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G. W. DEMUTH
VOLUME CONTROL MEANS

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Fig. 1.

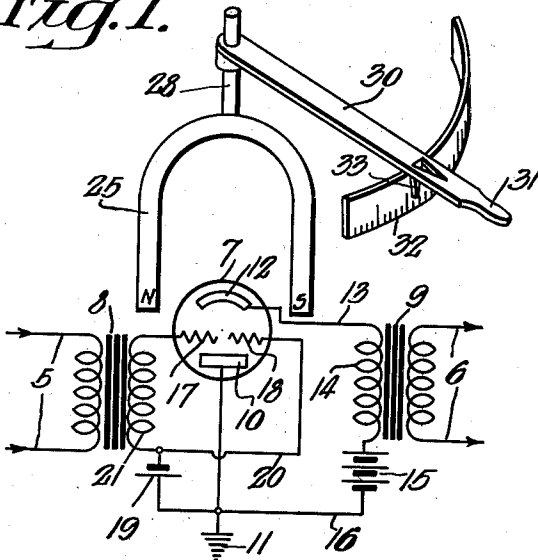


Fig. 2.

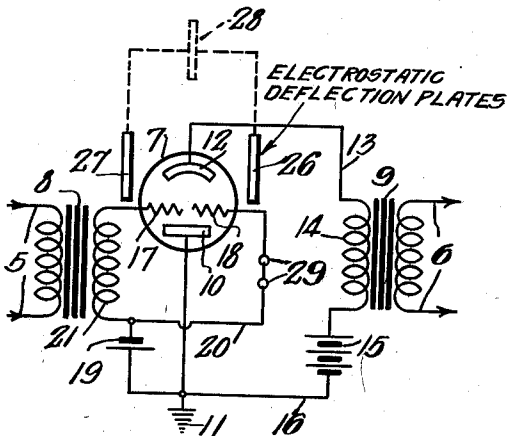


Fig. 3.

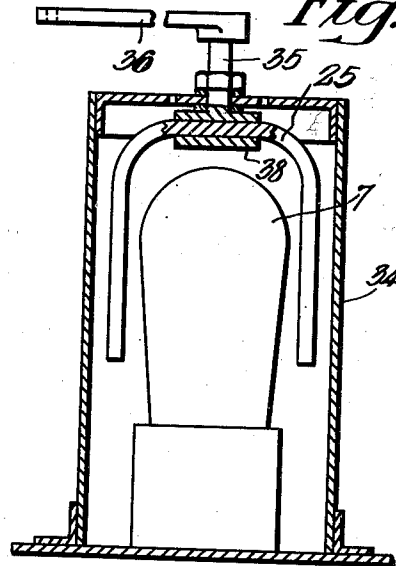
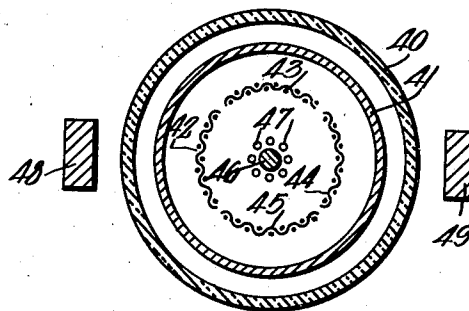


Fig. 4.



Inventor

Galan W. Demuth

By

[Signature]
Attorney

UNITED STATES PATENT OFFICE

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VOLUME CONTROL MEANS

Galan W. Demuth, Moorestown, N. J., assignor to
Radio Corporation of America, a corporation of
Delaware

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11 Claims. (Cl. 179—171)

The present invention relates to a volume control system for signal amplifying channels, and more particularly to a volume control system for audio frequency or sound amplifiers requiring constant variation of gain or output volume over relatively wide volume control ranges.

