ELECTRON OPTICS APPARATUS

BACKGROUND OF THE INVENTION

The present invention relates to electron optics and, more particularly, to novel electron optics apparatus in which a relatively large number of electrodes are maintained at D.C. ground potential.

Electron optics apparatus capable of moving a finely focussed electron beam along a predetermined path upon a target, or of stopping at a predetermined point thereon, is utilized in electron-beam lithography and electron-beam-addressable memories. Typically, an electron "gun" comprising an electron emission source (cathode), an anode and a beam-forming electrode are utilized to emit a stream of electrons towards the target. Various other electrodes are interposed between the electron "gun" and the target to focus the beam to the required diameter at the target surface and to deflect the beam over the required pattern, or to the desired position, upon the target surface. Typically, many of the plurality of focus and deflection electrodes require drive potentials different from the potentials utilized by others of the electrodes, whereby various elements of the electron optics apparatus must be floated at high voltage, both with respect to ground and with respect to adjacent elements. The necessity for floating the driving electronics at high voltage is undesirable both for reasons of apparatus reliability and personal safety. It is, therefore, desirable to implement electron optics apparatus having a relatively large number, and percentage, of the necessary electrodes therefor at ground potential and, particularly, having the target, upon which the deflected and focussed electrode beam impinges, maintained at D.C. ground potential.

BRIEF SUMMARY OF THE INVENTION

In accordance with the invention, electron optics apparatus utilizes an electron gun, comprised of a cathode, beam-forming plate and anode, along with blanking and spray electrodes, to emit a slightly diverging beam of electrons; a tri-potential collimating condenser lens operates on the beam of electrons prior to coarse deflection of the collimated beam to address a desired one of a plurality of lenslets formed in an electron matrix lens. The collimated electron beam is focussed to a relatively small spot diameter upon the target surface by action of the matrix lens. Fine deflection elements are positioned between the electronic matrix lens and the target for sweeping, or positioning, the focussed electron beam within an area upon the target surface associated with the particular matrix lenslet to which the beam is coarsely deflected. The target, as well as at least one element of the condenser lens and the matrix lens, in addition to the beam-forming plate, anode and spray electrodes of the electron gun, are all maintained at ground D.C. potential.

In one preferred embodiment, a two-plate electronic matrix lens is utilized with an orthogonal grid of paralleled fine deflection bars. The first-encountered plate of the matrix lens is maintained at the same potential as the nearest electrode of the condenser lens, while the remaining matrix lens plate and the condenser lens electrode furthest therefrom are maintained at ground potential. In this manner, all high frequency electronics, except for the coarse deflection means interposed between the condenser and matrix lenses, is maintained at ground D.C. potential, while the beam is both collimated in the region immediately prior to the coarse deflection electrodes and variations in coarse deflection voltage have substantially zero first order effect on the beam. The tri-potential collimating lens is of the decelerating type and provides a potential barrier to stray electrons entering the region thereof, to prevent the stray electrons from reaching the matrix lens and deteriorating the focus of the beam impinged upon the target surface; the electron gun operates at a relatively higher voltage and with relatively greater efficiency, to further increase the advantages gained from the configuration of my novel electron optics apparatus.

Accordingly, it is an object of the present invention to provide novel electron optics apparatus having a relatively large number of electrodes therein operated at D.C. ground potential.

This and other objects of the present invention will become apparent upon consideration of the following detailed description, when taken in conjunction with the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a schematic, sectionalized side view of an electron-beam-addressing memory tube utilizing one embodiment of the novel electron optics apparatus of the present invention;

FIG. **2** is a schematic, sectionalized side view of one lenslet of the electronic matrix lens, fine deflection electrodes and target of the memory tube of FIG. **1**;

FIG. **3** is a schematic, sectionalized side view of a tri-potential collimating condenser lens, as utilized in the memory tube of FIG. **1**; and

FIG. **4** is a graph illustrating the relationship between beam current and spot size in a typical memory tube utilizing the electron optics apparatus of the present invention.

