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G. K. TEAL

2,160,797

ELECTRON DISCHARGE APPARATUS

Filed Nov. 20, 1936

FIG. 1

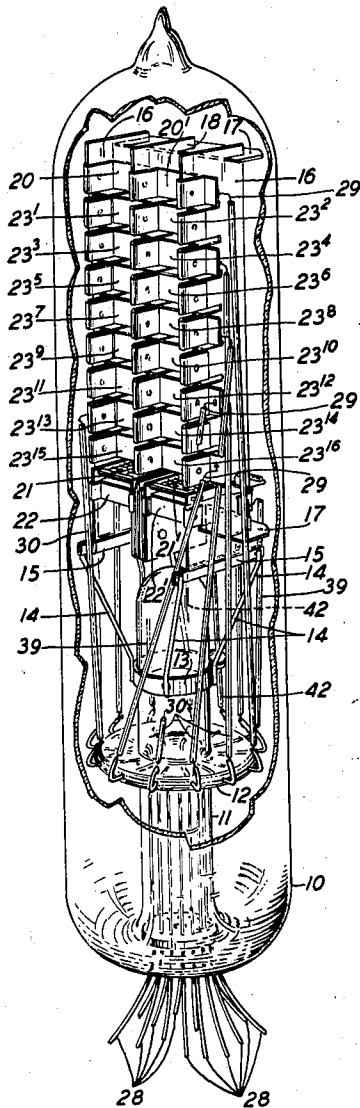


FIG. 2

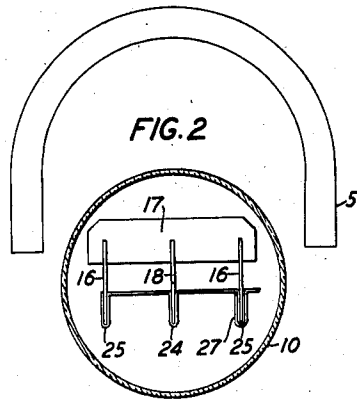


FIG. 3

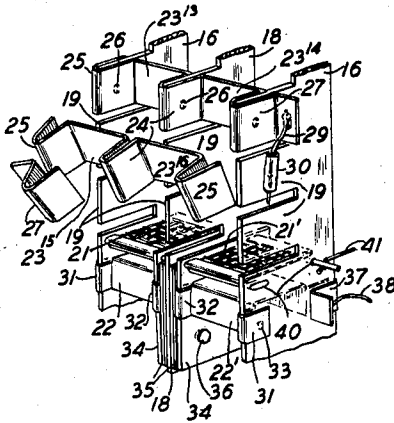


FIG. 4

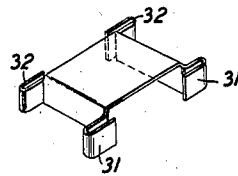
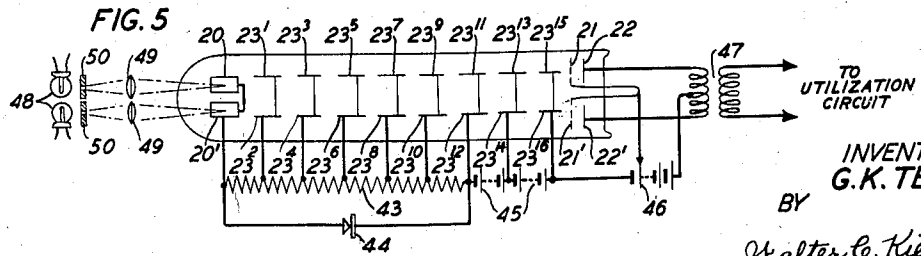


FIG. 5



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ELECTRON DISCHARGE APPARATUS

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Application November 20, 1936, Serial No. 111,809

7 Claims. (Cl. 250-166)

This invention relates to electron discharge apparatus and more particularly to push-pull amplifiers including electron discharge devices having secondary electron emitting electrodes.

One object of this invention is to simplify electron discharge amplifying apparatus and thereby to reduce the number of component elements requisite to produce a desired high degree of amplification.

Another object of this invention is to simplify and to improve the structure of electron discharge devices comprising a plurality of groups of electrodes within a single enclosing vessel.

In one illustrative embodiment of this invention, a push-pull amplifier comprises an electron discharge device including a pair of primary cathodes, a pair of anodes or collector electrodes each in cooperative relation with one of the primary cathodes, and a plurality of equal rows of secondary cathodes, each row being in alignment with one of the primary cathodes and in cooperative relation with the corresponding anode or collector electrode.

