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(54) Cathode ray tube storage device with an electroluminescent display panel.

(57) A cathode ray tube storage device has a display panel 26 incorporated in which is a layer of electroluminescent material which exhibits hysteresis characteristics. An a.c. voltage source 28 is connected to apply a bias a.c. field across the electroluminescent layer, the RMS value of which lies between the extinction and threshold values for the material. A charge pattern representing information to be displayed is written on the panel 26 by an electron beam 42 from an electron gun 14 as a result of which corresponding areas of the electroluminescent material are excited to produce a light output. The intensity of the light output varies with the intensity of the exciting electron beam 42. The electroluminescent layer can be either directly excited by the electron beam, or by a light output produced by electron beam radiation of an intervening layer of cathodoluminescent material also incorporated in the panel 26.

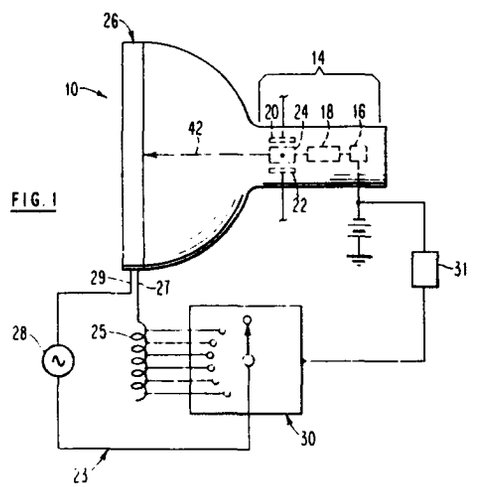


FIG. 1

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A CATHODE RAY TUBE STORAGE DEVICE

The invention relates to a cathode ray tube storage device having a display panel for producing a visible image corresponding to a charge pattern written on the panel by an electron gun within the tube. The invention relates in particular to such a storage device in which the display panel includes an electroluminescent layer which, in the presence of an a.c. field, can be activated to produce said visible image.

The information content required for computer displays is often large, and accordingly, conventional cathode ray tubes require a large store as a refresh buffer, which is costly. For instance, to display 8000 characters of text, a refresh buffer of 5×10^5 bits capacity is required. Thus the use of storage cathode ray tube devices with inherent internal memory provide an attractive alternative computer display device.

U S Patent No. 3 796 909 to Chang et al describes a bistable storage CRT device which utilises an a.c. field-sensitive electroluminescent material as the display medium. In this device a charge pattern is written on an

electroluminescent target layer by a "writing" electron beam. This charge pattern is maintained or stored by a "flood" electron beam via a secondary electron emission process. An a.c. potential is applied to the electroluminescent target via a transparent electrode on the face-plate. The a.c. potential produces an a.c. field in the electroluminescent target only in the region where its inner surface is maintained at a fixed collector potential by the flood electron beam thereby exciting the material to electroluminescence in these regions. Thus, the electroluminescent image is generated corresponding to a stored charged pattern. Apart from the need for a flood-gun, a major drawback of this device is that much of the flood beam energy is dissipated from the face-plate as heat. Moreover, since the device exhibits bistability only, that is the electroluminescent screen is either on or off, the usefulness of the display is limited. For example, in many display applications such as business graphing matrix displays and text editing displays, it is desirable to have multilevel intensities (brightness) so that images of grey scale and intensity modulation can be displayed.

The present invention provides a cathode ray tube storage device including a display panel incorporating a layer of electroluminescent material, means for applying an alternating voltage of predetermined magnitude across said electroluminescent material, and an electron gun operable to selectively write a charge pattern over selected regions of the display panel. The invention is characterised in that the electroluminescent material is of the type having hysteresis loop characteristics whereby two stable states exist for the material at said alternating voltage of predetermined magnitude, said material

emitting light when in one of said stable states but emitting no light, or substantially no light, when in the other of said states. The stable states are individually selectable in response to electron beam radiation of predetermined intensity from said electron gun and means are provided for controlling the intensity of the electron beam radiation during writing of said charge pattern such that a visible image corresponding to the charge pattern is produced by said display panel. A considerable advantage of the device according to the invention is the elimination of the flood gun required in the prior art device referred to above.

