ELECTRON BEAM DEVICE WITH HIDDEN CATHODE HAVING ANNULAR, FRUSTO-CONICAL EMISSIVE SURFACE

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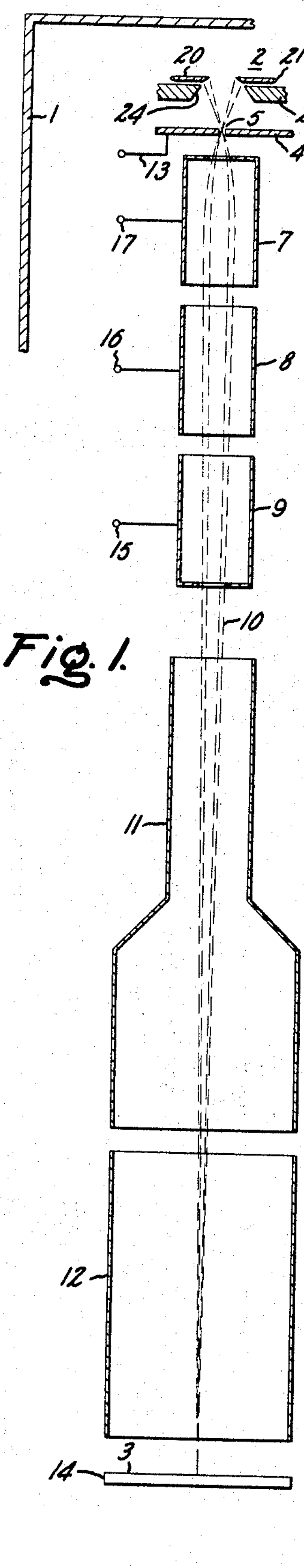


Fig. 1.

Fig. 2.

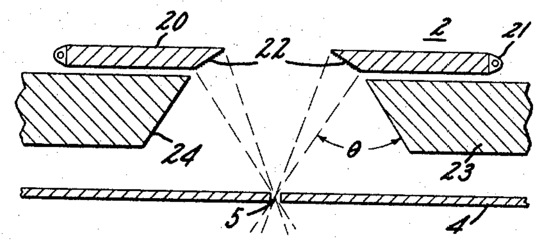
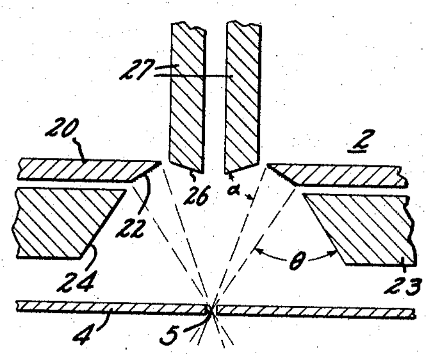


Fig. 3.



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ELECTRON BEAM DEVICE WITH HIDDEN CATHODE HAVING ANNULAR, FRUSTO-CONICAL EMISSIVE SURFACE

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6 Claims. (Cl. 313—82)

ABSTRACT OF THE DISCLOSURE

An electron beam device, having a target which is scanned by a pencil beam of electrons, has a cathode, hidden from the target, in the form of a frusto-conical emissive surface, the walls of which are slanted to direct emitted electrons through an accelerating electrode aperture which is out of line-of-sight between the target and the emitting surface. An additional frusto-conical electrode positioned between and symmetrically arranged with the cathode and accelerating electrode about the axis of the device is used to shape the emitted beam and direct it through the aperture in an accelerating electrode.

This invention relates to a device for directing an electron beam to a utilization means without exposing such means to heat or light radiation from an electron source.

A number of devices require the generation of an electron beam for scanning or deflection in a prescribed pattern across a sensitive target. One example is the television type camera tube wherein an electron beam deposits or attempts to deposit electrons upon a light-sensitive target in response to photosensitive currents in the target. The electron flow in the beam then provides output current variations for the tube. The ordinary electron emitting cathode or filament generating an electron beam exhibits certain disadvantages in that such electron source not only emits electrons but also radiates light and heat and is subject to the back bombardment of ions produced within the electron optical system. The radiation deleteriously affects the sensitivity of a target, particularly in the case of one sensitive in the infrared range, while ion bombardment shortens the life of the electron emitting cathode.

