

A. R. APPLGARTH, JR
AUTOMATIC GAIN CONTROL SYSTEM

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The diagram illustrates the signal flow in a television receiver. The signal path is as follows:

- ANTENNA**: Receives the broadcast signal.
- FIRST DETECTOR**: The first stage of signal processing.
- I.F. AMPLIFIER**: Intermediate Frequency Amplifier, which amplifies the signal.
- SECOND DETECTOR**: The second stage of signal processing.
- VIDEO AMPLIFIER**: Amplifies the video signal.
- VIDEO OUTPUT**: The amplified video signal is sent to the television set.
- DEFLECTING CIRCUIT**: Controls the deflection of the electron beam in the television set.

The diagram also shows various components and their connections, including resistors (10, 12, 13, 14, 15, 16, 17, 18, 19), capacitors (11, 12, 13, 14, 15, 16, 17, 18, 19), and a power supply (11).

Inventor,-
Alexander R. Applegarth Jr.
by his Attorneys
Houson & Houson

May 6, 1941.

A. R. APPLGARTH, JR

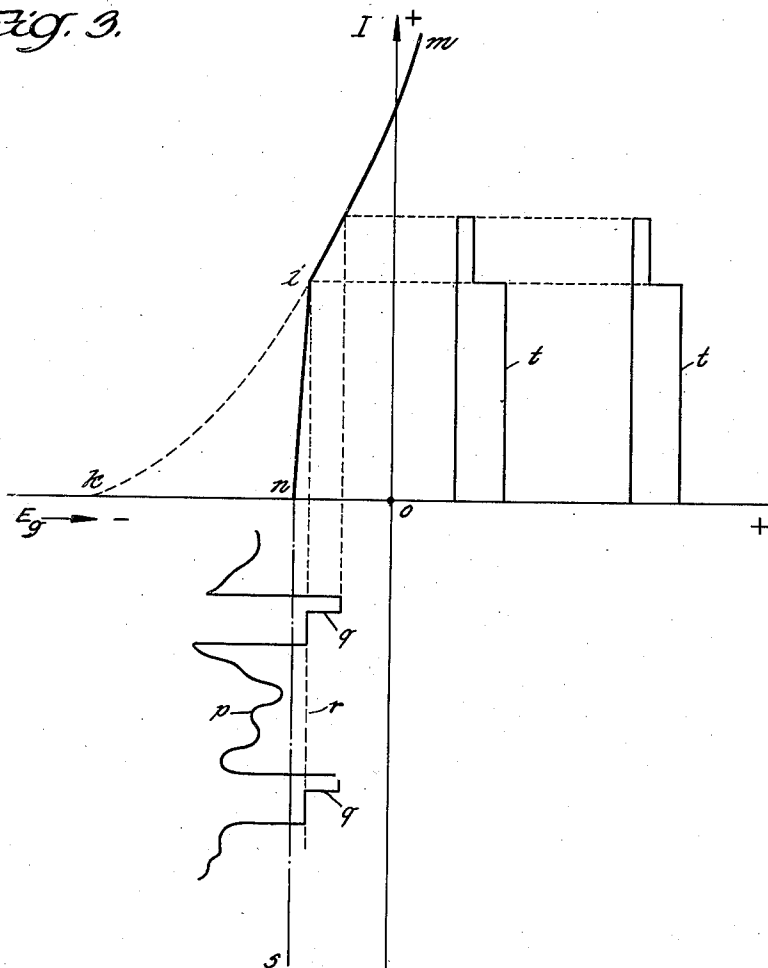
2,240,601

AUTOMATIC GAIN CONTROL SYSTEM.

Filed May 24, 1939

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Fig. 3.



Inventor:-
Alexander R. Applegarth Jr.
by his Attorneys
Howson Howson

UNITED STATES PATENT OFFICE

2,240,601

AUTOMATIC GAIN CONTROL SYSTEM

Alexander R. Applegarth, Jr., Philadelphia, Pa.,
assignor, by mesne assignments, to Philco Radio
and Television Corporation, Philadelphia, Pa.,
a corporation of Delaware

Application May 24, 1939, Serial No. 275,525

5 Claims. (Cl. 178—7.3)

This invention relates to a method of and apparatus for automatically controlling the gain of an electrical signaling system. This application is a continuation in part of copending application Serial No. 219,643, filed July 16, 1938. For reasons which will appear presently, the present invention is particularly adapted for use in a television receiver, though it is by no means restricted to this use and presents advantages which are desirable in automatic gain control systems in general.

