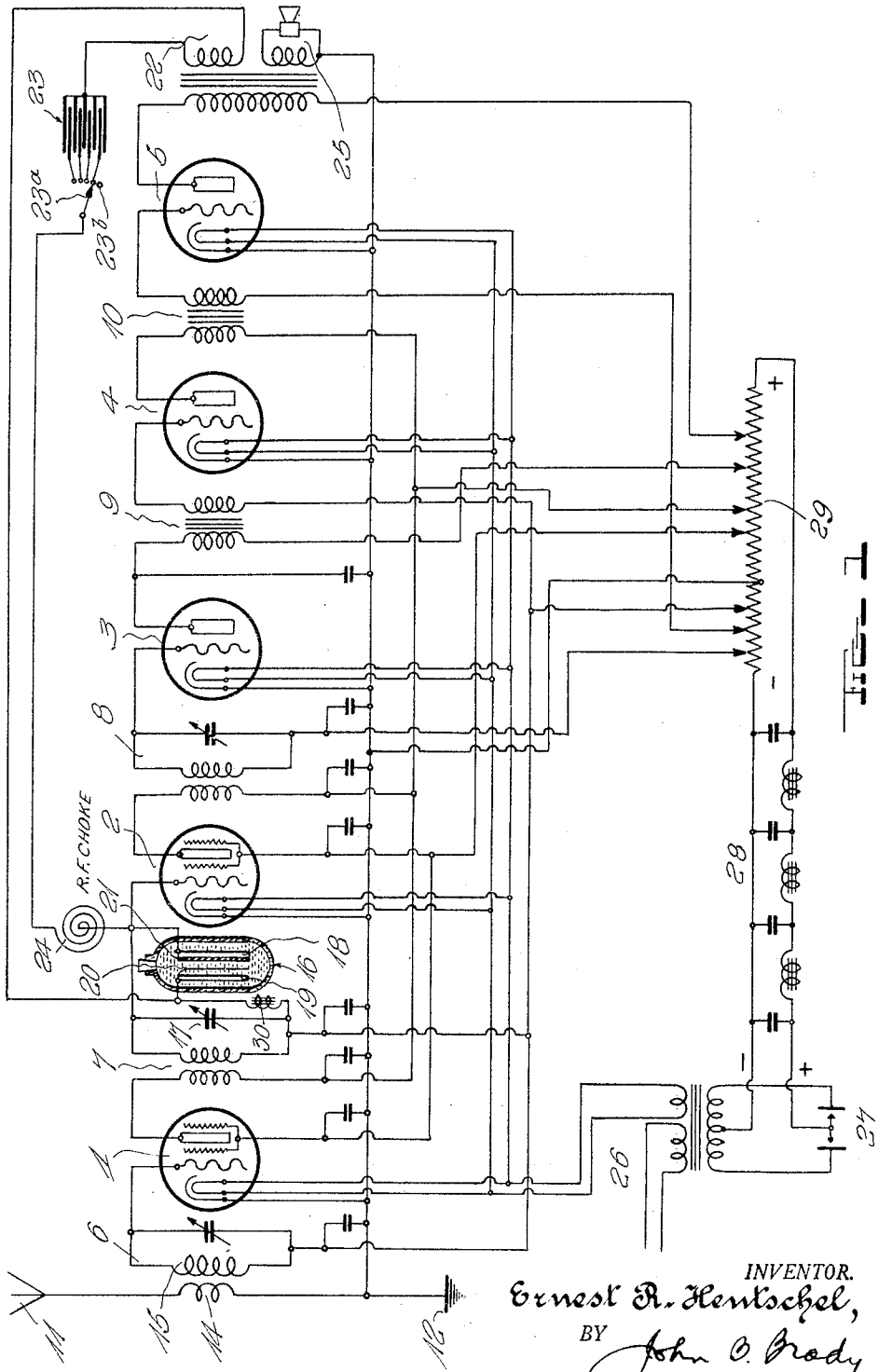
Oct. 25, 1932. E. R. HENTSCHEL 1,884,680

AUTOMATIC VOLUME CONTROL SYSTEM

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AUTOMATIC VOLUME CONTROL SYSTEM

