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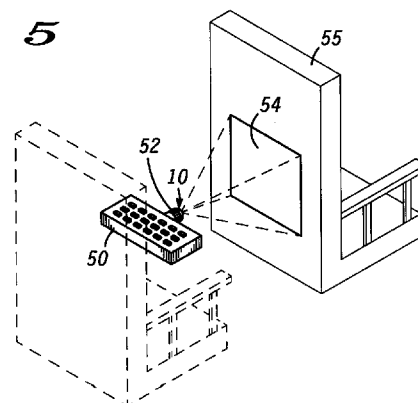
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(54) **Display for electronic devices.**

(57) A portable computer (50) having a projection display (10) using a plurality of cold cathode field emission devices (30) formed on a single substrate (12) in rows and columns to produce images which are projected through a lens system (52) onto a remote flat surface (54). Memory and switching devices (39, 40) are formed on the same substrate (12) so the display (10) can be simply connected to any portable electronic device (50) and the size of the device (50) is independent of the display (10).

FIG. 5



The present invention pertains, in general, to a display for electronic devices and more particularly to an integral image source incorporating field-emission devices.

Background of the Invention.

In portable electronic devices with relatively large displays, such as computers, it is common to use back-lit liquid crystal displays (LCDs) for the display. In portable electronic devices with smaller displays, such as in pagers and other communication devices, it is common to use light emitting diodes (LEDs) or LCDs.

Originally, computers were limited to the standard cathode ray tube display, which made the device very large and unwieldily. Eventually, lap-top computers were designed which used an LCD, plasma, or electroluminescent display. The display on these computers was hard to see in many brightly lit areas and the computers were not popular. Also, this type of display was relatively expensive.

A back-lit LCD display was then developed, which improved the display substantially. However, resolution still suffers in these displays. Sufficient resolution can be obtained by increasing the size of the display, however, as the display size increases so does the size of the device. Thus, portability and resolution are inversely related. A display which is too small or too dark to read easily, results in a useless or, at the very least, an unpopular product. However, a portable product that is too large to conveniently carry, or move around, also results in an unpopular product.

Summary of the Invention.

It is a purpose of the present invention to provide a new and improved display for electronic devices. In accordance with the present invention there is provided a display for electronic devices having an electrical output signal for controlling the display. The display includes a substrate having a plurality of cold cathode field emission devices formed thereon in a preferred pattern and having an electrical input terminal. Control electronics having an input terminal for receiving the output signal from the electronic device, are further connected to supply operating voltages and control signals to the electrical input terminal of the substrate. A faceplate is affixed over the plurality of cold cathode field emission devices on the substrate and is in sealing engagement with a substantial vacuum formed therebetween. The faceplate further including a layer of fluorescent material which radiates light when struck by emissions from the cold cathode field emission devices, and a lens system affixed to the faceplate directs light from the fluorescent material onto a surface remote from the electronic device.

The above mentioned, and other, purposes and

advantages are realized in a display for electronic devices as described above and wherein the control electronics are substantially included on the substrate. Furthermore, the cold cathode field emission devices are arranged into a plurality of rows and columns wherein emitter electrodes of each cold cathode field emission device in each row are coupled together, collector electrodes of each cold cathode field emission device in each row are coupled together and gate electrodes of each cold cathode field emission device in each column are coupled together. The control electronics supplies, sequentially, operating voltages to emitters/collectors of one row of said cold cathode field emission devices at a time, and a separate control signal to each gate of one column of cold cathode field emission devices having operating voltages applied to the emitter/collector thereof.

It will be appreciated that an invention so designed and described, and implemented within a display of an electronic device, produces the novel advantages of a display with substantially improved brightness and resolution. Furthermore, the invention, when incorporated in such a device, has the desirable advantage of substantially eliminating the size dependence of the device from that of the display associated therewith.

An exemplary embodiment will now be described with reference to the accompanying drawings.

Brief Description of the Drawings.

Referring to the drawings:

FIG. 1 is a sectional view of a portion of a display for electronic devices embodying the present invention;

FIG. 2 is a schematic diagram of a portion of the display illustrated in FIG. 1;

FIG. 3 is a simplified block diagram of the portion of the display illustrated in FIG. 2;

FIG. 3 is a simplified block diagram of the display illustrated in FIG. 1; and

FIG. 4 is a view in perspective of the display illustrated in FIG. 1 operatively attached to a portable electronic device.

