Feb. 18, 1958 J. T. McNANEY ET AL 2,824,250

CATHODE RAY APPARATUS UTILIZING CONVERGENCE MEANS

Filed May 12, 1955 3 Sheets-Sheet 1

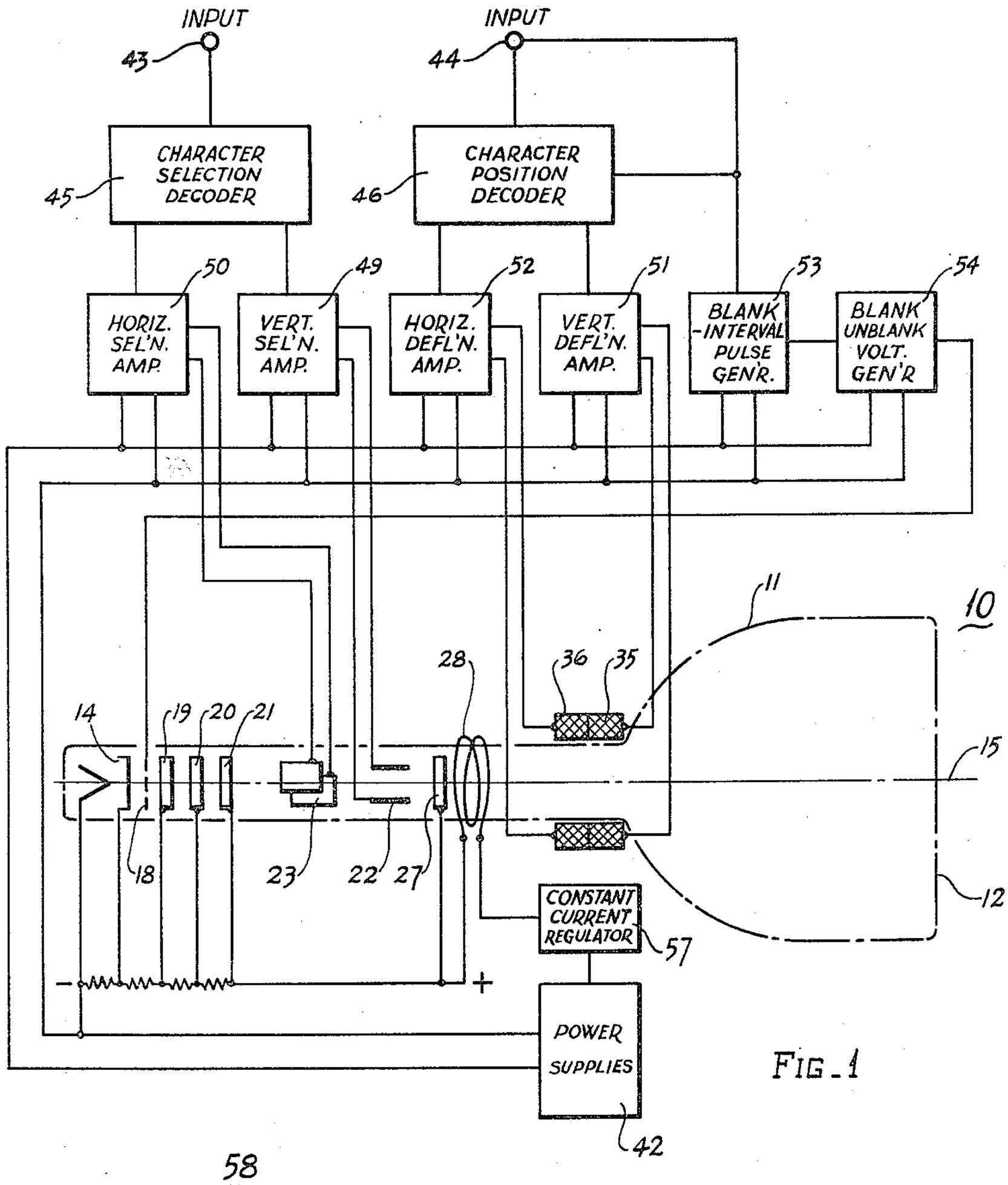

FIG_1

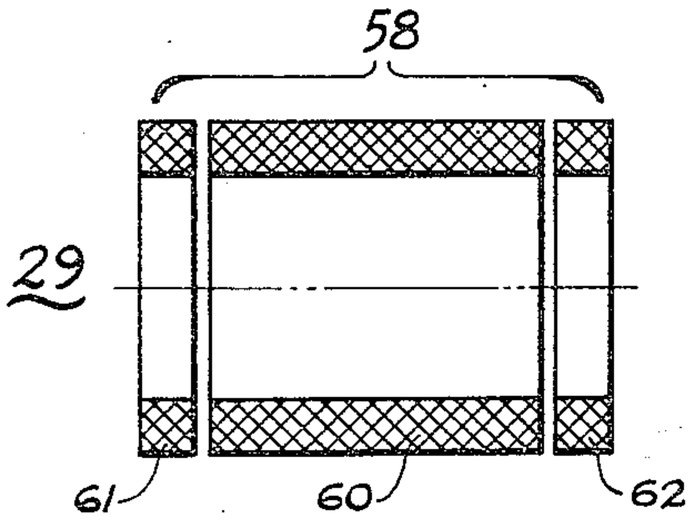

FIG_2b

INVENTORS.
JOSEPH T. McNANEY
OMER F. HAMANN
JAMES H. REDMAN

BY Walter J. Jason
Attorney

