March 29, 1949. M. ARDITI 2,465,342

ELECTRONIC DISCHARGE DEVICE

Filed April 13, 1943 2 Sheets-Sheet 1

FIG. 1.

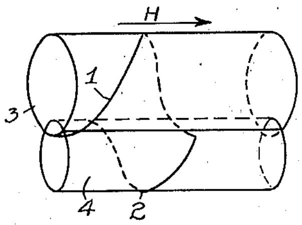


FIG. 2.

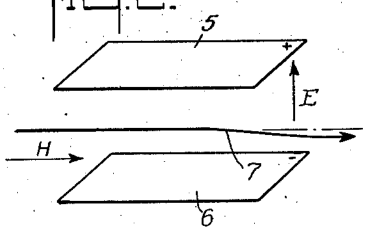


FIG. 3.

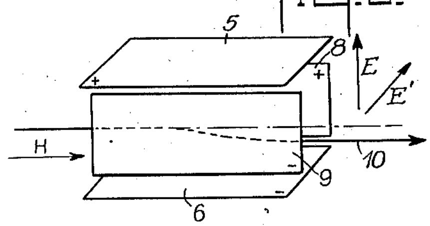


FIG. 4.

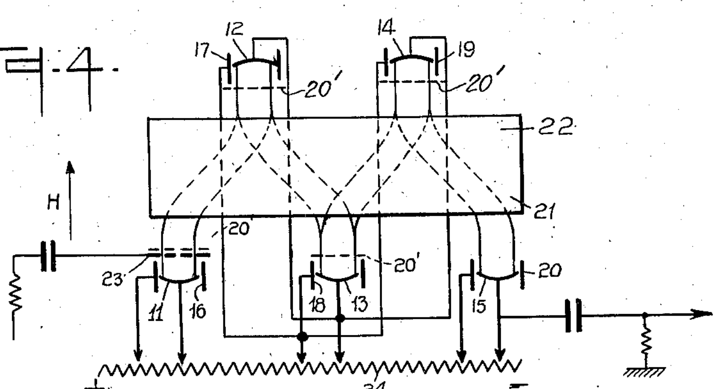
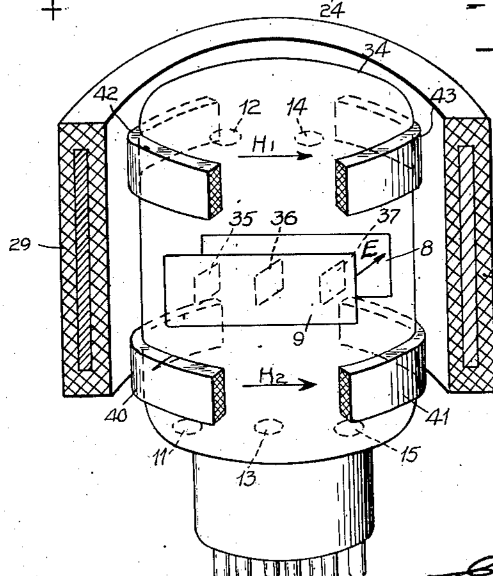


FIG. 8.



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March 29, 1949. M. ARDITI 2,465,342

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Filed April 13, 1943 2 Sheets-Sheet 2

FIG. 5.