The secondary cathodes in each of the rows may be channel shaped, for example rectangulated U in form, and disposed edge to edge with corresponding surfaces substantially coplanar as described in my copending application, Serial No. 111,808, filed November 20, 1936. Corresponding secondary cathodes in the two rows may be electrically connected.

The electrodes may be disposed in a strong magnetic field, which may be at substantially right angles to the axis of alignment of the cathodes and substantially parallel to the bases of the secondary cathodes. Successively increasing positive potentials may be applied to the secondary cathodes so that each secondary cathode is at a potential higher than that upon the next preceding one with reference to the corresponding primary cathode. An output circuit is connected to the anodes or collector electrodes.

The primary cathodes may be energized in any suitable manner to cause the emission of electrons therefrom and means are provided for varying the energization in accordance with a signal to be amplified, so that when the electron stream from one of the primary cathodes is increased that from the other of these cathodes is decreased to an equal degree. The primary electrons, under the influence of the magnetic field and the potentials upon the electrodes, are directed toward the secondary cathodes nearest the primary cathodes and impinge thereupon to cause the emission of secondary electrons. These electrons in turn im-

pinge upon the next succeeding and associated secondary cathodes to cause the emanation of other secondary electrons. This action is repeated at each of the secondary cathodes and the electrons emanating from the cathodes furthest removed from the primary cathodes flow to the collector electrodes and constitute the output current.

The secondary cathodes may have portions treated or coated so that the electron streams emanating therefrom are of greater magnitude than the electron streams flowing thereto. Hence, in effect an electron multiplication and an amplification obtains at each of the secondary cathodes.

The invention and the features thereof will be understood more clearly and fully from the following detailed description with reference to the accompanying drawing in which:

Fig. 1 is an elevational view in perspective of an electron discharge device illustrative of one embodiment of this invention, a portion of the enclosing vessel being broken away to show the internal structure more clearly;

Fig. 2 is a top view of the cathode structure included in the device shown in Fig. 1, showing the association of the device with an external magnet;

Fig. 3 is an enlarged detail view in perspective and partly exploded showing the association of the electrodes and the supporting uprights in the device shown in Fig. 1;

Fig. 4 is an enlarged detail view in perspective of a collector electrode or anode; and

Fig. 5 is a circuit diagram illustrating an amplifier embodying an electron discharge device constructed in accordance with this invention.

Referring now to the drawing, the electron discharge device shown therein comprises an elongated enclosing vessel 10 having a stem 11 provided intermediate its ends with an integral annular flange 12. Clamped about the stem 11 is a metallic band or collar 13 which has affixed thereto a plurality, for example four, of rigid uprights or supports 14. The supports or uprights 14 carry a pair of channel shaped parallel cross or tie members 15, each of which securely grasps and supports an insulating support or upright 16, for example a strip of mica or the like. The insulating uprights 16 are maintained in parallel relation by insulating braces or cross members 17, such as strips of mica or the like, having parallel slots in which the uprights 16 are frictionally fitted.

Disposed midway between the uprights 16 and

parallel thereto is a central insulating upright 18, frictionally held at the end thereof remote from the stem 11 in a slot in the upper insulating brace member 17. The upright 18 also may be a strip of mica or the like. The insulating supports 16 and 18 are provided with a plurality of parallel slots to form a plurality of aligned fingers 19 and support a pair of primary cathodes 20 and 20¹, shield or screen electrodes 21 and 21¹, anodes 22 and 22¹, and a plurality of secondary or auxiliary cathodes 23¹ to 23¹⁶ inclusive.

The secondary or auxiliary cathodes 23¹ to 23¹⁶ inclusive are arranged in two equal parallel rows, each in alignment with one of the primary cathodes 20 and the corresponding shield or screen electrode 21 and anode or collector electrode 22. As shown clearly in Fig. 2, the primary and secondary cathodes may be of rectangulated U shape and formed in units of two from a single strip of material having a central channeled flange 24 fitted on one of the fingers 19 of the central upright 18 and end channeled flanges 25 grasping corresponding fingers 19 on the insulating uprights 16. The flanges 24 and 25 may be provided with indentations 26 pressed into the uprights to securely lock the cathodes thereto. Corresponding surfaces of the cathode units preferably are disposed in the same plane. Each cathode strip may have affixed thereto a metallic clip 27 serving as a terminal lug to which a leading-in conductor may be secured.

