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VOLUME CONTROL SYSTEM

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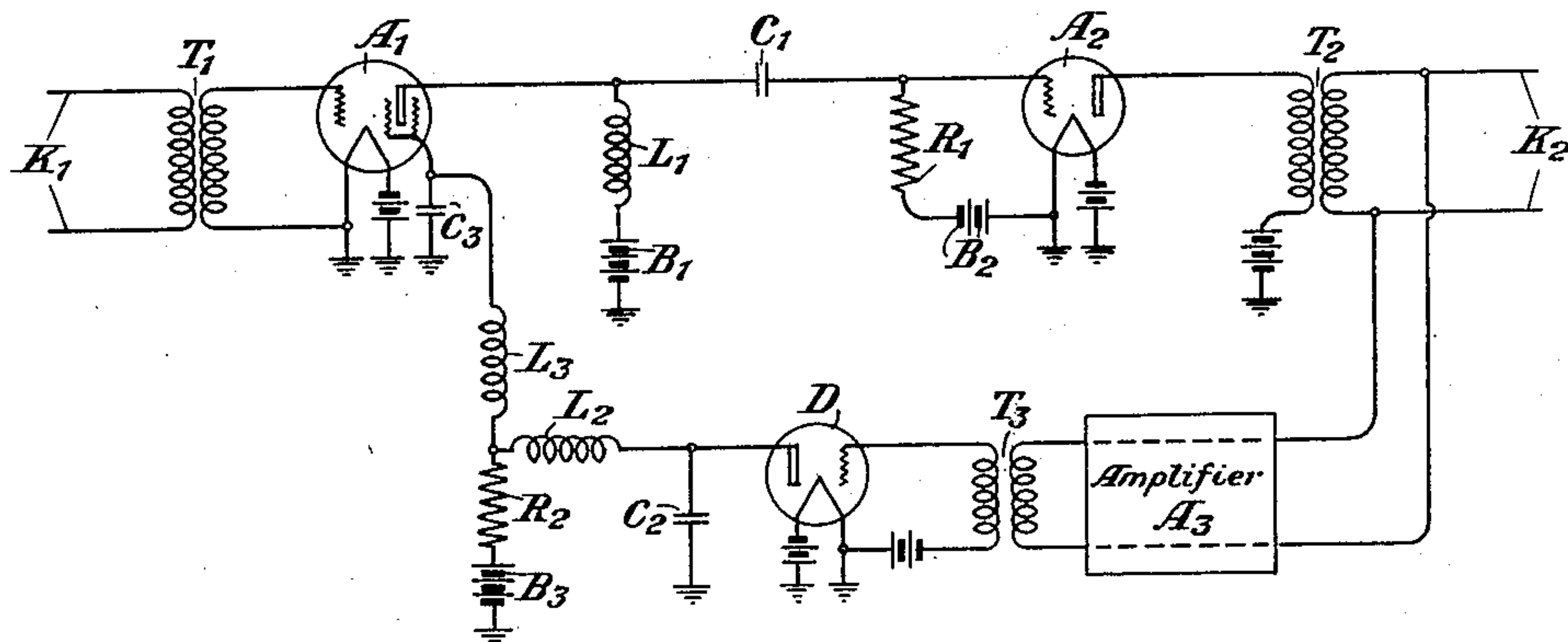


