

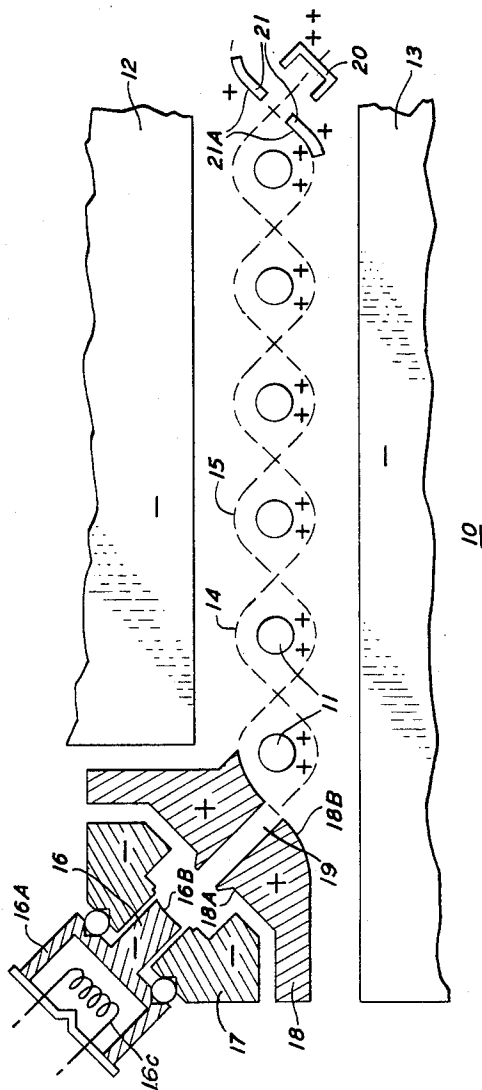
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ELECTRON GUN FOR SLALOM FOCUSING SYSTEMS

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ELECTRON GUN FOR SLALOM FOCUSING SYSTEMS

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8 Claims. (Cl. 315—3.5)

This invention relates to an electron beam system, and more particularly relates to an electron gun for use in electron beam systems which employ electrostatic fields for focusing the electron beam.

A broad object of the invention is to facilitate the injection of an electron beam into an electron beam system of the kind in which the electron beam must be injected with a particular velocity on an equipotential surface of an electrostatic field in a manner which little disturbs the electrostatic field.

It will be convenient to describe the principles of the invention with specific reference to an electron beam system for which it is particularly well adapted, although the application of its general principles may be extended beyond such limited use.

In particular, in a copending application of R. Kompfner and W. H. Yocom, Serial No. 514,423, filed June 10, 1955, now United States Patent No. 2,857,548, issued Oct. 21, 1958, there is disclosed an electron beam system in which a focusing electrode system is used to establish an electrostatic field having a pair of singular equipotential surfaces, which are characterized by the fact that electrons injected on either of such surfaces with a correct velocity will have a stable trajectory on such surface. In an illustrative form of an electron beam system of this kind, a linear array of elements, each of which is maintained at a positive potential with respect to the electron source, comprises the focusing electrode system which sets up a pair of singular equipotential surfaces. Each of these surfaces winds sinuously between successive elements of the array, the two surfaces being mirror images with the plane of the linear array as the reflection plane. In particular, the correct velocity which the electron beam should have when injected on one such surface for stable flow therealong is achieved by associating with the electron source an accelerating anode which is maintained at the potential of the singular equipotential surface.

In the use of an electron beam system of this kind, it is found relatively difficult to inject by usual expedients an electron beam of appreciable current onto one of the singular equipotential surfaces with the correct velocity. In particular, it is found that conventional beam injection arrangements result, at the region of injection of the electrostatic field, in a distortion of the field pattern, set up by the focusing electrode system, optimum for focusing of this kind. This, in turn, results in a loss of focusing efficiency.

Accordingly, a specific object of the present invention is to improve an electron beam system of the kind described by facilitating the injection of an electron beam with the correct velocity on the singular equipotential surface which is to serve as the trajectory of the electron flow.

To this end, for isolating the electron source from the focusing electrode system, a feature of the invention is an electrode having one surface so shaped and positioned to coincide with the first of the two singular equipotential

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surfaces associated with the focusing electrode system and being slotted at the point where the second singular equipotential surface intercepts the electrode surface. This electrode is maintained at the potential of the two singular equipotential surfaces, and an electron gun, typically of conventional design, is positioned behind the electrode. The beam provided by the gun is injected on the second equipotential surface by way of the slot in the electrode.

The region of the slot is essentially a region of zero electrostatic field, and, accordingly, there will be no forces acting on the beam at its point of injection on such singular equipotential surface. This makes possible smooth injection of the beam on this surface with the correct direction of velocity.

