Nov. 22, 1960 R. G. POHL 2,961,575

ELECTRON DISCHARGE DEVICE

Filed June 30, 1955 6 Sheets-Sheet 1

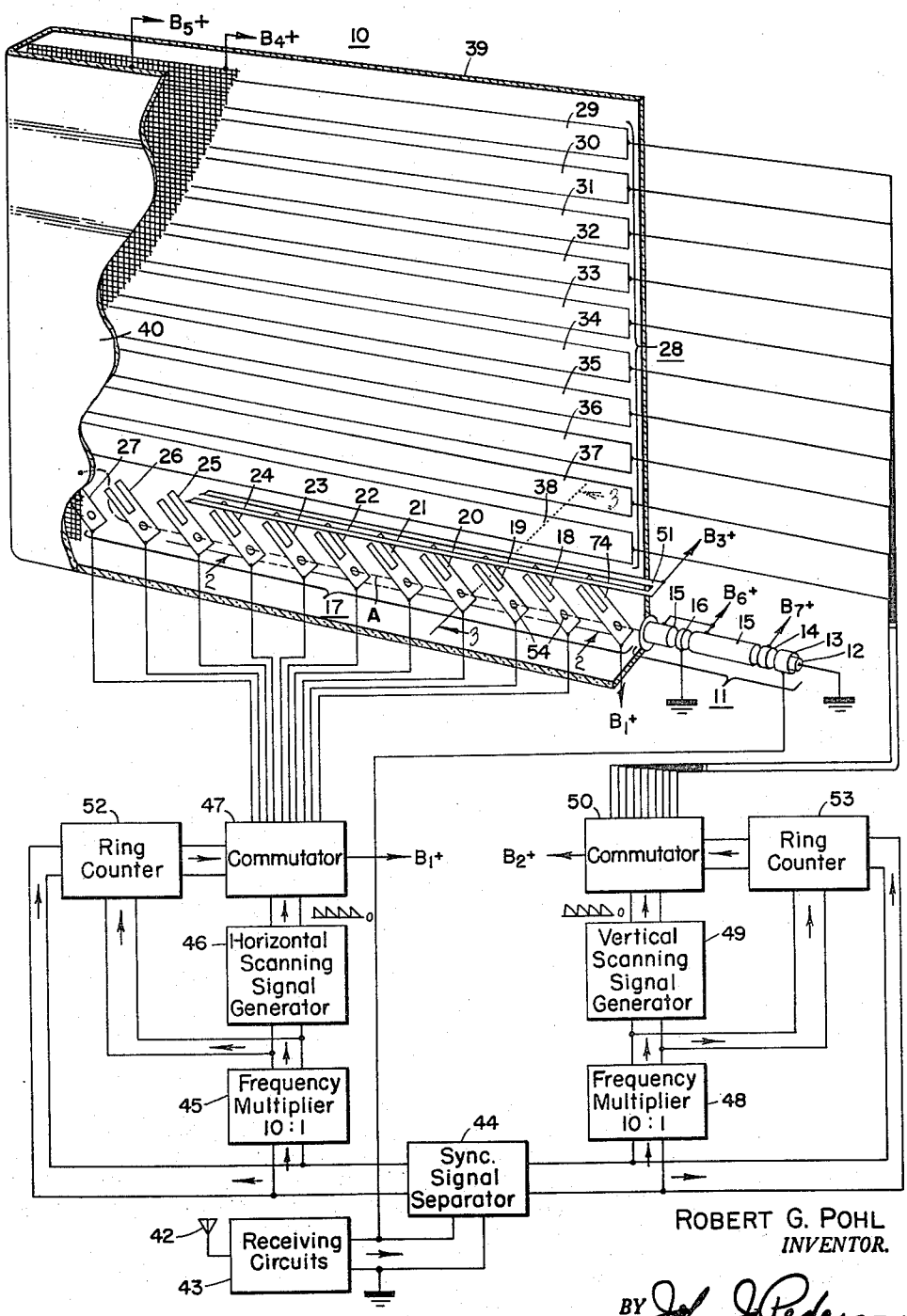


FIG. 1

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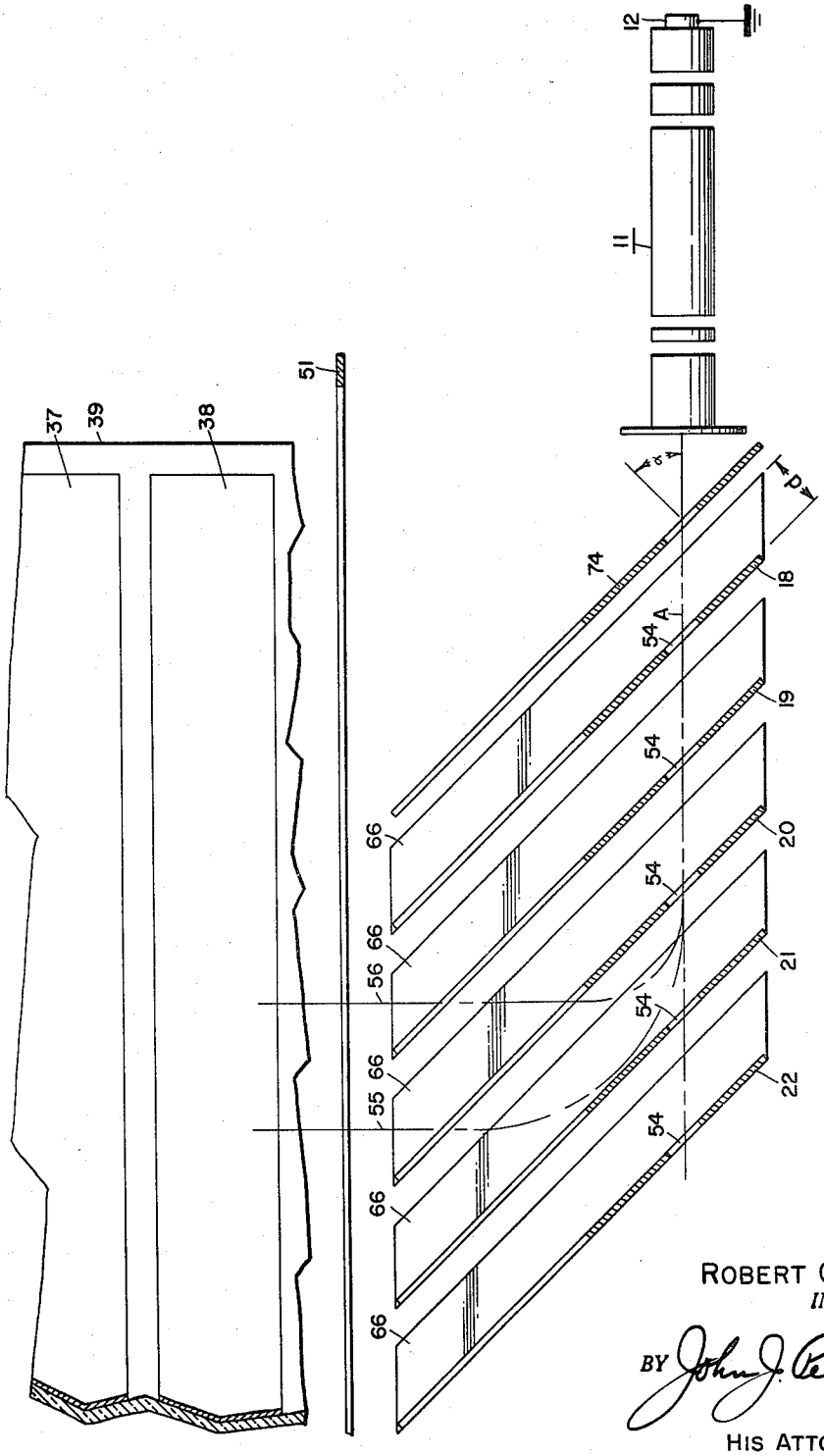


FIG. 2

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ELECTRON DISCHARGE DEVICE

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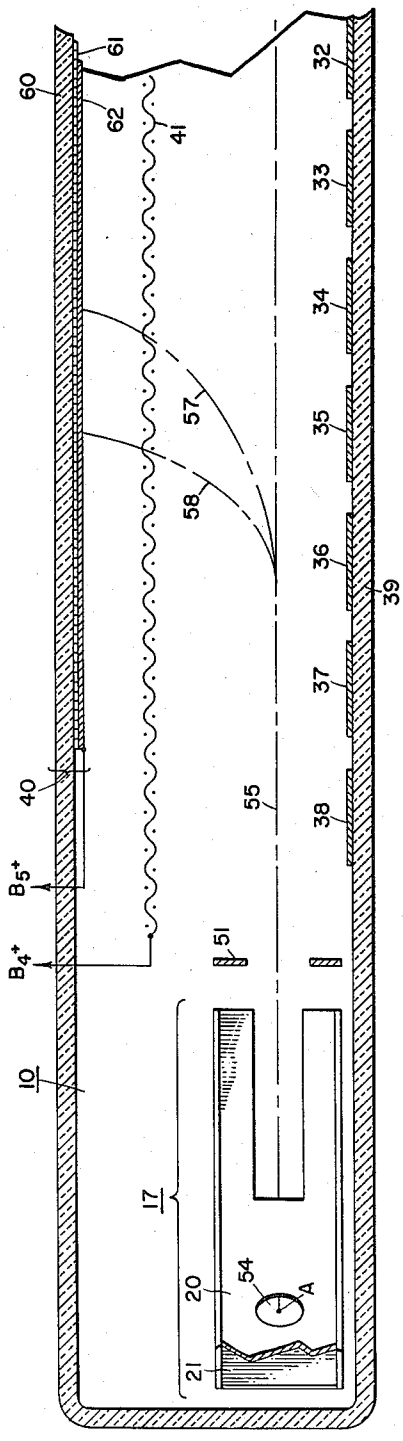


