

**LESSON  
38 R**

# **AUTOMATIC VOLUME CONTROL SYSTEMS**



# **RADIO-TELEVISION TRAINING SCHOOL, INC.**

**5100 SOUTH VERMONT AVENUE • LOS ANGELES 37, CALIFORNIA, U. S. A.**

## AUTOMATIC VOLUME CONTROL SYSTEMS

The development of our modern highly sensitive radio receivers soon created the need for convenient and effective methods of controlling this sensitivity, so that as reception is shifted from the weak signals of a distant station to the stronger impulses of a nearby powerful station, a pleasing and comfortable output level can be maintained at the loudspeaker. Formerly only manual (hand operated) volume control systems were available, but as the science of radio circuits progressed, automatic control systems were soon developed and applied.

An automatic volume control system, as the name suggests, is a circuit arrangement for providing more uniform receiver response and maintaining a more constant output level at the loudspeaker for varying degrees of input strengths. In other words, such a system provides within the receiving circuit itself means for compensating for sudden signal outburst or collapse. But although it has often been claimed for it, an automatic volume control does not completely counteract or eliminate fading; it merely minimizes the effects of it. Automatic volume control is truly automatic voltage control for in controlling the voltage of certain tubes we either increase or decrease the signal voltage.

### VOLUME CONTROL RANGE IN A RECEIVER

The sensitivity of the receiver can also be controlled in two ways, by regulating the radio frequency input or by varying the operating characteristics of the tubes, that is changing the grid bias or the screen grid voltage. If a manual volume control is provided, it is common practice to bring about this complete control through one unit, for it would hardly be practical to provide a separate sensitivity and level control.

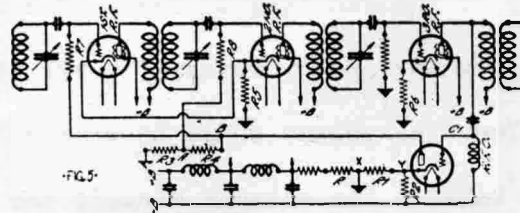
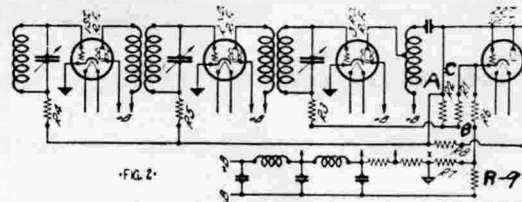
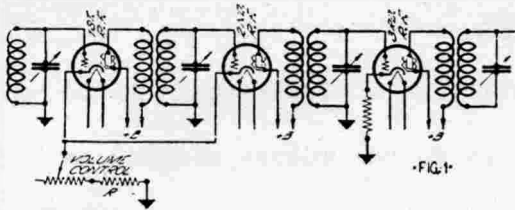
## MANUAL VOLUME CONTROL SYSTEMS

In radio entertainment receivers there are several ways of controlling the volume of the sound heard coming from the loudspeaker. One manual volume control method regulates the radio frequency input to the antenna or primary circuit of the first radio frequency transformer of the receiver by means of a variable resistor; another varies the grid bias or screen voltage by means of a rheostat or potentiometer in the respective circuits. Then the volume could be changed by using a means of changing the inductive coupling between the antenna circuit and the secondary winding of the transformer in the first radio frequency stage.

Practically all of these methods have certain disadvantages. The variable inductive or resistor methods inserted in the antenna circuit affect the selectivity and make it necessary for the R.F. gain in the receiver to be at a maximum at all times. This makes the set have a high internal noise level. Then if the variable resistor isn't smooth in its operation, there will be noise heard as it is adjusted.

The system which varies the grid bias or screen grid voltages of the R.F. stages seems to be a good method, as this does not affect the selectivity of the receiver, nor does it cause overloading of the detector. An examination of receiving sets not equipped with automatic volume control systems will reveal that the most common manual control system is to vary the cathode-to-chassis voltage of the radio frequency and of the first intermediate frequency amplifier tubes. This is accomplished by employing a rheostat or potentiometer of the proper value in the cathode return circuit.