Filed June 17, 1930 2 Sheets-Sheet 2

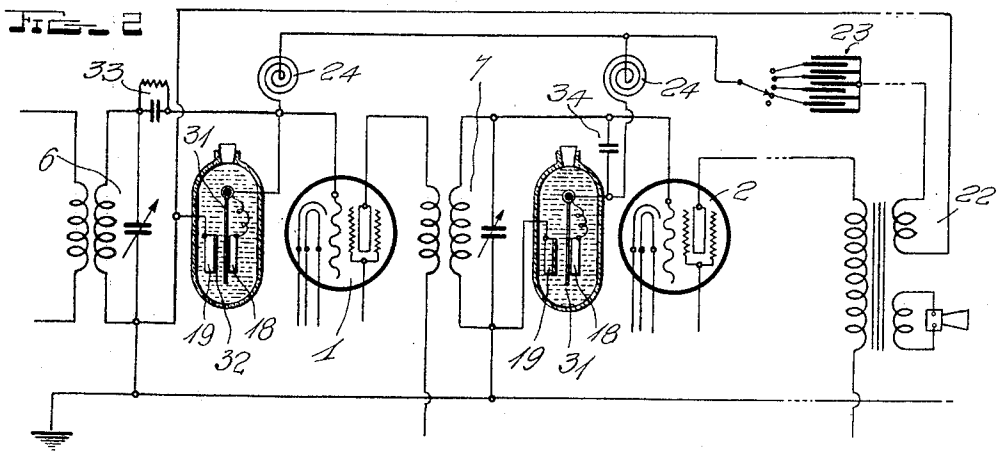


FIG. 2

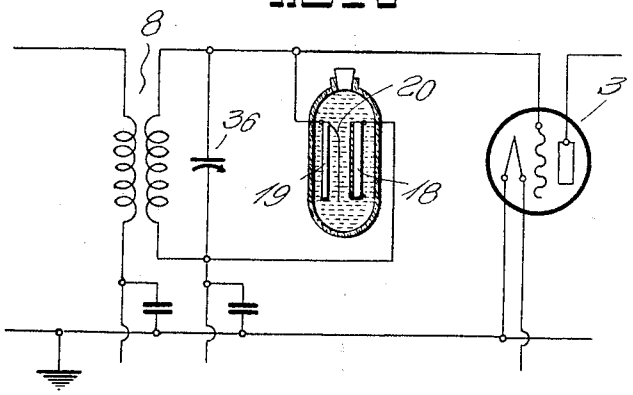


FIG. 3

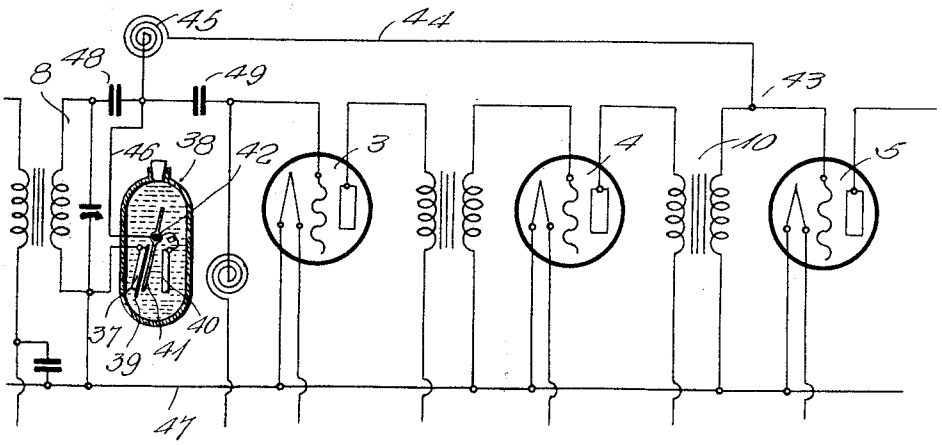


FIG. 4

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UNITED STATES PATENT OFFICE

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AUTOMATIC VOLUME CONTROL SYSTEM

Application filed June 17, 1930. Serial No. 461,822.

My invention relates broadly to signal receiving systems and more particularly to a system for automatically controlling the volume of received signaling energy.

One of the objects of my invention is to provide an automatic system for controlling the volume of received signaling energy for avoiding the effects of variations in power employed for energizing the circuits of the signal receiving apparatus.

Another object of my invention is to provide a circuit arrangement for a radio broadcast receiver in which automatic variable capacity devices are connected in circuit with the tuned system of the receiver and are automatically variable in their effective capacity according to the amplitude of the incoming signaling energy, whereby excessive incoming signaling energy serves to vary the effective capacity of the tuned system for automatically decreasing the volume of the reproduced sound under conditions of excessive signaling energy.

