



(11) **EP 2 081 172 A1**

(12) **EUROPEAN PATENT APPLICATION**

(43) Date of publication:
22.07.2009 Bulletin 2009/30

(51) Int Cl.:
G09F 9/33 (2006.01) G09F 13/22 (2006.01)
G09F 9/30 (2006.01)

(21) Application number: **08000921.0**

(22) Date of filing: **18.01.2008**

(84) Designated Contracting States:
**AT BE BG CH CY CZ DE DK EE ES FI FR GB GR
HR HU IE IS IT LI LT LU LV MC MT NL NO PL PT
RO SE SI SK TR**
Designated Extension States:
AL BA MK RS

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(54) **Display panel and display system**

(57) A display panel (24) having a plurality of pixels (30) disposed on a surface of the display panel, wherein the plurality of pixels (30) are configured to receive an electrical signal and power. The display panel further comprises a frame (26), and a plurality of elongated circuit boards (28) connected to the frame (26), wherein the plurality of pixels (30) are disposed on the plurality of elongated circuit boards (28). Further, the pixels (30) comprise light emitting diodes of surface-mount side-view type. Finally, the circuit boards (28) are oriented perpendicular with respect to the display surface.

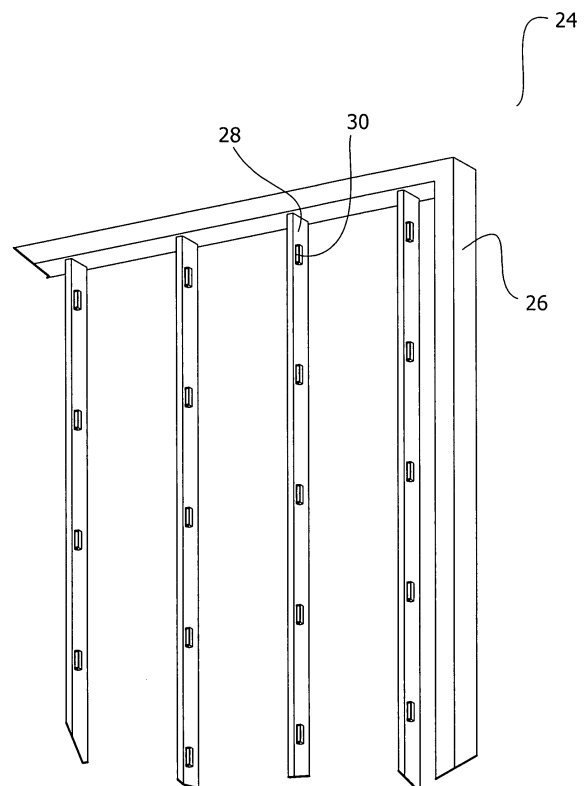


Fig. 4

Description

TECHNICAL FIELD OF INVENTION

[0001] The present invention generally relates to display panels, more particularly, the present invention relates to a LED display panel for use in a large-scale modular display composed of a plurality of such panels.

BACKGROUND OF INVENTION

[0002] Display units for entertainment, architectural, and advertising purposes have commonly been constructed of numbers of light emitting elements, such as light emitting diodes (LEDs). These LEDs may be selectively turned on and off to create patterns, graphics, and video displays for both informational and aesthetic purposes. It is well known to construct these displays of tiles or large panels, each containing a number of LEDs, which may be assembled in position for an entertainment show or event, or as an architectural or advertising display.

[0003] For stage and architectural applications transparency of the display to light, sound, and wind may be an important feature of the displays.

[0004] It is often required to light up a background behind the display, and/or place lights and lasers behind the display, so they can beam through the display surface. It is also often required that onstage objects do not reflect or disturb sound. And finally, it is also often required that display system have a reduced wind pressure, or wind load, during outdoor installation.

[0005] Examples of such transparent displays are disclosed in U.S. Pat. Nos. 5,900,850, 6,237,290, 6,699,341, and U.S. Patent Applications Nos. 2007/0176854 and 2007/0279338.

[0006] Another example of a transparent display is disclosed in U.S. Pat. No 6,677,918 to Yuhara et al., and EP 1 293 955 issued to G-LEC Europe GmbH. G-LEC is the market leader in the development of transparent LED video display technology.

[0007] According to EP 1 293 955 a display apparatus comprises a plurality of light-emitting element panels, each having a support frame and a plurality of light-emitting element bars arranged in parallel at regular intervals and connected to the support frame. The light-emitting element bar has a thin display module which comprises pixels mounted on the front surface of a long wiring board. Each pixel has LEDs (light-emitting diodes).

FIG. 1 shows an example of a prior art display apparatus. The display 10 comprises a support frame 12, a plurality of light-emitting element bars 14 having a number of pixels 16.

FIG. 2a, 2b, and 2c show an enlarged view of one light-emitting element bar 14. The light-emitting element bar 14 comprises a long wiring board 20 covered by a cylindrical translucent pipe 22 and having a number of pixels 16. Each pixel 16 has three LEDs 18.

[0008] The display system according to EP 1 293 955 is not susceptible to wind, the background of display can be seen and the display can be illuminated from behind.

[0009] However, in the prior art display, further increase of transparency is limited by the width of the wiring board. To increase transparency of the display, provided the pixel pitch, or density of light emitting elements is pre-set and cannot be changed, the width of the printed wiring board needs to be reduced, which is not feasible because of constructional and technological limitations.

[0010] The object of the present invention is to improve transparency of the display structure retaining the advantages of manufacturing the display panels using standard printed circuit board technology.

SUMMARY OF INVENTION

[0011] The general purpose of the present invention is to provide a display panel having improved transparency while retaining or even improving manufacturability and reliability of the prior art displays.

[0012] Transparency of a prior art display is mostly limited by the width of light-emitting element bars which in turn is mostly defined by the width of printed circuit boards (PCBs) placed inside the bars.

[0013] To increase transparency the width of the circuit board needs to be reduced. However the width of printed circuit boards in prior art displays already is about 16 mm and a further reduction of the width is problematic. A narrower PCB will be less reliable and more expensive in manufacturing.

