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METHOD AND APPARATUS FOR INSCRIBING A PATTERN IN A TARGET ELECTRODE STRUCTURE

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Fig. 1

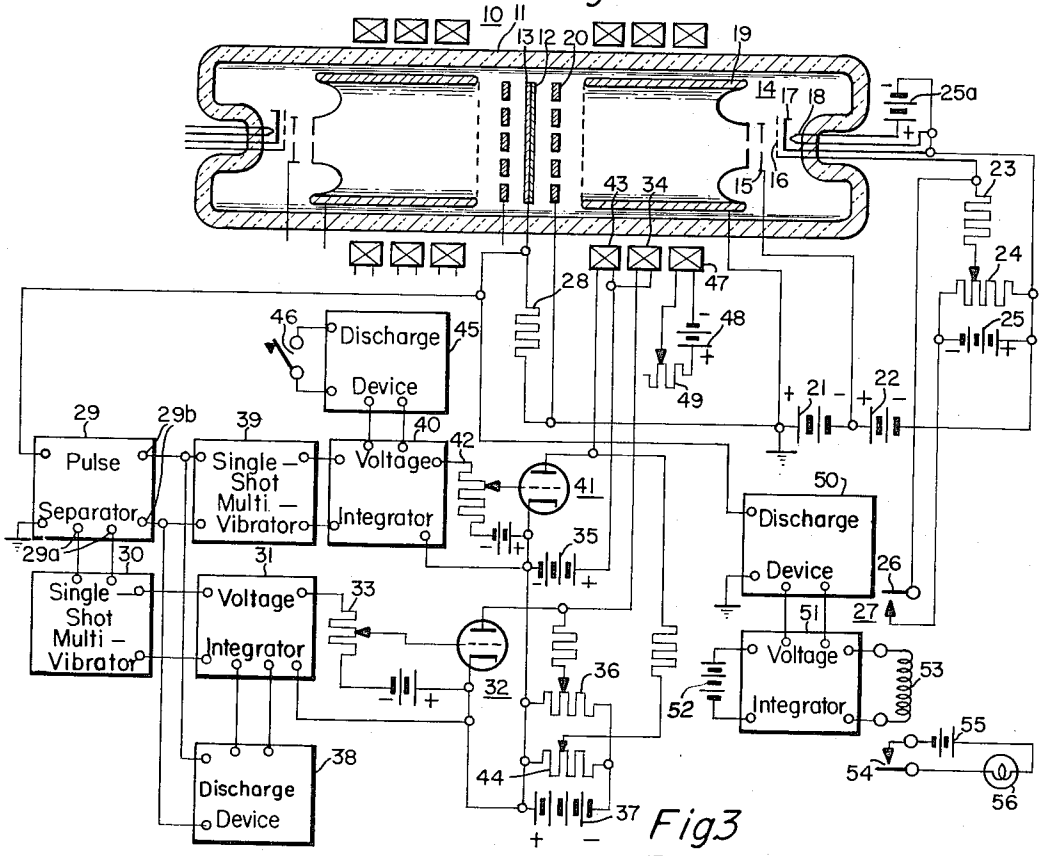


Fig. 2

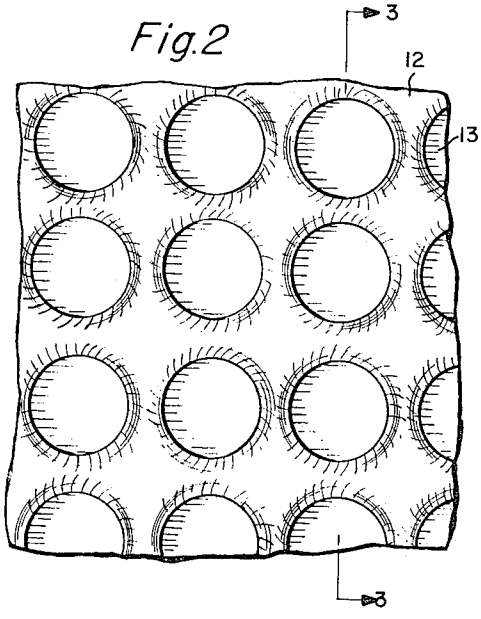
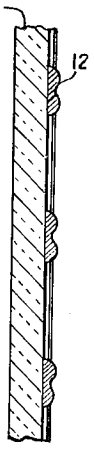