A further object of my invention is to provide an arrangement of electrostatic means in circuit with the multiple tuned stages of a radio frequency amplification system where the effective value of the electrostatic means is directly controllable by the amplitude of the incoming signaling energy for securing uniform reproduction in sound in a radio broadcast receiver.

A still further object of my invention is to provide an arrangement of electroscope in the tuned circuits of an amplification system wherein differential charges may be impressed upon the electroscope for varying the effective capacity thereof according to the amplitude of the incoming signaling energy and correspondingly controlling the tuning of the circuits of the amplification system for maintaining a substantially uniform volume of sound reproduction.

Other and further objects of my invention reside in the arrangement of electrostatic control devices in the multiple tuned circuits of a radio broadcast receiver as set forth more fully in the specification hereinafter following by reference to the accompanying drawings, in which:

Figure 1 illustrates the circuit arrangement of a radio broadcast receiver embodying the principles of my invention; Fig. 2 shows a circuit arrangement for an amplification system in which a multiple number of stages are equipped with the volume control circuit of my invention; Fig. 3 illustrates the application of the principle of my invention to a single stage of amplification wherein the amplitude of the incoming signaling energy is directly impressed upon the control device for effecting the required tuning compensation in the input circuit of one of the amplification stages; and Fig. 4 shows a further modified circuit arrangement for controlling the amplitude of the reproduced signaling energy independent of fading effects.

My invention makes use of the principles of the electroscope for automatic volume control in a radio receiving circuit. It is known that if two plates of different polarity are brought near one another, there is an attraction between them, and if the plates are at the same polarity there will be a repulsion. This holds true for both direct current voltages and alternating current voltages. If the plates are made of extremely light material, a small electro-motive force will cause the plates to move toward or away from one another. The gold leaf electroscope is an example. This principle may be used as an automatic volume control in a radio receiver. I arranged the electroscope device in circuit with the tuned stages of amplification in a radio receiver and apply across the terminals of the electroscope charges which are proportional to the amplitude of the reproduced signaling energy. I may impress charges upon the electroscope directly from the tuned input circuit in one of the amplification stages or I may transfer charges from the output circuit of the final stage of amplification and impress the same upon the electroscope for varying the effective capacity thereof. Inasmuch as the electroscope is connected with the tuned circuit of one or more amplification stages, the response characteristic of the tuned amplification stages may be directly controlled. A

change in capacity of the electroscopic devices results in a detuning of the tuning circuits of the amplification system, thereby reducing the volume of reproduced sound under conditions of excessive signaling energy. The circuits of the receiver are initially adjusted for the reproduction of sound at a predetermined signal level. However, under conditions of excessive signaling energy the electroscopic control serves to detune the receiving circuit thus bringing about a reduction in volume of the reproduced signaling energy. As the volume of reproduced sound returns to the normal level, the charges imparted to the electroscopic control system are reduced and the capacity effect thereof with respect to the tuning of the receiving circuit restored to normal. The reproduced sound is thus maintained at uniform volume regardless of fading effects or variation in the power supply to the electron tube circuits.

