June 15, 1943. A. E. ANDERSON 2,321,886

ELECTRON DISCHARGE DEVICE

Filed March 29, 1941

FIG. 1

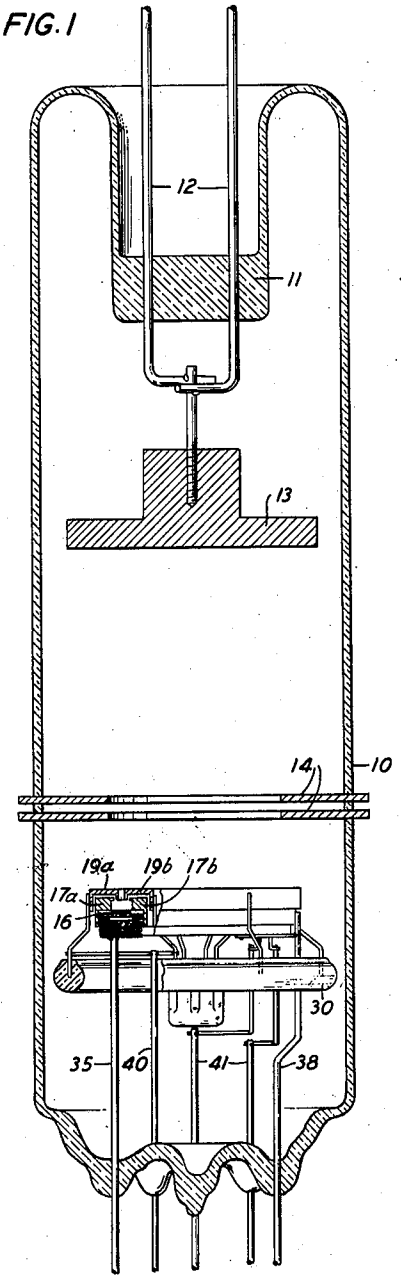


FIG. 2

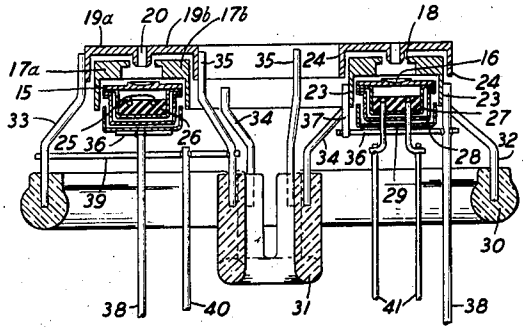
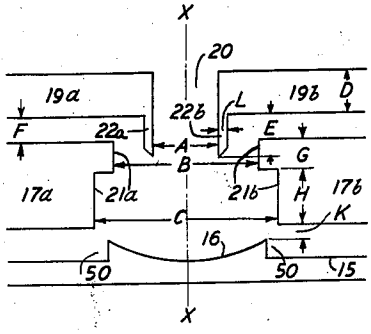


FIG. 3



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ELECTRON DISCHARGE DEVICE

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9 Claims. (Cl. 250—162)

This invention relates to electron discharge devices and more particularly to electrode systems, commonly referred to as electron guns, for producing a concentrated electron beam in such devices.

Electron guns comprise, in general, a source of electrons, such as a cathode, and two or more electrodes, one of which is maintained at a positive potential with respect to the electron source and generally designated as the accelerating anode, cooperatively associated with the electron source for concentrating the electrons emanating from the source into a beam and directing the beam toward a suitable target or electrode. As noted in Patent 2,308,800, granted January 19, 1943, to Alva Eugene Anderson, the efficacy of such an electron gun is dependent upon the magnitude of the total beam current in relation to the total electron current emanating from the source and the degree to and uniformity with which the electrons in the beam can be controlled or affected at points in the path traversed by the electron beam. As pointed out further in that patent, a high beam current and good control of the beam may be obtained with an electron gun which produces an electron beam hollow throughout a major portion of its length.

One general object of this invention is to improve electron guns adapted to produce a hollow electron beam. More specifically, objects of this invention are to simplify and to facilitate the construction of electron guns for producing a hollow electron beam and to obtain a high perveance for electron guns, the perveance being defined by the expression $I/V^{3/2}$, where I is the total beam current and V is the potential of the accelerating anode in the electron gun.

In one illustrative embodiment of this invention, an electron gun comprises a cathode and a pair of beam forming electrodes, one of which is an accelerating anode, associated with the cathode.

In accordance with one feature of this invention, the cathode and the beam forming electrodes are coaxial annular elements and are so constructed and arranged that substantially all of the electrons emanating from the cathode are concentrated into a hollow cylindrical beam in which the electrons traverse rectilinear and substantially parallel paths.

