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GAIN CONTROL SYSTEM

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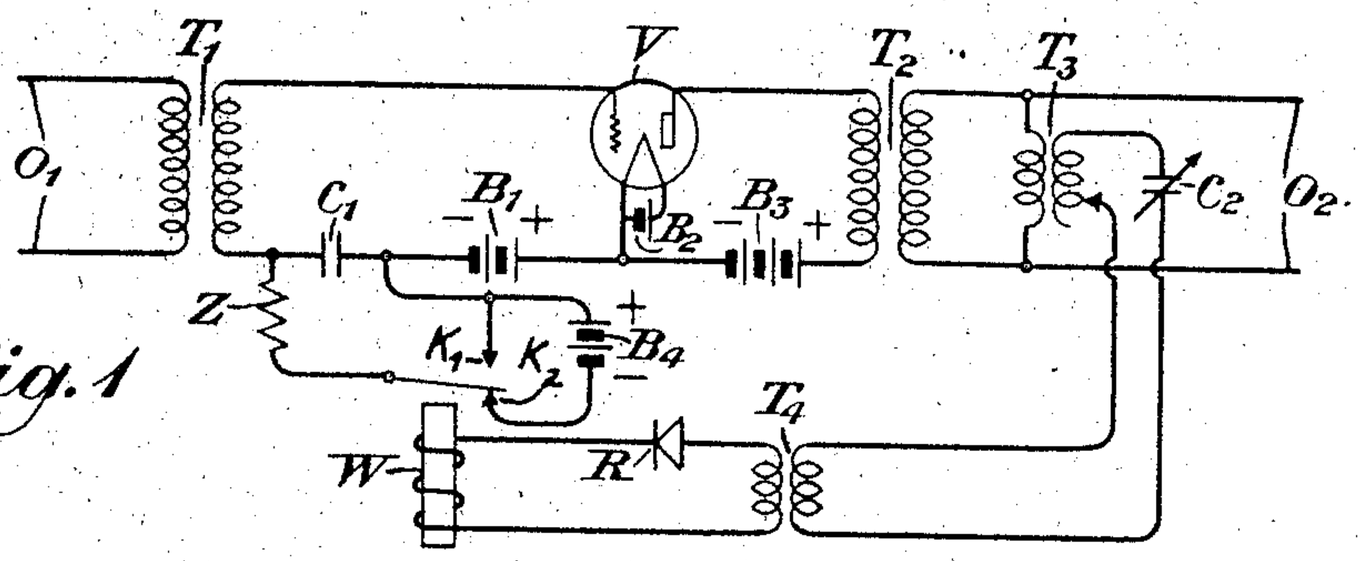

