Oct. 31, 1933. W. H. T. HOLDEN 1,932,588

VOLUME CONTROL SYSTEM

Filed Jan. 6, 1931

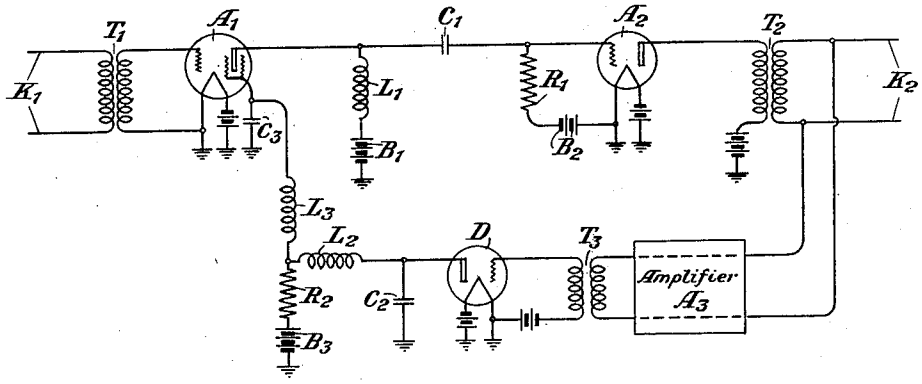


Fig. 1

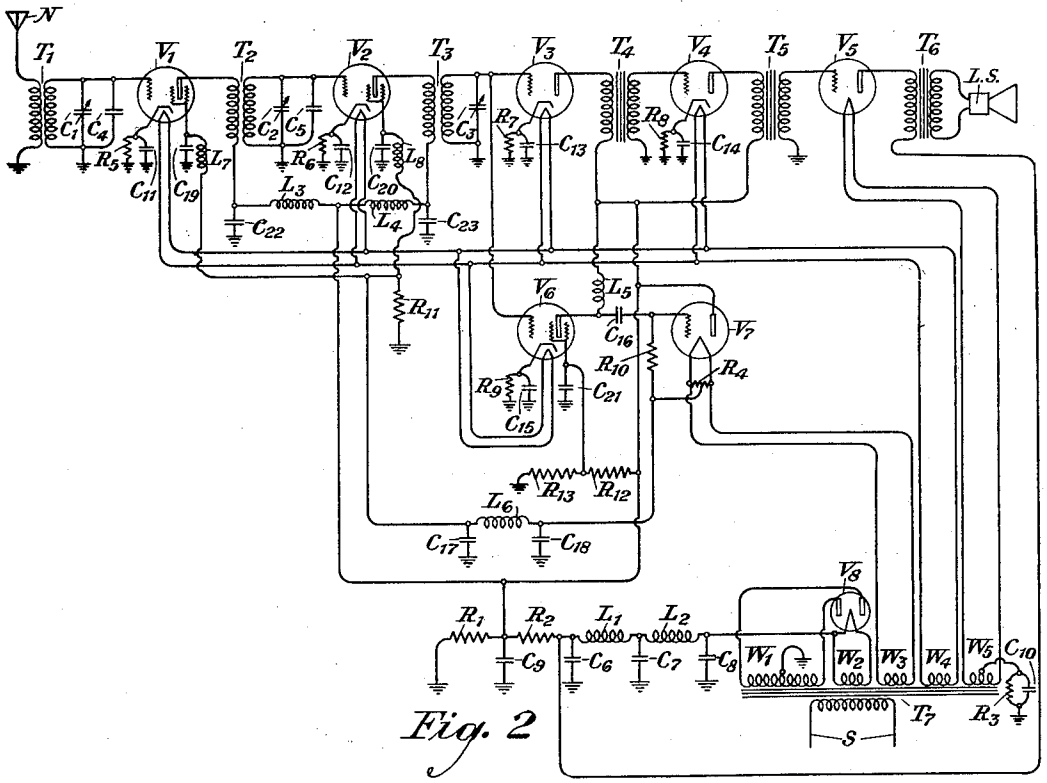


Fig. 2

INVENTOR
W. H. T. Holden
BY
ATTORNEY

Patented Oct. 31, 1933 1,932,588

UNITED STATES PATENT OFFICE

1,932,588

VOLUME CONTROL SYSTEM

William H. T. Holden, Brooklyn, N. Y., assignor to American Telephone and Telegraph Company, a corporation of New York

