Jan. 7, 1969 D. E. HULTBERG 3,421,042

ELECTRON BEAM SCANNER UTILIZING LABYRINTH STRUCTURE

Filed April 27, 1967 Sheet 1 of 3

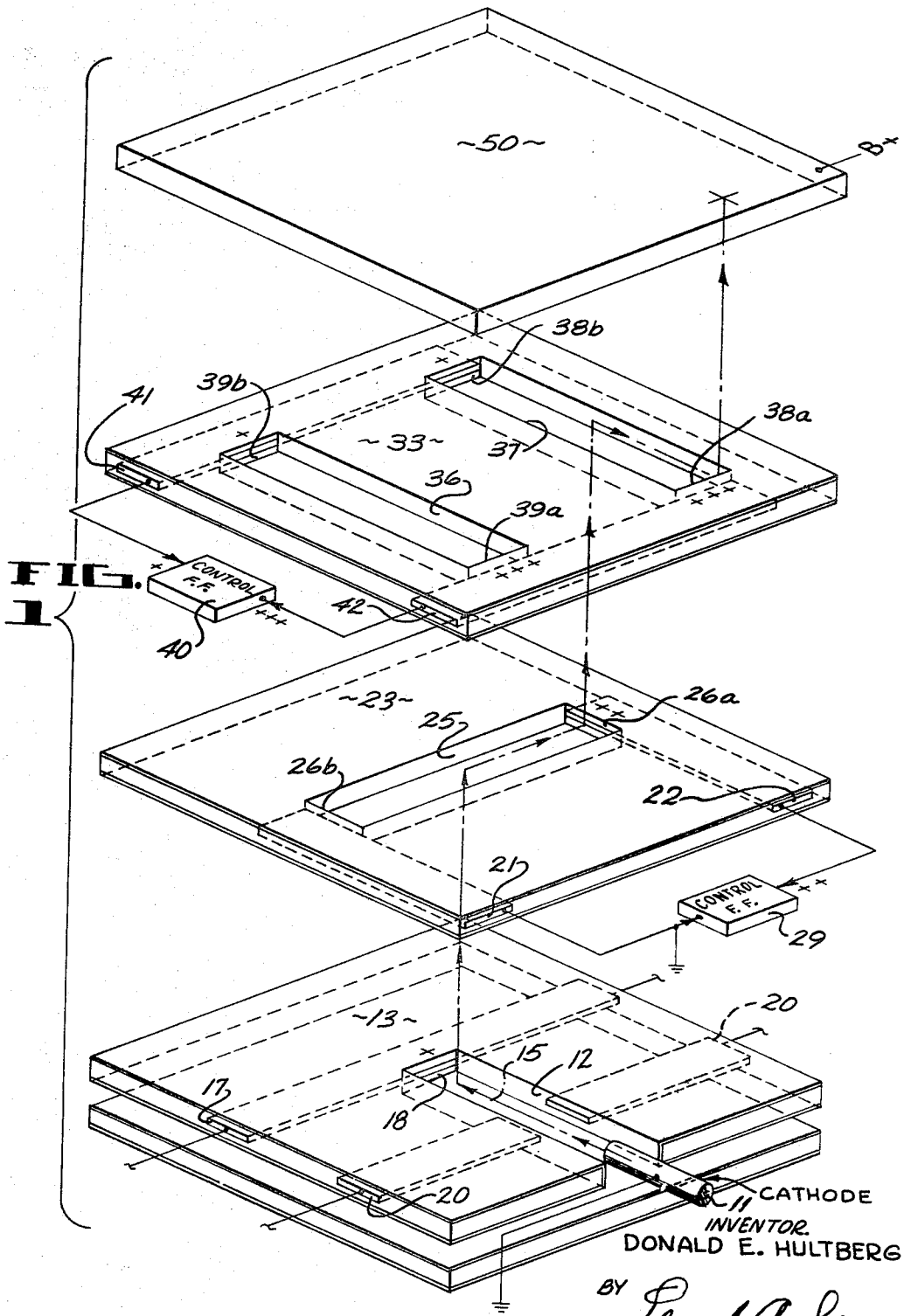


