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ELECTRON DISCHARGE APPARATUS

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FIG. 1

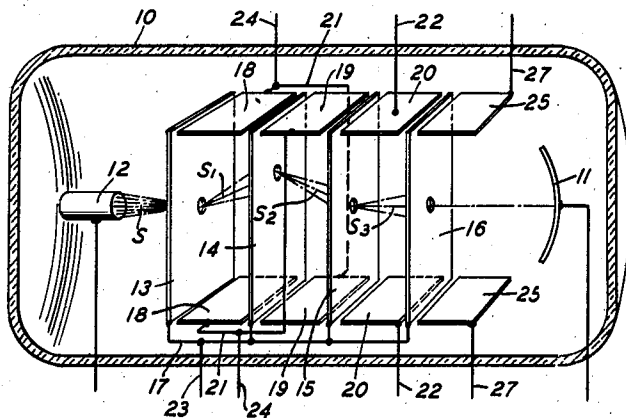


FIG. 2

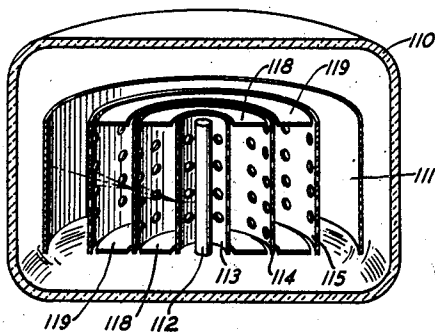


FIG. 3

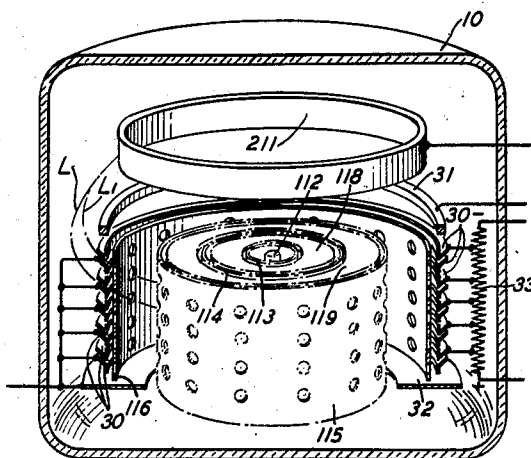
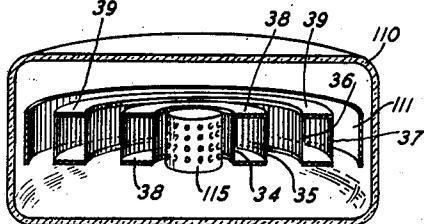


FIG. 4



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ELECTRON DISCHARGE APPARATUS

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3 Claims. (Cl. 250-158)

This invention relates to electron discharge apparatus and more particularly to electron discharge devices of the electron beam type.

In electron discharge devices, and particularly in those wherein a concentrated electron stream is utilized, a number of undesirable effects are attributable directly to differences in the velocities of the electrons constituting the space current. For example, in cathode ray oscillographs, differences in the velocities of the electrons constituting the electron beam result in distortion of the image produced on the screen by the beam. Also, for example, in electron discharge amplifiers, the noise generated is due in part to random velocities of the electrons.

One object of this invention is to produce a substantially univelocity electron stream in electron discharge devices.

In one illustrative embodiment of this invention, an electron discharge device comprises means, such as a cathode or an electron gun, for producing an electron stream, an electron receiving element, such as a fluorescent screen, target or output anode, and an electrode system between the electron stream producing means and the electron receiving element.

In accordance with one feature of this invention, the electrode system is so constructed and arranged that it effectively selects and permits of passage therethrough only those electrons in the stream which have a particular desired velocity or velocities within a limited range. In one specific construction, the electrode system includes a plurality of barrier electrodes mounted in succession between the electron stream source and the electron receiving element and pairs of deflector plates between each pair of successive barrier electrodes, the barrier electrodes being provided with apertures staggered or misaligned normal to the direction of projection of the electron stream. The barriers are maintained at suitable positive potentials and deflecting potentials are impressed between each pair of deflector plates.

The extent to which an electron will be deflected normal to its initial direction of travel by a field normal to this direction is dependent upon the velocity of the electron. Hence, when an electron stream composed of electrons having different velocities is projected into a deflecting field, the electrons will suffer different deflections, the slower moving electrons being deflected to a greater extent than the faster moving ones. The fast and slow moving electrons

may then be segregated by locating the aperture in the barrier toward which the electrons are traveling so that electrons with velocities lying within a desired range pass through the aperture whereas those with velocities outside of this range impinge upon and are collected by the barrier. This action is repeated at each barrier so that a high degree of selection between electrons of different velocities is realized and the stream emanating from the aperture in the last barrier of the series is composed of electrons having substantially equal velocities and, therefore, is substantially a univelocity stream.