Fig. 3



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METHOD AND APPARATUS FOR INSCRIBING A PATTERN IN A TARGET ELECTRODE STRUCTURE

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7 Claims. (Cl. 315—12)

This invention relates to a novel method of inscribing a pattern in a sheet of material. Although it is subject to numerous applications, the invention is ideally suited for producing a storage electrode for a signal storage device of the type described and claimed in the copending application of Constantin S. Szegho and William O. Reed, filed June 16, 1949, Serial No. 99,421, now Patent No. 2,687,492, and assigned to the same assignee as the present application. For convenience, the invention will be described in that connection.

One embodiment of the storage electrode for the above-mentioned signal storage device includes a conductive grid-like structure having a plurality of interstices or apertures. A dielectric film is distributed on one surface of the structure across the interstices in substantially coplanar relation with the structure. The signal storage device is arranged so that a charge image may be formed on the storage electrode by means of a writing electron beam and this image may be subsequently "read" by a reading electron beam. The resolution of this stored image is dependent upon the fineness of the grid-like structure, or in other words, the most numerous the interstices the greater the resolution. A mesh having 400 openings per square inch has been found suitable for many applications.

A member provided with a plurality of interstices to serve as a storage electrode, such as the one just described, may be formed by conventionally weaving a screen of conductive wires. Alternatively, the electrode may be fabricated by perforating a conductive sheet to produce the required pattern of apertures. In order to achieve a suitable number of apertures per unit area, complex and expensive mechanical fabricating devices are needed. Since these fabricating devices are but machines, there exists a practical limit to the fineness of screen which can be easily attained, and consequently, the image resolution of the signal storage device is limited.

Conductive meshes having a large number of interstices may also be formed by well-known electrolytic and chemical means. However, there is a practical limit of open area in comparison to mesh bar area for structures fabricated in this manner.

It is an object of this invention, therefore, to provide a novel method of inscribing a pattern in a sheet of material which method is not subject to the limitations of prior processes.

It is a further object of this invention to provide a novel method of inscribing a pattern in a sheet of material which is efficient in execution and yet is inexpensive to carry out.

An important feature of the invention is a method of inscribing a pattern in a target electrode structure which has a given secondary emission characteristic. The method comprises the formation of a beam of electrically charged particles which is directed toward a particular elemental area of the electrode structure materially to alter the secondary emission characteristic of that area. The beam is deflected in response to a preselected change of secondary emission characteristic in step-by-step fashion over the electrode structure in accordance with a preselected pattern similarly to alter the secondary emission characteristic of the scanned area of the electrode structure. A preferred embodiment of this feature utilizes a beam of electrons as the agency for inscribing the pattern, which is formed by melting apertures in the electrode structure.

Another feature of the invention provides a novel apparatus for inscribing a pattern in a target electrode structure having a given secondary emission characteristic. The apparatus comprises means for developing a beam of electrically charged particles and a deflection system is associated with the beam to direct the particles toward a particular elemental area of the electrode structure. The deflection system is responsive to a control potential for displacing the beam to another elemental area of the electrode structure. A load impedance is connected in the circuit with the beam-developing means for deriving a control potential when the secondary emission characteristic of the first elemental area is altered a selected amount. The apparatus further includes means for coupling the load impedance to the deflection system to effect displacement of the beam from the first area to another elemental area of the electrode structure in response to the control potential.

The features of the present invention which are believed to be novel are set forth with particularity in the appended claims. The present invention, both as to its organization and manner of operation, together with further objects and advantages thereof may best be understood by reference to the following description taken in connection with the accompanying drawing in which:

Fig. 1 is a block diagram of apparatus for inscribing a pattern in a sheet of material in accordance with the method of the instant invention and includes a sectional view partly schematic of a signal storage device which constitutes a part of this apparatus;

Fig. 2 is a fragmentary view of a storage electrode fabricated by the method of the instant invention;

Fig. 3 is a sectional view taken along line 3—3 of Fig. 2.