FIG. 3

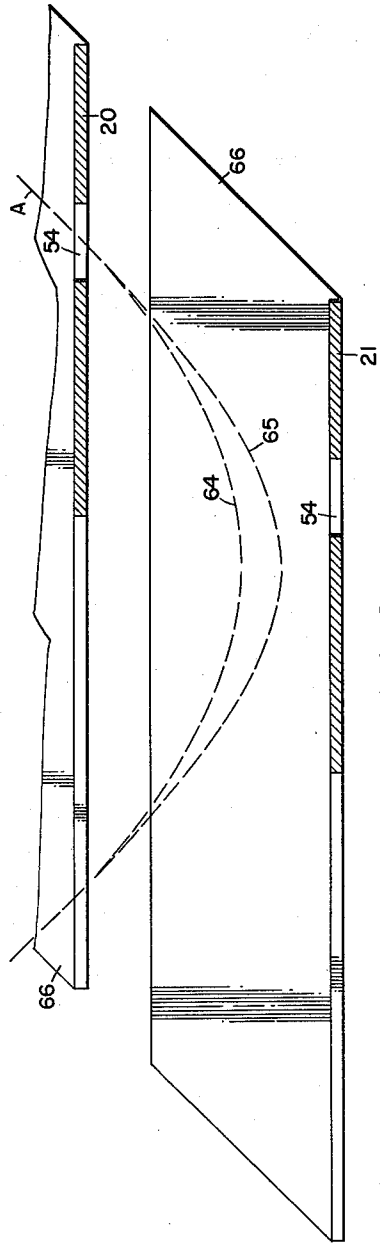


FIG. 4

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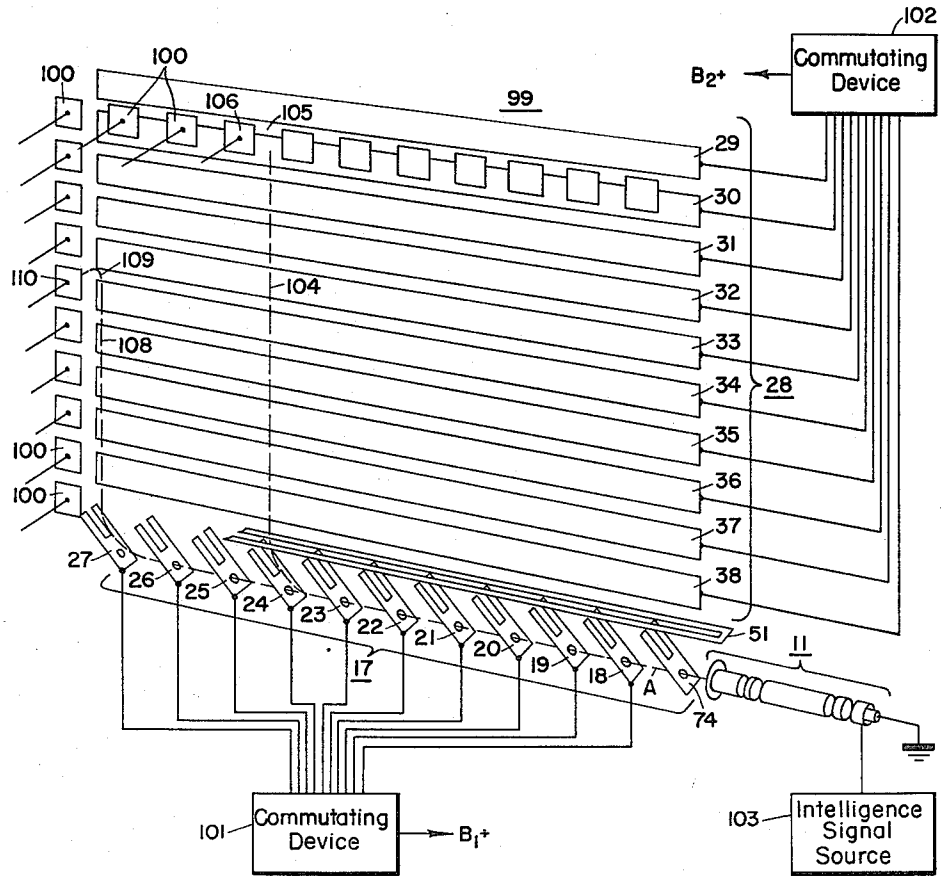


FIG. 7

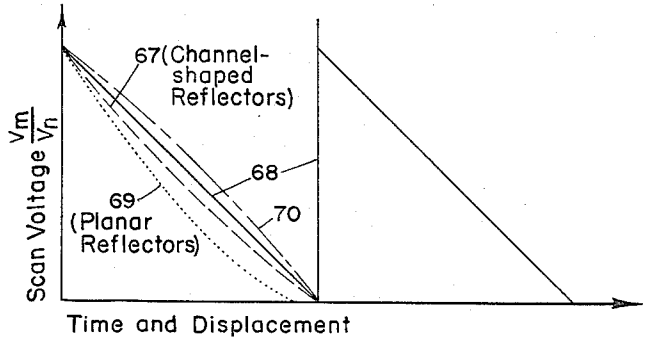


FIG. 5

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ELECTRON DISCHARGE DEVICE

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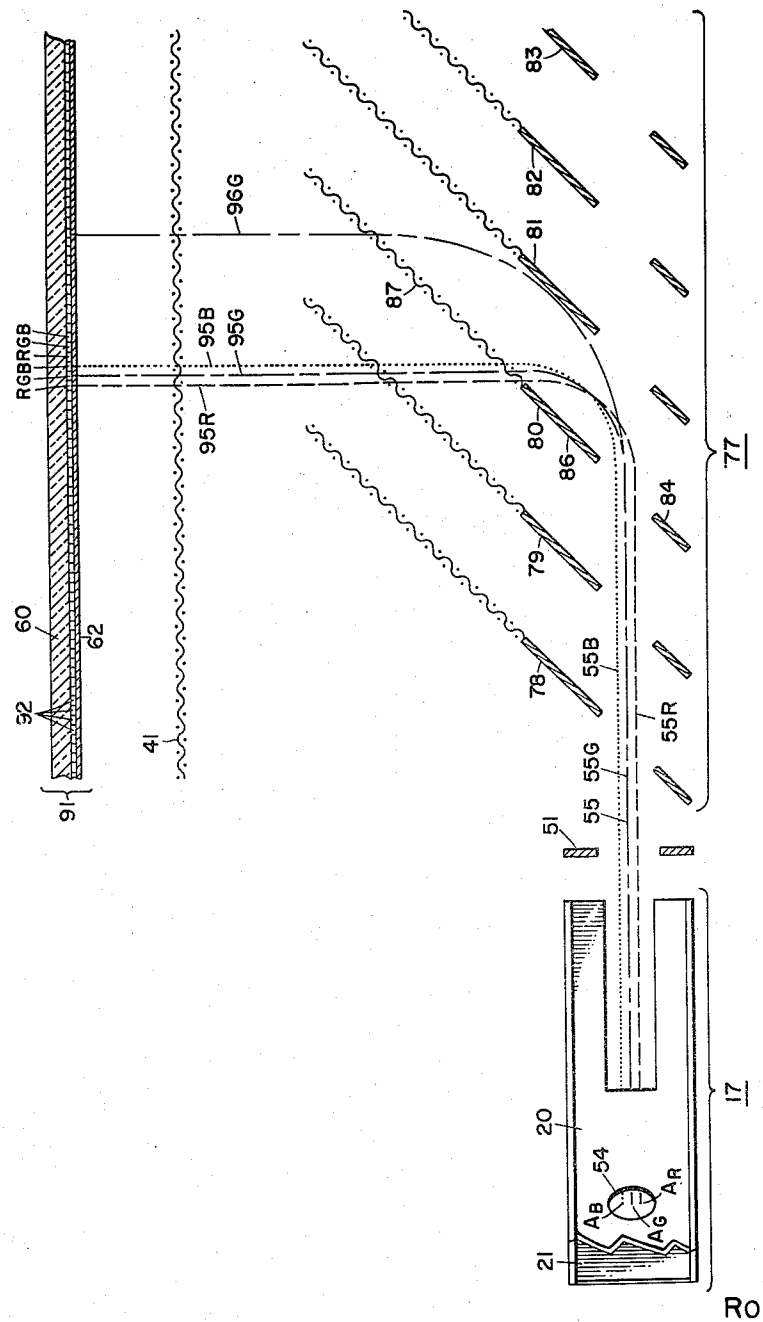