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CATHODE RAY APPARATUS UTILIZING CONVERGENCE MEANS

Filed May 12, 1955 3 Sheets-Sheet 2

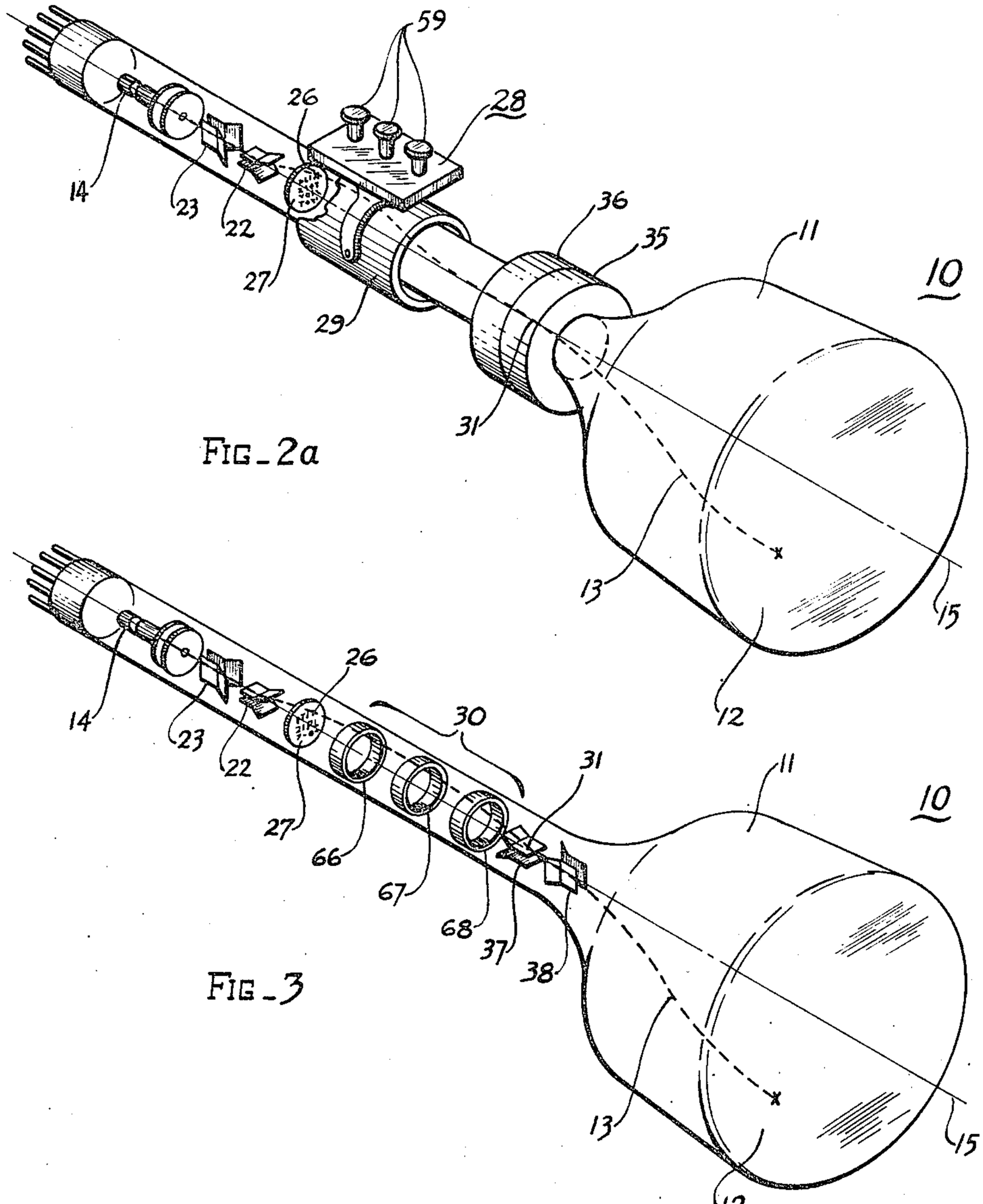

FIG_2a

FIG_3

INVENTORS.
JOSEPH T. McNANEY
OMER F. HAMANN
JAMES H. REDMAN

BY Walter J. Jason
Attorney

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CATHODE RAY APPARATUS UTILIZING CONVERGENCE MEANS

Filed May 12, 1955 3 Sheets-Sheet 3