The general circuit arrangement of such a manual control is illustrated in Fig. 1. Here is illustrated the skeleton circuit of a 3-stage radio frequency amplifier. The cathodes of the first two tubes are connected together and also to the sliding contact of the potentiometer resistor R-1, the latter being connected in series with a fixed resistor R-2 to ground. As the bias of the R.F. tubes is increased, the gain of the tubes is decreased, thereby reducing the amplification. Likewise, if the bias is reduced, the amplification is increased.



Figs. 1, 2 and 5. Skeleton circuits of the 2-element detector and the automatic volume control tube systems.

R-2 serves as a limiting resistor and prevents the bias from being reduced beyond the minimum value, that is the value prescribed by the tube manufacturer. If this value is exceeded, grid current will flow, distortion result, and the tuning selectivity be greatly reduced.

### AUTOMATIC VOLUME CONTROL

The automatic volume control as used today also operates upon the cathode or grid bias of the R.F. tubes, but accomplishes its results through the use of a variable current directed through a group of resistors. The control current is caused to change in accordance with the strength of the incoming signal, and by flowing through the resistors it causes a changing voltage drop that is applied as an additional bias on the respective tubes. The manual and automatic systems are thus very similar in that they both operate upon the grid bias of the tubes; one functions through the aid of a hand operated rheostat while the other is actuated by the signal itself.

With stronger incoming signals the bias is thus increased and the amplification reduced, while on weaker signals the bias inherently becomes less and

the amplification greater, with the result that a more constant output level is maintained. This automatic leveling action, however, is operative only within certain limits as determined by the design of the receiver. A manual volume control is, of course, also used in connection with the automatic volume control for establishing the desired audio level of the program heard from the loudspeaker.

#### THE DIODE DETECTOR IN AUTOMATIC VOLUME CONTROL

The diode detector derives its name from the fact that two of the elements are used, that is a cathode and an anode. For example, in some A.V.C. systems the type 27 tube, a triode, has its grid and plate connected together, thus acting as a diode. In some sets the plate electrode is connected directly to the cathode. The former arrangement is the one more commonly used; however, in any event electrons flow from the cathode to the grid and to the grid-plate if the plate electrode is connected to the cathode. These electrons flow only when the anode, formed by grid-plate electrodes, are at a positive potential with respect to the cathode. The electrons flow only on the positive peaks of the R.F. signal. This R.F. signal may be applied directly from one terminal of the R.F. transformer or through an R.F. coupling condenser. In any event there must always be a continuous d-c path provided for the flow of electrons from the cathode to the anode. The minus A.V.C. voltage is obtained from the voltage drop across a diode load resistor. This resistor is usually bypassed by a condenser having a capacity of approximately .00025 mfd. to remove all of the R.F. that may be in the circuit.

The type 27 tube operates purely as a rectifier and without the accompanying amplification that it had when the tube functions as a triode detector. Consequently, it is customary practice in circuits in which such a system is used to employ an additional tube for providing the audio amplification. The first tube is called the detector-rectifier and the second the detector-amplifier. In other words, the automatic volume control feature is produced at the expense of an additional tube.

The use of such a diode detector in the dual role of detector-rectifier and automatic volume control tube is illustrated in the skeleton circuit in Fig. 2. Here is again illustrated a 3-stage radio frequency amplifier feeding into a diode detector, a type 27 tube, with its grid and plate connected together. Two resistors, R-1 and R-2, of 100,000 ohms each are connected in series between the grid and cathode of the tube. The common or midpoint between R-1 and R-2 is connected through the isolating or decoupling resistor R-3 to the grid returns of the third R.F. amplifier tube, while the grid end of R-2 is connected through R-4 and R-5 to the grid returns of the first and second R.F. tubes. The cathodes of the three R.F. tubes are connected directly to ground.