FIG. 6

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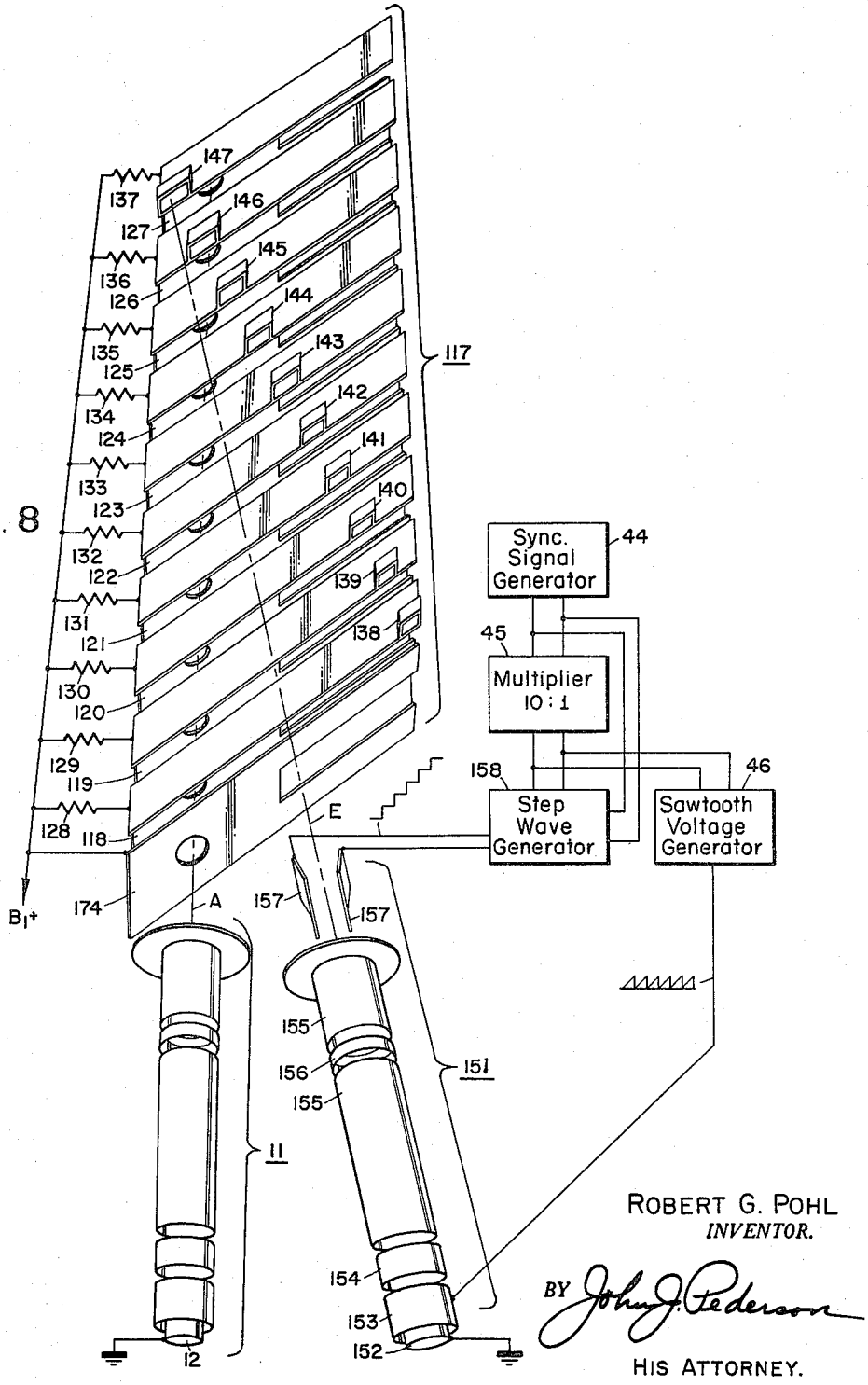
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FIG. 8



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United States Patent Office

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Patented Nov. 22, 1960

2,961,575

ELECTRON DISCHARGE DEVICE

Robert G. Pohl, Chicago, Ill., assignor, by mesne assignments, to Zenith Radio Corporation, a corporation of Delaware

Filed June 30, 1955, Ser. No. 519,110

21 Claims. (Cl. 315—21)

This invention is directed to a new and improved electron-discharge device in which a focused beam of electrons is deflected across a target structure. More specifically, the invention is directed to electron-discharge devices comprising scanning electrode systems which effectively permit scanning large target areas in a device of minimum dimensions. Electron-discharge devices constructed in accordance with the invention may include television image reproducers, switching devices, and other types of apparatus.

In many applications, such as television picture tubes, it is desirable to scan a relatively large target electrode such as a fluorescent screen or an array of many target electrodes with a focused beam of electrons. Conventional devices adapted to this purpose are often extremely bulky and very heavy, and may impose severe limitations upon the design of equipment with which they are employed. For example, the size and weight of conventional television receivers are to a great extent dictated by the size and weight of the picture tube. In these devices, an electron beam is projected toward a target screen along a path substantially normal thereto and is deflected by an electrostatic or an electromagnetic field to form an image raster on the target screen. Practical limitations in the maximum deflection angle obtainable make it extremely difficult to effect substantial reduction in the overall size of the picture tubes and of other devices of this general type.

In one known type of cathode-ray tube, some of the disadvantages of conventional devices are overcome to a certain extent and the overall size and weight of the tube is substantially reduced. In this device, an electron beam is projected along one edge of the target electrode. A series of deflection plates are disposed along the beam path closely adjacent thereto; by varying the voltages on these deflector electrodes, the beam may be deflected to follow any one of a series of secondary paths adjacent to and substantially parallel to the plane of the target. A second similar set of deflector electrodes are utilized to deflect the beam a second time to impinge upon the target. Thus, the electron beam may be made to scan an image raster upon the target by controlling the voltages applied to the two sets of deflection electrodes. This device, however, is subject to considerable difficulties arising from defocusing of the electron beam with changes in deflection angle in either of the two deflection systems. Moreover, the deflection angle of the beam varies substantially, depending upon the instantaneous voltage applied to the deflector electrodes; this effect is most serious with respect to the first deflection system, since it must be compensated in the second deflection system in order to permit scanning of a uniform raster.

It is an object of the invention, therefore, to provide a new and improved electron-discharge device which effectively overcomes the above-noted disadvantages of known devices.

It is another object of the invention to provide a new and improved electron-discharge device in which an electron beam may be deflected from a reference path to follow any one of a multiplicity of parallel secondary reference paths.

It is a further object of the invention to provide a new and improved electron-discharge device of the type in which a focused electron beam scans a relatively large target, which device is not substantially larger in dimensions than the target itself.

It is an additional object of the invention to provide an electron-discharge device including a scanning electrode system having substantially linear operating characteristics, thereby permitting extremely accurate control of the instantaneous position of a scanning electron beam.

It is another object of the invention to provide a new and improved scanning electrode system for an electron-discharge device which substantially reduces the complexity of auxiliary circuitry associated with the device.

It is a further object of the invention to provide a new and improved image reproducer for color or monochrome television which may be hung upon a wall.

An electron-discharge device constructed in accordance with the invention comprises electron gun means for projecting a focused beam of electrons along a predetermined reference path and a scanning electrode system for selectively reflecting that electron beam along any one of a multiplicity of secondary paths. The scanning electrode system comprises a plurality of reflector electrodes which are distributed along the beam path at predetermined intervals. Each of these reflector electrodes extends transversely of the beam path at a predetermined incidence angle, and the beam is reflected along secondary paths each of which forms an angle with the reference path which is approximately equal to twice the aforementioned incidence angle. Finally, additional means is associated with at least one of the secondary paths for utilizing the reflected electron beam.

The features of the present invention which are believed to be novel are set forth with particularity in the appended claims. The invention, together with further objects and advantages thereof, may best be understood, however, by reference to the following description taken in connection with the accompanying drawings, in the several figures of which like reference numerals indicate like elements, and in which:

Figure 1 is a perspective view, partially cut away, of an electron-discharge image-reproducing device constructed in accordance with one embodiment of the invention; the figure also includes a schematic showing of external circuitry utilized to incorporate the image reproducer into a television receiver;

Figure 2 is a cross-sectional view of a portion of one scanning electrode system of the television image reproducer taken along line 2—2 in Figure 1;

Figure 3 is a cross-sectional view of another scanning electrode system taken along line 3—3 in Figure 1;

Figure 4 illustrates the focusing characteristics of the electrode system of Figure 2;

Figure 5 is a graph showing scanning displacement as a function of voltage variations in the scanning electrode system of Figure 2;

Figure 6 is a cross-sectional view, similar to Figure 3, of a scanning electrode system constructed in accordance with another embodiment of the invention and applied to a color television image reproducer;

Figure 7 is a perspective view of an electron-discharge switching device constructed in accordance with another embodiment of the invention; and

Figure 8 is a perspective view illustrating a further embodiment of the invention.

The television receiver illustrated in Figure 1 includes an electron-discharge image-reproducting device 10 constructed in accordance with the invention; the envelope

of the image reproducer has been omitted from the drawing in order to provide a better view of the electrode structures of the tube. Picture tube **10** comprises an electron gun **11** of conventional construction; electron gun **11** may include, for example, a cathode **12**, a control electrode **13**, an accelerating electrode **14**, and a pair of focus anodes **15** separated by a lens electrode **16**. It will be recognized that the illustrated electron gun is a conventional electrostatically focused type; any other suitable gun structure may be substituted for electron gun **11** without departing in any way from the invention.