[0014] It is possible to totally eliminate PCB, for example, electrical wires may be used instead of a printed circuit board to electrically connect the pixels within a display panel. However, as a result, the construction will be too complicated and consequently more expensive in manufacturing and less reliable in use.

[0015] According to the present invention, the PCBs are turned at 90 degree to the display viewing surface. As the

side profile of the PCB is much thinner than its front face, the display panel will have a substantially more empty, transparent space.

[0016] However, the PCBs being turned through 90 degrees, the LEDs will emit light in a side direction or parallel to the viewing surface. There are known in the art different solutions for turning light emitted by LEDs through 90 degrees. For example, reflectors or light guides may be used to re-direct lights into required direction. However, mounting additional elements, such as reflectors or light guides on the PCB may significantly complicate assembling and rise cost of the display panel. Another solution may be to mount LEDs at an angle to the PCB, for example using LEDs with leads and bending these leads. However LEDs with leads are more expensive, and a process of mounting LEDs with bent leads, or a process of bending LED leads after the mounting would significantly complicate assembling and therefore rise cost, and reduce reliability of the display.

[0017] Surprisingly, it was found that there are devices in another technical field, capable to solve the above problem.

[0018] For a long time side-view or side-emitting LEDs have been widely used as light sources of backlight units of a small-sized liquid crystal displays (LCDs) in mobile phones, Personal Digital Assistants (PDAs) and so on.

[0019] These side-view LEDs are designed for mounting on PCB by surface mount technology (SMT), they emit light in parallel to the mount surface, and their light emitting parameters are similar to those of LEDs currently used in transparent large-screen displays.

[0020] According to the present invention there is provided a display panel having a plurality of pixels disposed on a surface of the display panel, wherein the plurality of pixels are configured to receive an electrical signal and power. The display panel further comprises a frame, and a plurality of elongated circuit boards connected to the frame, wherein the plurality of pixels are disposed on the plurality of elongated circuit boards. Further, the circuit boards are oriented perpendicular with respect to the display surface. Finally, the pixels comprise light emitting diodes (LEDs) of surface-mount side-view type.

[0021] Preferably, the pixels comprise LEDs of three different colours, thus allowing create full colour images.

[0022] Preferably, the pixels comprise LED drivers mounted on the circuit boards together with the LEDs. Mounting the LED drivers on the same circuit board allows to reduce a number of wires connected to the circuit board.

[0023] Preferably, the circuit boards are connected to the frame by detachable connectors, thus allowing an easy replacement of damaged board.

[0024] According to another aspect of the invention, there is provided a display system including a plurality of display panels. Each of the plurality of display panels includes a plurality of pixels disposed on a surface of the display panel, wherein the plurality of pixels are configured to receive an electrical signal and power. The display panel further comprises a frame, and a plurality of elongated circuit boards connected to the frame, wherein the plurality of pixels are disposed on the plurality of elongated circuit boards. Further, the circuit boards are oriented perpendicular with respect to the display surface. Finally, the pixels comprise LEDs of surface-mount side-view type.

[0025] According to still another aspect of the invention, there is provided a method for displaying an image. The method includes providing a display panel, wherein the display panel comprises: a plurality of pixels disposed on a surface of the display panel, wherein the plurality of pixels are configured to receive a data signal and power; a frame; and a plurality of elongated circuit boards connected to the frame, wherein the plurality of pixels are disposed upon the plurality of elongated circuit boards, wherein the circuit boards are oriented substantially perpendicular with respect to the display surface, and the pixels comprise LEDs of surface-mount side-view type. the method further comprises sending the data signal to the display panel, wherein the plurality of pixels are further configured to display the image based on the data signal.

[0026] Compared to the present technology level, combination of side emitting LEDs mounted at a printed circuit board by surface-mount technology and turning the PCB orthogonal to the viewing surface may increase transparency of the display by more than 40%, and allow to build transparent video displays with a smaller pixel pitch.

[0027] Other aspects of the invention will be apparent from the following description and the appended claims.

DEFINITIONS

[0028] By surface-mount side-view type light emitting diode herein is meant a LED lamp or LED package, designed for surface mount technology (SMT), that emits light substantially in parallel to the mounting surface. The lamp or package may comprise one or several LEDs. Such LED devices are usually called side-view or side-emitting LEDs.

[0029] Surface mount technology (SMT) is a method for constructing electronic circuits in which the components are mounted directly onto the surface of printed circuit boards (PCBs). An SMT component is usually smaller than its leaded counterpart because it has either smaller leads or no leads at all. Electronic devices so made are called surface-mount devices or SMDs.

[0030] Surface mounting lends itself well to a high degree of automation, reducing labour cost and greatly increasing production rates. In the industry it has largely replaced the through-hole technology construction method of fitting components with wire leads into holes in the circuit board.

[0031] By LED driver herein is meant a driver circuit configured to vary the intensity of light emitted from the LEDs. Usually LED drives are made as specialised integral circuit (IC), for example, DM412 manufactured by Silicon Touch Technology, Taiwan.

5 BRIEF DESCRIPTION OF DRAWINGS

[0032]

FIG. 1 shows a prior art display panel;
 10 FIG. 2a, 2b and 2c show enlarged views of the light-emitting element bar of prior art display panel;
 FIG. 3a and 3b show a front view and an enlarged cross-section view of a display panel according to the invention;
 FIG. 4 shows a perspective view of the upper right corner of a display panel according to the invention;
 FIG. 5 shows a perspective view of the upper right corner of another embodiment of a display panel according to the invention;
 15 FIG. 6 shows a display assembled of four panels;
 FIG. 7 shows a schematic diagram of a display system according to the invention.

DETAILED DESCRIPTION OF PREFERRED EMBODIMENTS

20 **[0033]** The invention is illustrated by the following examples.

