Nov. 12, 1940. T. J. HENRY 2,221,744

VOLUME CONTROL TUBE

Filed Sept. 30, 1939

Fig. 1

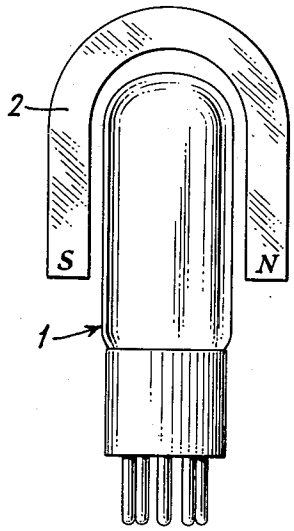


Fig. 3

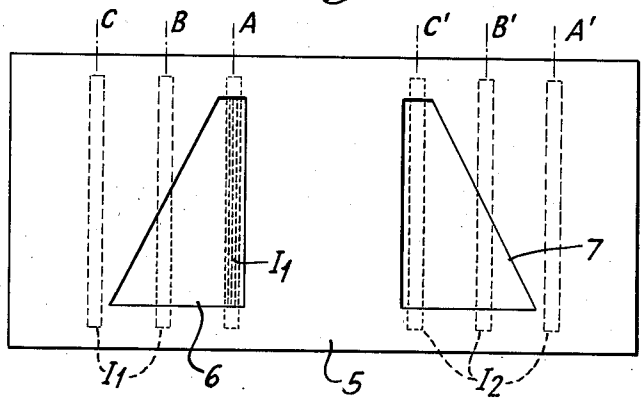


Fig. 2

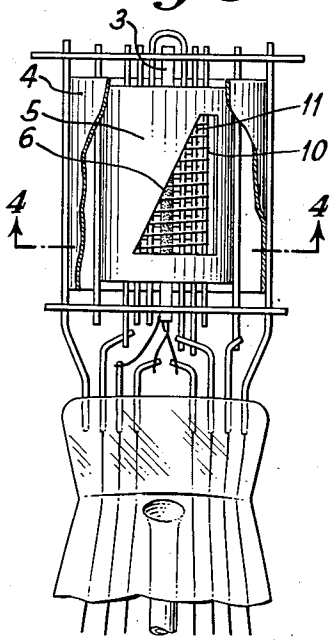


Fig. 4

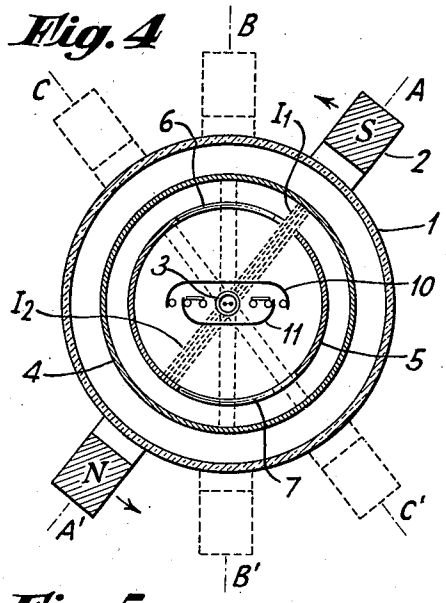
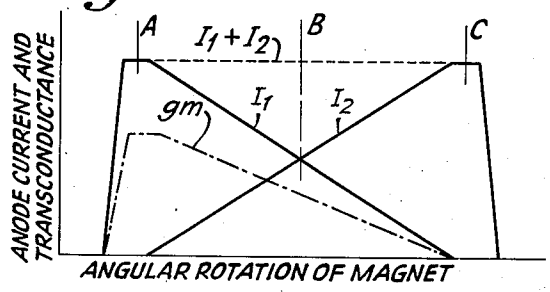


Fig. 5



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VOLUME CONTROL TUBE

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Application September 30, 1939, Serial No. 297,304

3 Claims. (Cl. 250—27.5)

My invention relates to volume control devices, particularly volume control tubes for signalling systems such as radio frequency or audio frequency amplifiers.

The principal object of my invention is an improved volume control tube in which gain or amplification of the tube may be varied at will and in which the direct current component of the output current remains substantially constant.

A more specific object of my invention is to make a volume control tube that is rugged in construction, easy to use, and commercially feasible to manufacture.

The copending application of Herbert M. Wagner, Serial No. 297,281, filed September 30, 1939, and assigned to the assignee of this application, discloses a volume control tube comprising a cathode, anode and apertured masking electrodes with a rotatable magnet for directing an electron beam into or out of registry with the apertures to control the space current to the anode. My improved tube embodies this principle of magnetic control, is designed for good mechanical construction and insures constant current in the output circuit of the tubes as the output signal level is varied.

The characteristic features of my invention are defined in the appended claims and the preferred embodiment is described in the following specification and shown in the accompanying drawing in which Figure 1 is an elevation of my improved tube mounted with a horseshoe magnet; Figure 2 shows the electrode assembly of my improved volume control tube; Figure 3 shows a flat development of the masking electrode of my improved tube; Figure 4 shows a transverse cross section of my improved tube with electron beams diagrammatically represented in three positions, and Figure 5 is a graphic representation of anode current and transconductance of my improved tube.

