July 3, 1962 H. M. OWREN 3,042,832

HIGH-SENSITIVITY CATHODE-RAY TUBE

Filed April 16, 1959

FIG-1

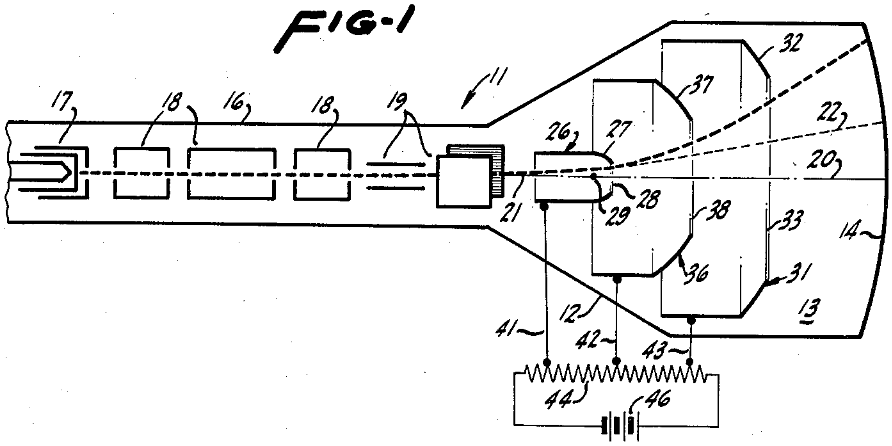
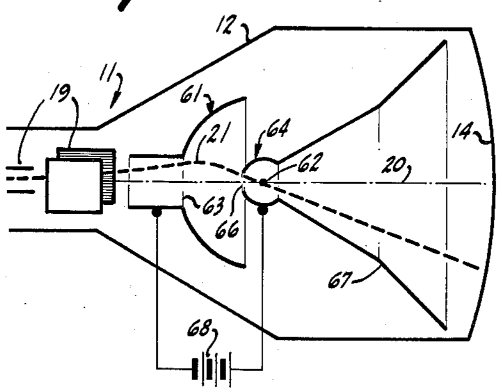


FIG-3



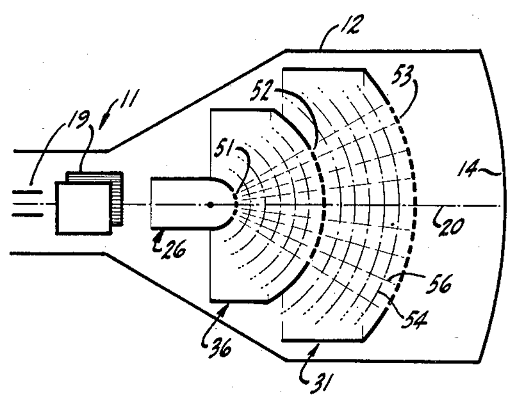


FIG-2

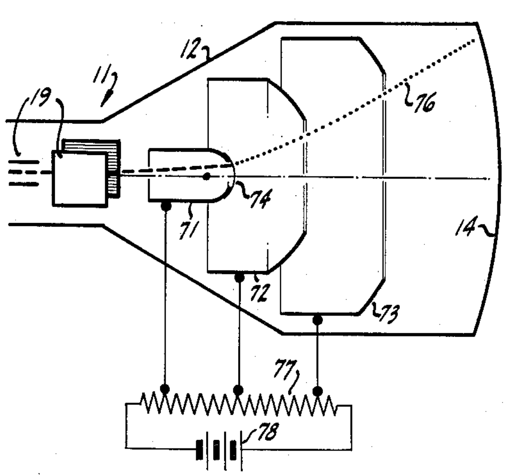


FIG-4

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HIGH-SENSITIVITY CATHODE-RAY TUBE

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The present invention relates in general to an improvement in the sensitivity of cathode-ray tubes, and more particularly to electrode means for a cathode-ray tube operating to additionally deflect and accelerate an electron beam therein to the end of providing improved tube sensitivity and magnification while preserving the beam focus therein.

