

April 13, 1937.

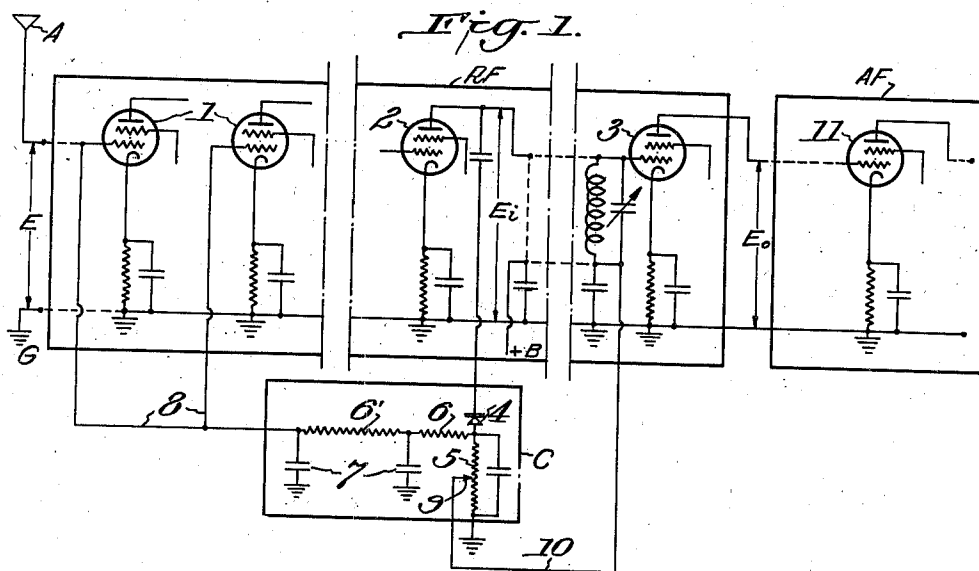
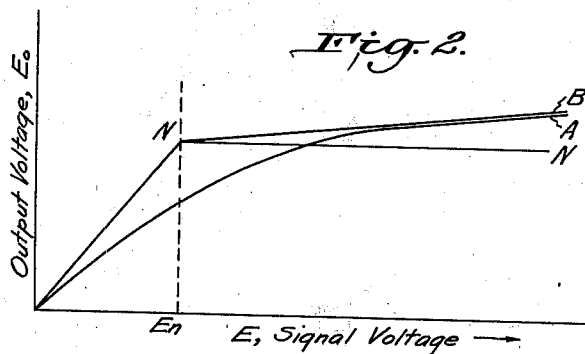
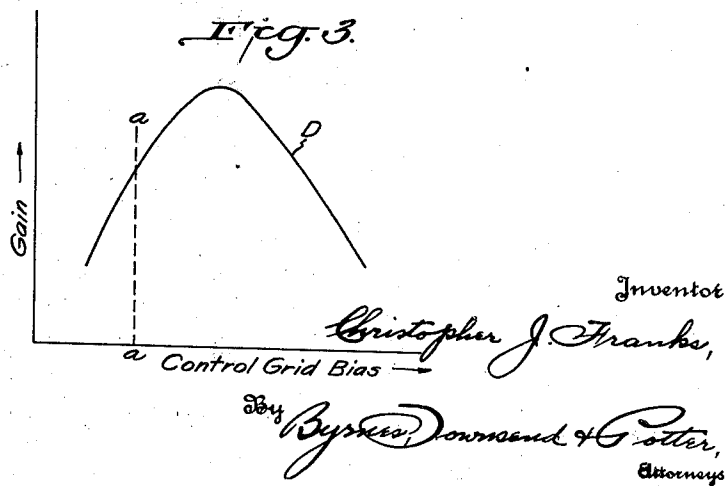
C. J. FRANKS

2,076,814

AUTOMATIC GAIN CONTROL

Filed July 11, 1933

2 Sheets-Sheet 1



April 13, 1937.