One object of the invention is to provide an improved system for obtaining delayed automatic gain control in an electrical signaling system.

Another object of the invention is to provide an automatic gain control system in which an exceptionally large change in control voltage is obtained for a given change in signal amplitude, whereby a very flat control characteristic results.

A further object of the invention is to provide a novel automatic gain control system which functions to maintain constant the peak value rather than the average value of a modulated carrier signal.

A still further object is to provide, in a television system of the type employing a signal comprising video and synchronizing components established on opposite sides of a predetermined blanking level, an automatic gain control system which tends to maintain the blanking level and the amplitudes of the synchronizing pulses constant, and which yields an unusually large variation in control voltage for a given change in signal strength.

In order to understand fully the operation of a system in accordance with the invention, reference may be had to the following description and the accompanying drawings in which:

Fig. 1 shows a specific embodiment of the invention applied to a television receiver; and

Figs. 2 and 3 are diagrams which explain the operation of the system according to the invention.

In Fig. 1, the incoming modulated carrier signal is picked up by the antenna 1 and converted, in a well-known manner, to an intermediate frequency in the first detector 2. The intermediate frequency signal is transferred through an intermediate frequency amplifier 3 to a second detector 4. The resulting demodulated signal contains the video component which is amplified in the video amplifier 5, whence it passes directly to the grid of a picture tube 6. Suitable deflecting signals are produced in the deflecting circuit 7 in response to the synchronizing component in the demodulated signal, which component may be derived from some point in the video amplifier. The deflecting signals may be used to actuate suitable deflecting means, such as the coil 8. The

portion of the system described thus far and shown schematically is of conventional form and requires no further description. The remainder of the system shown in detail and now to be described constitutes the novel gain control means provided in accordance with the invention.

The signal from which the control is developed may be derived from the last stage of the intermediate frequency amplifier though it will, of course, be understood that this is not a restriction upon the invention. For example, it would also be possible to use the detected signal obtained from the output of the second detector or from some point later in the system, the principal consideration being that the signal utilized should have its D. C. component present, as is the case when it is derived from the intermediate frequency amplifier in the manner shown. If the D. C. component has been removed it may, of course, be restored by the use of leveling means in the manner set forth in my copending application Serial No. 219,643 of which this application is in part a continuation. This signal may be applied to the grid of the tube 9 across a suitable leak resistor 10, the lower end of which may be connected to a source 11 of negative bias voltage. The cathode of the tube is maintained at a slightly less negative voltage by connecting it to the center tap of a voltage divider comprising the resistors 12 and 13. The resistor 13, being in the cathode circuit of the tube 9, is suitably bypassed by the condenser 14. Plate voltage may be supplied to the tube from a suitable source represented by the battery 15 through a large plate load resistor 16, which is by-passed by the condenser 17. The tube is so biased that it becomes conducting only when the synchronizing peaks of the received signal exceed a predetermined amplitude level, and hence it functions as a detector for the signal peaks which exceed this amplitude level. Additional smoothing of the voltage developed across the resistor 16 may be provided by means of the resistor 18 and the condenser 19. The condenser is shunted by a diode 20 connected in the sense shown. The filter comprising the resistor 18 and the condenser 19 is, of course, in the nature of a refinement and may be omitted without essentially modifying the operation of the device. The control voltage derived from the device may be supplied to the intermediate frequency amplifier stages or to some earlier point in the channel by means of the connection 21 and may be applied to control the gain of the said stages according to any of the conventional methods.

A preliminary consideration of the operation of the system will show that no positive voltage can be built up across the condenser 19 by reason of the presence of the diode 20 which acts as a short-circuit to any such voltage. Furthermore,

until a signal is applied to the grid of the tube 9 which is sufficiently large to cause the plate current to increase to a point at which the plate goes negative with respect to ground, there will be no negative voltage developed across the condenser 19. But when the plate of the tube 9 becomes negative the diode 20 ceases to conduct and the condenser 19 will be charged through the resistor 18 until equilibrium has been restored. As the plate potential again drops and the tube 9 becomes less conducting, the condenser 19 will be discharged at a much slower rate than that at which it was charged through the resistors 16 and 18, until another peak of signal occurs which is sufficient to again drive the plate negative.

