Nov. 10, 1942. R. C. WINANS 2,301,490

ELECTRIC DISCHARGE DEVICE

Filed June 25, 1940 2 Sheets-Sheet 1

FIG. 1

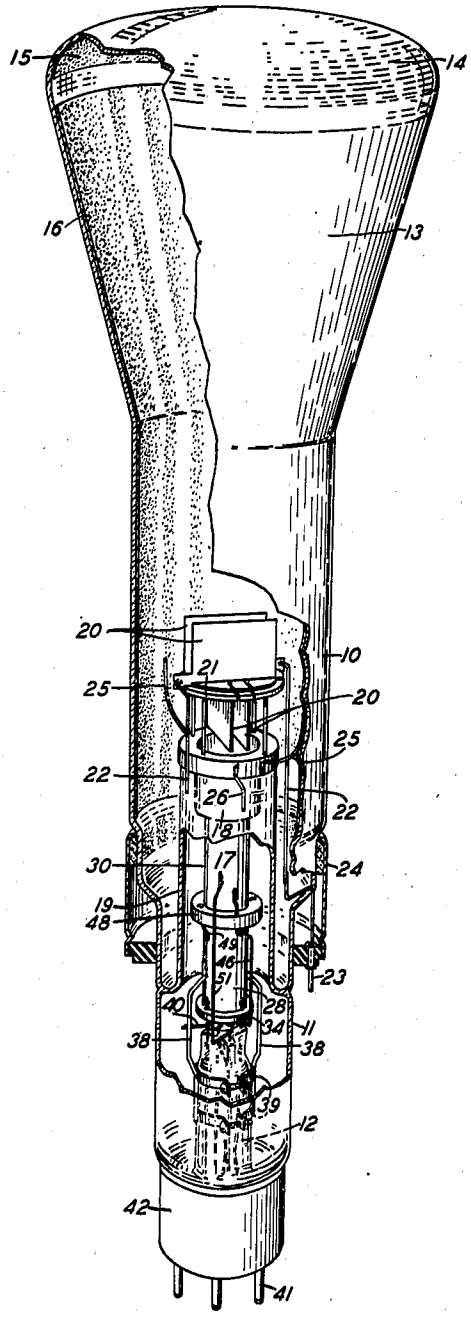
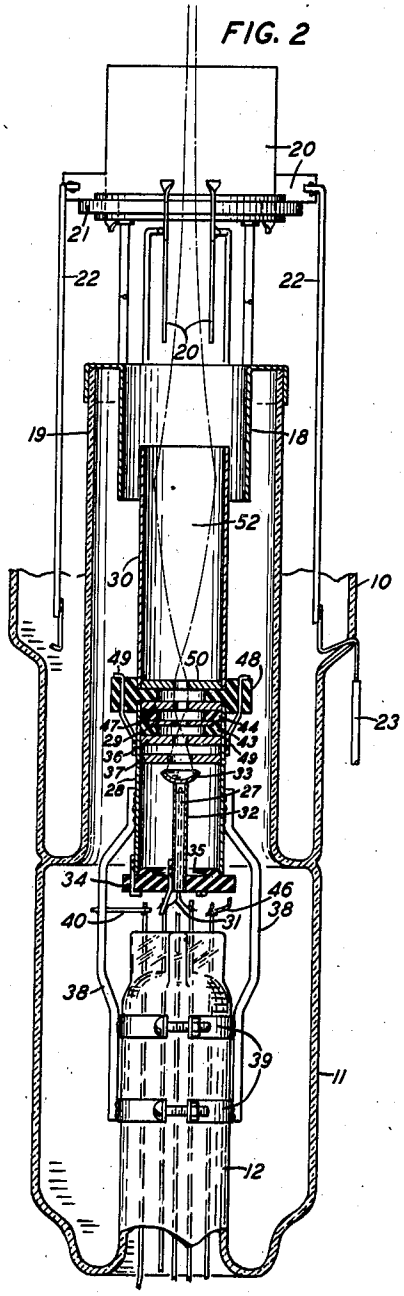


FIG. 2



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Filed June 25, 1940 2 Sheets-Sheet 2