It is highly desirable in any application of cathode-ray tubes to provide a maximized beam deflection in the tube to the end of providing a sweep of extended length and also it is highly desirable to provide a maximum screen brilliance. Although it is possible to attain in part these objectives by conventional means such as increasing the normal tube deflecting voltage or current yet such conventional approaches are limited in that same generally impose undue requirements on auxiliary tube circuitry. Thus, for example, requisite voltage variations and power delivery that would be necessary for such approaches would be excessive so as to preclude widespread usage thereof. Further, the additional acceleration of cathode-ray tube beams imposes in itself a serious difficulty. Full beam acceleration to very high beam energy prior to beam deflection has been found to be undesirable because of difficulties encountered in the deflecting system, i.e., the problem of achieving desired deflection and control of the beam. Post-deflection acceleration, i.e., acceleration of the beam after deflection, while overcoming the above-noted difficulties raises other problems in that image distortion results. While post-deflection acceleration systems are known and used, the tube resolution in such instances suffers thereby so that systems of that type are inherently limited, at least in their presently known form. Furthermore, conventional post-acceleration methods are directed to preserving the deflected beam direction so as to be applicable only in connection with increasing beam energy without improvement of tube sensitivity.

The present invention is directed to overcoming the above-noted difficulties encountered in the cathode-ray tube art as well as to the provision of other advantages in such art. It is contemplated by the present invention that there shall be provided within a cathode-ray tube and following the deflection means thereof, auxiliary or secondary beam accelerating electrodes which are so formed and disposed as to define, by appropriate potentials impressed therebetween, the electron beam accelerating and deflecting fields. Contrary to conventional post-deflection acceleration systems previously employed in the cathode-ray tube art, the present invention operates to additionally accelerate an electron beam and to magnify the original controlled deflection thereof without introducing image distortion. This is herein accomplished by the provision of spherical electric fields wherein beam acceleration is accomplished in the direction of deflection rather than parallel to the tube axis. In this manner the present invention is capable not only of further accelerating cathode-ray tube beams but also of further deflecting same in a uniform manner so that the resultant beam impinging upon the cathode-ray tube screen is additionally radially deflected to thereby expand or magnify the trace appearing upon the screen and at the same time to further energize the beam so as to intensify the magnified trace on the screen. The

foregoing is accomplished without in any way detracting from the trace resolution or in any way distorting the image or display.

In accordance with the foregoing it is an object of the present invention to provide the cathode-ray tube of improved sensitivity.

It is another object of the present invention to provide a cathode-ray tube with secondary or auxiliary beam deflection means for maximizing magnification of the tube display.

It is a further object of the present invention to provide a cathode-ray tube improvement including means producing post-deflection beam acceleration without image distortion.

It is yet another object of the present invention to provide an improved cathode-ray tube including means further accelerating the electron beam therein in a deflected direction for increasing beam energy while at the same time magnifying beam deflection.

Various other advantages and possible objects of the present invention will become apparent to those skilled in the art from the following description and drawing wherein there are illustrated several preferred embodiments of the present invention. Although only particular preferred embodiments of this invention are herein illustrated and described, it is not intended to limit the invention by the terms thereof but instead reference is made to the appended claims for a precise delineation of the true scope of the present invention.

The invention is illustrated in the accompanying drawing, wherein:

FIG. 1 is a schematic illustration of a cathode-ray tube including the improved accelerating and deflecting means of the present invention;

FIG. 2 is a schematic illustration of a portion of a cathode-ray tube including an alternative embodiment of the present invention;

FIG. 3 is a schematic illustration of a portion of a cathode-ray tube including a further embodiment of the present invention; and

FIG. 4 is a schematic illustration of a portion of a cathode-ray tube including yet another embodiment of the present invention.