With reference now to Fig. 1, there is shown an apparatus especially suited for inscribing a pattern in a sheet of material in accordance with the method of the present invention. This apparatus comprises an electron-discharge device 10 having an evacuated glass envelope 11 which encloses a sheet of conductive material 12 disposed on a support structure 13 of an electrical insulating material. The structure 13 may for example be a rectangular plate of quartz, glass, mica or similar material and sheet 12 may be a layer of silver, copper, or like material coated on one face of the plate. The metal layer should be thin enough so that it may be locally heated and melted. The material of sheet 12 normally has a given secondary emission characteristic and when the sheet is processed by the method of the invention it is inscribed with a pattern of areas having a materially different secondary emission characteristic. Specifically, a permanent pattern of apertures is produced in the metallic layer and the structure 12, 13 becomes a storage electrode for device 10, as will be more fully described hereinafter.

Except for the construction of target electrode 12, 13, the device 10 is generally similar to the signal-storage device described in the aforementioned Szegho-Reed application. This device is of the "double ended" variety and the portions thereof to the right and to the left of structure 12, 13 are identical. With reference only to the right-hand portion of device 10, the evacuated envelope 11 encloses an electron gun 14 which constitutes the means for developing a beam of electrically charged par-

icles, namely electrons. The electron gun includes a first anode 15, a control electrode 16, a cathode 17, and a heater filament 18 for maintaining cathode 17 at a suitable operating temperature. The device 10 also includes an accelerating electrode 19 followed by a decelerating electrode 20. In practicing the invention to process target electrode 12, 13, the normal role of electrode 20 as a decelerator is not employed and this electrode is connected externally of envelope 11 with accelerating electrode 19 both of which are grounded. A source of unidirectional potential 21 is connected between electrodes 15 and 19 to produce the required potential difference therebetween and a source of unidirectional accelerating potential 22 is connected between electrode 15 and cathode 17. Control electrode 16 is connected to one end of an isolation resistor 23, the other end of which is connected to the wiper arm of a potentiometer 24 shunted across a source of bias potential 25. The positive terminal of source 25 is connected to cathode 17 and the negative terminal is connected to control electrode 16 through a pair of normally open contacts 26 of a relay 27. A source of filament potential 25*a* is connected to filament 18.

A load impedance 28 is connected between the conductive target sheet 12 and ground and hence is in circuit with the beam-developing means which includes electron gun 14. This load impedance is effective for deriving a control pulse when the secondary emission characteristic of a portion of the sheet 12 is altered a preselected amount, or in other words when the electron beam locally heats an elemental area of sheet 12 on which it impinges to cause melting and so form an aperture therein a voltage pulse is derived across load 28. The load impedance is also effective for deriving a different type of pulse when the electron beam is deflected off sheet 12. In particular, the first-mentioned pulse is characterized by a leading edge having a rise time dependent upon the rate at which the material of the treated area is melted and this rise time is slow compared with that of the last-mentioned variety of pulse.

Load impedance 28 is coupled with a pulse-separator 29 which is effective to separate pulses of different rise times and may be of any well-known construction. The stage 29 has one pair of output terminals 29*a* across which voltage pulses having a slow rise time appear and another pair of output terminals 29*b* across which voltage pulses having a faster rise time appear. Terminals 29*a* are coupled to a first single-shot multivibrator 30, which may be of conventional form, arranged to fire once to produce a pulse of given voltage amplitude for every pulse applied to its input circuit. The output circuit of multivibrator 30 is coupled with a voltage integrator 31 which integrates the magnitudes of successive voltage pulses developed by stage 30. This integrator may comprise a capacitor and an associated circuit for operating the capacitor over the linear portion of its charge-time characteristic in known manner. The output terminals of integrator 31 are connected with a conventional direct-coupled amplifier 32 through an amplitude control 33 and the output circuit of the amplifier is coupled with the horizontal deflection coils 34 of device 10. A source of B-potential 35 supplies space current for stage 32 and a positioning control 36 is coupled to a source of positioning voltage 37 and to coils 34 to provide means for adjusting the quiescent position of the beam from gun 14 in a horizontal direction. A discharge device 38 is coupled with integrator 31 to discharge the capacitor thereof in response to a signal supplied to its input circuit which is coupled to terminals 29*b* of pulse separator 29.

