July 27, 1937. W. VAN B. ROBERTS 2,088,179

AUTOMATIC VOLUME CONTROL CIRCUITS

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Fig. 1

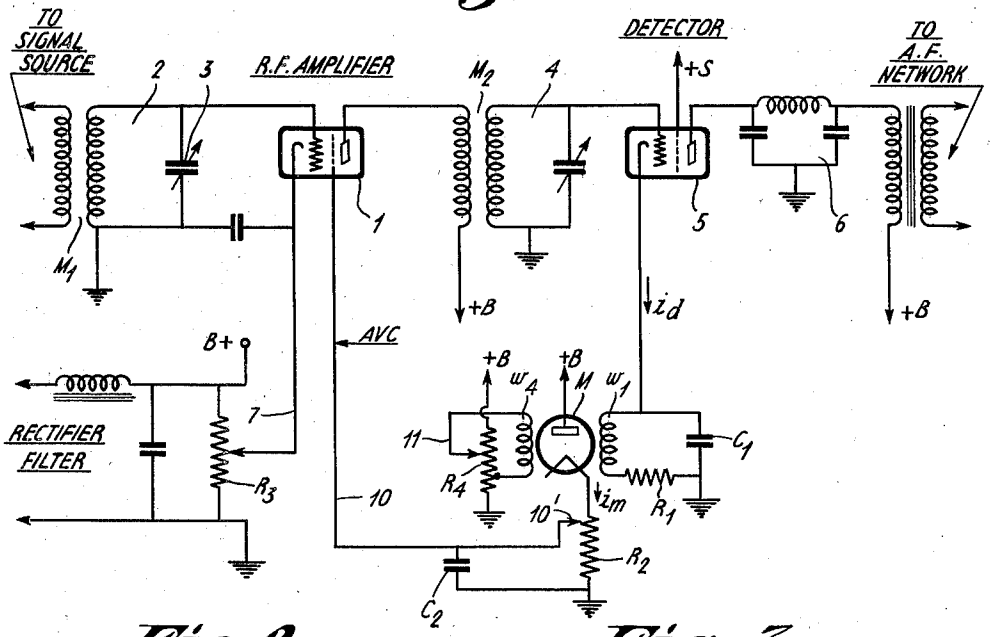


Fig. 2

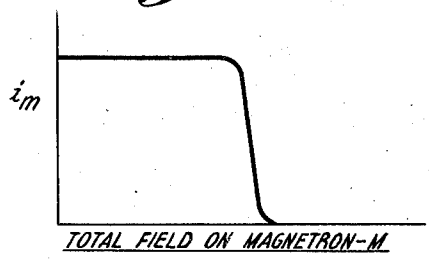


Fig. 3

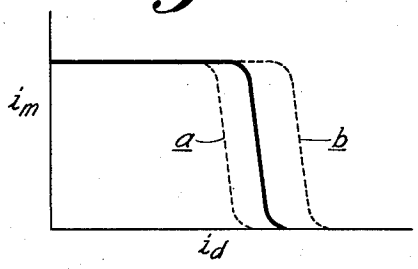
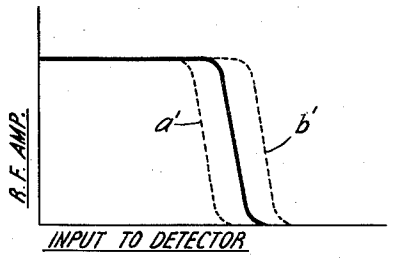