[0034] Referring to FIGs. 3a and 3b, a front perspective view and an enlarged cross-section view of a display panel 24 in accordance with embodiments disclosed herein are shown respectively. The display panel 24 includes a frame 26 having a plurality of elongated circuit boards 28 connected thereto. Further, each elongated circuit board 28 includes pixels 30 mounted on it, each of the pixels 30 including one or several LEDs of surface-mount side-view type. Thus, the display panel includes multiple circuit boards connected to the frame, and each of the circuit boards including multiple pixels.

[0035] The display panel 24 further comprises a control unit (not shown) configured to control the plurality of pixels 30 to display an image according to an input data signal. The control unit may be housed inside the frame 26 as in this preferred embodiment, or it may be made as a separate module attached to the frame. In case the control unit is made as a separate module one control unit may control one or several display panels.

[0036] Each panel control unit may be directly connected to the main control unit of the display system, or panel control units may be connected in series to each other and then to the main control unit.

[0037] The control unit may include communication means for receiving data signals from the main processor and LED drivers for controlling the LEDs.

35 **[0038]** The frame 26 consists of a number of metal tubes mechanically joined together to form a strong and stable construction. The frame may be made of a thin, rigid, lightweight material such as a metal so that the entire frame is very lightweight. Such metals can include aluminium or other lightweight metals. In addition, plastic, fibreglass, carbonaceous materials and other lightweight materials and various combinations thereof can be used.

[0039] Mechanical construction of frame 26 is such that it is sufficiently thin and flat, and does not reduce transparency of the display panel.

40 **[0040]** FIG 4. shows an enlarged perspective view of the upper right corner part of the display panel 24. The elongated circuit boards 28 are oriented substantially perpendicular with respect to the display surface, which means that the planar surface of the circuit board is orthogonal to the viewing plane of the display. With this orientation, the thinner side of the circuit board 28 is exposed to the visible path through the display surface thereby enhancing the transparency of the display panel 24.

45 **[0041]** Each circuit board 28 is made from a monolith single piece fibreglass material, preferably a non-reflective or substantially non-reflective material having a black pigment. In this preferred embodiment, the circuit board 28 is made as a single printed circuit board. Those skilled in the art will appreciate that the circuit board can be made from one-ply or multi-ply printed circuit board, mechanically and electrically connected together by means of connectors or other connecting means. The thickness of the printed circuit board is sufficiently smaller than its width. Thus, for an observer who looks at the front of the display panel, the transparency of the display panel 24 is substantially increased in comparison with a prior art display panel.

[0042] The circuit boards 28 may be connected to the frame 26 by any way known in the art, for example, by using bolts, screws, pins, connectors with latches or any other connecting means.

55 **[0043]** Each pixel 30 may include one or more LEDs of surface-mount side-view type. Preferably, the pixel includes LEDs of three colours, so called RGB LEDs of red, green and blue colours, in a single surface-mount ceramic package, for example, NSSM038AT manufactured by Nichia, Japan. As an alternative, the pixels may include a single colour LED of red, green, blue, yellow, amber, or white colour. As an alternative, the pixels may include several individual LEDs or

LED packages. Further, LEDs may be mounted on one or the both surfaces of the circuit board. Thus, the total light output power is increased with almost the same transparency level.

[0044] The LEDs are located in such a way that a light emitting surface of each LED is laying close to the edge of the circuit board. Thus, the circuit board does not deteriorate visibility of the light emitted from the LEDs, and a wide viewing angle is achieved.

[0045] In this preferred embodiment, the plurality of circuit boards 28 are mounted at the frame 26 in parallel to each other with a regular arrangement to achieve a distortion-free image displayed over the display panel 24. The plurality of pixels 30 are also mounted at the circuit boards 28 with a regular arrangement to form a regularly arranged pattern of pixels.

[0046] In this preferred embodiment, the pitch between the pixels is 40 mm in vertical and horizontal directions, however those skilled in the art will appreciate that other pitch values are possible depending on intended use of the display.

[0047] In operation, the panel 24 receives control signals from a main processor (not shown) by means of data cables (not shown) and uses those signals to activate and modulate the illumination of the pixels 30 that create a portion of an overall display image.

[0048] Another preferred embodiment is shown in FIG. 5. The panel 34 in this embodiment is similar to the panel 24 shown on FIGs. 3 and 4, it includes a frame 36 and elongated circuit boards 38 connected to the frame 36 and pixels 40 mounted on the circuit boards 38. However, in this embodiment, pixels 40 include LEDs and LED drivers 42 mounted on the same elongated circuit board 38.

[0049] Mounting the LED drivers 42 on the same circuit board 38 with pixels 40 allows to reduce the number of wires connected to the circuit board, wires that connect a circuit board to a panel control unit. Because each LED is connected to a corresponding LED driver by a separate wire, when 10 pixels are mounted on each board and each pixel comprises three LEDs, more than 30 wires are needed to connect the circuit board with its control unit, whereas if corresponding LED drivers are mounted on the same circuit board with the LEDs, then the circuit board may be connected to the control unit only by three wires.

[0050] Further, referring to FIG. 5, the circuit board 38 may be removably connected to the frame 36, for example, by a detachable connector 44, thus allowing an easy replacement of a damaged circuit board 38. Those skilled in the art will appreciate that only one end of the circuit board 38 needs to be electrically connected to the panel control unit (not shown) whereas another end may be removably connected to the frame 36 by any mechanical arrangement, for example, inserted in a slot made in the frame 36.

[0051] The panel 34 on FIG. 5 further comprises a data and power input 46 by which the display panel is connected to an external control unit (not shown) or another display panel (not shown).

[0052] Optionally, the elongated circuit boards of the preferred embodiments shown in FIGs. 3, 4, and 5 may be surrounded by a light transmitting material to protect them from elements. Preferably, the light transmitting material is to be in the form of a tube, still more preferably, of a tube of an elliptical or rectangular cross-section. Alternatively, the circuit boards may be covered with a light transmitting material, for example, a shrink-wrapped film or lacquer.

[0053] The display panel described above is the smallest user-configurable lighting element of a large-scale display and contains all the electronic circuitry necessary to power and drive an array of pixels. Several panels may be combined together to form a large-area transparent display system.