C. J. FRANKS

2,076,814

AUTOMATIC GAIN CONTROL

Filed July 11, 1933

2 Sheets-Sheet 2

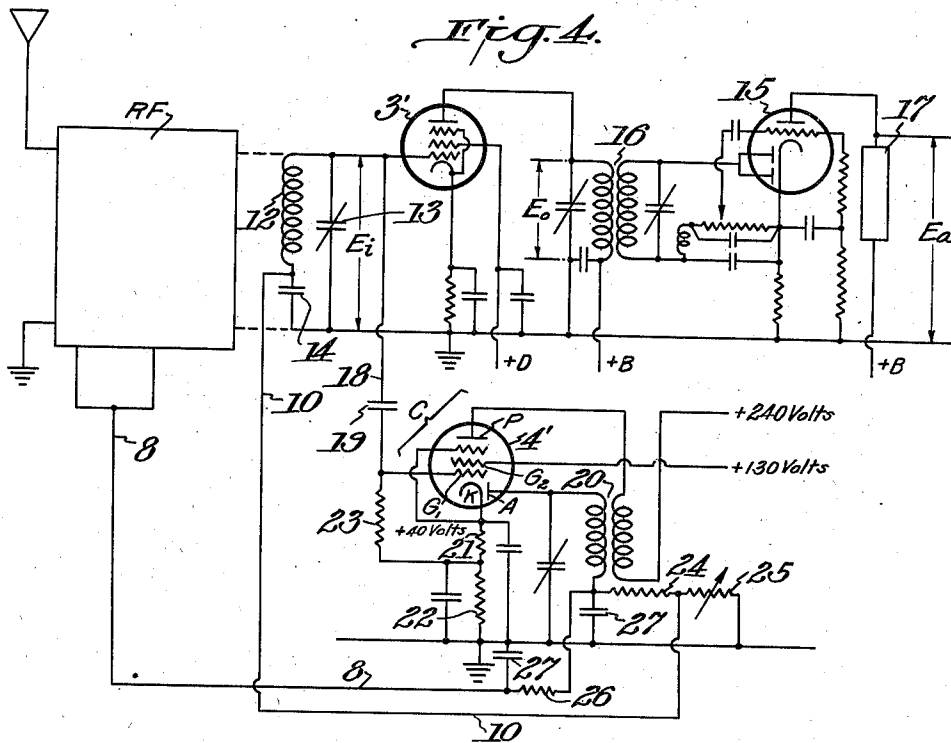
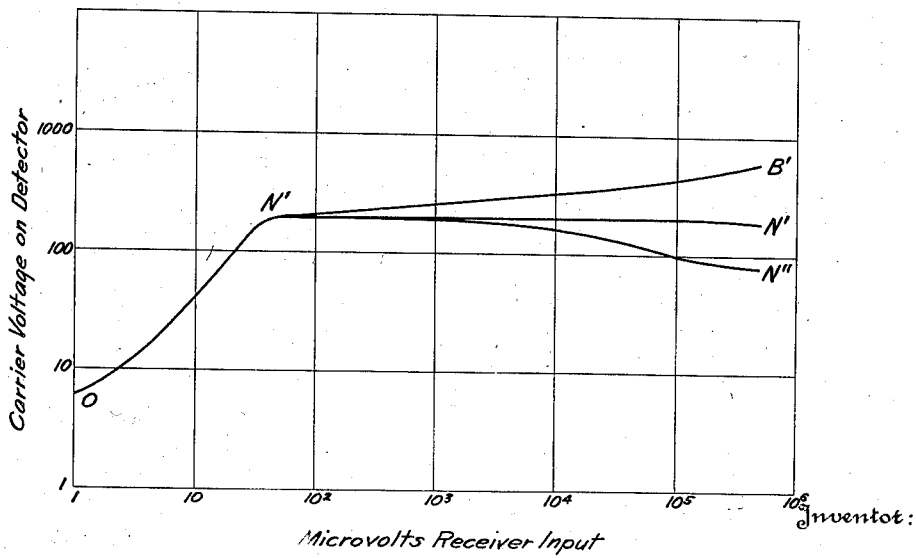


Fig. 5. Christopher J. Franks,

By Potter, Pierce & Schaffer,
Attorneys.