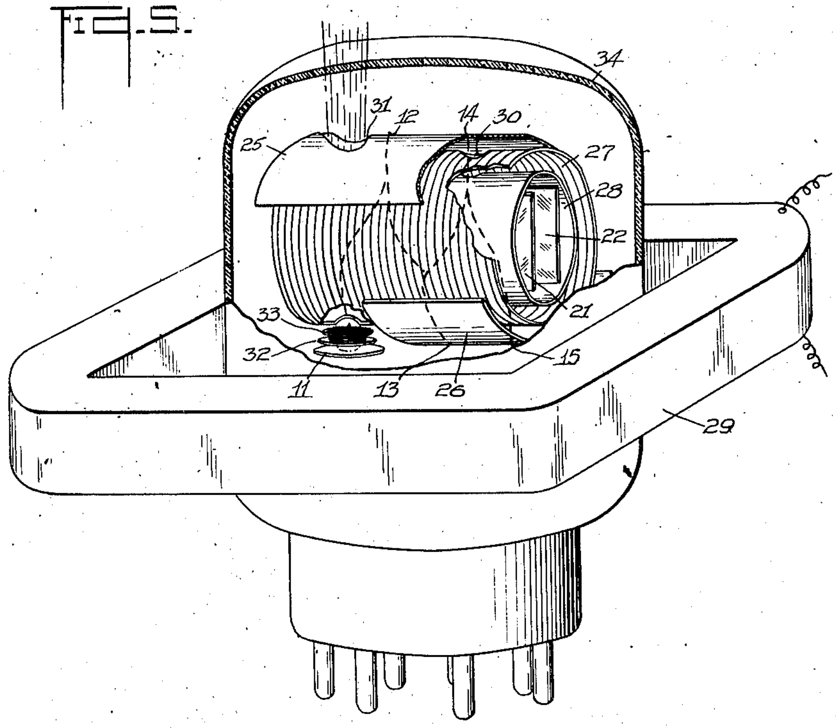


FIG. 7.

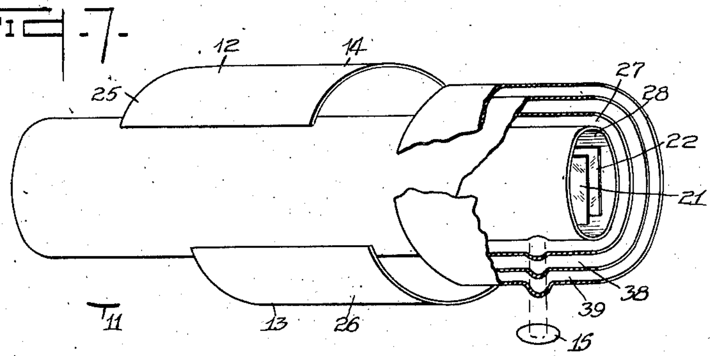
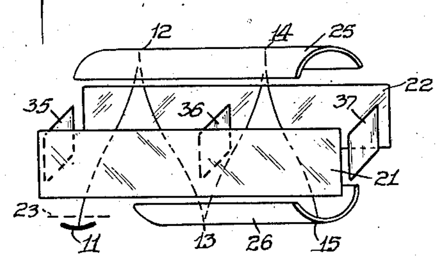


FIG. 6.



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UNITED STATES PATENT OFFICE

2,465,342

ELECTRONIC DISCHARGE DEVICE

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Section 1, Public Law 690, August 8, 1946
Patent expires July 28, 1961

33 Claims. (Cl. 250—27)

1

The present invention relates to electronic discharge devices and particularly discharge devices which provide for successive secondary electronic emissions.

A defect generally encountered in electronic discharge devices of this type is the appearance of interfering background noise in the output circuit. After careful research it has been discovered that this background noise is due to the fact that electrons leave the main beam paths and disperse across the structure, often dropping directly upon the collecting electrode or upon secondary emission electrodes which are removed from the electrode where these electrons originated. Moreover, in structures using a magnetic field disposed transversely to the electronic paths, an effect of the "magnetron" type may be produced which interferes with the grid control of the beams and is harmful to their homogeneity. As a result, the efficiency of the device is impaired.

It is therefore an object of the present invention to provide for sharp separation of the primary and secondary electronic beams at each secondary emission electrode.

Another object of the invention is to correctly concentrate the electronic beams upon emitting electrodes arranged in sequence.

I accomplish these and other objects of the invention, as will become more apparent hereinafter, by a novel and advantageous arrangement of elements and parts. In brief, according to one feature of the invention a magnetic field is disposed parallel to the mean direction of the electrons so as to insure sharp focussing of the various electronic beams.

