

Nov. 1, 1949.

C. N. KIMBALL ET AL

2,486,480

VOLUME CONTROL

Filed Feb. 8, 1946

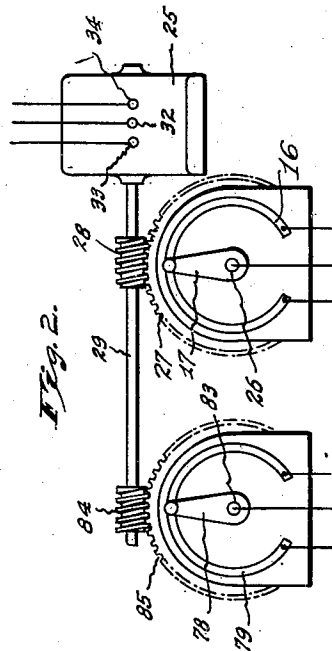
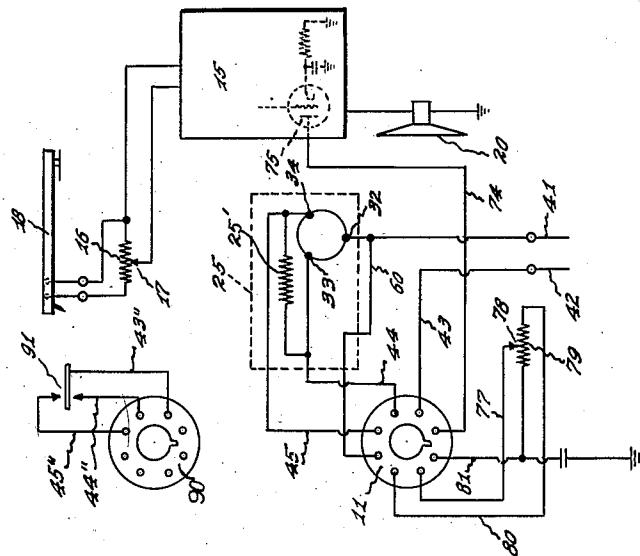
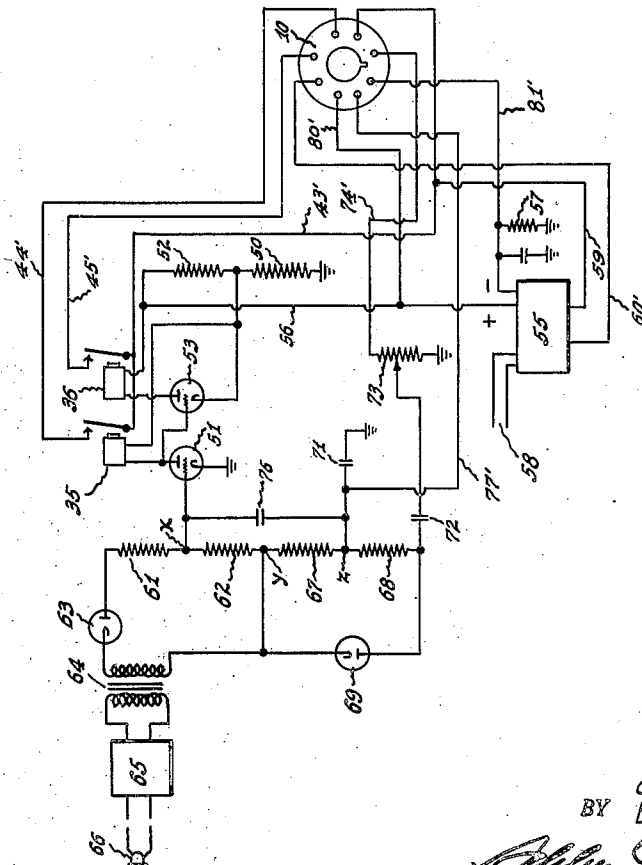


Fig. 1.



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2,486,480

VOLUME CONTROL

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Application February 8, 1946, Serial No. 646,450

11 Claims. (Cl. 179-1)

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It is an object of our invention to provide for a loud speaker, such as a speaker associated with a phonograph, radio receiving set, or public address system, a volume control means which will operate automatically to proportion speaker volume to the intensity of sounds originating from sources other than the speaker. More specifically, it is our object to produce a control means which will automatically increase output of the speaker upon an increase in the intensity, at a definite control point, of sounds originating from other sources. Another object of our invention is to produce control means which will function continuously while the speaker is in operation. A further object of our invention is to provide a control means which can readily be associated with a speaker and its associated amplifier without materially modifying the construction of the speaker and amplifier. Still another object is to provide a means through which speaker-volume can either be controlled automatically in response to the aggregate intensity of sounds having other origins or can be manually controlled.