The invention will now be described by way of example with reference to the drawings in which:

Figure 1 shows a cathode ray tube storage device according to the present invention;

Figure 2 shows the construction of one form of display panel suitable for use in the device shown in Figure 1 and which includes an electroluminescent layer which is directly activated by electron beam radiation;

Figure 3 shows the construction of another form of display panel suitable for use in the device shown in Figure 1 and which includes an electroluminescent layer which is activated by electron beam induced light emanating from an insulating cathodoluminescent layer;

Figure 4 shows the construction of yet another form of display panel suitable for use in the device shown in Figure 1 and which includes an electroluminescent layer which is activated by electron beam induced light emanating from a cathodoluminescent layer.

Figure 5 shows a modified construction of the display panel shown in Figure 4; and

Figure 6 shows a curve of brightness against applied voltage showing a hysteresis characteristic for the electroluminescent material.

In Figure 1, there is shown a CRT storage display tube indicated generally as 10 having a display screen or panel 26 and a high energy electron writing gun shown generally as 14. The gun is of conventional configuration having a high energy electron source 16 which acts to emit high energy electrons through focusing element 18 to the vertical and horizontal fields created by deflection plates shown at 20, 22 and 24. As can be seen, plates 20 and 22 act to vertically deflect the high energy electron beam while plates 24 (only one shown) act to horizontally deflect the electron beam. Alternatively, magnetic deflection and magnetic focus can be used. It should be noted that the flood gun required by the prior art CRT storage device is absent since in this invention continuous electron beams are not used to generate high brightness display nor to maintain a stored charge pattern.

The display screen or panel 26 differs from that of the prior art CRT storage device as will be shown later. An a.c. bias field is maintained across display panel 26 by means of a.c. source 28 via leads 27 and 29. Typically, the a.c. source 28 is a sinusoidal wave generator or an a.c. pulse generator capable of supplying from 0 volts to at least 300 volts. In order that the electroluminescent panel may be operated at optimum efficiency, a switching arrangement 30 is provided to vary the inductance 25 of resonant circuit 23 according to the capacitive load of

the panel 26 in a manner to be described in more detail later. The switch 30 is itself controlled by means of a conventional switching circuit 31 itself controlled from the tube control grid in order to vary the inductance in accordance with the energisation of the control grid 16. The various alternative construction of display panel 26 will now be described.

The display panel shown in Figure 2 consists of a glass face-plate 12 having deposited, or otherwise formed, thereon a transparent contiguous conductive layer 32 of, for example, SnO_2 or In_2O_3. A transparent contiguous layer 34 of an insulating material such as $BaTiO_3$, $SrTiO_3$, Al_2O_3, Y_2O_3, Si_3N_4 or AlN is formed on the conductive layer 32. An electroluminescent layer 36 is formed on the insulating layer 34. Although the electroluminescent layer may comprise any of a variety of well known electroluminescent materials, preferably it is in the form of an electroluminescent polycrystalline thin film, for example, Cu or Mn doped ZnS. Alternatively powdered electroluminescent materials may be employed. Examples of electroluminescent materials that may be employed and methods by which they may be made are described by Blazey et al in U S Patent No. 3 313 652. A second insulating layer 38 is formed contiguous with layer 36 and can be of the same or different material as insulating layer 34. A second conductive layer 40 is formed on insulating layer 38. This layer may be either a transparent or non-transparent thin film of SnO_2, In_2O_3, Al, Cu, Ag, Au or other thin metal layers. Likewise thin layers of copper iodide or graphite can be employed.

