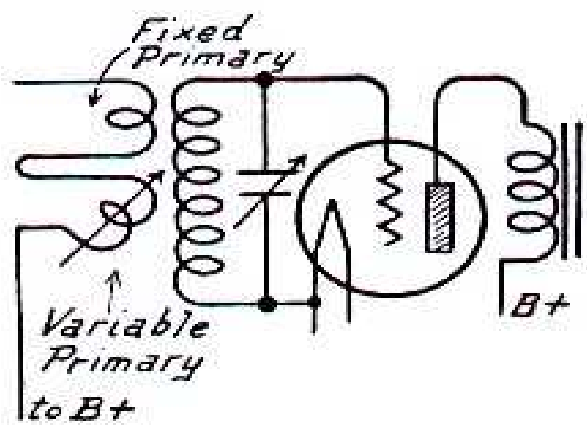


FIG. 12.—Regeneration Control with Variable Split Primary Winding.

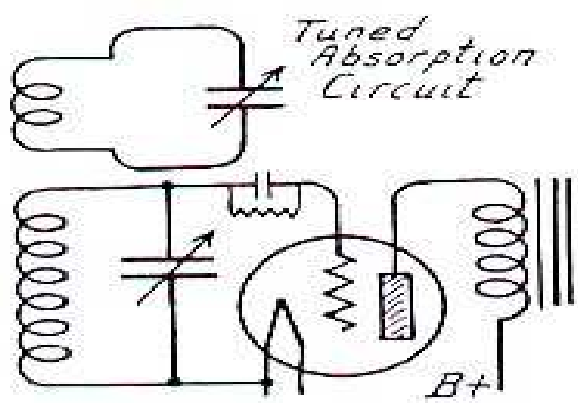


FIG. 16.—Absorption Circuit Control of Regeneration.

Automatic regeneration is always attended with considerable difficulty because of changes introduced by altering the antenna, by using different tubes, by movement or any coils, or by changes of any nature whatsoever in the receiver.

In Figs. 7, 8, 9, and 10, increasing the capacity of the control condensers increases the regeneration. Were these control condensers to be connected to the tuning condenser the two condensers should increase their capacities together so that regeneration would automatically increase at the higher wavelengths or lower frequencies. The size of the tickler coil and its coupling to the grid coil are matters for experiment. The proper values will differ for each circuit to which automatic regeneration control is being adapted.

With the control condenser fully in mesh, at lowest frequency, the tickler coil should be given just enough turns or its coupling should be made just loose enough to bring the circuit to maximum regeneration while preventing oscillation. The tuning condenser and control condenser are then turned to their lowest capacities at which reception is expected. If oscillation occurs at this point, it will be necessary to reduce the tickler coupling, to reduce the number of turns on the tickler coil, or to use a control condenser of lower minimum capacity.

Regeneration with a Loop.- Feedback regeneration may be obtained in any loop receiver by the method shown in Fig. 19. The number of turns on the loop is increased above the number ordinarily used by adding from one-fourth to three-fourths the original number of turns. The connection from the loop and the tuning condenser to the grid of the first tube is not disturbed. A tap is provided at the junction between the old and new parts of the loop winding. From this tap a connection is made to the filament circuit of the first tube and the loop tuning condenser. From the outer end of the added turns a connection is made through a variable condenser to the plate terminal of the first tube. This condenser may have a capacity between .00025 and .0005 microfarad.