Detailed Description of a Preferred Embodiment.

Referring specifically to FIG. 1, a portion of a display 10 for electronic devices, embodying the present invention, is illustrated. Display 10 includes a substrate 12 having a plurality of cold cathode field emission devices (FEDs) formed thereon. Each of the FEDs includes an emitter 14, formed on substrate 12 using any of the usual semiconductor manufacturing methods, with electrical connections 16 thereto. An insulating layer 18 is formed over emitters 14 and a first conductive layer 20 is formed over insulating layer 18, which conductive layer operates as a control

gate for the FED. A second insulating layer 22 is formed over conductive layer 20 and a second conductive layer 24 is formed over second insulating layer 22. Conductive layer 24 is used as a focusing electrode and, depending upon the application of the display, is optional.

A cavity is formed around each emitter 14, through layers 18, 20, 22 and 24. A face plate 25 is affixed to substrate 12 in overlying engagement over the FEDs. Faceplate 25 is shaped generally like an inverted cup and is sealed to substrate 12 along the lower edges of face plate 25, so that the inner surface of faceplate 25 is spaced from conductive layer 24 a predetermined distance. The volume under faceplate 25 is evacuated and in communication with the cavity around each emitter 14. Since any electronic particles emitted from emitters 14 travel through a vacuum to reach faceplate 25, there is very little resistance and, consequently, the particles can travel very fast and require a minimum amount of applied energy.

The inner surface of faceplate 25, opposite and in direct alignment with emitters 14, is coated with a fluorescent material 27 which will emit light when struck by emissions from emitters 14. Generally, fluorescent material 27 will contain a phosphor or the like. Since much of the known fluorescent material is relatively easily removed when struck by high speed particles from emitters 14, the operation and longevity of faceplate 25 can be greatly enhanced by applying a thin coating of electrically conductive material, such as aluminum coating 29, thereover. Aluminum coating 29 may be applied over the entire inner surface of faceplate 25 and electrically connected into the circuitry to remove accumulated charge from luminescent layer 27. Aluminum coating 29 prevents particles of luminescent layer 27 from breaking off as it is struck by emissions from emitters 14, thereby substantially increasing the life. In addition, aluminum coating 29 improves the luminous efficiency by approximately 50%. At sufficiently high voltages, in the present embodiment 10kV is applied between aluminum coating 29 and conducting layer 24, aluminum layer 29 is invisible to emissions from emitters 14.

Generally, the FEDs will be grouped into pixels for redundancy and each pixel contains from one to any convenient number of FEDs, all connected in parallel. In the present embodiment, for example, a pixel is formed by twenty five FEDs, operating in parallel as a single FED, illustrated schematically in FIG. 2. The pixels are formed on substrate 12 in a regular pattern as, for example, in rows and columns, illustrated in simplified block form in FIG. 3. The entire display includes 1280 pixels by 720 pixels, which numbers are selected for the high definition. If lower definition is required, a smaller number of pixels can be used with the consequent reduction in size and power.

It should be understood that a plurality of FEDs are utilized in each pixel for redundancy, to insure

proper operation even if a few FEDs are inoperative, and because of this number the brightness of individual FEDs can be reduced by reducing the current flowing through each FED.

In television, fluorescent spots similar to pixels are organized into rows on a screen and an electron beam scans the screen horizontally, one spot at a time. The screen fluoresces for a short time after a spot is contacted by the beam and the scanning occurs at such a high rate that to the human observer it appears as a continuous picture. Thus, in television there can never be more than one spot at a time being energized by the electron beam. This scanning procedure results in relatively low brightness. Further, because the electron beam travels relatively great distances to the screen it is difficult to achieve good resolution.

In display 10, signals are applied to the pixels a row at a time, rather than a pixel at a time as in television, so that an entire row is activated simultaneously and the brightness is much greater than the brightness achieved in television. It should be noted that there is no limitation in display 10 on the number of pixels that can be operated simultaneously. In another embodiment, all of the pixels in the display are operated simultaneously. In the embodiment in which all pixels are operated simultaneously, the amount of brightness is generally much higher than required and the current flowing in each FED can be reduced to as low as 0.05 microamperes.