The display panel shown in Figure 3 is similar to that shown in Figure 2 except that the second insulating

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layer 38 is replaced by a layer 44 of a material which is both insulating and cathodoluminescent. Whereas electroluminescent materials exhibit electroluminescence in response to an applied a.c. field, cathodoluminescent materials exhibit luminescence in response to direct electron beam or ultra violet radiation. The material selected generally emits light in the ultra violet and blue wavelengths of the spectrum in response to electron beam radiation. One example of such material is AlN, which is an efficient ultra-violet light emitter. Many other wide band gap materials such as metal oxides and metal tungstates may also be used. The remaining layers are identical to corresponding layers in the panel shown in Figure 2 and are identified by the same reference numerals.

The display panel shown in Figure 4 is again similar to that shown in Figure 2 with the addition of a catholuminescent phosphor layer 44 on the second conductive layer 40. Examples of cathodoluminescent phosphors which may be used in the present invention include lead doped barium zinc magnesium silicate, lead doped strontium hexaborate, copper doped zinc cadmium sulphide, manganese doped zinc silicate, silver doped zinc sulphide, zinc doped zinc oxide and the like. The display panel shown in Figure 5 is similar to that of Figure 4. In this arrangement, the cathodoluminescent layer 44 and the second conductive layer 40 are interchanged.

Whichever form of display panel is used, the a.c. voltage, V_{bias} from the a.c. source 28 is applied across the electroluminescent layer 36 by means of conductive layers 32 and 40 which are connected to conductors 29 and 27 respectively. Figure 6 shows a curve of brightness B

against applied voltage V (RMS) showing that the electroluminescent material exhibits hysteresis characteristics. The bias voltage level therefore selected to lie above the extinction voltage, V_e and below the turn-on threshold voltage, V_t for the material. With this arrangement the intensity of light output from the electroluminescent material can be selected by radiation with an electron beam or ultra-violet of appropriate magnitude. Thus, the application of exciting electrons switches the material from one stable state B, where the light output is substantially zero, to another one of a plurality of stable states such as indicated at C, where the light output is relatively high. By controlling the intensity of the exciting electrons or indeed ultra-violet light, the electroluminescent output can be selected to lie at any value between zero and saturation for the material. The threshold voltage V_t for electroluminescent materials is typically 50 V to 300 V (RMS) and the extinction voltage V_e is typically 0 to 270 V (RMS) depending on the layer thickness of the electroluminescent device.

The panel shown in Figure 2 operates directly by the penetration of electrons, illustrated by arrow 42, to electroluminescent layer 36. Such penetration activates the storage mechanism. It is thought that the incoming electrons or the secondary electrons and light radiation induced by the electron beam excite the trapping states or charge storage levels in the electroluminescent material. The excited charges are polarised under the biased field to result in an internal field. The internal field aids the external field in exciting the electroluminescence. With the panel shown in Figure 3, the electron beam (42) penetrates only to insulating

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cathodoluminescent layer 44 which emits high energy photons. These high energy photons then activate the electroluminescent storage mechanism in layer 36. Similarly, with the panel shown in Figure 4 the electron beam 42 penetrates only to cathodoluminescent layer 44 whereby said layer 44 is caused to emit high energy photons which in turn activate the electroluminescent storage mechanism in layer 36. The interchanged cathodoluminescent and conductive layers in the panel shown in Figure 5 provide a trade-off between low energy electrons and ease of activating the electroluminescent layer 36.

Generally, the bias voltage is not sufficient to cause any appreciable electroluminescence before electron excitations. When excited by electrons (and/or photons or secondary electrons generated by electrons) it is thought that the conductivity of the electroluminescent layer 36 is increased (or viewed as the threshold voltage is decreased) so that more current is flowing through and more light emission occurs. The higher current flow also establishes an internal polarisation which aids the a.c. voltage in phase to generate more electroluminescence. Thus the device is switched to the higher conducting state and through the internal polarisation field (switched in phase with external applied field) the device operates in a stable memory state.