DETAILED DESCRIPTION OF THE INVENTION

Referring initially to FIG. **1**, a preferred embodiment of my electron optics apparatus is utilized in an electron-beam-addressed memory tube **10**. Within the evacuated envelope **11** of the tube, an electron-emitting source, such as a cathode **12**, and a target **14** are positioned at opposite ends thereof. Target **14** may advantageously be of the metal-oxide-semiconductor sandwich type described and claimed in U.S. Pat. No. 3,761,895, entitled "Method and Apparatus for Storing and Reading Out Charge in An Insulating Layer", issued Sept. 25, 1973 to the assignee of the present invention and incorporated herein by reference. Target **14** has information stored at selected ones of a two-dimensional array of sites thereon, by impingement of an electron beam thereat, while the target is subjected to various potential biases between the layers thereof, as more fully described in the aforementioned patent, and stores this information as electric charge until erased; the information can be read from the target by again scanning the electron beam across a sequence of data sites, with biasing potentials of different magnitude and/or polarity (which potential biasing sources, and the circuitry coupling the sources and the target, are not shown for purposes of simplicity). The recovered signal from target **14** appears across a load resistance **15** and is coupled, via a coupling capacitor **16**, to external amplification and processing circuitry (also not shown for purposes of simplicity). For purposes of interfacing the signal from target **14** of the circuitry, it is desirable that the target be at, or relatively close to, ground potential.

The electron beam to be scanned across the surface of target **14** is developed from the electrons emitted by cathode **12**, energized to a negative potential, $-V_K$. The emitted electrons are attracted to an anode electrode **18**, having a central aperture **18***a*, with the aperture and anode axes lying along a central axis **20** of tube **10**. A beam-forming plate or plates **22** are utilized, intermediate cathode **12** and anode **18**, to provide a beam-forming aperture **22***a* of diameter d_s and having its axis lying along central tube axis **20**. Advantageously, the anode **18** is coupled to electrical ground potential, as at tube connection pin **24**. An object electrode **26** is positioned transverse to the direction of electron-beam travel and has an aperture **26***a* formed centrally therethrough and along tube axis **20**; the object electrode is also advantageously connected to ground potential, as at external connection pin **27**. A set of blanking electrodes **28** are positioned about tube axis **20** and coupled to a source of blanking potential V_B; if the blanking potential is maintained at substantially ground potential, blanking electrodes **28** have substantially no effect upon the electron beam traveling along central axis **20**; if a blanking potential of non-zero magnitude (either polarity) is impressed upon electrode **28**, an electric field is formed orthogonal to axis **20** and the electron beam is diverted from a central aperture **30***a* formed in a spray electrode **30**. The spray electrode aperture, of diameter greater than the diameter d_s of aperture **26***a*, has its axis also positioned along tube central axis **20** and allows the beam to pass only if blanking electrode **28** is not energized with a blanking potential; energization of the blanking electrode with a blanking potential diverts the electron beam from the aperture onto the conductive, solid material of electrode **30** for conduction to ground, coupled to electrode **30** at tube connection point **32**. Thus, a narrow, but somewhat diverging, beam of electrons is emitted through aperture **30***a* in the direction of target **14**. The electron beam, in the unblanked condition, passes along central axis **20** through a three-element collimating condenser lens **40**. Lens **40** comprises annular first, second and third electrodes **42**, **44** and **46**, respectively. In accordance with the desire to realize the object that as many of the electron optics apparatus elements be maintained at ground potential, at least for D.C. voltages, the initially-encountered annular condenser lens electrode **42** is coupled to ground potential at tube interconnection pin **48**. The exit condenser electrode **46** is coupled to a first potential of voltage magnitude V_1 at pin **49** and the middle condenser lens electrode **44** is coupled to another potential of voltage magnitude V_2 at pin **50**. Thus, as explained more fully hereinbelow, the electron beam exiting from condenser lens electrode **46** is a collimated beam traveling along the central tube axis **20**.

