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ELECTRON DISCHARGE DEVICE

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FIG. 1

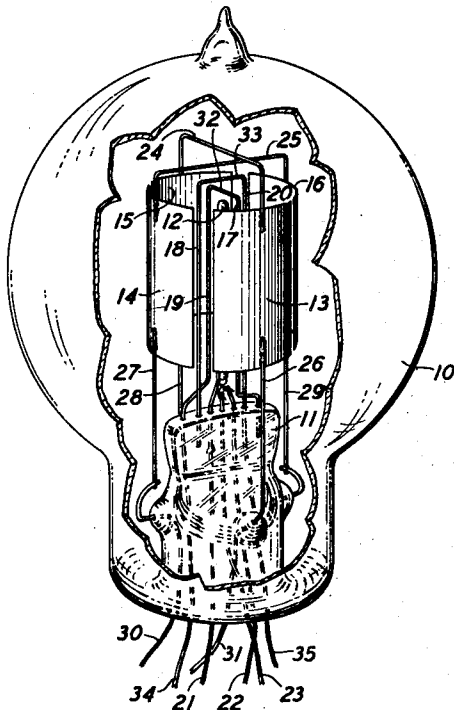


FIG. 3

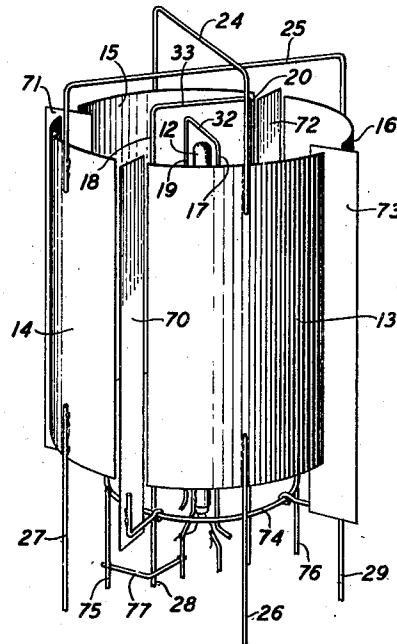
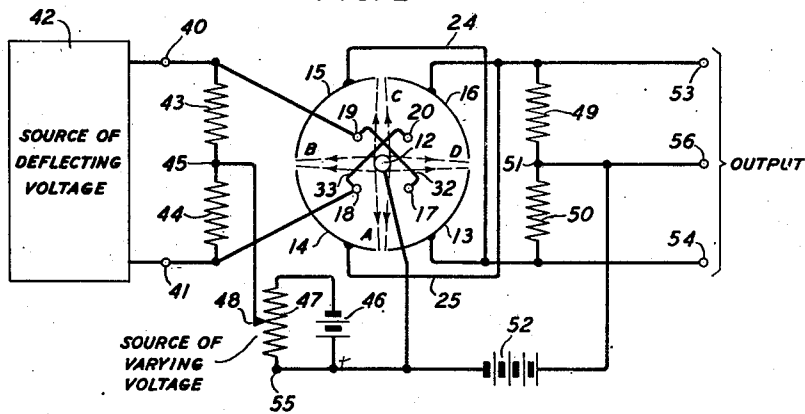


FIG. 2



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ELECTRON DISCHARGE DEVICE

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This invention relates to electron discharge devices and more specifically to devices of this character which operate by controlling the deflection of an electron beam.

5 In ordinary vacuum tubes, the emission of electrons from a cathode is controlled by the voltage supplied to a grid to thereby control the output current. The output current of such a tube, however, is not directly proportional to the input voltage over much of the operating
10 range of voltages and not strictly proportional over any of the range. Cathode ray tubes, on the other hand, ordinarily operate by deflecting a beam of electrons which electrons, for example, have been emitted by a cathode and focused and accelerated toward a target by one or more electrodes at positive potentials with respect to that of the cathode. The deflection may be caused by electrostatic or electromagnetic means. In tubes employing electrostatic deflection, the deflection is directly proportional to the deflecting voltage. This characteristic has been utilized in this invention to provide a tube suitable for many purposes. In its preferred form, the invention comprises a centrally located elongated cathode around which there are concentrically arranged portions of a divided or split anode and means for controlling the emitted electrons.

30 It is an object of this invention to provide an improved cathode ray device of the divided or split target type.

It is another object of this invention to provide forms of cathode ray devices in which two or more of the functions of modulating, focusing and deflecting the beam are performed by the same element or elements.

