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2,160,788

VOLUME CONTROL SYSTEM

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Fig. 1.

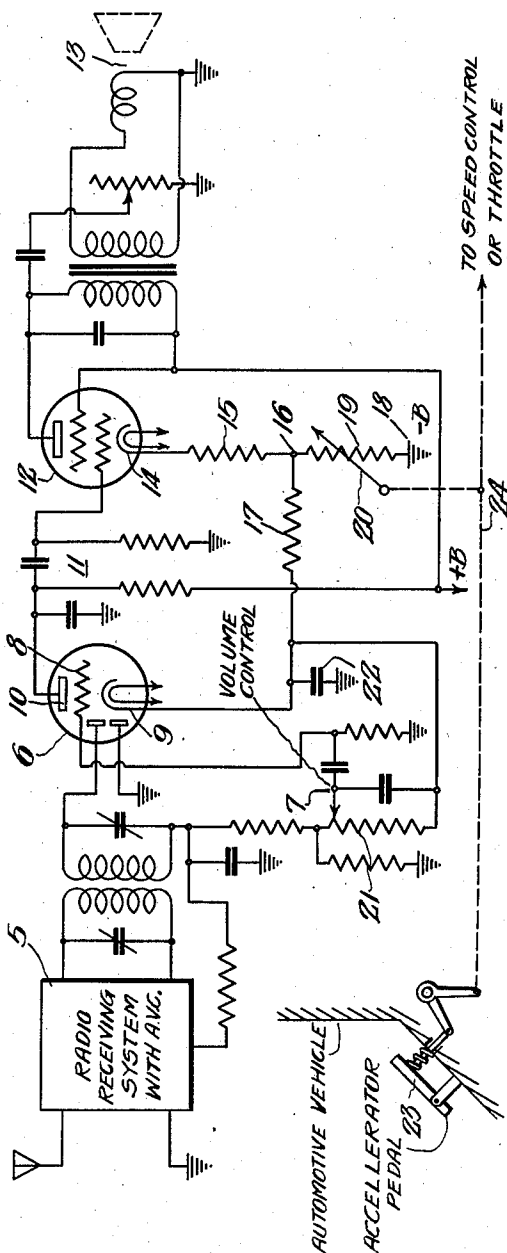


Fig. 3.

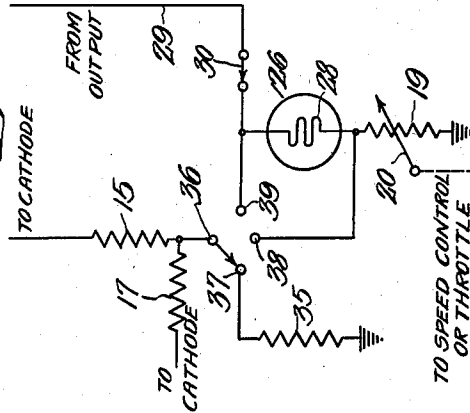
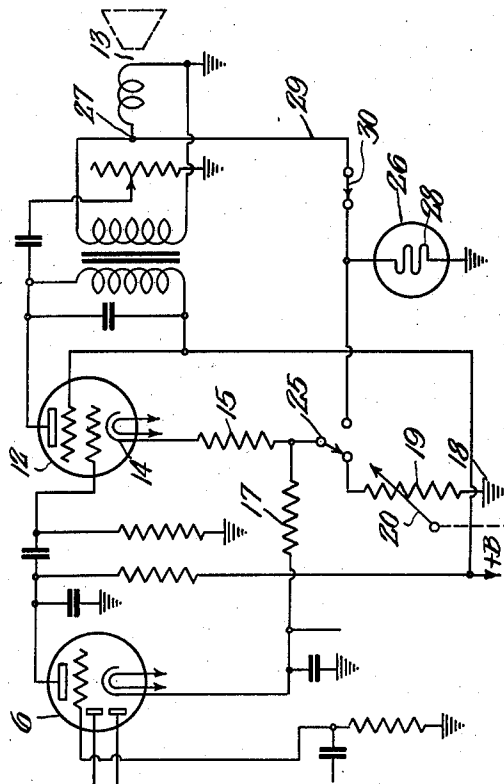


Fig. 2.