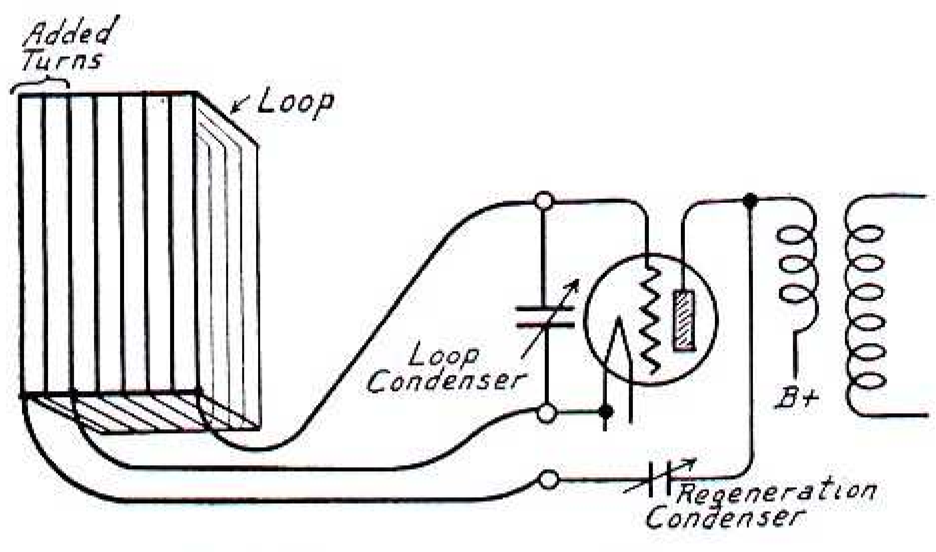


FIG. 19.—Regeneration Applied to a Loop.

Increasing the capacity of the added regeneration condenser will increase the feedback and the regeneration. Reducing the capacity of this condenser will lessen regeneration. It should be mentioned that this system will cause the loop to radiate sufficiently to bother nearby receivers. This system of regeneration may be added to tuned radio frequency receivers or to superheterodyne receivers. When added to a superheterodyne the connection from the added portion of the loop through the control condenser is made to the plate of the first detector tube.

Producing Regeneration in Balanced Circuits.- Various kinds of receivers are provided with small condensers which balance the feedback through the plate to grid capacity of the tube with an external feedback of equal voltage but of opposite phase. These receivers include those using the Neutrodyne, Roberts, Rice, Sampson and similar circuits. The Neutrodyne, the Roberts, and the Rice are shown respectively in Figs. 20, 21 and 22. In each case the balancing condenser has been replaced with a variable condenser marked "Control."

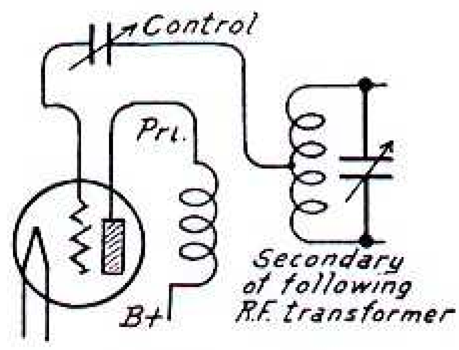


FIG. 20.—Neutrodyne Circuit with Balancing Condenser Used as Regeneration Control.

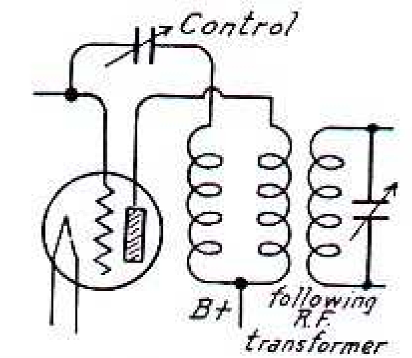


FIG. 21.—Roberts Circuit with Balancing Condenser Used as Regeneration Control.

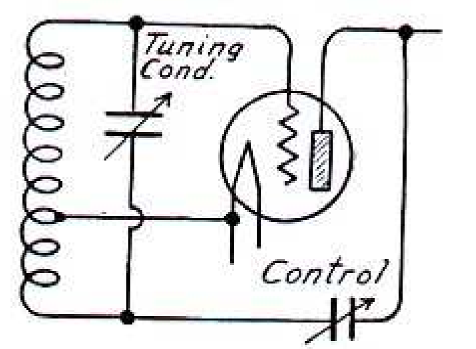


FIG. 22.—Rice Circuit with Regeneration Control.

With this control condenser adjusted to the capacity which exactly balances the internal capacity of the tube the receiver will be balanced and regeneration will be prevented. As soon as the control condenser is adjusted to provide either more or less capacity than the amount required for balancing, regeneration will take place. Increasing the capacity of the control condenser will allow the external feedback to be greater than the internal feedback. Reducing the capacity of the control condenser will allow the external feedback to be less than the internal feedback. Regeneration will take place in either case. To cause regeneration at the lower frequencies or higher wavelengths it is usually necessary to increase the control condenser capacity to provide a comparatively large external feedback.

It will be unnecessary to provide regeneration in more than one of the radio frequency stages. The best results will be obtained by unbalancing the circuit which immediately precedes the detector, this being the second radio frequency stage.

