May 15, 1934. E. R. HENTSCHEL 1,958,998

VOLUME CONTROL SYSTEM

Filed June 21, 1930 2 Sheets-Sheet 1

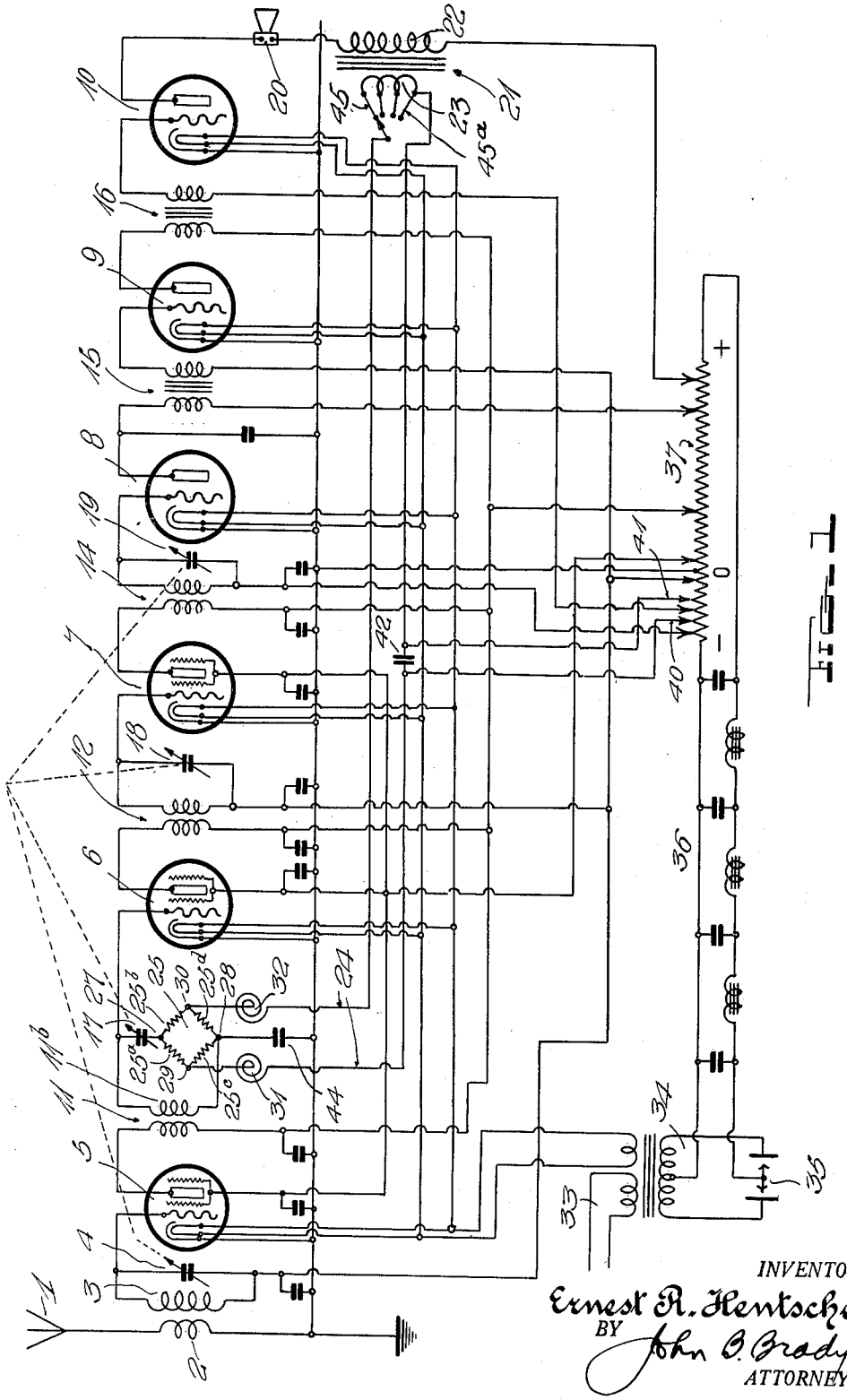


FIG. 1

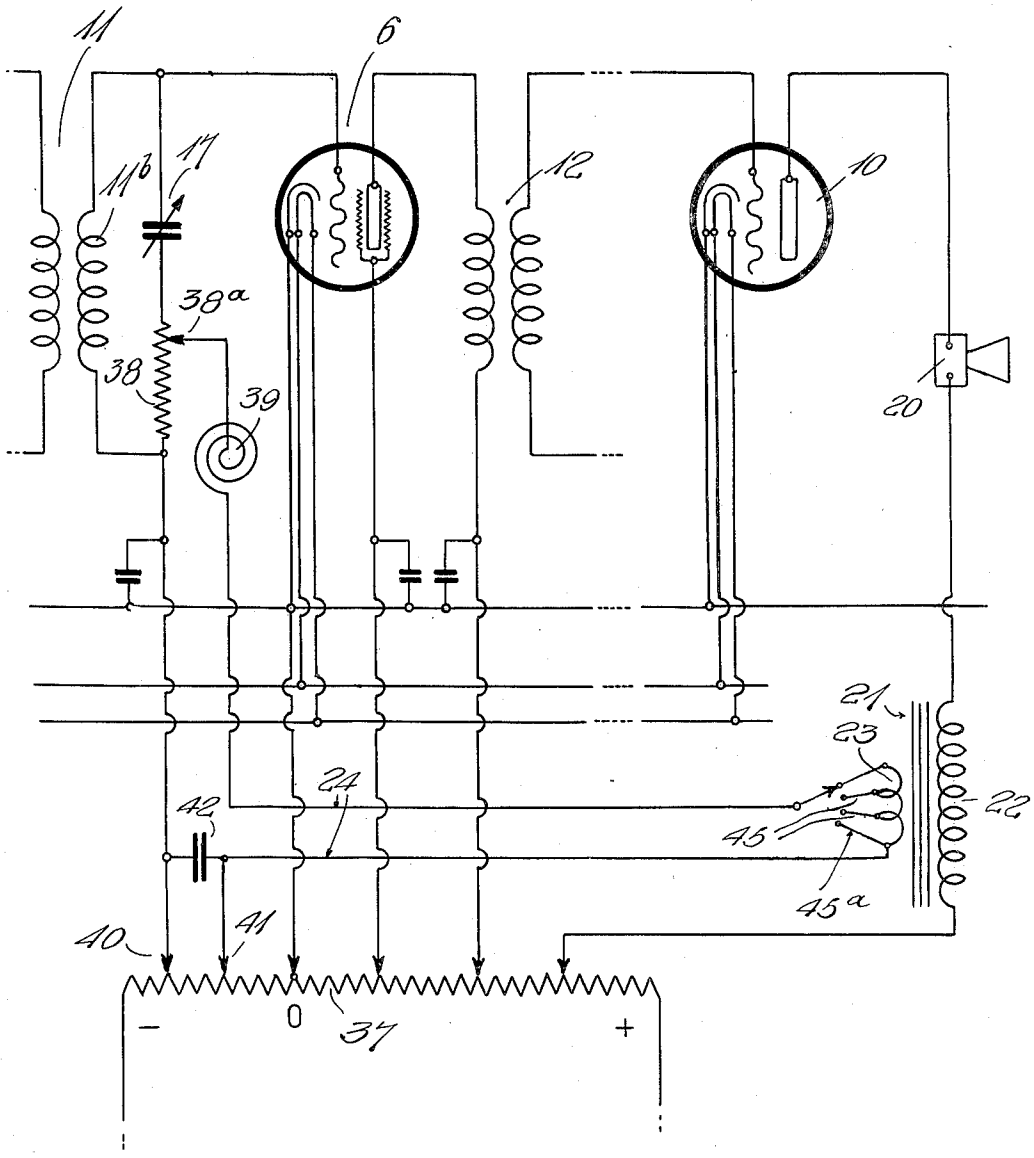
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FIG. 2



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VOLUME CONTROL SYSTEM

Ernest R. Hentschel, Washington, D. C.; John Olson, administrator of said Ernest R. Hentschel, deceased, assignor to Wired Radio, Inc., New York, N. Y., a corporation of Delaware

Application June 21, 1930, Serial No. 462,904

11 Claims. (Cl. 179—171)

My invention relates broadly to radio receiving circuits and more particularly to a volume control system for radio receiving circuits.

One of the objects of my invention is to provide a circuit arrangement for automatically controlling the volume of sound reproduced by a radio receiver independently of fading effects.