The a.c. voltage can be supplied by a sinusoidal wave generator or an a.c. pulse generator. Since the electroluminescent device is a capacitive load, it is advantageous as previously mentioned to arrange for the device to be included as part of a resonant circuit 23 (Fig.1) in series with the voltage driver 28. The inductance 25 of the circuit can be varied according to the capacitive load of

panel 20, i.e. proportional to the area of faceplate which is turned on. One method of obtaining this type of resonant tuning is to monitor the CRT grid voltage. When the grid voltage is in an off mode no electrons can be emitted out of the CRT gun 14 thus no faceplate area can be excited or turned on. Conversely when the grid voltage is turned on, the electrons are allowed to reach the faceplate 12. Therefore, by monitoring the grid voltage and the deflection signal one can keep track of how much faceplate area is in the on state thus switch in the proper amount of inductance into the resonance circuit. In this resonant drive mode power dissipation is minimized.

In order to display grey scale images or multilevel intensity displays, one simply modulates the electron beam intensity by modulating the control grid voltage as in the conventional T.V. CRT. In addition one has the freedom to modulate the amplitude and frequency of the biasing a.c. field in accordance with the video or data signal.

CLAIMS

1. A cathode ray tube storage device including a display panel (26) incorporating a layer of electroluminescent material (36), means (28) for applying an alternating voltage of predetermined magnitude across said electroluminescent material (36), and an electron gun (14) operable to selectively write a charge pattern over selected regions of the display panel (26), characterised in that the electroluminescent material (36) is of the type having hysteresis loop characteristics whereby two stable states exist for the material at said alternating voltage of predetermined magnitude, said material (36) emitting light when in one of said stable states but emitting no light, or substantially no light, when in the other of said states, said stable states being individually selectable in response to electron beam radiation of predetermined intensity from said electron gun (14), and means (16) for controlling the intensity of the electron beam radiation during writing of said charge pattern such that a visible image corresponding to said charge pattern is produced by said display panel (26).

2. A cathode ray tube storage device as claimed in claim 1, in which said electroluminescent material (36) has a plurality of different light emitting stable states at said alternating voltage of predetermined magnitude, each state being individually selectable in response to electron beam radiation of predetermined different intensities.

3. A cathode ray tube storage device as claimed in claim 1 or claim 2, in which said stable states are individually selectable by direct radiation of said electroluminescent material (36) with said electron beam of predetermined selected intensity.

4. A cathode ray tube storage device as claimed in claim 1, 2 or 3, in which said electroluminescent material (36) is sandwiched between two co-extensive layers of conductive material (32,40) separated from said electroluminescent material (36) by intermediate layers of insulating material (34,38), said layers of conductive material (32,40), the layers of insulating material (34,38), and the electroluminescent material (36) together with a tube face plate (12) forming the display panel (26), the alternating voltage of predetermined magnitude being applied across said conductive layers (32,40) and at least the layer of conductive material (40) and layer of insulating material (38) towards said electron gun (14) being of a nature to permit direct electron beam radiation of said electroluminescent material (36) therethrough by said electron gun (14).

5. A cathode ray tube storage device as claimed in claim 1 or claim 2, in which said stable states are individually selectable by light radiation of said electroluminescent material (36) induced in an adjacent intermediate layer of

cathodoluminescent material (44) in response to direct radiation of said cathodoluminescent material (44) by said electron beam of predetermined selected intensity.

6. A cathode ray tube storage device as claimed in claim 5, in which said display panel comprises a tube face plate (12), a first layer of conductive material (32) on said face plate (12), a layer of insulating material (34) on said first layer of conductive material (32), said electroluminescent layer (36) on said layer of insulating material (34) a layer of insulating cathodoluminescent material (44) on said electroluminescent material and a second layer of conductive material (40) on said layer of insulating cathodoluminescent material (44) said panel (26) being incorporated in said device with the second layer of conductive material (40) facing towards the electron gun (14) and being of a nature to permit direct electron beam radiation of said insulating cathodoluminescent material (44) therethrough by said electron gun (14), and said alternating voltage of predetermined magnitude being applied across said first and second conductive layers (32,40).