[0054] FIG. 6 shows a display system 50 in accordance with one or more embodiments of the present invention. The display system 50 comprises a plurality of display panels 52, such as panels described above. Each panel comprises a plurality of pixels 56 mounted on circuit boards 58. In this embodiment, a plurality of display panels 52 are arranged in two columns and two rows per column. However, those skilled in the art will recognise that various other combinations of the display panels 52 may be connected to each other to provide other configurations of the overall display.

[0055] Referring now to FIG. 7, the display system 50 further includes a power unit 62 configured to provide power to the pixels 56 and electronics of the display panel 52 and a main processor 60 providing a data signal to control units 54 of the display panels 52. The data signal may be any data signal known in the art, such as an analogue video signal, a digital video signal, or a still image.

[0056] The control unit 54 is configured to control one or more pixels 56 to emit a colour of light based on the input data signal and the location of the one or more pixels.

[0057] Furthermore, the display panel 52 may include a single control unit 54 configured to provide a control signal to each pixel 56 of the display panel 52, or the display panel 52 may contain more than one control unit 54, wherein each control unit 54 is configured to provide a control signal to a subset of pixels 56. For example, in one embodiment each pixel 56 may include a driver circuit, and the control unit 54 may send a control signal to each driver circuit, whereby the driver circuit controls the intensity of each LED to produce a specified colour. In another embodiment, each elongated circuit board 58 of the display panel 52 may instead include a control unit 54 configured to send a control signal to each driver circuit of the pixels on the board.

[0058] Alternatively, the driver circuits of the pixels 56 may constitute the control unit 54. In such an embodiment, the data signal from the main processor 60 may be sent to each driver circuit of each pixel 56. A driver circuit for a pixel would then pull the respective data for the corresponding pixel from the data signal. Those skilled in the art will recognise

that other configurations of a control unit 54 and driver circuits may be used such that the pixels of the display panel are controlled to emit a colour of light according to the data signal.

[0059] The signals between the main processor 60, the control unit 54, the driver circuits, and the pixels 56 may be transmitted by any way known in the art, such as by cables, traces on a PCB, or wireless communication. For example, a cable from the main processor 60 may be connected to a signal input on the display panel 52. Then, the control unit 54, the driver circuits, and/or the pixels 56 may be electrically connected to the input data signal by traces on a PCB. Alternatively, the panel 50 may receive the data signal from the main processor 60 by wireless communication.

[0060] Embodiments of the present invention may provide one or more of the following advantaged. First, embodiments disclosed herein may provide for a display panel and a display system having increased transparency. Second, embodiments disclosed herein may provide for a display panel having an improved manufacturability. By using standard printed circuit board technology the display panel may be easily manufactured. Finally, embodiments disclosed herein may provide for a display panel with improve reparability allowing easily replace damaged circuit board with pixels without dismounting a panel.

[0061] While the invention has been described with respect to a limited number of embodiments, those skilled in the art, having benefit of this disclosure, will appreciate that other embodiments can be devised which do not depart from the scope of the invention as disclosed herein. Accordingly, the scope of the invention should be limited only by the attached claims.

COMPARATNE EXAMPLES

[0062] In the preferred embodiment each panel has 10 PCB and each PCB has 10 pixels mounted on it. The distance between pixels in the preferred embodiment is 40 mm in both vertical and horizontal directions, thus the size of one panel is 500x500 mm and the panel as well as a display made of such panels have a transparency ratio of more than 85%.

[0063] For comparison, below in Table 1 there are listed parameters for several display models currently available on the market. Parameters are taken from manufacturer data sheets. In the last column there are show estimated transparency data for display panels according to the current invention, provided it would be designed with similar to the comparable models values of pitch and panel size.

Table I. Comparison of currently available display panels with a panel according to present invention.

Display model	Producer	Pitch	Panel size	Transparency	Estimated transparency according to this invention
Phantom-60	G-LEC	60 mm	0.96 x 0.96 m	75%	>90%
Phantom-30	G-LEC	30 mm	1 x 1 m	60%	>85%
Stealth	Element Labs	25 mm	0.4 x 0.4 m	60%	>85%
MiTRIX	Barco	25 mm	0.38 x 0.19 m	55%	>80%

REFERENCE NUMERALS

[0064]

- 10 a display panel (prior art)
- 12 a frame (prior art)
- 14 a light-emitting element bar (prior art)
- 16 a pixel (prior art)
- 18 a LED (prior art)
- 20 a wiring board (prior art)
- 22 a tube (prior art)
- 24 a display panel
- 26 a frame
- 28 an elongated circuit board(PCB)
- 30 a pixel
- 32 not used
- 34 a display panel
- 36 a frame
- 38 an elongated circuit board (PCB)

- 40 a pixel
- 42 a LED driver
- 44 a connector
- 46 a power and data input
- 5 48 not used
- 50 a display system
- 52 a display panel
- 54 a control unit
- 56 pixels
- 10 58 an elongated circuit board (PCB)
- 60 a main processor
- 62 a power unit.

15 Claims

1. A display panel, comprising:

- 20 a plurality of pixels disposed on a surface of the display panel, wherein the plurality of pixels are configured to receive an electrical signal and power;
- a frame; and
- a plurality of elongated circuit boards connected to the frame, wherein the plurality of pixels are disposed upon the plurality of elongated circuit boards,
- 25 **characterised in that**
- the circuit boards are oriented substantially perpendicular with respect to the display surface, and
- the pixels comprise light emitting diodes (LEDs) of surface-mount side-view type.

2. The display panel of claim 1, wherein the pixels further comprise LED drivers.

30 3. The display panel of claim 1, wherein the light emitting diodes are of RGB type.

4. The display panel of claim 1, wherein the circuit boards are connected to the frame by detachable connectors.

35 5. The display panel of claim 1, further comprising a control unit configured to control the plurality of pixels to display an image.