In carrying out our invention in its preferred form we provide motor-driven means for operating an element, such as a potentiometer, capable of controlling speaker-volume; and we control the operation of such motor-driven means in response to changes in a voltage which varies with the intensity of sounds originating at sources other than the speaker. To create the controlling voltage, we prefer to employ a pair of series-connected resistances, to pass through one of such resistances a current proportional to the aggregate intensity of all sounds received at a predetermined control point, and to pass through the other resistance a current proportional to speaker output, the two currents respectively flowing through the two resistances in such directions that the voltage drop across both resistances will equal the difference between the respective voltage drops across the two individual resistances. If a given potential is maintained at one end of the series-connected resistances, the potential at the opposite end will vary in the same sense as does the aggregate intensity of all sounds received at the control point from sources other than the speaker and may be employed to control the aforesaid motor-driven means to increase speaker-volume upon an increase in the intensity of sounds originating elsewhere than at the speaker and to decrease speaker volume upon a decrease in the intensity of such sounds.

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The accompanying drawing illustrates our invention:

Fig. 1 is a diagrammatic view of the electrical apparatus I employ and Fig. 2 is an elevation, also somewhat diagrammatic in character, illustrating a suitable form of motor-driven control means.

In Fig. 1 we have illustrated portions of the complete apparatus as interconnected through an eight-contact jack or socket 10 and a cooperating plug 11, as the apparatus is preferably so arranged in practice. Interengaging contacts of the plug 11 and jack 10 are shown in Fig. 1 as correspondingly positioned; and hereinafter, except as otherwise noted, it will be assumed that the plug and jack are engaged.

The apparatus which is to be automatically controlled comprises an audio-frequency amplifier 15 the input circuit of which includes a potentiometer 16 having a movable contact 17. The potentiometer 16 is adapted to be connected to a phonograph pick-up 18 or to some other source of audio-frequency current. The speaker 20, the volume of which is to be automatically controlled, is connected in the output circuit of the amplifier 15, as indicated.

It will be obvious that, in the apparatus as illustrated and so far described the output of the speaker 20 can be varied by varying the position of the movable potentiometer contact 17, and it is through such means that I prefer to exercise the desired automatic control. For this purpose, the contact 17 is operatively connected to a reversible electric motor 25. The precise means employed to interconnect the contact 17 and motor 25 may vary. In the arrangement shown in Fig. 2, the resistance element of the potentiometer is arcuate in form, and the contact 17 is mounted on a shaft 26 which is operatively connected through a worm gear 27 and worm 28 with the shaft 29 of the motor.

The motor 25 is of known type and has three terminals 32, 33, and 34. Conveniently the motor 25 is a split-phase induction motor, terminals of the two field windings being connected respectively to the terminals 33 and 34, the other terminals of the field windings being connected in common to the terminal 32, and a reactance 25' being connected between the two terminals 33 and 34. Such a motor rotates in one direction when current is supplied to terminals 32' and 33' and in the opposite direction when current is supplied to terminals 32' and 34'. By controlling the supply of current to the motor it can be made to rotate the shaft 29 in either direction and thus

to adjust potentiometer 26 to raise or lower speaker-volume. Operation of the motor 25 is controlled by two relays 35 and 36. To this end, one of two current-supply wires 41 and 42, shown as the wire 41, is connected to motor-terminal 32, while the other is connected through conductors 43 and 43' with the movable contacts of relays 35 and 36. Motor-terminal 33 is connected through conductors 44 and 44' with the fixed contact or relay 35, while conductors 45 and 45' interconnect motor-terminal 34 and the fixed contact of relay 36. Thus, by selective energization of the relays 35 and 36 the motor 25 can be caused to rotate in either direction.

The winding of relay 35, together with the grounded portion 50 of a voltage divider, is included in the plate circuit of a triode 51 the cathode of which is grounded. The winding of the relay 36 and the other portion 52 of the voltage-divider are connected in the plate circuit of a second triode 53. The grid of triode 53 is connected to the plate of triode 51.