Fig. 4



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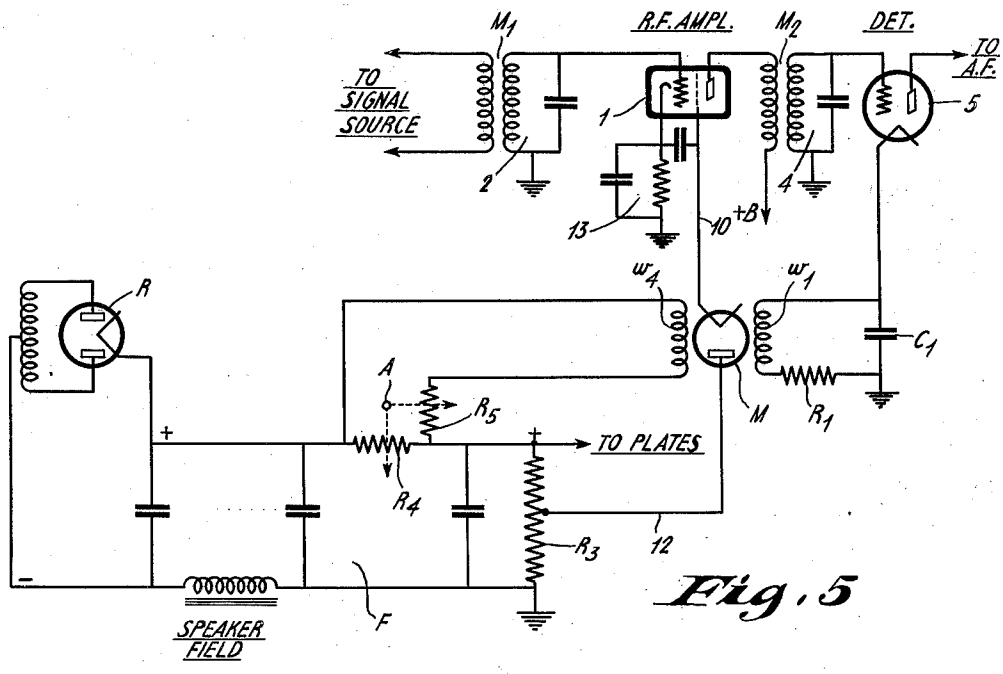


Fig. 5

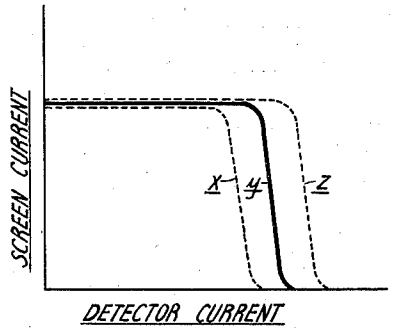


Fig. 6

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AUTOMATIC VOLUME CONTROL CIRCUITS

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Fig. 7

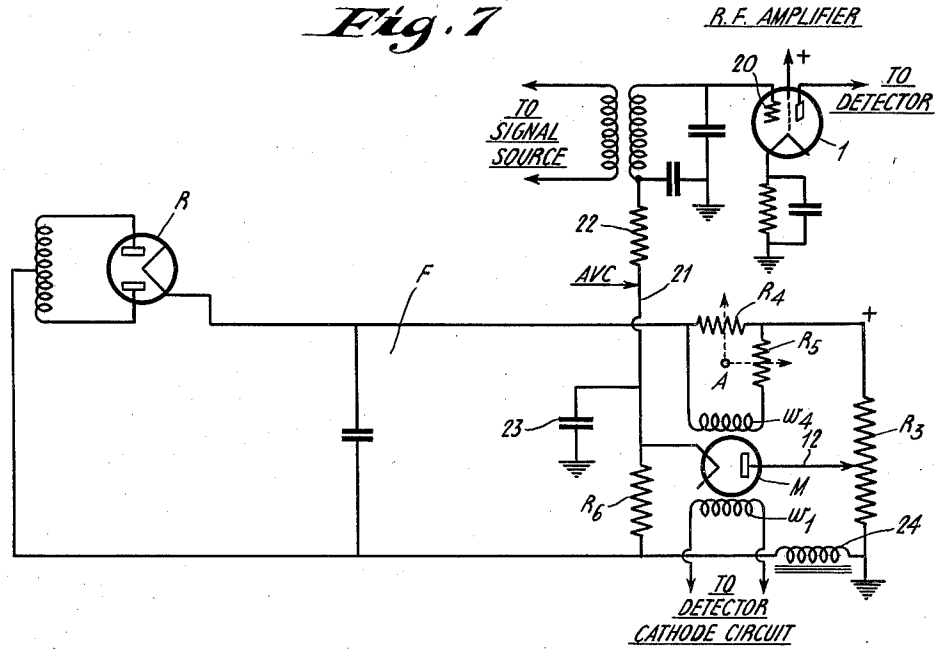
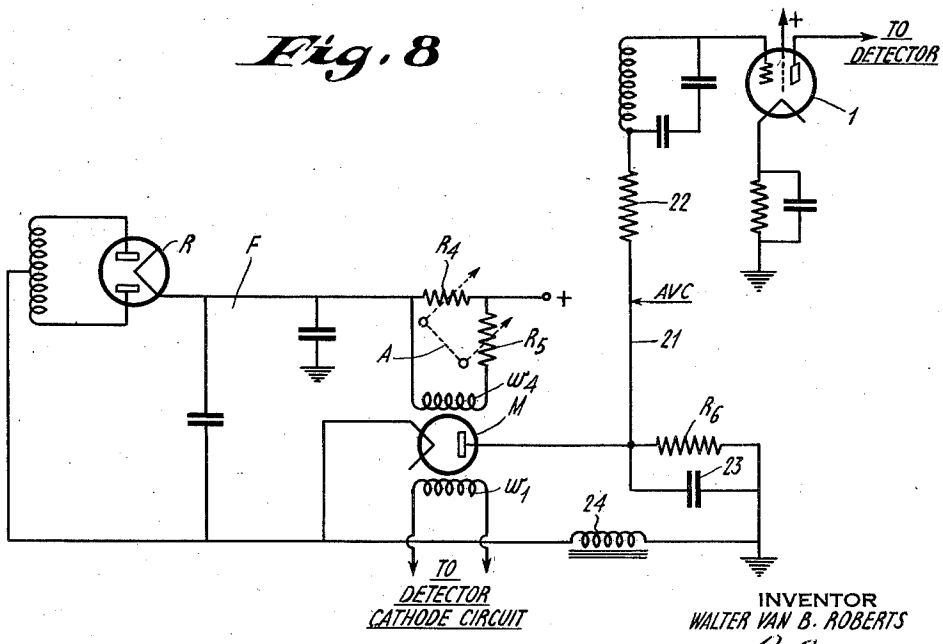