Considering now the present invention in some detail as regards the preferred embodiments thereof illustrated, and referring to FIG. 1 of the drawing, there will be seen to be illustrated in schematic form therein a cathode-ray tube **11** including an evacuated envelope **12**. In conformity with conventional cathode-ray tube practices, the envelope **12** defines an expanded chamber **13** at one end thereof with a cathodoluminescent screen **14** disposed at the end of the chamber and an elongated neck or tube **16** extending from this screen **14** to house at the opposite end of the neck an electron beam source **17**. This electron beam source **17**, upon appropriate and conventional energization, not shown, is adapted to produce an electron beam and to direct same along an axis **20** of the cathode-ray tube which intersects the tube screen **14** at the center thereof. Along the tube axis from the electron beam source **17** there is provided a primary electron lens **18** which may, as illustrated, include a plurality of elements spaced along the tube axis and through which the electron beam is adapted to pass for accelerating and focusing same. Following the primary lens system **18** there are provided deflection means **19** spaced along the tube axis and including horizontal and vertical deflection means such as the pairs of plates illustrated. It will be appreciated of course that either electrostatic or electromagnetic deflection means may be employed in conventional manner in the cathode tube modified by the present invention and also that conventional energization of the tube elements is intended. An electron beam 21 emitted from the beam source 17 and passing axially through the primary electron lens 18, is radially deflected in passing through the deflecting means 19 and such deflection is normally accomplished in such a manner as to impart desired intelligence to the beam, such as, for example, by the application in an electrostatic deflecting system of suitably modulated deflecting potentials. The beam 21, upon emergence from the deflecting means and passage through the chamber 13, is deflected to radially separate, as regards consecutive beam portion, to thereby impinge upon the screen 14 at successive spaced points to provide a trace thereon. Considering a single beam portion, for simplicity of explanation, there is indicated in FIG. 1 by the dotted line 22 the path followed by such a beam portion receiving a particular radial deflection in passage through the deflecting means 19 in a conventional cathode-ray tube. As noted above, conventional cathode-ray tubes, as described to this point, are limited in the maximum beam energy that may be provided, for inasmuch as beam acceleration is normally accomplished in the primary electron lens or source, such acceleration is prior to beam deflection and consequently with too high a beam energy or velocity as a result of excessive beam acceleration the deflecting means become unable to provide the desired beam deflection. This results from the limited time in which the electron beam is subjected to the deflecting forces of the deflection means and such deflection time will be seen to be a direct function of the beam velocity. As regards sensitivity, conventional cathode-ray tubes are limited by the fact that large beam deflections require large spacing between deflecting plates so that the deflected beam will not strike same and with increased spacing between deflecting plates, there results a lesser effect upon the beam by any particular potential applied to the plates. The present invention provides close spacing of the deflecting plates so that only very small deflecting potentials are required.

The present invention provides means for additionally accelerating electron beams in a cathode-ray tube after controlled deflection thereof and for magnifying the deflection without distortion of the resultant display. To this end there is herein provided, as shown in FIG. 1, a first electrode 26 disposed symmetrically about the beam axis adjacent the deflecting means 19 and toward the screen 14 therefrom. This first electrode 26 defines a semi-spherical surface and may to this end include a spherical portion 27 facing the screen 14 and including or defining a beam-transparent section of the electrode. This transparent portion of the electrode 26 is disposed immediately about the tube axis so as to admit of passage of the beam through the electrode. As shown in FIG. 1, the electrode 26 is formed as a hollow cylinder having a spherical end directed toward the screen 14 with an opening 28 through such end for the passage of an electron beam therethrough. This spherical electrode portion 27 is disposed with the center 29 of the spherical surface located upon the tube axis. Displaced axially of the tube from the first electrode 26 is a further electrode 31. This further electrode 31 also defines a spherical surface as by a semi-spherical end portion 32 formed on a radius of curvature substantially greater than that of the spherical portion 27 of the electrode 26, but however having the same center 29. The electrode 31, which is preferably radially displaced from the tube axis so as to be disposed adjacent the sides of the envelope 12, is also provided with a central beam transparent portion which, as is illustrated in FIG. 1, comprises a large opening 33 which may in fact approach the size of the tube screen 14. Inasmuch as the electron beam is radially deflected in passage through the electrodes of the present invention, a substantial beam opening is required in the electrode 31 in order that the beam 21 will not impinge upon the electrode. Intermediate the electrodes 26 and 31 there may be provided a further electrode 36 formed with a spherical surface 37 having the same center 29 as the spherical surfaces of the other electrodes and having a radius of curvature intermediate of the radius of curvature of the electrode 36 and electrode 31. Similar to the above-described electrodes 26 and 31, the intermediate electrode 37 is provided with a central beam transparent portion 38 disposed symmetrically about the tube axis and providing an unobstructed passage for the beam 21 through the electrode. In the illustrated embodiment, the intermediate electrode 36 is disposed equidistant between the electrodes 26 and 31 although other disposition thereof is possible. Suitable physical mounting of the electrodes within the envelope may be accomplished in accordance with conventional tube practice and is thus not illustrated. Also the electrode 31 may be formed upon the tube envelope.