One manner of solving the problem involves separating or turning the electron stream from the radiated heat and light present in the electron source. Thus an electron stream can be deflected at some angle with respect to the source, while heat and light radiation, and to some extent ion back bombardment, continue to follow a straight line path. Such arrangements require a complex plurality of beam forming and controlling electrodes, or a circuitous electron beam including a number of baffles around which the electron stream is directed while eliminating the unwanted accompanying radiation. In the copending application of Charles L. Andrews, Ser. No. 467,855, filed June 29, 1965, and assigned to the assignee of this present invention, there is disclosed another arrangement employing a ring cathode gun from which electrons emerge in a thin cone of about 20° semicone angle about the axis of the gun, electrons being focused into a small spot by appropriate electron lenses. In that arrangement, electrons are present in two distinct groups differing in forward velocity one of the groups being composed of electrons which pass directly from the ring cathode through an aperture in an electrode intermediate the cathode and a target, the other group being those electrons which pass through such aperture by way of a central space-charge cloud.

It is an object of my present invention to provide an electron beam device in which a target electrode is

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shielded from radiation from a thermionic cathode, the electrons from the cathode being guided to a target by a simple electrode arrangement.

It is still another object of my invention to provide such an electron beam device in which a space-charge limited electron flow is established between a target and an emitting cathode hidden from such target.

Briefly stated, my invention provides an electron gun for projecting a space-charge limited flow of electrons through an aperture toward a target surface in which the aperture is displaced from a direct path between the cathode and the target, an electrode being provided adjacent the cathode to direct the path of the electrons through the aperture toward the target. One of the features of the invention consists in tilting the emitting surface of the cathode to direct a beam of electrons toward the aperture and positioning a conical electrode at at angle with respect to the desired beam edge such that electrons are guided into a space-charge limited flow through the aperture, thus reducing electron velocity fluctuations in the beam and facilitating control of the beam current by accelerating potentials applied to the gun.

The subject matter which I regard as my invention is particularly pointed out and distinctly claimed in the concluding portion of this specification. The invention, however, both as to organization and method of operation, together with additional advantages and objects, though, may best be understood by referring to the following description taken in connection with the accompanying drawings wherein like reference characters refer to like elements and in which:

FIGURE 1 is a vertical cross-section schematic view of an electron beam device in accordance with the present invention.

FIGURE 2 is a vertical cross-section of an electron source employed in the device of FIGURE 1, and

FIGURE 3 is a vertical cross-section of a modification of the electron source of FIGURE 1.

In FIGURE 1 the electron beam device in accordance with the present invention includes an envelope **1**, having a cathode **2** located at one end thereof and an electron utilization target **3** at its other end. Target **3** may comprise for example, a semiconductor target sensitive to infrared radiation and the like and from which it is desired to exclude heat and light radiation from cathode **2**. Accordingly, the electron source includes a partition **4** positioned between the cathode **2** and target **3** and having an aperture **5** displaced from the direct straight-line radiation path between cathode **2** and target **3**.

Provided between the partition **4** and target **3** along the path of the electron beam are a plurality of electrodes **7**, **8** and **9** to focus the electron beam passing through aperture **5** to a small diameter spot as the beam **10** approaches the target electrode. Also positioned along the path of travel of the electron beam are a conventional electrostatic deflection system **11** and a collimator **12**.

Accelerating potentials are supplied to partition **4** by means of a lead **13** and to target electrode **3** by means of lead **14**. Also, conventional focusing potentials are supplied to focusing lens element **7–9** by means of lead **15–17**.

FIGURE 2 illustrates in larger scale details of the cathode structure **2** on the device of FIGURE 1. The cathode structure comprises a toroidal or annular metal member **20** which may consist, for example, of a disk of a suitable metal such as nickel around the outer edge of which is attached or bonded a helical filament **21** of conventional type and supplied with heating current in a conventional manner from a suitable source not shown. The heater may also be bonded to the back of the cathode disk **20**. The center of the disk **20** has a frusto-conical surface which is tilted or inclined toward aperture **5**. The inner surface of member **20** is provided with an electron emissive coating **22** which may be of any well-known type and which may comprise, for example, a coating of barium-strontium oxides. Supported between cathode disk **20** and the conductive partition **4** is an annular metallic member **23** having a central aperture provided with a second frusto-conical surface **24**. Preferably member **23** is maintained at the same potential as disk **20** with the surface **24** being inclined at an angle θ appropriate for guiding the electrons from surface **22** into a converging space-charge limited flow. The angle θ between surface **24** and the adjacent edge of the electron beam is between 50 and 75°, with an angle of 67.5° being preferred.

In the operation of the cathode structure illustrated in FIGURE 2, since the surface **22** is tilted toward the aperture **5** in partition **4**, the field near the emitting surface is shaped so that electrons are directed toward the aperture. The additional electrode surface **24** positioned at angle θ with respect to the desired edge of the beam assists in guiding the electrons as previously mentioned into a converging space-charge limited flow. In this manner, the coaction of surfaces **22** and **24** prevent the occurrence of two or more alternative electron paths between surface **22** and aperture **5** with corresponding different forwarding velocities. The use of space-charge limited flow also serves to smooth the velocity fluctuations in the beam and facilitates control of the beam current by proper control of the gun accelerating voltage supplied over leads **13** and **14**.