A so-called "flys eye" matrix lens **60** is positioned in front of target **14**. The matrix lens includes a multi-element lens **62** having a two-dimensional array of lenslet apertures **62***a* therethrough. The electron beam is caused to pass through a selected lenslet and is subsequently finely deflected over a limited area of target **14**. By deflecting the axial electron beam, exiting from tri-potential collimating lens **40**, to a desired lenslet of the array, essentially all of the information-storing area of target **14** can be addressed. A particular storage site within the area accessible to a particular lenslet, is addressed by means of a fine deflection selector **64**. In one preferred embodiment, fine deflection selector **64** consists of a first set of horizontally parallel, spaced-apart electrodes **66** arrayed in the vertical plane and having the spaces therethrough aligned with the lenslet apertures of lens **62**, for achieving vertical fine deflection in accordance with the magnitude of at least one (differential) vertical fine deflection potential impressed thereon via external connection pins **67**. A second set of parallel, spaced-apart fine deflection bars **68** are vertically disposed parallel to the plane of the first set of electrodes and with the spaces therebetween also aligned with the lenslet apertures. Suitable (differential) horizontal fine deflection potentials are impressed thereon, via external connection pins **69**, to accomplish horizontal fine deflection of the focussed beam.

As the overall electron optics system is of the demagnifying type, matrix lens **62** is somewhat critical in performance. In my preferred embodiment, a two-aperture immersion lens, as more fully described and claimed in U.S. Pat. Nos. 3,919,588 (issued Nov. 11, 1975) and 3,936,693 (issued Feb. 3, 1976) both assigned to the assignee of the present invention and incorporated hereby by reference, is utilized. The immersion lens consists of a pair of apertured plates **70** and **71**, respectively, having their apertures in alignment to form lens apertures **62***a* and having the planes thereof essentially parallel to one another and essentially perpendicular to axis **20**. Each of the plurality of aligned apertures acts to focus a collimated electron beam entering one of the apertures in plate **70** to a fine spot, on the order of a few microns in diameter, upon the surface of target **14**, after fine deflection by fine deflection means **64**. The deflected electron beam, shown by broken line **73**, is focussed upon the target, if the potential between lens plates **70** and **71** is held at a fixed value, commensurate with the spacing distance therebetween and other factors explained more fully hereinbelow. Accordingly, one electrode, e.g. plate **71**, of the lens is maintained at ground potential, as at connection pin **74**, while the remaining electrode, e.g. the apertured plate **70** first encountered by the electron beam, is maintained at a potential V_1, as at external connection pin **75**. Thus, the entire "flys eye" matrix lens assembly **60**, similar to that described and claimed in U.S. Pat. No. 3,534,219, issued Oct. 13, 1970, for a "Cascaded Electron Optical System", assigned to the assignee of the present invention and incorporated herein by reference, allows a focussed electron beam to be swept across the surface of target **14** and to be positioned at any data site thereon, if the on-axis collimated electron beam exiting from tri-potential collimating condenser lens **40** is directed to the associated lenslet (aligned apertures through electrodes **70** and **71**) and through the array of fine deflector electrodes **66** and **68**).

A "coarse" deflection means **80**, for selecting the proper one of the plurality of lenslets, is positioned between the exiting end of condenser lens **40** and the matrix lens plate **70** furthest from target **14**. In my preferred embodiment, lenslet selector means **80** comprises a pair of deflectrons **82** and **84**, respectively. The deflectrons, while shown in schematic form indicative of a side view of cylindrical deflectrons, may be rectangular, conical or the like shaped deflectrons. The initially-encountered deflectron **82** receives both vertical and horizontal deflection voltages, which deflection voltages include a D.C. potential, equal to the high voltage potential V_1 connected to exiting collimator lens electrode **46** and initially-encountered lens electrode **70**. In response to the instantaneous magnitude of the vertical and horizontal deflection voltages, coupled to first deflectron **82** from external connection means **86** and **87**, respectively, the electron beam **90** entering the volume of deflectron **82** is deflected away from central system axis **20**. It should be understood that while FIG. **1** shows a vertical deflection only, the illustrated deflection is limited by the two-dimensional character of the accompanying drawings and that simultaneously vertical and horizontal deflections of an electron beam **90** are easily achieved. The deflected electron beam **90***a* exits the first deflectron at some angle, determined by the magnitude of the deflection voltages, with respect to central axis **20**, and enters the volume of second deflectron **84**. A second set of vertical and horizontal "coarse" deflection voltages, at external connection means **92** and **93**, respectively, are coupled to the deflection electrodes of second deflectron **84**; the magnitude of the horizontal and vertical deflection voltages to second deflectron **84**, in addition to being floated at potential V_1, are chosen to deflect electron beam **90***a* in the vertical and/or horizontal directions so that the electron beam **90***b* emerging from second deflectron **84** is not only parallel to central axis **20**, but is essentially aligned with the center of the desired lenslet of the two-aperture matrix lens **62** and the "fine" deflection apparatus **64** thereafter.