Another object of my invention is to provide a circuit arrangement for a radio frequency amplification system in a radio broadcast receiver whereby resistance may be automatically introduced into the circuits of the radio frequency amplifier when the incoming signaling energy increases in strength and the resistance reduced to normal values when the signaling energy is of normal amplitude.

Still another object of my invention is to provide a circuit arrangement whereby a resistance interposed in the radio frequency circuits of a radio receiver may be normally activated to maintain the resistance in a condition in which it is immediately responsive to an increase in effective value upon increase in the amplitude of the received signaling energy for maintaining the reproduced sound at substantially constant volume.

A further object of my invention is to provide an arrangement of resistances which may be interposed in the resonant circuits of a radio frequency amplifier in a radio receiving system in such position that the resistance is subjected to heating effects by the incoming signaling energy for introducing resistance in the circuits of the receiving system upon increase in amplitude of the incoming signaling energy for compensating for changes in the amplitude of the signaling energy and maintaining the volume of reproduced sound substantially constant.

Other and further objects of my invention reside in the volume control and circuit arrangement as described more fully in the specification hereinafter following by reference to the accompanying drawings, in which:

Fig. 1 diagrammatically illustrates the circuit of my invention applied to a radio broadcast receiver and Fig. 2 illustrates a modified form of control circuit embodying the principles of my invention.

My invention employs means for automatically reducing the amplitude of current in one or more of the radio frequency amplification stages of a radio receiver when the incoming signaling energy becomes too strong. I arrange a resistance in circuit with one or more of the radio frequency amplifier stages and provide a connection from the output circuit of the final stage of amplification by which the temperature condition of the resistance may be controlled in proportion to the amplitude of the current in the sound reproducer circuit. Under normal values or conditions of this resistance there is substantially negligible effect upon incoming signaling energy. However, under conditions of fading the signaling energy may rise to greater proportions thus increasing the temperature of the resistance and correspondingly increasing the effective value of the resistance. The resistance thus interposed in the radio frequency amplification system tends to reduce the amplitude of the signaling energy which passes therethrough thus reducing the volume of the reproduced sound. As the volume of the reproduced sound decreases the temperature condition of the resistance device is reduced to normal and the effective resistance thereof correspondingly reduced, allowing the signaling energy which is supplied to the reproducer circuit to be maintained at normal.

Referring to the drawings in more detail, reference character 1 designates an antenna system connected with primary winding 2 of a transformer system having secondary winding 3, constituting part of a resonance circuit tuned by variable condenser 4 and connected to the input circuit of electron tube 5, which constitutes the first stage of radio frequency amplification for the receiving circuit. The receiver includes a second stage of radio frequency amplification constituted by electron tubes 6, a succeeding stage of radio frequency amplification including electron tube 7, a detector tube 8 and two stages of audio frequency power amplification indicated at 9 and 10. The several stages of the radio frequency amplifier and detector are suitably coupled through the transformers 11, 12 and 14. The audio frequency power amplifier circuits are coupled through transformers 15 and 16, respectively. Each stage of radio frequency amplification and the detector is tuned as designated at 4, 17, 18 and 19. The sound reproducer is indicated at 20 connected in the output of the final stage of power amplification. I provide an audio frequency transformer 21 having its primary winding 22 connected in series with the sound reproducer 20 in the sound reproducing circuit. The transformer 21 has a secondary winding 23 which is connected through the conductors 24 with the resistance bridge circuit designated at 25. The bridge circuit resistance comprises arms 25*a*, 25*b*, 25*c* and 25*d* connected as shown. The resonance circuit including the secondary winding of transformer 11 and tun-

ing condenser 17 constitutes a tank circuit and is disposed in series with the resistance bridge circuit across the terminals 27 and 28 thereof. The leads 24 connect to the resistance bridge circuit across the terminals 29 and 30 thereof. Radio frequency choke coils 31 and 32 are disposed in circuit with the leads 24 for preventing radio frequency currents from passing to the audio frequency control circuit. The transformer 21 has a tapped secondary winding 23 wherein the taps are connected to the adjustable switch 45. The tap 45*a* entirely eliminates the secondary winding 23 thus rendering the operation of the set independent of the automatic control feature. The adjustable switch 45 enables the volume control circuit to be adjusted to a selected operating point by varying the amount of audio frequency heating current supplied to the compensating resistance.