Other and ancillary objects will be apparent from the description below.

40 In accordance with this invention in a preferred form, an electron discharge device is provided having electrostatic grids which have the multiple function of forming the electron discharge into beams, which are preferably convergent, and switching all or a portion of each beam from a portion of a divided anode to another portion thereof and at the same time controlling the strength of the beam currents. For certain purposes, however, the last-mentioned
50 function may be absent.

In an embodiment of this preferred form of the invention, an electron discharge device is provided which comprises an elongated cathode surrounded by a cylindrical plate which is split
55 into an even number of sections or segments as,

for example, four, as shown in the accompanying drawing. Between the cathode and the anode segments are a number of wires parallel to the axis of the cathode and equidistant therefrom, one for each anode segment, in part performing the function of a grid in the ordinary vacuum tube. They will therefore be referred to as grid wires. The grid wires are all similarly biased negatively with respect to the potential of the cathode and form the electrons into four wedge-shaped beams each of which, in the absence of deflection signals, impinges upon the narrow elongated area between adjacent plate or anode segments. The potential of all the grid wires in common may be varied to control the intensity of the beam. The grid wires are connected into two groups, opposite grid wires being electrically connected together, with separate leads for each group. A varying voltage, which may be, for example, an alternating current voltage, is applied across the two portions of a split grid to cause each beam to swing from one section of the anode to another or to divide the energy of each beam between two sections or segments, depending on the amplitude of the varying voltage. Opposite segments of the anode or plate are connected in common; in effect, there are thus two electrically separate plates in the tube, and the electron stream (considered as a composite of the four beams) divides its energy between or among the plates in accordance with the switching voltage. The grid wires thus serve to focus the electron beams, control the strength of the beam currents (if desired), and to deflect the beams. A tube of this type may be used in high frequency switching operations serving, for example, as a high frequency commutator for dividing the transmission time between two image currents which are alternately transmitted over the line. It will also be apparent from the detailed description below that it may be used for amplifying, for detecting, for the modulation of a high frequency carrier wave with voice or image currents, etc.

The invention will be more readily understood by referring to the following description taken in connection with the accompanying drawing forming a part thereof in which:

Fig. 1 is a perspective view of an electron discharge device embodying the principles of this invention;

Fig. 2 shows a circuit in which a tube of the type shown in Fig. 1 may be used; and

Fig. 3 is an enlarged view of an electrode as-

samely suitable for tubes of the type shown in Fig. 1.

Referring more specifically to the drawing, Fig. 1 shows in perspective an electron discharge device embodying the principles of this invention, the envelope being partly broken away in order to show more clearly the electrode structure therein. The device comprises a gas-tight envelope 10 of, for example, glass, containing a press 11, in which are held in position a cathode 12, four anode sections or segments 13, 14, 15 and 16, and four grid wires or elements 17, 18, 19 and 20, the grid elements being located between the anode elements and the cathode.

The cathode 12 is preferably a metallic cylinder of either the open-end or closed-end type. It is heated by any suitable means (not shown). Coated on the outside of the cathode is a layer of electron emissive material. The connection to the cathode from an external circuit is made through the terminal 21. Terminals 22 and 23 are connected to the heating means of cathode 12 and these terminals are adapted to be connected to a source of potential to produce the heating current. Preferably, the terminal 21 is connected to the mid-point of the current supply for terminals 22 and 23 to prevent the possibility of a "free" input or "floating" element.

Anode segments 13, 14, 15 and 16 may either be segments of a single cylinder as shown in Fig. 1 or each may have two portions one of which is offset from the other, all the offset portions lying in one cylindrical surface, and all the remaining portions in a second concentric cylindrical surface somewhat nearer the cathode, these segments being so positioned that the offset portion of each plate overlaps one end of an adjacent plate. In this latter case each of the anodes 13, 14, 15 and 16 comprises a portion which is a segment of one cylinder and a portion which is a segment of a somewhat larger cylinder. The purpose of the overlapping arrangement is to avoid open spaces between the segments through which projected electrons can pass.