The invention will be better understood from the following more detailed description taken in conjunction with the accompanying drawing which shows in a cross sectional view an electron gun in accordance with the invention incorporated in an electron beam system of the kind described in the aforementioned copending application.

In the electron beam system 10 depicted, a plurality of conductive elements 11, which typically are wires extending transversely normal to the plane of the drawing, are aligned to form a linear array which extends longitudinally in the direction desired for flow. On opposite sides, conductive members 12 and 13 serve as conductive boundaries. As discussed in the aforementioned application, when the conductive elements 11 are maintained at a positive potential with respect to the conductive members 12, 13, (as is shown schematically in the drawing) this electrode system will establish in the interspace between the conductive members an electrostatic field which is characterized by a pair of singular equipotential surfaces which intersect the plane of the drawing, as shown by the broken lines 14 and 15. Each of such equipotential surfaces winds sinuously past successive elements, the two surfaces being mirror images of one another about the plane of the linear array and intersecting one another along a parallel succession of center lines. Moreover, it is found that there will flow adjacent such a surface an electron beam injected on either of such surfaces with a velocity in the direction of the surface and of a magnitude corresponding to the speed imparted to an electron in being accelerated from an electron source by an electric field of strength corresponding to the difference in potential of the singular equipotential surface and the electron source. The potential of the singular equipotential surface can be adjusted to a desired value by proper choice of the potentials at which the elements of the focusing electrode system are operated.

The electron beam is injected by an electron gun comprising a cathode 16, a beam focusing electrode 17 and an accelerating anode 18. Since the electron gun advantageously is to provide a strip beam which extends normal to the plane of the drawing, the various gun elements also extend normal to the plane of the drawing. The cathode 16 is of conventional design, including a heater compartment 16A in which extends a heating coil 16C and having a portion 16B of its surface which is electron-emissive. The electrons emitted from the electron-emissive portion are formed into an electron beam by the beam forming electrode 17. The accelerating anode 18 cooperates with electrode 17 in collimating the electrons into a beam and additionally serves to accelerate the electrons in the beam to a desired velocity. Typically, the cathode is maintained at a potential slightly positive with respect to the beam forming electrode but considerably negative with respect to the accelerating anode. The surface 18A which is more proximate to the cathode typically (although not necessarily) coincides with an equi-

potential surface associated with the electrode system of the gun. To the extent described up to this point, the electron gun is essentially of conventional design.

In accordance with the novel principles of the present invention, the portion of the surface 18B of the accelerating anode which is more proximate to the focusing electrode system made up of the linear array of elements 11 and the conductive blocks 12, 13 is shaped to coincide substantially with surface 15 of the two singular equipotential surfaces associated with such focusing electrode system. The length of such portion is approximately between a quarter and a half of the period of the sinuous surface 15. The accelerating anode 18 is maintained at the positive potential with respect to the cathode 16 which corresponds to the potential of the singular equipotential surface 15. Additionally, the electron gun is arranged so that the electron beam is projected through an aperture 19 provided in the accelerating anode 18 at a region which corresponds to the interception of the anode surface 18B by the singular equipotential surface 14. It is characteristic of this crossover region that no electric field is there present. Accordingly, since this is a region of approximately zero electric field, the electron beam may here be injected smoothly on singular equipotential surface 15 for flow therealong.

It is also characteristic of the beam injection arrangement described that the presence of the electron gun will be effectively shielded from the focusing electrode system by the effect of the surface 18B of the accelerating anode 18. Similarly, although of lesser importance, the presence of the focusing electrode system will little affect the operation of the electron gun because of the interposition of surface 18A of the accelerating anode. Accordingly, undesirable interaction between the electron gun and the focusing electrode system can be substantially eliminated.

At the downstream end of the linear array of elements, the electron beam may be collected by a target electrode 20 which is maintained at a suitably positive potential with respect to the electron source. Typically the target electrode is maintained at the potential of the elements 11 of the array. To minimize the effect of the target electrode on the field pattern set up by the focusing electrode system, the target electrode is positioned behind an isolating electrode 21. This electrode 21 is slotted at the region of interception by the singular equipotential surface 14 on which the electron beam flows and the surface 21A of this electrode is made to coincide with a portion of the other singular equipotential surface 15 and maintained at the D.-C. potential characteristic of this equipotential surface. As a consequence, the presence of the target electrode 20 is effectively shielded from the electrostatic field established by the focusing electrode system.

In a typical arrangement, the wire elements 11 were of 60 mils diameter with a center to center spacing of 150 mils, and were maintained at a potential of +350 volts. The conductive plates 12 and 13 were spaced apart 180 mils and maintained at a potential of -190 volts. The accelerating anode 18 was maintained at a voltage of +225 volts. The cathode 16 was at ground potential and the beam focusing electrode 17 about one half a volt positive.