In FIGURE 3 there is shown a modification of the cathode structure of FIGURE 2 in which an additional conical surface **26** is provided by metallic member **27** positioned inside the inner edge of and forming an obtuse angle with inclined surface **22**, to assist in concentrating the electron beam as it is directed toward aperture **5**. While the angle α between surface **26** and the inner edge of the beam may lie between a range of, for example 50–75°, an angle of 67.5° is preferred. As is in the case of electrode **24**, electrode **27** is likewise preferably maintained at the same potential as the cathode disk **20**.

In the operation of the device of FIGURE 1, electrons emitted from surface **22** are focused through the inclination of surface **22** toward partition **4** and through the assistance of auxiliary electrode **23** to travel with space-charge limited flow in a converging beam to aperture **5**. After passing through aperture **5**, the electron beam is focused to a small spot through the operation of electron lenses **7–9**. Electron beam **10** after it has passed through such lens system is deflected by appropriate voltages supplied to the electrostatic system **11** to scan the surface of the sensitive target **3**.

One of the advantages of my improved electron gun structure is that the current density of the cathode emissive surface is substantially uniform over the emitting area, permitting maximum electron emission per watt of heater power. The gun becomes space-charge limited, thus permitting effective control of beam current with the potential supplied to partition **4** without affecting the paths of electrons within the beam. Thus beam modulation is effected without requiring any adjustment of focusing condition. The only variation in the forward velocity of such electron beam is that attributable to variations in cathode temperature and, of course, to the width of the surface **22**. Since this construction eliminates alternative paths from the surfaces **22** to the aperture **5**, possibility of having electrons with widely different velocities is eliminated.

While I have shown and described a preferred embodiment of my invention, it will be apparent to those skilled in the art that many changes and modifications may be made without departing from my invention in its broader aspects; and I therefore intend the appended claims to cover all such changes and modifications as fall within the true spirit and scope of my invention.

What I claim as new and desire to secure by Letters Patent of the United States is:

1. An electron beam device for providing electrons to a utilization target without exposing the utilization target to heat or light radiation from a heated electron source comprising

an envelope having an electron utilization target at one end thereof and a cathode member displaced longitudinally of the envelope from the target,

an accelerating electrode comprising a conductive partition positioned between said cathode member and target provided with a single small axial aperture displaced from a direct radiation path between said cathode and target,

said cathode member comprising an annular member spaced from said partition and having a central aperture comprising a first frusto-conical surface which comprises an electron emissive surface, the aperture in said cathode member being substantially larger than the axial aperture in said partition and said surface being inclined at an angle to direct emitted electrons toward the single axial aperture,

annular electrode means positioned between said cathode and said partition, said electrode means also having a central aperture comprising a second frusto-conical surface symmetrically positioned with respect to the annular cathode member and axial aperture, the aperture in said annular electrode means being larger than the aperture in said cathode member, the wall of said second frusto-conical surface being inclined at an angle with the beam of electrons from said electron emissive surface, the edge of the smallest diameter portion of said second frusto-conical surface being positioned adjacent the edge of the largest diameter portion of said first frusto-conical surface whereby electrons emitted by such cathode are focused to travel with space-charged limited flow in a converging beam through said single axial aperture, and

electron lens means positioned between said partition and said target for focusing said electrons as a fine pencil beam directed at said target.

2. The device of claim **1** in which said angle of inclination is adjusted to make the angle between the annular electrode and the adjacent edge of the electron beam between 50° and 75°.

3. The device of claim **1** in which said angle of inclination is adjusted to make the angle between the annular electrode and the adjacent edge of the electron beam approximately 67.5°.

4. The device of claim **1** which includes an additional electrode means positioned on the opposite side of said cathode from the annular electrode means and having a third conical surface inclined at an obtuse angle with said electron emission surface, said third surface being symmetrically positioned with respect to said cathode member and having the edge of its largest diameter portion positioned adjacent the edge of the smallest diameter portion of said first conical surface.

5. The device of claim **4** in which the angles of inclination of both electrode means relative to the adjacent electron beam edges are approximately 67.5°.

6. The device of claim **1** in which electron deflecting means are positioned between said partition and said traget whereby electrons from said cathode may be focused into a narrow beam and scanned across the target.

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ROBERT SEGAL, *Primary Examiner.*