It is a primary object of the present invention to provide a volume control system for audio frequency or other signal amplifying channels, which may be operated substantially continuously without harmful effects on the volume control function over an extended operating life, and which may be changed rapidly from one position of adjustment to another in a relatively wide control range without introducing spurious electrical disturbances or noise in the circuits being controlled.

It is also a further object of the invention to provide volume control system adapted to be operated by foot pedal control means and having the capability of rapid variation without introducing electrical disturbances or noise in a control circuit and having long life and freedom from mechanical wear.

Volume control means of the type referred to is particularly adapted for use in connection with audio frequency amplifiers for musical instruments, such as electric pianos, organs, and other audio frequency sound producing devices requiring a wide variation in volume control under substantially constant variation, and providing a movable control element which in operation does not cause disturbances in the controlled electrical circuits even under conditions of extremely rapid variation in adjustment. To that end, it is a still further object of the present invention to provide volume control or signal mixing system adapted for the control of audio frequency amplifiers, which eliminates from the electrical circuits, moving contacts or circuit elements and which in operation, from maximum to minimum, does not disturb a steady state of operation in the electrical circuits controlled thereby.

In accordance with the invention, a volume control electronic tube is provided in a signal conveying circuit as a volume control element and is arranged to vary the flow of signals through said circuit without disturbing electrical circuit connections and operating potentials applied thereto, including the applied signal potentials, and with substantially no variation in the flow of anode current in said tube, thereby to eliminate electrical disturbances and

noises in the electrical circuits with volume control variation.

It is also a further object of the present invention to provide a volume control system including a tube and external control means therefor, for shifting the flow of anode current in said tube from one to another of a plurality of differing space paths, one of which passes through an interposed inactive control grid and another of which passes through an interposed active control grid, both grids having a steady state of biasing potential thereon for effecting a uniform flow of anode current in the several space paths and particularly during the transition from one grid to the other.

The electronic tube provided in the signal conveying circuit as a volume-control element comprises a cathode or source of electrons and an anode electrode with a grid structure therebetween providing two grid electrodes having substantially the same control grid characteristics and so located in the electron path that the electron stream may be shifted to flow through one or the other of said grids from the cathode to the anode, or may flow through both grids in any desired proportion under control of an external control element, such as a magnet of the permanent or electromagnetic type, of electrostatic deflecting plates.

It is, therefore, a still further object of the present invention to provide a volume control system embodying an electronic tube having two control grids and means for shifting the electron flow in said tube to pass through either or both of said grids thereby to provide an improved signal fading type of volume control arrangement without changing the anode current of the tube by the signal fading and volume control operation.

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 signal conveying system provided with volume control means embodying the invention;

Figure 2 is a similar schematic circuit diagram showing a modification of the volume control means of Figure 1 and also embodying the invention;

Figure 3 is a side view, partly in section, of a volume control tube and control means there-

for adapted for use in the circuits of Figures 1 and 2; and

Figure 4 is a sectional view, on an enlarged scale, of the volume control means of Fig. 4 showing an electrode arrangement of the tube.

Referring to Figures 1 and 2, in which the same reference numerals are applied to like parts, an audio frequency signal conveying channel is provided with an input circuit 5, an output circuit 6, and a volume control tube 7, coupled to said circuits through suitable audio frequency input and output transformers 8 and 9, respectively.

The tube comprises a cathode or electron source 10, preferably connected to chassis or ground 11 as indicated, and an output anode electrode 12 connected through an anode output circuit 13 with the primary 14 of the output transformer 9, and a source of anode potential 15 having a return connection 16 with the cathode.

Anode current flows between the cathode 10 and the anode electrode 12 through one or both of two control grids or electrodes 17 and 18 in varying proportions and is maintained substantially constant by a fixed bias potential applied to said grids from a suitable source indicated at 19. One grid 18 is connected directly to the bias supply means through a lead 20 and the other grid 17 is connected thereto through a signal input circuit provided by the secondary 21 of the input transformer 8. Thus the grid 17 is actively in the signal circuit while the grid 18 is inactive, except for maintaining a steady state of bias in the grid structure of the tube.