Application January 6, 1931. Serial No. 506,959

3 Claims. (Cl. 250—20)

This invention relates to signaling systems. More particularly, this invention relates to apparatus for the control of the gain of the energy transmitted through signaling systems. Still more particularly, this invention relates to gain control apparatus embodying screen grid tubes.

This invention includes a form of automatic volume control apparatus adaptable to arrangements employing screen grid vacuum tube amplifiers. Such apparatus may be so employed, for it has been known for some time that any variation of the screen voltage furnished an effective gain controlling means for the amplifiers employing the screen grid tubes. This invention is adaptable to single or multi-channel systems, and is here shown in one form as a single channel radio receiver.

This invention will be better understood from the detailed description hereinafter following when read in connection with the accompanying drawing in which Figure 1 represents one embodiment of the invention showing how the gain of an amplifier having a screen grid tube may be automatically controlled, and Fig. 2 shows a radio receiver embodying many of the features shown in Fig. 1 and still further features.

Referring to Fig. 1 of the drawing, the reference characters A_1 and A_2 will designate two tubes forming an amplifying system interconnecting an input circuit K_1 and an output circuit K_2 through transformers T_1 and T_2, respectively. These tubes are made to act as amplifiers, tube A_2 being of the simple three-electrode type and tube A_1 of the screen grid type. In this amplifying system a condenser C_1 connects the plate electrode of the tube A_1 to the grid electrode of the tube A_2. Moreover, the plate electrode of the tube A_1 is supplied with positive operating potential by a battery B_1 through a winding L_1. Furthermore, the grid electrode of the tube A_2 is connected to its filament electrode through a resistance R_1 and a battery B_2. If additional stages of amplification are required, tubes similar to A_1 may be connected in tandem in the circuit in any well known manner, all of the screens, however, being connected in parallel relationship.

A portion of the energy in the output circuit K_2 is transmitted to a rectifier or detector D through a transformer T_3 and an amplifier A_3, if one is found necessary or desirable. The output circuit of the detector D may be considered to be composed of a battery B_3, a resistance R_2, a winding L_2, the plate and filament electrodes of the tube D and ground. The battery B_3 supplies normal positive operating potential for the plate electrode of the tube D. This plate electrode is grounded thru a condenser C_2.

It is to be noted that the current in the output circuit of the detector D is normal when the level of the energy flowing through the output circuit K_2 is at a predetermined value or fluctuates between certain closely spaced predetermined levels. Any rise in the level of the energy flowing through the output circuit K_2 will cause a corresponding increase in the current of the output circuit of the detector D above its normal value. Similarly, any decrease in the level of the energy of the output circuit K_2 will cause a corresponding decrease in the current of the output circuit of the detector D below its normal value. It is to be here noted that the winding L_2 and the condenser C_2 form a section of a low pass wave filter which may have many more sections having similar series windings and shunt condensers, and this filter will suppress such alternating currents as may tend to flow through the output circuit of the tube D.

The screen electrode of the tube A_1 is connected to ground through a circuit which includes a winding L_3, resistance R_2 and battery B_3. This screen electrode is also grounded through a condenser C_3. By virtue of the connection of the screen electrode in series with resistance R_2 and battery B_3, the voltage applied to the screen electrode will be determined by the normal voltage of the battery B_3 and by the drop in voltage across the resistance R_2. It is to be noted that the screen electrode is normally positive with respect to the filament electrode of the tube A_1 and yet it is negative with respect to the plate electrode of this tube and remains negative with respect to this plate electrode at all times. The condenser C_3 is one of large capacity, thereby providing a path of low impedance for all the operating frequencies.