The invention and the aforenoted and other 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 partly in section of an electron beam discharge device including an electron gun constructed in accordance with this invention, a portion of the gun being broken away to show the elements thereof;

Fig. 2 is a cross-sectional view of the electron gun included in the device illustrated in Fig. 1; and

Fig. 3 is an outline view of a radial section of the electron gun shown in Fig. 2, illustrating the form and relation of the juxtaposed surfaces of the cathode and the beam forming electrodes associated therewith.

Referring now to the drawing, the electron discharge device shown in Fig. 1 comprises an elongated evacuated enclosing vessel **10** having at one end thereof an inwardly extending stem **11** from which there is supported, by leading-in conductors **12**, a target or collector electrode **13**. Mounted at the other end of the vessel **10** and in alignment with the electrode **13** is an electron gun, described in detail hereinafter, which projects a beam of electrons toward the target or collector electrode **13**. In flowing to the target or collector electrode **13**, the beam may be controlled, for example in intensity, direction or velocity, by suitable electrodes or sets of electrodes of various forms and arrangements. For simplicity of disclosure only two such electrodes **14**, in the form of annular metallic discs sealed to and extending outside of the enclosing vessel **10**, have been shown in the drawing.

The electron gun, as shown clearly in Figs. 2 and 3, comprises a cathode including an annular plate **15** having in one face thereof a central annular recess **16** the surface of which is coated with a material having good thermionic emission characteristics, the cathode plate **15** being cut away as shown at **50** to prevent creepage of the coating material when the gun is operated. The gun comprises, also, a beam forming electrode having two annular portions **17***a* and **17***b* coaxial with the cathode and spaced to define an annular gap **18** centrally aligned with the recess **16**. Overlying the beam forming electrode **17** is an accelerating anode having two annular portions **19***a* and **19***b* coaxial with the cathode and spaced to define an annular gap **20** in alignment with the gap **18** and the recess **16**.

As shown clearly in Fig. 3, the generatrix of the emissive surface in the recess **16** is an arc of a circle the center of which lies on a point on the axis X—X and within the gap **20**. The juxtaposed surfaces **21***a* and **21***b* of the two parts of the beam forming electrode **17** are cylindrical

and stepped and equally spaced from the axis X—X. The two parts of the accelerating anode have parallel cylindrical flanges **22***a* and **22***b* equally spaced from the axis X—X and terminating within the narrower portion of the gap **18**. The parts of the beam forming electrode **17** are also provided with depending cylindrical flanges **23** opposite the inner and outer edges of the annular plate **15** of the cathode, as shown in Fig. 2, and the parts of the accelerating anode **19** are provided with similar cylindrical flanges **24** opposite the lateral extremities of the beam forming electrode **17**.

The cathode, beam forming electrode **17** and accelerating anode **19** are dimensioned and related in accordance with the basic principles and method disclosed in Patent 2,268,197 granted December 30, 1941 to John R. Pierce so that substantially all of the electrons emanating from the emissive surface of the cathode are directed along rectilinear paths and constitute in the aggregate at the end of the gap **20** toward the electrode **13**, a hollow cylindrical beam. In a specific embodiment, the arcuate cathode emissive surface may have a radius of ⅛ inch, the maximum depth of the recess may be .017 inch and other dimensions indicated in Fig. 3 may be as follows:

	Inches		Inches
A	.050	F	.020
B	.115	G	.0225
C	.145	H	.045
D	3/32	K	.010
E	.0324	L	.007

The gap **20** may be of a diameter of $^{23}/_{32}$ inch, the flanges **23** and **24** may be 1/64 inch in thickness, the flanges **23** being spaced .015 inch from the plate **16**, which may be .314 inch in width, and the flanges **24** being spaced 1/64 inch from the electrode members **17***a* and **17***b*.

An electron gun of this construction having the dimensions noted has been found to have a beam formation efficiency of about 95 per cent and has enabled the realization of a perveance of as high as 66×10^{-6} with the beam forming electrode **17** operated at zero volts with respect to the cathode and the accelerating anode operated at a potential of 250 volts with respect to the cathode. An electron gun constructed in accordance with this invention, therefore, enables the attainment of very high efficiency, a high beam current with a relatively low potential on the accelerating anode and a high current beam with a cathode of small dimensions. In addition, it will be noted that all of the electrode surfaces in the gun are plane or cylindrical so that these electrodes may be fabricated facilely and in quantity. Also, the electron gun produces a thin, hollow cylindrical beam so that efficient and uniform control of the beam is enabled.

The cathode structure included in the electron gun comprises also a heater element which may be a multiturn resistance coil **25** embedded in an insulating body **26**, the heater element being mounted within an annular dished metallic member **27** affixed to the cathode plate **15**. The dished member **27** is mounted in turn within a pair of nested metallic members **28** and **29** which are secured to one another and one of which is secured to the member **27** as shown in Fig. 2. The several members **27**, **28** and **29** serve as heat shields whereby heat radiation from the cathode is greatly reduced and efficient heating of the emissive coating in the recess **16** is obtained.