According to another feature of the invention, one or more transverse electric fields are provided. The latter are electrostatically created by deflecting plates and serve to insure the deflection of the beams and the separation of the paths of the primary and secondary electrons at each of the emitting electrodes or targets. In order to obtain a still greater deflection of the electronic beams from one target to the next, one or more magnetic fields are perpendicularly disposed to the mean direction of the electrons at points of the structure located outside the operative region of the deflecting electric field or fields. Said magnetic fields act upon the electronic beams to produce the desired deflection. According to a further feature of the invention, a zero electric potential gradient region is created to allow the orthogonal deflecting electric field (or deflecting electric fields) to deflect the electrons accelerated by the accelerating electric potential gradient existing in the vicinity of the emitting electrodes. However, this electric potential gradient has accelerating effect only upon the electrons leaving an electrode, its direction being such that it retards the electrons approaching the same. According to still another feature of the invention, control and focussing grids are provided in the vicinity of the various emitting electrodes for the control of the electronic beams.

2

The present invention is fully explained in the following description and illustrated, by way of example, in the accompanying drawings, in which—

Fig. 1 is a diagram illustrating the action of a magnetic field on electronic paths directed in the same direction as the lines of force of the field;

Fig. 2 is a diagram illustrating the action of a pair of deflecting plates on an electronic path directed in the same direction as the lines of force of a magnetic field in which the plates are immerged;

Fig. 3 is a diagram illustrating the action of two pair of deflecting plates on an electronic path directed in the same direction as the lines of force of a magnetic field in which the plates are immerged;

Fig. 4 is a diagrammatic view of a device using successive secondary electronic emissions and incorporating the novel features of the present invention;

Fig. 5 illustrates another embodiment of the present invention using successive secondary electronic emissions;

Figs. 6 and 7 illustrate, respectively, two modifications of the device according to Fig. 5; and

Fig. 8 illustrates a modification of the structure according to Fig. 4.

Fig. 1 illustrates the spiral paths 1, 2 of electrons at initial speeds issuing from an emitting surface, such as a thermionic or photo-electric cathode or a secondary emission electrode (not shown). At these initial speeds, paths 1, 2 form a relatively small angle with the direction of the lines of force of a magnetic field H. Due to magnetic field H, electrons following paths 1 and 2 about imaginary cylinders 3 and 4 (whose axes are parallel to the lines of force of field H) are focussed and concentrated. As a result of this focussing or concentration, the electrons fall on a following emitting or collecting electrode, in a beam which reproduces, nearly in the same size, the image of the surface emitting these electrons. This image depends primarily upon the speed of the electrons, the strength of the magnetic field H and the dimensions of any electron-optic lenses arranged in the vicinity of the electrodes in order to accelerate the electrons, which are driven by the magnetic field, at their departure, or retard same at their arrival.

If the pair of electrostatic deflection plates 5, 6, shown in Fig. 2 is immerged in magnetic field H and an electric potential gradient, indicated by electric field E, is established between plates 5, 6 at right angles with respect to the direction of magnetic field H, the electronic paths are deflected by the electric field when the electrons pass between the plates, as shown at 7 in Fig. 2. Nevertheless, focussing of the electronic beam is always insured by the longitudinal magnetic field H. Instead of one pair of plates 5, 6, two pair of orthogonal plates 5, 6 and 8, 9 may be used as shown in Fig. 3. These two pair of plates furnish, respectively, orthogonal electric deflecting fields E and E' in the region surrounded by them. If plate pairs 5, 6, 8, 9 are immerged in longitudinal magnetic field H, the electronic paths such as 10, which cross this region will be deflected spatially. If desired, the two pair of plates 5, 6, 8, 9 may be replaced by two series of plate pairs being orthogonal between themselves and of different potentials. These potentials may for instance increase successively so as to modify the deflection of the beam during its travel between the plates. The value of deflection in every case is a function of the speed of the electrons at the input of the deflecting plates; it is inversely proportional to the strength of magnetic field H and is a function, moreover, of the value of the electrostatic potential gradient or gradients established between the plates.

The phenomenon of focussed electrons, as a result of a magnetic field disposed parallel to their directions, and the phenomenon of electron deflection due to the application of transversal electrostatic fields are utilized in the various embodiments of the present invention shown in Figs. 4 to 8.