6. The display panel of claim 1, further comprising a power and signal input.

7. The display panel of claim 1, wherein the elongated circuit boards are surrounded by a light transmitting material.

40

8. A display system, comprising:

a plurality of display panels, wherein each of the plurality of display panels comprises:

- 45 a plurality of pixels disposed on a surface of the display panel, wherein the plurality of pixels are configured to receive an electrical signal and power;
- a frame; and
- a plurality of elongated circuit boards connected to the frame, wherein the plurality of pixels are disposed upon the plurality of elongated circuit boards,
- 50 **characterised in that**
- the circuit boards are oriented substantially perpendicular with respect to the display surface, and
- the pixels comprise light emitting diodes of surface-mount side-view type.

55 9. The display system of claim 8, wherein each of the plurality of display panels further comprises a control unit configured to control the plurality of pixels to display an image.

10. A method for displaying an image, the method comprising:

providing a display panel, wherein the display panel comprises:

a plurality of pixels disposed on a surface of the display panel, wherein the plurality of pixels are configured to receive a data signal and power;

a frame; and

a plurality of elongated circuit boards connected to the frame, wherein the plurality of pixels are disposed upon the plurality of elongated circuit boards,

characterised in that

the circuit boards are oriented substantially perpendicular with respect to the display surface, and

the pixels comprise light emitting diodes of surface-mount side-view type;

sending the data signal to the display panel, wherein the plurality of pixels are further configured to display the image based on the data signal.

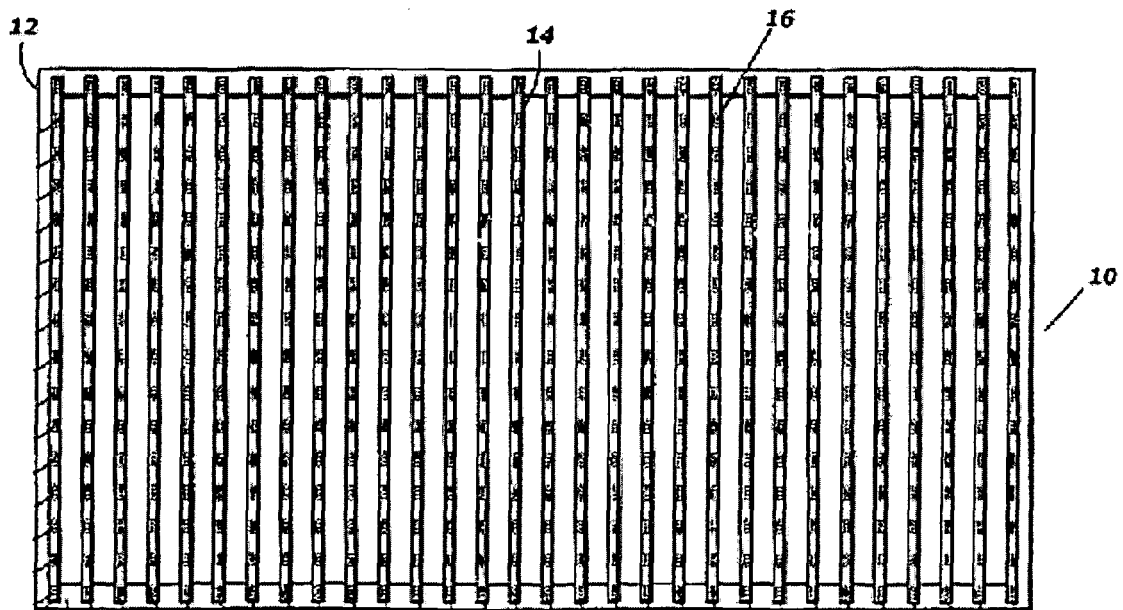
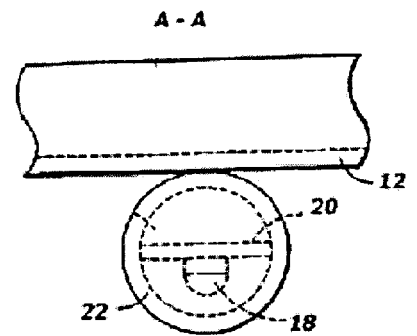
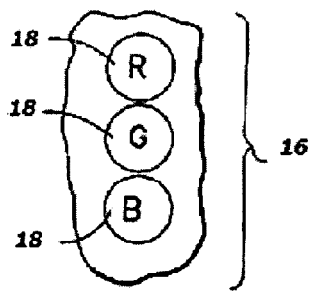
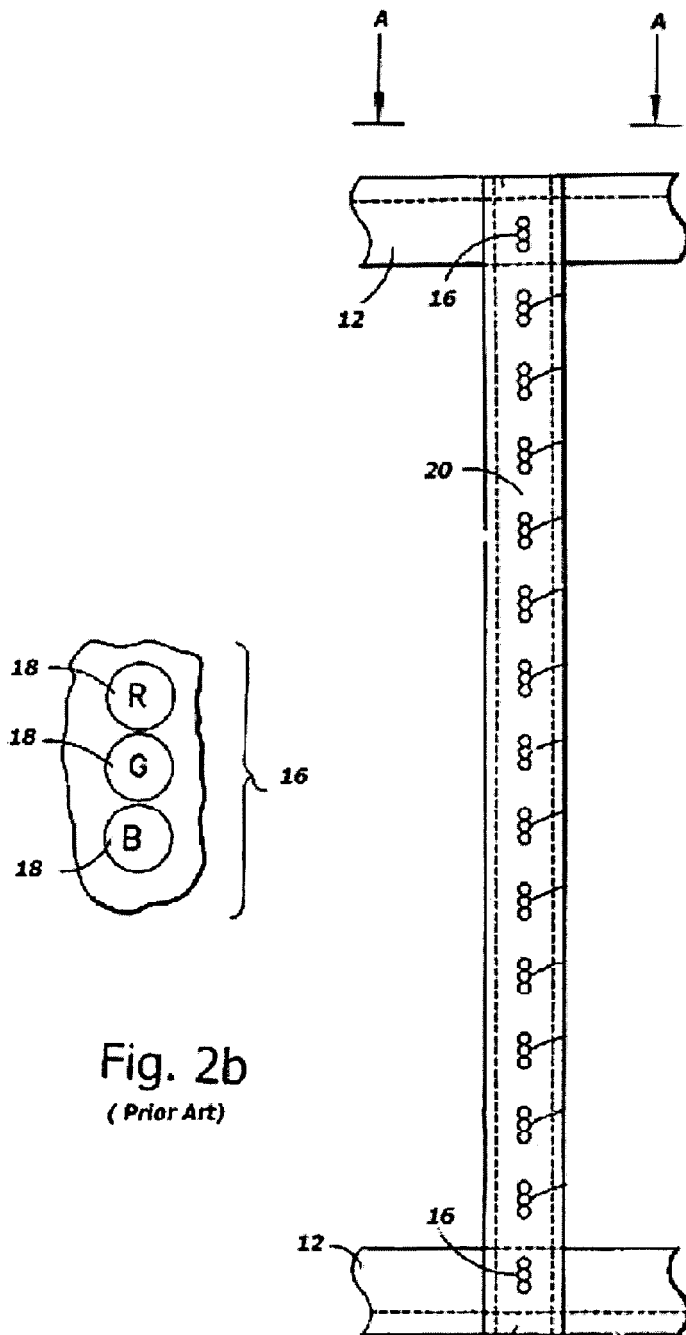