Plate voltage for the triodes 51 and 53 is provided by a power-pack 55 having its positive high-voltage terminal connected by conductor 56 to the ungrounded end of the voltage divider 50—52 and its negative high-voltage terminal grounded through a resistance 57. Low-voltage leads 58 from the power pack 55 may be employed to supply current to cathode-heating filaments (not shown) of the triodes 51 and 53 and of other electron discharge devices incorporated in the apparatus. Current for the power pack 55 is supplied through a conductor 59, connected to conductor 43', and conductors 60' and 60 extending to supply wire 41.

The control grid of triode 51 is connected to a point x between two resistances 61 and 62 connected in series with a rectifier 63 so arranged that any current flowing in the circuit 63—62—61 will cause the potential at point x to be negative with respect to that at point y at the opposite end of resistance 62. The circuit 63—62—61 is coupled, as by an audio-frequency transformer 64, with the output circuit of a voltage amplifier 65 the input circuit of which is connected to a microphone 66 located at the desired control point. As a result, the current flowing through the resistance 62, and hence the voltage drop across such resistance, will be generally proportional to the sound intensity at the microphone. The amplifier 65 may include an adjustable element (not shown) to control the gain it provides.

A resistance 67 has one terminal connected at the point y and its other terminal z connected to a resistance 68, and the two resistances 67 and 68 are connected in series with a rectifier 69 so arranged that the potential at y will be positive with respect to that at point z when direct current flows through the circuit 69—68—67. Across the resistance 68 we impress an audio-frequency voltage proportional to the audio-frequency voltage impressed on the speaker 20 by the amplifier 15. To this end, the point z is grounded, through a condenser 71, and the opposite terminal of resistance 68 is connected through a condenser 72, a potentiometer 73, and conductors 74' and 74 with the plate 75 of one of the tubes in the last stage of the amplifier 15. The condenser 72 isolates the point z from the direct-current voltage maintained on the plate 75, while the condenser 71 isolates such point from ground, thus making it possible to control the potential at the point z by means hereinafter to be described. Obviously, the current traversing the

resistance 67 and the voltage-drop across such resistance will vary in the same sense as does the audio-frequency voltage impressed on the speaker 20 by the amplifier 15. A condenser 76, connected between points x and z , co-operates with the resistances 61, 62, 67, and 68 to form a filter network which will compensate at least in part for audio-frequency fluctuations.

Conductors 77' and 77 connect the point z with the movable contact 78 of a potentiometer 79 the terminals of which are connected respectively, through conductors 80—80' and 81—81', with the high-voltage terminals of the power pack 55. For a purpose which will hereinafter become apparent, the contact 78 is operated by the motor 25, conveniently by being mounted on a shaft 83 driven at reduced speed through a worm 84 and worm-gear 85 from the motor shaft 29.

Before proceeding with an explanation of the operation of the apparatus as a whole, it may be well to note the manner in which the energization of the relays 35 and 36 is controlled by the triodes 51 and 53. Since the control grid of triode 53 is negatively biased by the amount of the voltage drop across the winding of relay 35, since the current flowing through such winding is controlled by the bias of the grid of triode 51, and since the cathode of triode 51 is grounded, the potential at point x , to which the grid of triode 51 is connected, is the controlling factor in the operation of the relays 35 and 36. Normally, the bias of the grid of each triode will be such as will prevent the passage of sufficient plate current to energize the associated relay. A drop in the potential at point x , if sufficient in extent, will decrease the current in the winding of relay 35 to a point such that the resultant reduction in the negative bias of the grid of triode 53 will increase the plate current there-through to a value great enough to energize relay 36. On the other hand, an increase in the potential at point x will cause the triode 51 to increase the current traversing the winding of relay 35 and thereby to increase the negative bias of the grid of triode 53. If the increase in potential at point x is sufficient, the relay 35 will be energized.

The potential at point x is determined jointly by the potential at point z and the respective voltage drops across resistances 67 and 62. More specifically, the potential at x will equal that at z plus the voltage drop from y to z minus the voltage drop from y to x . As long as the position of the microphone 66 is not changed, the current through resistance 67 and the voltage-drop from y to z will be generally proportional to the intensity of the sound received at the microphone from the speaker 20. The current through resistance 62 and the voltage-drop from y to x will be generally proportional to the aggregate of the intensities of all sounds received at the microphone. Accordingly, the potential difference between points z and x will reflect the intensity of sound received at the microphone from all sources other than the speaker 20, the potential at x dropping with an increase and rising with a decrease in the intensity of such sounds.