In Fig. 4, the emitting electrode structure comprices a primary cathode 11, of the photo-electric or thermionic type. Elements 12, 13 and 14 represent electrodes having good secondary electronic emission properties. Element 15 is a collecting electrode producing no secondary emission. Electrodes 11 to 15 are surrounded by cylindrical electrodes 16 to 20, respectively, acting as focusing cylinders for the electrode with which they are associated. Electrodes 20' serve to accelerate the electrons leaving the respective emitting surfaces, to shoot them at an appreciable speed into space comprised between the two electrostatic deflection plates 21, 22. Electrodes 16 to 20 create a retarding potential gradient for the incident electrons striking secondary emission surfaces 12 to 14 at a speed of between 500 and 700 volts, corresponding in general to the maximum secondary electronic emission. It will be clear, of course, that instead of simple focusing cylinders more complex electrode structures, performing the same functions, may be used.

A control grid 23 may be associated with the primary cathode and with other emitting electrodes of the structure in order to control the flow of electrons. This arrangement may be used for example if it is desired to have the device operate as an amplifier, as indicated by the input circuit of grid 23 which is the usual amplifier connection type.

The output circuit of the device is likewise shown as the usual type of resistance-capacity connecting circuit. The potential applied to the various electrodes 11 to 20 may be taken from a single potentiometer 24, as shown. A magnetic field H is provided which is adapted to act in the direction of the paths of the mean directions of electrons coming from one of the emitting electrodes 11 to 14. An electric field E (Fig. 8) is created between deflection plates 21 and 22.

The primary electrons emitted by cathode 11 are controlled by grid 23 and then accelerated by electrode 20'. The electrons are driven by magnetic field H without deflection until they enter between deflecting plates 21 and 22. Between deflecting plates 21, 22, the electrons are deflected, as shown, and directed towards secondary emission electrode 12. However, upon leaving plates 21, 22, and before arrival at electrode 12, the electrons are retarded by focusing cylinder 17 and consequently fall on electrode 12 at a speed substantially corresponding to the maximum extraction of secondary electrons from electrode 12.

The secondary electrons emitted by electrode 12 are accelerated thereupon and travel the same path as the primary electrons until they enter between plates 21 and 22. The secondary electrons are then deflected towards the right, whereby separation of the primary and secondary beams is obtained, and directed towards electrode 13, where the process is repeated. The secondary electrons emitted by the last secondary emission electrode 14 are gathered by collecting electrode 20.

Secondary emission electrodes 12, 13, 14 may be brought to the same potential. Similarly, focusing cylinders 17, 18, and 19 associated with these electrodes may be brought to the same potential (by means of potentiometer 24). The reason for this is that the secondary emission electrodes need not have increasing potentials because electronic beam control, i. e. the deflection of the beams from one electrode to the next, is accomplished by a different means, to wit: by electrostatic plates 21, 22. Moreover, electrostatic plates 21, 22 may be broken up, if desired, into several pair of plates raised to different potentials; the emitting electrodes are then spaced to a greater or lesser extent, depending upon the deflections produced by these successive plate pairs.

Since electrodes 12 to 14 may all be brought to the same potential, they may be made of a single conductive support, or of two supports to facilitate mounting. These supports may consist, for instance, of flat conductive plates, but preferably, are given the shape of cylinders or cylinder portions. The focusing electrodes may then be replaced by a grid common to all the electrodes; if the emitting electrodes are formed on cylinder portions, it becomes convenient to use a cylindrical grid electrode. These variations are incorporated in the embodiment shown in Fig. 5.

In Fig. 5, electrodes 12 and 14 are formed on the inner surface of a conductive cylinder portion 25 and electrodes 13 and 15 on the inner surface of another conductive cylinder portion 26, preferably of the same radius of curvature as portion 25. The two cylindrical portions 25 and 26 are arranged so as to have the same axis, which serves as the general axis of the entire structure. A single grid electrode 27, formed by a spiral conductive wire winding, is arranged coaxially within cylinder portions 25 and 26. This grid 27 serves the purpose of focusing cylinders 17 to 20 of Fig. 4.