The cathode strips may be of any suitable metal and portions thereof, for example only the inner surfaces of the strips between the flanges 24 and 25 or all surfaces of the strips, may be treated to assure copious electron emission therefrom. For example, the strips may be of silver and have portions thereof oxidized and treated with caesium to form a coating including silver, caesium oxide and some free caesium.

Suitable potentials, as described hereinafter, may be applied to the primary and secondary cathodes through leading-in conductors 28 extending from the stem 11, sealed in uniform space relation in the annular flange 12 and projecting therefrom. Connecting wires 29 are affixed at one end to one of the conductors 28 and at the other end to one of the terminal clips 27. Preferably all but the ends of the wires 29 are encased in insulating material, such as glass sleeves 30.

Each of the anodes or collector electrodes 22 and 22¹, as shown clearly in Fig. 4, comprises a plate member provided at its corners with integral U shaped flanges 31 and 32, the flanges 31 grasping the insulating uprights 16 and being locked thereto by indentations 33. The flanges 32 grasp and are locked to insulating strips 34 which are spaced from each other by other insulating strips 35 and are affixed to the central upright 18, together with the insulating strips 35, as by rivets 36, only one of which is shown. Each anode has affixed thereto a terminal clip 37 to which there is secured a connecting wire 38, encased in a glass sleeve 39, in turn secured to one of the leading-in conductors 28.

The shield or screen electrodes 21 and 21¹ include a coarse mesh screen supported by rigid wires 40 extending through the insulating uprights 16 and the insulating strips 34. Suitable potentials may be impressed upon these electrodes by tie wires 41 each connected to one of the wires 40 and one of the leading-in conductors 28, and encased in an insulating sleeve 42.

During operation of the device, the secondary cathodes 23 are operated at successively higher

positive potentials with respect to the primary cathodes. For example, the first secondary cathodes 23¹ and 23² may be operated at a potential of the order of 135 volts positive with respect to the primary cathodes 20 and 20¹ and the next secondary cathodes 23³ and 23⁴ may be operated at a potential of the order of 135 volts positive higher than the cathodes 23¹ and 23². The remaining cathodes are maintained at positive potentials of the order of 135 volts higher than the next preceding ones. The shield or screen electrodes 21 and 21¹ may be operated at a positive potential of the order of 135 volts above that upon the secondary cathodes 23¹⁵ and 23¹⁶ and the anodes 22 and 22¹ may have a positive potential of the order of 250 volts higher than that of these cathodes applied thereto. The various potentials may be obtained conveniently as illustrated in Fig. 5, wherein a number of the secondary cathodes are shown connected to equally spaced points on a potentiometer 43 supplied by a suitable source such as a rectifier 44. Because of the large current drains the last two pairs of secondary cathodes are supplied with potentials from separate sources such as batteries 45, and the anodes and screen electrodes are connected to a separate source such as a battery 46. The anodes 22 and 22¹ may be connected to opposite ends of the primary winding of a transformer 47, the secondary winding of which is connected to a utilization circuit.

A magnetic field of constant and high intensity is produced, during operation, as by a magnet 51, at substantially right angles to the longitudinal axis of the enclosing vessel 10 and substantially parallel to the faces of the primary and secondary cathodes.

The primary cathodes 20 and 20¹ may be energized to cause the emission of electrons therefrom by light beams emanating from sources, such as lamps 48, and focussed upon the coated portions of the cathodes by lenses 49. The intensity of the light beams may be varied in accordance with a signal to be translated, as by films 50, the films preferably being so striated and correlated that the variations in the two light beams are equal but opposite in phase, that is, as the intensity of one beam is increased the intensity of the other beam is decreased to an equal degree. If, desired, in order to reduce the impedance of the amplifying system, the two signal light beams may be super-imposed upon biasing beams in phase.

Under the influence of the magnetic field and the potential gradients extant in the device, the electrons emanating from the primary cathodes 20 and 20¹ are directed to and impinge upon the secondary cathodes 23¹ and 23² respectively and cause the emission of secondary electrons therefrom. These secondary electrons in turn are attracted to and impinge upon the secondary cathodes 23³ and 23⁴ to cause the release of other secondary electrons. This action is repeated at each of the secondary cathodes and the secondary electrons emanating from the cathodes 23¹⁵ and 23¹⁶ flow to the collector electrodes or anodes 22 and 22¹ and constitute the output current. As will be apparent from Fig. 5, the electrodes of the discharge device are so associated as to constitute two units connected in push-pull, one unit comprising the primary cathode 20, shield electrode 21, collector electrode 22, and the secondary cathodes 23 having odd exponents and the other unit comprising the primary cathode 20¹, shield electrode 21¹, collector electrode 22¹ and the sec-

ondary cathodes 23 having even exponents. The channel-shaped form of the cathodes prevents substantial lateral dispersion of the electrons and assures the formation of two substantially independent electron streams, one along each of the electrode units.