Referring to the drawings in more detail, Figure 1 illustrates a circuit arrangement for a broadcast receiver including electron tubes 1, 2, 3, 4 and 5. Electron tubes 1 and 2 are connected in tuned radio frequency amplification stages designated at 6 and 7. Electron tube 3 is a detector connected in the tuned circuit 8. Electron tubes 4 and 5 constitute power amplification stages intercoupled through audio frequency transformers 9 and 10. An antenna-ground system is designated at 11 and 12 supplying the incoming signaling energy through primary winding 14 to the secondary winding 15 of the tuned input circuit 6. The received energy is increased in amplitude by the radio frequency amplification stage 1 and is impressed upon the tuned circuit 7 for further amplification through the radio frequency amplifier stage constituted by electron tube 2. The electroscopic device of my invention is indicated at 16 having the electrodes thereof connected across the tuning condenser 17 of the tunable circuit 7 though the series connected impedance device 30. The elestroscopic device 16 comprises a vessel in which there is mounted a fixed conductive electrode 18 in parallel relation to a similar fixed conductive electrode 19. The light flexible conductive member 20 is supported by conductive electrode 19 and is adapted to be moved in accordance with electrostatic charges developed by the potential difference existing across electrodes 18 and 19. The electrode 18 has its surface covered with an insulation material indicated at 21 to prevent contact between the flexible conductive member 20 and the plate 18. By impressing similar charges on electrode 19 and the flexible conductive member 20, repulsion forces are rendered effective which tend to spread light flexible electrode 20 with respect to electrode 19. Charges of opposite polarity impressed upon electrode 18 tend to attract the light flexible member 20 thereby causing the light flexible member 20 to move toward electrode 18. By connecting the electrodes 18 and 19 in parallel with condenser 17, the effective capacity of condenser 17 may be varied according to the change in spacial relation between the flexible conductive member 20 and the electrode 18. In order to impress variable charges upon the electroscopic device, I arrange a circuit 22 between the output system of the radio broadcast receiver and the electrodes of the electroscopic device. The circuit which extends from the output circuit of the final stage of power amplification 5 includes an adjustable series connected condenser 23, a radio frequency choke coil 24, and the electrodes 18 and 19 of the electroscopic device 16. The choke coil 24 tends to exclude radio frequency currents from the control circuit while permitting the passage of variable audio frequency current from the output circuit to the electroscopic device. The sound reproducer for the radio receiver is designated generally at 25. Under conditions of excessive current in the output circuit of the power amplification stage 5, the current increases in circuit 22 and the potential difference across electrodes 18 and 19 of electroscopic device 16 increases. The increased current which flows into the electroscopic device increases the charge on the plates 18 and 19. Inasmuch as the flexible plate member 20 is charged at the same potential as the electrode 19 to which it is directly connected the flexible plate 20 is repelled by electrode 19. The charge of opposite polarity on electrode 18 tends to attract flexible plate 20. The capacity of the device is thereby increased and by virtue of the parallel connection with condenser 17 serves to increase the capacity which is effective across the resonant circuit 7 thus detuning the amplification stage, resulting in the decrease in volume of reproduced sound thus restoring the circuits to normal operating condition. The power supply circuit for the receiver is designated generally at 26 including a suitable rectifier diagrammatically shown at 27 connected with a filter system 28 and connected with a potentiometer and power distribution circuit 29 by which power is supplied to the several circuits of the amplification system. Fluctuations in the power supply system 26 may bring about corresponding changes in the volume of reproduced sound and compensation may be accordingly effected in accordance with the principles hereinbefore described. The impedance device 30 is interposed in series between the tuned circuit 7 to the electroscopic device for preventing an effective short-circuit through the inductance of the resonant circuit and permitting the capacity variation of the electroscopic device to be effective with respect to the tuning capacity 17 in the resonant cir-

cuit 7. The impedance element 30 is of such value that it offers practically no obstruction to the passage of radio frequency currents although it serves as a substantial impedance to audio frequency currents. Although I have indicated the impedance device 30 as being a choke coil, I may employ a condenser as the impedance element as has been shown, for example, in Fig. 2.

Referring to Fig. 2 in detail, it will be seen that electroscopic devices are applied thereto to two of the radio frequency stages of an amplifier system constituted by electron tubes 1 and 2 coupled in any suitable manner. In the electron tube stage 1, the electroscopic device is shown as comprising two fixed electrodes 18 and 19 with a light stiff electrode 31 depending between the stationary electrodes 18 and 19 and pivoted for swinging movement at the top thereof. An electrical connection extends between the light plate 31 and the electrode 18 and is connected in the audio frequency control circuit 22 in a manner similar to the arrangement illustrated in Fig. 1 including the adjustable condenser 23 and the radio frequency choke coil 24 whereby electrostatic charges are impressed across the movable plate element 31 and the fixed electrode 19. A suitable layer of insulation 32 extends over the face of electrode 19 preventing a short-circuit in the event that movable plate 31 approaches the electrode 19. A similar electroscopic device is connected in the input circuit of the radio frequency stage 2 of the amplification system. In the first amplification stage an impedance element in the form of a condenser 33 is disposed between one side of the resonant circuit 6 and the electrode 31 of the electroscopic device. In the second stage of amplification an impedance element 34 connects with the movable element 31 and stationary electrode 18 on the one side and with the upper part of tank circuit 7 and the grid of tube 2 on the other side. The terminals of the electroscopic devices connect with the audio frequency control circuit 22 through choke coil 24 at one side and through the common ground connection 35 at the other side. Accordingly, two of the amplification stages are governed with respect to the frequency response thereof according to the amplitude of the energy in the reproducer circuit. The condenser 34 in the second stage of amplification may be replaced by a choke coil. This choke coil or condenser serves as an impedance element of such value as will readily by-pass radio frequency current while impeding the passage of audio frequency current.