Deflecting plates 21 and 22 are arranged within grid 27. According to a further feature of the invention, a solid conductive and non-magnetic cylinder 28 is preferably arranged coaxially with grid 27 between grid 27 and electrostatic deflection plates 21 and 22. The purpose of cylinder 28 is to serve as an electric screen between the region near grid 27 and the region of the electrostatic plates 21, 22. As a matter of fact, focussing and control of the beams by means of magnetic field (H in Fig. 4), on the one hand, which is furnished by a permanent magnet or electromagnet 29 and the electrostatic deflection field, on the other hand (which is created by the potential gradient between plates 21 and 22) will be impaired if same are subjected in the deflection region to the influence of a gradient of electrical potential directed in the same direction as the magnetic field. Such combined action would entail distortions of the electronic beams and direct passages of interfering ions or electrons from one end of the structure to the other, with the result that interfering currents and a substantial obscuring current would be produced.

Suitable openings such as 30, 31, etc., are provided in grid 27 for the passage of the electronic beams, in front of electrodes 11 to 15, and, if cathode 11 is a photo-electric cathode, an opening may be provided in cylinder portion 25 in order to permit passage of the light beam controlling the electronic emission of cathode 11.

Cathode 11 is independent of the other electrodes and may be associated with any electron-optic system accelerating and controlling the flow of electrons. For example, Fig. 5 shows an accelerating ring 32 and a control grid 33 associated with photo-cathode 11.

The various connections and supports of the electrodes in insulating vessel 34 are omitted in Fig. 5 in order to simplify the drawing.

Instead of using a single electrostatic deflection, through a pair of plates (or a series of pairs of plates), spatial deflection may be obtained by means of two plates or a series of orthogonal plates. As an alternative, a series of orthogonal plates 35, 36 and 37, may be arranged between plates 21 and 22, as shown in Fig. 6. Plates 35, 36 and 37 are brought to increasing potentials along the structure. Such an arrangement allows better adjustment of the gradient and of the direction of the successive deflections of the electronic beams.

One or more cylindrical grids may also be added in the structure shown in Figs. 5 and 6, same being disposed coaxially with grid 27. These cylindrical grids may perform divers functions. Specifically, instead of being provided with openings in front of electrodes 11 to 15, they may be shaped at these points so as to constitute together electron-optic systems insuring acceleration (or retardation) and focussing of the electronic beams. Alternatively, they may be coated at these points with a substance having good secondary emission properties, and thus serve to increase the amplification of current in the device, their forms assuring a suitable passage of the secondary electrons emitted from one grid to the next and to the external electrode. As shown in Fig. 7, these grids 38, 39, may for instance be provided only at one end of the structure, opposite collecting electrode 15. It will be clear that such an arrangement may also be used in the structure according to Fig. 4.

An additional deflection of the electronic beams, facilitating the spacing of the various active electrodes of the structure, may be obtained by means of supplementary magnetic fields directed perpendicularly to the general paths of the electronic beams outside the electrostatic deflection region. Fig. 8 shows an embodiment of the invention providing for such additional magnetic deflection. The device according to Fig. 8 corresponds to that of Fig. 4 except that it is provided with auxiliary deflecting plates 35, 36 and 37, as in the case of Fig. 6. Emitting electrodes 11 to 14 and collecting electrode 15 are spaced from electrostatic plates 8, 9 and 35, 36, 37. Two pair of coils 40, 41 and 42, 43 are provided around the respective ends of vessel 34, as shown. These coil pairs create deflecting magnetic fields H1 and H2 disposed at right angles to the mean paths of the electrons in the spaces comprised between the emitting electrodes and the electrostatic plates. The paths of the beams are then such as indicated by the dotted lines shown in Fig. 4. The primary and secondary beams of each electrode separate only between the electrostatic plates. Thereafter, they follow the same path in the region between the electrode and the plates, joint deflection being obtained over this path by magnetic field H1 or H2. The positions of coil pairs 40, 41 and 42, 43 may be adjusted at will around vessel 34. If desired, a single coil pair, producing a single additional deflection may be used.

It will be clear that many changes may be made in the foregoing embodiments of the present invention without departing from the spirit and scope of the same. I therefore do not wish to be understood as limiting myself to the details of construction and arrangement shown and described herein.