Since, as described heretofore, portions of the secondary cathodes are specially treated, the electron streams emanating from each of these cathodes will be materially greater in intensity than the electron stream flowing thereto from the next preceding cathode. Hence, in effect an electron multiplication occurs at each of the secondary cathodes and an amplification of the signal corresponding to the light beams playing upon the primary cathodes obtains. The degree of amplification will be dependent upon, among other factors, the character of the treated surfaces of the cathodes, the potentials upon the electrodes and the parameters of the electrodes. In devices of the specific construction heretofore described, amplifications of the order of 18,000 have been obtained.

As described more fully in my copending application, Serial No. 111,808, filed November 20, 1936, the output characteristics of the device are dependent upon the depth, height and width of the secondary cathodes and it has been found that if the depth and width are properly related, a linear relationship may be obtained between the intensity of the light beams and output current.

Although a specific embodiment of the invention has been shown and described, it will be understood that this embodiment is merely illustrative of the invention and that various modifications may be made therein. For example, although in the specific embodiment disclosed each electrode unit includes eight secondary cathodes, a greater or lesser number may be employed. Also, although the primary cathodes 20 and 20¹ have been shown as of the photoelectric type, other types, for example thermionic, directly or indirectly heated, may be utilized and separate grids provided adjacent the primary cathodes for varying the electron streams from the primary cathodes to the first secondary cathodes 23¹ and 23² in accordance with the signals to be translated. Moreover, the primary cathodes may be energized by an electron beam or beams directed thereupon from a suitable electron source within the enclosing vessel. Other modifications may appear to those skilled in the art without, however, departing from the scope and spirit of this invention as defined in the appended claims.

What is claimed is:

1. Electron discharge apparatus comprising a plurality of primary cathodes, a plurality of laterally adjacent rows of secondary cathodes, each of said rows being in alignment with a corresponding one of said primary cathodes, means segregating the electron emissive surfaces of the secondary cathodes in each row from the emissive surfaces of the cathodes in the other rows, a plurality of collector electrodes each in cooperative

relation to a corresponding row of said secondary cathodes, and means electrically connecting corresponding secondary cathodes in said rows.

2. Electron discharge apparatus comprising a pair of primary cathodes, a pair of collector electrodes each in alignment with one of said primary cathodes, and a pair of rows of superposed channel shaped secondary cathodes, the secondary cathodes in each row being mounted edge to edge, each row being in alignment with one of said primary cathodes and the corresponding collector electrode, and corresponding cathodes in said rows being mounted side by side.

3. Electron discharge apparatus comprising a pair of primary cathodes disposed side by side, a pair of collector electrodes insulated from each other and each disposed in alignment with one of said primary cathodes, and a plurality of metallic strip members between said primary cathodes and said collector electrodes, said strip members having two spaced electron emitting portions each in alignment with one of said primary cathodes and the collector electrode corresponding thereto and having a flange segregating said electron emitting portions.

4. Electron discharge apparatus comprising a pair of primary cathodes, a pair of collector electrodes each in alignment with one of said primary cathodes, and a plurality of conductive strip members between said primary cathodes and said collector electrodes, each of said strip members including two U-shaped electron emitting portions each disposed in alignment with one of said primary cathodes and the collector electrode corresponding thereto.

5. Electron discharge apparatus in accordance with the next preceding claim wherein the U-shaped portions of successive strip members are disposed edge to edge with corresponding sides thereof in common planes.

6. Electron discharge apparatus comprising a unitary assembly including a pair of insulating supports, a pair of primary cathodes supported adjacent one end of said supports, a pair of collector electrodes affixed to said supports adjacent the other end thereof, and each in cooperative relation to a corresponding one of said primary cathodes, a plurality of metallic members disposed one above the other between said primary cathodes and said collector electrodes and having two spaced electron emitting portions each in alignment with one of said primary cathodes and the collector electrode associated therewith, said metallic members having also aligned flanges between said electron emitting portions, and an insulating support secured to said flanges.

7. Electron discharge apparatus in accordance with the next preceding claim comprising an envelope enclosing the unitary assembly, said envelope having a stem, and means carried by said stem and secured to said pair of insulating supports, mounting said unitary assembly from said stem.

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