Electron gun **11** may be utilized to project a focused beam of electrons along a reference path indicated by dash line A. The picture tube **10** further includes a first scanning electrode system **17** comprising a plurality of reflector electrodes **18–27** distributed along reference path A at predetermined intervals and each extending transversely of the beam path at a predetermined incidence angle. The term "incidence angle," as used throughout this specification and in the appended claims, refers to the angle of the beam path with respect to the normal to the plane of the reflector, in accordance with standard optical terminology. In the illustrated embodiment, reflectors **18–27** are equally spaced along path A and the angle of incidence of the beam path with respect to the reflector electrodes is approximately 45°. Scanning electrode system **17** may be employed to selectively reflect the electron beam from reference path A along any one of a multiplicity of secondary beam paths each extending from path A at an angle substantially equal to twice the incidence angle, as will be explained more fully hereinafter.

The image-reproducing device also includes a second scanning electrode system **28** comprising a plurality of individual scanning electrodes **29–38** distributed adjacent the aforementioned secondary beam paths in spaced relation thereto. Scanning electrodes **29–38**, in the illustrated embodiment, comprise flat strips of conductive material extending in a direction substantially parallel to reference path A and distributed in a common plane. The deflectors may be formed from sheet metal or may comprise conductive coatings upon an insulating base **39**, as shown. An isolating electrode **51**, comprising a pair of conductive elements disposed on opposite sides of the secondary beam paths, is preferably interposed between scanning electrode systems **17** and **28**.

Scanning electrode system **28** is employed to impart a second deflection to the electron beam and thereby direct the beam to follow any one of a multiplicity of tertiary electron beam paths extending away from the plane of scanning electrode system **28** to impinge upon a luminescent target **40** included in the image reproducer. Target **40** may comprise a layer of phosphorescent material deposited in conventional manner upon a suitable transparent substrate; for example, the luminescent target may be formed by settling a phosphor layer upon the internal surface of the faceplate of tube **10**. The picture tube may also include an electron-transparent electrode comprising a mesh screen **41** interposed between luminescent target **40** and scanning electrode system **28**.

The simplified television circuitry for picture tube **10** comprises an antenna **42** coupled to receiving circuits **43**; receiving circuits **43** may, for example, include the usual radio-frequency amplifier, first detector, intermediate-frequency amplifier, and second detector stages found in most television receivers. Receiving circuits **43** are coupled to control electrode **13** of electron gun **11** and to a synchronizing-signal separator **44**, which may be of conventional construction. Synchronizing-signal separator **44** is coupled to a first frequency multiplier circuit **45**, which, in turn, is coupled to a horizontal-frequency scanning signal generator **46** and to a ring counter circuit **52**. The output stages of generator **46** and ring counter **52** are connected to a commutator **47** which is individually coupled to each of the reflector electrodes **18–27** of scanning electrode system **17**. Commutator **47** is also coupled to a first source of positive unidirectional operating potential B_1+. Ring counter **52** may comprise any of a wide variety of stepping circuits well known in the computer art; the ring counter should include a reset circuit which is coupled to synchronizing separator **44** for phase control purposes. Commutator **47**, on the other hand, may comprise a series of gated amplifiers having separate plate load resistors individually coupled to electrodes **18–27**; if conventional triode amplifiers are employed, their cathodes are preferably connected together and coupled to generator **46** whereas their control electrodes are individually coupled to the separate stages of ring counter **52**. Scanning electrode system **17** further includes an auxiliary electrode **74** which is preferably substantially similar in structure to scanning electrodes **18–27** and which is disposed intermediate electrode **18** and gun **11**; auxiliary electrode **74** is preferably directly coupled to D.C. source B_1+ and co-operates with electrode **18** in establishing one of the electron mirrors of the system.

Synchronizing-signal separator **44** is also coupled through a frequency-multiplier circuit **48** to a vertical-frequency scanning signal generator **49** and to a second ring counter **53**; signal generator **49** and counter **53** are coupled to a commutator **50** which is individually coupled to scanning electrodes **29–38** of scanning electrode system **28**. Commutator **50** is also connected to a second source of positive operating potential B_2+. The reset circuit of ring counter **53** is coupled to synchronizing-separator **44**. Operating potentials for the other electrodes of the picture tube are provided by connecting focus anodes **15** to an operating potential source B_6+ and by connecting isolating electrode **51**, mesh screen **41** and luminescent target **40** to positive operating potential sources B_3+, B_4+ and B_5+ respectively; lens electrode **16** is grounded. In addition, accelerating electrode **14** of gun **11** is connected to a suitable operating potential source B_7+.

When the television receiver schematically illustrated in Figure 1 is placed in operation, a transmitted television signal is intercepted by antenna **42** and supplied to receiving circuits **43**, wherein the signal is detected and amplified in conventional manner to produce a composite signal including picture and scansion-synchronizing information free of the transmission carrier. This signal is applied in conventional manner to control electrode **13** of electron gun **11** to intensity modulate the electron beam produced by the gun. The detected television signal is also supplied to synchronizing-signal separator **44**, which segregates the horizontal- and vertical-frequency synchronizing pulses and supplies them to multipliers **45** and **48** respectively; the synchronizing pulses are also applied to the reset circuits of counters **52** and **53** respectively. In multiplier **45**, the horizontal-frequency synchronizing signal is utilized to develop a synchronizing signal having a frequency ten times the normal horizontal scanning frequency; this is not a fixed and immutable multiplication ratio, but is determined by the number of reflector electrodes in scanning electrode system **17**, which in this instance includes ten individual reflectors. The frequency-multiplied synchronizing signal is supplied to horizontal scanning signal generator **46**, which develops a scanning signal of sawtooth voltage waveform similar to that used in the deflection system of a conventional electrostatic-deflection picture tube except that the frequency, of course, is ten times as great as that usually employed in a comparable television receiver. The horizontal scanning signal is applied to commutator **47**, which is actuated in synchronism with the incoming scanning signal by means of gating pulses supplied from ring counter **52** to supply individual cycles of a sawtooth scanning signal in succession to reflector electrodes **18–27**.

Thus, commutator 47 couples the reflector electrodes to scanning signal generator 46 in a predetermined sequence determined by the horizontal scanning frequency of the received television signal. The commutator is also arranged to connect reflectors 18–27 to operating potential source B_1+ at all times when they are not coupled to horizontal scanning signal generator 46.

The vertical scanning signals included in the received telecast are supplied from synchronizing-signal separator 44 to frequency multiplier 48, which develops a synchronizing signal having a frequency ten times that of the normal vertical scanning frequency of the received telecast. As in the case of the first multiplier 45 and scanning electrode system 17, the multiplication ratio of circuit 48 is determined by the number of scanning electrodes in deflection system 28. The frequency-multiplied vertical synchronization signal is supplied to signal generator 49, which develops a vertical scanning signal of sawtooth voltage waveform and supplies that sawtooth signal to commutator 50. Commutator 50 selectively couples individual ones of deflector plates 29–38 to vertical scanning signal generator 49 in predetermined sequence at a rate determined by the frequency of the vertical scanning signal; as in the case of the horizontal scanning system, commutator 50 is phase and frequency synchronized with the scanning signal generator by gating pulses supplied from ring counter 53, which in turn is controlled by synchronizing pulses from multiplier 48 and separator 44. As in the previously described system, each of the scanning electrodes is connected to operating potential B_2+ at all times when not connected to scanning signal generator 49.

The electron beam from gun 11, intensity modulated in accordance with picture information from the received television signal, is projected along path A and passes through a series of apertures 54 in scanning electrodes 18–27. At a given instant, all of the scanning electrodes 18–26 may be connected to operating potential B_1+, with the final reflector electrode 27 being coupled to signal generator 46 through commutator 47. Under these circumstances, the electron beam is reflected along one of a plurality of secondary paths originating between electrodes 26 and 27 and extending in a direction substantially normal to the primary reference path A of the beam; the particular secondary path which the beam follows is, of course, determined by the instantaneous value of the scanning voltage supplied from commutator 47. The electron beam continues along this secondary path until deflected by one of the electrodes of the second scanning system 28. For example, at a given instant, deflector 37 may be connected to vertical scanning signal generator 49 with all of the remaining deflectors of system 28 coupled to D.C. source B_2+. The electron beam is then deflected from its secondary path in accordance with the instantaneous vertical scanning signal voltage to follow a selected one of a plurality of tertiary paths which extend through electron-transparent electrode 41 and terminate at luminescent screen 40.