FIG. 3

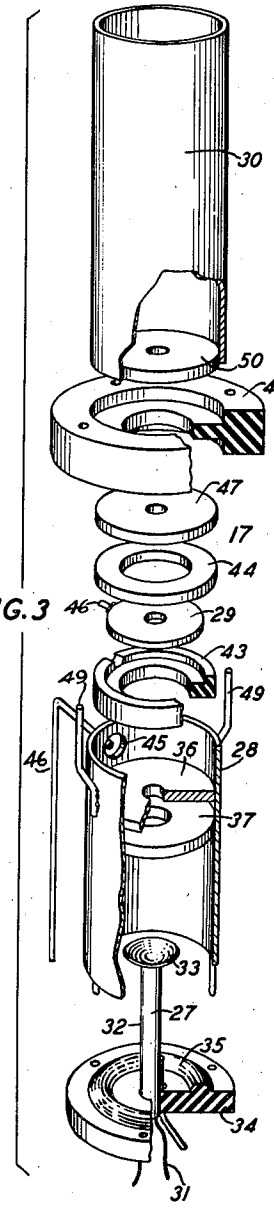
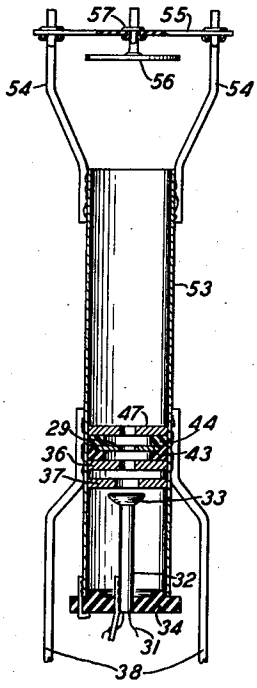


FIG. 4



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2,301,490

ELECTRONIC DISCHARGE DEVICE

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Application June 25, 1940, Serial No. 342,194

6 Claims. (Cl. 250—162)

This invention relates to electronic discharge devices and more particularly to electron beam gun structures therefor.

An object of the invention is to facilitate a sensitive control or modulation of the beam of electrons in projection systems of discharge devices.

Another object of the invention is to produce a sharp cut-off of the beam and obtain discriminate contrast and favorable half-tone reproductions in television systems.

In accordance with this invention, these objects are attained in a device including an electron gun assembly comprising an electron emissive cathode surrounded by an anode with one or more apertured partitions in axial relation to the cathode. The anode potential field initially forms the emitted electrons into a beam of high intensity and the first aperture of the anode is located at or near the primary cross-over point so that the focus of the system may be extended beyond the normal focal point. A second anode is axially aligned with the first anode and a modulator electrode is insulatingly mounted between the anodes and positioned at the common cross-over point of the electrons in the beam so that control of the beam occurs at the point of least potential change and very sensitive modulation may be secured to vary the beam without affecting the paths so as to change the focus of the spot as projected on the screen.

In a more specific aspect of the invention, the gun assembly comprises a concave cathode which produces a maximum gradient along the radii to initially focus the beam of electrons projected toward the screen. The cathode is surrounded by a tubular elongated anode having one or more apertured partitions in axial relation to the cathode so that the focus of the system is extended to an area between the partitions and a modulator electrode is insulatingly mounted between the partitions to facilitate the control of the beam and to effect a sharp cut-off in a field least affected to distort the paths of the electrons. The modulator electrode is supplied with a control voltage by a conductor extending through an opening in the side of the anode adjacent the modulator electrode. A second tubular accelerating electrode extends beyond the first anode and is spaced and supported thereby through a spacing insulating collar which is seated intermediate the anodes. A third tubular anode may be provided to accelerate the electrons in the beam and focus the beam on the screen at the opposite end of the enclosing vessel. The deflection of the beam is provided by a set of plates arranged parallel to the axis of the vessel.

A modification of the invention involves a single elongated tubular anode with the apertured partitions and the modulator electrode positioned therein in relation to the cathode with a target supported by the anode and adapted to be impinged by the beam from the cathode, the beam being cut off under suitable operating voltages applied to the modulator electrode. This arrangement may be utilized in electron switching apparatus employing a high beam current.

These and other features of the invention will be more clearly understood by reference to the following detailed description and the accompanying drawings.

Fig. 1 is a perspective view of one form of a discharge device with portions of the vessel broken away to show the internal electron gun assembly of this invention.

Fig. 2 is an enlarged view in cross-section of the gun assembly of Fig. 1, and the closely associated parts of the vessel and illustrates the details of the gun in assembled relation.

Fig. 3 is a perspective view of the details of the gun assembly in exploded fashion with some of the parts shown in section for clearer representation; and

Fig. 4 is a modified form of the invention in cross-section in which the screen or target is associated with the gun assembly.

Referring to the drawings and Figs. 1 and 2 specifically, the electron beam device of this invention is embodied in an enclosing vessel having a tubular portion 10 joined to an extension 11 which is provided with an inwardly projecting stem 12 forming a support for the lead-in wires and the electron gun assembly. The vessel is also provided with a conical portion 13 terminating in a dome portion 14 which is provided with a fluorescent coating 15 forming an electron responsive surface or screen for indicating the manipulation of the electron beam within the device. The conical and tubular portions are provided with an opaque coating, such as graphite, to reduce reflection of the beam and to form a continuing accelerating surface for the beam in its travel to the screen. The specific construction of the vessel and the advantages thereof are more clearly disclosed and claimed in Patent 2,141,387, issued December 27, 1938 to D. A. S. Hale.