Multiple Regeneration.- While regeneration is applied only to the detector grid circuit as a general rule, there is no reason why it cannot also be applied to the grid circuits of any radio frequency tube including the one immediately following the antenna.

Systems have been designed in which variable regeneration control is applied to the detector grid circuit and fixed or semi-fixed regeneration is applied to one or more of the radio frequency stages preceding the detector. One method substitutes for a single radio frequency tube two tubes having their grid circuits in parallel. The plate circuit of one of these tubes is connected through a transformer to the following stage as usual. The plate circuit of the other tube is connected to a tickler coil in the tube's grid circuit and is not connected to the following stage. To be effective in increasing signal strength and selectivity, regeneration must be increased as the received frequency is decreased, consequently no method of fixed regeneration is of much value except at some one frequency among all those to he handled.

One of the simplest and easiest ways of controlling regeneration and preventing oscillation is by the use of a variable rheostat for the tube in which regeneration is desired. Any radio frequency stage in which the tube is fitted with a variable rheostat may be made to regenerate and if this system is used on two or more radio frequency stages we will have multiple regeneration.

REFLEXING, PRINCIPLES OF- It is possible to use a single vacuum tube for the amplification of two different frequencies at one time, this being called reflexing. The principle is shown by the diagram in Fig. 1. The operation of a reflex amplifier is shown in Fig. 2. The two frequencies travel as follows: High frequency or radio frequency is introduced from the winding *1* which is coupled with the winding *2* to form a radio frequency transformer. Voltage changes in winding *2* are impressed on the grid of the tube. The grid circuit is completed to the filament through the bypass condenser *A* which carries the high frequency around the high impedance of the iron core transformer.

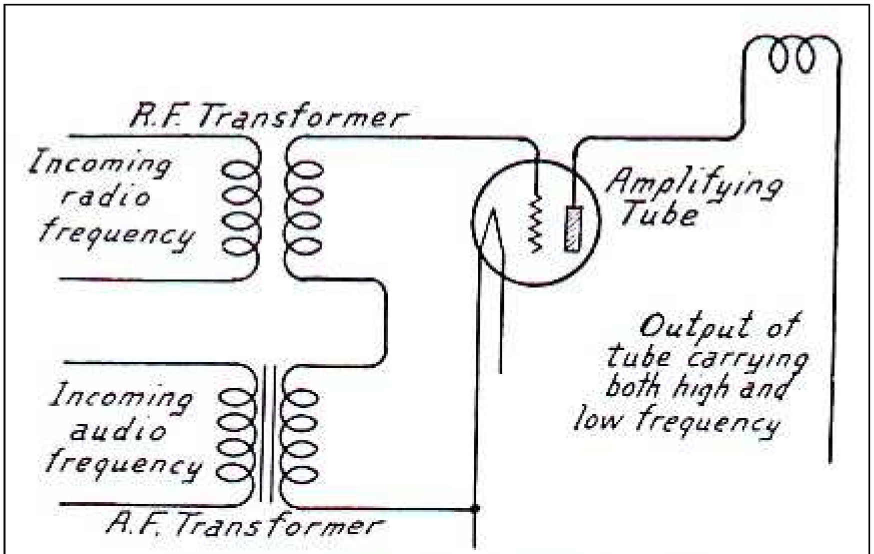


FIG. 1.—Effect of Reflexing on Amplifying Tube.

The high frequency output from the plate of the tube passes through the winding *3* which is coupled with winding *4* to make a transformer. The high frequency circuit is completed through the bypass condenser *B* from winding *3* to the filament circuit of the tube. Plate voltage from the B-battery is applied through the winding of the right hand air-core radio frequency transformer. The amplified high frequency appears in the winding *4.*

Still referring to Fig. 2 low frequency or audio frequency is introduced through the left hand audio frequency transformer. The audio frequency voltages pass to the grid of the tube through winding *2,* the grid circuit being complete through the winding of the audio frequency iron-core transformer and winding *2* of the air-core radio frequency transformer. Bypass condenser *A* is of small capacity which offers a very high reactance to the low frequency, therefore does not bypass it but forces it through the winding of the audio transformer. Winding *2* of the air-core radio frequency transformer is of comparatively few turns, has no iron core, and is therefore of low reactance to the audio frequency voltages and offers practically no opposition.