FIG. 1

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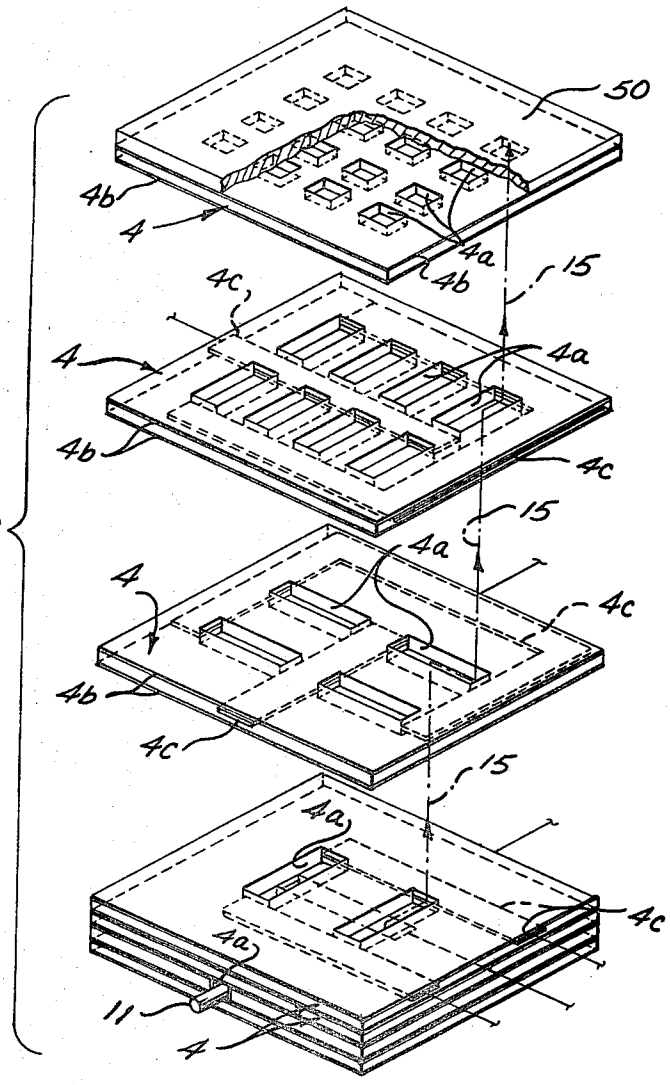
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FIG. 2