In the power supply filter and voltage divider circuit, which is of conventional design, there are two screen grid voltage dividers and it will be noted that point X is grounded. The negative terminal of the power supply is through resistors R-7 and R-9. The voltage drop across R-7 then becomes the normal grid bias for the first three tubes, and by means of the tap connection is imparted through R-6, R-1 and R-3 to the grid of the third tube, and through R-6, R-1, R-2, R-4, and R-5 to the grids of the first and second tubes respectively.

#### OPERATION OF THE DIODE DETECTOR

With this arrangement, the detector-rectifier tube performs as a pure rectifier with the direction of electron flow from the cathode to grid-plate electrodes. Resistors R-1 and R-2 serve as a voltage divider and diode load. When a station is tuned in, the R.F. signal reaches this rectifier and during every positive half R.F. cycle, the grid-plate electrodes will receive electrons from the cathode.

As this rectified current flows through resistors R-1 and R-2, it sets up across them a potential drop which makes point "B" more negative than "C" and point "A" more negative than "B". Since the grid of the third tube is connected to point "B", the drop across R-1 becomes an additional negative bias for the third tube, and the drop across R-1 and R-2 becomes an additional bias for the first and second tubes. As long as no signal is tuned in, no rectified current flows through R-1 and R-2, and only the normal bias (the drop across R-7) is applied to the first three tubes. When a signal is being received, a rectified current flows through R-1 and R-2, and the voltage drop across them becomes an additional bias. This increased bias decreases the effective amplification in the first three tubes and thus reduces the output of the speaker. The circuits are designed so that for weak signals the increased bias is very small; but as the signal strength increases, the bias increases more rapidly and the amplification is reduced accordingly.

Even though the incoming signals may vary in strength over wide limits, through the action of this automatically regulated bias the output at the speaker is maintained at a practically constant level. Of course, in addition to this automatic control, a manual volume control is also used. With this manual control the volume is set at the degree of loudness wanted. Then if the signal strength increases, the bias is automatically increased and the amplification decreased, and the output maintained at the desired level. If the signal strength decreases, the bias is automatically decreased and more amplification rendered available, so that the output comes up to the original level. But if the signal strength should decrease very appreciably, it might happen that the bias drops to its minimum normal value and that the full amplification of the receiver is rendered available, and still the output does not come up to the required level. In that case it is necessary to readjust the manual

volume control. If the signal strength falls so far down that even with the manual control "full on" the loudspeaker volume does not come up to where it is wanted, then nothing further can be done. In other words, the incoming signal strength has dropped below the sensitivity of the receiver. Really the automatic volume control circuit is a volume suppressing device rather than a volume magnifier, for after all it merely regulates the amount of amplification in accordance with the variations in signal strength. It cannot add to the amplification or overall sensitivity of the receiver; it can merely hold it down. Probably a better term for it would be automatic sensitivity control; however, since its primary function is to automatically hold the volume at a desired level, it is properly called an A.V.C.

The automatic bias voltages applied to the radio frequency tubes, it was explained, are tapered somewhat, that is, these voltages are applied to the first two tubes of a receiver and are less than that applied to the third tube. This seems to give a smoother A.V.C. action, although some design engineers apply the same A.V.C. voltages to all three tubes.

#### SOME PECULIARITIES OF THE DIODE DETECTOR

It was previously mentioned that the diode detector, when used for automatic volume control, is purely a rectifier. It can also serve as a regular diode detector while it is being used for A.V.C. purposes. The diode detector lacks amplification obtained from triode detectors. To make up for this amplifying deficiency another triode tube is customarily used so that the detected signal strength is brought up to the desired level. The diode detector has a perfectly linear response, which means that the A.F. output signal voltage is in direct proportion to the input signal voltage. This feature tends to give us more perfect reproduction.



Another virtue of the diode detector is that it can safely handle a greater input, that is, it will not overload as readily on strong signals. Thus where it is lacking in one respect, it has advantages in another, and the use of the additional detector-amplifier tube is therefore easily justified. However, a diode detector as used previously for automatic volume control cannot have a tuned input system, on account of the high resistance that would be introduced into the tuned circuit. Consequently, an untuned transformer or autotransformer type of coupling is generally used, as these insure best results.