Fig. 8



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Patented July 27, 1937 2,088,179

UNITED STATES PATENT OFFICE

2,088,179

AUTOMATIC VOLUME CONTROL CIRCUITS

Walter van B. Roberts, Princeton, N. J., assignor to Radio Corporation of America, a corporation of Delaware

Application October 20, 1934, Serial No. 749,204

1 Claim. (Cl. 250—20)

My present invention relates to automatic gain control circuits for radio receivers, and more particularly to improved and novel types of automatic volume control circuits adapted for use in connection with radio broadcast receivers.

In my U. S. Patent 1,913,959 of June 13, 1933, there have been shown various types of automatic volume control circuits for radio broadcast receivers. In general the purpose of these various circuits is to automatically control the amount of amplification in a receiving circuit, the systems disclosed in the patent utilizing the strength of a carrier wave, rather than the maximum wave amplitude, whereby the radio frequency amplification is not varied by audio frequency variations of the incoming wave amplitude, which would reduce the effectiveness of demodulation, but is varied only by variation of carrier wave amplitude which may be due to general fading effects, or to tuning in of different stations. Furthermore, in the said patent there are disclosed different types of automatic volume control circuits utilizing a magnetron as the amplification control element, the direct current component of detected signal energy being employed to regulate the operation of the control magnetron.

One of the main objects of the present invention is to provide automatic volume control circuits of the general magnetron type disclosed in my aforementioned patent, and wherein the magnetron control circuits are improved so as to maintain full amplification in the high frequency amplifier stages of a radio receiver up to the point where the input to the detector reaches a predetermined value after which the automatic volume control mechanism rapidly reduces the amplification until at a value slightly greater than the said predetermined value the amplification becomes substantially zero.

Another important object of this invention is to provide an automatic volume control circuit for a radio receiver, the control mechanism utilizing a space discharge device of the magnetron type, and wherein the voltage input to the detector is maintained constant within narrow limits for all signals whose strength exceeds the value required in order that the amplifying system may bring them up to the desired level of detector input.

Another object of the invention is to provide an automatic volume control network for a radio broadcast receiver, the network utilizing a space discharge device of the magnetron type, and the volume control system being constructed in such a manner that it is not necessary to provide a higher rectified voltage than required for normal operation of the receiver.

Still another object of the invention is to provide an improved volume control circuit for a radio receiver wherein variations of current flow in the space current path of the signal detector are utilized to regulate the operation of a space discharge device of the magnetron type, and wherein the magnetron is adapted to vary the operating potential of a positive grid electrode, such as the screen grid, of a signal amplifier of the receiver.

Still other objects of the invention are to improve generally the simplicity and efficiency of automatic volume control circuits of the magnetron type for radio receivers, and particularly to provide such circuits which are not only reliable and efficient in operation, but economically constructed and assembled in radio receivers.