Referring specifically to FIG. 4, a simplified block diagram of display 10 is illustrated. Display 10 includes a matrix 30 of pixels organized into rows and columns on substrate 12, as explained above. A data input terminal 35 appears as an electrical connection to substrate 12 and is adapted to receive digital data signals in a serial mode from a portable electronic device. It will of course be understood that data could be supplied in parallel, a row at a time, for example, or in any other convenient form.

The data received at terminal 35 is supplied as a synchronizing signal to a clock 37 and to a data input of a sequencer 39. Data applied to sequencer 39 is stored until a complete row of data is available, at which time clock 37 supplies a clock signal to an enable circuit 40 and to sequencer 39. The clock signal causes enable circuit 40 to connect a voltage supply to the control gate of each FED of each pixel in the proper row in sequence. Simultaneously, sequencer 39 uses the row of data stored in memory to control a plurality of constant current sources 41, one for each pixel in a row of pixels. Each constant current source 41 turns on the associated pixel by supplying an appropriate current to the emitters of the FEDs in the pixel. The amount the pixel is turned on, or the amount of current supplied, determines the grey level for that pixel. A high voltage supply 42 is connected to the collector/faceplate to enhance the operation of display

10, but it will be understood that this is an optional feature. Thus all required operating voltages are applied to an entire row of pixels, simultaneously, each time a clock pulse is generated by synchronous clock 37.

It will of course be understood that the emitters 14 of the FEDs can be connected together into rows of pixels and the entire aluminum coating 29 can be a one piece collector connected in common. Alternatively, the emitters of all of the FEDs can be connected together through substrate 12 and aluminum coating 29 can be formed in rows, rather than a continuous coating. Further, because there are 720 row connections to enable circuit 40 and 1280 parallel control gate connections through constant current devices 41 to sequencer 39, or a total of 2000 connections to matrix 30, the control electronics for matrix 30 is formed by normal semiconductor manufacturing techniques in substrate 12. Forming matrix 30 and the control electronics in the same substrate not only reduces the Connecting procedure to a relatively well known and simple manufacturing technique, but greatly reduces the inter-circuit power requirements. Generally, high voltage supply 42 is constructed exterior to substrate 12, but synchronous clock 37, sequencer 39 and enable circuit 40 are all formed internal to, or as a portion of, substrate 12. In fact, the control electronics may actually be formed in substrate 12 beneath matrix 30, to save on chip size.

In the present embodiment, each FED conducts approximately 0.5 microamperes of current, so that each pixel in the described embodiment draws 12.5 microamperes of current when activated. Since the display is operated a row at a time, if the rows are situated so that there are 1280 pixels per row, matrix 30 will draw a maximum current of sixteen milliamperes. If the rows are situated so that there are 720 pixels per row, matrix 30 will draw a maximum current of nine milliamperes. As explained above, the maximum current drawn depends upon the brightness required for a particular application and the number of pixels, (number of rows or the entire display), being operated simultaneously. Thus, it can be seen that the described display offers a great amount of flexibility in the production thereof and the amount of power required can be greatly reduced in specific applications where power is a problem.

Since it is intended that display 10 project images onto a remote flat surface, which it is assumed will generally be relatively light in color, display 10 has been described such that pixels are normally off and are only activated to produce the desired image. It will be understood, however, that display 10 could be operated in an opposite mode.

Referring specifically to FIG. 5, display 10 is illustrated in conjunction with a portable electronic device 50. Portable electronic device 50 is a portable computer which, because display 10 has substantially eliminated the dependence upon the size of the dis-

play, is substantially only a keyboard with the various semiconductor chips mounted therein. Display 10 is mounted in a front edge of the computer and projects a visual, easily viewed image directly onto a remote surface in front of the computer. For example, in FIG. 5 the visual display is being projected onto the rear surface 54 of an airplane seat 55.

Because display 10 produces an image many times brighter than a television receiver, the projection is very bright and easily viewed. Further, display 10 includes an additional adjustable lens system 52, including one or more lenses that are relatively adjustable to change the focal length of lens system 52, which can be used to focus the projected image onto any convenient surface at substantially any practical distance from the viewer. Also, because of the number of FEDs used and the resolution possible in each FED, the resolution of the projected image is substantially better than the projected images of television and the like.