UNITED STATES PATENT OFFICE

2,076,814

AUTOMATIC GAIN CONTROL

Christopher J. Franks, Boonton, N. J., assignor,
by mesne assignments, to Radio Corporation of
America, New York, N. Y., a corporation of
Delaware

Application July 11, 1933, Serial No. 679,947

2 Claims. (Cl. 250—20)

This invention relates to automatic gain control circuits of the type in which the carrier voltage is rectified to obtain a direct current potential for varying the gain of an amplifier.

The automatic volume control systems customarily employed to control the gain of a radio amplifier place the rectifier of the control system after the amplifier, and the rectified potential is fed back to the amplifier. Such systems necessarily result in a substantial variation in the output level since the control depends upon a variation in the magnitude of the amplifier output voltage which is impressed upon the rectifier and upon the detector.

An object of the present invention is to provide an automatic gain control which is capable of giving a constant output level for all radio input voltages above the critical value which, at maximum gain, will give the desired output level.

An object is to provide methods of and circuit arrangements for automatic gain control which are characterized by a control of the gain of a portion of the radio amplifier which succeeds that point in a multistage radio amplifier at which an amplified radio voltage is passed to the gain control system. More specifically, an object is to provide a multi-stage amplifier in which the radio voltage at an intermediate point in the amplifier is rectified to obtain a gain control voltage, and the gain control voltage is impressed upon one or more stages preceding and subsequent to the intermediate or control point. A further object of the invention is to provide a radio receiver of the automatic gain control type, and in which the gain control unit includes a radio amplifier for impressing upon the control elements a radio voltage of greater magnitude and, if desired, more sharply restricted to the frequency of the desired carrier wave signal than is the radio output of the amplifier stage which works into the control unit and into the detector.

These and other objects and advantages of the invention will be apparent from the following specification when taken with the accompanying drawings in which:

Fig. 1 is a somewhat diagrammatic view of a circuit embodying the invention;

Fig. 2 is a curve sheet showing the general relationship between receiver input and audio output level with known systems and with a control system embodying the invention;

Fig. 3 is a curve showing the relation between the grid bias and the gain of one of the controlled tubes;

Fig. 4 is a fragmentary circuit diagram of a receiver embodying the invention; and

Fig. 5 is a family of receiver input-detector input curves plotted from data obtained for a plurality of adjustments of the resistance which controlled that fraction of the available gain control voltage that passed to the amplifier stage succeeding the gain control system.

In the drawings, the reference characters AG identify a collector structure of any desired form for receiving carrier wave signals and transferring the same to amplifier RF that includes a plurality of cascaded amplifier tubes 1, 2, and 3. The coupling circuits between successive tubes may be of any desired construction, and the amplification may be at the received carrier frequency and/or at an intermediate frequency.

According to the invention, the automatic gain control voltage obtained by rectification of the amplified radio voltage E_1 developed in a circuit of the intermediate tube 2 is applied not only to one or more of the preceding tubes 1, as is the known practice, but also to one or more of the succeeding tubes 3 of the multi-stage amplifier.

As shown in Fig. 1, the radio voltage E_1 at the output circuit of the tube 2 is impressed upon the succeeding amplifier tube and also upon a rectifier 4 of the automatic gain control system which is indicated generically at C. The direct current potential developed across the output resistance 5 of the rectifier is passed, through the filter network formed by resistances 6, 6' and condensers 7, to the leads 8 that run to the control grids of the amplifier tubes 1.

Any desired portion of the control voltage is transferred, by adjustable tap 9 and lead 10, to the control grid of one or more of the amplifier tubes 3 which follow the tube 2. The last tube 3 may serve only as an amplifier or it may be both a radio amplifier and detector, for example, a plate circuit detector. When the tube 3 functions only as an amplifier, the first tube 11 of the audio frequency system AF acts as the detector.

The operation and advantages of the invention will be apparent from the generalized curves of Fig. 2. With automatic bias applied to tubes 1, and not to the tube or tubes 3, the relation between the output level, or voltage E_o , and the signal voltage E , will be substantially as indicated by curve OA. As the carrier wave voltage increases, the radio voltage E_1 at tube 2 increases, thereby increasing the bias on the control grids of tubes 1 and decreasing the gain of the amplifier. At that normal signal strength E_n which,

with maximum gain would give the desired output voltage, the gain has been substantially reduced by the automatic volume control. A better control, such as shown by the line ONB, may be obtained by the known systems for delaying the operation of the automatic gain control until the carrier voltage rises to the normal value E_n , but even with such systems, the branch NB of the control curve must rise with increasing signal strength since an increased radio voltage E_i must obtain at the output of the last controlled tube 1 to produce that increase in rectified radio voltage which is required to reduce the gain as the signal strength increases.