The novel features which I believe to be characteristic of my invention are set forth in particularity in the appended claim, the invention itself, however, as to both its organization and method of operation will best be understood by reference to the following description taken in connection with the drawings in which I have indicated diagrammatically several circuit organizations whereby my invention may be carried into effect.

In the drawings:—

Fig. 1 diagrammatically shows a receiving system embodying the invention,

Figs. 2, 3, and 4 show the various operating characteristics of the system in Fig. 1,

Fig. 5 shows a circuit diagram of a modified form of the invention,

Fig. 6 graphically shows the operation of the system shown in Fig. 5,

Fig. 7 shows another modification of the invention,

Fig. 8 illustrates still another embodiment of the invention.

Referring now to the accompanying drawings, wherein like reference characters in the different figures represent similar circuit elements, there is shown in Fig. 1 a receiving system reduced to its most essential networks. Those skilled in the art will fully understand that the present invention is to be applied to modern broadcast receivers of the superheterodyne or tuned radio frequency types. In Fig. 1 the essential networks include the controlled signal amplifier which may comprise a tube 1 of the screen grid type. The input electrodes of the

tube are coupled to a resonant input circuit 2, the input circuit including the tuning condenser 3 for tuning the input circuit 2 to a desired signal frequency.

The input circuit 2 is coupled, as at M_1, to any desired source of signal energy. The anode of the tube 1 is coupled, as at M_2, to the tuned input circuit 4 of the following screen grid tube 5. The anode circuit of tube 5 includes a radio frequency filter network 6 for preventing the flow of radio frequency currents to the following audio frequency network, the latter not being shown.

It is to be understood that the tube 1 functions as a radio frequency amplifier, and the tube 5 functions as a signal rectifier, or detector. When the present invention is to be applied to a superheterodyne type of receiver, then the amplifier 1 may be of the intermediate frequency type, and the detector 5 will be the second detector. One, or more, stages of audio frequency amplification may follow the detector 5. The signal source coupled to input circuit 2 would, in that type of receiver, comprise the usual signal amplifier followed by a first detector network. In the superheterodyne receiver, of course, the tuning condensers in the input circuits of tubes 1 and 5 would be adjusted to maintain the circuits 2 and 4 fixedly tuned to the operating intermediate frequency.

If the receiver is of the tuned radio frequency type, then the tuning condensers of the input circuits 2 and 4 are to be considered as continuously variable, and any desired type of mechanical uni-control may be utilized to vary the rotors of the condensers. In such a case the signal source preceding circuit 2 will usually include one, or more, additional stages of tuned radio frequency amplification. Regardless of which type of receiver is employed, it is to be understood that the automatic control circuit to be described can be used to control the amplification of the various tubes preceding the detector 5. In other words, in the superheterodyne type of receiver the AVC (hereinafter used to designate the automatic volume control network) network to be described can be used to control the amplification of the radio frequency amplifier, the first detector and the intermediate frequency amplifier.

The electrodes of the controlled tubes and the detector tube are energized from the usual bleeder resistor of the power supply network, and there has been shown in Fig. 1 the rectifier filter portion of the power supply network, as well as the supply resistor R_3. One side of the resistor is grounded, while the other side is the +B side of the supply network. Those skilled in the art are fully aware of the points on the supply resistor R_3 to which the different electrodes of the tubes of the receiving system are to be connected for proper energization. The cathode of controlled amplifier 1 is shown connected by an adjustable lead 7 to an intermediate point on resistor R_3. Bias for the signal control grid of tube 1 is secured by grounding the low alternating voltage side of input circuit 2, and the signal grid of the amplifier 1 will then be at a negative voltage with respect to the cathode of tube 1; this voltage is equal to the voltage drop across the portion of resistor R_3 between ground and the adjustable tap of lead 7. This method of providing a bias for the controlled amplifier is utilized as it provides a bias which is substantially unaffected by the amount of space current flowing in the amplifier. In order to economize on rectified current the cathode of tube 1 may be tapped onto resistor R_2, as this resistor is also at a positive potential. Again, the cathode of tube 1 may be tapped onto resistor R_4, but for the sake of simplicity these three resistors are shown separately so that each one has only one function.

Grid bias for the detector tube 5 is provided by the flow of detector space current through resistor R_1 in the customary fashion. However, it will be noted that resistor R_1 is arranged in series with the magnetic field winding w_1. It is pointed out that the resistor R_1 may be wholly, or in part, the resistance of the field winding w_1. The condenser C_1 shunts the field winding and resistor R_1 in the usual fashion to by-pass audio frequency currents. If desired, this condenser can be made large enough to by-pass variations in voltage space current due to the more rapid changes in modulation intensity. The function of winding w_1 is to provide a magnetic field acting upon magnetron tube M.