This electron optics apparatus advantageously allows a substantial portion of the high frequency electronics, except for the high frequency deflection circuitry (not shown) utilized for the "coarse" deflection, or lenslet select, voltages, to be maintained at D.C. ground potential. Further, as the electron beam is collimated prior to coarse deflection, variations in coarse deflection voltages have essentially a zero first-order effect on the beam; the tri-potential collimating condenser lens **40** is a decelerating lens whereby stray electrons generated at previous electrode apertures, such as spray aperture **30***a*, encounter a potential barrier and are essentially prevented from reaching matrix lens assembly **60**. In a typical memory tube using my preferred embodiment, the potential V_1 upon the exit electrode **46** of collimating lens **40** and upon the initially-encountered matrix lens plate **70** is on the order of −6 kilovolts, with respect to ground, while the cathode potential V_K is on the order of −10 kilovolts with respect to ground, whereby the electron optics apparatus functions as a relatively high voltage to realize a relative high efficiency.

These advantages, as well as additional details of operation of my novel electron optics apparatus, will become apparent from consideration of FIGS. **2**, **3** and **4** and the following analysis. For purposes of analysis, the finely deflected electron beam **90***c* will be focussed to a spot size upon the storage surface **14***a* of the target, commensurate with storing a bit of information at a data site of about 4 microns diameter. It should be understood that the electron beam may be focussed to accommodate other beam spot sizes on the surface of the target, in accordance with the particular usage to which my novel electron optics apparatus is to be employed. The collimated beam **90***b* of electrons **95** enters an aperture **70***a*, of diameter D, of initially-encountered lens electrode **70** and passes therethrough toward the aperture **71***a*, of the same diameter D as the aperture **70***a*, in second lens plate **71**. A spacing of distance S exists between the essentially parallel, facing interior surfaces of electrodes **70** and **71**. Attached to second lens electrode **71**, and maintained at the same essentially ground potential thereof, is a spray electrode **100** having an aperture **100***a* therein, centered along the center of the electron beam and of diameter D_A, for reducing the diameter of the electron beam being focussed. Typically, for a 4 micron bit spacing, the matrix lens aperture diameters D are on the order of 30 milli-inches, with the spray aperture diameter D_A being on the order of 9.8 milli-inches, for a lens electrode spacing S on the order of 60 milli-inches. The action of the two-plate matrix lens is such that the reduced-diameter electron beam is converged, as beam **90***c*, to be focussed essentially upon the target surface **14***a*. The beam **90***c* passes through the aligned slots formed between the parallel vertical deflection bars **66***a* and **66***b* and the horizontal deflection bars **68** associated with each lenslet. Advantageously, the deflection bars are formed of an insulative material, such as a ceramic and the like, and have conductive electrodes **102** fabricated upon their facing surfaces to facilitate generation of the necessary electrostatic deflection fields. The distance Z between facing surfaces of the exiting-electrode **100** of the matrix lens and the vertical deflection bars **66***a* and **66***b*, and between the vertical deflection bars and the horizontal deflection bars **68**, is established to be on the order of 20 milli-inches, with the separation distance S_y between facing surfaces of deflection electrodes **102** (and a similar distance S_x, into and out of the plane of the drawing and therefore not shown for purposes of simplicity, between the electrodes on facing surfaces of the horizontal deflection bar **68**) is established on the order of 20 milli-inches. The entire "flys eye" matrix lens **60** is positioned such that the mid-lens distance L_{ct}, between target surface **14***a* and a plane parallel to and midway between the facing surfaces of matrix lens electrodes **70** and **71**, is on the order of 600 milli-inches.