I claim:

1. An electron discharge device comprising a primary electrode for emitting electrons, a plurality of secondary electrodes for emitting secondary electrons, said electrodes being arranged in sequence, said secondary electrodes being arranged to receive incident electrons emitted from a preceding electrode and to emit secondary electrons to a following electrode in an adjacent path directed parallel with and opposite to the path of the incident electrons, a collecting electrode for receiving secondary electrons, means arranged about said electrodes for producing a magnetic field parallel to the mean direction of said parallel paths for focusing incident and emitted electrons in said parallel paths, and means for deflecting the emitted from the incident electrons in the several parallel paths into distinctly separate paths.

2. The device claimed in claim 1, in which said electrodes are arranged along a substantially spiral path on which electrons pass from the path originating from the primary electrode to the path originating from the first secondary electrode along an arc of a spiral, and from the path originating from said secondary electrodes will pass along another arc to the path originating from the second secondary electrode and so forth until the last emitted secondary electrons are received upon said collecting electrode.

3. The device claimed in claim 1, in which said primary electrode is provided with a control grid.

4. The device claimed in claim 1, in which said primary electrode and at least one of the secondary electrodes are each provided with an accelerating electrode, same serving to project the electrons leaving the emitting surfaces of said electrodes into the space between said electrostatic fields.

5. The device claimed in claim 1, comprising a

plurality of retarding electrodes, one for each of said primary, secondary and collecting electrodes, whereby electrons approaching the emitting surfaces of said primary, secondary and collecting electrodes are retarded.

6. The device claimed in claim 1, in which said electric means consists of a pair of deflecting plates disposed parallel to each other, said electrostatic field produced by said plates extending uniformly over said paths and disposed perpendicularly to said magnetic field.

7. The device claimed in claim 1, in which said secondary electrodes are interconnected and adapted to be brought to the same potential.

8. The device claimed in claim 1, comprising a plurality of retarding electrodes, one of said retarding electrodes being associated with each one of said primary, secondary and collecting electrodes, whereby electrons approaching the emitting surfaces of said primary, secondary and collecting electrodes are retarded and conductive means interconnecting said retarding electrodes, the latter being adapted to operate at the same potential.

9. The device claimed in claim 1, comprising a plurality of retarding electrodes, one of said retarding electrodes being associated with each one of said primary, secondary and collecting electrodes, whereby electrons approaching the emitting surfaces of said primary, secondary and collecting electrodes are retarded; and conductive means interconnecting said retarding electrodes, the latter being adapted to operate at the same potential; said secondary electrodes being interconnected and adapted to be brought to the same potential.

10. The device claimed in claim 1, in which said electric means consists of a pair of deflecting plates disposed parallel to each other, said electrostatic field produced by said plates being disposed perpendicularly to said magnetic field and a plurality of electrostatic control plates, same being disposed parallel to one another, between and at right angles to said deflecting plates, said control plates aiding in the deflection of said electron beams.

11. The device claimed in claim 1, in which said electric means consists of a plurality of pairs of deflecting plates.

12. In an electron discharge device, the combination of a primary electrode, a plurality of secondary electrodes, a collecting electrode, means for supplying a plurality of different potentials to said primary and collecting electrodes, respectively, conductive means connecting said secondary electrodes to one another and to said supply means, a retarding electrode associated with each one of the aforementioned electrodes, said retarding electrodes acting as focusing cylinders, the retarding electrodes associated with said primary and collecting electrodes, respectively, being separately connected to said supply means, said retarding electrodes associated with said secondary electrodes being connected to one another and said supply means, a plurality of accelerating electrodes associated with said primary and control electrodes and selected secondary electrodes, and a control grid associated with said primary eelctrode, an input resistance-capacity circuit connected to said control grid, and an output resistance-capacity circuit connected to said collecting electrode, means for producing a magnetic field, the latter being disposed parallel to the mean speed direction of the emitted electrons, a pair of electrostatic plates disposed parallel to each other and producing an electrostatic field disposed perpendicularly to said magnetic field, whereby said magnetic field concentrates the emitted electrons in sharply focussed electron beams, while said electrostaic plates deflect said beams, electrons being projected by said primary electrode to the first secondary electrode and secondary electrons travelling from the latter to the next following secondary electrode and so forth, the last secondary electrons emitted being projected onto the collecting electrode.