By applying the gain control voltage to a tube 3 which follows the intermediate point, tube 2, at which the control system is connected across the amplifier, the variation in the amplified radio voltage E_i may be offset by corresponding variations in the gain of the tubes 3, thus giving a branch NN of the control curve which may be substantially flat over an extended range of signal voltages.

To prevent the reduction in gain for signals below the normal value E_n , the initial bias on the tube or tubes 3 may be such that the gain increases as the automatic gain control first comes into action with increasing signal strength, and then decreases. As shown in Fig. 3, the gain-control grid bias curve D changes curvature within the operating range of bias voltages and the initial bias aa may be so chosen that, as the gain control component of the bias voltage increases, the gain of the portion of the controlled amplifier succeeding the control unit C increases to counteract the decreased gain of the tubes 1, thus giving a net gain-curve for signals below E_n that approximates the branch ON, and then decreases to effect the reduction in gain that cannot be produced by applying the control to tubes preceding the control unit C.

It will be apparent, however, that the invention is generally applicable to known types of gain control systems to modify the relation between the output level and the signal input in any desired manner. The compensation for the variation of the voltage E_i may be either greater or less than that necessary to maintain a constant amplifier output E_o . The control of the gain of stages succeeding the control point may also be applied to systems which include some provision for delaying the action of the gain control until the received signals exceed the normal input voltage E_n .

As shown in Fig. 4, the radio amplifier RF, which may include one or more controlled amplifier tubes and, if desired, one or more amplifier tubes on which the gain is not controlled automatically, is coupled in any appropriate manner to the input circuit of the radio amplifier tube 3'. The input circuit is shown as an inductance 12 which is tuned by a condenser 13, the blocking condenser 14 being connected between the lower terminal of the inductance and ground to permit the application of a gain control bias through the lead 10. The tube 3' works into a combined diode detector and audio amplifier tube 15 which may be of the known Type 55, and the interstage coupling may be a transformer 16 having tuned primary and secondary windings. The details of the circuits of tube 15 do not constitute an essential part of the invention and therefore a description of the same is not believed to be necessary, it being sufficient to note that an audio frequency voltage E_a is developed

across the tube output impedance 17 for application to a succeeding amplifier stage or reproducer.

The amplified radio voltage E_i which is impressed upon the amplifier tube 3' is also impressed upon the control system C through the lead 18 and condenser 19. The tube 4' of the gain control system is not a simple rectifier but comprises a combined pentode amplifier and diode rectifier. The input radio voltage is impressed between control grid G_1 and the cathode K to produce an amplified radio voltage in the plate circuit, and the amplified voltage is impressed on the anode A through the tuned transformer 20. The cathode circuit of tube 4' preferably includes bias resistors 21, 22 for establishing a delay bias on the rectifier A—K, the control grid being returned through the leak resistance 23 to the junction of the resistor to place an appropriate bias for amplification on the control grid.

The anode output circuit includes a fixed resistor 24 and an adjustable resistance 25 between the lower terminal of the transformer secondary and the terminal of resistance 22 which is remote from the cathode. With this arrangement, the delay bias on the rectifier is equal to the potential drop established across series resistances 21, 22 by space current flow in tube 4' and, as indicated by the legend "+40 volts", the anode A may be so biased that no rectification takes place until the peak input voltage on the rectifier exceeds 40 volts.

The lead 8 which extends to the controlled tubes of the radio amplifier RF is connected to the anode terminal of resistor 24 through a filter comprising resistance 26 and condensers 27, and the total direct current voltage developed by the control unit C is therefore impressed on one or more of the amplifier tubes preceding the tube 3'. Only that fraction of the available direct current voltage which is developed across the resistance 25 is applied through lead 10 to the tube 3' as a gain control bias.