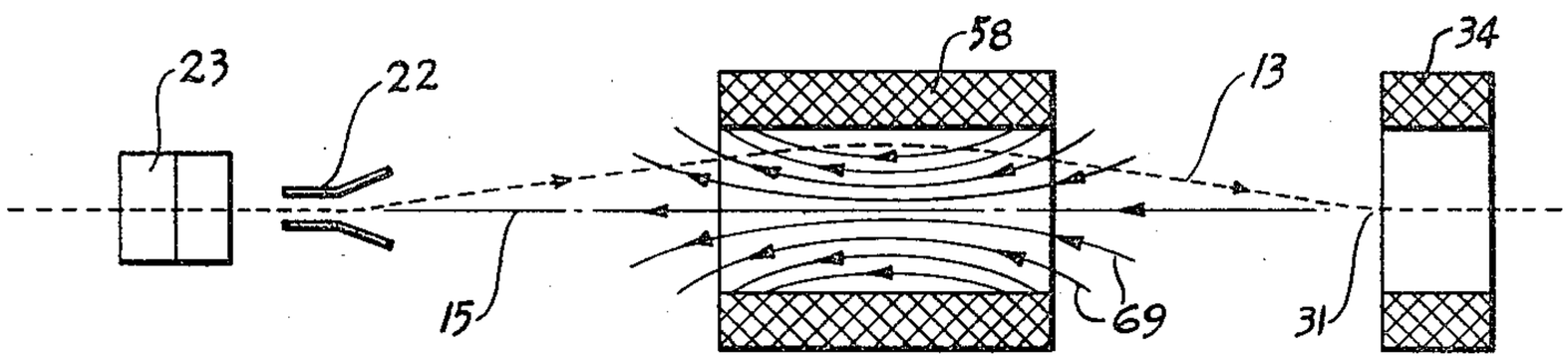

FIG_4

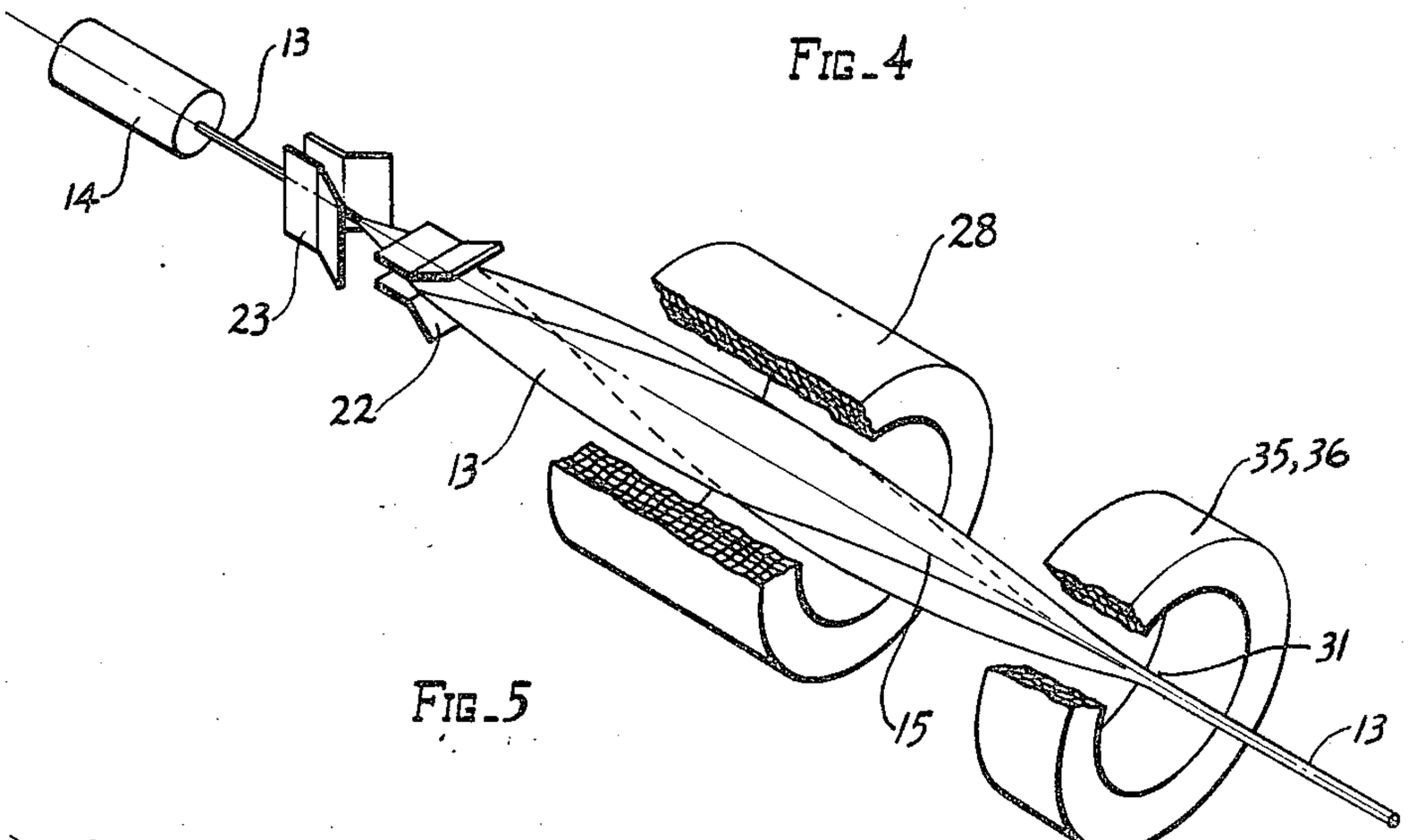

FIG_5

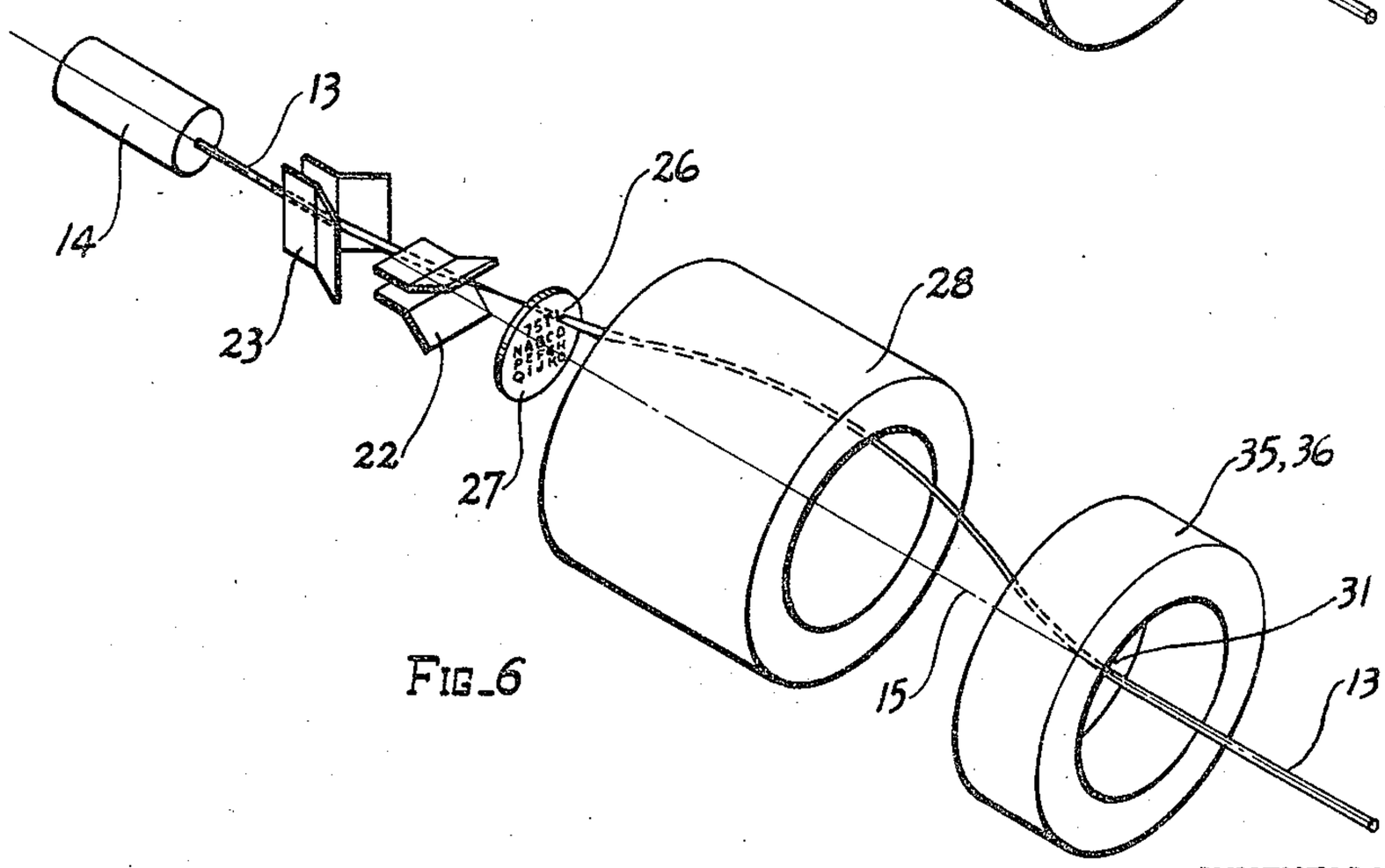

FIG_6

INVENTORS.
JOSEPH T. McNANEY
OMER F. HAMANN
JAMES H. REDMAN

BY Walter J. Jason
Attorney

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CATHODE RAY APPARATUS UTILIZING CONVERGENCE MEANS

Joseph T. McNaney, La Mesa, and Omer F. Hamann and James H. Redman, San Diego, Calif., assignors to General Dynamics Corporation, San Diego, Calif., a corporation of Delaware

Application May 12, 1955, Serial No. 507,856

6 Claims. (Cl. 313—77)

This invention relates generally to cathode ray display tubes and more particularly to an electron beam convergence means therefor.