Fig. 1

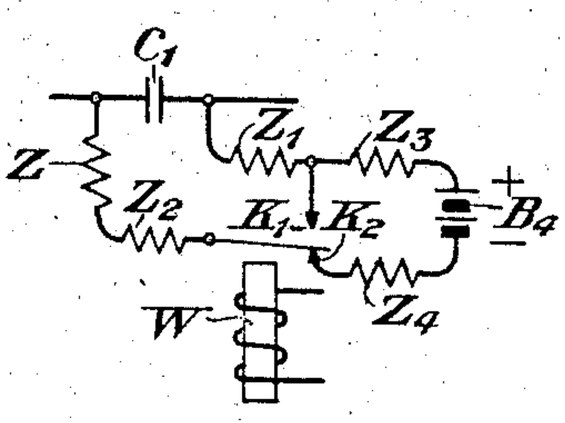

Fig. 2

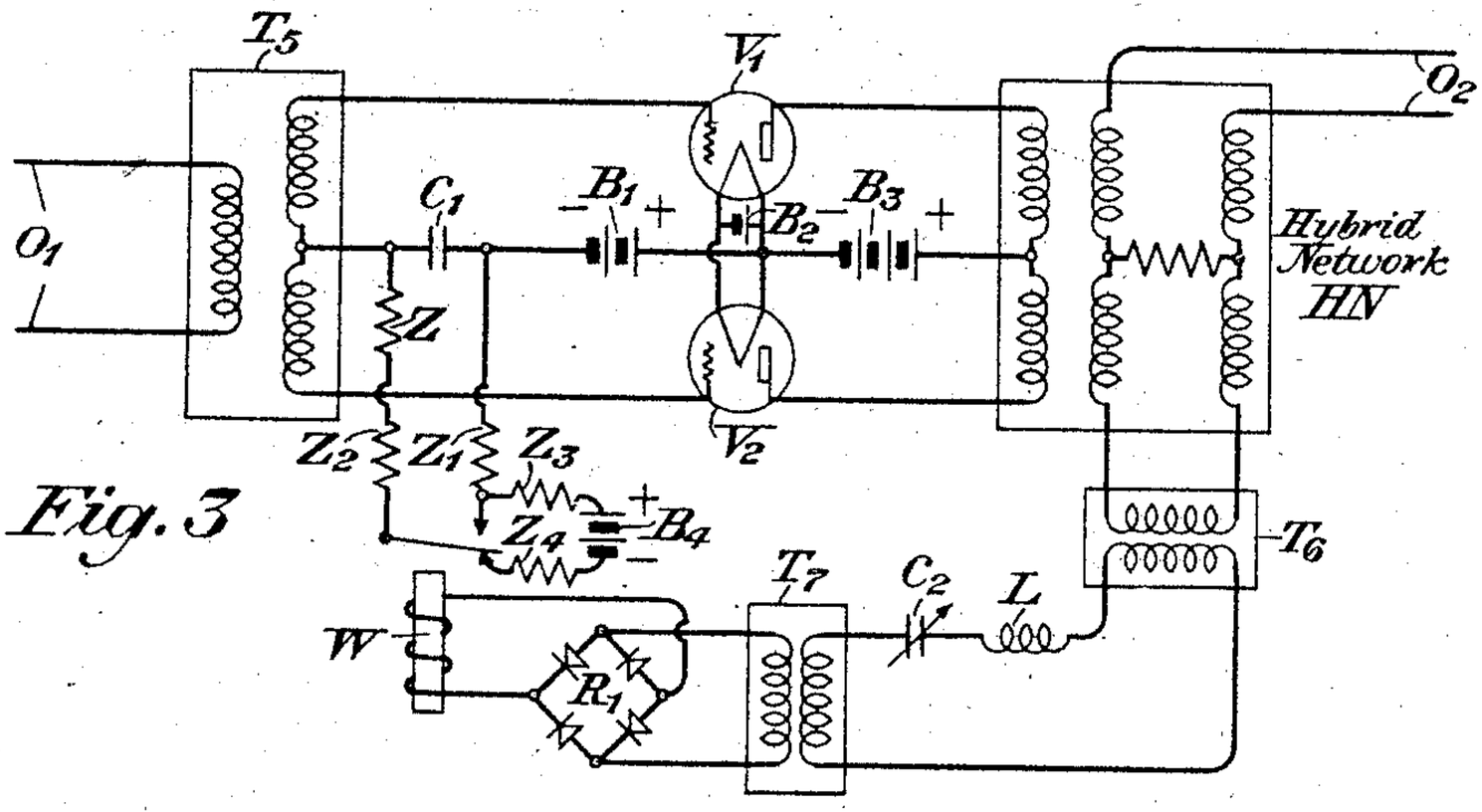

Fig. 3

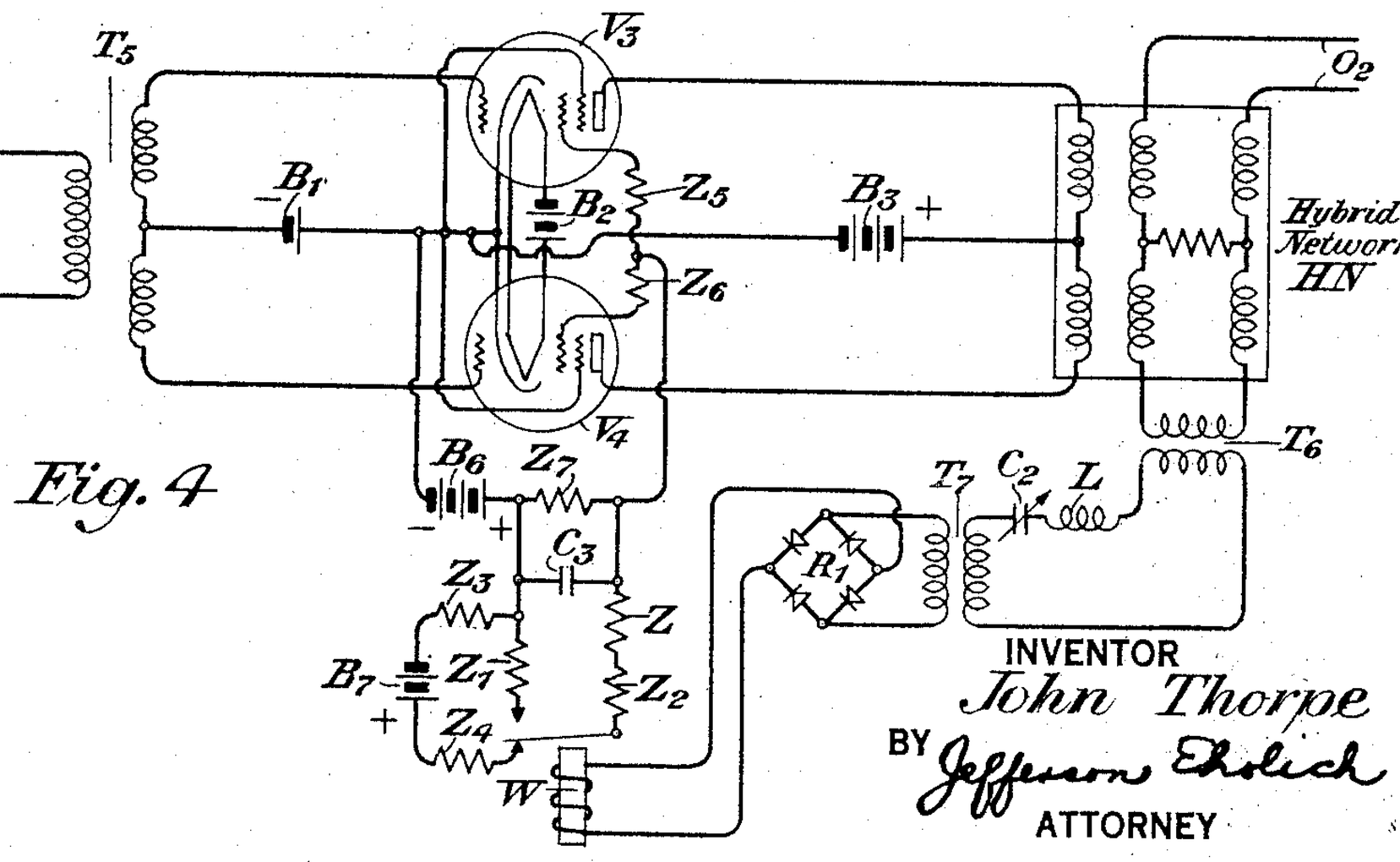

Fig. 4

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GAIN CONTROL SYSTEM

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5 Claims. (Cl. 178—44)

This invention relates to signaling systems and particularly to apparatus to adjust the gain of such systems. More particularly, this invention relates to arrangements for adjusting the gain of a repeater in a signaling system to compensate for variations in the transmission equivalent of the circuit transmitting signals under varying conditions of temperature, weather, etc.

In carrier signaling systems amplifiers are often located at various points along the circuit transmitting signals for increasing the level of the transmitted energy to overcome the attenuation in the circuit. In order to maintain a substantially constant level, a pilot current is sometimes transmitted over the same or a separate circuit, the amplitude of the pilot current changing in accordance with the changes in the transmission equivalent of the circuit. This pilot current is caused to actuate apparatus connected or coupled to the amplifier to change the gain of the amplifier in accordance with the varying amplitude of the pilot current. That is, as the pilot current decreases in amplitude due to increased attenuation in the circuit, the gain adjusting apparatus will be operated to increase the gain of the amplifier while, on the other hand, if the amplitude of the pilot current increases, the gain adjusting apparatus will be so operated as to reduce the amplifier gain.

According to the present invention a different form of gain regulating arrangement is provided by which the gain of the associated amplifier is periodically increased and decreased as long as the gain of the amplifier remains within certain predetermined limits. If the gain of the amplifier is such that it is controlled by the negative bias on the grid of the associated tube, the invention is intended to provide an additional bias which will be inserted into the biasing circuit and removed therefrom at more or less regular intervals.