The drop in voltage across the resistance R_2 corresponds to the flow of current through the output circuit of the tube D. The voltage drop across the resistance R_2 will increase when the current of the output circuit of the tube D increases, and conversely, this voltage will decrease when the current through the output circuit of the tube D decreases. As the drop in voltage across the resistance R_2 increases above its normal value, the voltage of the screen electrode of the tube A_1 will be correspondingly decreased, thereby reducing the amplification of the tube A_1. Moreover, as the drop in voltage across the resistance R_2 decreases below its normal value, the voltage of the screen electrode of the tube A_1 will

be correspondingly increased, thereby increasing the amplication of the tube A_1.

The winding L_2 and the condenser C_2 not only act as a section of a wave filter, but their respective magnitudes are such that they provide a time constant which will prevent the too rapid readjustment of the gain of the system. Any too rapid readjustment of the gain is undesirable because it will affect the quality of the signals upon their demodulation.

A radio receiver completely operated by alternating current is shown in Fig. 2 of the drawing. Here the reference characters V_1, V_2, V_3, V_4 and V_5 designate a plurality of tubes employed to translate radio frequency signals which may become impressed upon an antenna N into voice frequency fluctuations which may be rendered audible by a loud speaker LS. The tube V_1 is coupled to the antenna circuit through a transformer T_1. The tube V_1 is also coupled to a tube V_2 through a transformer T_2. The tube V_2 is coupled to a tube V_3 through a transformer T_3. The tubes V_1 and V_2 are screen grid tubes of the heater type and act as amplifiers of radio frequency currents. The secondary windings of the transformers T_1, T_2 and T_3 are bridged by variable condensers C_1, C_2, and C_3, respectively, and these condensers may be adjusted so as to selectively transmit such radio frequencies as are impressed upon the antenna N and are desired. Obviously, the variable elements of these condensers may be mounted on a common shaft so that their reactive values may be changed by the same amount simultaneously. Condensers C_4 and C_5 are shown in shunt with the condensers C_1 ad C_2 and are provided for the purpose of compensating for the additional capacity across the tuned circuit working into the tube V_3 in order that these circuits may be simultaneously tuned.

The tube V_3 is employed to act as a detector in the arrangement shown in Fig. 2. This tube is coupled to a tube V_4 through a transformer T_4. Tube V_4 is similarly coupled to a tube V_5 through a transformer T_5. A transformer T_6 couples the output circuit of the tube V_5 with the loud speaker LS. The tubes V_4 and V_5 are employed to act as audio frequency amplifiers, and the transformers T_4, T_5 and T_6 may be of the iron core type, as shown. The tube V_5 may be any form of power amplifier.

Tubes V_6 and V_7 form the essential devices of the automatic vacuum control apparatus of this invention. Tube V_6 is an auxiliary amplifier of the screen grid and heater type, the grid electrode of which is connected in parallel relationship with the grid electrode of the tube V_3. Tube V_7 is of the ordinary three-electrode type and is operated as a grid leak detector, and the details of its operation will be considered in greater detail hereinafter.

The potentials required to energize the electrodes of the various vacuum tubes are derived from a source of alternating current designated S. This source is connected to the primary winding of a transformer T_7, the secondary of which includes windings W_1, W_2, W_3, W_4 and W_5. A tube designated V_8 is used for the purpose of providing rectification, and this tube includes a filament and two plate electrodes. The plate electrodes of this tube are connected to the terminals of the secondary winding W_1, the midpoint of which is grounded. The secondary winding W_2 is connected to the filament of the tube V_8, this winding supplying the current required to heat the filament of this tube to incandescence. The circuit receiving rectified current derived from the tube V_8 includes resistances R_1 and R_2, windings L_1 and L_2, the filament of the tube V_8, both of the plate electrodes of the tube V_8, both halves of the secondary winding W_1 and ground. The terminal common to the winding L_1 and the resistance R_2 is grounded through a condenser C_8; the terminal common to the windings L_1 and L_2 is grounded through a condenser C_7; the right hand terminal of the winding L_2 is grounded through a condenser C_8; and the terminal common to the resistances R_1 and R_2 is grounded through a condenser C_9. It is to be noted that the windings L_1 and L_2 and the condensers C_6, C_7 and C_8 form a pair of sections of a low pass wave filter which is designed to suppress such alternating currents as may tend to pass through the circuit supplied with rectified current by the tube V_8.