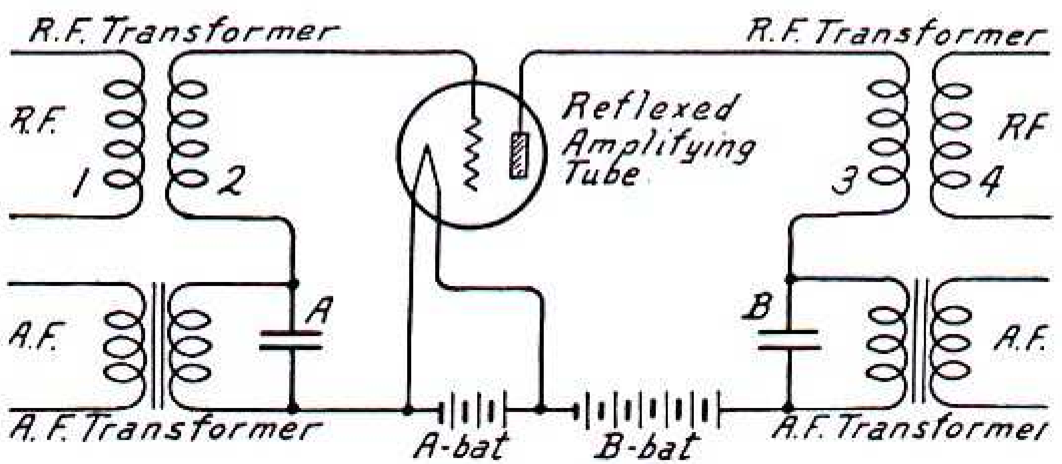


FIG. 2.—Circuits of Reflexed Amplifying Tube.

The audio frequency output from the plate of the tube passes through winding *3* of the right hand radio frequency transformer. The reactance of this winding is very low to the audio frequency and it passes through with practically no opposition until the right hand bypass condenser *B* is reached. This condenser, being of small capacity, offers such great reactance that the audio frequency is forced through the winding of the right hand iron-core audio frequency transformer. The audio frequency output then appears in the secondary of this transformer.

Reflex receivers provide two paths for the grid voltages and two paths for the plate currents of all reflexed tubes. One path carries the radio frequency current. This path is of low reactance to the radio frequency and of high reactance to audio frequency. The other part carries audio frequency current and is of high reactance to the radio frequency. The two paths meet in the tube and in the batteries. The radio frequency circuit is always carried around the windings of iron-core transformers, speakers, etc. by bypass condensers.

Reflex Receivers.- A complete single-tube reflex receiver with crystal detector is shown in Fig. 3. Windings *1*, *2*, 3 and 4 of Fig. 3 correspond to similarly numbered windings of Fig. 2. The radio frequency output of transformer 3-4 passes through the crystal detector. The rectified output from the detector passes through the primary of the audio transformer. The audio frequency output from the secondary of the audio transformer reaches the grid of the tube through winding 2 and is amplified by the tube. The audio frequency output from the plate of the tube passes through winding 3 and to the jack to which is connected the speaker or headphones. Tuning is accomplished with the variable condenser across winding 2. Winding 1 is in the antenna circuit. The bypass condensers C in these receivers are usually of .001 microfarad capacity. The best value for the bypasses may be found by experimenting with condensers of from .00025 to .002 microfarad capacity.