7. A cathode ray tube storage device as claimed in claim 5, in which said display panel comprises a tube face plate (12), a first layer of conductive material (32) on said face plate (12), a first layer of insulating material (34) on said conductive material (32), said layer of electroluminescent material (36) on said insulating material (34), a second layer of insulating material (38) on said electroluminescent material (36), a second layer of conductive material (40) on said second layer of insulating material (38), and a layer of cathodoluminescent material (44) on said second layer of conductive material (38), said panel

(26) being incorporated in said device with the cathodoluminescent material (44) facing towards the electron gun (14), the second layer of conductive material (40) and the second layer of insulating material (38) being of a nature to permit radiation of said electroluminescent material (36) therethrough by light from said cathodoluminescent material (44) produced by direct electron beam radiation of said cathodoluminescent material (44) from said electron gun (14), and said alternating voltage of pre-determined magnitude being applied across said first and second conductive layers (32,40).

8. A cathode ray tube storage device as claimed in claim 5, in which said display panel (26) comprises a tube face plate (12), a first layer of conductive material (32) on said face plate (12), a first layer of insulating material (34) on said conductive material (32), said layer of electroluminescent material (36) on said insulating material (34), a second layer of insulating material (38) on said electroluminescent material (36), a layer of cathodoluminescent material (44) on said second layer of insulating material (38), and a second layer of conductive material (40) on said cathodoluminescent material (44), said panel (26) being incorporated in said device with the second layer of conductive material (40) facing towards the electron gun (14), the second layer of conductive material (40) being of a nature to permit radiation of said cathodoluminescent material (44) therethrough by electron beam radiation from said electron gun (14), said second layer of insulating material (38) being of a nature to permit radiation of said electroluminescent material (36) therethrough by light from said cathodoluminescent material (44) produced by said electron beam radiation, and said alternating voltage of

predetermined magnitude being applied across said first and second conductive layers (32,40).

9. A cathode ray tube storage device as claimed in any one of the preceding claims, in which said means (29) for applying an alternating voltage of predetermined magnitude forms part of a resonant circuit having a variable inductive load (25) and means (30) for selecting the value of the inductive load (25) in accordance with the value of the capacitive load of the face plate (26).

10. A cathode ray tube storage device as claimed in claim 9, in which said means (30) for selecting the inductive load is operated by a switching circuit (31) controlled by the grid voltage of the electron gun (14).