Figure 1 shows my novel volume control device mounted on the panel of my amplifier apparatus and comprises a tube 1 of conventional envelope and basic construction with its longitudinal axis coincident with the center of a journal of a magnet 2 of the horseshoe type, the poles of the magnet being positioned on opposite sides of the tube. Rotation of the magnet may vary the amplitude of the signal in the output circuit of the tube from zero to the maximum signal level capable of the tube.

One preferred embodiment of my novel tube, shown in Figures 2, 3 and 4, comprises a cathode, preferably of the indirectly heated type, coaxial with a cylindrical anode 4. Between the anode and cathode and coaxial therewith is a cylindrical masking electrode 5 of sheet metal coaxial with the cathode and anode. Slotted windows or openings 6 and 7 are made in the masking electrode opposite two emitting sections of the cathode, the openings preferably being on opposite sides of the cathode. A magnet with poles placed on opposite sides of the cathode draws the electrons into two relatively flat beams, the beams extending the coated length of the cathode and terminating at their ends on the cathode and anode. Movement of the poles of the magnet by rotation rotates the beams into or out of registry with the slotted openings in the masking electrode and thus controls the electron current through each opening.

In Figure 3 the cylindrical masking electrode is shown developed and laid out flat to better illustrate the slotted openings in the electrode. Dotted sections A, B and C represent three positions of beam I_1 from one side of the cathode, and sections A', B' and C' represent the three corresponding positions of the other electron beam I_2 for three positions of the magnet. With the sides of the slots tapered in opposite directions as shown, one beam is moved toward the wider section of one slot as the other beam is moved toward the narrow portion of the other slot, so that as one beam produces maximum current to the anode the other beam is completely interrupted by the masking electrode and produces no current to the anode. The graphic representation of the two currents in Figure 5 shows how they add to a constant value irrespective of the position of the magnet in the operating range of the magnet. The current to the masking electrode also remains constant.

A signal grid 10 is placed in the path of one beam opposite one emitting section of the cathode to signal modulate the one beam. This grid may conveniently comprise two side rods in a plane transverse to a line through the openings with a ladder type arrangement of grid wires joined at their ends to the side rods. In the tube illustrated a second grid 11 with side rods and ladder type grid wires placed across the other emitting section of the cathode is provided with the side rods of both grids in a common plane. Grids 10 and 11 may each conveniently be made by winding a fine wire on side rods, notching and peening the wires in place in the usual manner and then cutting away the wires

on one side of the side rods. The spacing of the grid wires along the side rods and from the cathode of the two grids is preferably chosen so that with the same bias on the two grids the same current flows in the two beams of electrons. In operation one grid is connected to the signal input circuit for the tube and the other grid is connected to a fixed biasing source. As the magnet is rotated the signal modulated beam reaching the plate varies and the transconductance, *gm*, of the tube, as graphically represented in Figure 5, varies from a maximum to zero. A third pair of rods in the plane of the grid side rods with the rods on opposite sides and close to the cathode may be provided to improve forming of the beam and shield the control grid. The shielding rods may conveniently be connected to the side rods of grid 11.

Rapid rotation of the magnet changes the gain only and can cause no undesirable noise in the speaker circuit, as distinguished from the conventional volume control devices where plate current is changed with volume change. In my improved tube the transconductance only of the tube is changed in volume control.

The ends of the side rods of the grids and masking electrodes and the ears at the ends of the anode and the ends of the cathode may be inserted in holes in mica spacers and the electrode assembly mounted on lead-in conductors in the usual way. My improved tube may thus be assembled, exhausted, sealed off and based in the manner extensively used in the manufacture of radio tubes. My improved tube has new and useful electrical characteristics, is rugged in construction and easy to make.

I claim:

1. A cathode, an anode, means for forming two beams of electrons from the cathode to the anode, means for rotating said beams about the cathode as a pivot, a masking electrode between the cathode and anode, said masking electrode having two windows on opposite sides of said cathode, the edges of one window converging toward a point in the masking electrode to decrease the electron current to the anode as the beam through said one window is rotated toward said point, the other window having edges converging toward a point so that the corresponding rotation of said other beam moves the other beam away from said second mentioned point and increases current through the window to said anode, and a grid in the path of one beam.

2. In combination a cathode, a tubular anode coaxial with said anode, a tubular masking electrode of sheet metal coaxial with said cathode and inside said anode, said masking electrode having windows on opposite sides of said cathode, a grid between said cathode and one window and another grid between said cathode and the other window, and a magnet with poles on opposite sides of said cathode, said magnet being rotatable on an axis coincident with said cathode.

3. An electrode assembly comprising two parallel insulating spacers, a cathode, a tubular anode coaxial with said cathode, a tubular masking electrode of sheet metal, said cathode, anode and masking electrode being supported at their ends in said spacers, windows in said masking electrode on opposite sides of said cathode, four side rods in a plane transverse to the plane through said windows, grid wires between one window and said cathode supported at their ends upon two of said rods and a second set of grid wires supported at their ends between the other window and the cathode supported at their ends on the other two side rods.

THOMAS J. HENRY.