The filaments of the tubes V_1, V_2, V_3, V_4 and V_6 are connected in parallel relationship with the secondary winding W_4. The filament of the tube V_5 is connected to the winding W_5, the midpoint of which is connected to ground through a resistance R_3 and a condenser C_{10} which are arranged in parallel relationship. The filament of the tube V_7 is connected to the secondary winding W_3 and it is also shunted by a resistance R_4, and yet it will be understood that the filament of this tube need not be of a type which is indirectly heated.

The heaters of the tubes V_1, V_2, V_3, V_4 and V_6 are respectively connected to ground through resistances R_5, R_6, R_7, R_8 and R_9. These resistances are shunted by condensers C_{11}, C_{12}, C_{13}, C_{14} and C_{15}. These resistances are common to the output circuits of the respective tubes, and moreover, they are in effect connected between the grid electrodes of these tubes and their heaters, and provide the necessary bias therefor. The shunting condensers by-pass alternating currents around these resistances.

The necessary positive operating potentials for the plate electrodes of the tubes V_1 to V_7, inclusive, are provided by the drops in voltage across the resistances R_1 and R_2. The right-hand terminal of the resistance R_1 is connected to the plate electrode of the tube V_1 through the winding L_3 and the primary winding of the transformer T_2. This same terminal of the resistance R_1 is also connected to the plate electrode of the tube V_2 through a winding L_4 and the primary winding of the transformer T_3. This same terminal is also connected to the plate electrodes of the tubes V_3 and V_4 through the primary windings of the transformers T_4 and T_5, respectively, and moreover, it is directly connected to the plate electrode of the tube V_7. It is also connected to the plate electrode of the tube V_6 through a winding L_5. The right-hand terminal of the resistance R_2 is connected to the plate electrode of the power tube V_5 through the primary winding of the transformer T_6. The voltage drop across the resistance R_1 may, for example, be about 180 volts, and that across both resistances R_1 and R_2 may, for example, be about 400 volts. Both of these resistances may, if desired, be variable in their respective magnitudes in order to provide the desired positive operating potentials for the plate electrodes of the various tubes. It is to be noted that the winding L_5 is a choke coil and couples the tubes V_6 and V_7, thereby avoiding the necessity for tuning the system at this point.

The tube V_7 is arranged to operate as a grid leak detector and as such its plate current is reduced and the resistance between its plate and filament electrodes increased when alternating current is applied to its grid electrode. Here a relatively large condenser C_{16} connects the plate electrode of the tube V_6 with the grid electrode of the tube V_7, and a high grid leak resistance R_{10} is interposed between the grid electrode of the tube V_7 and the midpoint of the resistance R_4. It is to be noted that the lower terminal of the resistance R_{10} is connected to ground through a winding L_6 and a resistance R_{11}. The opposite terminals of the winding L_6 are grounded through condensers C_{17} and C_{18}. Winding L_6 and condensers C_{17} and C_{18} form one of the sections of a low pass wave filter which may have a cut-off frequency of about ten cycles. The capacity of the condenser C_{16} is large and the resistance of the leak R_{10} is high so as to eliminate from the detector V_7 frequencies above the cut-off frequency of the filter having the elements composed of winding L_6 and condensers C_{17} and C_{18}, all of which tend to reduce the attenuation required in the detector.

