

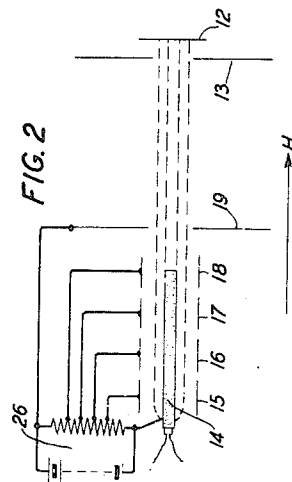
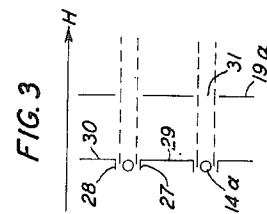
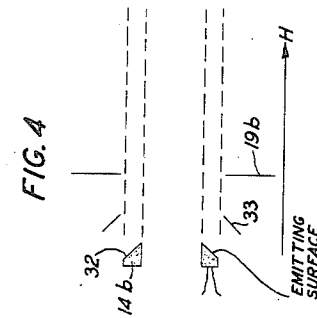
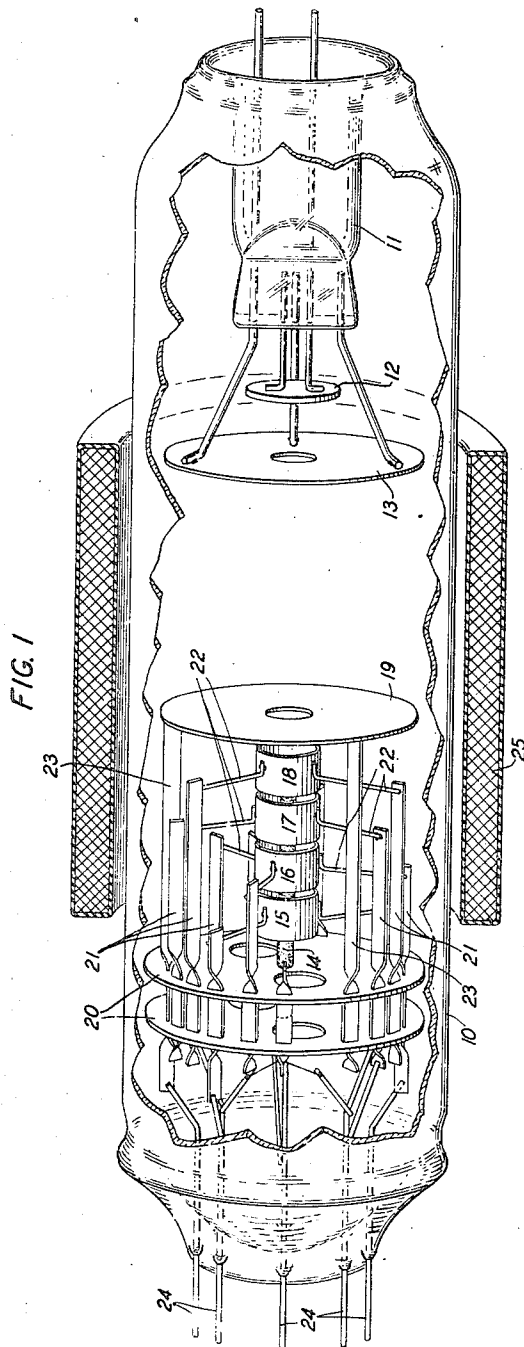
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A. M. SKELLETT

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ELECTRON DISCHARGE DEVICE

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INVENTOR
BY A. M. SKELLETT

Walter C. Kiesel
ATTORNEY

UNITED STATES PATENT OFFICE

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ELECTRON DISCHARGE DEVICE

Albert M. Skellett, Madison, N. J., assignor to
Bell Telephone Laboratories, Incorporated, New
York, N. Y., a corporation of New York

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

One object of this invention is to facilitate the production of a high current electron beam.

Another object of this invention is to expedite the generation of a hollow cylindrical beam wherein the electrons are focussed to traverse generally paraxial paths.

A further object of this invention is to enable the attainment of a highly concentrated electron beam of relatively small diameter from a large area cathode.

Still another object of this invention is to reduce space charge effects adjacent the cathode in an electron gun for producing a high current electron stream.

In one illustrative embodiment of this invention, an electron gun includes a cathode, one or more field electrodes in proximity to the cathode for drawing electrons away therefrom, and another electrode, designated as an accelerating anode, for accelerating the electrons away from the cathode.