The operating characteristics of the two scanning electrode systems 17 and 28 may best be understood by reference to Figures 2 and 3 respectively, in which the individual electrodes of the scanning systems are shown in greater detail. Figure 2 shows reflector electrodes 18–22 and auxiliary electrode 74 of scanning electrode system 17 in an enlarged cross-sectional view and illustrates more clearly the position of these elements with respect to electron gun 11 (shown schematically), isolating electrode 51, and the first deflector electrode 38 of scanning electrode system 28. The electron beam developed in gun 11 is projected along reference path A through apertures 54 in reflectors 18–22 and electrode 74; the scanning electrodes and auxiliary electrode 74 are each disposed at an angle of incidence a with respect to beam path A. In the illustrated system, $a=45°$. If the reflector electrodes were all maintained at the same potential, the electron beam would continue unimpeded along the reference path and no scanning action would be obtained. However, the potential on electrode 21 may be reduced to form an electron mirror and the effective location of the plane of reflection of the mirror may be varied by suitably adjusting the potential on reflector electrode 21. For example, the normal operating potential of the reflector electrodes may be established at approximately six kilovolts by means of the connection to D.C. source B_1+ through commutator 47 (Figure 1). The potential of reflector 21 may then be reduced to approximately one-half this normal operating potential, thereby establishing an electron mirror between electrodes 20 and 21 which reflects the electron beam along the secondary path indicated by dash line 55. The effective plane of the electron mirror may be moved closer to electron gun 11 by further reducing the potential on electrode 21; with the reflector held at a potential approximately equal to that of cathode 12 of electron gun 11, the beam is reflected along a different secondary path indicated by dash line 56. Of course, the beam may be swept across the distance between dash lines 55 and 56 by applying a sawtooth voltage to reflector 21, as described in connection with Figure 1; the peak-to-peak voltage swing of the sawtooth voltage should be from approximately one-half the B_1+ voltage to zero voltage (cathode potential). In the illustrated apparatus, with each of reflectors 18–22 disposed at an angle of 45° with respect to reference path A, all of the multiplicity of possible secondary electron paths between the approximate limits represented by dash lines 55 and 56 form an angle of 90° with respect to the primary reference path A, since the electron mirror developed by the scanning electrode system reflects the beam at an angle equal to twice the angle of incidence a. The electron beam may be made to traverse the entire width of the second scanning electrode system, here represented by deflector plate 38, by applying successive cycles of the high-frequency sawtooth scanning signal to the individual reflector electrodes in sequence.

Figure 3 provides an enlarged cross-sectional view of a portion of the second scanning electrode system 28 of tube 10 and shows deflector electrodes 33–38 in relation to scanning electrodes 20 and 21 of the first scanning electrode system, isolating electrode 51, electrode 41 and target 40. The initial electron beam path is indicated by dash line 55, which corresponds to the secondary path of the electron beam with electrode 21 established at approximately one-half the normal operating potential of the scanning electrode system 17. When all of the deflectors of the second scanning electrode system 28 are maintained at the common operating potential established by D.C. source B_2+, as described in connection with Figure 1, the electron beam continues along the secondary path 55 and does not reach target 40. However, when the potential on deflector 36, for example, is substantially reduced, the electron beam is deflected along a tertiary path indicated by dash line 57. Further reduction in the potential of deflector 36 sweeps the beam through a multiplicity of tertiary paths; for example, when the potential of deflector 36 is reduced to approximately the potential of cathode 12 (Figure 1), the beam is deflected along a path indicated by dash line 58. Thus, by applying a sawtooth voltage to the deflector electrode, the electron beam may be swept through a series of tertiary paths to scan a portion of target 40 and, by applying individual cycles of the frequency-multiplied sawtooth voltage in succession to the different deflector electrodes, the entire area of target 40 may be scanned in the vertical direction. It should be noted, however, that the tertiary paths represented by dash lines 57 and 58 do not extend from secondary path 55 at equal angles; rather, the angle of deflection varies considerably through the range of deflection voltages. It is usually desirable to limit the negative-going swing of the scanning signal

voltage to cathode potential, which in this instance is ground potential; because 90° deflection cannot be attained at this voltage, as evidenced by path 58, it is desirable to locate the initial deflector 38 closer to scanning electrode system 17 than the edge of target 40 to permit scanning of the entire target area.

In order to permit the use of relative low operating voltages on the various electrodes of the two scanning systems of tube 10 (Figure 1), it is desirable that the tube be constructed to operate as a post-deflection-acceleration device. To permit this type of operation, luminescent target 40 may be constructed as shown in Figure 3 to comprise a transparent substrate 60, a layer of phosphor material 61 and a conductive film of aluminum or other suitable conductive material 62 deposited upon phosphor layer 61. Alternatively, the surface of substrate 60 may be iridized or otherwise treated to be conductive. Luminescent target 40 may then be maintained at a relatively high potential as compared to the operating potentials of mesh screen 41 and of the various electrodes of the scanning electrode systems. Typical operating voltages for tube 10 may be as follows:

Cathode 12		Ground
Lens electrode 16		Ground
Control electrode 13	volts	0 to −100
B_1+, B_2+, B_3+, B_4+	kilovolts	6
B_5+	do	16
B_6+	do	6
B_7+	volts	300
Horizontal scanning signal	kilovolts	0 to 3
Vertical scanning signal	do	0 to 3

Thus, the scanning electrode operating voltages are relatively low, subtsantially simplifying design problems in constructing commutators 47 and 50. On the other hand, the target is scanned with a relatively high velocity beam due to the potential difference between mesh 41 and coating 62 of target electrode 40. Substrate 60 may comprise the faceplate of the tube envelope for picture tube 10, whereas the support 39 for the deflection electrodes of the second scanning electrode system may comprise the rear wall of the envelope; this construction is illustrated in Figure 3. Alternatively, the deflector electrodes may be independently supported within the tube envelope and spaced from the envelope wall to prevent difficulties with wall charges. In any event, as indicated in Figure 3, the tube envelope may be made essentially flat and very thin as compared to the characteristic dimensions of target 40 so that an image reproducer constructed in accordance with the invention may be readily mounted on the wall of a room or in any other area where a picture tube of very restricted depth is desired.

It is the operating characteristics of deflection system 17 which provide the important advantages of the present invention. The principal and most important characteristic of this system results from the fact that all of the multiplicity of secondary beam paths represented by dash lines 55 and 56 in Figure 2 extend from reference path A at the same angle. Consequently, the horizontal displacement of the electron beam with respect to target 40 is independent of vertical deflection and a rectangular image raster may be scanned on the target electrode without requiring compensation in the vertical deflection system to correct for angular variations in horizontal deflection. Of course, if it is desired to scan a trapezoidal raster, this effect may easily be obtained by modifying the angle of incidence of the reflector electrodes with respect to reference path A so that the secondary beam paths form an angle other than 90° with respect to path A.

In addition, reflector system 17 has other important operating characteristics, as indicated in Figures 4 and 5. For example, Figure 4 shows the path of the electron beam through the mirror comprising reflectors 20 and 21 as the beam is deflected to follow secondary reference path 56. As the beam follows path A through the aperture 54 in electrode 20 into the mirror field it decelerates, due to the fact that electrode 21 is at a substantially lower potential than electrode 20. Deceleration of the beam may cause it to spread somewhat, as indicated by dash lines 64 and 65. However, as the beam passes the half-way point in the electron-mirror section, it begins the accelerate and to converge upon secondary path 56, in a manner exactly symmetrical to the divergence on deceleration. Thus, it is seen that the electron mirror system does not spread or defocus the electron beam in the plane of the incident and reflected beams, whereas a more conventional deflection system of the type shown in Figure 3 exhibits considerable defocusing effects directly dependent upon the angle of deflection. Indeed, the mirror electrodes of system 17 may be made to exhibit a substantial focusing effect in a direction normal to the plane of the incident and reflected beams if they are constructed as substantially channel-shaped members having sides 66 as shown in Figures 2 and 4. It can be demonstrated that the cross-sectional area of the beam as it leaves scanning electrode system 17 may be substantially reduced by using channel-shaped mirror electrodes, particularly if the sides 66 of each of the channel sections has a depth d of the order of three-fourths the spacing between adjacent mirror electrodes, although considerable focusing advantage may also be attained with channel sides no greater in depth than four-tenths the adjacent electrode spacing.

Figure 5 is a plot of the scanning voltage applied to electrodes of system 17 in relation to time and displacement of the secondary beam paths along reference path A. For a linear sawtooth scanning voltage, shown by solid line 68, the voltage-displacement characteristic is indicated by dash line 67. Beam displacement is an almost linear function of the scanning voltage ratio V_m/V_n, where V_m is the instantaneous voltage on the mirror electrode and V_n is the normal operating voltage of the scanning electrode system determined by voltage source B_1+. It will be seen that completely linear scanning with respect to time may be achieved by modifying the sawtooth scanning voltage supplied from generator 46 to a somewhat concave sawtooth configuration corresponding to that of curve 70. It should be noted that characteristic curve 67 is based upon the use of channel-shaped mirror electrodes as illustrated in Figures 2 and 4; with simple planar electrodes, as shown in Figure 1, the voltage-displacement characteristic is slightly different although still almost linear as indicated by dash line 69 in Figure 5.

Figure 6 illustrates a somewhat different embodiment of the invention as applied to a color television image reproducer. In this embodiment, which is shown in a cross-sectional view corresponding to that of Figure 3, the first deflection system 17 comprising reflector electrodes 20 and 21 and isolation electrode 51 may be constructed to conform to the embodiment of Figures 1 and 2. The second scanning electrode system 77 of the embodiment of Figure 6, however, is quite different from scanning electrode system 28 of Figures 1 and 3. Scanning electrode system 77 comprises a series of reflector electrodes 78–83 distributed along the secondary reference paths of the tube, here generally represented by dash line 55. Each of electrodes 78–83 comprises three distinct sections. Electrode 80, for example, includes a first electron-opaque section 84 disposed on the side of beam path 55 farthest from the tube target. Electrode 80 further includes a second electron-opaque section 86 which is located on the opposite side of the reference path and an electron-transparent section 87 extending from the edge of section 86 farthest from the reference path. Electrode sections 84 and 86 may, for example, comprise simple metallic strips punched or otherwise cut from sheet stock, whereas transparent section 87 may comprise a relatively open metallic mesh.