Thus, a new and improved display for portable electronic devices has been disclosed. The improved display substantially eliminates the dependence of the size of the portable electronic device on the associated display. Further, the new display has improved resolution and brightness. Also, the size of the display can easily be adjusted with a simple movement of the position of the portable device relative to a remote surface and/or adjustment of the lens system. Thus, the combination of variable size, better resolution and brighter images greatly improves the usefulness of an electronic device and allows its use for many more applications.

In addition, the present display can be utilized on a great variety of portable electronic devices, such as computers, pagers, telephones, especially for the hearing impaired, etc. While the described display has been directed chiefly at portable electronic devices, because of its small size and convenience, it will be understood by those skilled in the art that the display could be conveniently connected to computers, telephones and the like that are movable but not normally sold as portable. Also, it should be understood that portable electronic devices with projection displays can be constructed with the manual controls as the only size limiting feature. This is a great advantage over the normal portable electronic devices because the normal devices must include a directly viewed display as a portion of the device. While the described cold cathode field emission device type of display is preferred for this purpose because of its brightness and superior definition, it will be understood that other types of projection systems might be utilized in conjunction with portable electronic devices to substantially reduce their size and improve their usefulness.

It will, of course, be understood that the above description has been given by way of example only and

that modifications in detail, such as the sequential energisation of alternative configurations of pixels and, specifically, the coupling together of the collector, emitter and gate electrodes contained therein e.g. the control of pixel illumination in terms of concentric configurations or blocks rather than in terms of row by row control, may be made within the scope of the invention. Furthermore, it will be appreciated by one skilled in the art that emissions from cold cathode field emission devices may be induced by the combination of a constant and insufficient field applied between an emitter and collector thereof and the periodic application of a gate potential sufficient to induce emissions therefrom.

Claims

1. A display (10) for electronic devices having an electrical output signal for controlling the display characterized by:

a substrate (12) having a plurality of cold cathode field emission devices (30) formed thereon in a preferred pattern and having an electrical input terminal;

control electronics (37, 39, 40, 41) having an input terminal (35) for receiving the output signal from the electronic device and further connected to supply operating voltages and control signals to the electrical input terminal of said substrate (12);

a faceplate (25) affixed over the plurality of cold cathode field emission devices (30) on said substrate (12) and in sealing engagement with a substantial vacuum formed between said substrate (12) and said faceplate (25);

said faceplate (25) further including a layer of fluorescent material (27) which radiates light when struck by emissions from the cold cathode field emission devices (30); and

a lens system (52) affixed to said faceplate (25) for directing light from the fluorescent material (27) onto a surface remote from the electronic device.

2. display (10) for electronic devices as claimed in claim 1 wherein the lens system (52) is further characterized by at least two lenses mounted together for relative movement therebetween to provide for a variable focal length of the lens system

3. A display (10) for electronic devices as claimed in claim 1 or 2, wherein the preferred pattern of the cold cathode field emission devices (30) is further characterized by a plurality of rows and columns of cold cathode field emission devices, each cold cathode field emission device having an emitter

electrode (14), a collector electrode (25) and a gate electrode (20);

wherein:

the emitter electrodes (14) of each cold cathode field emission device in each row being connected together, the collector electrodes (25) of each cold cathode field emission device in each row being connected together and the gate electrodes (20) of each cold cathode field emission device in each column being connected together; and

the control electronics (37, 39, 40, 41) supply, sequentially:

i) operating voltages to the emitter/collectors of one row of cold cathode field emission devices at a time; and

ii) a separate control signal (40) to each of the gate electrodes of one column of cold cathode field emission devices having operating voltages applied to the emitter/collectors thereof.

4. A display (10) for electronic devices as claimed in claim any preceding claim, wherein the control electronics (37, 39, 40, 41) are further characterized by memory and switching circuitry (39, 40, 41) that is formed on the substrate (12) and connected to the cold cathode field emission devices (30) through conductors formed in the substrate.

5. A display (10) for electronic devices as claimed in claim 4, wherein the preferred pattern of the cold cathode field emission devices (30) is characterized by pluralities of cold cathode field emission devices connected together, with the cold cathode field emission devices in each plurality operating simultaneously as a pixel.

6. A display for electronic devices as claimed in claim 5, wherein the control electronics (37, 39, 40, 41) is further characterized by circuitry (39, 41) for simultaneously supplying operating voltages to the emitter/collector electrodes and (40) control signals to the gate electrodes of each of the pixels in a row.