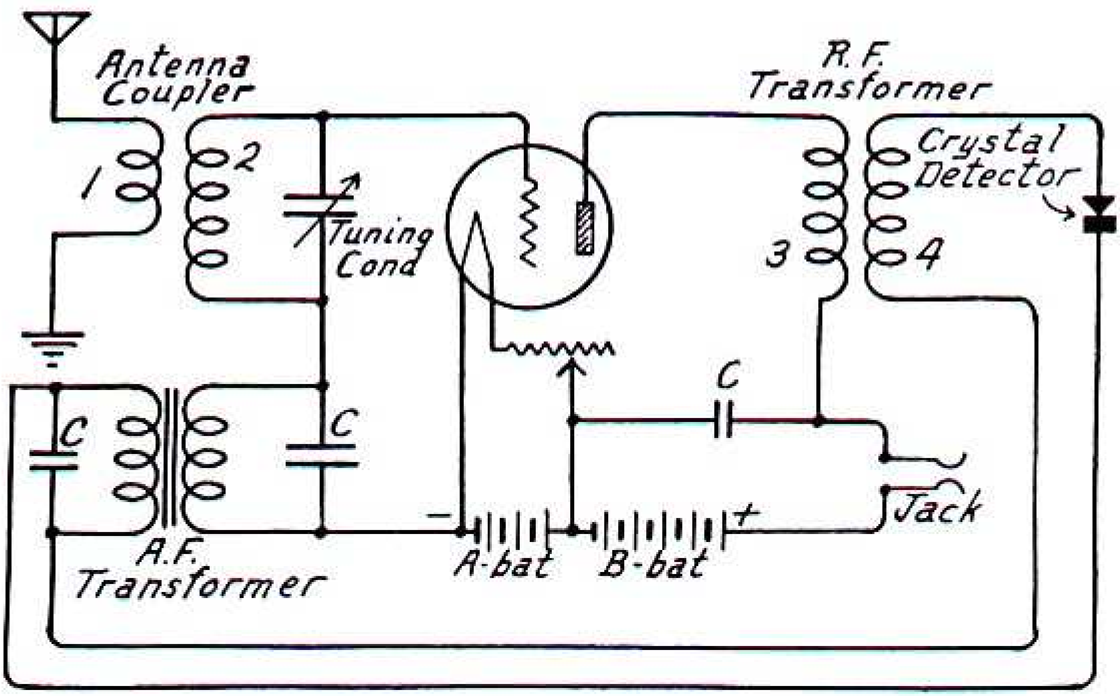


FIG. 3.—Single Tube Reflex Receiver with Crystal Detector.

Fig. 4 shows the circuits for a two-tube reflex receiver. This receiver employs a tube for its detector but is otherwise the same as the arrangement of Fig. 3. In Fig. 3 the radio frequency output from winding 4 is carried through the crystal. In Fig. 4 the output of winding 4 is carried to the grid of the detector tube. The output from the plate of the detector tube is carried to the primary of the audio frequency transformer, the B-battery or plate voltage supply for the detector being connected to the other end of this primary winding.

The output from the secondary of the audio frequency transformer is carried to the grid of the left hand amplifier tube and is amplified at audio frequency. From the plate circuit of this left hand tube the amplified audio frequency passes through winding 3 to the jack just as in Fig. 3. Tuning is accomplished by two variable condensers, one across winding 2 and the other across winding 4.

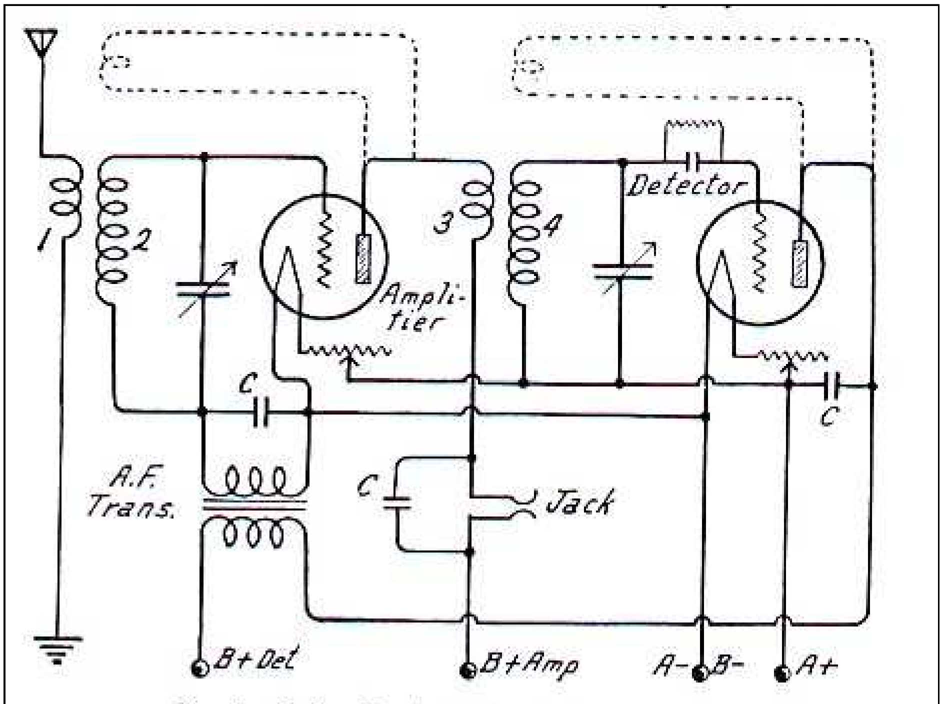


Fig. 4.—Reflex Receiver with Tube Detector.