If preferred, the entire electrode in each instance may be constructed from a conductive mesh material, though it is sometimes difficult to maintain the desired uniformity of spacing where only mesh electrodes are employed. The entire reflector electrode, in each instance, is disposed in an angle of approximately 45° with respect to reference path 55.

The embodiment of Figure 6 further includes the electron-transparent mesh 41 disposed adjacent scanning electrode system 77 and a color target electrode 91 located on the opposite side of mesh 41 from the scanning system. Target electrode 91 may comprise the usual transparent substrate 60 and conductive film 62; in this embodiment, however, the luminescent target is provided with a multiplicity of strips 92 of phosphor material which extend in a direction parallel to reflector electrodes 78–83. Phosphor strips 92 may, for example, comprise three different phosphors which emit light in the additive primary colors red, green and blue respectively when subjected to electron bombardment. Moreover, the strips are preferably arranged in a regular repeating pattern which may correspond to the indicated pattern of R, G, B, R, G, B, shown in the drawing. It will be understood, of course, that any other desired order of repetition may be employed for the phosphor strips.

The color image reproducer of Figure 6 utilizes a multiple-beam electron gun system which may comprise three individual electron guns (not shown) to project three focused electron beams through the apertures 54 in the reflector electrodes of the first scanning electrode system. These three electron beams follow parallel paths indicated at A_R, A_G, A_B. In the scanning electrode system comprising reflectors 20 and 21, the three beams are simultaneously deflected along the three paths 55_R, 55_G, 55_B, through scanning electrode system 77. When the potential on reflector electrode 81, for example, is reduced substantially with respect to the operating potential of the remainder of the reflectors, the three electron beams are reflected from their secondary paths to follow tertiary paths 95_R, 95_G, and 95_B.

Scanning electrode system 77, like scanning electrode system 17 of Figures 1 and 2, functions as a true mirroring system and reflects each of the beams at an angle equal to twice the angle of incidence of the beams with respect to reflector electrodes 78–83. Consequently, with reflectors 78–83 disposed at an angle of 45° with respect to secondary paths 55, tertiary paths 95 all extend at an angle of 90° with respect to paths 55 and, preferably, perpendicular to the plane of target 91. Thus, each of the beams may be made to impinge upon only a desired group of phosphor strips 92. The relative positions of the beams are, of course, inverted in the mirror system just as they would be in an optical mirror system. The scanning action of system 77 is essentially similar to that of the previously-described system 17, as indicated by tertiary beam path 96_G which represents the limit of deflection for the "green" beam. Because the beam paths are perpendicular to the target plane, the accelerating field between mesh electrode 41 and target 91 has no deflection or refraction effects; consequently, no color error can be introduced from this source. Moreover, by adjusting the scanning voltage waveform to provide maximum linearity of scanning, relatively accurate reproduction may be obtained throughout the entire area of target 91. Subdivision of the scanning operation increases the linearity by a factor approximately equal to the number of subdivisions, or reflector elements, as compared to conventional cathode ray tubes. Consequently, there is no necessity for special color-switching or color-selecting electrode structures intermediate the scanning deflection system and the color target, nor is it essential to employ any feedback arrangement to correct the scanning voltages, although both of these well known types of color-control arrangements can be employed in a tube constructed in accordance with the invention if desired.

Figure 7 illustrates another embodiment of the invention in a view substantially similar to that of Figure 1. The switching device 99 shown in Figure 7 comprises an electron gun 11, a first scanning electrode system 17 and a second scanning electrode system 28; these portions of the device may be similar in construction to the corresponding devices described above. In this embodiment of the invention, however, there is no luminescent target. Instead, the target structure of switching device 99 comprises a multiplicity of individual target plates 100 arranged in a predetermined geometric pattern facing scanning electrode system 28. For example, there may be one hundred individual target plates 100 arranged in regular rows and columns corresponding to the ten reflector electrodes in system 17 and the ten deflectors of system 28; only a few of the target electrodes are illustrated in order to avoid confusion in the drawing. Each of the reflector electrodes of system 17 is connected through a commutating device 101 to positive operating potential source B_1+; the commutating device is constructed to individually selectively connect the reflector electrodes to ground. Similarly, the individual deflector electrodes of system 28 are connected to D.C. source B_2+ through a commutating device 102 which may be actuated to ground the individual deflectors on a selective basis. The control electrode of electron gun 11, on the other hand, is coupled to an intelligence signal source 103, which may for example, comprise an incoming telephone signal circuit.

When the apparatus of Figure 7 is placed in operation, electron beam 11 projects a focused beam of electrons along reference path A through scanning electrode system 17; the electron beam is reflected generally toward target structure 100 along a secondary reference path determined by commutating device 101, which is actuated to ground one of the deflector electrodes. For example, the beam may be reflected along a secondary reference path indicated by dash line 104 by grounding reflector electrode 24. Similarly, commutating device 102 is actuated to ground one of the deflectors of system 28; for example, with deflector 29 grounded, the beam is directed along a tertiary path indicated by dash line 105 to impinge upon a selected target plate 106. Thus, under the conjoint control of two ten-position commutating devices 101 and 102, the electron stream from gun 11 may be made to impinge upon any of the one hundred target plates 100. The intelligence signal from source 103 may thus be simultaneously amplified and switched to any of a multiplicity of output circuits (not shown) individually coupled to target electrodes 100. As shown in Figure 7, the output circuits are coupled to target electrodes 100 by means of a corresponding plurality of terminal conductors electrically connected individually to each of electrodes 100. Of course, the beam may at any time be switched to any other portion of the target electrode system. For example, commutating device 101 may be actuated to ground reflector 27 and at the same time to return reflector 24 to its normal positive operating potential, thereby reflecting the beam from path A along reference path 108. At the same time commutating device 102 may be changed to ground deflector 33 instead of deflector 29; as a consequence, the beam is deflected from reference path 108 along path 109 to impinge upon individual target plate 110, thus coupling intelligence signal source 103 to an entirely different output circuit.

Figure 8 illustrates a somewhat modified form of scanning electrode system 117 generally similar to the reflector system 17 of Figure 1. Scanning system 117 comprises a series of reflector electrodes 118–127 which are generally similar in alignment and configuration with the corresponding electrodes 18–27 of the previously described system; reflectors 118–127 are distributed at equally spaced intervals along the reference path A of a focused

beam of electrons projected from an electron gun 11 at a predetermined angle of incidence with respect to the beam path. Reflectors 118–127 are individually connected to a source of positive unidirectional operating potential B_1+ by means of a corresponding plurality of load resistors 128–137. System 117 further includes an auxiliary electrode 174 corresponding to electrode 74 of system 17; electrode 174 is directly connected to D.C. source B_1+.

The first reflector electrode in the series, electrode 118, is provided with a target-extension area projecting from the leading edge of one end of the reflector electrode and terminating in a substantially cup-shaped target section 138. Similarly, reflector 119 is provided with an extension terminating in a target section 139; however, target section 139 is displaced along the length of the reflector electrode as compared to the position of target section 138 of reflector 118. Electrodes 120–127 are all provided with similar target sections 140–147 which form a regular geometric pattern of targets facing an auxiliary or scanning electrode gun 151. Electron gun 151 may be of any suitable conventional construction and may, for example, include a cathode 152, a control electrode 153, a first anode 154, and a pair of focus anodes 155 with a lens electrode 156 interposed between the two focus anodes. Gun 151 further includes a pair of deflection plates 157 disposed on opposite sides of the reference path E of the electron beam projected from the scanning gun.

The scanning electrode system illustrated in Figure 8 may be incorporated in an image reproducer of the type illustrated in Figure 1 or in a switching device such as shown in Figure 7; when included in a television picture tube, the control electrode 153 of scanning gun 151 coupled to the horizontal scanning-signal generator 46 of the receiver which, in turn, is driven from a frequency multiplier 45 as in the embodiment of Figure 1. In the embodiment of Figure 8, however, no separate commutator or ring counter is required. Instead, a step-function signal generator 158 is coupled to the output stage of multiplier 45 and to synchronizing signal generator 44; step-function generator 158 is in turn coupled to deflection plates 157 of scanning gun 151.

In many respects, the operational characteristics of scanning electrode system 117 are essentially the same as those of the corresponding scanning system 17 of Figure 1. The electron beam from gun 11 is again projected through system 117 along reference path A and is reflected from a predetermined point in the scanning electrode system to follow any one of a multiplicity of secondary paths extending at a predetermined angle from primary reference path A. In system 117, however, the position of the traveling electron mirror is determined by scanning gun 151 in cooperation with the target electrode sections 138–147 and load impedances 128–137 of the scanning electrode system.

All of electrodes 118–127 are normally maintained at a common operating potential with respect to the cathode 12 of electron gun 11 by virtue of their connection to D.C. source B_1+. However, when the electron beam from securing gun 151 impinges upon target section 147, for example, the beam current from electron gun 151 flowing through load resistor 137 substantially reduces the potential on reflector 127, establishing an electron mirror between reflectors 127 and 126. The effective reduction in the potential of reflector 127 may of course, be determined by varying the intensity of the electron beam from scanning gun 151 to control the amount of current flowing through the load resistor. Thus, the reflector current may be varied over a predetermined range to sweep the primary beam from gun 11 through the available secondary path area provided by the electron mirror formed between electrodes 127 and 126 in the same manner as described in connection with Figure 2. The electron beam may be shifted from its reference path E to impinge upon another of the target electrode sections, such as target section 139, by varying the relative potentials upon deflectors 157. Consequently, if the beam is deflected to impinge upon target section 139 of reflector 119, the current flowing through load resistor 129 causes a drop in the operating potential of the reflector electrode and establishes an electron mirror between electrodes 118 and 119. As before, the intensity of the electron beam from scan gun 151 may be varied to sweep the beam through a plurality of secondary paths originating intermediate reflectors 118 and 119.