A cathode ray display tube, such as exemplified by a co-pending application of J. T. McNaney, Serial No. 298,603, now U. S. Patent 2,735,956, and assigned to the common assignee hereof, is provided with means for shaping an electron beam into desired character information for direct reading visual presentation upon a screen of the tube. The electron beam, emitted at one end of the tube toward the screen or target at the other end thereof, is caused to select a character opening in a matrix thereby shaping the beam into a cross-sectional shape corresponding to that of the character opening illuminated. To effect such selection, the electron beam, which is emitted substantially along the longitudinal axis of the tube, is deflected away from that axis an amount necessary to illuminate the desired character opening in the matrix providing the beam with a cross-sectional shape corresponding to the character opening illuminated. The beam, being directed away from the axis by the deflection, must be redirected from that path and converged to the axis at a focus or cross over point. This action, which may be referred to as lens action, is effected by a convergence means which is positioned about the axis to effect beam convergence. The convergence means, which may be either electrostatic or electromagnetic, redirects the electron beam's path to the convergence or cross over point on the axis and in addition to the redirection, effects lens action upon the beam, so shaped, to effect a minimal cross-sectional area of the beam at the cross-over point on the axis. This problem is peculiar to the display tube. The electron beam in the display tube must be directed from the axis to select the desired character opening for illumination in the matrix, and the resulting character shaped beam must thereafter be returned to the axis of the tube at minimal cross section thereof, prior to deflection of the beam onto the desired screen position. Should the beam be off axis or of large cross-sectional area at the point of deflection, deflection of such beam would cause undue distortion of the character impinged upon the target thereby rendering such character partially or totally unintelligible.

The convergence means, therefore, permits operation and utilization of the beam over a relatively large variety of angles of deflection of the beam and reconverging the beam to axis at its minimal cross-section to minimize character distortion upon the screen.

Such convergence means may include an electrostatic or electromagnetic lens system, each effecting redirection and focusing at minimum cross section of the electron beam to and at the axis by their respective fields of influence. The prime requisite of the convergence means, whether electrostatic or electromagnetic, is the need for redirecting or converging of the divergent curvature of the electron path, effecting this in a smooth transition having predictable characteristics, and in focusing the

beam to minimal cross-section at the cross over point on the axis.

It is an object of this invention to provide a cathode ray display tube which will present clear and undistorted characters upon a screen of the tube.

It is an object of this invention to provide a cathode ray display tube with means for causing an electron beam having angularity with respect to the tube axis, to become coaxial, at minimum beam cross section at a point on the tube axis prior to deflection of the beam to predetermined target locations.

It is an object of this invention to provide a cathode ray display tube with means for substantially eliminating adverse effects caused by deflection of the electron beam to selectively illuminate character openings in a matrix.

It is an object of this invention to provide an improved cathode ray display tube wherein the electron beam may be projected at angles with respect to the tube axis and returned to axis prior to deflection of the beam to a predetermined position on the target.

It is an object of this invention to provide a cathode ray tube for producing and directing an electron beam toward a target along paths which are angular with respect to the tube axis and wherein means are provided to eliminate the adverse effects of non-linearities resulting from such irregular paths.

Objects and advantages other than those set forth above will be apparent from the following description when read in connection with the accompanying drawings, in which:

Figure 1 is a schematic block diagram of a cathode ray display tube and its energizing system embodying the invention;

Figure 2*a* is a view, in perspective, of a cathode ray display tube embodying an electromagnetic lens;

Figure 2*b* is an enlarged view, in cross-section, of a portion of the electromagnetic lens;

Figure 3 is a view, in perspective, of a cathode ray display tube embodying an electrostatic lens;

Figure 4 is a diagrammatic illustration of the convergence means, and its field of influence on the electron beam;

Figure 5 is a diagrammatic view showing the path of the electron beam through the convergence means;

Figure 6 is a diagrammatic view showing path of a single electron beam through the convergence means.

The diagram of Figure 1 illustrates an embodiment of the invention block diagram form showing a cathode ray display tube **10** connected with electronic circuitry necessary to effect its operation. The display tube **10** portrays selected characters upon its screen in response to predetermined voltages applied to the tube.

Specifically, display tube **10** comprises an evacuated container **11** in which a target or screen **12** is positioned at one end thereof and a source of electrons for forming an electron beam **13**, such as an electron emitting cathode **14** is positioned at the other end thereof. The electron beam **13** emitted by the cathode **14** is projected substantially along longitudinal axis **15**, of container **11**, toward the target **12**. As the electron beam **13** leaves the cathode **14** on its path along axis **15** and toward target **12**, beam **13** passes successively through a control grid **18**, anodes **19**, **20**, and **21**, thence intermediate a first deflection means, which may be electrostatic or electromagnetic but are shown in this embodiment as electrostatic having vertical selection plates **22** and horizontal selection plates **23**. Vertical and horizontal selection plates **22** and **23** are of known electrostatic deflection plate construction and are supplied with selectively supplied predetermined operating potentials for control thereof deflecting electron beam **13** to illuminate

a desired character opening 26 in beam-shaping member or matrix 27. Matrix 27 shapes the electron beam 13 into a cross-sectional shape corresponding to that of the character opening 26 illuminated.