For the desired mid-focal length L_{ct}, of 600 milli-inches, I have determined that, for collimated operation, a normalized focal length ratio (2f/D) is about 49.7, and a normalized spherical abberation constant (2Cs/D) is about 1.1×10^4, with a lens accelerating ratio (V) of about 2.28. The beam half-angle ϕ at the target is determined by the diameter D_A of aperture **100***a* in spray electrode **100**.

The principal aberration effect determining the optics performance is the spherical aberration of the matrix lens. The maximum beam current I in a beam, at target surface **14***a*, with a spot diameter d and a given beam brightness β_i, and with a lenslet spherical aberration constant C_s is given by:

$$I=(k_1 d)^{8/3}(\beta_i/C_s)^{\frac{2}{3}}$$

with an optimum beam half-angle (ϕ_o) at the target of:

$$\phi_o=(k_2 d/C_s)^{\frac{1}{3}}$$

and a beam diameter of geometric spot size (dg) of:

$$dg=k_3 C_s \phi_o^3,$$

where the constants k_1, k_2 and k_3 are dependent upon the percentage of total beam current found in the spot at target suface **14***a*. For a spot having about 90% of the total beam current therein, the values of the constants are approximately $k_1=1.3$, $k_2=0.9$ and $k_3=0.96$. The maximum theoretical brightness β_T, at the image, is given in terms of the Langmuir limit, in units of amperes per square centimeter per steradian, by:

$$\beta_T = j_0(11{,}600/\pi T)V_L$$

where j_0 is the cathode loading in amperes per square centimeter, T is the cathode temperature in °K. and V_L is the landing potential, in volts, at the target. As practical electron "guns" do not produce this theoretical brightness value, the actual beam brightness β_i is given by:

$$\beta_i = \gamma\beta_T,$$

where γ is the electron "gun" efficiency, which for high brightness sources, as utilized herein, is about 80% (with high voltages in the range of 6–10 kilovolts). Thus, in my preferred embodiment, the electron optics apparatus has a landing potential of about 10 kilovolts (the cathode-target potential) and the various parameters of the electron "gun", are summarized in Table I, for various practical values of cathode loading (j_0).

Table I

j_O(amp/cm^2)	T(°K)	β_i(amp/cm^2/str)
1	1273	2.98 . $V_{L\gamma}$
2	1323	3.58 . $V_{VL\gamma}$
3	1353	8.2 . $V_{L\gamma}$

The spot diameter d for maximum current is given by:

$$d = (2C_s/D)(D/2)\phi_o^3(1/k_2) = 3.27 \text{ microns.}$$

The geometric spot size (dg) is given by:

$$dg = k_3C_s\phi_o^3 = k_3K_2d = 2.82 \text{ microns.}$$

The required optical magnification M, assuming that a source aperture of 20 microns is utilized, is given by:

$$M = dg/ds = 0.14.$$

Referring to FIG. **3**, the tri-potential condenser lens used in the electron optics apparatus, as described hereinabove, has a first cylindrical electrode **42** into the bore of which the beam **110** of electrons **111** enters from the object aperture **26***a* (of FIG. **1**) of the electron source. Electrode **42** has a length L_L and is at a potential V_3 (D.C. ground potential, as hereinabove explained). The mid-condenser electrode **44** is also of cylindrical shape, having a length T_c and spaced by a separation distance S_c from the adjacent end plane of first-encountered condenser lens electrode **42**; a potential of magnitude V_2 is coupled to mid-condenser electrode **44**. The condenser exit electrode **46** is also a cylindrical electrode having the same length L_L as the initially-encountered electrode **42** and having its entrance plane situated the condenser spacing distance S_c from the exit plane of mid-condenser electrode **44**. Each of the three condenser electrodes **42, 44** and **46**, respectively, have a bore diameter D_c substantially equal to one another. As previously explained hereinabove, exit electrode **46** has impressed thereon an electrical potential of magnitude V_1, being essentially the high voltage applied to the initially-encountered lens electrode **70** of the matrix lens. The potentials on each of the three condenser lens electrodes are different from one another:

$$V_1 \neq V_2 \neq V_3.$$

The magnitude V_1 of the potential on exit electrode **46** is established by the accelerating factor V previously found for the matrix lens, i.e. V=2.28. The matrix lens acceleration factor is also given by:

$$V = (V_3 - V_k)/(V_1 - V_k)$$

For a four micron diameter data site, with the cathode potential Vk set at about −10 kilovolts and the anode and initially-encountered condenser lens electrode **42** at ground potential (V_3=0 volts) the potential V_1 in the coarse deflection region, and more particularly upon exit electrode **46**, is found to be about −5.614 kilovolts.

The slightly divergent electron beam **110** entering the condenser lens is converged therein to exit the condenser lens as a collimated beam **90** lying on the central tube axis **20**. Collimation is achieved by establishing the voltage at the mid-condenser electrode **44**, in accordance with the function:

$$V_c = (V_2 - V_k)/(V_3 - V_k),$$

where V_3 is hereinabove given as zero volts and V_c is a function of the electron-optics apparatus parameters and particularly of the normalized spherical aberration constant and the magnification requirements of the matrix lens. Choosing a value of V_c of about 0.45, and an object aperture diameter d_s of about 24.1 microns, a potential V_2 on the central electrode **44** of about −5.5 kv, is obtained. The geometric center of condenser lens **40** is established at a distance Z_{MO} from the object aperture (the object electrode aperture **26***a*) of about 5.49 inches.

The above-described embodiment of my electron optics apparatus provides a spot having an aberration disk of diameter substantially equal to 0.019 microns, which, when compared to a source size of about 24.1 microns, illustrates that the aberrations introduced by the condenser lens are essentially negligible. Thus, the condenser lens essentially collimates the beam and the final image position at the target surface **14***a* is dependent only upon the angle, with respect to central axis **20**, at which the collimated beam enters the selected lenslet, for focussing and subsequent fine deflection. The coarse deflection deflectrons are so proportioned to preserve this angle relatively independently of the actual deflection voltages, whereby small variations in the "coarse" deflection drive voltages will have substantially no effect on the final beam position at the target.

Referring now to FIG. **4**, the cathode loading requirements for the electron optics apparatus are considered; FIG. **4** graphically illustrates the relationship between the required beam current, plotted along ordinate **120**, for a given spot size, plotted along abscissa **121**, for different values of cathode loading (j_0). The cathode loading curves **122, 123** and **124**, respectively, correspond to cathode loadings of 1, 2 and 3 amperes per square centimeter, respectively. For the above-described example, wherein a 4 micron data site is selected, the required beam spot size, of about 3.27 microns, is indicated by vertical broken line **126**. Broken horizontal line **128** indicates the beam current (in amperes) required for a beam-addressable-memory tube utilizing 4 micron diameter data sites; the desired operating point **129** is thus well within a cathode loading of 1 ampere per square centimeter with an 80% efficient electron "gun", due to the high efficiency of the matrix lens **60** when operating with the collimated input beam provided by the tri-potential condenser lens **40**. Thus, an electron "gun" of somewhat less than 80% efficiency and a cathode loading of somewhat less than 1 ampere per square centimeter (as achieved with aging, element misalignment and the like effects) still allows the desired 4 micron data site operation to be achieved with all of the aforementioned advantages: all high frequency drive electronics, except for the drive electronics to the "coarse" deflection electrodes, can be operated at ground D.C. potential; the beam is collimated in the "coarse" deflection region whereby variations in coarse deflection voltage have substantially zero first order effect on the beam; the collimating lens is initially decelerating whereby secondary electrons generated by the object aperture, prior to the condenser lens, will not reach either the matrix lens or the target; the condenser lens has negligible aberration effects and allows the full electron-optical advantages of the two-aperture matrix lens to be realized; the electron gun operates at a higher voltage to achieve relatively high electron "gun" efficiency; and, with the collimated input beam, the matrix lens may be optimized for a significant reduction in cathode loading whereby increased cathode life is possible.