In accordance with one feature of this invention, the emissive surface of the cathode is mounted at an angle, for example, a right angle, to the axis of the electron beam to be produced, the field electrode or electrodes are cooperatively associated with the cathode so that electrons are drawn from the emissive surface substantially normal thereto, the accelerating anode is positioned to accelerate the electrons in the direction of the beam desired, and means are provided for focussing the electrons along substantially paraxial paths in the direction of their acceleration.

The invention and the above-noted and other features of this invention 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 and of the magnetic coil being broken away to show the electrodes of the device;

Fig. 2 is a diagrammatic view illustrating the physical and electrical relation of the electrodes in the device shown in Fig. 1; and

Figs. 3 and 4 are diagrammatic views, similar to Fig. 2, showing electron guns illustrative of other embodiments of this invention.

Referring now to the drawing, the electron

discharge device illustrated in Fig. 1 comprises an elongated evacuated enclosing vessel 10 having at one end thereof a stem 11 from which there are supported an anode or collector electrode 12 and a centrally apertured shield electrode 13 coaxial with the anode or collector electrode 12.

Mounted opposite the other end of the vessel 10 is an electrode system or electron gun coaxial with the electrodes 12 and 13. The gun comprises a cathode 14, for example, of the indirectly heated equipotential type, having an elongated cylindrical electron emissive surface, a series of cylindrical field or accelerating electrodes 15 to 18, inclusive, coaxial with the cathode and, as shown in Fig. 2, substantially coextensive, in the aggregate, with the emissive surface of the cathode, and a centrally apertured accelerating anode 19 coaxial with the cathode 14. The cathode 14 is fitted in central apertures in parallel insulating spacers 20, such as mica discs, and the several cylindrical electrodes 15 to 18 are supported from rigid metallic supports 21 by radially extending metallic members 22, the supports 21 being frictionally fitted in suitable slots in the insulating spacers 20. The accelerating anode 19 is mounted by rigid metallic supports 23 frictionally fitted in slots on the insulating spacers 20. Electrical connection is established to the several electrodes of the electron gun through leading-in conductors 24 connected to the cathode 14 and appropriate ones of the support 21 and 23.

Mounted about the enclosing vessel 10 is a coil 25 for producing a magnetic field parallel to the axis of alignment of the electron gun and the anode or collector electrode, the coil being substantially coextensive with the space between the disc 20 nearest the electrode 15 and the collector electrode or anode 12.

During operation of the device, the several electrodes 15 to 19, inclusive, are maintained at successively higher positive potentials with respect to the cathode 14, as by a potentiometer or voltage divider 26. For example, the annular accelerating electrode 19 may be operated at 150 volts positive with respect to the cathode 14; the electrode 15 may be operated 30 volts positive with respect to the cathode, and each of the electrodes 16 to 18 may be operated at 5 volts positive with respect to the next preceding electrode.

Under the influence of the positive potentials upon the electrodes 15 to 18, inclusive, electrons are drawn from the cathode emissive surface in directions generally normal to this surface and,

due to the potential difference between these electrodes and the positive potential upon the accelerating anode 19, are accelerated in the direction of the longitudinal axis of the electron gun. The magnetic field produced by the coil 25 causes the electrons to spiral about parallel lines parallel to the longitudinal axis of the electron gun so that the electrons are concentrated into a hollow cylindrical beam coaxial with the electrodes of the device. The magnetic field is made of such intensity that the radius of the electron orbits about the parallel lines mentioned is sufficiently small that the electrons are not collected by the electrodes 15 to 18. The outline of the beam thus produced is indicated by the dotted lines in Fig. 2, the magnetic field being indicated by the arrow H.

The hollow electron beam, it has been found, is susceptible to ready and uniform control in its travel toward the anode. Thus, for example, the beam may be velocity varied or otherwise modulated by suitable electrodes between the electron gun and the anode or collector electrode. For simplicity of disclosure, such electrodes have not been shown in the drawing. Furthermore, the electron gun shown and described above enables the attainment of a high current beam with relatively low potentials upon the electrodes constituting the electron gun. Also, it will be appreciated that this gun enables the production of a large current, focussed beam of small diameter from a cathode of considerable size and also enables the use of a high capacity cathode whereby large beam currents are realized.

In the embodiment of this invention illustrated in Fig. 3, the cathode 14a is annular in form, for example a circular filament, and is positioned between and uniformly spaced from coaxial cylindrical flanges 27 and 28 on a pair of beam forming electrodes 29 and 30. The accelerating anode 19a is provided with an annular opening 31 of the same mean diameter as, and opposite the cathode 14a. The electrodes 29 and 30 are connected together electrically and operated at a potential, for example of the order of 30 to 40 volts, positive with respect to the cathode so that there is produced a field normal to the direction of projection of the beam, that is, normal to the axis of alignment of the cathode 14a and the annular aperture 31, drawing electrons away from the cathode at substantially right angles to the magnetic field. Under the influence of the accelerating anode 19a, which is operated at a positive potential, for example 150 to 200 volts, with respect to the cathode, the electrons are accelerated toward the accelerating anode and through the aperture 31 therein, along generally parallel paths. The magnetic field, as in the device illustrated in Figs. 1 and 2, serves to confine the electrons to generally paraxial paths so that the electrons constitute a hollow cylindrical beam, the boundaries of which are indicated by the dotted lines in Fig. 3.