The invention and the above-noted 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 a perspective view, partly diagrammatic, of an electron discharge device constructed in accordance with this invention and including plane, parallel barrier electrodes, a portion of the enclosing vessel being broken away;

Fig. 2 is a sectional view of an electron discharge device illustrative of another embodiment of this invention and comprising coaxial cylindrical electrodes;

Fig. 3 is a view similar to Fig. 2 of an electron discharge device particularly suitable for producing a single substantially univelocity, high current electron stream; and

Fig. 4 is a view partly diagrammatic and mainly in section of an electron discharge device of the velocity variation type embodying features of this invention.

Referring now to the drawing, the electron discharge device shown in Fig. 1 comprises an evacuated enclosing vessel 10 having at one end thereof a collector electrode or anode 11 and at the other end a cathode or electron gun 12 for producing an electron stream S. Mounted between the cathode or gun 12 and collector electrode 11 is an electrode system for eliminating from the electron stream those electrons having velocities outside of a desired restricted range. This system comprises a plurality of parallel barrier electrodes 13, 14, 15 and 16 electrically connected together by a conductor 17 and each having therein a small diameter aperture, the several apertures lying in a common plane passing through the cathode 12 and the collector electrode 11. In the particular construction shown in Fig. 1, the apertures in the barrier electrodes 13, 15 and 16 are in alignment and the aperture

in the electrode 14 is offset in the common plane noted. Between each pair of successive barrier electrodes are pairs of deflector plates 18, 19 and 20, the plates 18 and 19 of the first two pairs being cross-connected by conductors 21, and the plates 20 being provided with leading in conductors 22.

During operation of the device, the barrier electrodes are maintained at a positive potential with respect to the cathode or electron gun by a suitable source, not shown, connected to the conductor 23 and a fixed potential is impressed between the pairs of deflector plates 18 and 19 by way of conductors 24. In the construction shown in Fig. 1, the latter potential is such that the upper plate 18 is positive with respect to the lower plate 19. The anode or collector electrode 11 is maintained at a positive potential with respect to the barrier electrodes. The deflector plates 20 may be connected together electrically and have the same or different potentials applied thereto to focus the electron stream upon the aperture in the barrier electrode 16.

The electron stream emanating from the cathode or gun 12 passes through the aperture in the barrier electrode 13 and into the deflecting field due to the potential difference between the two deflector plates 18. Consequently the stream is deflected upwardly as indicated by the dotted lines S₁. The electrons constituting the stream inherently have different velocities so that, as described hereinabove, the electrons will suffer different deflections. Thus, electrons having velocities within a restricted range will pass through the aperture in the electrode 14 while those having velocities outside of this range, greater or smaller, will be collected by the electrode 14. Hence, a segregation of electrons of a desired velocity from those of other velocities is realized.

The electrons which pass through the aperture in the barrier electrode 14 are projected into the deflecting field between the deflector plates 19 and are deflected downwardly as indicated by the lines S₂. The deflection of electrons of different velocities is different so that, as a result, only those whose velocities fall within a restricted range pass through the aperture in the barrier electrode 15. These electrons are then directed through the aperture in the electrode 16 and constitute a substantially univelocity electron stream S₃ flowing to the electrode 11.

The intensity of the stream S₃ may be controlled or modulated by the application of a control or modulating potential to the plates 20 through the leading in conductor 22.

The stream emanating from the aperture in the barrier electrode 16, which aperture is in alignment with that in the electrode 15, may be deflected, if desired, by deflector plates 25 having leading in conductors 27 connected thereto.

It will be understood that the range of velocities of the electrons passing through the apertures in the several barrier electrodes is dependent upon the position and size of the apertures and the magnitudes of the deflecting and accelerating fields. These parameters may be correlated so that only low velocity electrons are passed through the electrode system while high velocity electrons are intercepted, or so that high velocity electrons only are passed and low velocity electrons are intercepted, or so that only electrons of substantially a particular velocity are passed while those of higher or lower velocities are intercepted.

Although in the specific construction illustrated in Fig. 1, two stages of velocity selection are shown, a single stage or a greater number of stages may be employed. As the number of stages is increased, the accuracy of selection of electrons of a particular desired velocity likewise increases. Also, although in the construction shown in Fig. 1, the deflector plates 18 and 19 are cross-connected so that the direction of deflection between the plates 19 is opposite to that between the plates 18, the several pairs of plates may be connected in such manner that the stream is deflected in the same direction between all of the pairs of deflector plates.

The invention may be embodied also in high current, coaxial electrode devices as illustrated in Fig. 2 wherein the elements corresponding to those in the device shown in Fig. 1 are designated by the same reference character increased by one hundred. The device illustrated in Fig. 2 includes, in coaxial relation, a cylindrical cathode 113, a series of cylindrical barrier electrodes 113, 114 and 115 and a collector electrode or anode 111 and includes also pairs of annular deflector plates 118 and 119. The barrier electrodes are provided with a plurality of vertical rows of apertures, corresponding rows of the several electrodes being in radial alignment and the apertures in successive rows being misaligned in the vertical direction to produce the velocity segregation in the deflected streams as in the device shown in Fig. 1. The deflector plates may be cross-connected as illustrated in Fig. 1 or may be connected in such manner that the deflection between each pair of deflector plates is in the same direction. The apertures in each barrier electrode are so spaced that all electrons other than those of the desired velocities are intercepted and further so that the electrons emanating from an aperture in one of the inner two barrier electrodes pass through only a corresponding aperture in the next succeeding barrier electrode. More specifically, the spacing between the apertures in each of the barrier electrodes is greater than the limits of deflection, vertical and lateral, as measured at the electrode, of all the electrons in the streams flowing from the preceding electrode.