The internal electrode construction involves a unitary electron gun assembly 17 mounted on the stem 12 and projecting axially towards the screen

15 on the end of the vessel. The gun unit is followed by a large diameter accelerating anode 18 supported on a tubular extension 19 within the vessel in telescopic relation to the free end of the gun unit. A set of deflector plates 20 is arranged in parallel pairs, the pairs being at right angles to each other and forming a rectangular passageway about the axis of the vessel. These plates are supported on a platform 21 which is mounted in suitable spaced relation to the accelerating anode 18. A plurality of leading-in conductors 22 extend from the plates and emerge from the vessel at a sealed joint between the tubular portion 10 and the extension 11. These conductors are connected to terminals 23 mounted on an annular base 24, affixed to the vessel below the tubular portion 10. The accelerating anode 18 carries a pair of curved springs 25 which are in contact with the graphite coating 16 and the accelerating voltage is applied to the anode and the coating through a conductor 26 which is joined to a terminal in the base 24.

The gun unit comprises a series of electrodes mounted in axial symmetry including, in the order named, an electron source or cathode 27, a tubular anode 28, a control or modulating electrode 29, and a second tubular anode 30. The electron source may be an equipotential type cathode having an internal heater element 31 insulatingly enclosed in the tubular shell 32 which terminates in a curved head 33. This head is in the form of a section of a sphere of revolution which is coated with electron emitting material, such as barium and strontium oxides which, when activated and heated to emission temperature, generate a copious supply of electrons to be projected into a beam of high current magnitude for energizing the fluorescent coating on the screen 15. The spherical cathode or emitting surface produces a maximum gradient along the radii to initiate focussing of the electrons into a beam to a normal focal point in the gun unit. The cathode structure 27 is centrally supported in an aperture of an insulating disc 34 which is provided with a spacing ridge 35 to form a boundary for the elongated tubular anode 28 which encloses the cathode and is secured to the insulator 34. The anode 28 is provided with a pair of closures or partitions in spaced relation immediately adjacent the surface of the cathode head in the form of apertured metallic discs 36 and 37, the disc 37 adjacent the cathode having a large diameter aperture and the disc 36 having a smaller diameter aperture. A pair of supporting arms 38 extend downwardly from the outer surface of the anode 28 and are attached to a pair of collars 39 clamped about the circumference of the stem 12, one of the arms being connected to a leading-in wire by a short stub wire 40 to apply a suitable positive potential to the anode for accelerating the electrons in the beam. The leading-in wires extending through the stem 12 are connected to terminals 41 carried by a base 42 secured to the extension 11 of the vessel. The accelerating field of the combined structure of the anode 28 and the apertured partitions tends to extend the focus of the beam beyond the normal focal point so that the first cross-over of the electron paths is located beyond the partition 36 in a direction toward the screen.

Since the common cross-over point of the electron paths represents a region of least potential change of the electrons, it is proposed, in accordance with this invention, to control or modulate the beam at this point so that very sensitive modulation may be secured to vary the beam without affecting the paths so as to change the focus of the spot as projected on the screen. This is produced by isolating the modulator or control electrode 29 within the first anode structure by a recessed annular insulator 43 which is fitted within the anode and seated upon the apertured disc 36, the apertured modulator disc 29 being seated or nested in the recess of the ring 43. A flat insulating ring 44 is seated over the ring and disc to completely insulate the modulator element from the anode and the partitions therein. The first anode 28 is provided with an aperture or opening 45 to permit the insertion of a conductor 46 which is secured to the modulator element 29 so that a control voltage may be applied to the modulator. The anode 28 is completed by a supplementary apertured closure disc 47 which maintains the insulation packing of the modulator element in proper position in the anode. A spacing collar or ring 48, of insulating material has an internal flange which forms a seat over the closure 47 and the collar is secured to the anode 28 by wires 49. The second anode 30 having an apertured closure 50 at its lower end is seated on the flange of the collar 48 and is secured thereto so that this anode is in coaxial alignment with the first anode 28. The second accelerating anode 30 is provided with a current conductor 51 in order to supply the accelerating voltage thereto for projecting the beam towards the screen. The envelope 52 of the beam, as shown in Fig. 2, shows modulation of the beam at the first cross-over and the focussing of the electrons to a small beam diameter as the screen is reached. The unitary gun assembly facilitates the production of an intense high current electron beam and the modulation thereof at the most desirable position whereby a sharp cut-off of the beam is secured to obtain good contrast and excellent half-tone reproduction in the spot which is projected on the fluorescent screen of the device to depict the transmitted material in television or other allied systems. Furthermore, the focus of the beam is not disturbed in accordance with the modulation arrangement of this invention so that the area of the spot on the screen is not enlarged or diminished in size by the modulation action. This is beneficial in the reproduction of televised subjects.