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VOLUME CONTROL SYSTEM

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Application June 30, 1937, Serial No. 151,215

11 Claims. (Cl. 179—171)

The invention relates to volume control systems for electric signal amplifiers for radio receiving apparatus and the like and has for its primary object to provide an improved and simplified volume control system for amplifiers of the character referred to.

The invention particularly relates to audio frequency amplifiers and has for its further object to provide an auxiliary volume control circuit for such amplifiers in addition to a normal volume control means as ordinarily provided in radio receiving systems and the like.

It is also a further object of the invention to provide a volume control system for automobile radio receiving systems which may be actuated independently of the normal volume control therefor, by the accelerator or other speed responsive control means in an automotive vehicle.

A volume control system in accordance with the invention further contemplates the elimination of certain bypass capacitors for the audio frequency circuits whereby the cost of the apparatus may be reduced.

The invention will, however, be better understood from the following description when considered in connection with the accompanying drawing and its scope will be pointed out in the appended claims.

In the drawing, Figure 1 is a schematic circuit diagram of a radio receiving apparatus provided with a volume control system embodying the invention,

Fig. 2 is a similar schematic circuit diagram showing a portion of the circuit of Fig. 1 modified to include a further embodiment of the invention, and

Fig. 3 is a circuit diagram showing an additional modification of the circuit of Fig. 2, in accordance with the invention.

Referring to Fig. 1, a radio receiving system adapted for use in an automotive vehicle is indicated at 5 and is provided with a detector 6 of the diode rectifier type from which audio frequency signals are derived through a volume control device 7 and applied to the control grid 8 of an audio frequency amplifier included in the same envelope with the rectifier.

The amplifier and rectifier have a common cathode 9 and the amplifier is provided with an output anode 10, the latter being coupled through an output coupling circuit 11 with a second audio frequency amplifier 12 which supplies signals to a loudspeaker or sound producing device 13.

The cathode of the amplifier tube 12 is indi-

cated at 14 and is connected through a self-bias resistor 15 to a terminal 16 to which the cathode 9 of the amplifier and detector 6 is connected through a bias resistor 17. The terminal 16 is connected to ground 18, which is the negative plate supply connection for the receiving system, through a resistor 19 which may be adjusted to a desired value as indicated by the arrow 20 representing any adjustable or variable control element therefor.

The volume control network at 21 is of relatively high impedance with respect to the resistance of the cathode circuit comprising the resistors 15, 17 and 19 and the value of a bypass capacitor for the cathode 9 is relatively low being substantially .01 mfd. in connection with a resistor 17 of 3000 ohms, a resistor 15 of 330 ohms and a resistor 19 variable between zero and 20 ohms, for example. In this case the tubes employed at 6 and 12 are RCA 6Q7G and 6V6G, respectively, although the system is not limited thereto.

With a relatively small bypass capacitor at 22 and with no bypass capacitor across the cathode resistor 15 each stage may operate degeneratively by inverse feedback or lose gain by a factor of

$$1 + \frac{\mu R_K}{R_P + R_L + R_K}$$

where the constants refer to those of the stage in question, and where

R_K = cathode circuit resistance,

R_P = plate resistance, and

R_L = load resistance in the plate circuit.

The feedback causes a loss of gain sufficient to reduce the amplification below normal, this being caused by the resistors 15 and 17 in the present example. This loss in gain is restored to a desired value by the common cathode resistor 19 which is in the cathode circuit of both stages of the amplifier and, since it is also unbypassed, a stable direct feedback between the input and output is obtained which raises the gain of the amplifier to a value determined by the amount of resistance inserted at 19. This feedback is substantially uniform over the frequency range of the amplifier and introduces no appreciable distortion. Therefore, there is no appreciable detrimental effect upon the fidelity of reproduction of received signals.