The grids 17, 18, 19 and 20 preferably comprise single wires located between the cathode 12 and the plate or anode segments 13, 14, 15 and 16 and parallel to the axis of the cathode. The grids are located substantially 90 degrees apart and are preferably placed on lines drawn through the cathode to the center lines of the plate or anode segments 13, 14, 15 and 16, respectively. Anode segments 13 and 15 are electrically connected together by a wire 24 which also serves to help support these plates in their proper positions. Anode segments 14 and 16 are electrically connected together by a wire 25 which has a supporting function similar to that of the wire 24. Wires 26, 27, 28 and 29 serve to support the anode segments 13, 14, 15 and 16 from the press 11. External terminals 30 and 31 are connected to the support wires 27 and 26, respectively. Grid wires 17 and 19 are electrically connected together by wire 32 and grid wires 18 and 20 are connected together by wire 33. Wire 19 is connected to an external connection 34 and wire 20 is connected to an external connection 35.

From a consideration of the arrangement described above, it will be immediately apparent that there are two electrically separate plates (or anode assemblies or structures) in the tube, that is, 13 and 15 taken together constitute one plate (electrically) and 14 and 16 taken together constitute the second plate, and two electrical grids, that is, 17 and 19 taken together constitute one

electrical grid and 18 and 20 taken together make up the other.

Due to the symmetry of the grid wires and the anode segments with respect to the cathode, the capacity of each grid with respect to its anode is substantially equal to the capacity between each of the other grids and its corresponding anode.

Fig. 2 illustrates how the tube may be used. A deflecting voltage, as for example, an alternating current voltage is applied between the two electrical grids by means of the terminals 40 and 41 which are connected to a source of deflecting voltage (indicated by the block 42). Across the terminals 40 and 41 are connected equal high resistances 43 and 44, the common terminal 45 of which is connected to a source of varying voltage represented by the source 46 and potentiometer 47 having a movable tap 48. It is obvious, of course, that the source of varying voltage may comprise a fixed direct current bias with a superimposed alternating voltage, such as image or voice signals. The positive terminal of the source 46 is connected to the cathode 12 and thus a negative bias is placed on all of the grid wires 19, 20, 21 and 22 together and causes the electron stream from the cathode 12 to be formed into four beams each having a substantial line focus as indicated in this figure, or the beams may be less convergent so that each of them may impinge partly upon one plate and partly upon another. The latter would be used wherever it is desired to have the energy of each of the beams divisible between two of the plates. For convenience of description these beams have been designated A, B, C and D. Equal high resistances 49 and 50 are connected in series with plates 16 and 13. The common terminal 51 of the resistances 49 and 50 is connected to the positive terminal of a source of potential 52, the negative terminal of which is connected to the cathode 12. The plate or anode segments are thus all placed at a positive potential with respect to that of the cathode 12.

The operation of the circuit shown in Fig. 2 is as follows:

The cathode 12, heated by a heater element (not shown), is caused to emit a stream of electrons which electrons are focused by the action of the negative potentials of the grids 17, 18, 19 and 20 and the positive potentials of the anode segments into four beams A, B, C and D. In the absence of a deflecting voltage or signal from the source 42, each grid is placed at the same potential by means of the source of direct current 46 acting through the potentiometer resistance 47, assuming a stationary position for the tap 48. In this condition, the axes of the beams B and D are at right angles to those of beams A and C and each beam strikes the division line between adjacent anodes 13, 14, 15 and 16. If now a deflecting voltage, which may be, for example, a square topped alternating wave generated by the source 42, a wave suitable for switching, is applied between the terminals 40 and 41, the potential of the grids 19 and 17 will swing from that of the grids 18 and 20. If it is assumed that the potential of the grids 17 and 19 is swinging positive with respect to that of the grids 18 and 20, beam C will swing toward grid 19, beam B will swing toward grid 19, beam A will swing toward grid 17 and beam D will swing toward grid 17. If the switching signal is large enough, beams B and C will both entirely impinge upon plate or anode segment 15 and beams A and D will both entirely impinge upon plate segment 13. In this condition, all of the current flows through resistance 50 and

none through resistance 51. When the potentials of the grids 19 and 17 swing negatively with respect to the potentials of the grids 18 and 20, by analogy, the opposite is true and all of the current flows through resistance 49. When it is desired to completely switch the output current, the voltage from the source 42 is made large enough to cause the beams to impinge wholly upon one anode assembly on the positive half waves and wholly upon the other on the negative half waves. The respective output currents are taken off the terminals 53 and 56 of resistance 49 and terminals 56 and 54 of resistance 50.