Fig. 1
(Prior Art)



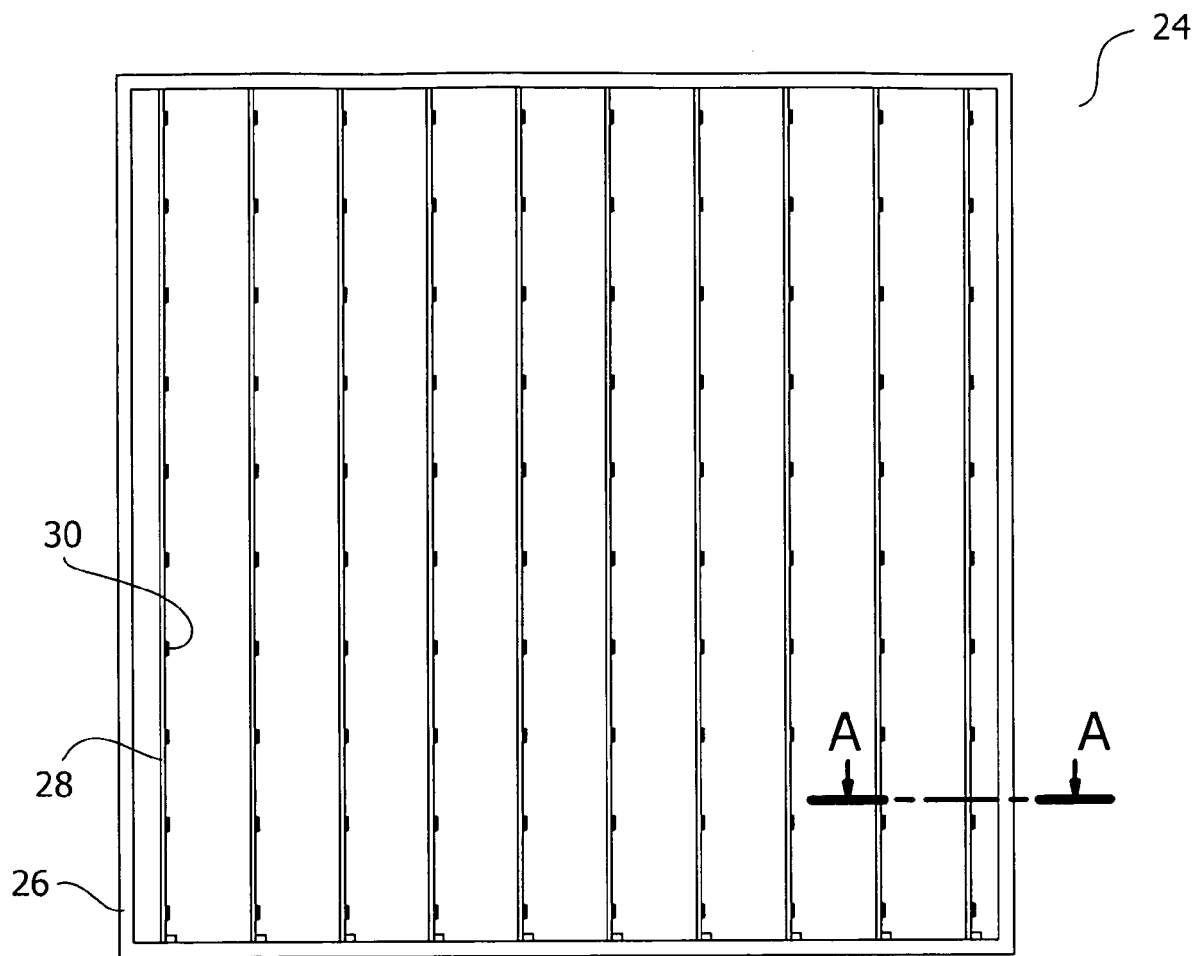


Fig. 3a