It will be seen that independent control of gain may thus be obtained to control the signal volume

in a receiving system having a normal volume control device such as that shown at 7. The latter is usually mounted in position to be operated from the driving position in an automotive vehicle and is adjusted for normal volume, as desired, from a signal or transmitting station program being received.

By connecting the control element 20 of the feedback control resistor 19 to a speed responsive or speed control device such as an accelerator pedal indicated at 23 through a connection indicated at 24, the gain of the amplifier may be increased automatically with increases in speed thereby to increase the volume or signal level and compensating for the normal rise in noise level accompanying increased speed in automotive vehicles, whereby a received program may be heard with substantially constant apparent volume at any speed of travel.

The resistor 19 is of relatively low resistance to limit the amount of feedback to a predetermined value and may be provided in some instances by a low resistance lamp filament as shown in the circuit of Fig. 2 to which attention is now directed.

In this circuit the same circuit elements as in Fig. 1 bear the same reference numerals. It will be seen that the resistor 19 may be disconnected from the cathode circuit by a switch 25 and the cathode circuit may then be completed through a low resistance lamp 26 whereby the speed responsive control is eliminated and the amount of feedback is determined by the lamp resistance.

If the lamp is connected to a variable source of heating current such as the loudspeaker output circuit indicated at 27 an increase in the sound output of the receiving system will result in increased current through the lamp and an increase in the resistance of the filament 28. The increase in resistance causes an increase in the feedback potential developed across the lamp filament and an increased gain whereby volume range expansion is provided by a simple circuit connection between the lamp and the loudspeaker circuit.

In the present example this circuit is indicated at 29 and is controlled by a switch 30 whereby the volume range expansion may be cut off when the switch 30 is opened. In the latter case the lamp filament 28 remains at a substantially constant resistance whereby a predetermined amount of feedback is obtained for normal amplification of signals.

Also if the amplifier is overbiased or operated such that the average cathode current increases as signal output increases, volume range expansion may be obtained by opening switch 30 and connecting the cathode circuits through the lamp filament 28 to ground, etc.

In either of the circuits described the use of relatively low or no bypass capacitors across the cathode resistors results in a material saving of cost in the construction of a receiver which in turn is multiplied by the number of receivers constructed which may in certain manufacturing lots run into several thousands. The phase relation between the current supplied to the resistor 26 through the resistor 15 and through the lead 29 are aiding in providing the same control of degeneration and regeneration as with the resistor 19 in circuit. The operation of the feedback system in Figure 2 is otherwise the same as that for Fig. 1 and further description is believed to be unnecessary.

Referring now to Fig. 3, wherein the same reference numerals are applied to like parts as in Fig. 2, it will be seen that a fixed resistor 35 is

substituted for the variable resistor 19 and is controlled by a switch arm 36 in connection with a contact 37. With the switch in the position shown the operation of the amplifier to which the circuit leads are connected is the same as in Fig. 1 or Fig. 2 with the resistor 19 adjusted to a fixed value.

The switch 36 is provided with two additional contacts 38 and 39 the latter providing a connection in the common cathode circuit to include both the temperature responsive variable resistance device 26 and the variable resistance device 19. The contact 38 is connected between the series connected resistors 19 and 28 whereby as the switch arm 36 is connected with the contact 38 only the resistor 19 is included in the regeneration circuit whereby the operation of the control device 19 is the same as in Fig. 1. Under such conditions of operation the switch 30 may be opened.

With the switch 30 closed and with the switch contact 36 at the contact 38 the variable resistor 19 not only controls the feedback and the gain of the amplifier to control the volume in a direction to increase the signal level or volume with increased speed, but also operates to reduce the load upon the output circuit or loudspeaker voice coil thereby additionally increasing the volume. In this manner a combined control of the output load and amplifier gain is provided by a single control means in response to a variation in the speed of travel of the vehicle.

At low speeds with the resistor 19 at a relatively low value the temperature responsive resistance device 26 will respond to increases in the signal output from the receiver and by increasing the resistance of the device, will tend to unload the output circuit with increases in the signal level, thereby providing volume expansion. This effect is gradually reduced as the resistance of the device 19 is increased since the two devices are in series in the same circuit. The phase relation between the current through the resistor 15 and through the lead 29 are the same as in Fig. 2 to aid the degenerative-regenerative control action described in connection with Fig. 1.