Electron beam acceleration and deflection is accomplished by the above-described electrodes through the application of suitable potentials to these electrodes for forming deflecting and accelerating electric fields in the beam path. Electrical potentials are applied between the electrodes in such a manner as to maintain the first electrode 26 at a relatively negative potential with respect to the electrode 31 and further to maintain the intermediate electrode 36 at an intermediate potential of a value dependent upon the physical location of same between the other two electrodes 26 and 31. Electrical connection is made, as by means of conductors 41, 42 and 43, from the electrodes 26, 36 and 31, respectively, into connection at appropriate points upon such as a voltage dividing resistor 44 connected across a power supply, illustrated as a battery 46.

The intermediate electrode 36 is maintained at an appropriate potential to further establish the spherical deflecting and accelerating field. As illustrated, the electrode 36 is maintained at a potential about 0.7 of the total voltage between electrodes 26 and 31, as by connection to the center of a logarithmic resistor 44. Any desired number of electrodes may be employed to establish the desired spherical field configuration and appropriate potentials applied thereto for this purpose, however, somewhat different potentials may also be employed in order to distort the field to produce certain desired results such as compensation for some other cause of distortion or suitable direction of the beam onto a planar screen.

By the foregoing electrical connection of the electrodes 26, 31 and 36, there is established an electric field intermediate the deflecting means 19 and screen 14 of the cathode-ray tube wherein the field lines are normally spherical about the tube axis. Thus, between the electrodes 26 and 31 there is established an electric field having lines of equal potential which lie upon spheres having the electrode center 29 as the center thereof and, in effect, radiating outward therefrom. The intermediate electrode 36 operates only to further define this field, particularly wherein the physical separation of the electrodes 26 and 31 is substantial. It will be seen from a consideration of the electric field established by the electrodes of the present invention, that there is provided thereby a potential gradient axially of the tube and radially thereof. With the electrode 31 closest to the tube screen 14 maintained at a relatively positive potential with respect to the electrode 26 disposed adjacent to tube deflecting means 19, this potential gradient operates to urge electrons within the field axially of the tube toward the screen 14 and radially of the tube outward of the axis thereof. Consequently, an electron beam deflected by the deflecting means 19 and passing through the electrode 26 enters a spherical electric field of substantial extent wherein the potential gradient is of proper polarity to urge electrons radially outward of the tube and also to urge electrons toward the screen **14**. With the field established by the electrodes of the present invention, a deflected electron beam is thereby accelerated toward the screen **14** while at the same time being deflected radially outward of the tube axis. In effect, electron acceleration occurs in the direction of deflection so that consequently no distortion of the beam display results, as would be the case with electric fields established normal to the tube axis and extending perpendicularly therefrom. In addition to the general case of exactly spherical fields, there may herein be readily introduced such variations in the fields as are necessary to compensate for distortions that otherwise result in the display from other causes. This is herein accomplished by variations in the shape of the intermediate electrodes or in the potentials applied thereto.

A modification of the present invention is illustrated in part in FIG. 2 wherein there is shown the electrodes **26**, **31** and **36** of the present invention substantially as illustrated and employed in FIG. 1, described above. The modification herein illustrated is that of providing a continuation of each of the electrodes into a complete sphere or semi-spherical surface about the tube axis. Such electrode continuation is herein made in the form of electronic grids **51**, **52** and **53**, enclosing the electrode openings **28**, **38** and **33**, respectively. These electronic grids are disposed, as above stated, upon a spherical surface which is, in the case of each electrode, a continuation of the electrode curvature. Additionally, these grids **51**, **52** and **53** are formed in a conventional manner as a very high permeance structure, as for example, of wire mesh. Stated otherwise, each of the grids has a high transmissivity or transparency for electrons and are thus formed with a maximum area of openings therein and a minimum area of grid wires or elements. With the grids having a high transmission factor for the electron beam only a very small proportion of the beam is intercepted thereby so that problems of grid heating or beam attenuation or minimized. The function of the grid structures illustrated in FIG. 2 is to further delineate the electric field established by the electrodes of the present invention. There is illustrated in FIG. 2 by the lines **54** a representation of equipotential lines resulting from the above-noted potentials applied to the grids. It will be seen that these lines **54** have the same radius of curvature as the electrodes and as each other inasmuch as each lies on circles having the common center **29** of the electrodes. Also illustrated in FIG. 2 are lines of force of the electric field established by the electrodes and such are thereby shown as dashed lines **56** which will be seen to emanate uniformly from the first electrode **26** radially outward of the tube axis and directed toward the tube screen with the focal point of the lines being the center of curvature **29** of the electrodes. It will be appreciated that electrons entering the field established between the electrodes **26** and **31** of the present invention will tend to follow the lines of force **56** illustrated in FIG. 2 and that also electrons following such lines of force will be accelerated along same inasmuch as the positive terminal of the field is disposed adjacent the screen **14** of the tube. Consequently it is clear from a study of FIG. 2 that an electron beam passing through the first electrode **26** and entering the electric field established by the electrodes will in fact be radially deflected while at the same time being accelerated in the direction that the beam is traveling so that the electrodes thereby operate not only to further energize the beam but also to radially deflect same outwardly of the tube axis. The acceleration imparted to the beam by the field established with these electrodes is not parallel to the tube axis, and therefore does not operate to distort the display so that no reduced resolution accompanies the intensification.