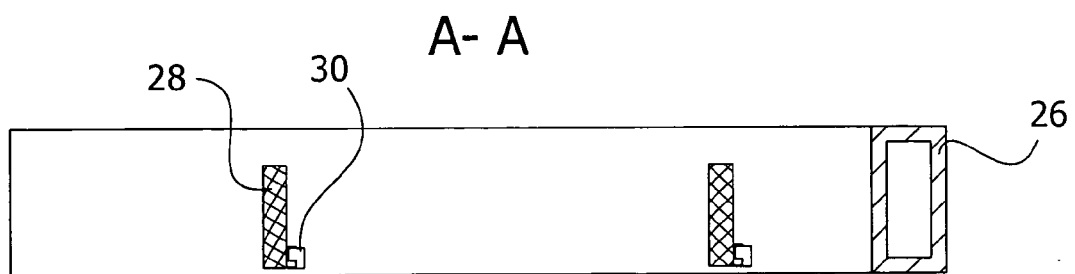


Fig. 3b

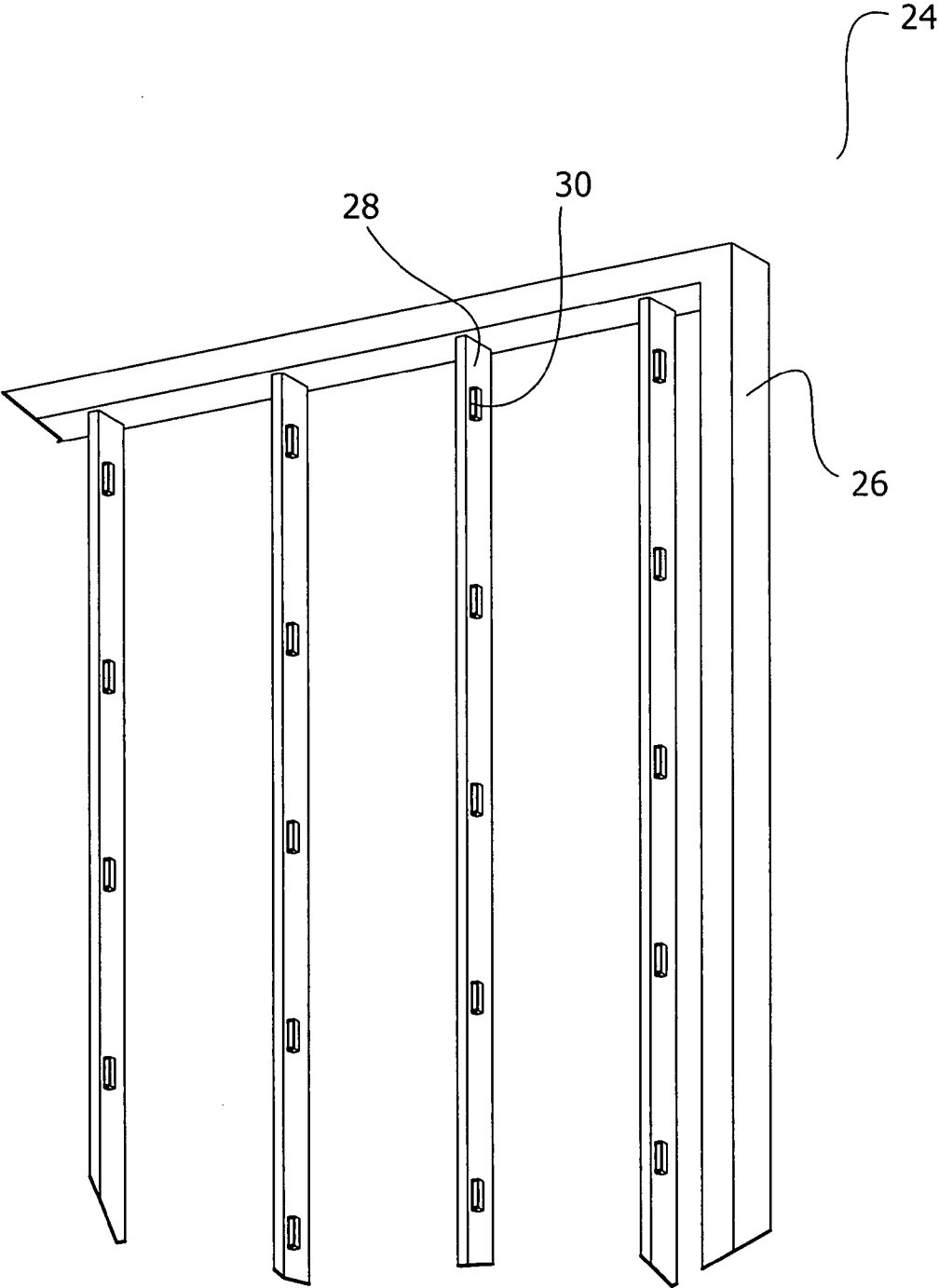


Fig. 4