Both grids preferably have identical control characteristics over the electron current so that for the biasing potential provided, the anode current flow through either grid will be the same. Thus the electron stream of the tube may be caused to vary over a plurality of differing paths through the grid structure, that is, through either or both grid electrodes, without appreciably changing the anode current flow, and without introducing electrical disturbances tending to create noise potentials in the audio frequency signal conveying system.

By causing the electron stream of the tube to flow entirely through the grid structure of the grid 17 full amplification of the signals and maximum gain or volume through the amplifying channel is provided, whereas causing the electron stream to flow entirely through the inactive grid 18, causes the transmission of signals or volume to be reduced substantially to zero or any desired minimum. By causing the electron stream to flow through intermediate paths, various degrees of gain or volume may be provided, and variation in volume from one setting to another, may be effected as rapidly as desired, and continuously, without introducing electrical disturbances, as would be the case with variations in anode current or grid circuit variations either as to potential or circuit impedance, so that the control is entirely free of noise by reason of operation in any manner.

The flow of the electron stream through the various paths referred to is controlled by any suitable means for establishing a movable electrical field through the tube, such as magnetic means represented by a permanent magnet 25 of Fig. 1, or electrostatic deflecting plates 26 and 27 indicated in Fig. 2. The deflecting means is mounted to rotate on a suitable axis 28 about the tube on opposite sides thereof in the

manner indicated schematically in the drawing.

As is well known, the electron flow through a tube under control of a magnetic or electrostatic field is across said field between the poles or electrodes of the external controlling means. Thus the magnet or the electrostatic plates, in one position, may cause all the electrons to flow through one grid and in another position may cause all the electrons to flow through the second grid, with intermediate positions of the magnet or deflecting plates causing the electrons or anode current to flow through both grids in varying and corresponding degrees.

Thus the volume of signal flow through said control means may be varied with substantially constant anode current for all positions of the volume control element.

As shown in Figure 1, the volume control element may be controlled by any suitable means such as an operating arm indicated at 30 having an operating handle 31, an indicator scale 32 and indicator 33, providing a required range of adjustment, such as substantially 90°, in the present example.

In case that signal mixing is desired, additional signals from any suitable external source (not shown) may be connected to the terminals indicated at 29 by removing the short-circuit therefrom and, in this case, as the electron stream is shifted from the influence of the grid 17 to the influence of the grid 18, the output circuit 13 will receive signals from the second signal source through the terminals 29 until finally, as the electron stream is fully shifted to the grid 18, full volume output and amplification signals from the second channel will be obtained.

Referring now to Figure 3, in an electrical musical instrument, such as an electric piano, the volume control tube 7 is mounted in a suitable shield casing 34 in the top of which is journaled a rotary shaft 35 having a lever 36 mounted on the outer end thereof for operation by suitable means, such as a pedal control or the like (not shown). The inner end of the shaft 35 is provided with a resilient supporting member 38 for the magnet 25 which depends at its poles about the sides of the tube as shown, to create a magnetic field through the tube.

The control action of the tube may be further understood by reference to Figure 4 along with Figure 3, in which the tube envelope is indicated at 40 with a cylindrical anode electrode 41 of non-magnetic material surrounding a cylindrical grid structure also of non-magnetic material, comprising four substantially contiguous sections or segments 42, 43, 44 and 45, having a common radius or distance from the central cathode 46 for which a central supporting member 47 is provided.

The grid segments 42 and 44 of the structure may be connected to provide the active grid electrode and the segments 43 and 45 may be connected to provide the inactive grid electrode. It will be seen that with the magnet poles, indicated at 48 and 49, in the positions shown, the electron flow from the cathode 46 will be entirely through the active grid structure and full control and amplification of applied signals will be effected.

When the magnet is rotated 90°, it will be seen that the electron flow will be through the inactive grid structure and the signal flow through the device will be reduced substantially to zero.