In the electron gun illustrated in Fig. 4, the cathode 14b, which may be of the indirectly heated equipotential type, is annular in form and has a frusto-conical electron emissive surface 32. Mounted opposite the cathode and coaxial therewith is a frusto-conical electrode 33 the elements of which are parallel to the elements of the emissive surface 32. The accelerating anode 19b is annular and coaxial with the cathode.

During operation of the gun, the electrode 33 is maintained positive, for example of the order of 40 to 50 volts, with respect to the cathode

14b and the accelerating anode 19b is maintained at a higher positive potential, for example of the order of 150 to 200 volts, with respect to the cathode. The electrode 33 produces a field serving to draw electrons from the emissive surface 32 substantially normal to this surface and these electrons are then accelerated through the accelerating anode 19b due to the positive potential of this anode. The magnetic field, as in the devices shown in Figs. 1, 2 and 3, focusses the electrons along paraxial paths so that a concentrated hollow cylindrical beam is formed, the boundaries of the beam being indicated by the dotted lines in Fig. 4.

A particular advantage of the construction illustrated in Fig. 4 is that the electrons emanating from the surface 32 and which traverse spiral orbits near this surface are drawn away from the surface a sufficient distance to substantially prevent return thereof to the cathode and to prevent their increasing appreciably the space charge at the emissive surface.

Although specific embodiments of this invention have been shown and described, it will be understood that they are 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 electrode system for producing an electron beam comprising an electron emissive surface, means for producing an electric accelerating field adjacent said surface and substantially normal thereto, means for producing a greater electric accelerating field adjacent said surface and at an angle to said first field, and means for producing a magnetic field adjacent said surface and parallel to said second field.

2. An electrode system for producing an electron beam comprising an electron emissive surface, means including an electrode opposite said surface and uniformly spaced therefrom for producing an electric field normal to and away from said surface, means including an accelerating anode spaced from said surface and extending substantially at right angles thereto for producing an accelerating electric field at substantially right angles to said first field, and means for producing a magnetic field having its lines of force substantially parallel to said accelerating field.

3. An electron gun comprising an electron emissive surface, and means for concentrating electrons emanating from said surface into a hollow cylindrical beam, said means including means for producing an accelerating electric field adjacent said surface and at an angle to the longitudinal axis of said beam, means for producing an accelerating electric field adjacent said surface and parallel to said axis, and means for producing a magnetic field adjacent said surface and having its lines of force substantially parallel to said axis.

4. An electron gun comprising a cathode having an elongated electron emissive surface, means for producing an electric accelerating field adjacent said surface and normal thereto, said means including a plurality of electrodes opposite said surface, uniformly spaced therefrom and mounted in end-to-end relation, means for producing an accelerating electric field substantially parallel to said surface including an accelerating anode opposite one end of said surface, and means for producing a magnetic field adjacent

said cathode and substantially parallel to said surface.

5. An electron gun comprising a cylindrical electron emissive surface, means for producing a positive electric field adjacent said surface and substantially normal thereto, said means including a plurality of cylindrical electrodes encompassing said surface, coaxial therewith and mounted in end-to-end relation, an apertured accelerating anode mounted opposite one end of and coaxial with said surface, and means for producing a magnetic field between said surface and said anode and having its lines of force substantially parallel to said surface.

6. An electron gun comprising a cathode having an elongated cylindrical electron emissive surface, means for producing a positive electric field adjacent said surface having a component normal to said surface and a component parallel to said surface, said means including a plurality of cylindrical electrodes encompassing said sur-

face and coaxial therewith, said electrodes being mounted in end-to-end relation and substantially coextensive with said surface, a centrally apertured accelerating anode opposite one end of said surface and coaxial therewith, said anode being planar and extending normal to the longitudinal axis of said surface, and means for producing a magnetic field between said surface and said anode and substantially parallel to said surface.

7. An electron gun comprising a cathode having a frusto-conical electron emissive surface, a first accelerating anode having a frusto-conical surface opposite, equally spaced from and coaxial with said emissive surface, a second accelerating anode spaced from and coaxial with said emissive surface, and means for producing a magnetic field having its lines of force substantially parallel to the axis of coaxiality of said frusto-conical surfaces and said second anode.

ALBERT M. SKELLETT.