Fig. 1

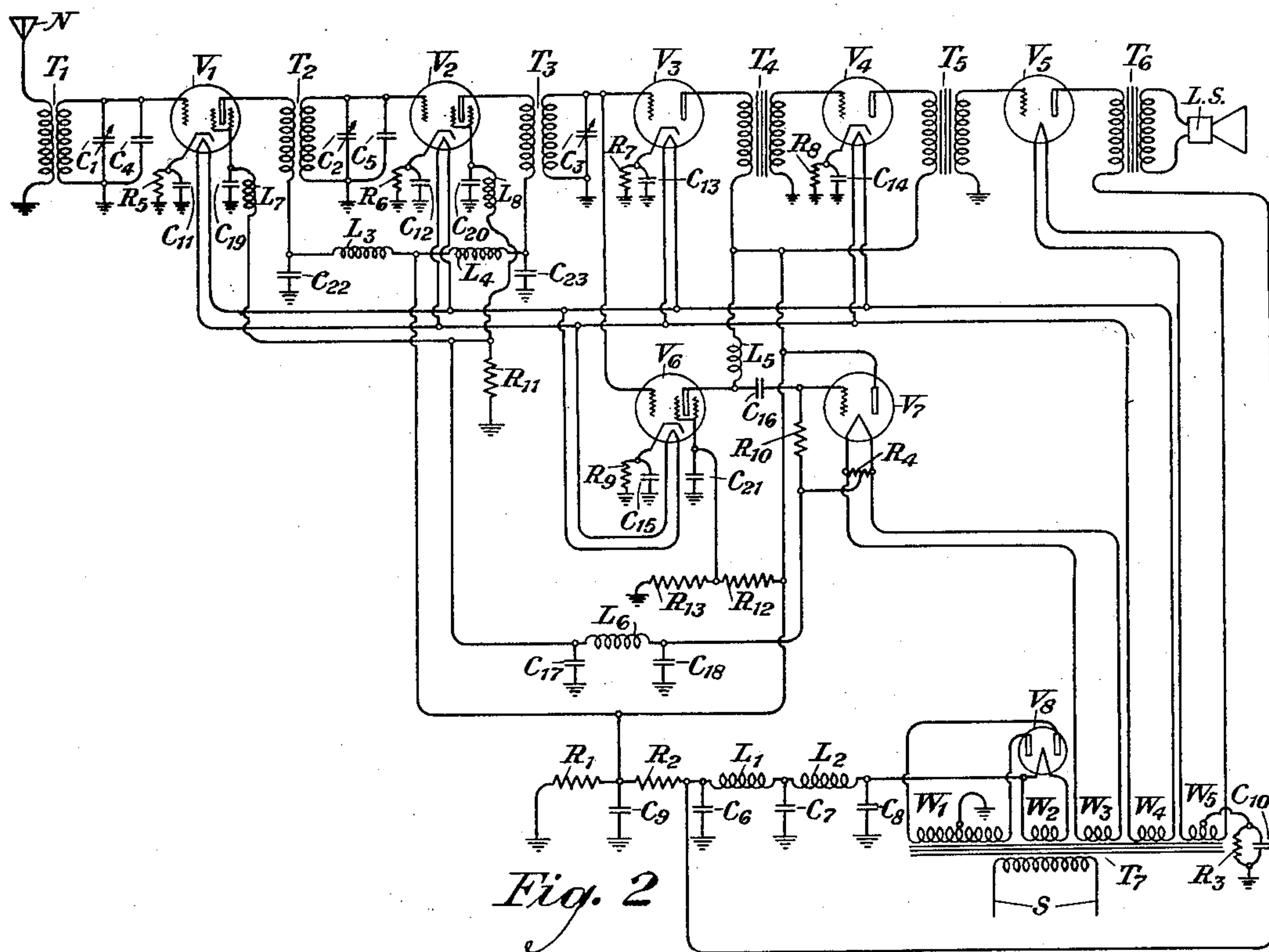


Fig. 2

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VOLUME CONTROL SYSTEM

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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 amplification of the tube A₁.

The winding L₂ and the condenser C₂ 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 V₁, V₂, V₃, V₄ and V₅ 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 V₁ is coupled to the antenna circuit through a transformer T₁. The tube V₁ is also coupled to a tube V₂ through a transformer T₂. The tube V₂ is coupled to a tube V₃ through a transformer T₃. The tubes V₁ and V₂ are screen grid tubes of the heater type and act as amplifiers of radio frequency currents. The secondary windings of the transformers T₁, T₂ and T₃ are bridged by variable condensers C₁, C₂, and C₃, 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 C₄ and C₅ are shown in shunt with the condensers C₁ and C₂ and are provided for the purpose of compensating for the additional capacity across the tuned circuit working into the tube V₃ in order that these circuits may be simultaneously tuned.

The tube V₃ is employed to act as a detector in the arrangement shown in Fig. 2. This tube is coupled to a tube V₄ through a transformer T₄. Tube V₄ is similarly coupled to a tube V₅ through a transformer T₅. A transformer T₆ couples the output circuit of the tube V₅ with the loud speaker LS. The tubes V₄ and V₅ are employed to act as audio frequency amplifiers, and the transformers T₄, T₅ and T₆ may be of the iron core type, as shown. The tube V₅ may be any form of power amplifier.

Tubes V₆ and V₇ form the essential devices of the automatic vacuum control apparatus of this invention. Tube V₆ 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 V₃. Tube V₇ 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 T₇, the secondary of which includes windings W₁, W₂, W₃, W₄ and W₅. A tube designated V₈ 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 W₁, the midpoint of which is grounded. The secondary winding W₂ is connected to the filament of the tube V₈, this winding supplying the current required to heat

the filament of this tube to incandescence. The circuit receiving rectified current derived from the tube V₈ includes resistances R₁ and R₂, windings L₁ and L₂, the filament of the tube V₈, both of the plate electrodes of the tube V₈, both halves of the secondary winding W₁ and ground. The terminal common to the winding L₁ and the resistance R₂ is grounded through a condenser C₆; the terminal common to the windings L₁ and L₂ is grounded through a condenser C₇; the right hand terminal of the winding L₂ is grounded through a condenser C₈; and the terminal common to the resistances R₁ and R₂ is grounded through a condenser C₉. It is to be noted that the windings L₁ and L₂ and the condensers C₆, C₇ and C₈ 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 V₈.

The filaments of the tubes V₁, V₂, V₃, V₄ and V₆ are connected in parallel relationship with the secondary winding W₄. The filament of the tube V₅ is connected to the winding W₅, the midpoint of which is connected to ground through a resistance R₃ and a condenser C₁₀ which are arranged in parallel relationship. The filament of the tube V₇ is connected to the secondary winding W₃ and it is also shunted by a resistance R₄, 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 V₁, V₂, V₃, V₄ and V₆ are respectively connected to ground through resistances R₅, R₆, R₇, R₈ and R₉. These resistances are shunted by condensers C₁₁, C₁₂, C₁₃, C₁₄ and C₁₅. 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 V₁ to V₇, inclusive, are provided by the drops in voltage across the resistances R₁ and R₂. The right-hand terminal of the resistance R₁ is connected to the plate electrode of the tube V₁ through the winding L₃ and the primary winding of the transformer T₂. This same terminal of the resistance R₁ is also connected to the plate electrode of the tube V₂ through a winding L₄ and the primary winding of the transformer T₃. This same terminal is also connected to the plate electrodes of the tubes V₃ and V₄ through the primary windings of the transformers T₄ and T₅, respectively, and moreover, it is directly connected to the plate electrode of the tube V₇. It is also connected to the plate electrode of the tube V₆ through a winding L₅. The right-hand terminal of the resistance R₂ is connected to the plate electrode of the power tube V₅ through the primary winding of the transformer T₆. The voltage drop across the resistance R₁ may, for example, be about 180 volts, and that across both resistances R₁ and R₂ 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 L₅ is a choke coil and couples the tubes V₆ and V₇, 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 filament 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.

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