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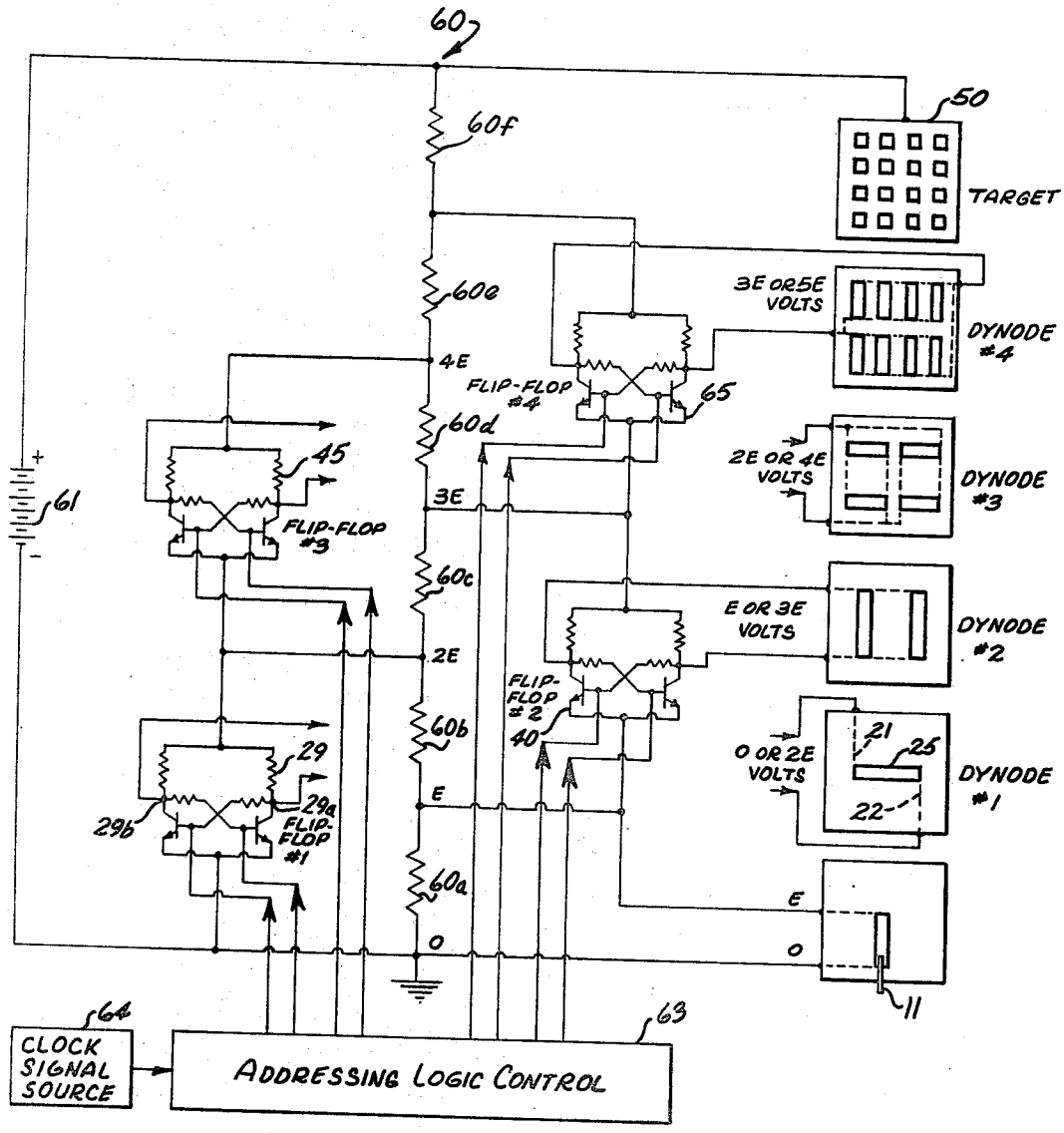


FIG. 3

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3,421,042

ELECTRON BEAM SCANNER UTILIZING LABYRINTH STRUCTURE

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U.S. Cl. 315—12 12 Claims
Int. Cl. H01j 29/41

ABSTRACT OF THE DISCLOSURE

A labyrinth structure is formed from a series of plate members forming dynodes which are stacked one on top of the other. Each of such plates has a channel or plurality of channels or apertures formed therein and on top of the uppermost plate is an electron target. At the very bottom-most portion of the labyrinth structure, a point source of electrons is installed. Separate switching means is connected to the opposite ends of the channels of each of the plates which allows an electron accelerating potential to be alternatively switched to one or the other of the ends of each of such channels. In this fashion, the electron beam is directed through the labyrinth to any particular desired portion of the target in accordance with the control signals fed to the switching means.

This invention relates to electron beam scanning devices, and more particularly to such a device of relatively flat and thin configuration which operates in response to a randomly addressed or sequential digital control signal. In co-pending application Ser. No. 511,747, filed Dec. 6, 1965, for an electron beam scanning device, which is assigned to Northrop Corporation, the assignee of the instant application, a relatively flat, thin electron beam scanning device is described which operates in response to a digital control signal and is capable of random or sequential addressing. This type of device has many advantages over cathode ray devices of the prior art, such as video camera tubes, video display tubes, memory and storage tubes, in that it provides a compact configuration having excellent linearity and definition which is capable of both random and sequential addressing and is not subject to ambient electrostatic and electromagnetic fields.

The device of this application, while having all of the advantages of the device described in the aforementioned co-pending application, additionally provides a number of significant additional advantages. Firstly, in the device of this invention, a point source of electrons can be used rather than a flat plate source. The use of a point electron source in the device of the invention not only makes for more uniform electron emission at the output but makes possible the use of a generally commercially available type cathode which is both economical to fabricate and easy to energize. Further, the rate of emission of a point source of electrons is much easier to control than a broad surfaced source. Also, in view of the fact that in the device of this invention a single electron beam is channeled through a labyrinth to the target, rather than a plurality of beams as in the device of the aforementioned pending application, a greater inherent electron beam intensity is feasible. Further, in the device of the invention there is substantially less possibility of stray electrons inadvertently passing through the target due to the highly effective isolation provided by the labyrinth structure. Still further, due to the much lower electron secondary emission gain required in the device of the invention, lower accelerating potentials are needed, lessening the insulation and power supply requirements. Another significant advantage of the device of this invention is that there is less necessity for

precise registration of the control dynodes forming the labyrinth.