A three-tube reflex receiver is shown in Fig. 5. Tube number *1* is the first radio frequency tube and the second audio frequency tube. Tube number *2* is the second radio frequency tube and the first audio frequency tube. Tube number *1* thus carries the lightest radio frequency load and the heaviest audio frequency load. In tube number *2* this condition is reversed by carrying the heaviest radio frequency load and the lightest audio frequency load. This division of load is the inverse duplex principle devised by David Grimes. Tube number *3* is the detector and is not reflexed.

In this three-tube receiver tuning is done with the three variable condensers. Bypass condenser *A* may be from .002 to .005 microfarad capacity, bypass *B* is of one microfarad or even greater capacity, bypasses *C* are of .001 microfarad capacity, and bypass *D* is of .002 microfarad capacity.

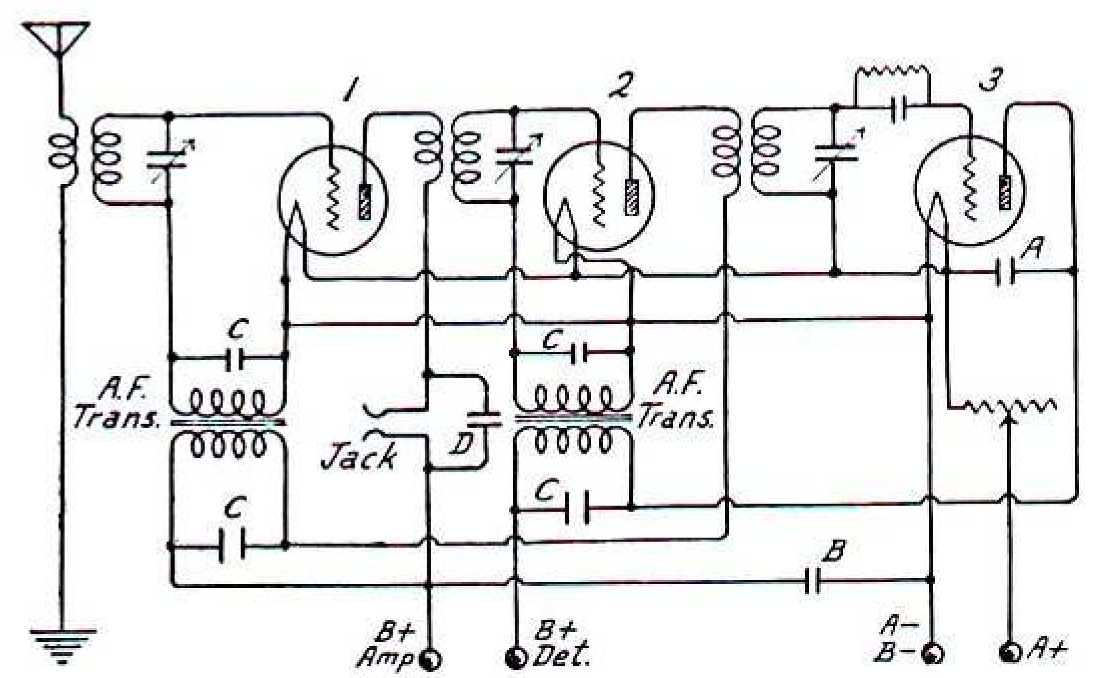


FIG. 5.—Three-Tube Reflex Receiver.

Regeneration may be applied to any reflex receiver either in the detector circuit or in the radio frequency tube circuits. Connections of tickler coils for regeneration are shown by broken lines in Fig. 4. While only the tickler coil method is shown, any kind of regeneration control may be applied to these receivers.