In Fig. 3, I have shown a further modification of an electroscopic frequency control circuit in which the actuating energy for moving the flexible element 20 is supplied directly from the resonant circuit 8 which connects to the input circuit of electron tube 3. In connecting the electroscopic device directly to the resonant circuit, I select the final stage of radio frequency amplification or the detector circuit in order to obtain relatively large signal amplitude for impressing relatively large charges across the electrodes 18 and 19 of the electroscopic device. It will be seen that an increase in signal energy increases the electromotive force across resonant circuit 8, thereby increasing the electrostatic charge across the terminals of the electroscopic device which results in the movement of flexible member 20 toward electrode 18 and the increase in capacity across condenser 36 of the resonant circuit 8 automatically detuning the amplifier circuit.

In Fig. 4, I have illustrated a further modified form of electroscopic device which is operated by electrostatic charges transferred from one of the succeeding stages of amplification to the electroscopic device in a preceding amplification stage. The modified electroscopic device shown in Fig. 4 includes an electrode 37 normally disposed at an acute angle within the vessel 38, one surface of the electrode being covered with an insulating layer indicated at 39. A vertically disposed electrode is arranged within the vessel 38 as shown at 40. A pivotally mounted conductive strip 41 is hinged at 42 within vessel 38 and is electrically connected with stationary electrode 40. Electrostatic charges supplied from the succeeding amplification stage shown at 5 are conveyed to the electroscopic device connected in the input circut of any one of the radio frequency amplification stages or the detector stage as represented at 3 in Fig. 4. An audio frequency circuit extends from the tap 43 in the circuit of the final amplification stage indicated at 5 and connects to the movable strip 41 through conductor 44 and choke coil 45. The audio frequency charges are impressed upon the opposite electrode 37 through lead 46 and common ground connection 47. Impedance elements 48 and 49 connect on each side of the connection extending to the movable strip 41, impedance element 48 connecting to one side of resonant circuit 8 and impedance element 49 connecting to the input circuit of tube 3. While I have illustrated condensers, choke coils may be substituted for these elements. As the signal energy increases, the amplitude of the charges which are impressed upon movable plate 41, its interconnected plate 40 and the angularly disposed plate 47 increase. Similar charges on movable plate 41 and stationary plate 40 tend to repel plate 41 about the pivot. Unlike charges between movable strip 41 and angularly disposed plate 47 tend to attract movable plate 41 thus increasing the capacity across condenser 36 and detuning cir-

cuit 8 for reducing the volume of reproduced sound.

The electroscopic devices of my invention permit the receiving circuits to respond quickly to changes in amplitude in the output circuit of the receiver. Under certain conditions it is necessary to increase the inertia of the moving part of the electroscope by such means as immersion in oil or preventing undue vibration of the moving parts under conditions of normal modulation. The natural period of the moving parts of the electroscope is outside of the range of the normal fluctuations of sound intensity. That is to say, the moving parts have such inertia that there is no tendency for the moving parts to follow the individual variations of sound intensity. The electroscopic devices will, however, be directly controlled by increases in volume of the reproduced sound. The characteristics of the electroscopic devices are such that they are not subject to variation in capacity under rapid changes in volume of reproduced sound as occurs with normal voice or musical modulation but are effected by gradual fluctuations in volume of the reproduced sound. By selecting the viscosity of the oil employed as the damping means, I may control the rate at which the electroscopic devices change in effective capacity.

The electroscopic devices may be inexpensively manufactured and inserted in the stages of amplification in a radio broadcast receiver, due consideration being given to a reduction in capacity in each of the tuned stages of amplification. The electroscopic devices have such capacity relation to the main condensers in the tuned stages that a variation of from five to ten percent displacement from the resonant point may be obtained by actuation of the electroscopic devices. This detuning is sufficient to reduce the volume of the reproduced sound pending restoration of the condition of signaling to normal. The radio receiver is tuned for maximum sensitivity by adjusting the multiple resonant circuits 6, 7 and 8 and with switch 23*a* moved to open circuit contact 23*b*. Switch 23*a* is then moved over the series of associated contacts for the connection of condenser 23 until enough energy is transferred through the audio frequency control circuit to operate electroscopic device 16 for detuning the receiver to produce the desired volume at the sound reproducer 25. The circuits are now automatically set to respond to increases in volume of reproduced sound for the further operation of the electroscopic device and the further detuning of the receiving circuit for reduction in volume as the signaling energy increases. As the signaling energy falls off the electroscopic device reduces in capacity again enabling the receiving circuit to approach a condition of resonance for bringing in the signaling energy at required volume.