The power supply system for the circuits of the receiving apparatus lead from the primary connection 33 through the transformer system 34, rectifier 35, filter circuit 36 to the potentiometer circuit 37 from which taps are taken to the several power circuits of the receiver.

In order to maintain the resistance device in a sensitive condition so that it will respond rapidly to a resistance change due to a temperature change under conditions of increase in signal amplitude, I introduce in circuit with the resistance, a predetermined normal potential. This energy is obtained from the potentiometer 37 and in Fig. 1 I have shown the manner of obtaining this potential by means of taps 40 and 41 on potentiometer 37, which taps are disposed in series with the audio frequency control circuit 24 with condenser 42 disposed in shunt thereto. The connection to the common cathode return lead extends from one end of the resonance circuit which contains the secondary winding 11*b* of the coupling transformer 11.

The grid bias circuit is completed through choke coils 31 and 32 and resistors 25*c* and 25*d* to taps 40 and 41 on potentiometer 37 through the secondary winding 23 of transformer 21. The resistance of the transformer secondary 23 is small as compared to both resistors 25*c* and 25*d* and the portion of potentiometer 37 between taps 40 and 41 and therefore will not affect the bias potential nor the value of the direct current which maintains the resistance bridge circuit at operating temperature. Condenser 44 completes the radio frequency path in the tuned input circuit returning to the cathode in tube 6. An example of the values of the resistances employed in the compensation system is as follows: The radio frequency inductance 11*b* of the coupling transformer is constructed with a high degree of efficiency having as small a radio frequency resistance as possible. This coil, as well as the other coupling coils in the radio frequency amplifier is wound with conductor having a minimum radio frequency resistance. For example at very high frequencies solid conductor is to be preferred whereas within the broadcast band litzendraht conductor is to be preferred. The resistance of secondary inductance 11*b* may be for example approximately 10 ohms. A similar resistance is effective across the resistance bridge, that is each resistance member 25*a*, 25*b*, 25*c* and 25*d* has a value of 10 ohms when operating at normal signal intensity and subject to the passage of current from taps 40 and 41 along the potentiometer 37. Condenser 44 has a capacity of approximately .001 mfd. Condenser 42 has a value of 1 mfd.

In Fig. 2 I have shown a modified circuit arrangement wherein the electron tube 6 has its input circuit connected with the tuned resonance circuit including variable condenser 17 with the variable resistance member 38 disposed directly in series therein. The leads 24 from the audio frequency control circuit which connect through transformer 21 with the output circuit of the final stage of power amplification, convey variable energy to resistance 38 through the choke coil 39 and variable tap 38*a*. Tap 38*a* may be selectively positioned along resistance 38 in order to regulate the amount of volume control which may be obtained. As the amplitude of the current increases through the sound reproducer 20 the current flow through the audio frequency control circuit increases and the current through the resistance 38 increases raising the temperature thereof and increasing the resistance so that the effective strength of the incoming signaling energy may be reduced.

The normal temperature regulating current passes through resistance 38 from taps 40 and 41 on potentiometer 37 as hereinbefore explained in connection with Fig. 1. The bias potential which is applied to the grid electrode of tube 6 is a potential intermediate the potential along resistance 37 at either tap 40 of 41. The amount of current normally passed through the resistance bridge 25 or the resistance device 38 is regulated by selectively positioning taps 40 and 41 on potentiometer 37. The resistance element 38 or the resistance elements of the resistance bridge 25 are brought up to a sensitive condition by the passage of current therethrough so that upon increase in current due to fading effects the temperature rise increases the effective resistance of the resistance members and decreases the volume of sound from the sound reproducer 20.

The compensation circuit may be disposed in any one or more of the stages of radio frequency amplification. Various modifications may be made in the circuit arrangements and it will be understood that rapid changes in fluctuations of sound will not serve to change the effective resistance of the amplification circuit to a sufficient extent to change the value of reproduced sound. The effective resistance changes only under a condition of gradual volume change such as is brought about under conditions of fading. The wire constituting the resistance elements is selected for required resistance values and in order to insure more rapid response the resistance elements may be mounted within a vacuum of selected value. The greater the vacuum the more rapid will be the control action. The compensation system of my invention insures reproduction of sound at uniform volume adding to the quality and enjoyment of radio broadcast programs.