Intermediate positions of the magnet to cause the poles to lie in intermediate positions will cause a corresponding change in the path of the anode current. As more anode current is caused to flow through the active grid structure 42—44, a corresponding increase in the amount of amplification or volume will result. The operation for signal mixing is the same except that signals from a second source are applied to the normally inactive grid, as hereinbefore described. In any case, however, the volume or signal mixing variation produces no change in the steady state of the circuit or of the operating potentials and substantially no variation in anode current, whereby the volume control and signal mixing may be effected substantially noiselessly regardless of the rapidity of movement of the controlling element.

Furthermore, it will be seen that with a single movable control element having a simple mechanical movement, the continued operation of the device, as in an electric piano for variation in volume, has substantially no effect upon the life of the control means, slight mechanical wear of the bearing will not introduce noise into the electrical circuit. It has been found desirable, however, to mount the tube and control element in a shield casing as shown in Figure 3 and it is preferable that it be mounted in such a manner that the tube and magnet are substantially free from vibration.

I claim as my invention:

1. In a signal amplifying system, a volume control circuit comprising an amplifier tube having a cathode, a signal input electrode, an output anode, signal input and output circuits for said tube providing a steady state of operation therefor, and means for shifting the flow of anode current between said anode and cathode from a path through said input electrode to a second path between said anode and cathode exclusive of said input electrode, substantially without change in the value of said anode current in said output circuit and the steady state of operation of said tube.

2. In a signal amplifying channel, a volume control system comprising an amplifier tube having a cathode, a control grid, an output anode and circuits for said tube including an output anode circuit providing a steady state of operation therefor, said grid comprising one section of a divided grid structure, a second section of said structure inactive in response to signal applied to said first grid having substantially the same control grid characteristic with respect to the flow of anode current in said tube as said first named control grid, and means for shifting the flow of anode current from a path through said control grid to a path through the second section of said grid structure to control the signal flow in said output circuit with substantially constant anode current and without change in the steady state of operation of the tube.

3. In a signal channel, a volume control system comprising in combination, an electron tube having a cathode, an output anode electrode, a signal output circuit connected between said anode electrode and said cathode, a grid structure interposed between said cathode and anode electrode providing a pair of control grids, and biasing means for said grids permitting the shifting of the electron stream of said tube from a path through one grid to a path through the other grid with substantially constant anode current, means for applying signals to at least one of said grids,

and means providing a movable electrical field in said tube for shifting said electron stream.

4. In a signal channel, a volume control system comprising in combination, an electron tube having a cathode, an output anode electrode, a signal output circuit connected between said anode electrode and said cathode, a grid structure interposed between said cathode and anode electrode providing a pair of control grids and biasing means for said grids permitting the shifting of the electron stream of said tube from a path through one grid to a path through the other grid with substantially constant anode current, means for applying signals to at least one of said grids, means external to the tube for establishing an electrical field through said tube in a direction to control the path of the electron stream, and means for adjusting said last-named means to shift the path of the electronic stream within the tube through a predetermined range including each of said grids to the exclusion of the other.

5. In a signal amplifying channel, a volume control system comprising an amplifier tube having a cathode, a signal input grid, an output anode, signal input and signal output circuits for said tube connected with said tube electrodes and providing a steady state of operation and operating potentials therefor, and means for shifting the flow of anode current from a path through said input grid to a path exclusive of said grid, substantially without change in said circuits and in the value of said anode current, said last-named means comprising a second grid in said tube having substantially the same control grid characteristics with respect to said anode current as the first-named grid, and positioned to lie in the second-named path of the anode current, a device for establishing an electrical field through said tube, and means for moving said field through a predetermined range of movement for shifting the flow of anode current from one path to the other to control the signal flow in said output circuit.