7. A display (10) for electronic devices as claimed in claim 6, wherein

the memory (39) stores data relating to a row of pixels and the memory is connected to receive said data from said input terminal (35); and the switching circuitry (40, 41) is coupled to both said memory and said input terminal.

8. A display (10) for electronic devices as claimed in any preceding claim, wherein the electronic device is a portable electronic device (50).

9. A display (10) for electronic devices as claimed in

any preceding claim, wherein the electronic device is a computer, a pager or a telephone.

- 10.** A method for generating a display for an electronic device, comprising the steps of: 5
- a) forming a plurality of cold cathode field emission devices (30) on a substrate;
 - b) encapsulating said plurality of cold cathode field emission devices (30) with a luminescent material covered faceplate; 10
 - c) substantially evacuating a volume between said substrate and said faceplate;
 - d) selectively applying a field between at least one of said plurality of cold cathode field emission devices and said faceplate, whereby emissions from said at least one cold cathode field emission devices strike the luminescent material of the faceplate therein causing the luminescent material to luminesce and form an image; 15 20
 - e) projecting and focusing said image from said faceplate onto a remote surface independent of said electronic device.
- 11.** A method in accordance with claim 10, further comprising the steps of: 25
- f) arranging said plurality of cold cathode field emission devices into a plurality of pixels, wherein each pixel comprises at least one cold cathode field emission device; 30
 - g) arranging said plurality of pixels into a plurality of sections, wherein each section comprises more than one pixel; and
 - the step of selectively applying a field (d) is further characterised in that : 35
 - emissions from a specific pixel within a section, as determined by emissions from each cold cathode field emission device comprised therein, are independently controllable from any other pixel in that section; and 40
 - said field is sequentially applied to each one of said plurality of sections.

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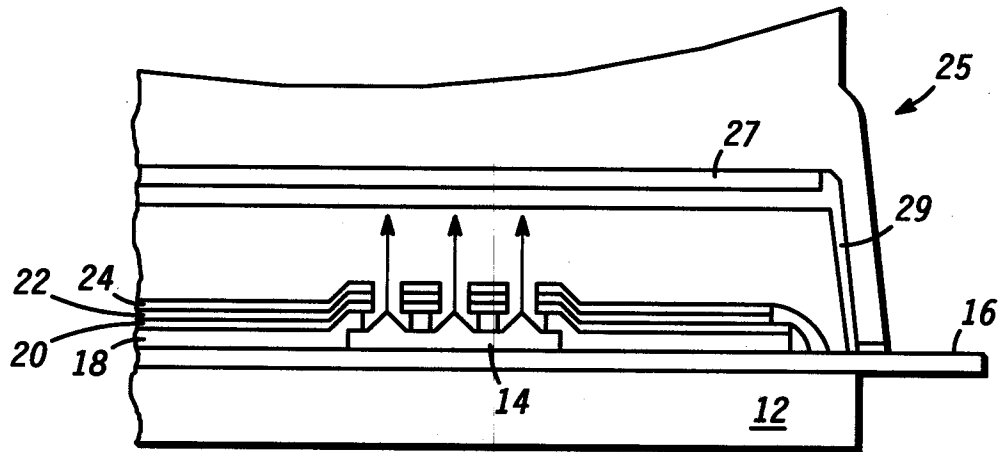