As shown in Fig. 2, the electron gun may be fabricated as a unitary assembly in which the constituent elements are accurately maintained in the requisite space relation through an insulating ring **30**, for example of glass, and a multilegged insulating member **31**, which also may be of glass. The outer portions **17***a* and **19***a* of the beam forming and accelerating electrodes respectively are rigidly mounted on the insulating ring **30** by a plurality of rigid wires **32** and **33** respectively, only one of each of which is shown in Fig. 2, embedded in the ring **30** and are thus maintained in fixed relation. The inner portions **17***b* and **19***b* of the beam forming electrode and the accelerating electrode respectively are rigidly affixed to the insulating body **31** by a plurality of rigid wires **34** and **35** embedded in the body **31**, and are thus maintained in fixed relation. The two subassemblies thus formed are secured to one another and to the cathode structure by a plurality of rigid wires **36**, secured, as by welding, to the base of the heat shield **29** and to rigid wires **37** and **38** affixed to the portions **17***a* and **17***b* of the beam forming electrode, the wires **38** being sealed to one end of the enclosing vessel **10**, as shown in Fig. 1, and serving as supports for the electron gun and also as leading-in conductors for the cathode **15**, **16** and the beam forming electrode **17**. The inner and outer portions **19***a* and **19***b* of the accelerating anode are connected electrically and mechanically by a rigid wire **39** secured to two of the wires **33** and **35** and having connected thereto a leading-in conductor **40** sealed in one end of the vessel **10**. The cathode and the two beam forming electrodes **17** and **19** associated therewith, it will be appreciated, are thus accurately located and fixed in the requisite relation to one another.

Current to the heater coil **25** may be supplied through a pair of conductors **41** sealed in the end wall of the vessel **10**.

Although a specific embodiment of the invention has been shown and described, it will be understood that it is but illustrative and that various modifications may be made therein without departing from the scope and spirit of this invention as defined in the appended claims.

What is claimed is:

1. An electron gun comprising a cathode having an annular electron emissive surface of substantial radial width, and means for concentrating electrons emanating from said surface into a hollow cylindrical beam of a thickness substantially less than the radial width of said surface, said means comprising a pair of electrode members in juxtaposition to said cathode and having coaxial annular walls lying on opposite sides of said surface and defining an annular gap axially aligned with said surface, and a second pair of electrode members adjacent said first members and having opposed cylindrical surfaces defining a cylindrical aperture axially aligned with and of materially less width than said gap, said cylindrical surfaces extending into said gap.

2. An electron gun comprising a cathode having an annular electron emissive surface, a beam-forming electrode including a disc portion immediately adjacent said cathode and having therein an annular gap in axial alignment with said surface, and an accelerating anode including a disc portion overlying and extending substantially parallel to said disc portion of said beam-forming electrode and having an annular aperture therein in alignment with said gap, said accelerating anode including also a pair of coaxial cylindrical portions extending into said gap and

defining an annular passageway in alignment with said surface.

3. An electron gun comprising a cathode having an annular electron emissive surface, a beam-forming electrode including a disc portion immediately adjacent said cathode and having therein an annular gap in axial alignment with said surface, and an accelerating anode including a disc portion overlying and extending substantially parallel to said disc portion of said beam-forming electrode and having therein an annular aperture of substantially the same mean diameter as said gap and in axial alignment therewith, said emissive surface being arcuate in radial section and the center of curvature of the generatrix thereof lying within said aperture.

4. An electron gun comprising a cathode having an annular electron emissive surface, a beam forming electrode adjacent said cathode and having juxtaposed coaxial surfaces defining an annular gap in axial alignment with said emissive surface, said coaxial surfaces each including a pair of coaxial cylindrical portions of different diameters whereby said gap includes annular portions of different widths, the wider of said annular portions being nearest said emissive surface, and an accelerating anode adjacent said beam forming electrode and having therein an annular aperture in alignment with said gap.

5. An electron gun in accordance with claim 4 wherein said accelerating anode comprises a pair of coaxial cylindrical portions defining a portion of said aperture and extending into said gap.

6. An electron gun in accordance with claim 4 wherein said emissive surface is arcuate in radial section.

7. An electron gun comprising a cathode including a plate member having an annular recess therein, the surface of which is coated with a thermionic material, a beam forming electrode including plate portions parallel to said plate member, immediately adjacent thereto and spaced to define an annular gap in alignment with said recess, and an accelerating anode including plate portions immediately adjacent and parallel to said first plate portions and spaced to define an annular opening in alignment with said gap.

8. An electron gun in accordance with claim 7 wherein the gap defined by said first plate portions includes two coaxial annular sections of different widths the wider of which is nearest said cathode, and wherein said accelerating anode includes coaxial spaced cylindrical flanges extending into the narrower of said annular sections.

9. An electron gun in accordance with claim 7 wherein said beam forming electrode includes a cylindrical flange encompassing said plate member of said cathode and said accelerating anode includes a cylindrical flange encompassing said beam forming electrode.

ALVA EUGENE ANDERSON.