The action of the vertical and horizontal selection plates 22. 23 to select the character opening 26. will generally cause the beam 13 to depart from its initial path along the longitudinal axis 15. which path the beam 13 continues to follow after passing through matrix 27. This path diverges from the longitudinal axis 15. While the beam 13 is following such divergent path. it enters the sphere of influence of a convergence means 28. Convergence means 28 may be an electromagnetic lens 29 or an electrostatic lens 30. as illustrated in Figures 2 and 3. respectively. The convergence means 28 will substantially effect redirection and focusing of the beam. Convergence means 28. through its electromagnetic or electrostatic fields. acts on the electron beam 13 to redirect the beam from its diverging path away from the axis 15 and effect convergence of the beam toward the axis 15 to a predetermined focus point 31 positioned on and along the axis 15. Convergence means 28 also effects a lens or focusing action upon the beam (beam cross section while under the influence of the convergence means will correspond in shape to that of the character illuminated) which action reduces the beam cross section to a minimum at or substantially adjacent focus point 31. Focus point 31 lies on the axis 15 substantially adjacent the electromagnetic field or electrostatic field generated by a second deflection means 34. The second deflection means 34 may be electromagnetic as illustrated in Figure 2*a* by vertical and horizontal deflection yokes 35, 36 or may be electrostatic as shown in Figure 3 as vertical and horizontal deflection plates 37, 38. The field of influence of the second deflection means 34, whether electromagnetic or electrostatic, is positioned so as to effect deflection of the beam 13 substantially adjacent the predetermined focus point 31. The desired deflection is thereby effected at or substantially adjacent the point 31 and beam 13 has at this point 31 minimal cross-section, therefore, eliminating undesired distortions which may result from deflection of the beam 13 to predetermined locations on the target 12.

The various components of the display tube 10 are supplied with predetermined potentials from a power supply 42, which may be of any known construction incorporating well regulated voltage and current supplies. Power supply 42 also supplies the necessary power requirements of decoders, amplifiers and generators shown in Figure 1.

The input signals, which may be of pulse coded information, such as computer output information, are presented to inputs 43, 44. Input 43 is connected with a character selection decoder 45. Input 44 is connected with a character position decoder 46. Decoders 45, 46 are generally pulse to binary code converters and may have various circuitry arrangements for effecting such decoding. A particular circuitry suitable therefor is illustrated in a co-pending application of J. T. McNaney, Serial No. 340,245, assigned to the common assignee hereof. The character selection decoder 45 reduces the input 43 to predetermined vertical and horizontal selection voltage signals. These vertical and horizontal selection voltage signals are amplified by vertical and horizontal selection amplifiers 49, 50 to predetermined amplitudes to energize, respectively, the vertical selection plates 22 and horizontal selection plates 23.

Signals from input 44 are decoded by character position decoder 46 into vertical and horizontal position voltage signals for positioning the selected character at a predetermined position upon the screen 12. Vertical and horizontal deflection amplifiers 51, 52 receive the respective vertical and horizontal position voltage signals and amplify them for presentation to the vertical and horizontal deflection means either deflection yokes, 35, 36 or deflection plates 37. 38 as desired.

In addition, a blank-interval pulse generator 53 receives its information from input 44 and character position decoder 46 to effect proper character intervals and de-energize the tube 10 intermediate characters. Blank-interval pulse generator 53 supplies a blank-unblank voltage generator 54 with necessary excitation to effect energizing of control grid 18 from generator 54 with the predetermined blanking pulses.

Convergence means 28, if of an electromagnetic lens 29 construction, will generally be supplied with a constant current regulator 57; if of an electrostatic lens 30 construction, will generally be supplied with a constant high voltage source (not shown), but of a construction familiar to the prior art.

During development of the display tube 10 it became apparent that a problem peculiar to this type of character display was that of deflecting the electron beam 13 from the longitudinal axis 15 an amount necessary to effect selection of a desired character opening 26 in the matrix 27 and then redirecting the shaped beam 13 back to the axis 15 at minimum cross-sectional area prior to deflection to predetermined positions on the screen 12. If the shaped beam 13 were deflected at a time when the beam was not on axis 15, or of other than minimal cross-sectional area the resulting character distortion on the screen 12 rendered the character distorted in shape and unintelligible. Therefore, it became necessary to return the beam 13 to axis 15 with minimal beam cross section, at or substantially adjacent the field of influence exerted upon the beam 13 by the second deflection means 34.

This lens action or focusing action of convergence means 28 effected such a redirecting of the beam from its divergent path from the axis 15 and to converge the beam at minimal cross section with axis 15 at focus point 31. The convergence means 28, as previously stated may be of the type of electromagnetic lens 29 or electrostatic lens 30. The electromagnetic lens 29, illustrated in Figure 2*a*, and 2*b* comprises an electromagnetic convergence coil 58 positioned about the evacuated container 11 in spaced relation to and generally symmetrically disposed about the longitudinal axis 15 of the tube 10. As is illustrated in Figure 2*a*, convergence coil 58 may be adjusted in three space positions by actuation of any one or more of adjusting knobs 59.