FIG. 1

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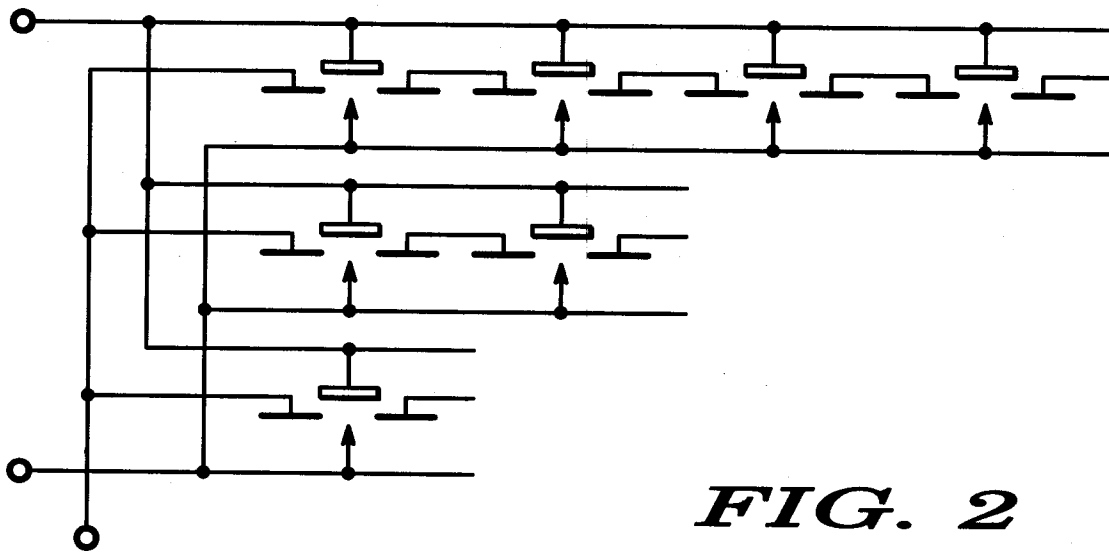
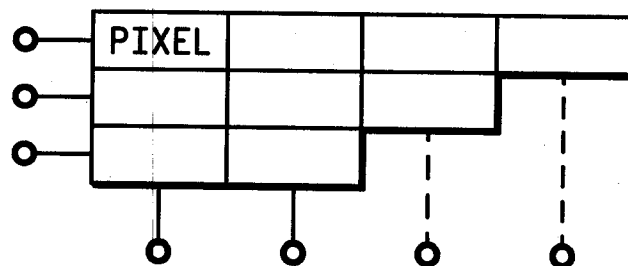