This invention will be better understood from the detailed description hereinafter following, when read in connection with the accompanying drawing in which Figure 1 illustrates one embodiment of the invention in which the negative bias of the grid of the associated amplifier tube is periodically changed, Fig. 2 is a modification of the arrangement of Fig. 1 designed to prevent clicks in the circuit carrying the signals as the grid biasing voltage is periodically changed by a finite amount, Fig. 3 shows the invention applied to a pair of vacuum tubes of the three-electrode type and Fig. 4 shows the invention applied to a push-pull arrangement of pentode vacuum tubes of the variable mu type.

Referring to Fig. 1 of the drawing, the reference character O_1 designates an input circuit which supplies modulated carrier currents which are to be transmitted to an output circuit O_2. These carrier currents are transmitted through a transformer T_1, the secondary of which is connected to the grid and filament of an amplifier tube V. The usual grid biasing battery is designated B_1 and a condenser C_1 is connected in series with the battery B_1 in the grid circuit of the tube V. The amplified currents flowing in the plate circuit of the tube V are transmitted through a transformer T_2, the secondary of which is connected to the output circuit O_2. The battery B_2 is the filament battery for the tube and the battery B_3 in its plate battery.

Along with the modulated carrier currents traversing the circuit there is a pilot current which may be of a frequency lying outside of the range of frequencies conveying signals between the circuits O_1 and O_2. This pilot current is amplified by the tube V along with the signaling currents and is then picked off the output circuit O_2 through a transformer T_3, the secondary of which is connected to a condenser C_2 and one of the windings of a transformer T_4. The latter circuit is tuned so as to freely pass the pilot current to the exclusion of all other currents. The pilot current is then rectified by a rectifier R, and the rectified current is caused to traverse the windings of a relay W. The armature of the relay W is movable between two contacts K_1 and K_2 between which a battery B_4 is connected. When the contact K_1 is closed by the armature of the relay W, a resistor Z will be bridged around the condenser C_1. When the armature of the relay W closes its other contact K_2, the condenser C_1 will then become charged by the battery B_4, the charging current flowing through the armature of the relay W and the resistor Z. The function of the armature of the relay W is to permit the voltage of the battery B_4 to be impressed upon the condenser C_1 when the relay W is operated, and then to allow the condenser to discharge through the resistor Z when the relay W is released.

It will be observed that when the relay W is released, the only biasing voltage for the grid of the tube V will be that supplied by the battery B_1. This biasing voltage will be such as to maintain the gain of the tube large enough to overcome any ordinary changes in the transmission equivalent of the circuit supplying signals

to the input circuit O_1. As the level of the signals approaches its upper predetermined limit, the pilot current picked off through the transformer T_3 will be transmitted through transformer T_4, rectified by rectifier R and impressed upon the winding of relay W. The rectified current may be sufficient, however, to operate the relay W. When this happens the closure of the contact K_2 will cause the battery B_4 to charge the condenser C_1 through the resistor Z to the voltage of battery B_4 and hence increase the negative bias of the grid of the tube V. The negative bias on the grid of the tube V will then tend to rise to a value which equals the sum of the voltages of the batteries B_1 and B_4. Due to the increasing bias on the grid, the gain of the amplifier will be reduced progressively and as the pilot curent is thus reduced in amplitude, the rectified current traversing the winding of relay W will eventually become insufficient to maintain that relay operated. Hence the contact K_1 will be closed by the armature of the relay. When this happens, the charge on the condenser C_1 will commence to be dissipated through the resistor Z, and would eventually leave the battery B_1 as the only source of negative bias for the grid of the tube V. But as the amplifier gain gradually increases and approaches its upper prescribed limit, the increased current rectified by the rectifier R will again cause the relay W to operate, again causing the condenser C_1 to commence to become charged by battery B_4. This will go on and on as described. Thus the voltage applied to the grid of the tube V will be limited by that of battery B_1 on the one extreme and that of batteries B_1+B_4 on the other, but in practice will be equal to B_1 plus a certain portion of the voltage of B_2 represented by the charge which condenser C_1, is permitted to accumulate through resistance Z by the cyclical operation of relay W actuated by the rectified pilot tone derived from the output of tube V through rectifier R. The operation and release of relay W will continue as long as the level of the transmitted energy reaches or approaches its predetermined limits.