The terminals 29*b* of pulse separator 29 are further coupled with a multivibrator 39 of another channel similar to the one just described and which likewise includes a voltage integrator 40, a direct-coupled amplifier 41 and an amplitude control 42. Stage 41 derives its B-power from supply source 35 and its output circuit is connected

to vertical deflection coils 43 which are coupled with a vertical-positioning control 44, in turn, connected to source 37. A discharge device 45 is coupled with integrator 40 and its input circuit is shunted by a normally open discharge switch 46.

The coils 34 are a part of a deflection system associated with the beam of electrically charged particles emanating from gun 14 for directing the particles toward an elemental area of sheet 12. The deflection system is responsive to a control potential for displacing the beam from one to another elemental area of the sheet. Stage 32 provides the means for coupling integrator 31 to coil 34 of the deflection system to effect successive displacement of the beam across a succession of elemental areas of sheet 12 in response to the control potential developed by integrator 31. The pulse separator 29 which effectively is coupled between the load impedance 28 and integrator 31 through discharge device 38, selectively returns the integrator to a discharged or quiescent condition only in response to the type of pulse that is derived when the electron beam is deflected off the sheet.

Tube 10 is provided with a conventional focusing coil 47 and a suitable current source 48 is coupled thereto through a focus control 49. The current from this source is adjusted by means of control 49 so that the beam of electrons from gun 14 is directed in a focused spot toward target sheet 12.

In addition to being coupled with separator 29, load impedance 28 is coupled to a discharge device 50, in turn, coupled with a third voltage integrator 51. This integrator which is similar to integrator 31 includes one set of terminals coupled with a source of fixed potential 52 and its output terminals are coupled with the actuating coil 53 of relay 27.

The relay 27 is provided with a second set of contacts 54. These contacts are normally open and are in circuit with an indicator system including a source of potential 55 and an indicator lamp 56.

In describing the operation of the apparatus of Fig. 1, let it be assumed that integrators 31, 40 and 51 are in their respective quiescent or discharged conditions. The currents in the deflection system including coils 34 and 43 are adjusted by means of controls 36 and 44 so that the beam of electrons from gun 14 strikes the sheet 12 at its upper left-hand corner, looking at the sheet from the gun end of device 10. Electrons that strike the conductive sheet find a return path to ground through load 28 and locally heat the sheet in the area on which they strike. A sufficient accelerating potential is provided by source 22 and a suitable bias is provided for grid 16 so that the heating of the sheet produces melting and a substantially circular aperture is formed in the sheet.

When this occurs, some of the electrons pass through the newly formed opening and the current flowing through load 28 changes to effect a voltage pulse across the load. This type of pulse is of the type having a relatively slow rise time and is not translated to multivibrator 39 by discriminator 29, but is supplied to multivibrator 30. The resulting pulse from multivibrator 30 is stored in integrator 31 and the voltage increase of the integrator is supplied as a current change to the horizontal deflection coil 34 through translator 32. Thus, the electron beam is deflected in a horizontal direction by a predetermined amount and is directed to another elemental area of the sheet adjacent the initially treated area. Separator 29 is effective to prevent the transfer of a pulse to either of the multivibrators 30 or 39 in response to the voltage change across load 28 effected by movement of the beam from the area of the newly formed aperture to the body of the conductive sheet.

An aperture is now formed in the elemental area of the sheet adjacent the first-mentioned aperture in the manner described and a second voltage pulse is derived across load 28 when the opening is effected. This pulse triggers multivibrator 30 again and another voltage pulse

of constant amplitude is supplied to integrator **31** which is added to the voltage already stored therein. The current in deflection coil **34** is changed by another preselected incremental amount and the beam is shifted to another elemental area of the sheet **12**. This process continues until the beam has scanned the sheet to form a line of apertures across the upper extremity thereof.

When the beam is deflected off the sheet a voltage pulse is derived in load **28** having a faster rise time than the pulse formed in response to aperture production. This steeper pulse fires only multivibrator **39** and a voltage pulse of constant amplitude is applied to integrator **40**. The increase in voltage in integrator **40** effects a current change in vertical deflection coil **43** through amplifier **41** and the beam of electrons from gun **14** is displaced in a downward direction by a preselected amount. At the same time, the pulse from separator **29** that effects vertical beam movement operates discharge device **38**. The operation of device **38** discharges integrator **31** which returns to its quiescent condition and the beam of electrons is carried to the left-hand boundary of sheet **12**. The aforedescribed sequence for the first line of sheet **12** is repeated and a second line of apertures in vertical alignment with the first line is produced.