If it is desired to use the tube as an amplifier, for example, then each beam is wide enough to bridge the gap between plates, which gap may be small or may be eliminated by overlap as explained above. Then in general the beams A, B, C and D divide their energy between the plates 13, 14, 15 and 16. In this case a portion of the plate current flows through resistance 49 and a portion through resistance 50, the output circuit connected between the outside terminals 53 and 54 of the resistances 49 and 50 receiving the differential current flowing through these resistances. As only a very small deflecting voltage is required to move the beam and this controls a relatively large beam current, an amplified output is obtained in the output circuit between terminals 53 and 54. Typical operating constants which have been used for a tube operating as above described are: plate voltage, 124 volts; grid bias, -22 volts; amplification constant μ 3.8; voltage for complete deflection, 40 volts; beam current, 1.7 milliamperes. However, a wide variety of operating constants may obviously be used.

It may be noted that the type of tube herein described is suitable for so-called "push-pull" operation, the circuit shown in Fig. 2 being a push-pull circuit. In the ordinary vacuum tube push-pull circuit, as one grid or grid assembly swings in the positive direction, the other grid or grid assembly swings in the negative direction. The current in one of the differential output circuits is thus increased while that in the other is correspondingly decreased. By combining the currents of these differential circuits an amplified current is obtained. The principle is that of the well-known Colpitts amplifier disclosed for example in Patent 1,128,292, February 16, 1915. See also "Principles of Radio Communication," by J. H. Morecroft, 1933, page 1004, for a description of push-pull amplification.

When a suitable feedback is provided, the arrangement becomes a push-pull oscillator, the circuit connection being, for example, like that shown in Scriven 1,396,786, November 15, 1921, or Carson 1,463,796, August 7, 1923.

Obviously, the arrangement shown in Fig. 2 may be employed as a modulator of high frequency current as in the well-known push-pull modulator circuits employing ordinary vacuum tubes. The source 42 is then the source of carrier frequency and the modulating signals are applied in the common portion of the divided input circuit. For a description of push-pull modulating circuits like that here shown and modified forms in which a tube of the type here disclosed may be employed, if desired, see for example page 824 of "Principles of Radio Communication," by Morecroft or Carson 1,463,796, August 7, 1923.

When the deflecting voltage is a modulated carrier and the source of varying voltage in the

common branch of the input circuit is of carrier frequency the arrangement functions in the reverse manner and becomes a detector. Any of the well-known push-pull detector circuits may be used.

It will be obvious to one skilled in the art of vacuum tubes how this tube may be used in push-pull circuits for uses other than those mentioned above.

It will be apparent that the grid wires 17, 18, 19 and 20 ordinarily serve the triple function of focusing the electron beams, deflecting the beam so that the current or energy of the composite beam is divided between the effective parts of the anode, and controlling the strength of the beam current.

Condensers may be shunted across resistances 43 and 44, respectively, when the varying voltage applied in the same phase to all the grids is higher in frequency than the switching or deflecting voltage from the source 42, the function of the condensers being to offer a low impedance path to the high frequencies.

Electrons striking a plate will normally cause an emission of secondary electrons with a consequent flow of cross-current from this plate to other plates. If these cross-currents are troublesome they may be substantially suppressed by coating the plates with a material that gives only a small secondary emission, such as carbon, for example.

The arrangement shown in Fig. 3 has not only the advantage of suppressing the secondary electron currents but also causing the beams to switch more sharply from one plate to another. The arrangement is like that shown in Fig. 1 with the addition of electrode elements 70, 71, 72 and 73 located respectively in the openings between adjacent plate segments. These electrodes are placed at a negative potential with respect to the cathode 12, or at the same potential as that of the cathode. They may be supported in any suitable manner, the arrangement shown in Fig. 3 being merely illustrative. As shown, these electrodes are supported from and electrically connected to a metal ring 74 which is held in position in the press 11 (not shown in this figure, but which is similar to the press 11 in Fig. 1), by support members 75 and 76, the support member 75 being electrically connected to cathode 12 by the connection 77. The structure of Fig. 3 is otherwise similar to that of Fig. 1. Inasmuch as the members 70, 71, 72 and 73 have a negative potential with respect to the plate or anode segments 13, 14, 15 and 16 adjacent thereto, they tend to repel secondary electrons emitted by each anode segment back to the anode segment from which they were emitted and thus substantially prevent secondary electron cross-currents. Furthermore, as the electrons of a beam directed to the region between anodes approach the edge of one of these elements, they are deflected laterally by the element because of its negative potential, that is, the beam is split and the two portions are deflected laterally as it passes on to the plates. As the beam moves laterally over the edge of the auxiliary electrode there is a continual relatively rapid shift in the direction of the electrons in the portion of the beam near the edge of the auxiliary electrode. This action is somewhat analogous to a snap switch action, but there is no actual sweep of any elemental portion of the beams across the openings between the plates. As one elemental portion after another of the beam reaches the edge of the auxiliary electrode,

its direction is abruptly changed so that this element of the beam ceases to fall on the plate to which it was previously directed, and passes to the adjacent plate.