In setting up the apparatus, the microphone 66 is located at the point where the desired control is to be exercised. With the speaker operating to produce sound of the desired intensity at the microphone, with no other sounds of material intensity reaching the microphone, and

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with the movable contact 78 at or near the low-potential end of the potentiometer 79, the potentiometer 73 is adjusted to vary the voltage-drop across resistance 67 until the potential at x is at least roughly midway between the value which results in energization of the relay 35 and the value which results in energization of the relay 36. In this connection, it is to be noted that the presence of the resistance 57 in the ground lead to the negative terminal of the power-pack 55 makes it possible to bias the grid of triode 51 negatively relative to its associated, grounded cathode.

The apparatus, after being initially set up as above set forth, operates as follows:

As long as the sound intensity at the microphone from sources other than the speaker 20 is not too great, the relays 35 and 36 are open, the motor 25 is not running, and the potentiometer 16—17, which controls speaker volume, remains in a fixed condition of adjustment. As sound from sources other than the speaker increases, the potential at point x and on the control grid of triode 51 decreases, thus decreasing the plate current, the voltage drop across the winding of relay 35, and the negative bias of the grid of triode 53. When the decrease in the negative grid-bias of triode 53 becomes sufficient, the relay 36 is energized to complete a circuit from supply wire 41 through terminals 32 and 34 of motor 25, conductors 45 and 45', contacts of relay 36, and conductors 43' and 43 to the other supply wire 42. In the resultant operation of the motor, the contact 17 of potentiometer 16 is moved to increase the output of speaker 20. At the same time, the motor moves contact 78 toward the high-voltage end of the potentiometer 79. The increase in the output of the speaker 20 will increase sound intensity at the microphone 66 to increase the current flowing through the resistance 62, thus tending to lower still further the potential at x and on the grid of triode 51; but this tendency is counteracted by the increase in the potential drop from y to z which accompanies increased speaker output. As a result, the potential difference between points x and z remains reasonably unaffected by variations in sound intensity at the microphone which result from changes in speaker output. However, as the potentiometer 16—17 is adjusted by motor 25 to increase speaker output, the potentiometer-contact 78 is adjusted by the motor to raise the potential at point z , and thus the potential at x will be restored to the value at which relay 36 is de-energized. When this occurs, the circuit through motor 25 is broken and the motor stops.

When the intensity of sound from sources other than the speaker decreases, the current through resistance 62 decreases to decrease the voltage drop from y to x and raise the potential at x . If these changes are of sufficient magnitude, the plate current through triode 51 becomes sufficient to energize relay 35 and complete a circuit from supply wire 41, through motor 25 between terminals 32 and 33 thereof, conductors 44 and 44', contacts of relay 35, and conductors 43' and 43 to supply wire 42. This causes the motor 25 to adjust contact 17 of potentiometer 16 to reduce speaker output and contact 78 of potentiometer 79 to reduce the potential at point z . The resulting increases in the currents through resistances 62 and 67 and in the voltage drop across such resistances have opposite effects on the potential difference between points x and z , but the drop in potential at point z lowers the potential at x and

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reduces the current traversing the winding of relay 35. This operation continues until the relay 35 becomes de-energized to interrupt the supply of current to the motor 25.

The constants of the system are preferably selected so that the contact 78 of potentiometer 79 may have imparted to it a potential which, if imposed on the grid of triode 51, would maintain both relays 35 and 36 de-energized and so that the potential drop from y to x will substantially equal that from y to z when no sound other than that originating from speaker 20 reaches the microphone 66. The resistances 61, 62, 67, and 68 are so proportioned that a change in speaker output will produce substantially equal changes in the respective voltage drops across resistances 62 and 67. If the normal voltage-drop across the winding of relay 35 is not of a magnitude to produce the desired bias on the grid of triode 53 the leads from such relay-winding and the cathode of such triode, instead of being connected to the same point on the voltage divider 50—52, may be connected to different points thereon.

To facilitate the setting up of the apparatus, the amplifier 15 may include any suitable form of adjustable element (not shown) for varying speaker volume independently of potentiometer 16—17. Also, one or both of the motor-operated contacts 17 and 78 may be adjustable on its driving shaft, or one or both of the annular resistance elements 16 and 79 may be mounted for adjustment about its axis, to vary the relation between the respective settings of the contacts 17 and 78.