If perchance the pilot current should be greatly reduced in amplitude, as would be the case, for example, when the level of the transmitted energy falls below the lower prescribed limit, then the rectified pilot current will be insufficient to operate the relay W. In that case the contact K_1 will remain closed during that interval and the gain of the tube V will remain stationary at its maximum value. Moreover, if the level of the transmitted energy should at any time rise above the upper prescribed limit, then the rectified pilot current will maintain the relay W operated continuously. In this case the contact K_2 will remain closed during the interval and the voltage of batteries B_1 and B_4 will together cause the amplifier to introduce its minimum gain. But barring these extraordinary changes in the level of the transmitted energy, the relay W will be supplied with current which varies between the values required to operate the relay and then to release it so that the battery B_4 will supply negative voltage through the condenser C_1 to the grid of the tube V at more or less irrregular intervals.

In one arrangement set up according to this invention the amplifier was incorporated as part of a Type C carrier signaling system. The tube V was of the 101–D type, the condenser C_1 of a capacity of 2 microfarads, the resistor Z of a 2 megohm value, the battery B_4 of 22½ volts and the relay W of the KS–6364 type. In practicing the invention the rectifier R may be of any well-known type, i. e., either of the vacuum tube type, or of the copper oxide type, with or without an accompanying amplifier. It was also found that as carrier telegraph signals were transmitted through the tube V, such signals were satisfactorily reproduced, and, moreover, short hits did not interfere with the operation of the circuit to any appreciable extent.

Fig. 2 shows how a portion of the circuit of Fig. 1 may be modified to improve the operation of the arrangement described in connection with Fig. 1. It will be observed that two additional resistors Z_1 and Z_2 have been inserted into the discharge circuit for the condenser C_1. These resistors are relatively small, i. e., of about 1,000 ohms each. Additional resistors Z_3 and Z_4 may also be interposed in the circuit of the leads of battery B_4 as shown, and these resistors may also be of about the same order of magnitude. The addition of such resistors will tend to prevent oscillations which might otherwise result in clicks in the circuits connected or coupled to the output circuit O_2. Such resistors will also tend to prevent excessive erosion at the contacts K_1 and K_2 of relay W. The additional resistors Z_1 to Z_4 are, of course, optional, and are not necessarily required in the operation of the system. They may be especially useful in cases where the voltage of battery B_4 is relatively large.

The transformer T_3 is shown bridged across the output circuit O_2 in an arrangement employing but one stage of amplification. It will be understood that other stages of amplification may be added if desired, and that the pilot current may be obtained at any point along the circuit and fed back in such a way as to change the grid bias of the first tube of the system according to this invention.

Fig. 3 shows a modified circuit arrangement which may be used for the control of greater volumes of the signals. To accomplish this a push-pull or duplex type of circuit is employed.

The tubes of the push-pull or duplex circuit of Fig. 3 are designated V_1 and V_2. The plate circuit of these tubes are connected to the input terminals of a hybrid network HN. One pair of output terminals of the network HN forming the main output circuit O_2 may extend to another repeater point. The other output circuit of the network HN is connected through a transformer T_6, a series tuned circuit of inductance L and capacity C_2 and a transformer T_7 to a full wave rectifier R_1 which rectifies the pilot or carrier current selected by the series tuned circuit. The rectified current then flows through the winding of relay W, the latter relay being operated or released depending on the magnitude of the rectified current. The condenser C_1 is charged upon operation of relay W and discharged upon release of relay W as already described in connection with Figs. 1 and 2. The condenser C_1 and battery B_1 are common to the grid circuits of both tubes V_1 and V_2 and they control the gains of both tubes V_1 and V_2.

As distinct from the circuit of Fig. 1, the Fig. 3 arrangement permits the control or grid circuits of the tubes V_1 and V_2 to adjust the gain of the push-pull amplifier so that the pilot tone which may be accompanied by any other signal is transmitted at the desired level from the output circuit O_2 over a line to a second repeater point. The influence of the tuning and rectifying cir-

cuits just described on the signals and pilot current flowing through circuit O_2 is reduced to a nullity by the hybrid network HN.

Fig. 4 shows the invention applied to a pair of variable mu pentode types of vacuum tubes V_3 and V_4 arranged in push-pull relationship. The control grids of these tubes are connected to their cathodes by means of a common battery B_1 which supplies the same negative potential to both control grids. The anodes of both tubes are connected to their cathodes by a common plate battery B_5. The suppressor grids of both tubes are connected to cathodes of the tubes as is the usual practice. The screen grids of the tubes are connected through corresponding large resistors Z_5 and Z_6 and a resistor Z_7, to the positive terminal of a battery B_6, the negative terminal of which is connected to the cathodes of both tubes. The condenser C_3 is bridged across resistor Z_7. This condenser is charged by battery B_7 or discharged through resistors Z_1, Z_2 and Z_3 according to the operation or release of relay W.