The improvement is achieved in the device of the invention by forming a labyrinth structure with a plurality of control plates or dynodes which are stacked one upon the other between a point source cathode member and an electron target. Each of the dynodes has a channel or a number of channels or apertures formed therein, the number of such channels doubling with each higher stacked dynode member as we approach the target. Separate electrodes are provided at each of the opposite ends of the channels of each dynode member and connected between the electrodes of each dynode member is a binary switching device for alternatively reversing an electron accelerating potential between the pair of such electrodes. By controlling the switching of these switching devices, the electron beam is channeled to any desired portion of the target to provide an output signal thereon.

It is therefore an object of this invention to provide an improved electron beam scanning or addressing device.

It is a further object of this invention to provide an electron beam scanning or addressing device of relatively flat and compact construction utilizing a point electron source.

It is still a further object to provide an electron beam scanning or addressing device utilizing a labyrinth structure for channeling an electron beam between a point electron source cathode and a target plate.

It is another object of this invention to provide an electron beam scanning device directly operable in response to a digital control signal which is capable of random addressing or sequential switching.

It is a further object of this invention to provide a high definition electron beam scanning device of compact configuration capable of utilization as an image display, memory device, or image sensing device.

Other objects of this invention will become apparent from the following description taken in connection with the accompanying drawings, of which:

FIG. 1 is an exploded view of plate elements of a preferred embodiment of the device of the invention schematically illustrating the operation thereof,

FIG. 2 is an exploded view of the preferred embodiment of the device of the invention, and

FIG. 3 is a schematic diagram illustrating electronic circuitry which may be utilized to provide power and signals for the device of the invention.

Referring now to FIG. 2, a preferred embodiment of the device of the invention is illustrated. Dynode members **4** in the form of plates, which are fabricated of an insulating material such as glass, have channels or apertures **4***a* formed therein. The dynode plates **4** further have resistive coatings **4***b* on their upper and lower surfaces which may be of a material such as reduced lead or other suitable material which has secondary emission characteristics. The surfaces of the sides of channels **4***a* are also coated with resistive secondary emissive material. In the channel **4***a* of the lowermost dynode, point electron source cathode **11** which may be of the thermionic variety is installed. Adjacent to the uppermost dynode is a target **50** which may be a phosphorescent display, a memory or a sensor plate. The number of channels **4***a* in plates **4** increase in binary fashion as we proceed from cathode **11** to target **50**, such channels being arranged so that each pair of channels is bridged by a single channel in the next lowest dynode.

Embedded in each of the dynodes **4** are electrical conductors **4***c*. Each of such conductors forms an electrode making contact to the secondary emissive wall coating at each of the ends of channels **4***a*. Each of plates **4** may be formed from two separate plate units with the conductors

4*c* formed by electro-deposition techniques on the surface of one of these plate units and sandwiched between the two plate units.

The plates **4** are stacked together with the channels therein forming an electron labyrinth between cathode member **11** and target member **50** which is utilized to address the beam to any desired portion of target **50** as now to be explained in connection with FIG. 1.

In FIG. 1, different and separate numerals are utilized to identify the various parts of each of the plates shown to specifically identify and distinguish the separate components thereof, this to facilitate the comprehension of the operation of the labyrinth. FIG. 1 is a schematic view showing only a few of the plates that would be utilized in a normal operative device, the explanation of the function of these few plates illustrating the principles of the invention.

Cathode **11** emits a beam of electrons **15** into channel **12**. This beam is accelerated towards anode **18** at the end of the channel by virtue of the positive potential at such anode. Anode **18** is formed by conductive strip **17** to which a positive potential is applied. A control electrode for controlling the intensity of electron beam **15** is formed by strip members **20** to which are applied a control potential.