The sequence of line scanning continues until the beam has scanned the entirety of sheet **12**. After the beam is deflected beyond the lower right hand extremity of the sheet, it is returned toward the left-hand boundary at the same time it is displaced downwardly. This places the beam below the lower left-hand extremity of sheet **12**. In this operating condition no aperture formation occurs and the afore-described sequence of aperture-forming operations thus ends. If it is desired to repeat the sequence, switch **46** is closed whereupon discharge device **45** returns integrator **40** to its quiescent condition and the cycle begins again.

During the aperture-forming operations, integrator **51** tends to accumulate a voltage charge from source **52**. However, the pulses from load **28** continually cause dissipation of this charge through the operation of discharge device **50**. A charge does build up within integrator **51** when the electron beam is disposed beyond the confines of the lower left-hand corner of sheet **12** since for this condition no sequence of pulses appears across load **28** and a sufficient voltage is produced to energize coil **53** of relay **27**. The resulting magnetic field of coil **53** closes contact **26** to turn off the beam of device **10**. This field also closes the indicator lamp circuit through contacts **54** and indicator lamp **56** affords a visual indication that the entire aperture-forming sequence has been completed.

The just-described system for deflecting the electron beam in response to a pre-selected change of secondary emission characteristic of the target is provided with means sensitive to the rise time of the pulses developed in the target load impedance for designating horizontal and vertical scanning steps, respectively. It is entirely within the scope of the invention to utilize the different pulse amplitudes produced by aperture formation and by deflection of the beam off the target for designating scanning steps. This may be achieved by employing any well-known circuit construction in stage **29** that is effective for separating pulses of different amplitudes and operating the remainder of the system essentially as described hereinbefore.

With reference now to Fig. 2, the plan view there represented shows the sheet **12** after a pattern of apertures has been formed in accordance with the above-described sequence of operation for the apparatus of Fig. 1. These apertures are circular in shape and their diameter may be predetermined by the beam intensity from electron gun **14** and/or the time interval that elapses between the first appearance of a small aperture in the elemental area being treated and the deflection of the electron beam from that area. This time interval may be preset by providing a suitable time delay adjustment in separator **29** or in multivibrator **30**. As better illustrated in Fig. 3, the material that is removed to form the aperture tends to build up the area of the sheet surrounding the apertures into a crater-like configuration. However, for practical purposes when utilized in device **10**, the insulator **13** is substantially coplanar with sheet **12** and the structure **12, 13** may be properly operated as a storage electrode. It is important to note that as soon as the aperture-forming operations are completed, nothing further need be done before device **10** is connected into another circuit for operation as an image storage device, for example, in the circuit of the afore-mentioned Szegho-Reed application.

From the above discussion it is apparent that the apparatus of Fig. 1 is effective for inscribing a pattern in a sheet of material having a given secondary emission characteristic. This method comprises, as a first step, the formation of a beam of electrically charged particles such as electrons. The beam is directed toward an elemental area of the sheet to be inscribed, materially to alter the secondary emission characteristic of this area. Specifically, the area toward which the beam is directed is melted to form an aperture, and hence the secondary emission characteristic is changed from some given value to zero, assuming for this discussion that the insulator **13** does not contribute to the secondary emission characteristic of sheet **12**. If the composite target be considered, the secondary emission is low for the conductive surface and a large number of electrons flow at the outset. After an aperture is formed to expose the insulator target portion, the electron beam charges the insulator and electron flow to the conductive target portion is greatly altered. The beam is then deflected over the sheet in accordance with a preselected pattern determined by the integrator-amplifier systems as described above similarly to melt other elemental portions of the scanned area of the sheet.

It is apparent that by suitably adjusting the accelerating potential which causes electrons to strike sheet **13** to form small apertures and by closely spacing the series of apertures relative to one another, a much finer mesh may be constructed than heretofore possible by mechanical methods. No intricate mechanical device is needed to carry out the method of the invention and, in general, the relatively simple electronic apparatus for carrying it out is less complex and less expensive that the mechanical fabricating devices employed in practicing the prior-art methods.