THE PHILCO MODEL 96 RECEIVER

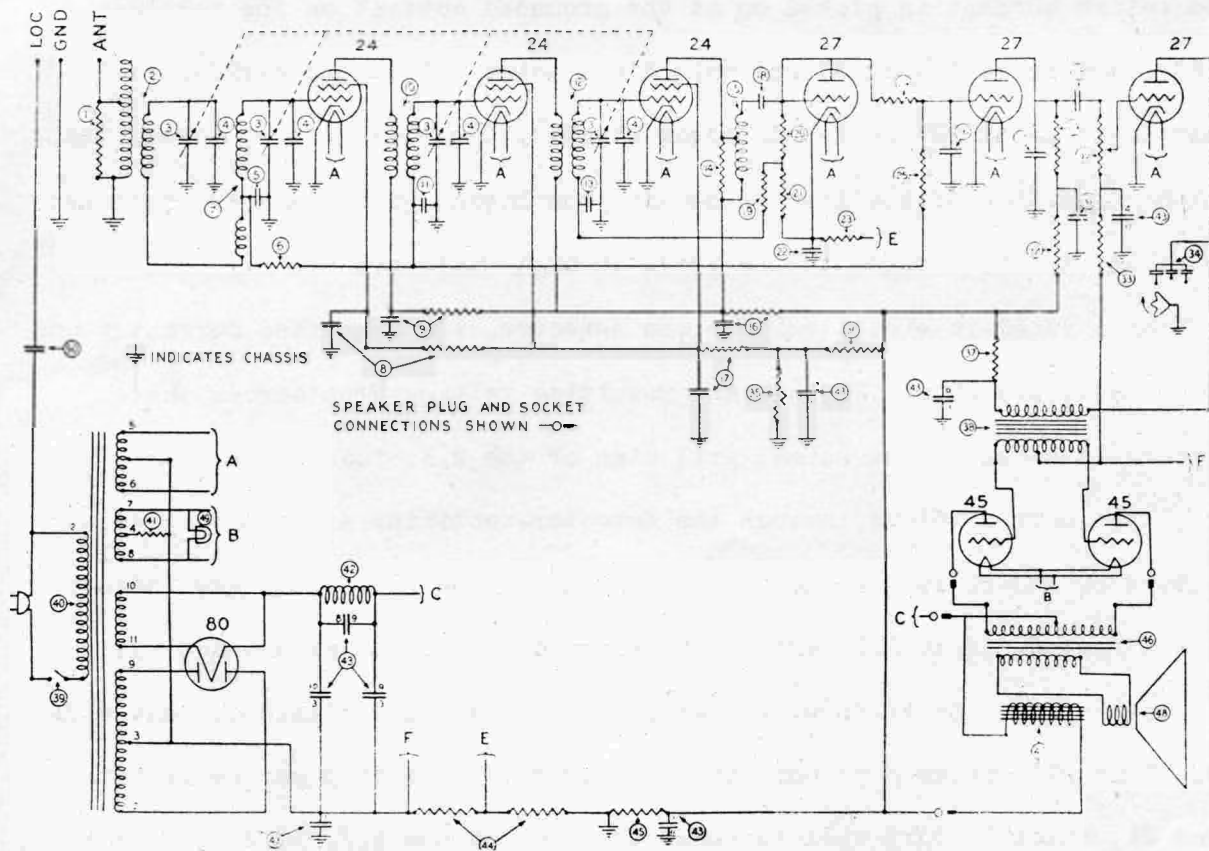


Fig. 3. Circuit diagram of the Philco Model 96 radio receiver.