Suitable electrodes may be provided between the barrier electrode 115 and collector electrode 111 to control or modulate the space current to the collector electrode.

If lateral deflection of the electrons in the output space current is not objectionable, the barrier electrodes may be provided with appropriately spaced, circular, circumferential slots in place of the multiplicity of small diameter apertures shown in Fig. 2.

The electron discharge device illustrated in Fig. 3 includes a cathode and velocity selecting electrode system of the same construction as the device shown in Fig. 2. It comprises in addition a cylindrical electrode 116 having apertures in alignment with the apertures in the barrier electrode 115 and a series of annular louver-like electrodes 20 defining a series of upwardly inclined annular slots, one for each lateral row of apertures in the electrode 116. A collector electrode 211 is mounted opposite one end of the electrode system and normal to the axis thereof. Also mounted opposite this end of the system and coaxial therewith is an annular accelerating anode 31. Mounted adjacent the other end of the electrode system is an annular

auxiliary electrode 32 connected directly electrically to the electrode 116.

As shown in Fig. 3, alternate of the annular electrodes 30 are connected together electrically and to the auxiliary electrode 32 so that all of these electrodes may be maintained at the same potential. The other annular electrodes 30 are connected to spaced points on a voltage divider 33, the connections being such that the electrode 30 connected to the divider 33 and nearest the auxiliary electrode 32 is at the highest positive potential with respect to the electrode 32 and the electrode 116 connected thereto.

An electron emanating from any aperture in the electrode 116 will pass between two of the louver-like electrodes 30 and, under the influence of the potential therebetween and the accelerating potential upon the anode 31, will be directed along a curved path, such as indicated by the broken lines L and L₁, toward the collector electrode 211. The potentials between adjacent electrodes 30 defining the circular slots and of the accelerating anode 31 are made such that all the electrons emanating from the apertures in the electrode 116 arrive at the collector electrode 211 with the same velocity.

In another embodiment similar to that illustrated in Fig. 3, the louver-like electrodes 30 are omitted and means are provided for producing externally to the electrode 116 a magnetic field having its lines of force parallel to the longitudinal axis of the electrodes. The electrons emanating from the apertures in the electrode 116 are projected, thus, into substantially parallel electric and magnetic fields and traverse spiral paths in flowing toward the accelerating anode 31 and collector electrode 211. The magnetic field is made of such strength that the pitch of the spiral paths traversed by the electrons is equal to the distance between the apertures in the electrode 116 whereby a single electron stream composed of electrons following spiral paths and having the same velocity is produced adjacent the end of the electrode 116 nearest the collector electrode 211.

It will be understood that in the construction illustrated in Fig. 3, suitable means may be provided between the stream producing system and the collector electrode to control or modulate the electron stream.

The electron discharge device illustrated in Fig. 4 is of the velocity variation type and comprises a cathode and velocity selecting structure of the form included in the device shown in Fig. 2. It comprises also two pairs of grids 34, 35 and 36, 37 which are mounted in coaxial relation with one another and the velocity selecting structure and are spaced by insulating annuli 38 and 39 respectively.

The substantially univelocity electron streams emanating from the apertures in the electrode 115 are projected radially through the gap between the grids 34 and 35 between which a high frequency potential is impressed whereby the electrons undergo a velocity variation. The velocity varied stream then traverses the space between the two pairs of grids and is converted into a density varied stream which passes between the grids 36 and 37. Energy may be taken from the density varied stream in the region of the grids 36 and 37 in known ways.

Although specific embodiments of the 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. Electron discharge apparatus comprising an electron receiving element, means for projecting an electron stream toward said element, and means intermediate said element and said first means for removing from the electron stream substantially all electrons having other than a desired velocity, said second means comprising a plurality of barrier electrodes mounted in spaced relation between said first means and said element and having misaligned apertures and electrostatic deflecting plate means in cooperative relation with said barrier electrodes for deflecting the electron stream approaching each barrier to an extent sufficient to allow only electrons having the desired velocity to pass through said apertures.

2. Electron discharge apparatus comprising an electron gun, an electron receiving element spaced from said gun, a plurality of barrier members mounted in succession and spaced relation between said gun and said element, each of said barrier members having a restricted aperture therein and the apertures in said members being misaligned, and a pair of deflector plates adjacent each of said barrier members and on opposite sides of a line extending between said gun and said element.

3. Electron discharge apparatus comprising a cathode having a cylindrical electron emissive surface, a collector electrode, a plurality of cylindrical barrier electrodes encompassing said cathode and mounted in succession between said cathode and said collector electrode, each of said barrier electrodes having a plurality of apertures therein, the apertures in successive barrier electrodes being aligned radially but misaligned in the direction of the longitudinal axis of said cathode, and deflector plates adjacent the ends of said barrier electrodes.

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