With the switch 36 at the contact 37 as shown, the effect of the volume expansion control by the lamp or resistance device 26 may be controlled by speed changes while the gain of the amplifier remains substantially constant.

When the switch contact 36 is at the contact 39 the signal variable resistance device 26 and the speed responsive variable resistor 19 are both in the gain controlling circuit of the amplifier and jointly operate to increase the gain with increase in volume or output level and speed whereby both speed control of the volume and volume expansion are obtainable through the same circuit. In this case as in the previous case mentioned an increase in the resistor 19 tends to reduce the volume expansion effect which is not required at relatively high speeds because wide variations in volume range tend to carry the lower volume level below the noise level of the vehicle resulting from windage and motor operation.

The use of the series speed and volume expansion circuit alone as provided by the temperature responsive resistance element 28 and the speed responsive variable resistance element 19 across the loudspeaker circuit is shown, described and claimed in my copending application Serial No. 151,216 filed June 30, 1937, concurrently herewith for Volume control system and assigned to the same assignee as this application.

I claim as my invention:

1. In an electric discharge amplifier comprising a plurality of electric discharge amplifying tubes connected in cascade relation, a common cathode circuit for a pair of said tubes, a resistor element connected in circuit with each cathode, a resistor element in said cathode circuit, and circuit connections for causing the alternating current output of said tubes to flow through said resistors, whereby a predetermined degeneration is established by said first named resistor elements and a compensation regeneration established by said last named resistor element in said cathode circuit.
2. In an electric discharge amplifier comprising a plurality of electric discharge amplifying tubes connected in cascade relation, a common cathode circuit for a pair of said tubes, a resistor element connected in circuit with each cathode, a resistor element in said cathode circuit, and circuit connections for causing the alternating current output of said tubes to flow through said resistors, whereby a predetermined degeneration is established by said first named resistor elements and a compensation regeneration established by said last named resistor element in said cathode circuit, said common cathode resistor element being variable, and means for varying said resistance to vary the gain of said amplifier.
3. In a radio receiver for an automotive vehicle, the combination of a plurality of electric discharge signal amplifier tubes having a common cathode circuit, individual cathode resistors for at least two of said tubes, a common variable resistor in said cathode circuit, circuit connections for said resistors for causing the alternating current output of said tubes to flow therethrough, and a speed control element connected with said last named resistor to vary the same in accordance with variations in speed.
4. In a radio receiver for an automotive vehicle, the combination of a plurality of electric discharge signal amplifier tubes having a common cathode circuit, a separate cathode resistor for each of at least two of said tubes connected with said common cathode circuit, a common variable resistor in said cathode circuit, a speed control element connected with said last named resistor to vary the same in accordance with variations in speed, an output circuit for said receiver, means providing a temperature responsive variable resistance element in said output circuit, and selector switch means for including said last named element in said common cathode circuit.
5. A volume control system for radio receiving apparatus and the like including in combination, a signal amplifier comprising a plurality of amplifier tubes having a common cathode circuit, separate impedance elements, one in circuit with each cathode of at least two of the amplifier tubes, for effecting a flow of the output alternating current through said impedance elements and a predetermined degree of degeneration in said amplifier, a variable impedance element in said cathode circuit common to said tubes, volume control means for applying a signal to said amplifier, and means for independently varying said last named resistor thereby to control the gain of said amplifier.
6. A volume control system for radio receiving apparatus and the like including in combination, a signal amplifier comprising a plurality of amplifier tubes having a common cathode circuit, separate impedance elements, one in circuit with each cathode of at least two of the amplifier

tubes for effecting a flow of the output alternating current through said impedance elements and a predetermined degree of degeneration in said amplifier, a variable impedance element in said cathode circuit common to said tubes, volume control means for applying a signal to said amplifier, and means for independently varying said last named resistor thereby to control the gain of said amplifier, said last named means comprising a speed control element for an automotive vehicle whereby the gain of said amplifier is controlled in accordance with variations in speed control of said vehicle.