The midpoint of the resistance R_4 is connected to the screens of the tubes V_1 and V_2 through winding L_6 and individual windings L_7 and L_8, respectively. These screens are also grounded through condensers C_{19} and C_{20}, respectively. The right-hand terminal of the resistance R_1 is connected to ground through resistances R_{12} and R_{13}. The terminal common to these resistances is connected to the screen of the tube V_6. This screen is also grounded through a condenser C_{21}.

The windings L_7 and L_8 and the condensers C_{19} and C_{20} prevent any intercoupling of the output circuits of the tubes V_1 and V_2. It will be understood that the condensers C_{22} and C_{23} are connected, respectively, in the output circuits of the tubes V_1 and V_2 in series with the primary windings of the transformers T_2 and T_3, and that these condensers freely transmit all radio frequencies amplified by the tubes V_1 and V_2.

A circuit deserving special study is the one including the resistance R_1, the plate and filaments electrodes of the tube V_7, the resistance R_4, the winding L_6, the resistance R_{11} and ground. In shunt with the resistance R_{11} are two parallel paths including windings L_7 and L_8 and the screens of the tubes V_1 and V_2, respectively. The resistance between the plate and filament electrodes of the tube V_7 and the resistance R_{11} are the largest impedances in the series circuit just described, and it may be assumed for this illustration that the total voltage across the resistance R_1 is divided therebetween in accordance with their relative magnitudes. This is especially true when it is appreciated that the screens of the tubes V_1 and V_2 receive substantially no currents and are affected merely by voltage changes. Of course, any change in the magnitude of the resistance R_{11}, which may be accomplished manually in any manner well known in the art, will permit the screens of the tubes V_1 and V_2 to be normally supplied with any predetermined positive potentials. The normal positive potentials for these screens may be considered as those potentials impressed thereon when no alternating current reaches the input circuit of the tube V_7.

When the various radio frequency stages of the receiving system shown in Fig. 2 are tuned to the frequency of some desired carrier current, the impression of this current on the input circuit of the tube V_7 will, if of sufficient magnitude, cause an increase in the resistance between the plate and filament electrodes of the tube V_7. The greater the current impressed upon the input circuit of the tube V_7 the greater will be the resistance between the plate and filament electrodes of the tube V_7. Each increase in resistance between these electrodes will reduce the gain of the tubes V_1 and V_2. Generally, the greater the resistance between the plate and filament electrodes of the tube V_7 the lower will be the gain of the tubes V_1 and V_2.

The screen of the tube V_6 is supplied with a positive potential determined by the drop in voltage across the resistance R_{13}. The voltage applied to this screen is constant and, therefore, the gain of the tube V_6 remains unchanged.

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. The combination of a vacuum tube grid leak detector, a resistance, a source of direct current potential connected in series with said resistance and the plate and filament electrodes of said detector, and a plurality of tubes all having screen electrodes which are connected in parallel relationship, said parallel connected screen electrodes being in parallel with said resistance and in series with said source of direct current potential and the plate and filament electrodes of said detector.

2. The combination of a vacuum tube grid leak detector, a resistance, a source of direct current potential connected in series with said resistance and the output circuit of said detector, a source of alternating current coupled to the input circuit of said detector, and a plurality of amplifiers all having screen electrodes which are connected in parallel relationship, the parallel arrangement of said screen electrodes being connected in parallel with said resistance and in series with said source of direct current potential and the output circuit of said detector.

3. The combination of a source of rectified direct current potential, a vacuum tube grid leak detector having an input circuit and an output circuit, the output circuit of said detector having a space discharge path, a resistance connected in series with said source of direct current potential and the output circuit of said detector, a plurality of amplifiers each having a screen electrode, the screen electrodes of all of said amplifiers being connected in parallel relationship, the parallel screen electrodes being connected in parallel with respect to said resistance, a source of signals coupled to the input circuit of said detector, and means for preventing the source of signals from impressing alternating voltages on the screen electrodes of said amplifiers.

WILLIAM H. T. HOLDEN.