While I have described my invention in certain of its preferred embodiments, I desire that it be understood that modifications may be made and that no limitations upon my invention are intended other than are imposed by the scope of the appended claims.

What I claim as new and desire to secure by Letters Patent of the United States is as follows:

1. A volume control system for a signal receiving circuit comprising in combination a resonant circuit, an electroscopic device having a pair of capacity areas connected with said resonant circuit and means for controlling the effective capacity of said electroscopic device in accordance with the amplitude of the incoming signaling energy by variable displacement of said capacity areas with respect to each other.

2. In a signal receiving circuit, a resonant system and electroscopic means for automatically detuning said resonant system when the amplitude of the incoming signaling energy increases above a predetermined value.

3. A signal receiving system comprising an adjustable circuit tunable over a predetermined frequency range and an electroscopic device constituting a variable impedance element connected with said adjustable circuit and automatically variable in the effective impedance thereof over a range within the frequency range of said adjustable circuit for automatically detuning said adjustable circuit when the amplitude of the incoming signaling energy increases beyond a predetermined limit.

4. In a signal receiving circuit a resonant system responsive to a particular band of frequencies and an electroscopic device controllable in capacity according to the amplitude of the incoming signaling energy, said electroscopic device being connected with said resonant system and operative to detune said resonant system when the amplitude of the incoming signaling energy exceeds a predetermined value.

5. In a signal receiving system a resonant circuit responsive to a predetermined band of frequencies tuning means in said circuit and an electroscopic device connected in circuit with said tuning means and changeable in its effective capacity according to the amplitude of the incoming signaling energy for shifting the frequency response characteristic of said tuning means.

6. A signal receiving system including a circuit tunable over a predetermined range of frequencies, a variable impedance element for selectively adjusting said circuit, and an electroscopic device connected in parallel with said variable impedance element and changeable in its effective electrical capacity according to the amplitude of the incoming signaling energy.

7. In a signal receiving circuit composite

tuning means one portion of which is adjustable over a predetermined frequency range and another portion of which is constituted by a pair of spacially related capacity areas electroscopically adjustable with respect to each other according to the amplitude of the incoming signaling energy for selectively fixing the frequency to which said tuning means is responsive.

8. In a signal receiving circuit a composite tuning system comprising two portions connected in parallel one portion thereof being variable over a predetermined frequency range and the other portion thereof being constituted by an electroscopic device having a pair of spacially related capacity areas, said device having an effective variation in capacity from maxima to minima within a range of 5 to 10% of the maximum capacity of the portion of the tuning system which is variable over a predetermined frequency range.

9. In a signal receiving system, a multiplicity of tuned amplification stages, electroscopic devices connected in the input circuits of certain of said stages and means for impressing electrostatic charges derived from a succeeding stage of amplification upon said electroscopic devices for controlling the condition of resonance of said tuned stages of amplification according to the amplitude of the energy in the said succeeding stage of amplification.

10. In a signal receiving system, a multiplicity of tuned amplification stages, electroscopic devices connected in certain of said tuned amplification stages, means for deriving audio frequency electrostatic charges from a succeeding stage of amplification and impressing such charges upon said electroscopic devices for controlling the effective capacity thereof and correspondingly modifying the condition of resonance of said tuned amplification stages.

11. In a signal receiving system, a multiplicity of stages of electron tube amplification, tuned circuits connected in certain of said electron tube amplification stages, electroscopic devices connected with certain of said tuned circuits, means for deriving electrostatic charges proportional to the amplitude of the energy in a succeeding stage of amplification and impressing such charges upon said electroscopic devices for varying the effective capacity thereof for detuning said tuned amplification stages according to the amplitude of the energy in said succeeding amplification stage.

12. In an amplification system, a multiplicity of electron tube stages, means for tuning certain of said stages electroscopic devices connected with said means in certain of said stages, an audio frequency control circuit extending from a succeeding stage of amplification for impressing electrostatic charges upon said electroscopic devices according to the amplitude of the received signaling energy for changing the effective capacity of said tuned circuits and means for excluding the audio frequency control currents from said tuned circuits.

In testimony whereof I affix my signature.

ERNEST R. HENTSCHEL.