7. A volume control system for radio receiving apparatus and the like comprising in combination, an audio frequency amplifier including at least two amplifier tubes, volume control means for applying controlled audio frequency signals to said amplifier, a cathode circuit for each of said tubes, at least one of which includes an impedance element having no appreciable frequency characteristic within the audio frequency range, said circuits being joined, a negative anode current supply connection for said amplifier, and a second impedance element connected between said last named connection and the junction of said circuits, said last named means having no appreciable frequency characteristic within the audio frequency range, the alternating current output of said tubes being caused to flow through said impedance elements, and the relation between the impedance values of said elements being such that a predetermined degree of degeneration is introduced into the amplifier and a predetermined degree of added compensating regeneration whereby audio frequency bypass means in the cathode circuits are eliminated.

8. A volume control system for radio receiving apparatus and the like comprising in combination, an audio frequency amplifier including at least two amplifier tubes, volume control means for applying controlled audio frequency signals to said amplifier, a cathode circuit for each of said tubes, at least one of which includes an impedance element having no appreciable frequency characteristic within the audio frequency range, said circuits being joined, a negative anode current supply connection for said amplifier, a second impedance element connected between said last named connection and the junction of said circuits, said last named means having no appreciable frequency characteristic within the audio frequency range, the relation between the impedance values of said elements being such that a predetermined degree of degeneration is introduced into the amplifier and a predetermined degree of added compensating regeneration whereby audio frequency bypass means in the cathode circuits are eliminated, an audio frequency output circuit for said amplifier, a low resistance temperature responsive resistance device connected with said output circuit to receive at least a portion of the signal output therefrom whereby the temperature and resistance of said device varies in accordance with variations in the signal output level from said amplifier, and means for selectively including said last named device in circuit with said cathodes between said negative anode circuit connection and the junction of said cathode circuits.

9. In a radio receiving system for automotive vehicles and the like, the combination of an audio frequency amplifier including at least two amplifier tubes, volume control means for applying controlled audio frequency signals to said

amplifier, a cathode circuit for each of said tubes, at least one of which includes an impedance element having no appreciable frequency characteristic within the audio frequency range, said circuits being joined, a negative anode current supply connection for said amplifier, a second impedance element connected between said last named connection and the junction of said circuits, said last named means having no appreciable frequency characteristic within the audio frequency range, the relation between the impedance values of said elements being such that a predetermined degree of degeneration is introduced into the amplifier and a predetermined degree of added compensating regeneration whereby audio frequency bypass means in the cathode circuits are eliminated, an audio frequency output circuit for said amplifier, a low resistance temperature responsive resistance device connected with said output circuit to receive at least a portion of the signal output therefrom whereby the temperature and resistance of said device varies in accordance with variations in the signal output level from said amplifier, means for selectively including said last named device in circuit with said cathodes between said negative anode circuit connection and the junction of said cathode circuits, said second impedance being variable, and means responsive to variations in the speed control of a vehicle by which said receiver is carried for varying said impedance device thereby to vary the volume level of the receiver output in accordance with variations in speed.

10. In a radio receiver for an automotive vehicle, the combination of a plurality of electron discharge signal amplifiers having a common cathode circuit, separate cathode resistors for at least two of said amplifiers providing connections between said amplifiers and said common cathode circuit, a fixed resistor, a resistor arranged to be varied in accordance with the speed control of said vehicle, and means for alternatively including in said common cathode circuit said fixed resistor or said variable resistor.

11. In a radio receiver for an automotive vehicle, the combination of a plurality of electron discharge signal amplifiers having a common cathode circuit, separate cathode resistors for at least two of said amplifiers, a fixed resistor, a resistor arranged to be varied in accordance with the speed control of said vehicle, a temperature responsive variable resistor, and means for alternatively including in said common cathode circuit said fixed resistor, said speed responsive resistor or said variable resistor and said temperature responsive variable resistor.

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