The Philco Model 96 and 96A radio receivers have incorporated in their circuit a diode detector that serves as an automatic volume control tube. An analysis of the circuit as illustrated in Fig. 3 will reveal that three tuned radio frequency stages with type 24 tubes are employed ahead of the detector, a type 27 tube. The plate and grid of this tube are shorted externally, and between the cathode and grid are connected in series two 100,000-ohm resistors, No. 20 and 21. The midtap between these resistors is connected through a 500,000-ohm isolating resistor No. 19 to the grid of the third R.F. tube, while the end of resistor No. 20 is connected through the isolating resistors 24 and 25 to the grids of the first and second R.F. tubes. The cathodes of these three tubes are connected directly to ground, while the plate return current is picked up at the grounded contact on the voltage divider between resistors 44 and 45. Since point "E" on the divider is connected to point "E" on the detector circuit, the voltage drop across the right hand section of resistor 44 becomes the normal grid bias for the three R.F. tubes, and is applied to the grids through resistors 23, 21, etc.

When a tuned-in signal reaches the detector, the rectified current flows through resistors 20 and 21, and the resulting voltage drop across these resistors is added to the normal grid bias of the R.F. tubes. On weak signals only little current flows through the detector-rectifier and the drop across resistors 20 and 21 is very small. The grids of the R.F. tubes are therefore little affected, if at all, and the receiver can function with practically full sensitivity. On stronger signals, however, an appreciable current will flow. This will cause a proportionately large voltage drop across resistors 20 and 21, which in turn will increase the bias on the R.F. tubes and thus cut down the amplification accordingly. Variations in signal strength thus automatically cause simultaneous changes in the amplification gain in the receiver,



The Fada Models 41, 42, 44, 46 and 47 also have a built-in automatic volume control that employs a diode detector-rectifier of the type described previously. A study of the circuit diagram as illustrated in Fig. 4 will disclose that again a 3-stage R.F. amplifier is used that feeds through an untuned transformer into a type 27 tube used as a detector. In this case, however, the plate and cathode are tied together externally, and the rectified current can flow from the grid to the plate and cathode but not in the reverse direction.

Two 25,000-ohm resistors in series are connected between the cathode and the lower end of the grid coil. The midpoint between these resistors is joined through a 500,000-ohm isolating resistor to the grid of the third R.F. tube, while the end of the resistor combination is similarly connected through isolating resistors to the grids of the first and second R.F. tubes. The audio signals are sent on to the detector-amplifier through the 250,000-ohm resistor connected to the lower end of the grid lead.

The cathode of the three R.F. tubes are connected directly to ground; and since the voltage divider is grounded as illustrated at point "X", the plate return current of these tubes is picked up at this point. The voltage drop across the 100-ohm resistor "XY", then becomes the normal grid bias for the three R.F. tubes, and is applied to the grids by means of the lead connecting point "Y" through the 50,000-ohm isolating resistor to the cathode of the detector.

When the receiver is put into operation and the tuned-in signal reaches the detector, the rectified current is caused to flow through the two 25,000-ohm load resistors, and the voltage drop across these resistors automatically adds itself to normal grid bias on the three R.F. tubes. This reduces the signal amplification and thus holds the output down to the level as determined by the

manual volume control connected into the grid circuit of the detector-amplifier tube. If the signal is weak, it is permitted more amplification through a reduction in the R.F. grid bias; but if the signal strength drops below the sensitivity of the receiver, the automatic volume control is helpless, for it cannot put into effect more amplification than is available in the receiver.

#### THE AUTOMATIC VOLUME CONTROL TUBE

The automatic volume control tube operates on the principle of the vacuum tube voltmeter. The circuit is generally arranged so that the received signal can produce the necessary changes in current flow in the plate circuit of the control tube, and this variable current is then sent through one or several resistors across which it produces proportional voltage drops. These are added on to the normal grid biases of the tubes to be controlled, with the result that the sensitivity of the tubes varies as the strength of the incoming signal changes.