The modification of the invention as shown in Fig. 4 shows the gun structure having a single elongated tubular anode 53, which replaces the two anodes 28 and 30, with the various partitions and the modulator electrode arranged in relation to the cathode within the enclosing anode. The free end of the anode 53 is provided with extension rods 54 which support a mica disc 55 which spans the end of the gun and carries a target or contact 56 which is secured to the mica disc by an eyelet 57. This arrangement provides an efficient high current switching device or relay in which the beam is projected toward the target and may be completely cut-off from the target by applying a suitable potential to the modulator element 29.

While the invention has been described in connection with a specific relationship of elements in the gun of this invention, it is of course understood that various modifications may be made in the detailed assembly without departing from the scope of this invention as defined in the appended claims.

What is claimed is:

1. An electronic beam translating device com-

prising a vessel having an electron responsive surface at one end thereof, an electron gun at the other end including an emissive cathode capable of projecting a beam of electrons towards said surface, an anode coaxially surrounding said cathode, a plurality of spaced apertured partitions supported in engaging relation within said anode having their apertures axially aligned with said cathode in a direction toward said surface, a modulator electrode insulatingly mounted between said partitions, and a second anode beyond said first anode and insulatingly supported thereby.

2. An electronic beam translating device comprising a vessel having an electron responsive surface at one end, and an electron beam projecting gun at the other end, said gun including an equipotential cathode having an emitting head in the form of a section of a sphere of revolution, a hollow anode surrounding and enclosing said cathode and head, a pair of spaced apertured partitions within said anode located at or near the center of curvature of said head, said head and partitions being capable of extending the focus of the beam beyond said partitions at a common cross-over point, and a modulator element positioned at said cross-over point in insulating relation to said anode.

3. An electronic beam translating device comprising a vessel having an electron responsive surface at one end, and an electron beam projecting gun at the other end, said gun including an equipotential cathode having an emitting head in the form of a section of a sphere of revolution, a hollow anode surrounding and enclosing said cathode and head, a pair of spaced apertured partitions within said anode and located at or near the center of curvature of said head, said head and partitions being capable of extending the focus of the beam beyond said partitions at a common cross-over point, a modulator element insulatingly positioned at said common cross-over point, and a second anode axially aligned with said first anode and having an apertured partition adjacent said modulator element.

4. An electronic beam translating device comprising a vessel having an electron responsive surface at one end, and a unitary gun assembly mounted on the other end and comprising an elongated tubular anode, an insulating closure at one end thereof, a central equipotential cathode supported by said closure and extending within said anode, said cathode having a spherical section emitting surface, an insulating collar seated on the opposite end of said anode, a second elongated tubular anode extending from said collar in axial symmetry with said first anode, a plurality of spaced apertured partitions electrically in contact with the inner surface of said first anode adjacent said collar, and a control electrode insulatingly nested between a pair of said partitions.

5. An electronic beam translating device comprising a vessel having an electron responsive surface at one end, and a unitary electron gun assembly mounted on the other end thereof and comprising an elongated tubular anode, an insulating closure in one end thereof, a central equipotential cathode supported by said closure and extending within said anode, said cathode having a spherical section emitting surface, an insulating collar seated on the opposite end of said anode, a second elongated tubular anode extending from said collar in axial symmetry with said first anode, an apertured disc in each of said anodes abutting against said collar, an apertured modulator electrode in said first anode and insulatingly supported adjacent said apertured disc therein, and a second apertured disc within said first anode between said cathode and said modulator electrode.

6. An electronic beam projection device comprising a vessel having a fluorescent screen at one end and a stem at the other end thereof, a unitary electron gun assembly extending toward said screen including a pair of tubular anodes, an insulating spacing collar joining said anodes in axial alignment, an insulating closure on the end of one anode adjacent said stem, means supporting said unit from said stem, an electron emitting cathode extending from said closure, a plurality of apertured discs in axial spaced relation within and connected to said anode and forming partitions for guiding the paths of electrons through said anode, an isolated modulator electrode positioned intermediate said discs at the common cross-over point of said electron paths, a larger diameter anode mounted in telescopic relation to the free end of said unit, and a plurality of deflector plates mounted in relation to said larger diameter anode between said screen and said unit.

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