While I have described my invention in certain 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. An amplification system comprising a plurality of electron discharge devices coupled one to another, resonant circuits connected with each of said electron discharge devices and means disposed in series in one of said resonant circuits for automatically controlling the amplification char-

acteristics of one or more of said electron discharge devices in accordance with variations in the signal output of said electron discharge devices.

2. An amplification system including a multiplicity of thermionic tube circuits coupled one to another and thermally responsive means connected in series in the resonant circuit connecting with one of said tube circuits and controlled by a succeeding thermionic tube circuit for varying the effective resistance of said preceding selected tube circuits according to the amplitude of the reproduced signaling energy in the circuit of said succeeding electron tube circuit.

3. An amplification system including a plurality of electron tube radio frequency amplification stages, tuned circuits connected therewith, an amplification system, an impedance device connected in series in a selected tuned circuit, and means connected with said amplification system for energizing said impedance device according to the amplitude of the reproduced signaling energy for controlling the effective resistance of said selected tuned circuit.

4. A volume control system for amplifiers comprising in combination with a multiplicity of amplification stages, coupling circuits intermediate said stages, tuning means for said coupling circuits, resistance elements disposed in circuit with the tuning means in one of said coupling circuits, a circuitous path from one of said amplification stages to said resistance elements for subjecting said resistance elements to the effects of a thermal current proportional to the intensity of the reproduced signaling energy for correspondingly controlling the effective resistance of the coupling circuit containing said resistance elements and maintaining the volume of reproduced sound substantially constant.

5. In a radio receiving system a multiplicity of electron discharge devices, resonant circuits connected therewith, a resistor in one of said resonant circuits, and means for effecting a change in the resistance of said resistor in accordance with variations in signal output of the receiving system.

6. In a signal receiving system a multiplicity of electron tubes, resonant circuits connected therewith, a resistor in the form of a bridge connected in one of said resonant circuits, and means for subjecting said bridge to heating current in accordance with current changes through a succeeding electron tube for changing the effective resistance of said bridge and correspondingly controlling the amplitude of current through said succeeding electron tube.

7. A volume control system for amplifiers comprising in combination with a multiplicity of amplification stages, coupling circuits intermediate said stages, tuning means for certain of said stages, resistance elements disposed in circuit with the tuning means in one of said coupling circuits, means for passing heating current continuously through said resistance elements, a circuitous path from one of said amplification stages to said resistance elements for subjecting said resistance elements to the effects of a thermal current proportional to the intensity of the reproduced signaling energy for correspondingly controlling the effective resistance of the coupling circuit in which said resistance elements are connected and maintaining the volume of reproduced sound substantially constant.

8. A signal amplification system comprising a multiplicity of electron tube amplification stages interconnected one with another, tuning means for certain of said stages, a resistance member disposed in series with the tuning means in one of said electron tube amplification stages, means for varying the conductivity of said resistance member according to the change in volume of the reproduced signaling energy and means for determining the normal effective value of said resistance.

9. A signal amplification system comprising a multiplicity of electron tube amplification stages interconnected one with another, an inductance and capacity path for tuning certain of said amplification stages, a resistance member disposed in circuit with the inductance and capacity path in one of said electron tube amplification stages, means for varying the conductivity of said resistance member according to the change in volume of the reproduced signaling energy and means for subjecting said resistance to the passage of a continuous heating current for fixing the normal conductivity of said resistance whereby the effective resistance of said amplification stages to the passage of signaling energy may be controlled.

10. A signal amplification system comprising a multiplicity of electron tube amplification stages interconnected one with another, means for tuning certain of said stages, a resistance member disposed in circuit with the tuning means in one of said electron tube amplification stages, a circuit for subjecting said resistance member to the passage of a continuous heating current and means for superimposing a variable current upon said resistance proportional in amplitude to the volume of the reproduced signaling energy for correspondingly varying the effective value of said resistance member.

11. A signal receiving system comprising a multiplicity of electron tube amplification stages, a resistance member connected in circuit with one of said amplification stages, a circuit including a transformer connected with a succeeding amplification stage for supplying heating current to said resistance member, and means for selectively fixing the ratio of said transformer for controlling the amount of heating current supplied to said resistance member.

ERNEST R. HENTSCHEL.