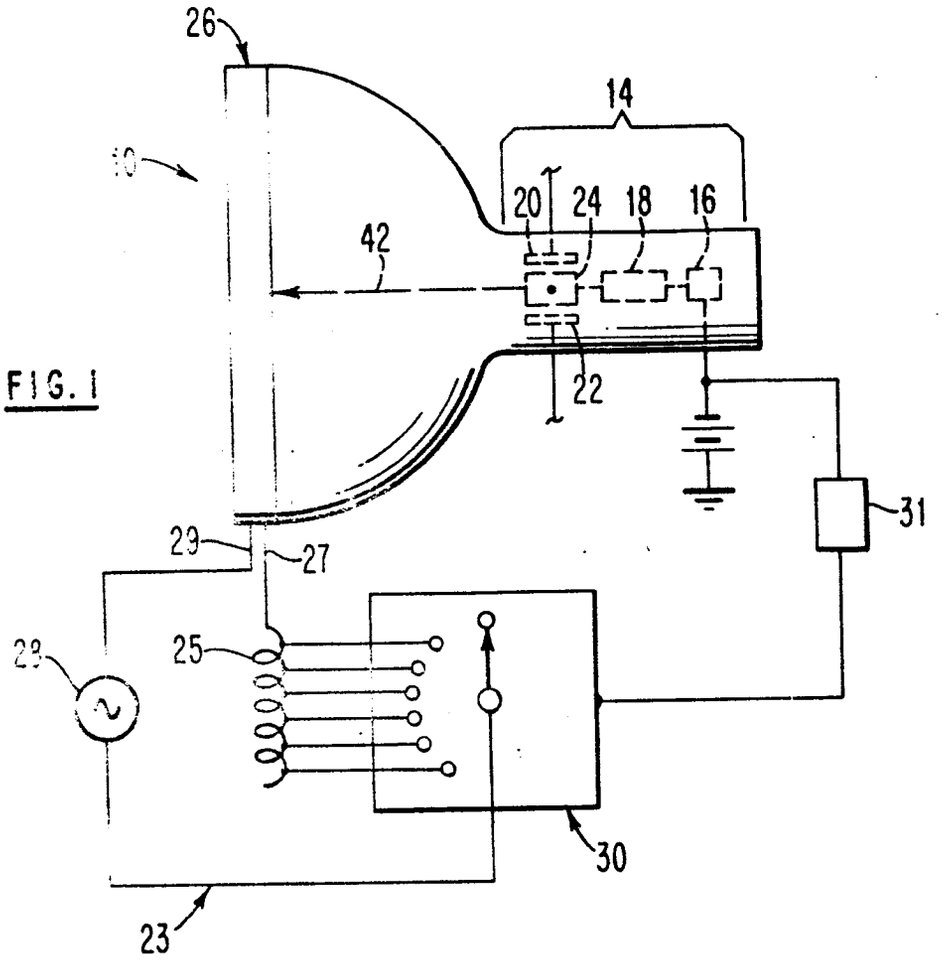

26
14
10
20
24
18
16
42
22
31
29
27
28
25
30
23

FIG. 1

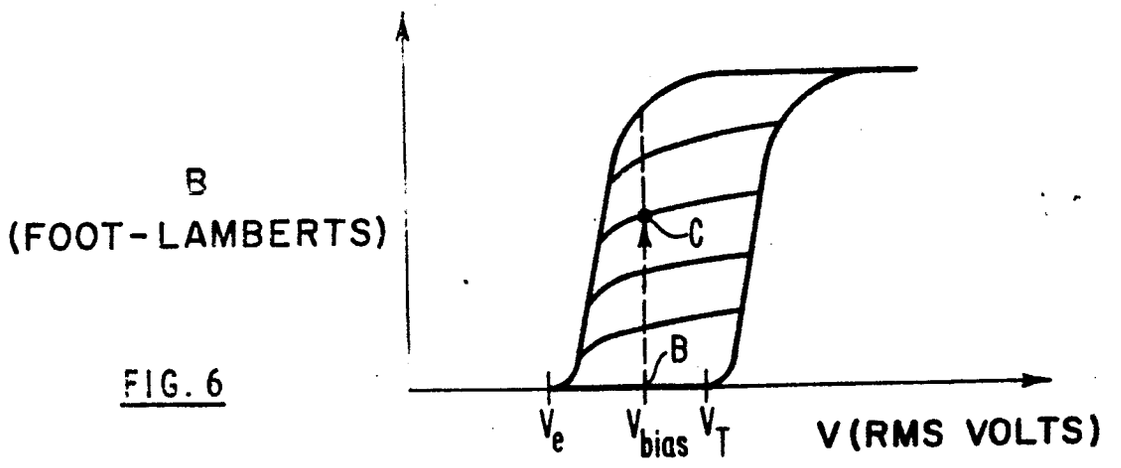

B
(FOOT-LAMBERTS)
C
B
V_e
V_{bias}
V_T
V (RMS VOLTS)