While one preferred embodiment of the present invention is described with particularity herein, many variations and modifications will now become apparent to those skilled in the art. It is, therefore, my intent that limitation not be by way of the sole presented embodiment, but only in accordance with the appending claims.

What is claimed is:

1. Electron optics apparatus comprising:

source means for emitting a beam of electrons along an apparatus axis;

a target spaced from said source means along said axis and having a surface generally facing said source means;

blanking means disposed along said axis for selectively blanking said electron beam emitted towards said target by said source means;

multi-electrode means disposed along said axis between said source and blanking means and said target for collimating the electron beam emitted toward said target from said blanking means;

multi-electrode lens means situated along said axis between said collimating means and said target and having a two-dimensional array of apertures therethrough for focussing upon said target surface an electron beam passing through any of said apertures;

means positioned along said axis for coarsely deflecting the electron beam from said collimating means to a selected one of said array of lens apertures; and

means positioned between said lens means and said target surface for finely deflecting the focused electron beam from any of said lens apertures to a specific point within an area of the target surface associated with that lens aperture through which the beam passes;

said target, said finely deflecting means and at least one electrode of each of said source, collimating and lens means being operated at a D.C. component of the potential thereon substantially equal to ground potential; and

said coarsely deflection means and at least one element of each of said collimating and lens means being operated at a D.C. component of the potential thereon different from ground potential.

2. Electron optics apparatus as set forth in claim **1**, wherein said collimating means comprises three electrodes sequentially arranged along said axis, each electrode having a potential thereon differing from the potentials on the remaining two electrodes.

3. Electron optics apparatus as set forth in claim **2**, wherein each of said electrodes is a cylindrical member having the axis thereof aligned along said apparatus axis.

4. The electron optics apparatus as set forth in claim **2**, wherein the electrode of said collimating means nearest to said source means is maintained substantially at ground potential.

5. Electron optics apparatus as set forth in claim **2**, wherein the middle electrode of said collimating means is maintained at an electrical potential more negative than the electrical potential at the collimating means electrode furthest from said source means.

6. Electron optics apparatus as set forth in claim **2**, wherein said lens means comprises a pair of planar electrodes arranged substantially parallel to one another and essentially transverse to said apparatus axis, each of said lens electrodes having an electrical potential thereon differing from the electrical potential on the remaining lens electrode.

7. Electron optics apparatus as set forth in claim **6**, wherein the electrical potential on the lens electrode closest to said target is ground potential.

8. Electron optics apparatus as set forth in claim **6**, wherein the electrical potential on the lens electrode closest to said source means is substantially equal to the electrical potential on the collimating means electrode furthest from said source means.

9. Electron optics apparatus as set forth in claim **1**, wherein said lens means comprises first and second planar electrodes positioned parallel to one another and essentially transverse to said apparatus axis, each of said lens electrodes having said array of apertures therethrough in alignment with the array of apertures through the other lens electrode each of said lens electrodes having an electrical potential thereon differing from the electrical potential on the other lens electrode.

10. Electron optics apparatus as set forth in claim **9**, wherein the electrical potential on the lens electrode closest to said target is equal to ground potential.

11. Electronic optics apparatus as set forth in claim **9**, wherein the electrical potential on the lens electrode nearest to said source means is maintained at a value less than the potential on the remaining lens electrode.

12. Electron optics apparatus as set forth in claim **1**, wherein said coarse deflection means comprises first and second deflection electrodes sequentially arranged along said apparatus axis.

13. Electron optics apparatus as set forth in claim **12**, wherein each of said first and second deflection electrodes comprises a deflectron.

14. Electron optics apparatus as set forth in claim **12**, wherein each of said first and second deflection electrodes are operated at a potential having a D.C. component substantially equal to the non-zero potential on an element of each of said collimating means and said lens means closest to said coarse deflection electrodes.

15. Electron optics apparatus as set forth in claim **1**, wherein said finely deflecting means comprises first and second pluralities of parallel deflection bars, said first plurality of deflection bars being arranged parallel to one another and orthogonal to the apparatus axis, and the parallel-disposed deflection bars of the second plurality being arranged orthogonal to the apparatus axis and to the first plurality of deflection bars.

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