The close approximation to the flat gain control curve NN of Fig. 2 which may be obtained by an appropriate choice of the values of resistances 24 and 25 is shown by the curve O'N'N' of Fig. 5. The data from which this curve was plotted was obtained when resistor 24 was 500,000 ohms and resistance 25 had a value of 130,000 ohms. The control bias applied to tube 3' was therefore approximately one-fifth of the available voltage that was impressed on the controlled tubes of amplifier RF. Curve O'N'B' was plotted from readings made when resistance 25 was zero, i. e., when the Fig. 4 circuit was so adjusted that the automatic gain control functions in the same manner as the known gain control systems. On the arbitrary scale of values of carrier voltage on the detector, the desired detector input level had a value of approximately 200 and it will be noted that the curve O'N'B' rose to approximately 600 for a receiver input of $\frac{1}{2}$ volt. As this 3 to 1 rise of detector input amounts to a 9 to 1 rise in the power output at the reproducer, it is apparent that the expected variation in receiver input produces substantial changes in the output level when the invention is not employed. Even greater variations in the output level may obtain when the known control systems are not carefully designed to obtain the best possible gain characteristic.

Curve O'N'N'' represents the observed relation between receiver input and detector input

when the resistance 25 was set at a value of 260,000 ohms, i. e., about one-third of the available voltage was impressed on the control grid of tube 3'. This curve shows the possibility of obtaining a falling output level with increase in receiver input but, in general, the substantially flat characteristic O'N'N' is to be preferred. The particular fraction of the control voltage which should be applied to a succeeding tube or tubes 3' will depend upon the type and number of controlled tubes in the amplifier and, for any given receiver design, it is not necessary that the resistance 25 be adjustable since its value is not to be varied as an operating adjustment of the receiver.

The problem of receiver design, and particularly in the case of high fidelity receivers, is materially simplified by the invention as the audio system is not subjected to relatively wide variations in input voltage when resistances 24, 25 are so chosen as to produce a substantially flat gain characteristic. The audio amplification may be set at a definite value to obtain the desired output level with the assurance that there will be no danger of overloading the audio system, and thereby introducing distortion, since the top N'N' of the control curve closely approximates a horizontal line for an extended range of input voltages.

The advantage of introducing an independent amplification of the radio voltage E_i for application to the rectifier is that a sharp control of the gain characteristic may be obtained when the voltage E_i is comparatively low, as is the case when the audio system is designed for high gain. When this amplification system includes a circuit tuned to the frequency of the desired carrier wave, such as the tuned transformer 20, there is the further advantage that the gain control system has a sharper characteristic of developed voltage versus frequency off tune than does the cascaded amplifier system of the receiver.

The detailed construction and design of the several elements of the radio amplifier and of the control system may be varied at will without departure from the spirit of my invention as set forth in the following claims.

This application is a continuation-in-part of

my copending application Ser. No. 600,750, filed March 23, 1932, for improvements in Automatic gain control.

I claim:

1. In a transmission system, the combination with a plurality of tubes and a circuit network connecting said tubes in cascade for amplification of radio frequencies, means initially biasing said tubes to establish the gain thereof in the absence of received signals, and a rectifier having an input circuit effectively connected across points of said network subjected to a radio voltage developed intermediate the input and output terminals of said amplifier, of means for impressing upon a tube preceding and a tube succeeding said intermediate points of said network direct current bias potentials proportional to the direct current potential developed by said rectifier, wherein the initial bias on the tube succeeding said network points is less than the value corresponding to maximum amplification, whereby the gain of said tube increases and thereafter decreases as the magnitude of the direct current bias potential impressed on said tube increases towards its maximum value.

2. In an electrical wave transmission system, the combination with a plurality of tubes and a circuit network connecting said tubes in cascade for transmission of said waves, means initially biasing said tubes to establish the gain thereof in the absence of waves, a rectifier having an input circuit effectively connected across points of said network subjected to a wave voltage developed intermediate the input and output terminals of said system, means for impressing upon a tube preceding and a tube succeeding said intermediate points of said network direct current bias potentials proportionally to the direct current potential developed by said rectifier, the initial bias on said succeeding tube being less than a value corresponding to maximum gain whereby the gain of said succeeding tube increases and thereafter decreases as the magnitude of the direct current bias potential impressed thereon increases towards its maximum value.

CHRISTOPHER J. FRANKS.