6. In a signal amplifying channel, a volume control system comprising an amplifier tube having a cathode, a signal input grid, an output anode, signal input and signal output circuits for said tube connected with said tube electrodes and providing a steady state of operation and operating potentials therefor, and means for shifting the flow of anode current from a path through said input grid to a path exclusive of said grid, substantially without change in said circuits and in the value of said anode current, said last-named means comprising a device providing a movable electrical field through said tube and a second grid in said tube having substantially the same control grid characteristics with respect to said anode current as the first-named grid and positioned substantially contiguous to said first-named grid and in the second-named path of the anode current, and means for applying signals to said second grid, whereby fading control of signals on said grids is provided in response to shifting of the anode current flow.

7. In an audio frequency amplifier, the combination with a signal input circuit and a signal output circuit, of an amplifier tube having a cathode, an output anode coupled with said output circuit, and a control grid structure interposed between said cathode and anode providing a pair of grid electrodes having substantially the same control characteristics and being responsive to predetermined biasing potentials for establish-

ing substantially the same anode current flow in the space path of the tube through either grid electrode, means for establishing a magnetic field through said tube in a direction to control the path of the anode current through said tube, means for causing said magnetic field to shift through a range of movement having one limit at which the anode current is caused to traverse one grid electrode and in another limit at which the anode current is caused to traverse the other grid electrode with intermediate paths of current flow through both grids corresponding to intermediate positions of adjustment of said field in the said range of movement, and means for coupling one of said grid electrodes to said signal input circuit.

8. In an audio frequency amplifier, the combination of an amplifier tube provided with a pair of grid electrodes having substantially the same control characteristics to cause the anode current flow through either grid electrode to be substantially the same, means for establishing a magnetic field through said tube in a direction to influence the flow of anode current through said tube, means for causing said magnetic field to shift through a range of movement to cause the electron flow in one extreme position to traverse one grid electrode and in another extreme position to traverse the other grid electrode, with intermediate degrees of current flow through both grids corresponding to intermediate positions of adjustment of said field in said range of movement, means providing a signal input circuit for each of said grid electrodes thereby to effect fading control in the output circuit of signals applied to said grid electrodes through said input circuits as the magnetic field is moved through said range of movement.

9. In a volume control system for sound-producing electrical apparatus, the combination of a volume control tube of the electron discharge amplifier type, means for creating an electrical field through said tube, means providing a pivotal mounting for said last-named means having an operating element to shift said field, said tube having two control grids arranged to be traversed by the electron stream of said tube when said operating element is moved to shift the electrical

field through a predetermined range and being arranged to permit the electron stream to shift gradually from a path through one to a path wholly through the other of said control grids, means for applying signals to at least one of said grids, and means for establishing a biasing potential on said grids such that the electron stream provides substantially constant anode current when shifted from one path to another.

10. In a volume control system for sound-producing electrical apparatus, the combination of a volume control tube of the electron discharge amplifier type, a casing for said tube, means in said casing for creating a deflecting field through said tube, means providing a pivotal mounting for said last-named means having an operating element projecting through said casing to shift said field, said tube having a control grid structure providing two control grids arranged to be traversed by the electron stream of said tube when said operating element is moved to shift the electrical field through a predetermined range and being arranged to permit the electron stream to shift gradually from a path through one of said control grids to a path wholly through the other of said control grids, means for applying signals to at least one of said grids, and means for establishing a biasing potential on said grid structure such that the electron stream provides substantially constant anode current when shifted from one path to another.

11. In a signal channel, a volume control system comprising in combination, an electron tube having a cathode, an output anode electrode, a signal output circuit connected between said anode electrode and said cathode, a pair of control electrodes interposed between said cathode and anode electrodes, means for applying signals to at least one of said control electrodes, and means external to said tube providing a movable electrical field through said tube for shifting the electron stream between said cathode and anode electrode in said tube from a path through one of said control electrodes to a path through the other of said control electrodes with substantially constant anode current.

GALAN W. DEMUTH.