The magnetron tube is a controlled space discharge device and its construction is well known to those skilled in the art. The electron emission element, or cathode, of the magnetron is connected to ground through a resistor R_2, the screen grid electrode of the controlled amplifier 1 being connected by lead 10 to a point on resistor R_2 adjacent the cathode of the magnetron tube. The tap 10′ of lead 10 enables the lead to be adjusted to any desired point on resistor R_2. A by-pass condenser C_2 is connected between lead 10 and the grounded side of resistor R_2. The anode of magnetron tube M is connected to a suitable positive voltage point on the bleeder resistor R_3.

The magnetron tube is, additionally, provided with a second field winding w_4, one end of which is connected to an intermediate point on the resistor R_4, one side of this resistor being grounded. The other side of resistor R_4 is connected to a suitable point of positive potential on the voltage supply resistor. The opposite end of the winding w_4 is connected by an adjustable lead 11 to any desired point on resistor R_4.

Fig. 2 is a graphical representation of the dependency of the magnetron current i_m upon the total field impressed on magnetron M. It will be seen that the current is constant until the field reaches a certain critical value, and that a further increase of field intensity rapidly shuts off the magnetron current approximately completely.

The solid curve in Fig. 3 shows the relationship between the magnetron current and the direct current component of the detector current i_d. The direct current component of the detector space current flows through the field winding w_1, and the solid line curve of Fig. 3 shows how the magnetron current i_m depends upon the current i_d. It will be observed that this solid line curve is of exactly the same shape as that in Fig. 2, because the field on the magnetron varies directly with the current through the field winding w_1.

The field winding w_4 of the magnetron tube, also, acts upon the magnetron, and its terminals are adjustably tapped upon the resistance R_4, the latter being energized by direct current, so that a fixed field of reversible sign and adjustable magnitude can be impressed upon the magnetron by winding w_4. Hence, the total field upon the magnetron is the sum of the fields produced by the two windings w_1 and w_4. In Fig. 3 the dotted line curve a shows the characteristic when the fixed field due to winding w_4 is made to aid the

field due to winding w_1, while the dotted curve b shows the characteristic when the fields of the two windings are in opposition.

It will, thus, be seen that by suitable adjustment of the current through winding w_4, the magnetron current can be caused to cut off at any desired value of detector current i_d. In series with the magnetron there is disposed the resistance R_2, and the voltage which is developed across this resistor by the passage of the magnetron current, or a part of this voltage, is applied to the screen electrode of the radio frequency amplifier tube 1. When the magnetron current is shut off as a result of the detector current increasing to the critical value, the voltage on the screen of the controlled amplifier vanishes. Since the detector current i_d increases as the input to the detector increases, an over-all characteristic as shown in Fig. 4 results.

The curves of Fig. 4 are obtained by plotting amplification of the controlled amplifier against signal input to the detector. Fig. 4 shows how the radio frequency amplification remains constant up to a certain value of detector signal input, and then drops rapidly to zero for a slight increase in detector signal input. The dotted line curves a' and b' correspond to those of Fig. 3; it is evident that the adjustment of the fixed field produced by winding w_4 provides a method of adjusting the detector input level which is to be maintained constant by the automatic volume control action.

In Fig. 5 there is shown a modification of the circuit arrangement of Fig. 1. In this arrangement the rectifier tube of the power supply system is shown, although the alternating current source is omitted. The rectifier filter F includes in its negative side the speaker field, and the bleeder resistor R_3 is again shown connected across the output of the filter F. The positive side of resistor R_3 is connected in the well known fashion to the various anodes of the tubes. The anode of the magnetron tube M is connected by lead 12 to a suitable point on resistor R_3, while the electron emission element, or cathode, of the magnetron is connected by lead 10 to the screen grid electrode of the controlled amplifier 1. The cathode of the controlled amplifier is connected to ground through the usual grid biasing network 13, and a radio frequency by-pass condenser is connected between the screen grid and cathode of the controlled amplifier.