FIG. 6

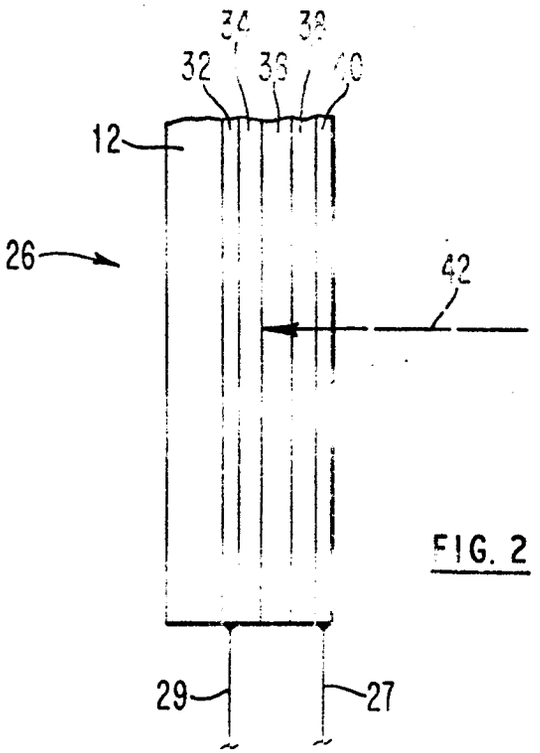


FIG. 2

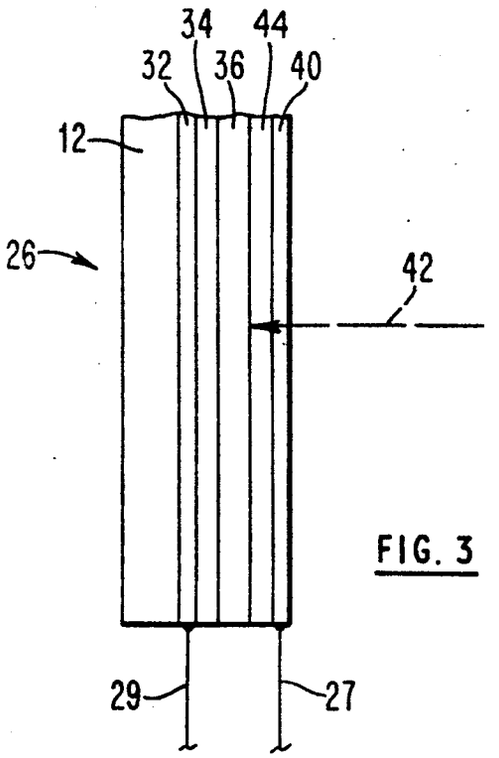


FIG. 3

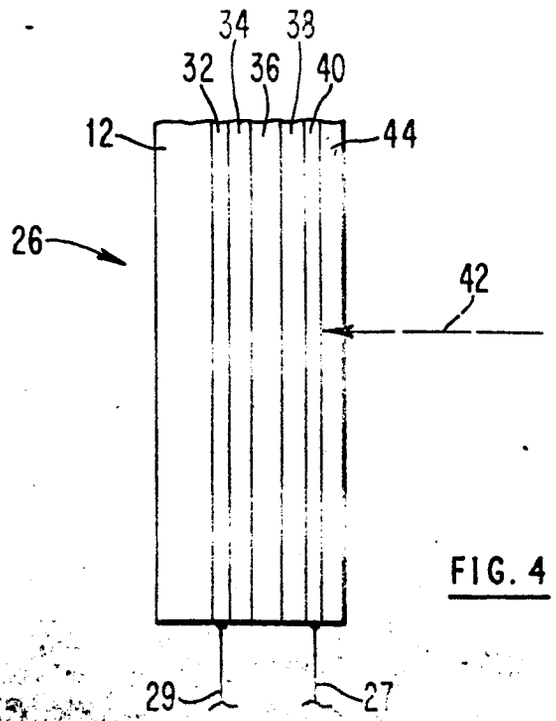


FIG. 4

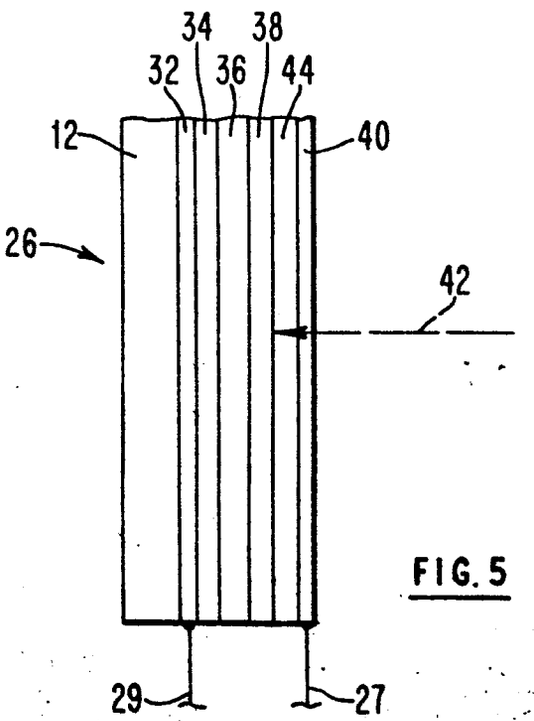


FIG. 5

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EUROPEAN SEARCH REPORT

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Application number

EP 78 30 0019

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim
	JOURNAL OF ELECTRONIC ENGINEERING no. 118, october 1976 TOKYO T. INOGUCHI et al.: "Memory effect in EL devices points way to new usages" pages 30-33 * Page 30 - page 31 right-hand column, paragraph "Memory effects" to page 33; figures 1, 5 to 7 *	1-5
	GB - A - 818 106 (GENERAL ELECTRIC) * Page 1, line 28 to page 2, line 79, lines 91 to 127; page 3, lines 88 to 106; page 4, lines 20 to 79, page 5, lines 21 to 42; figures 1 and 2 *	1,5,7
	US - A - 2 733 367 (J.L. GILLSON) * Column 2, lines 50 to 61; column 6, lines 67 to column 7, line 2; figure 3 *	4,6-8
	FR - A - 2 120 927 (INTERNATIONAL SCANNING DEVICES) * Page 1, lines 17 to 36; figure 1 *	9