The unique advantages inherent in the system just described will be better understood by reference to Fig. 2, and for this purpose it will be convenient to disregard the resistor 18 and assume that the diode 20 is connected directly across the plate load resistor 16 and the battery 15. Fig. 2 shows the plate current-plate voltage characteristics for the tube 9 of Fig. 1 functioning as a detector for various peak values of modulated intermediate frequency signal. It should be noted at this point that strictly speaking these curves cannot be used to describe the operation under these circumstances since actually they represent an ordinary plate family; what is really needed is a detection characteristic. However, as a first approximation made for the sake of simplicity, they serve to show qualitatively the operation of the system as shown and would give an accurate picture of the operation in the case where the detected signal is applied to the grid of tube 9. In the absence of the diode shunting the load resistor, and with a smaller resistor in place of 16, the tube might operate on a load line such as that represented by the line *ab* in Fig. 2. From this it may be readily seen that a change in the peak input signal from the value 4 to the value 5 will cause the plate current to increase an amount corresponding to the length of the line *de*. The value of load impedance then being equal to be/de , the slope of the line *ab*, it follows that the change in voltage across the load resistor is equal to the product $de \times be/de = be$ which is designated E_1 .

As is well known in the art, and subject to certain practical limitations, the change in control voltage for a given change in signal applied to the grid may be increased by increasing the load impedance. This appears when we consider the load line *ac* in Fig. 2. For a change in peak input signal from value 4 to value 5 the plate current will change by the amount corresponding to the length of the line *fg*. The slope of the load line being gh/fg it follows that the change in control voltage is measured by *gh* which is designated E_2 and is somewhat greater than E_1 .

By the method of the invention, the use of the diode in the manner described has the effect of modifying the load line to the heavy line *bfa*, giving a sudden change in plate current corresponding to *bf* between the grid voltage values 4 and 5. The slope of the portion *af* of the load line being bc/bf it will be seen that the change in control voltage is represented by the length of the line *bc* which is designated by E_3 . This change in the control voltage will immediately be seen to be much larger than can possibly be obtained by simply changing the magnitude of the plate load resistor alone. Furthermore, the

change in control voltage, which it is possible to effect for a given change in the magnitude of the grid signal by applying the method of the invention, is limited only by practical considerations in the choice of the plate load resistor.

Of course, it is now apparent that the greater the change in control voltage developed across the resistor 16 for a given change in grid signal in the device of Fig. 1, the more rapid will be the charging of the condenser 19, and hence the more quickly the gain of the intermediate frequency amplifier will be changed to compensate for variations in received signal strength. However, it will be desirable to refer to the diagram of Fig. 3 to explain more clearly the operation of the device of Fig. 1 when a standard television signal is impressed on the grid of the tube 9. This figure shows a conventional plot of plate current versus grid voltage for a single value of plate voltage, the characteristic being represented by the dotted and solid line *kim*. This is modified in the device of the invention, by the introduction of the diode, to correspond to the heavy line *kim*. Thus, for all values of grid signal not exceeding the value *n*, no plate current will be drawn. When the signal exceeds this value, plate current increases very rapidly along the line *ni* to the point *i* where it again follows the tube characteristic. If a television signal whose envelope is represented by *p* be applied to the grid of the tube, the synchronizing peaks *q* and small portions of the signal below the blanking level *r* will tend to exceed the level designated *n-s* corresponding to cut-off in the tube. When this condition obtains, the impulses of plate current which are produced will be of the form shown at *t*. The magnitude of the control signal as compared with the magnitude of the input signal will be immediately apparent.

It will be well, at this point, to mention the delay in the operation of the system which obtains by the use of the diode in the output of the automatic gain control tube. Since no control voltage is developed across the diode until the plate of the gain control tube goes negative, the point at which the control begins to operate may be definitely fixed by suitably biasing the diode, or by varying the other voltages and circuit elements. In Fig. 1 the cathode of the diode is grounded, but it will be clear that a battery or other convenient voltage source may be inserted to maintain the diode cathode at any desired potential whereby the threshold of control is fixed. The exceptionally large change in control voltage which obtains when the threshold is reached may be regarded as a result of achieving the delay according to the method of the invention. By the cooperation of these two features of delay and exceptionally large control, it is possible to obtain what is referred to in the art as a very flat gain control.