Coil 58, shown in detail in Figure 2*b*, preferably may include one or more windings, and is shown in this embodiment as including the main or center winding 60, trim winding 61, and trim winding 62. Center winding 60 effects the field of influence to redirect beam 13 from its divergent path from the axis 15 to one converging with axis 15 substantially at focus point 31 and focuses the beam to its minimum cross section at focus point 31. However, in so acting upon beam 13, the field of influence may cause the beam 13 to rotate as it is converged as is shown in Figure 5. This rotational effect may be controlled to any degree desired by addition of at least one trim winding, which may be aiding or opposing the center winding 60. The preferred embodiment utilizes two such windings 61, 62 and the rotation is preferably controlled at 90° beam rotation by selective energization and proportioning of currents as between the trim windings 61, 62 and center winding 60.

The electrostatic lens 30, shown in Figure 3, comprises a plurality of electrostatic electrodes 66, 67 and 68, having preferably an annular shape, positioned within the evacuated container substantially symmetrically spaced from and coaxially about axis 15 intermediate the matrix 27 and the deflection plates 37, 38. The electrostatic electrodes 66, 67 and 68 present fields of influence which have a converging action and a lens action upon beam 13 similar to that of the electromagnetic lens 29. Electrodes 66, 67 and 68 converge the divergent beam 13 to focus point 31 and effect minimum beam cross section

at point 31. The problem of beam rotation present in the electromagnetic lens 29 does not exist when the electrostatic lens 30 is utilized.

The electromagnetic lens 29 and the electrostatic lens 30 are very similar in operation, effecting the desired convergence of the electron beam 13 from its diverging path to one converging with the axis 15 with minimum beam cross section at the predetermined focus point 31. Generally speaking, the necessary control voltage supplies for the two lenses 29, 30 are similar. However, the power requirements for the electromagnetic lens 29 are greater than those for the electrostatic lens 30. Copper power consumption losses of the electromagnetic lens 29 requires power consumption greater than electrostatic lens 30. The electrostatic lens 30 has very small power requirements and utilizes static potentials to effect the desired convergence of beam 13.

The method of operation of the convergence means 28 will be restricted to explanation of the operation of the electromagnetic lens 29. As previously explained, the operation of the field of influence of the electrostatic lens 30 upon the electron beam 13 will be similar to that of the field of influence of the electromagnetic lens 29. A representative field pattern 69 of the center winding 60 of convergence coil 58 is shown in Figure 4 in a cross-sectional view of coil 58. The field plot of the center winding 69 is generally the same for any plane which contains the coil axis since the coil is symmetrically disposed about the longitudinal axis 15 and coaxial therewith. The divergent path of the electron beam 13 is slightly over-exaggerated in Figure 4 in order to more effectively demonstrate the action of the field upon the beam to converge the same to the longitudinal axis. In actual practice the approximate angle at which the electron beam 13 leaves the axis 15 approximates 4°, which angle represents a departure of about 2/10 of an inch radially away from the axis 15 in a display tube 10 having a 19 inch display screen 12. This radial distance is rather small in comparison to the actual diameter of convergence coil 58 which in this embodiment is approximately 2.25 inches. Therefore, the electron beam 13 is influenced chiefly by magnetic field components normal to the direction of the path of beam 13. The axial field components will exert very slight influence upon the beam 13 when it enters the field of influence of the coil 58. It is the radial or normal component of the field 69 which acts upon the beam to effect the convergence necessary to return the beam to the predetermined focus point 31 on the axis 15. This converging action is then utilized to effect focusing of the beam to minimum cross-section at focus point 31. The electron beam 13 will spiral slightly as is illustrated in Figure 5, wherein the beam is rotated approximately 90° clock-wise from its beginning divergent position to its convergent position at the focus point 31. To control this rotation, the previously mentioned at least one of trim windings 61, 62 are utilized to effect predetermined rotational control. As shown in Figure 6, the convergence means 28 accepts the electron beam from its divergent path and redirects and converges the beam 13 to axis 15 to the focus point 31 substantially adjacent the second deflection means 34 for desired positioning upon the target 12. The beam as shown in Figure 5, is focused by convergence means 28 to minimum cross section at focus point 31.

The particular embodiment of the invention illustrated and described herein is illustrative only and the invention includes such other modifications and equivalents as may readily appear to those skilled in the art, within the scope of the appended claims.

We claim:

1. In an evacuated container having a target at one end and a source of electrons at the other end for projecting a beam of electrons toward the target and substantially along a longitudinal axis of said container, a beam-shaping member positioned along said axis for altering the cross-sectional shape of the beam in accordance with a selected portion of the beam-shaping member through which the electron beam is projected, said beam emerging from said member on a divergent path from said axis, a first deflection means substantially symmetrically disposed about said axis and positioned intermediate said source and said member for deflecting the electron beam along two directions from said axis and causing the beam to pass sequentially through selected portions of the beam-shaping member, a convergence means capable of substantially redirecting and focusing the beam, said convergence means being adapted to cause said beam to be influenced from said divergent path to converge with the axis and focus the beam's cross section at a predetermined focus point on the axis with minimal beam cross section at said point and a second deflection means substantially adjacent said predetermined focus point for directing the shaped beam toward predetermined locations on the target.