13. The system claimed in claim 12, in which all said eelctrodes are disposed in spaced relation to each other along a substantially spiral path.

14. The system claimed in claim 12, in which said secondary electrodes are made in one piece and provided with a plurality of individual emitting surfaces.

15. The system claimed in claim 12, in which said electrodes are disposed in spaced relation to each other along a substantially spiral path, and the said secondary and collecting electrodes are disposed in substantially two planes along said spiral path, said secondary electrodes in the first plane being made of one piece and forming a first electrode unit and said secondary and collecting electrodes in the second plane being made of one piece and forming a second electrode unit, each of said electrode units being shaped like a portion of a cylinder mantle.

16. The system claimed in claim 12, in which said electrodes are disposed in spaced relation to each other along a substantially spiral path, and the said secondary and collecting electrodes are disposed in substantially two planes along said spiral path, said secondary electrodes in the first plane being made of one piece and forming a first electrode unit and said secondary and collecting electrodes in the second plane being made of one piece and forming a second electrode unit, each of said electrode units being shaped like a portion of a cylinder mantle, a conductive non-magnetic cylinder surrounding said electrostatic plates, a cylindrically wound wire surrounding said conductive non-magnetic cylinder and being disposed within said electrode units, an envelope containing the aforesaid electrodes and electrostatic plates; said magnetic field producing means being disposed without said envelope.

17. The system claimed in claim 12, in which said electrodes are disposed in spaced relation to each other along a substantially spiral path, and the said secondary and collecting electrodes are disposed in substantially two planes along said spiral path, said secondary electrodes in the first plane being made of one piece and forming a first electrode unit and said secondary and collecting electrodes in the second plane being made of one piece and forming a second electrode unit, each of said electrode units being shaped like a portion of a cylinder mantle, a conductive non-magnetic cylinder surrounding said electrostatic plates, a cylindrically wound wire surrounding said conductive non-magnetic cylinder and being disposed within said electrode units, an envelope containing the aforesaid electrodes and electrostatic plates; said magnetic field producing means being disposed without said envelope and auxiliary means for producing an auxiliary magnetic field, said means being disposed outside said envelope with the auxiliary magnetic field arranged perpendicularly to the magnetic field produced by said first means.

18. The system claimed in claim 12, in which said electrodes are disposed in spaced relation to

each other along a substantially spiral path, and the said secondary and collecting electrodes are disposed in substantially two planes along said spiral path, said secondary electrodes in the first plane being made of one piece and forming a first electrode unit and said secondary and collecting electrodes in the second plane being made of one piece and forming a second electrode unit, each of said electrode units being shaped like a portion of a cylinder mantle, a conductive non-magnetic cylinder surrounding said electrostatic plates, a cylindrically wound wire surrounding said conductive non-magnetic cylinder and being disposed within said electrode units, an envelope containing the aforesaid electrodes and electrostatic plates; said magnetic field producing means being disposed without said envelope; the said electrode units being provided with an electron emitting surface, each representing an individual electrode, said conductive non-magnetic cylinder and cylindrically wound wire being provided with apertures registering with said individual emitting surfaces; said primary electrode being formed by electron-optic means and said cylindrically wound wire and conductive non-magnetic cylinder each having an opening registering with said primary electrode to admit a beam of light thereto.

19. An electronic discharge device, a primary electrode emitting electrons in one path, a first secondary emitting electrode adapted to receive primary electrons and emit secondary electrons in an adjacent path directed parallel with and opposite to said first path, at least one further secondary electrode separated from the first secondary electrode and adapted to receive electrons from a preceding path and emit secondary electrons in a subsequent adjacent path extending in a direction parallel with and opposite to said preceding path, a collecting electrode adapted to receive secondary electrons from a preceding path, the potential difference between cooperating secondary electrodes being substantially zero, means for producing a magnetic field parallel to the mean direction of the electrons emitted by said emitting electrodes to focus the primary and secondary electrons in said parallel paths, and means for deflecting the electrons in the several parallel paths into distinctly separate paths.