The operation of relay W controls the charge by battery B_7 of condenser C_3 in manner described hereinabove. This condenser establishes a certain average potential across resistor Z_7 which potential is effectively in series with battery B_6. The battery B_6 and condenser C_3 jointly establish the operating potential of the screen grids with respect to the cathodes of tubes V_3 and V_4 and hence control the gain of these tubes at the desired values.

It will be understood that in Fig. 3 pentode types of tubes such as V_3 and V_4 of Fig. 4 may be substituted for tubes V_1 and V_2 in which case their screen potentials may be fixed in the usual manner and their gains controlled by the adjustment of the potential of the control grids.

While this invention has been shown and described in certain particular arrangements merely for the purpose of illustration, it will be understood that the general principles of this invention may be applied to other and widely varied organizations without departing from the spirit of the invention and the scope of the appended claims.

What is claimed is:

1. In a carrier signaling system, the combination of an amplifier, means to continuously control the gain of said amplifier, said means including a rectifier and a relay having its winding connected to said amplifier through said rectifier so that rectified currents will flow through said winding, said relay being responsive to the level of the signals, said relay being operated as the signals reach an upper predetermined limit and released as the signals reach a lower predetermined limit, a condenser which is fully discharged, means for charging said condenser in response to the operation of said relay to change the gain of said amplifier in one direction, and means for fully discharging said condenser in response to the release of said relay to change the gain of said amplifier in the opposite direction.

2. In a gain control system, the combination of a vacuum tube having a source of voltage to control the gain of the tube, a condenser connected in series with said source of voltage, means for charging said condenser so as to increase the effective voltage in the circuit of said source of voltage, means for fully discharging said condenser, means comprising a relay responsive to a rise in the level of the energy transmitted through said vacuum tube to a first predetermined value to operate the charging means, means including said relay and responsive to a recession of the level of the energy transmitted through said vacuum tube below a second predetermined value to operate the discharging means, and a rectifier connecting said vacuum tube to the winding of said relay so that the current traversing said relay winding will be the current of said vacuum tube as modified by said rectifier.

3. A gain control system including a vacuum tube having grid, filament and plate electrodes, a source of voltage for biasing the grid electrode with respect to the filament by a fixed amount, said vacuum tube transmitting current of a fixed frequency, a by-pass circuit coupled to the circuit of the plate and filament electrodes of said tube through which said current of fixed frequency is freely transmitted, means for rectifying the by-passed current, a relay supplied by the rectified current, said relay being operated when the rectified current corresponding to a change in level in one direction exceeds a first predetermined value and released when said rectified current corresponding to a change in gain in the opposite direction recedes below a second predetermined value, a condenser connected in series with the grid biasing source of voltage, means responsive to the operation of said relay to charge said condenser so as to increase the bias of the grid electrode with respect to the filament electrode, and means responsive to the release of said relay to fully discharge said condenser.

4. Gain control apparatus for a system transmitting modulated carrier currents and a pilot current of a frequency outside of the range of the modulated currents, comprising a vacuum tube having a grid circuit and a plate circuit through which all of the currents are transmitted, the grid circuit including a source of biasing voltage and a condenser in series with said source, means coupled to the plate circuit of the vacuum tube for receiving and rectifying said pilot current, a relay the winding of which is energized by said rectified pilot current, means for charging said condenser so as to increase the bias of the grid circuit of said tube, means for fully discharging said condenser, means for operating said charging means in response to the operation of said relay, and means for operating said discharging means in response to the release of said relay.

5. A gain control system including a vacuum tube having a grid circuit and a plate circuit, a condenser included in said grid circuit upon which a voltage may be applied to control the bias of said grid circuit, a tuned circuit coupled to the plate circuit of said tube for obtaining a selected current transmitted through said vacuum tube, means comprising a relay responsive to the level of said selected current to charge said condenser in order to change the gain of said vacuum tube in one direction, means responsive to the level of the selected current to fully discharge said condenser in order to change the gain of said vacuum tube in the opposite direction, and a rectifier connecting the plate circuit of said vacuum tube to the winding of said relay so that the current traversing said relay winding will be the current of said plate circuit as modified by said rectifier.

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