A skeleton circuit illustrating the use of such an automatic volume control (AVC) tube is illustrated in Fig. 5. Here is illustrated a 3-stage R.F. amplifier feeding into a standard grid bias detector, which can be either a type 27 or type 24 tube. The special AVC tube is also illustrated, and it may be either a 27 or 24 tube, both are used commercially. It is connected into the circuit in rather a peculiar manner. Its filament is connected across the R.F. filament line, while the plate is connected to ground through two resistors, R-3 and R-4, connected in series. In the filter and voltage divider which again are of conventional design, point "X" is grounded, the cathode of the AVC tube is connected to point "Y", while the grid is connected through an R.F. choke (an isolating resistor might also be used) to the negative side

of the line. Since by definition the grid bias of a tube is the potential difference between the cathode and grid, the voltage drop across resistor R-2 in Fig. 5 would constitute the normal bias for the AVC tube. Similarly the drop across R-1 would constitute the normal plate pressure. The grid bias on this tube is designed so that no current will flow in the plate circuit until a certain predetermined signal strength is being received. This means that for ordinary weak signals the AVC tube is inoperative.

The cathodes of the first two R.F. tubes are normally biased through resistor R-5, and the cathode of the third R.F. tube through resistor R-6. Further examination of the circuit reveals that the grid of the second tube is connected through the isolating resistor R-8 to the midtap "A" between resistors R-3 and R-4, and the grid of the first tube through resistor R-7 to point "B" at the other end of R-4. Also, the grid of the AVC tube is further connected through condenser C-1 to the output circuit of the third R.F. tube.

As long as no signal is tuned in, or when only a weak signal is being received, the AVC tube is inoperative and the receiver functions normally as though this tube were not present at all. On stronger signals, however, sufficient voltage is developed in the output circuit of the third R.F. tube to swing the grid of the AVC tube and cause plate current to flow. This plate current flows through resistors R-3 and R-4 and sets up a voltage across them. Due to the nature of the circuit, the drop across R-3 is applied as an additional bias to the grid of the second R.F. tube, and the drop across R-3 and R-4 as an additional bias to the grid of the first tube. The stronger the incoming signal, the greater will be the grid swing on the AVC tube and the more current will be drawn. This in turn increases the bias on the first two R.F. tubes and decreases the amplification, thereby holding down the

output of the receiver. On weak signals, it was stated, no current is drawn by the AVC tube and the full amplification of the receiver is available. Thus the sensitivity of the first two R.F. tubes is again caused to vary as the signal strength changes by causing the grid bias to be a variable quantity dependent upon the received signal strength.

THE STROMBERG-CARLSON MODEL 846

The Stromberg-Carlson Model 846 radio receiver employs an automatic volume control system with a special control tube as was just described. The circuit arrangement of the receiver is illustrated in Fig. 6.