A further embodiment of the present invention is illustrated in FIG. 3 of the drawing wherein a relatively inverted electrode system is illustrated. In this embodiment of the invention there is provided a first semi-spherical electrode **61** having the center of curvature **62** thereof disposed upon the beam axis **20**, but in this instance oriented to provide the convex electrode surface in facing relation to the cathode-ray tube deflecting means **19**. This electrode **61** is disposed adjacent the deflecting means **19** of the cathode-ray tube and is provided with a central opening or electron beam transparent portion **63**, about the tube axis **20** of sufficient diameter to accommodate the deflected beam **21** passing therethrough. An additional electrode **64** is provided as a semi-spherical element having the same center **62** as the electrode **61** and having a much smaller radius of curvature than that of the prior electrode **61**. This second electrode **64** is disposed intermediate the first electrode **61** and the tube screen **14** with the convex side thereof facing the concave side of the electrode **61** and has a minute opening **66** therein about the tube axis **20** for the passage of an electron beam therethrough. As an additional portion of this second electrode **64** there is preferably provided a diverging funnel or horn-shaped portion **67** directed toward the screen **14** and flaring outwardly toward same. As in the above described embodiments the spherical electrodes of the present embodiment are adapted to establish therebetween a spherical electric field for deflecting and accelerating an electron beam entering same. To this end the electrodes are connected to a suitable source of potential, herein illustrated as a battery **68**, maintaining the first electrode **61** at a relatively negative potential with respect to the second electrode **64**.

It will be appreciated from a consideration of the electrostatic field configuration established by the relative potentials of the electrodes **61** and **64** that an electron beam **21** entering the electrode field region of the embodiment illustrated in FIG. 3 will undergo a deflection which will, in fact, reverse the beam deflection radially of the tube. Lines of force of the deflecting electric field will be seen to converge toward the screen **14** rather than oppositely, as in the above described embodiments of the invention, and thus the radial potential gradient acting upon an electron beam entering the field urges the beam toward the axis of the tube so that the beam is in fact redirected. The beam deflection produced by the spherical accelerating and deflecting fields of this embodiment of the invention is such as to cause the beam to cross the tube axis and the resultant radial beam deflection is proportional to the original deflection but in excess thereof. It will be seen further that with the second spherical electrode **64** having a relatively small radius of curvature and also a relatively small beam opening **66** therein, that the electron beam is generally constrained to follow lines of force of the electric field and will be in fact focused through the electrode aperture **66** to pass generally through the center of curvature **62** of the electrodes and thence onward in a relatively field-free region within the funnel or horn **67** into impingement upon the screen **14**. In this instance the second electrode **64** and funnel or horn **67** thereof may be electrically connected to the screen **14** so that there is in fact established an electric field free region through which the beam passes after entering the second electrode **64**. In the above described embodiments the electrode adjacent the screen of the cathode-ray tube may also be electrically connected thereto. Here again in the embodiment of the present invention illustrated in FIG. 3 of the drawing, an electron beam **21** entering the electric field established between the electrodes of the present invention will experience an acceleration toward the screen **14** along the deflected path of the beam while at the same time experiencing a radial potential gradient operating to further radially deflect the beam. Thus in this embodiment the same result pertains in that following conventional beam deflection of the cathode-ray tube there is established a spherical electric field in the beam path which operates to further accelerate and deflect the electron beam whereby such beam impinges upon the cathode-ray tube screen at an increased energy and with an increased radial deflection.