Obviously, the grid wires shown in Figs. 1 and 3 may be given various forms and configurations and may be spaced at any desired distances between the cathode and anode plates, the results of such modifications of the exact illustrated arrangement described herein being obvious to one familiar with ordinary vacuum tube and cathode ray tube design. It is also obvious that there may be six, eight, ten, twelve or more anode segments and grid elements in a single tube instead of the number shown in the drawing. Other modifications of the embodiment herein described may obviously be made without departing from the spirit of the invention.

What is claimed is:

1. A cathode beam device comprising a cathode capable of emitting electrons, an anode structure, a plurality of electrostatic electron control elements between said cathode and said anode structure and substantially equidistant from said cathode, each of said elements being spaced from an adjacent element by the same distance, means electrically connecting a group of said elements together to form a unitary control member, and means electrically connecting together a second group of said elements to form a second unitary control member, each element of one of said groups being adjacent an element of the other of said groups.

2. A cathode beam device comprising an elongated cathode, two anode structures insulated from each other, all effective portions of which lie in a cylindrical surface coaxial with said cathode, portions of one of said anode structures being positioned in said surface adjacent similar portions respectively of the other of said anode structures, and two grid structures insulated from each other, all effective portions of which lie on a cylindrical surface between said cathode and said anode structures and coaxial therewith, portions of one of said grid structures being positioned in said second surface adjacent corresponding portions respectively of the other of said grid structures.

3. A cathode beam device comprising a cathode, a plurality of elongated parallel anode members mounted in a cylindrical boundary encompassing said cathode, electron beam forming and controlling means including a plurality of elongated elements mounted between said cathode and said boundary, each of said elements being opposite a corresponding one of said anode members, and means electrically connecting alternate elements into two groups.

4. A cathode beam device comprising an elongated cathode, two anode structures insulated from each other, each comprising an even number of plates each of which is of segmental cylindrical shape, means supporting said anodes in

position surrounding said cathode with narrow openings parallel to said cathode between the edges of adjacent ones of said plates, each plate of one anode structure lying between plates of the other, and two grid structures insulated from each other, all effective portions of which lie on a cylindrical surface between said cathode and said anode structures and coaxial therewith, portions of one of said grid structures being positioned in said surface adjacent corresponding portions respectively of the other of said grid structures.

5. A cathode beam device comprising an elongated cathode, two anode structures insulated from each other, each comprising an even number of plates each of which is of segmental cylindrical shape, means supporting said anodes in position surrounding said cathode with narrow openings parallel to said cathode between the edges of adjacent ones of said plates, each plate of one anode structure lying between plates of the other, and two grid structures insulated from each other, each consisting of two linear elements parallel to said cathode, means supporting said elements in a cylindrical surface between said cathode and said anode structures with each element of one grid structure lying between elements of the other along said surface.

6. A cathode beam device comprising an elongated cathode, two plate-like anodes positioned in a cylindrical surface concentric with said cathode with one edge of each anode parallel to said cathode and also to an adjacent edge of said other anode, two elongated grid elements positioned between said cathode and said anodes respectively, each element being parallel to and equidistant from said cathode, for causing electrons emitted from said cathode to pass therebetween in a converging path and to reach said surface at different positions thereon dependent upon the potentials of said grid elements, and a shield member between the adjacent edges of said anodes.

7. In combination, anode members and two groups of grid structures in respective concentric cylindrical surfaces, a cathode axially positioned with respect thereto, the respective grid structures being spaced with respect to each other and to the anode members to form beams projecting outwardly from the cathode through the spaces between the grid structures toward the anode members, said grid structures when properly biased serving to form the beams normally toward points between the respective anode members and serving to shift the beams away from certain anode members toward other anode members under the influence of applied electromotive forces, said grid structures consisting of elongated elements parallel to said cathode and the grid structures of one of said groups being positioned between corresponding grid structures of the other of said groups.

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