Plate member **23** has a single channel **25** formed therein with conductive strip members **22** and **21** forming anodes **26***a* and **26***b* respectively at opposite ends of channel **25**. Control flip-flop **29** is connected between strip members **21** and **22**.

Plate member **33** has two channels **36** and **37** which run normal to channel **25**. Anodes **38***b* and **39***b* are formed by strip member **41** on one end of channels **37** and **36** respectively, while anodes **39***a* and **38***a* are formed on the opposite ends of these channels by strip member **42**. Control flip-flop **40** is connected between strip members **41** and **42** and provides the preselected accelerating potential to these strip members. Control flip-flop **29** is alternatively driven to either provide an electron accelerating potential toward strip member **21** or toward strip member **22**. Similarly control flip-flop **40** is alternatively driven to either provide an accelerating potential toward strip member **41** or strip member **42**. The positive potential outputs of flip-flops **29** and **40** are such that higher accelerating potentials are provided to strip **41** or **42** than to strip **21** or **22**.

Let us assume now, for example, that flip-flop **29** is driven to provide an accelerating potential to anode **26***a*, while flip-flop **40** is driven to provide an accelerating potential to anodes **38***a* and **39***a*. Under such conditions the electron beam **15** is initially accelerated towards anode **18**, which is directly below the central portion of channel **25**. The electron beam strikes anode **18**, emitting secondary electrons, which are drawn into channel **25**. From this point, the beam is accelerated towards anode **26***a* where it is directly below the central portion of channel **37**. Again, secondary electrons are emitted at anode **26***a* which are drawn into channel **37**, from where the beam is accelerated towards anode **38***a*. Secondary electrons emitted at anode **38***a* are then accelerated towards target **50**.

The electron beam path through the labyrinth formed by the dynodes is also illustrated in FIG. 2, which shows a greater number of dynode members forming the labyrinth structure. It thus can be seen that by placing a flip-flop between each pair of strip members **4***c* (FIG. 2) that the beam can be addressed to any predesired portion of target **50**, the dynode members forming an effective electron labyrinth for channeling the beam in response to the control signals.

Referring now to FIG. 3, control circuitry which may be utilized to control the channeling of the electron beam through the labyrinth is schematically illustrated. Voltage divider **60** comprises a plurality of resistors **60***a*–**60***f* and is connected between the positive and negative terminals of DC power source **61**. The positive terminal of power source **61** is connected to target **50** while the negative terminal of the power source which is normally grounded is connected to cathode **11**. Transistor flip-flops **29**, **40**, **45** and **65**, there being one such flip-flop unit for each of the dynodes **4** forming the labyrinth, are connected at succeeding points along voltage divider **60**, the emitters of each transistor flip-flop pair being connected to a separate voltage divider point.

The collector of transistor stage **29***a* is connected to control strip **22** of labyrinth plate **23**, while the collector of transistor stage **29***b* is connected to control strip **21** of this plate. The base electrodes of transistor stages **29***a* and **29***b* are connected to receive the output of addressing logic control **63** which operates in response to clock signal source **64**.

In accordance with the output of clock signal source **64**, the addressing logic which includes conventional logical control circuitry will alternatively provide a signal to either transistor stage **29***a* or stage **29***b* to actuate one or the other of these transistors. When transistor stage **29***a* is turned off, the collector of this transistor will assume the potential of the flip-flop supply voltage (+2E) thereof and thus the voltage divider potential at the point between resistors **60***b* and **60***c* will be applied to control strip **22**. Alternatively when transistor stage **29***b* is turned on, this control potential will be applied to control strip **21**. In this manner, the electron beam is directed to one or the other of the ends of channel **25** as described in connection with FIGS. 1 and 2. In similar manner, each of transistor stages **40**, **45** and **65** provide a control signal to the control strips of a separate one of the labyrinth plate members, in response to the addressing logic received thereby from addressing logic control **63** in response to clock signal source **64**. Thus it can be seen that beam **15** can be addressed to any desired portion of target **50** in response to a control signal. It is to be noted that the control circuitry illustrated in FIG. 3 is shown for exemplary purposes only, and that other control means may be employed to actuate the plate members to address the electron beam through the labyrinth structure in the desired manner. It is also to be noted that the dynodes are shown as gray coded areas whereas conventional binary or other coding could be used.