2. In an evacuated container having a target at one end and a source of electrons at the other end for projecting a beam of electrons toward the target and substantially along a longitudinal axis of said container, a beam-shaping member positioned transversely of and along said axis for altering the cross-sectional shape of the beam in accordance with a selected portion of the beam-shaping member through which the electron beam is projected, said beam emerging from said member on a divergent path from said axis, a first deflection means substantially symmetrically disposed about and along said axis and positioned intermediate said source and said member for sequentially deflecting the electron beam along two directions substantially transverse of said axis to cause the beam to pass through selected portions of the beam-shaping member, a convergence means capable of simultaneously redirecting and focusing the beam, said convergence means being adapted to cause said beam to be influenced from said divergent path to converge with the axis and simultaneously focus the beam's cross section at a predetermined focus point on the axis with minimal beam cross section at said point and a second deflection means substantially adjacent said predetermined focus point for directing the shaped beam toward predetermined locations on the target.

3. In an evacuated container having a target at one end and a source of electrons at the other end for projecting a beam of electrons toward the target and substantially along a longitudinal axis of said container, a beam-shaping member positioned along said axis for altering the cross-sectional shape of the beam in accordance with a selected portion of the beam-shaping member through which the electron beam is projected, said beam emerging from said member on a divergent path from said axis, a first deflection means substantially symmetrically disposed about said axis for deflecting the electron beam from said axis along two directions to cause the beam to pass sequentially through selected portions of the beam-shaping member, a convergence means capable of substantially simultaneously redirecting and focusing the beam, said convergence means being adapted to cause said beam to be influenced from said divergent path to converge with the axis and simultaneously focus the beam's cross section at a predetermined focus point on the axis, said convergence means including an electromagnetic lens symmetrically disposed about the axis, said lens being adapted to effect electromagnetic redirection of the beam focused to its minimal cross section at said focus point, and a second deflection means disposed about and adjacent said predetermined focus point for directing the shaped beam toward predetermined locations on the target.

4. In an evacuated container having a target at one end and a source of electrons at the other end for projecting a beam of electrons toward the target and substantially along a longitudinal axis of said container, a

beam-shaping member positioned along said axis for altering the cross-sectional shape of the beam in accordance with a selected portion of the beam-shaping member through which the electron beam is projected, said beam emerging from said member on a divergent path from said axis, a first deflection means substantially symmetrically disposed about said axis for deflecting the electron beam along two directions from said axis and causing the beam to pass sequentially through selected portions of the beam-shaping member, a convergence means capable of substantially simultaneously redirecting and focusing the beam, said convergence means being adapted to cause said beam to be influenced from said divergent path to converge with the axis and simultaneously focus the beam's cross section at a predetermined focus point on the axis, said convergence means including an electromagnetic lens symmetrically spaced from and coaxially disposed about the axis, said lens having a main winding and at least one trim winding, said windings being positioned about said container, said trim winding being disposed adjacent an extremity of the main winding, said main winding effecting rotational convergence and focusing of said beam to said focus point, said trim winding effecting predetermined control of rotation of said beam, and a second deflection means substantially adjacent said predetermined focus point for directing the shaped beam toward predetermined locations on the target.

5. In an evacuated container having a target at one end and a source of electrons at the other end for projecting a beam of electrons toward the target and substantially along a longitudinal axis of said container, a beam-shaping member positioned along said axis for altering the cross-sectional shape of the beam in accordance with a selected portion of the beam-shaping member through which the electron beam is projected, said beam emerging from said member on a divergent path from said axis, a first deflection means substantially symmetrically disposed about said axis for deflecting the electron beam along two directions from said axis and causing the beam to pass sequentially through selected portions of the beam-shaping member, a convergence means capable of substantially simultaneously redirecting and focusing the beam, said convergence means being adapted to cause said beam to be influenced from said divergent path to converge with the axis and simultaneously focus the beam's cross section at a predetermined focus point on the axis, said convergence means including an electrostatic lens symmetrically disposed about the axis within said container and being adapted to effect electrostatic redirection and focusing of the beam to said focus point said beam having a minimum cross section at said focus point, and a second deflection means substantially adjacent said focus point for directing the shaped beam toward predetermined locations on the target.

6. In an evacuated container having a target at one end and a source of electrons at the other end for projecting a beam of electrons toward the target and substantially along a longitudinal axis of said container, a beam-shaping member positioned transversely of and along said axis for altering the cross-sectional shape of the beam in accordance with a selected portion of the beam-shaping member through which the electron beam is projected, said beam emerging from said member on a divergent path from said axis, a first deflection means substantially symmetrically disposed about and along said axis for deflecting the electron beam along two directions substantially transverse of said axis and causing the beam to pass sequentially through selected portions of the beam-shaping member, a convergence means capable of substantially simultaneously redirecting and focusing the beam, said convergence means being adapted to cause said beam to be influenced from said divergent path to converge with the axis and simultaneously focus the beam's cross section at a predetermined focus point on the axis, said convergence means including an electrostatic lens within said container symmetrically disposed about the axis and being adapted to effect electrostatic redirection and focusing of the beam, said lens having a plurality of annular electrodes disposed in spaced relation about and along the axis, said electrodes effecting convergence of the beam to the focus point on the axis with a minimum beam cross section at said focus point and a second deflection means substantially adjacent said focus point for directing the shaped beam toward predetermined locations on the target.

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