The improved electron beam accelerating and deflecting system of the present invention is also adapted to various other applications as, for example, the one illustrated in FIG. 4 of the drawing. Therein there is shown an electrode system including first, second and third electrodes **71**, **72** and **73** disposed in the named order between cathode-ray tube deflecting means **19** and screen **14**. As in the embodiments of FIGS. 1 and 2, the electrodes **71**, **72** and **73** are herein formed as spherical surfaces, or at least semi-spherical surfaces, with a common center disposed on the tube axis and with the electrodes disposed symmetrically about the axis. The electrodes are provided with electron beam openings therethrough of progressively increasing size toward the cathode-ray tube screen in order to afford adequate passageway for an electron beam traversing the tube to the screen thereof.

As a departure from the above teaching, there is provided in this embodiment a thin sheet or film **74** across the opening in the first electrode **71** disposed adjacent the deflecting means **19**. This film **74** lies upon the spherical surface of the electrode to define with the electrode the semi-sphere thereof. Additionally, this film **74** is formed of a material that is a good emitter of secondary electrons upon bombardment by primary electrons. More particularly the film **74** is adapted to produce from the convex side thereof a plurality of electrons for each electron impinging the concave side of the film with such emission occurring directly through the film from the point of impingement of the primary electron. It will thus be seen that a deflected primary electron beam **21** of the cathode-ray tube strikes the film **74** upon the concave side thereof to produce thereby an electron beam **76** formed of secondarily emitted electrons from the convex side of the film **74**, which secondary electrons are then further accelerated by a spherical field established by the electrodes **71**, **72** and **73**. As noted above, electrons are secondarily emitted from the convex side of the film **74** directly opposite the point of impingement of a primary electron on the concave side thereof so that in effect the secondary electron beam **76** forms a continuation of the primary beam but is composed of a much greater number of electrons. Suitable electrical connections from the electrodes **71**, **72** and **73** to appropriate points on a voltage dividing resistor **77** connected across a power supply, illustrated as a battery **78**, serve to establish a spherical electric field symmetrically about the tube axis **20** in the same manner as described above in relation to FIG. 1. It will be seen that the spherical magnetic field established by the electrodes **71**, **72** and **73** of FIG. 4 operate in the same manner as described above in connection with FIG. 1 to provide an additional electron beam acceleration to thereby materially increase the beam energy and further to additionally radially deflect the beam in proportion to the amount of the original deflection accomplished in the deflecting means **19** of the cathode-ray tube.

A further and material advantage of the embodiment of FIG. 4 is that of providing a substantial increase in the beam current by the utilization of a secondary emitter in the beam path. It is herein contemplated that the primary electron beam of the cathode-ray tube need not be of a high current value, for the multiplication afforded by the secondary emitter **74** is sufficient to provide a resultant or secondary beam **76** having a current density greatly in excess of those available from conventional cathode-ray tubes.

An improved cathode-ray tube constructed in accordance with the principles of the present invention has, during operation and test, proven to have a sensitivity some ten times that of conventional cathode-ray tubes. A suitable ratio of radii of first and last electrodes has been found to be 5:1. Additionally, an advantage of the present invention lies in the fact that deflection sensitivity may be made materially higher even with a high final beam energy as the deflection is largely independent of the final potential. It is also to be noted in connection with the present invention that additional focusing of the electron beam may be provided by appropriate control of the relative potential between the electrode system and the electron gun assembly, including the above-defined electron beam source and primary electron lens.

What is claimed is:

1. A high-sensitive cathode-ray tube comprising an electron beam source, deflecting means for controllably deflecting an electron beam therefrom, a screen for intercepting said beam, and a plurality of electrodes disposed along said beam path intermediate said deflecting means and said screen and establishing substantially semi-spherical electric fields symmetrically about the tube axis with lines of force radiating from a point which is disposed on said tube axis and is displaced from said deflection means for further deflecting said beam radially outward of the tube axis to spread same upon said screen.

2. In a cathode-ray tube having means establishing an electron beam along an axis thereof and means controllably deflecting the beam from said axis to impinge at controllable points on a tube screen displaced axially of the tube: the improvement comprising at least two electrodes spaced along the tube axis intermediate the deflecting means and screen, said electrodes being disposed symmetrically about the tube axis and each defining thereby, including projections thereof, a semi-spherical surface with each having a common center of curvature displaced along the tube axis from the beam deflection means of the tube; and means applying a potential difference between said electrodes to maintain the one nearest said screen positive with respect to the other for establishing beam deflecting and accelerating fields.