For television scanning, step wave generator 158 develops a stair-step waveform which is applied to deflectors 157 to deflect the beam from scanning gun 151 to impinge upon target sections 147–138 in sequence; the entire group of target sections are each excited once during each horizontal scanning line. Proper phasing of the step-function deflection voltage is achieved by triggering pulses applied to generator 158 from synchronizing signal separator 44. At the same time, horizontal scanning-signal generator 46 develops a sawtooth voltage having a period equal in duration to that of each step of the step-voltage waveform from generator 158; this sawtooth voltage is applied to control electrode 153 of electron gun 151 to vary the intensity of the scanning beam.

Certain precautions must be taken in connection with the self-commutating scanning electrode system illustrated in Figure 8. For example, the target electrode sections 138–147 should be located as closely adjacent the preceding electrode as possible to reduce the deflection effect of the decelerating field. Otherwise, the cathode 152 of scanning-control gun 151 may be operated at a much lower potential than the cathode of electron gun 11 so that the scanning beam can be effectively directed to the individual target sections and will not be deflected onto undesired portions of the reflector electrodes. Thus, if cathode 12 of electron gun 11 is maintained at ground potential, and reflectors 118–127 are normally operated at approximately six kilovolts positive with respect to cathode 12, cathode 152 may be maintained at ground if target sections 138–147 are located on the leading edges of the channel-shaped reflectors. If the target sections are set back substantially from the preceding electrodes, cathode 152 should be maintained at approximately six kilovolts negative with respect to cathode 12, i.e., twelve kilovolts negative with respect to the reflectors 118–127. Simple metal tabs may be used for target sections 138–147 of reflectors 118–127; however, the substantially cup-shaped sections illustrated are preferred for the purpose of suppressing secondary emission from the target sections. Coating the interior of the cups with a colloidal graphite solution such as aquadag further decreases secondary emission. It will be recognized that the incorporation of the commutating arrangement in the scanning electrode system does not require any substantial increase in the overall size of the picture tube or other device in which the system is used, since the target sections 138–147 need not extend above the target structure of the tube.

Image reproducers and other devices constructed in accordance with the invention are very much smaller in depth than conventional tubes in which an electron beam is scanned across a target of substantial area. The equiangular deflection characteristics of the inventive scanning electrode system provide substantially linear scanning and avoid any necessity for compensating the second scanning system to correct for angular variations in deflection in the first scanning electrode system. Moreover, when reflector systems are employed to scan in both directions, extremely accurate control of the instantaneous position of the scanned beam is provided and, in addition, the effective cross-sectional area of the beam as it impinges upon the target may be minimized

by maintaining the angle of incidence of the beam upon the target structure constant at approximately 90°. In one embodiment, a portion of the scanning circuitry is incorporated in the tube itself, thereby substantially reducing the complexity of the external scanning circuitry.

While particular embodiments of the present invention have been shown and described, it is apparent that changes and modifications may be made without departing from the invention in its broader aspects. The aim of the appended claims, therefore, is to cover all such changes and modifications as fall within the true spirit and scope of the invention.

I claim:

1. An electron-discharge device comprising: electron gun means for projecting a focused beam of electrons along a predetermined reference path; a scanning electrode system, comprising a plurality of reflector electrodes distributed along said beam path at predetermined intervals and each disposed transversely across said path at a predetermined incidence angle, for selectively reflecting said electron beam along any one of a multiplicity of secondary paths each extending from said reference path at an angle substantially equal to twice said incidence angle; and additional means associated with at least one of the secondary paths for utilizing said reflected electron beam.

2. An electron-discharge device comprising: electron gun means for projecting a focused beam of electrons along a predetermined primary reference path; a first scanning electrode system, comprising a plurality of reflector electrodes distributed along said beam path at predetermined intervals and each disposed transversely across said path at a given incidence angle, for selectively reflecting said electron beam along any one of a multiplicity of parallel secondary reference paths each extending from said primary reference path at an angle substantially equal to twice said incidence angle; and a second scanning electrode system, comprising a plurality of scanning electrodes distributed along said secondary paths, for selectively directing said electron beam along any one of a multiplicity of tertiary beam paths.

3. An electron-discharge device comprising: electron gun means for projecting a focused beam of electrons along a predetermined primary reference path; a first scanning electrode system, comprising a plurality of reflector electrodes distributed along said beam path at predetermined intervals and each disposed transversely across said path at a first given incidence angle, for selectively reflecting said electron beam along any one of a multiplicity of parallel secondary reference paths each extending from said primary reference path at an angle substantially equal to twice said first incidence angle; and a second scanning electrode system, comprising a plurality of reflector electrodes distributed along said secondary beam paths at predetermined intervals and each disposed transversely across said paths at a second given incidence angle, for selectively reflecting said electron beam along any one of a multiplicity of tertiary paths each extending from said secondary reference paths at an angle substantially equal to the supplement of twice said second incidence angle.

4. An electron-discharge image-reproducing device comprising: a luminescent target; electron gun means for projecting a focused beam of electrons along a reference path adjacent one edge of said target; a scanning electrode system, comprising a plurality of reflector electrodes distributed along said beam path at predetermined intervals and each disposed transversely across said path at a predetermined incidence angle, for selectively reflecting said electron beam along a multiplicity of secondary paths each extending from said reference path at an angle substantially equal to twice said incidence angle to sweep said electron beam across said target in a first predetermined direction; and means for selectively directing said electron beam along a multiplicity of tertiary paths extending from said secondary paths to sweep said beam across said target in a second predetermined direction.

5. A color television image reproducer comprising: a multi-color luminescent target including a plurality of groups of elemental phosphor areas distributed in a predetermined pattern upon a substantially planar viewing surface; electron gun means for projecting a focused beam of electrons along a predetermined primary reference path adjacent to one edge of said target; a first scanning electrode system, comprising a plurality of reflector electrodes distributed along said beam path at predetermined intervals and each disposed transversely across said path at a predetermined incidence angle, for selectively reflecting said electron beam along any one of a multiplicity of secondary reference paths each extending from said primary reference path in a plane substantially parallel to said target at an angle substantially equal to twice said predetermined incidence angle; and a second scanning electrode system, comprising a plurality of reflector electrodes distributed along said secondary beam paths at predetermined intervals and each disposed transversely across said paths at a given incidence angle, for selectively reflecting said electron beam along any one of a multiplicity of tertiary paths, each extending from said reference path at an angle substantially equal to twice said given incidence angle, to impinge upon said multi-color target.

6. An electron-discharge device comprising: electron gun means for projecting a focused beam of electrons along a predetermined reference path; a scanning electrode system, comprising a plurality of reflector electrodes distributed along said beam path at predetermined intervals and each disposed transversely across said path at a predetermined incidence angle, for selectively reflecting said electron beam along any one of a multiplicity of secondary paths each extending from said reference path at an angle substantially equal to twice said incidence angle; and additional means, including a target electrode structure comprising a plurality of individual collector electrodes distributed in a predetermined geometrical pattern, associated with said secondary paths for utilizing said reflected electron beam.

7. An electron-discharge device comprising: a target electrode structure comprising a plurality of individual collector electrodes distributed in a predetermined geometrical pattern; electron gun means for projecting a focused beam of electrons along a predetermined primary reference path adjacent said target electrode structure; a first scanning electrode system, comprising a plurality of reflector electrodes distributed along said beam path at predetermined intervals and each disposed transversely across said path at a predetermined incidence angle, for selectively reflecting said electron beam along any one of a multiplicity of secondary reference paths extending adjacent said target electrode system at an angle substantially equal to twice said incidence angle with respect to said primary reference path; and a second scanning electrode system, comprising a plurality of scanning electrodes distributed along said secondary paths, for selectively directing said electron beam toward said target electrode structure along any one of a multiplicity of tertiary beam paths individually intercepting said collector electrodes.

8. An electron-discharge image reproducing device comprising: a luminescent target comprising a layer of luminescent material disposed upon a substantially planar viewing surface; electron gun means for projecting a plurality of focused beams of electrons along substantially parallel individual primary reference paths adjacent said target electrode system; a first scanning electrode system, comprising a plurality of reflector electrodes distributed along said reference paths at predetermined intervals and each disposed transversely across said paths at a given incidence angle, for selectively reflecting said electron beams along any of a multiplicity of secondary reference paths each extending from said primary reference paths

at an angle substantially equal to twice said incidence angle; and a second scanning electrode system, comprising a plurality of scanning electrodes distributed along said secondary paths, for selectively directing said electron beam along any one of a multiplicity of tertiary beam paths to impinge upon said luminescent target.

9. An electron-discharge device comprising: electron gun means for projecting a focused beam of electrons along a predetermined reference path; and a scanning electrode system comprising a plurality of bifurcated reflector electrodes distributed along said beam path at predetermined intervals and each disposed transversely across said path at a predetermined incidence angle, for selectively reflecting said electron beam along any one of a multiplicity of secondary paths each extending from said reference path through the open portion of one of said reflector eletcrodes at an angle substantially equal to twice said incidence angle.