The intensity of the fixed field winding w_4 is controlled, in this form of a circuit, by connecting the terminals of the winding to resistors R_4 and R_5. The resistor R_4 is arranged in the positive side of the rectifier filter F, and the resistor R_5 is connected in series with resistor R_4 and with the winding w_4. The reference letter A represents a device for uni-controlledly varying inversely the resistances of resistors R_4 and R_5. Adjustment of element A results in an adjustment of the current flow through winding w_4 without changing the filter terminal voltage. Again, as in the case of Fig. 1, the resistance R_1 may be the resistance of winding w_1. The portion of resistor R_3 between ground and the tap point of lead 12 may be omitted, and the upper portion of this resistor may be shorted if found satisfactory. Variation of the control A adjusts the level at which the detector carrier input is maintained.

Fig. 6 graphically shows the relation between screen current flow and detector space current in the circuit shown in Fig. 5. The dotted line curve x shows the relation between the two currents for a large current flow through the field winding w_4; solid line curve y shows the characteristic when a medium current flows through this field winding; and dotted line curve z shows the same characteristic for a small current flow through the field winding w_4, the fields being assumed to be additive in each case.

It is not necessary to the present invention to regulate amplification of the radio frequency amplifiers by varying the screen grid voltage. For example, and as shown in Figs. 7 and 8, the signal control grid voltage can be adjusted in response to variations in the detector space current flow. In Fig. 7 the controlled amplifier 1 has its signal grid 20 connected to the electron emitter of magnetron M by the AVC lead 21; the usual ripple suppression resistor 22 and condenser 23 are included in the AVC connection. Resistor R_6 is connected between the emitter of magnetron M and the ungrounded side of reactor 24, and the latter may function as the speaker field.

The detector space current flows through magnetron field winding w_1; the adjustment device A—R_4—R_5 again is used to determine the level of the detector signal input which is to be maintained. The current flow through winding w_4 is adjusted to permit flow of current through resistor R_6 in the presence of weak signals. This results in placing the signal grids of the controlled amplifiers at substantially ground potential when received signals are weak. As the intensity of the detector space current increases the field of winding w_1 adds to that of the field of winding w_4, and stops the current flow through resistor R_6. This, of course, results in the impression of a large negative bias on the signal grids since their potential becomes the same as that of the ungrounded end of choke 24, and the amplification of the controlled amplifiers is thereby reduced. The action of the magnetron tube is such that a slight increase in detector space current causes a very large increase in gain control bias on the signal control grids of the controlled amplifiers.

An alternative circuit arrangement is shown in Fig. 8; in this case resistor R_6 is connected between the cold electrode of magnetron M and ground, and the condenser 23 is connected across resistor R_6. The AVC lead 21 is connected between the signal grid of the controlled amplifier and the cold electrode side of resistor R_6. The magnetron emitter is connected to the ungrounded side of reactor 24. The adjustment device A, maintaining a constant impedance to flow of current through filter F, can be set so as to adjust the current through winding w_4 to cut-off the current through the magnetron M until a desired amount of detector space current flows through winding w_1. The latter is connected so as to reduce the total field on the magnetron. If the detected current exceeds this predetermined value, current flows through the magnetron and resistor R_6.

In this way additional bias is applied to the controlled amplifier grids when signal input to the detector increases. The detector input is held at a substantially fixed value determined by the adjustment of device A. In brief, then, in Fig. 8 the magnetron current is cut off for weak signals, thus fixing the controlled amplifier grids at ground potential; the fields of windings w_1 and w_4 "buck" each other whereby when the detector current exceeds a predetermined value, magnetron current flows and causes the signal

grids to become negative with respect to their cathodes.

While I have indicated and described several systems for carrying my invention into effect, it will be apparent to one skilled in the art that my invention is by no means limited to the particular organizations shown and described, but that many modifications may be made without departing from the scope, as set forth in the appended claim.

What I claim is:—

A radio receiver having a controlled signal transmission tube and a detector, a common direct current voltage supply source, including a bleeder resistor, for the transmission tube and detector, a magnetron gain control tube, a direct current connection from the anode of said magnetron tube to a point of proper positive potential on said bleeder resistor, a field winding for said magnetron tube disposed in the space current path of said detector, a second field winding for said magnetron tube, a pair of resistors connected in series with said second field winding, one of said resistors being disposed in series with said bleeder resistor, a gain control connection between a gain control electrode of said transmission tube and said magnetron tube, and means for simultaneously varying the magnitudes of said two series resistors in inverse relation whereby the direct current flow through the second field winding may be adjusted without any substantial effect on the voltage across said bleeder resistor.

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