It is to be understood that the specific arrangement described is merely illustrative of the general principles of the invention. Various other embodiments may be devised without departing from the spirit and scope of the invention. In particular, various modifications may be made in the focusing electrode system used to establish the pair of singular equipotential surfaces. For example, either or both of the conductive members 12, 13 may be eliminated or may comprise a linear array of wire elements, so long as the necessary compensation is made in the other parameters of the focusing electrode system as described more fully in the above-mentioned Kompfner-Yocom copending application. Alternatively, the focusing electrode system may be of the kind described in copend-

ing application Serial No. 514,422, filed June 10, 1955, by C. F. Quate and J. W. Sullivan, now United States Patent 2,849,650, issued August 26, 1958.

What is claimed is:

1. In an electron beam system, means defining a region for traversal by an electron beam comprising an electron beam source and a collector electrode, a focusing electrode system which establishes in said region a pair of singular equipotential surfaces which intersect at at least one point in said region, and an arrangement for injecting said beam into said region on one of said surfaces for flow therealong comprising said electron beam source and an accelerating anode characterized in that a portion of the surface of the accelerating anode substantially coincides with one of said singular equipotential surfaces and said anode surface is apertured for passage of the electrons therepast substantially at the region of its intersection with the other of said singular equipotential surfaces.

2. In an electron beam system, means defining a region for traversal by an electron beam comprising an electron source and a collector electrode, a focusing electrode system which establishes in said region a pair of singular equipotential surfaces which intersect at at least one point in said region, means including said electron source for providing an electron beam for injection into said region on one of said surfaces for flow therealong, and means for isolating the electron source from the focusing electrode system comprising a conductive element having a portion of its surface substantially coincident with one of said equipotential surfaces said surface being apertured for passage of the electron beam therepast substantially at the region of intersection with the other of said singular equipotential surfaces.

3. In an electron beam system, means defining a region for traversal by an electron beam comprising an electron gun and a collector electrode, a focusing electrode system which establishes in said region a pair of singular equipotential surfaces which intersect at at least one point in said region, said electron gun being positioned to direct an electron beam for flow along one of said singular equipotential surfaces, and means for isolating the electron gun from the focusing electrode system comprising a conductive portion which is maintained at the potential of said singular equipotential surfaces and positioned intermediate between the gun and the focusing electrode system having a surface coincident with one of said equipotential surfaces over an extended region, said surface being apertured for passage of the electron beam therethrough substantially at the region of intersection with the other of said singular equipotential surfaces.

4. In an electron beam system, a focusing electrode system which establishes a pair of singular equipotential surfaces characterized by at least one intersection with each other, an electron source and a collector positioned at opposite ends of the focusing electrode system for projecting a electron beam therepast for flow along one of said singular equipotential surfaces, and means adjacent separate ends of the beam path for isolating the electrode beam system from the electron source and the collector, each of said means comprising a conductive element having a portion of its surface substantially coincident with one of the singular equipotential surfaces and apertured for passage of the electron beam there-through at the region of intersection with the other of said singular equipotential surfaces.

5. An electron discharge device comprising spaced inner and outer conducting members defining a region for traversal by an electron beam, means for establishing a pair of equipotential surfaces in the space between said members which intersect at at least one point in said region, and electron gun means adjacent one end of said region for projecting an electron beam substantially onto one of said surfaces for flow therealong, said gun means

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comprising an electron source and an accelerating anode having an outer surface portion substantially coinciding with one of said equipotential surfaces and being apertured for passage of electrons therethrough substantially at the point of intersection of said one surface with the other of said equipotential surfaces.

6. An electron discharge device in accordance with claim 5 further comprising a collector electrode at an end of said region, and a conductive element positioned between said collector electrode and said region, said conductive element having an outer surface substantially coinciding with said one equipotential surface and being apertured for passage of electrons therethrough substantially at the region of the intersection of said one surface with said other surface.

7. An electron discharge device comprising a plurality of linear conducting elements positioned in an array, means for establishing a pair of singular equipotential surfaces encompassing each of said elements and intersecting between adjacent of said elements, and electron gun means adjacent one end of said array for projecting an electron beam substantially onto one of said surfaces for flow therealong, said electron gun means comprising an electron source and an accelerating anode having an outer surface portion substantially coinciding with one of said singular equipotential surfaces and being apertured for passage of electrons therethrough substantially

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at the region of the intersection of said one surface with the other of said equipotential surfaces.

8. An electron discharge device in accordance with claim 7 further comprising a collector electrode at the other end of said array positioned on said other equipotential surface, and a conductive element positioned between said collector electrode and the last of said linear elements in said array, said conductive element having an outer surface substantially coinciding with said one singular equipotential surface and being apertured for passage of electrons therethrough substantially at the region of the intersection of said one surface with said other equipotential surface.

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