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

I claim:

1. The method of inscribing a pattern in a target electrode structure having a given secondary emission characteristic which comprises the steps of: forming a beam of electrically charged particles; directing said beam toward an elemental area of said electrode structure materially to alter the secondary emission characteristic of said area; and deflecting said beam in response to a preselected change of secondary emission characteristic in step-by-step fashion over said electrode structure in accordance with a preselected pattern similarly to alter the secondary emission characteristic of other elemental areas of said electrode structure.

2. The method of inscribing a pattern in a target electrode structure having a given secondary emission characteristic which comprises the steps of: forming a beam of electrically charged particles; directing said beam toward an elemental area of said electrode structure materially to alter the secondary emission characteristic of said area; deflecting said beam in response to a preselected change of secondary emission characteristic in step-by-step fashion over said electrode structure in accordance

with a preselected pattern similarly to alter the secondary emission characteristic of other elemental areas of said electrode structure; and interrupting the deflection of said beam when said beam has completed a selected number of scansions of said electrode structure.

3. The method of inscribing a pattern in a target electrode structure having a given secondary emission characteristic which comprises the steps of: forming a beam of electrons; directing said beam toward an elemental area of said electrode structure materially to alter the secondary emission characteristic of said area; and deflecting said beam in response to a preselected change of secondary emission characteristic in step-by-step fashion over said electrode structure in accordance with a preselected pattern similarly to alter the secondary emission characteristic of the scanned area of said electrode structure.

4. The method of inscribing a pattern in a target electrode structure formed from a sheet of material having a given secondary emission characteristic which comprises the steps of: forming a beam of electrically charged particles, directing said beam toward an elemental area of said electrode structure to melt said material and alter the secondary emission characteristic of said area by forming an aperture in said target electrode structure generally corresponding to said area; and deflecting said beam in response to a preselected change of secondary emission characteristic in step-by-step fashion over said electrode structure and in accordance with a preselected pattern similarly to melt said material and effect apertures in other portions of the scanned area of said electrode structure.

5. Apparatus for inscribing a pattern in a target electrode structure having a given secondary emission characteristic comprising: an envelope, a target electrode structure having a given secondary emission characteristic mounted therein, means for developing a beam of electrically charged particles; a deflection system associated with said beam for directing said particles toward an elemental area of said electrode structure and responsive to a control potential for displacing said beam to another elemental area of said electrode structure; a load impedance in circuit with said beam developing means for deriving a control potential when the secondary emission characteristic of said first-mentioned area is altered a preselected amount; and means for coupling said load impedance to said deflection system to effect displacement of said beam from said first-mentioned area to another elemental area of said electrode structure in response to said control potential.

6. Apparatus for inscribing a pattern in a target electrode structure having a given secondary emission characteristic comprising: an envelope, a target electrode structure having a given secondary emission characteristic

mounted therein, means for developing a beam of electrically charged particles; a deflection system associated with said beam for directing said particles toward an elemental area of said electrode structure and responsive to a control potential for displacing said beam to another elemental area of said electrode structure; a load impedance in circuit with said beam developing means for deriving a voltage pulse when the secondary emission characteristic of any elemental area of said electrode structure is altered a preselected amount; an integrator coupled to said load impedance for integrating successive voltage pulses developed by said impedance to derive a control potential; and means for coupling said integrator to said deflection system to effect successive displacement of said beam across a succession of elemental areas of said electrode structure in response to said control potential.

7. Apparatus for inscribing a pattern in a target electrode structure having a given secondary emission characteristic comprising: an envelope, a target electrode structure having a given secondary emission characteristic mounted therein, means for developing a beam of electrically charged particles; a deflection system associated with said beam for directing said particles toward an elemental area of said electrode structure and responsive to a control potential for displacing said beam to another elemental area of said electrode structure; a load impedance in circuit with said beam developing means for deriving one type of voltage pulse when said given secondary emission characteristic of said elemental area is altered a given amount, and for deriving a different type of voltage pulse when said beam is deflected off said electrode structure; an integrator coupled to said load impedance for integrating successive voltage pulses of said first-mentioned type to derive a control potential; means for coupling said integrator to said deflection system to effect successive displacement of said beam across a succession of elemental areas of said electrode structure in response to said control potential; and a pulse separator coupled between said load impedance and said integrator for selectively returning said integrator to a quiescent condition only in response to said different type of voltage pulse.

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