Reflex receivers have the advantage of saving in the number of tubes required for a given amount of amplification. For example, the single-tube receiver of Fig. 3 consists of one radio frequency stage, one audio frequency stage and a crystal detector. The receiver of Fig. 4 consists of one audio frequency and one radio frequency stage with a tube detector. The receiver of Fig. 5, while using only three tubes, provides two radio frequency stages and two audio frequency stages. A crystal detector might be substituted for the tube detector in Figs. 4 and 5. Reflex receivers are generally rather unstable and are more inclined to oscillate than receivers using separate tubes for radio frequency and audio frequency amplification.

RE-RADIATION.- The antenna of a radio receiver is supposed to receive energy from passing radio waves but is not supposed to radiate or send out radio frequency energy. Radiation of energy is presumed to take place only from the aerials of transmitting stations. Yet a majority of radio receivers in use are capable of radiating energy which hampers or completely spoils the reception of other receivers within a wide radius.

Any feedback of energy from receiver circuits which are in an oscillating condition will cause radiation when this feedback reaches the antenna circuit. The antenna is tuned more or less closely to the frequency to which the receiver is tuned and the antenna then radiates this frequency.

If the antenna of a radiating receiver sent forth only the frequency to which the receiver is tuned, things would not be so bad. But it almost invariably sends out at least two frequencies because of the two points of resonance that exist in coils which are quite closely coupled. Not satisfied with radiating two frequencies the receiver will also send out harmonics of the received frequency, these harmonics being at twice the received frequency, three times the received frequency, etc.

A receiver does not radiate sufficiently to cause harm unless one or more of its tubes are oscillating. The oscillating condition is brought about by pushing regeneration or "volume" too far so that regeneration gives way to oscillation. It is fortunate that a receiver other than a superheterodyne operated with any tubes oscillating will not give satisfactory reception to its operator. If the operator is sufficiently experienced to recognize the cause of his own trouble, he will take steps to stop the oscillation provided his receiver has the necessary control over oscillation. About the only type of receiver from which radiation cannot be prevented is the superheterodyne. This is partly because the oscillator tube, which must oscillate to operate the receiver, is coupled almost directly to the antenna.

A superheterodyne operated with a loop antenna does not do a great deal of harm with its re-radiation because the loop is an inefficient radiator and its radiated energy travels for only a few yards in any direction. Regeneration in the loop of a superheterodyne or ony other receiver makes this re-radiation reach far enough to bother at least some of the neighbors. A superheterodyne operated with an outdoor antenna makes itself a nuisance to all other receivers within a considerable distance.

Regenerative receivers, especially those of the single-circuit variety, are among the worst offenders in the matter of re-radiation. Any receiver which uses regeneration in the tube immediately following the antenna will re-radiate badly when regeneration is carried so far as to cause oscillation. A stage of radio frequency amplification which is properly balanced and placed between the antenna and the tube using regeneration will quite effectively prevent re-radiation. This is one of the chief advantages of properly built and properly balanced Neutrodyne, Browning-Drake, Roberts and similar balanced receivers. But when these receivers are not properly balanced and kept balanced they are as bad as any others.

The easiest way to locate a distant station on the dials of a regenerative receiver is to turn the regeneration control to a point which causes oscillation, then to rotate the tuning dials until the carrier wave of the desired station causes a heterodyne whistle with the oscillations of the receiver. Regeneration may then be brought about by stopping oscillation and the station will be received satisfactorily. But during the process of locating the whistle, the oscillating receiver is acting as a transmitter and spoiling the reception of neighbors operating their receivers near that frequency.

Whether a certain receiver re-radiates may be determined by a simple test with the help of someone within a short distance who also has a receiver. The two receivers are tuned to the same frequency, tuned to receive the same station at the same time. The regeneration control of the receiver to be tested is then set at its highest point to produce maximum regeneration. The tuning dial or dials are then turned back and forth across this setting a number of times. If the other receiver gives vent to a series of whistles and squeals as the dials are turned on the first one, the receiver being tested is re-radiating and is capable of causing much interference.

Whistles and squeak heard in a receiver may originate either in the same receiver or in others which are re-radiating. If the pitch of the whistle rises and falls while the tuning dials and other controls remain unchanged, the interference is coming from another receiver. But if the whistle remains at exactly the same pitch until the receiver controls are moved and then rises and falls with movement of the controls, it indicates that the receiver being tested is oscillating and is undoubtedly re-radiating.

The End

Comments? Suggestions? E-mail page author Kim Smith

Check out Kim Smith's The Radio Electronique.(link is bad)

Return to Skywaves for more early radio exploration.