3. Electron beam deflecting and accelerating means for a device producing an electron beam and controllably deflecting same to direct the beam upon a screen displaced axially of the device from the point of beam deflection, and comprising at least two electrodes having concentric semi-spherical shapes and each disposed symmetrically about the axis of said device, said electrodes each having a portion about the axis of said device which is transparent to said electron beam, and means maintaining upon said electrodes a potential of decreasing positive polarity from the electrode adjacent said screen to the one adjacent the beam deflection for establishing spherical electric fields in the path of said beam, said fields having coincident centers of curvature displaced along the tube axis toward said screen from said controllable beam deflection to further deflect said beam radially outward of the device and to accelerate same in such deflected direction whereby the beam impinges upon said screen at radially displaced positions without beam defocusing.

4. Means claimed in claim 3 further defined by said electrodes comprising a pair of concentric segments of spheres of different radius disposed symmetrically about said axis with the center of curvature disposed thereon and the one with the larger radius disposed adjacent said screen with the convex side thereof facing said screen.

5. Means claimed in claim 3 further defined by said electrodes each having a central grid portion of high transparency for electrons and each of said portions being disposed symmetrically about the axis of said device.

6. An improved cathode-ray tube comprising an electron beam source projecting an electron beam along an axial path, deflecting means adapted for controlled energization to radially deflect an electron beam directed therethrough, a screen displaced from said deflecting means along the beam axis and disposed to intercept said beam, a first electrode having a centrally apertured spherical portion disposed symmetrically about said beam axis adjacent

said deflecting means, a second electrode disposed between said first electrode and said screen and having a centrally apertured spherical portion disposed symmetrically about said beam axis concentrically with the spherical portion of said first electrode, the spherical portions of said electrodes having the centers of curvature thereof disposed on the tube axis toward said screen from said deflecting means, and means maintaining said second electrode at a positive potential with respect to said first electrode for establishing a radially diverging electron accelerating field whereby an electron beam traversing same is accelerated and deflected radially outward of the beam axis into outwardly displaced impingement upon said screen.

7. Beam deflection and acceleration means for a cathode-ray tube including a beam source directing a beam along an axis through the beam deflection means toward a screen, and comprising a pair of concentric semi-spherical electrodes spaced along said axis between said deflecting means and screen with each having beam transparent portions therein about said axis and adapted to have a potential impressed therebetween with the one nearest said screen maintained at a relatively positive potential with respect to the other for establishing beam accelerating and deflecting fields diverging from a point on said axis displaced from said deflecting means toward said screen and operating substantially uniformly upon an electron beam passing at any deflection therethrough.

8. Beam deflection and acceleratoin means as defined in claim 7, further defined by the first of said electrodes having a greater radius of curvature than the second and disposed on the opposite side of the second electrode from said screen, said first electrode having a large beam transparent portion therein, and said second electrode having a minute beam transparent portion therein through which the beam is focused by fields established between the electrodes.

9. Beam deflecting and accelerating means as claimed in claim 7 further defined by the beam transparent portion of said electrodes comprising electrical grids of high transparency for electron beams to define spherical electric fields shaped about the axis of the tube.

10. Beam deflecting and accelerating means for a cathode-ray tube having an electron beam source directing a beam axially of the tube toward a tube screen through deflecting means operable to controllably radially deflect the beam, and comprising a plurality of electrodes spaced along the tube axis between said deflecting means and said screen with each of said electrodes defining a semi-spherical surface disposed symmetrically about the tube axis, said semi-spherical electrode surfaces being concentric and parallel and having coincident centers of curvature displaced along the tube axis from said deflecting means, and said electrodes being adapted to have impressed therebetween electrical potentials of increasingly positive polarity toward said screen to establish uniformly diverging electron beam accelerating fields for focusing said beam at radially displaced points on the screen.

11. Beam deflecting and accelerating means as claimed in claim 10, further defined by one of said electrodes disposed closest to said deflecting means having a portion of the spherical surface defined thereby intercepting the tube axis, said portion being formed of a sheet of secondarily emissive material producing on the side facing said screen a plurality of electrons for each electron of said beam striking the opposite side at a point directly through the sheet therefrom.

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