FIG. 2

FIG. 3



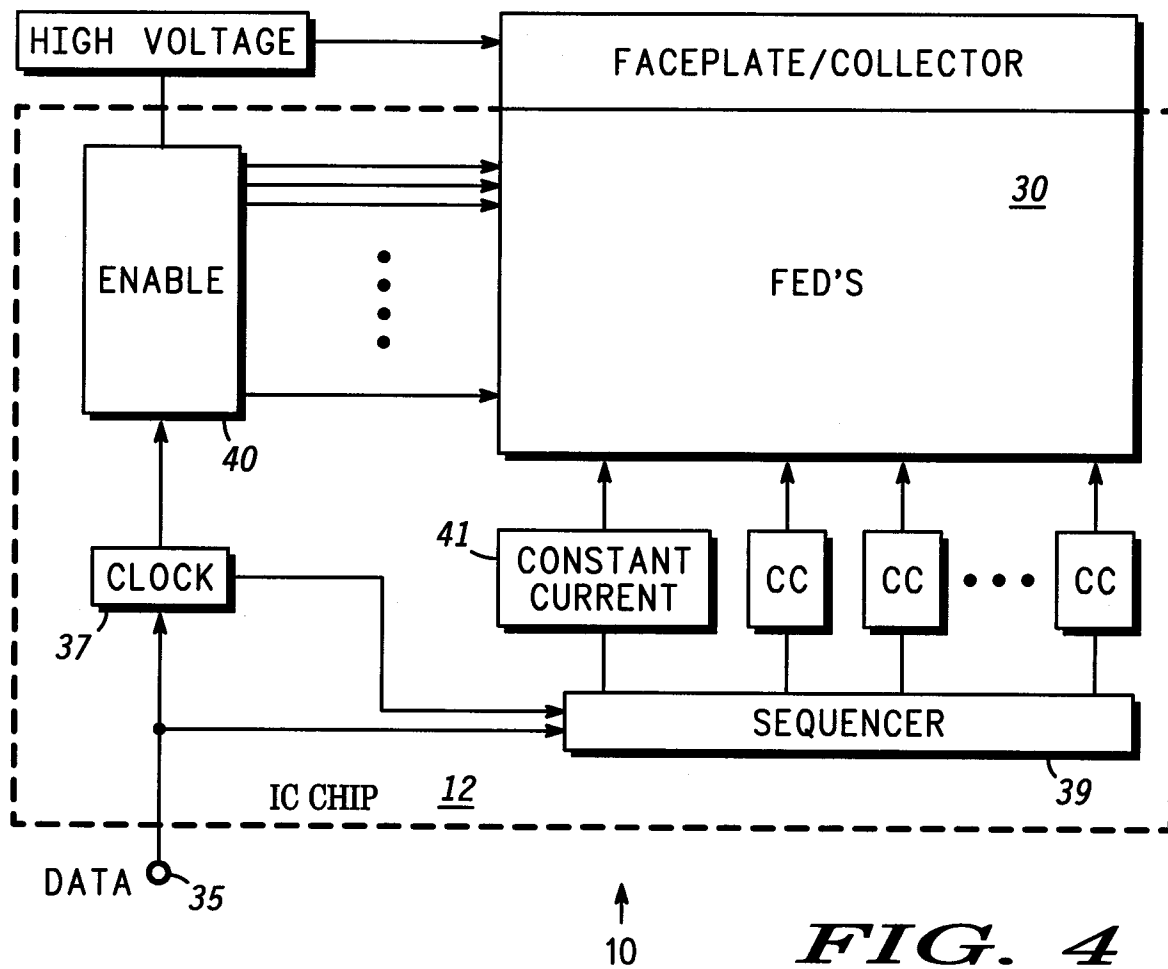
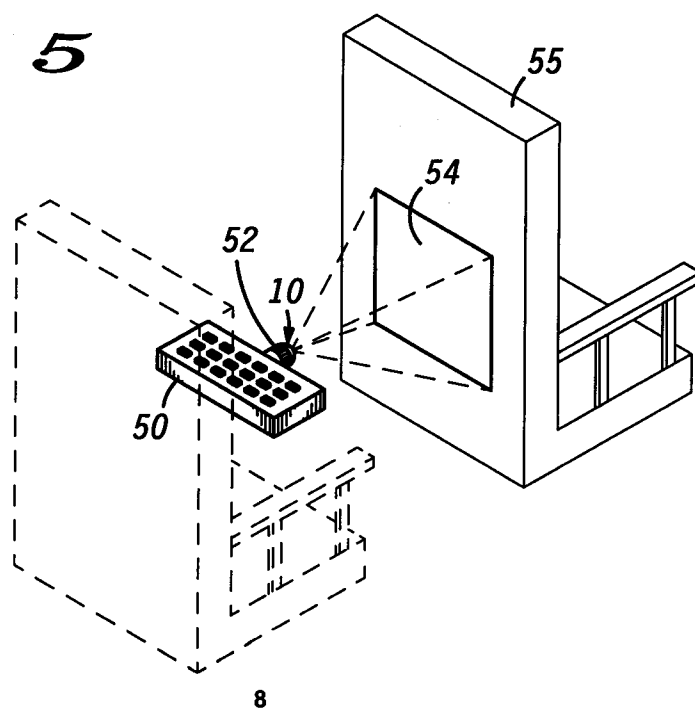


FIG. 5





European Patent
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EUROPEAN SEARCH REPORT

Application Number

EP 92 30 5272

DOCUMENTS CONSIDERED TO BE RELEVANT			
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int. Cl.5)
A	WO-A-8 801 098 (COMTECH) * Abstract * * page 9, line 19 - page 10, line 21 * * figures 1-4 * ---	1, 3, 4, 6, 10, 11	H01J31/12
A	PATENT ABSTRACTS OF JAPAN vol. 13, no. 216 (E-760)19 May 1989 & JP-A-01 029 070 (SEIKO EPSON) 31 January 1989 * abstract *	1, 8, 10	
A	PATENT ABSTRACTS OF JAPAN vol. 14, no. 72 (P-1004)9 February 1990 & JP-A-01 289 913 (MATSUSHITA) 21 November 1989 * abstract *	1, 8, 10	
A	EP-A-0 234 989 (COMMISSARIAT A L'ENERGIE ATOMIQUE) * Abstract * * column 2, line 16 - line 31 * * figures 1-2 * -----	1, 3, 5, 10	
The present search report has been drawn up for all claims			TECHNICAL FIELDS SEARCHED (Int. Cl.5)
			H01J
Place of search THE HAGUE		Date of completion of the search 02 SEPTEMBER 1992	Examiner DAMAN M. A.
CATEGORY OF CITED DOCUMENTS X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons ----- & : member of the same patent family, corresponding document			

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