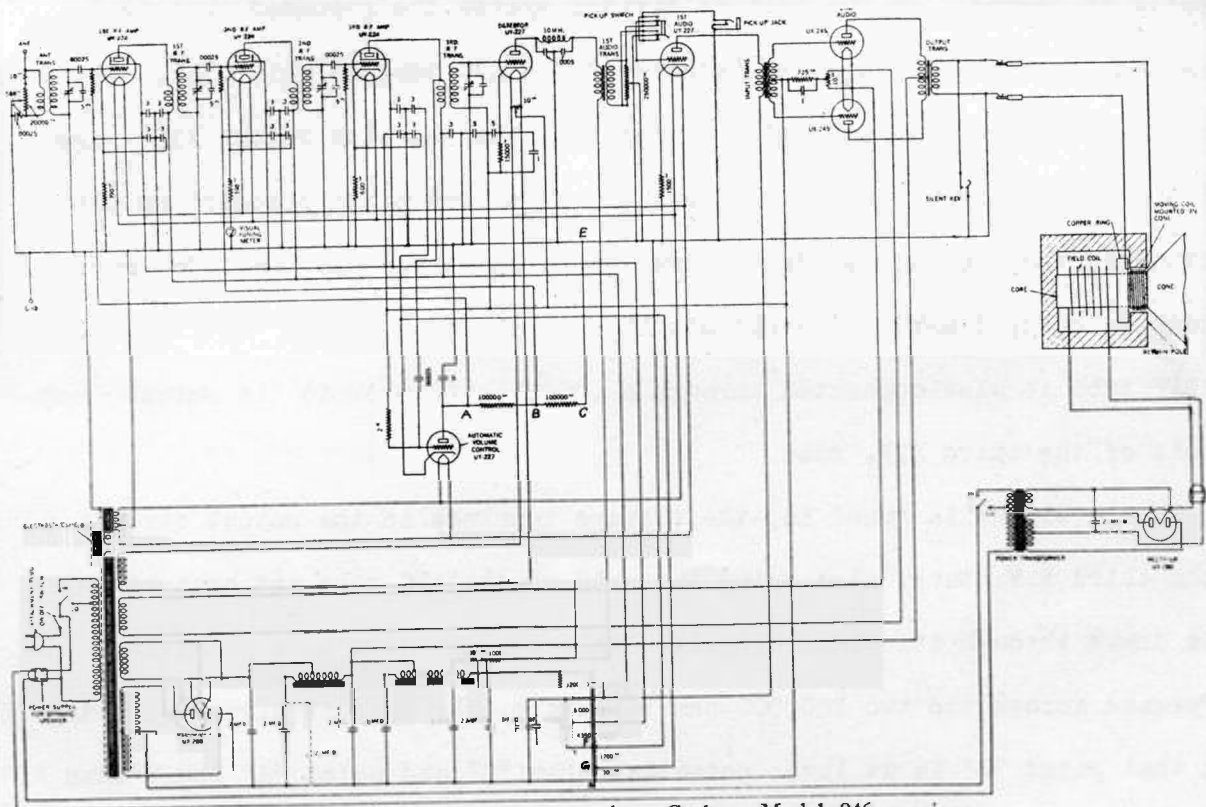


Fig. 6. Circuit diagram of the Stromberg-Carlson Model 846 receiver.

There are three tuned R.F. stages feeding into a grid bias detector. The cathodes of the R.F. tubes are biased to ground through individual biasing resistors and the potential difference across these resistors is the normal grid bias for the tubes.

The automatic volume control (AVC) tube, a type 27 tube, is connected across the R.F. filament circuit, and has its plate connected through two 100,000-ohm resistors in series to ground at point "E". The grid of the second R.F. tube is connected to the midtap "B" between these resistors, while the grid of the first R.F. tube is connected to point "A" as illustrated. The grid of the third R.F. tube is connected through an isolating resistor directly to ground. In the voltage divider system the grounded chassis is connected to point "F", and the cathode of the AVC tube to point "G". The grid is connected through an isolating resistor to the negative return line. An analysis of the circuit will show that the effective plate pressure on the AVC tube is the drop across "FG" (minus the drop across "AB" and "BC" when current is being drawn). The cathode bias is the drop across "GN". The grid of this tube is also connected through a .00025 condenser to the output circuit of the third R.F. tube.

When a signal is tuned in, the voltage impulses in the output circuit of the third R.F. tube, also swing the grid of the AVC tube and cause current to be drawn through its plate circuit. This current sets up a potential difference across the two 100,000-ohm resistors, the current direction being such that point "B" is at lower potential than "C" and point "A" lower than "B". Then, since the R.F. cathode returns are connected to ground which is at the same potential as point "C", the grid of the first R.F. tube being connected to point "A" will become more negative by an amount equal to the drop across "AC"; and similarly the grid of the second R.F. tube will be more negative by an



amount equal to the drop across "BC". Since the plate current flow is proportional to the grid swing, that is the strength of the incoming signal, the grid bias of the two R.F. tubes will also vary accordingly. As the signal strength increases, the tubes are biased more, the amplification is reduced, and the receiver output is held down. It is another case of automatically varying the sensitivity of the receiver in accordance with the strength of the incoming signal, the weaker signals are allowed more amplification while the stronger ones are allowed less.

### THE DETECTOR AS AN AVC TUBE

A rather simple and unique automatic volume control system is employed in the Crosley Model 77 and 84 receivers, as illustrated in Fig. 7.