A further important detail relating to the mode of operation of the system will also be apparent from the diagram of Fig. 3. The amount of control is dependent upon the areas of the plate current pulses which are designated *t* and by far the greater part of this area corresponds to the portion of the input signal below the blanking level *r* as compared with that which corresponds to the synchronizing component of the input signal. The portion of the signal below the blanking level used to form the control signal must necessarily be kept small in order that the background component be not removed from the

video signal. This is fully explained in applicant's above-mentioned copending application. In order to make the best possible use of this small portion below the blanking level, it is desirable that the average amounts by which the blanking level r exceeds the cut-off level ns should correspond to the change in grid voltage along the characteristic corresponding to the steep portion of the characteristic ni in Fig. 3. This permits of the greatest degree of control with the utilization of a minimum of the blanking signal below the level, the resultant inclusion of the least possible amount of video component, and hence the least tendency to destroy the D. C. or average brightness component contained in the video signal. The amount of signal utilized is dependent fundamentally upon the size of the plate load resistor 16 of Fig. 1 and the bias, if any, applied to the diode 20. This will be clear by reference to Fig. 3 where it will be seen that the desired operation obtains when the average value of the blanking level corresponds to a value of grid voltage on the part of the characteristic designated $n-i$ or slightly greater (i. e. less negative) but preferably not less.

It will be understood that the present disclosure is illustrative only and is not intended to impose any limitation upon the invention, the scope of which is defined by the appended claims.

I claim:

1. In a television system of the type employing a composite signal having video and synchronizing components established on opposite sides of a predetermined blanking level, a signal channel, means for deriving a signal from said channel, a gain control tube operable by said derived signal, means for causing the effective plate current of said tube to decrease rapidly and abruptly from a substantial value to cut-off, means for adjusting the operation of said tube in predetermined relation to its cut-off point such that the blanking level normally exceeds the cut-off point of said tube but not sufficiently to permit the tube output to include an appreciable portion of the video component, whereby the tube output is substantially independent of variations in the video component, and means for applying the output signal from said tube to said channel to control the gain thereof.

2. In a television system of the type employing a composite signal having video and synchronizing components established on opposite sides of a predetermined blanking level, a signal channel, means for deriving a signal from said channel, a gain control tube operable by said derived signal, means for causing the effective plate current of said tube to decrease rapidly and abruptly from a substantial value to cut-off, means for adjusting the operation of said tube in predetermined relation to its cut-off point such that the average value of the blanking level exceeds the cut-off point of said tube but not sufficiently to permit the tube output to include an appreciable portion of the video component, whereby the tube output is substantially independent of variations in the video component, and means for applying the output signal from said tube to said channel to control the gain thereof.

3. In a television system of the type employing a composite signal having video and synchronizing components established on opposite sides of a predetermined blanking level, said synchroniz-

ing component comprising time-spaced pulse signals occurring during intervals of duration greater than said pulse signals and in which said video signal component is established at said blanking level, a signal channel, means for deriving a signal from said channel, a gain control tube operable by said derived signal, means for causing the effective plate current of said tube to decrease rapidly and abruptly from a substantial value to cut-off, means for adjusting the operation of said tube in predetermined relation to its cut-off point such that the blanking level normally exceeds the cut-off point of said tube but not sufficiently to permit the tube output to include an appreciable portion of the video component, whereby the tube output is substantially independent of variations in the video component, and means for applying the output signal from said tube to said channel to control the gain thereof.

4. In a television system of the type employing a composite signal having video and synchronizing components established on opposite sides of a predetermined blanking level, a signal channel, means for deriving a signal from said channel, a gain control tube having at least an anode, a cathode and a control grid, means for supplying said derived signal to the control grid of said tube, a load impedance for said tube characterized in that it decreases suddenly in magnitude when the plate current in the tube falls below a predetermined value, thereby causing the plate current to decrease rapidly for a small change in grid voltage within a certain range, means for so operating said tube that the average value of the blanking level of the applied composite signal exceeds the grid voltage corresponding to cut-off of the tube but not sufficiently to permit the tube output to include an appreciable portion of the video component, whereby the tube output is substantially independent of variations in the video component, and means for applying the output signal from said tube to said channel to control the gain thereof.

5. In a television system employing a composite signal having video and synchronizing components established on opposite sides of a predetermined blanking level, a signal channel, means for deriving a signal from said channel, a gain control tube having at least an anode, a cathode, and a control grid, means for supplying said derived signal to the control grid of said tube, a load impedance for said tube, a connection including a diode between a point on said load impedance and a point of predetermined potential, for effectively causing said load impedance to decrease suddenly in magnitude when the plate current in the tube falls below a predetermined value, thereby causing the plate current to decrease rapidly for a small change in grid voltage within a certain range, means for so operating said tube that the average value of the blanking level of the applied composite signal exceeds the grid voltage corresponding to cut-off of the tube, but not sufficiently to permit the tube output to include an appreciable portion of the video component, whereby the tube output is substantially independent of variations in the video component, and means for applying the output signal from said tube to said channel to control the gain thereof.

ALEXANDER R. APPLGARTH, JR.