20. An electronic discharge device, a primary electrode emitting an electron beam, a first secondary electrode adapted to receive said beam and emit secondary electrons in an adjacent path of parallel and opposite direction to the path of the received beam, at least one further secondary electrode separated from said first secondary electrode and adapted to receive a preceding beam and emit an adjacent beam in a path parallel with and opposite to the direction of the path of the received beam, a collecting electrode adapted to receive electrons from a preceding beam, the potential difference between cooperating secondary electrodes being substantially zero, means for producing a magnetic field parallel to the mean direction of the electrons emitted by said emitting electrodes to focus the primary and the secondary electrons in said parallel paths, and means for generating an electrostatic field uniformly extending over said adjacent beams and substantially perpendicular thereto to deflect the electrons in the several parallel paths into distinctly separate paths.

21. An electronic discharge device, a primary electrode having an emitting surface adapted to emit electrons in one path, a series of secondary electrodes separated from each other each having an emitting surface adapted to receive electrons from a preceding emitting surface and to emit secondary electrons in an adjacent path parallel with and opposite to that from the preceding emitting surface, a collecting electrode adapted to receive electrons emitted from the last emitting surface, the potential difference between secondary electrodes of said series being substantially zero, means for producing a magnetic field parallel to the mean direction of emitted electrons to focus the incident and emitted electrons into sharply defined parallel paths, and means for producing a plurality of electrostatic fields perpendicular to said beams to deflect incident electrons from emitted electrons in the several parallel paths into distinctly separate paths.

22. An electronic discharge device, end electrode means including a primary electrode to start electrons on a winding path and a collector electrode to receive electrons therefrom, a series of intermediate electrode means arranged along said path separated from each other and each adapted to receive electrons from and to emit electrons in said paths, said means including secondary electrodes having a potential difference between each other which is substantially less than that existing between one of said end electrodes and said secondary electrodes, and means for directing electrons received at and emitted from a secondary electrode to pass, for at least part of their way, in adjacent separate paths of parallel and opposite directions.

23. An electronic discharge device, end electrode means including a primary electrode to start electrons on a winding electron path and a collector electrode to receive electrons therefrom, a series of intermediate electrode means arranged along said path separated from each other and adapted to receive electrons therefrom and to emit electrons therein, said means comprising substantially equipotential secondary electrodes, the paths of the received and emitted electrons being substantially parallel adjacent the said intermediate electrode means, means arranged about said intermediate electrode means for focusing said received and emitted electrons in said parallel paths, and means for separating the emitted from the incident electrons in the several parallel paths and for deflecting the emitted electrons into the said winding path.

24. A device as claimed in claim 22, comprising a magnetic field parallel to said paths to separate said electrons.

25. A device as claimed in claim 23, comprising a magnetic field parallel to said paths to separate said electrons.

26. A device as claimed in claim 23, comprising an electrostatic field to deflect said paths equally and perpendicularly to the direction of electron emission.

27. A device as claimed in claim 23, comprising a number of electrostatic fields, each deflecting electrons from one path to an adjacent path of similar direction.

28. A device as claimed in claim 23, in which primary and secondary electrodes are arranged opposite, and displaced with respect to, each other, said primary electrode emitting electrons to be received by one of said secondary electrodes which emits secondary electrons in a parallel path of opposite direction.

29. A device as claimed in claim 23, in which said primary and secondary electrodes are ar-

ranged opposite, and displaced with respect to, each other, said primary electrode emitting electrons to be received by one of said secondary electrodes which emits secondary electrons in a parallel path of opposite direction, a further number of secondary electrodes each arranged opposite, and displaced with respect to, the immediate preceding secondary electrode to receive electrons therefrom and to emit further secondary electrons in a parallel path of opposite direction, and a receiving electrode arranged opposite, and displaced with respect to, the immediate preceding electrode to receive electrons therefrom.

30. A device as claimed in claim 23, in which said intermediate electrode means include means for accelerating the electrons.

31. A device as claimed in claim 23, in which said intermediate electrode means include means for focusing the electrons.

32. A device as claimed in claim 23, in which said secondary electrodes are provided on the inner surface of a conducting cylinder surrounding said electron path.

33. A device as claimed in claim 23, in which said secondary electrodes are provided on the inner surfaces of a number of co-axial cylinders.

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