The device of the invention thus provides a unique electron labyrinth structure which can be effectively utilized for addressing an electron beam generated by point source cathode to a target plate.

While the device of the invention has been described and illustrated in detail, it is to be clearly understood that this is intended by way of illustration and example only and is not to be taken by way of limitation, the spirit and scope of this invention being limited only by the terms of the following claims.

I claim:

1. In an electron beam scanner, said scanner including means for emitting electrons, a target for receiving said electrons and a potential source connected between said electron emitting means and said target for accelerating the flow of electrons between said electron emitting means and said target, means for addressing the electrons to predetermined portions of said target comprising

a plurality of dynode members stacked one on the other between said electron emitting means and said target, each of said dynode members having apertures providing channels formed therein in a predetermined pattern, said dynode members combining to form an electron labyrinth between said electron emitting means and said target,

means for alternatively applying an accelerating potential to one or the other of the opposite ends of the apertures of each of said dynode members, and

means for controlling the application of potential to said aperture ends in a predesired manner,

whereby an electron beam originating at said cathode

is directed through said labyrinth structure to a predetermined portion of said target member.

2. The scanner as recited in claim 1 wherein said dynode members each comprise a flat plate fabricated of an insulating material, said plates being coated on the surfaces of both sides and the channels thereof with a resistive secondary emissive material.

3. The scanner as recited in claim 1 wherein said dynode member apertures are in the form of longitudinally extending strips.

4. The scanner as recited in claim 1 wherein each succeeding dynode member has double the number of channels as the dynode member next closest to the electron emitting means.

5. The scanner as recited in claim 4 wherein pairs of channels of said dynode members are each bridged by a single channel in the adjacent dynode member closer to the electron emitting means.

6. The scanner as recited in claim 1 wherein said means for alternatively applying an accelerating potential to one or the other of the ends of the dynode member channels comprises a power source and binary switching means for alternatively connecting the potential outputs of said power source between the ends of said dynode member channels in a first direction or a direction opposite said first direction.

7. The scanner as recited in claim 6 wherein said means for alternatively applying an accelerating potential to said dynode members additionally includes conductors embedded in said dynode members for connecting the ends of said channels to said binary switching means.

8. The scanner as recited in claim 6 wherein said power source includes a voltage divider having a plurality of voltage taps thereon and said binary switching means comprises a plurality of flip-flop units, each of said flip-flop units being connected between a separate pair of voltage taps on said voltage divider.

9. In an electron beam scanner, said scanner including means for emitting electrons, a target member for receiving said electrons and a potential source connected between said means for emitting electrons and said target for accelerating the flow of electrons therebetween, the improvement including means for addressing the electrons to predetermined portions of said target comprising

an electron labyrinth for channeling said electrons between said electron emitting means and said target, said labyrinth comprising a plurality of substantially flat dynode members stacked on each other between said electron emitting means and said target, each of said dynode members having a plurality of linear channels formed therein and passing through the broad surfaces thereof, said dynode members each having double the number of channels as the adjacent dynode member closer to said electron emitting means,

means for alternatively applying an accelerating potential to one or the other of the opposite ends of said dynode channels, and

means for controlling the application of said accelerating potential to said channel in accordance with a control signal.

10. The scanner as recited in claim 9 wherein pairs of said dynode member channels are bridged by single channels in the dynode member next closest to said electron emitting means.

11. The scanner as recited in claim 9 wherein said dynode members each comprise a flat plate fabricated of an insulating material, said plates being coated on all the surfaces except the outer edges thereof with a resistive secondary emissive coating.

12. The scanner as recited in claim 9 wherein said means for alternatively applying an accelerating potential to one or the opposite ends of the dynode channels comprises a power source and binary switching means for alternatively connecting the potential outputs of said power source between the ends of said channels in a first direction or a direction opposite said first direction.

References Cited

UNITED STATES PATENTS

3,005,127 10/1961 Aiken ..... 315—18

FOREIGN PATENTS

932,212 7/1963 Great Britain.

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U.S. Cl. X.R.

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