	US - A - 3 173 057 (W.A. THORNTON) * Column 1, lines 9-12 and 37-64; column 2, lines 1 to 11 and 45 to 54; figure *	9
	GB - A - 824 242 (THORN ELECTRICAL INDUSTRIES) * Page 1, lines 13 to 35; page 4, lines 19 to 49; figure 5 *	10

CLASSIFICATION OF THE APPLICATION (Int. Cl.²)

H 01 J 31/12
H 01 J 29/18
H 05 B 33/00
H 05 B 33/22

TECHNICAL FIELDS SEARCHED (Int.Cl.²)

H 01 J 31/12
H 01 J 29/10
H 01 J 29/18
H 05 B 33/00
H 05 B 33/22

CATEGORY OF CITED DOCUMENTS

X: particularly relevant
A: technological background
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E: conflicting application
D: document cited in the application
L: citation for other reasons

&: member of the same patent family, corresponding document

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
The Hague	23-08-1978	MAUGAIN

European Patent Office

EUROPEAN SEARCH REPORT

0000613

Application number

EP 78 30 0019

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim
A	FR - A - 1 461 803 (HUGHES AIRCRAFT) * Figures 10-12; pages 1, 10,11 *	1
A	FR - A - 1 543 309 (XEROX) * Pages 1,7, right-hand column and figure 9 *	

CLASSIFICATION OF THE APPLICATION (Int. Cl.²)

TECHNICAL FIELDS SEARCHED (Int. Cl.²)