If it should be desired to substitute manually operated control of speaker output for the automatic control provided by the apparatus connected to socket 10, I may employ a socket 90 which will receive plug 11 and which, through conductors 44'', 43'', and 45'', will serve to connect the conductors 44, 43, and 45 respectively with the movable contact and fixed contacts of a single-pole, double-throw switch 91 the movable contact of which is desirable biased to open position. By operation of the switch 91, the supply wire 42 may be connected to either terminal 33 or 34 of the motor 25, thus making it possible to cause the motor to move the contact 17 of potentiometer 16 and lower or raise speaker volume.

We claim as our invention:

1. In combination with an electrically operated, sound-emitting speaker, means for supplying an audio-frequency current thereto, two series-connected resistances, means for creating through one of said resistances a direct current which flows from the point of interconnection of the resistances and which varies in the same sense as does the audio-frequency current supplied to said speaker, means for creating through the other of said resistances a direct current which flows from the point of interconnection of the resistance and which varies in the same sense as does the intensity of sound at a predetermined control point, and means responsive to the potential difference across both resistances for controlling the audio-frequency current supplied to the speaker.

2. In combination with an electrically operated, sound-emitting speaker, means for supplying an audio-frequency current thereto, two electrical circuits, means for creating in one of said circuits an electric current which varies in the same sense as the audio-frequency current supplied to the speaker, means for creating in the

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other circuit an electric current which varies in the same sense as does the intensity of sound at a predetermined control point, and means controlled jointly by the currents in said two circuits for varying the audio-frequency current supplied to the speaker.

3. In combination with an electrically operated, sound-emitting speaker, means for supplying an audio-frequency current thereto, sound-responsive means located at a predetermined control point, means controlled jointly by said sound-responsive means and by the audio-frequency current supplied to said speaker for varying said audio-frequency current.

4. In combination with an electrically operated, sound-emitting speaker, means for supplying an audio-frequency current thereto, and automatic control apparatus for varying said audio-frequency current, said control apparatus including a resistance, means for creating across said resistance a potential-difference responsive to the intensity of sound received at a predetermined control point from sources other than said speaker, means for imposing on one terminal of said resistance a potential proportioned to the current supplied said speaker, and means responsive to the potential at the other terminal of said resistance for controlling said speaker-current.

5. In combination with a loud speaker, an adjustable device for varying the volumes of said speaker, a reversible electric motor for operating said device, and means responsive to the intensity of sound received at a predetermined control point from sources other than said speaker for selectively controlling said motor.

6. In combination, first and second electron discharge devices each having an anode, a cathode, and a control element, a first plate circuit including the anode and cathode of said first device and the winding of a first relay, a second plate circuit including the anode and cathode of said second device and the winding of a second relay, a grid circuit including the cathode and control element of said first device, and a grid circuit including the cathode and control element of said second device, said second grid circuit also including the winding of said first relay so connected in said second grid circuit that an increase in the current flowing in the first plate circuit will reduce the potential of the control element of the second device.

7. In combination, first and second electron discharge devices each having an anode, a cathode, and a control element, a first plate circuit including the anode and cathode of said first device and the winding of a first relay, a second plate circuit including the anode and cathode

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of said second device and the winding of a second relay, and means for causing the potential of the control element of said second device to vary in a sense opposite to the value of the current in the first plate circuit.

8. In combination, first and second electron discharge devices, each having an anode, a cathode, and a control element, a first plate circuit including the anode and cathode of said first device, a second plate circuit including the anode and cathode of said second device, means for imposing a variable potential on the control element of the first device, and means responsive to the value of current flowing in said first plate circuit for varying the potential of the control element of the second device in a sense opposite to that in which said plate current varies.

9. In combination, first and second electron discharge devices each having an anode, a cathode, and a control element, a first plate circuit including the anode and cathode of said first device, a second plate circuit including the anode and cathode of said second device, means for imposing a variable potential on the control element of the first device, and means responsive to the value of current flowing in said first plate circuit for varying the potential of the control element of the second device.

10. The invention set forth in claim 7 with the addition of a translating device selectively controllable by said relays.

11. A method of controlling the volume of an electrically operated, sound-emitting speaker, which comprises controlling current supplied to said speaker in accordance with the difference of potential between two points in an electric circuit and automatically varying such potential difference in accordance with the difference between the intensity of sounds received from all sources at a predetermined control point and the intensity of sound received from said speaker at such control point.

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