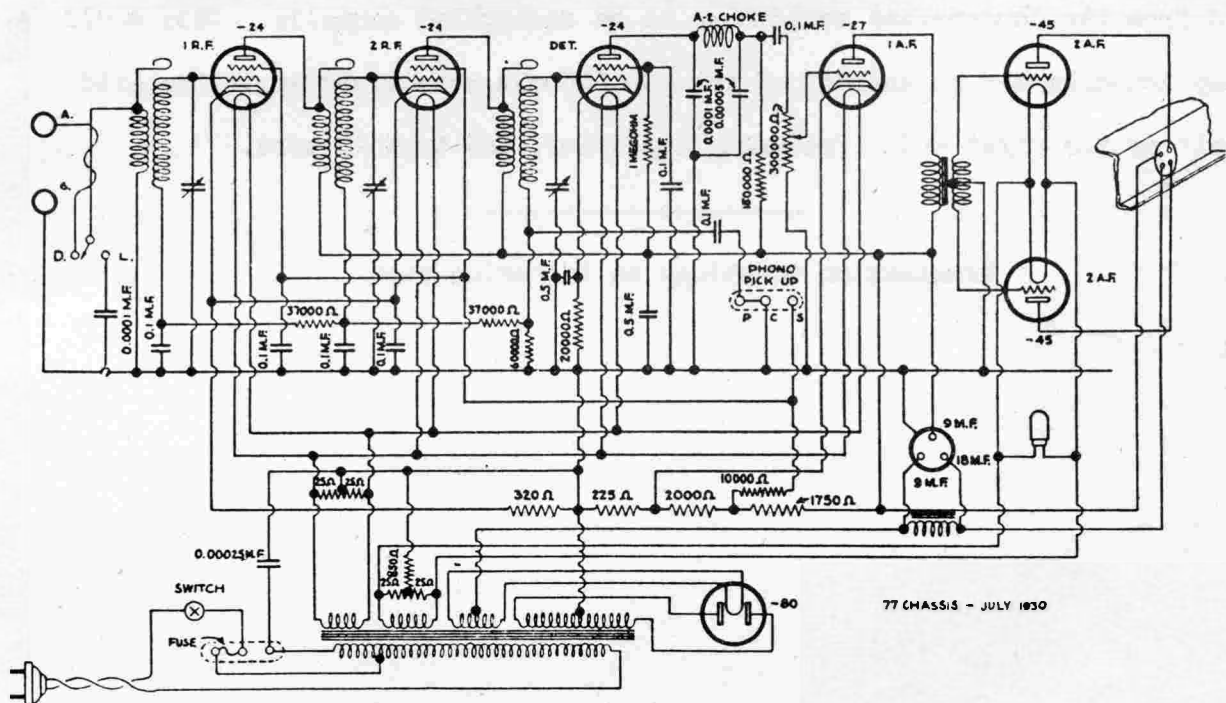


Fig. 7. Circuit diagram of the Crosley Model 77 and 84 receivers.

In this system the grid returns of the two R.F. tubes are brought together through their respective isolating resistors and connected to ground through a common 60,000-ohm resistor that is also in the detector grid return

circuit. Under ordinary conditions the circuit functions normally, but if a signal is received of sufficient strength to cause grid current to flow, a voltage drop is set up across the 60,000-ohm resistor. This drop is then added to the normal grid bias of the two R.F. tubes and reduces the R.F. amplification, thereby decreasing the intensity of the R.F. signal reaching the grid of the detector, the type 24 tube.

It is evident that this control action is operative only when the received signal is of sufficient intensity to cause current to flow in the grid-cathode circuit of the detector tube. It is in this respect that it differs from the other control systems previously explained. It could be referred to as an automatic overload control rather than an automatic volume control. For received signals that do not cause grid current to flow, the variation in the volume heard from the loudspeaker would have to be controlled manually. This would be accomplished by the adjustment of the 600,000-ohm potentiometer in the grid circuit of the first audio frequency amplifier, the type 27 tube.

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Examination Questions on following page.