10. An electron-discharge device comprising: electron gun means for projecting a focused beam of electrons along a predetermined reference path; and a scanning electrode system for selectively reflecting said electron beam along any one of a multiplicity of secondary paths at a predetermined exit angle, said scanning electrode system comprising a plurality of channel-shaped reflector electrodes distributed along said path at predetermined intervals and each disposed transversely across said path at a predetermined incidence angle substantially equal to one-half said exit angle, each of said channel-shaped electrodes including an aperture in the base portion thereof substantially encompassing said primary reference path.

11. An electron-discharge device comprising: electron gun means for projecting a focused beam of electrons along a predetermined reference path; and a scanning electrode system, comprising a plurality of reflector electrodes, each including a substantially electron-transparent conductive mesh section, distributed along said beam path at predetermined intervals and each extending transversely of said path at a predetermined incidence angle, for selectively reflecting said electron beam along any one of a multiplicity of secondary paths each extending from said reference path at an angle substantially equal to twice said incidence angle.

12. An electron-discharge device comprising: electron gun means for projecting a focused beam of electrons along a predetermined reference path; a scanning electrode system, comprising a plurality of reflector electrodes distributed along said beam path at periodic intervals and each disposed transversely across said path at a predetermined incidence angle, for selectively reflecting said electron beam along any one of a multiplicity of secondary paths each extending from said reference path at an angle substantially equal to twice said incidence angle; target means for utilizing said reflected electron beam; and additional means associated with said secondary paths for controlling said reflected electron beam in its passage to said target means.

13. An electron-discharge device comprising: electron gun means for projecting a focused beam of electrons along a predetermined reference path; and a scanning electrode system, comprising a plurality of reflector electrodes distributed along said beam path at predetermined intervals and each extending transversely of said path at a predetermined incidence angle, for selectively reflecting said electron beam along any one of a multiplicity of secondary paths each extending from said reference path at an angle substantially equal to twice said incidence angle, said reflector electrodes each comprising a first electron-opaque section disposed at one side of said reference path, a second electron-opaque section disposed on the opposite side of said reference path, and an electron-transparent section extending from the edge of said second section farthest from said reference path.

14. An electron-discharge device comprising: electron gun means, including an electron-emissive cathode, for projecting a focused beam of electrons along a predetermined reference path; a scanning electrode system, comprising a plurality of reflector electrodes distributed along said beam path at predetermined intervals and each disposed transversely across said path at a predetermined incidence angle; means for maintaining said reflector electrodes at a predetermined positive operating potential with respect to said cathode; means for individually selectively reducing the operating potential of said reflector electrodes to establish an electron mirror within said scanning electrode system and reflect said electron beam along any one of a multiplicity of secondary paths each extending from said reference path at an angle substantially equal to twice said incidence angle; and additional means associated with at least one of said secondary paths for utilizing said reflected electron beam.

15. An electron-discharge device comprising: electron gun means including an electron-emissive cathode for projecting a focused beam of electrons along a predetermined reference path; a scanning electrode system, comprising a plurality of reflector electrodes distributed along said beam path at predetermined intervals and each disposed transversely across said path at a predetermined incidence angle; means for maintaining said reflector electrodes at a predetermined positive operating potential with respect to said cathode; commutator means for individually selectively reducing the operating potential of said reflector electrodes in a predetermined sequence to establish an electron mirror within said scanning electrode system which varies in position in accordance with said sequence to reflect said electron beam along a multiplicity of secondary paths each extending from said reference path at an angle substantially equal to twice said incidence angle; and additional means associated with at least one of said secondary paths for utilizing said reflected electron beam.

16. An electron-discharge device comprising: electron gun means including an electron-emissive cathode for projecting a focused beam of electrons along a predetermined reference path; a scanning electrode system, comprising a plurality of reflector electrodes distributed along said beam path at predetermined intervals and each disposed transversely across said path at a predetermined incidence angle; means for maintaining said reflector electrode at a predetermined positive operating potential with respect to said cathode; means for developing a scanning signal of sawtooth waveform; and commutator means for individually selectively applying said scanning signal to said reflector electrodes in predetermined sequence to establish within said scanning system an electron mirror which traverses said system at a predetermined rate to reflect said electron beam along a multiplicity of secondary paths in predetermined sequence, each of said secondary paths extending from said reference path at an angle substantially equal to twice said incidence angle.

17. An electron-discharge device comprising: a target electrode structure; electron gun means, including an electron-emissive cathode, for projecting a focused beam of electrons along a predetermined reference path adjacent said target electrode structure; a scanning electrode system, comprising a plurality of reflector electrodes distributed along said beam path at predetermined intervals and each disposed transversely across said path at a predetermined incidence angle; means for maintaining said reflector electrodes at a predetermined positive normal operating potential with respect to said cathode; means for individually selectively reducing the operating potential of said reflector electrodes to reflect said electron beam along any one of a multiplicity of secondary reference paths each extending toward said target electrode structure from said primary reference path at an angle substantially equal to twice said incidence angle; and means for maintaining said target electrode structure at a positive potential substantially higher than the normal operating potential of said reflector electrodes.

18. An electron-discharge image reproducing device

comprising: a luminescent target comprising a layer of luminescent material disposed upon a substantially planar viewing surface; electron gun means, including an electron-emissive cathode, for projecting a focused beam of electrons along a predetermined primary reference path adjacent one edge of said target; a first scanning electrode system, comprising a plurality of reflector electrodes distributed along said beam path at predetermined intervals and each disposed transversely across said path at a given incidence angle; means for maintaining said reflector electrodes at a predetermined positive normal operating potential with respect to said cathode; means for individually selectively reducing the potential upon said reflector electrodes in predetermined sequence to reflect said electron beam along a multiplicity of secondary reference paths each extending from said primary reference path in a plane substantially parallel to the plane of said target and at an angle substantially equal to twice said incidence angle; a second scanning electrode system comprising a plurality of scanning electrodes distributed along said secondary paths; means for maintaining said scanning electrodes at a predetermined positive normal operating potential with respect to said cathode; means for individually selectively varying the potential of said scanning electrodes in accordance with a predetermined sequence to direct said electron beam along a multiplicity of tertiary beam paths extending toward said luminescent target; a substantially electron-transparent electrode interposed between said second scanning electrode system and said luminescent target; means for maintaining said electron-transparent electrode at a potential substantially equal to the normal operating potential of said scanning electrodes of said second scanning electrode system; and means for maintaining said luminescent target at a positive potential substantially higher than said normal operating potential of said second scanning electrode system to establish an accelerating field between said electron-transparent electrode and said target.

19. An electron-discharge device comprising: first electron gun means, including an electron-emissive cathode, for projecting a first focused beam of electrons along a predetermined reference path; a scanning electrode system, comprising a plurality of reflector electrodes distributed along said beam path at predetermined intervals and each disposed transversely across said path at a predetermined incidence angle; means for maintaining said reflector electrodes at a predetermined positive operating potential with respect to said cathode; second electron gun means for developing and projecting a second focused beam of electrons; and a deflection system associated with said second electron gun means for selectively directing said second electron beam to impinge upon one of said reflector electrodes to vary the operating potential of said one reflector electrode and establish an electron mirror within said scanning electrode system to reflect said first electron beam along any one of a multiplicity of secondary paths each extending from said reference path at an angle substantially equal to twice said incidence angle.

20. An electron-discharge device comprising: first electron gun means, including an electron-emissive cathode, for projecting a focused beam of electrons along a predetermined reference path; a scanning electrode system, comprising a plurality of reflector electrodes distributed along said beam path at predetermined intervals and each disposed transversely across said path at a predetermined incidence angle; means, comprising a corresponding plurality of load impedances individually connecting said reflector electrodes to a source of positive operating potential, for maintaining said reflector electrodes at a predetermined positive operating potential with respect to said cathode; second electron gun means, including a second electron-emissive cathode, for developing and projecting a second focused beam of electrons; means for maintaining said second cathode at a potential substantially negative with respect to said first cathode; deflection means associated with said second electron gun; means for applying a step-function deflection signal to said deflection system to direct said second electron beam to impinge upon said reflector electrodes in predetermined sequence and establish within said scanning electrode system an electron mirror which traverses said scanning electrode system in accordance with said predetermined sequence to selectively reflect said first electron beam along a multiplicity of secondary paths each extending from said reference path at an angle substantially equal to twice said incidence angle; and means for controlling the intensity of said second electron beam to determine at any given instant the secondary path along which said first electron beam is reflected.

21. An electron-discharge device comprising: a target electrode structure comprising a plurality of individual collector electrodes distributed in a predetermined geometrical pattern; a like plurality of terminal conductors respectively coupled to said collector electrodes; electron gun means for projecting a focused beam of electrons along a predetermined reference path adjacent said target electrode structure; a first scanning electrode system comprising a plurality of reflector electrodes distributed along said reference path at predetermined intervals for selectively reflecting said electron beam along any of a multiplicity of secondary paths each extending from said primary reference path in a plane substantially parallel to said target electrode structure; and a second scanning electrode system, comprising a plurality of scanning electrodes distributed along said secondary paths, for selectively directing said electron beam along any one of a multiplicity of tertiary beam paths individually intercepting said collector electrodes.

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