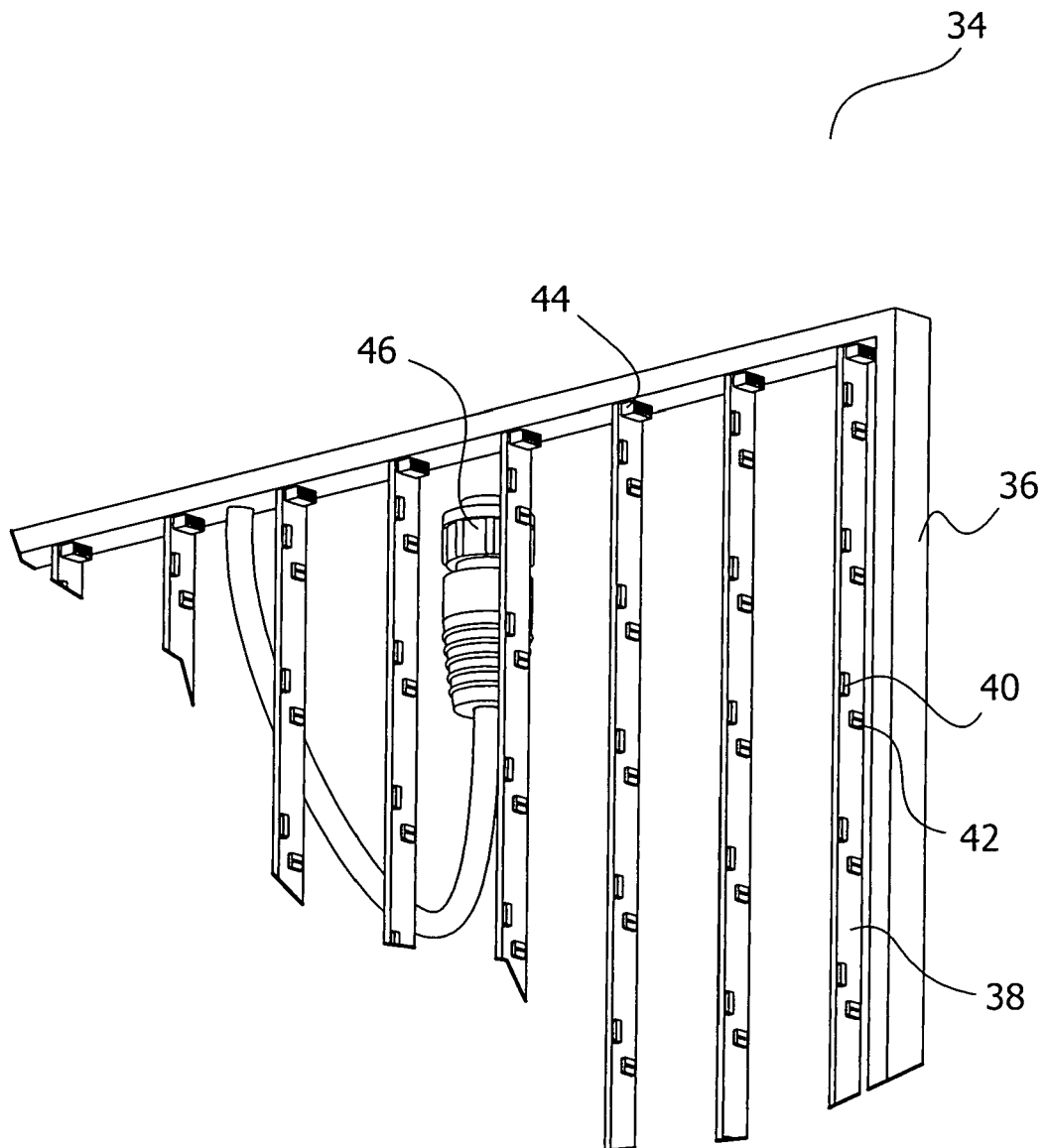


Fig. 5

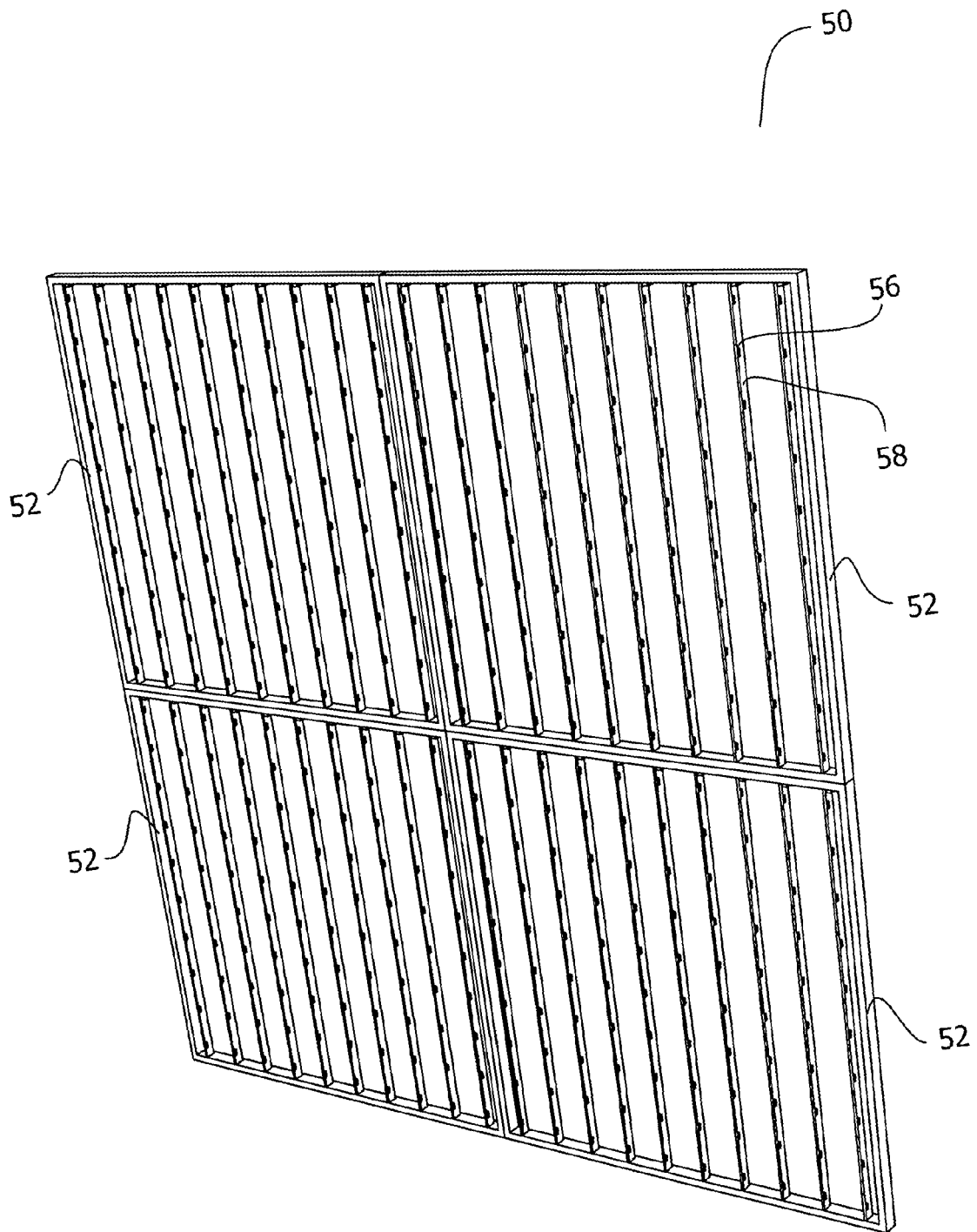


Fig. 6

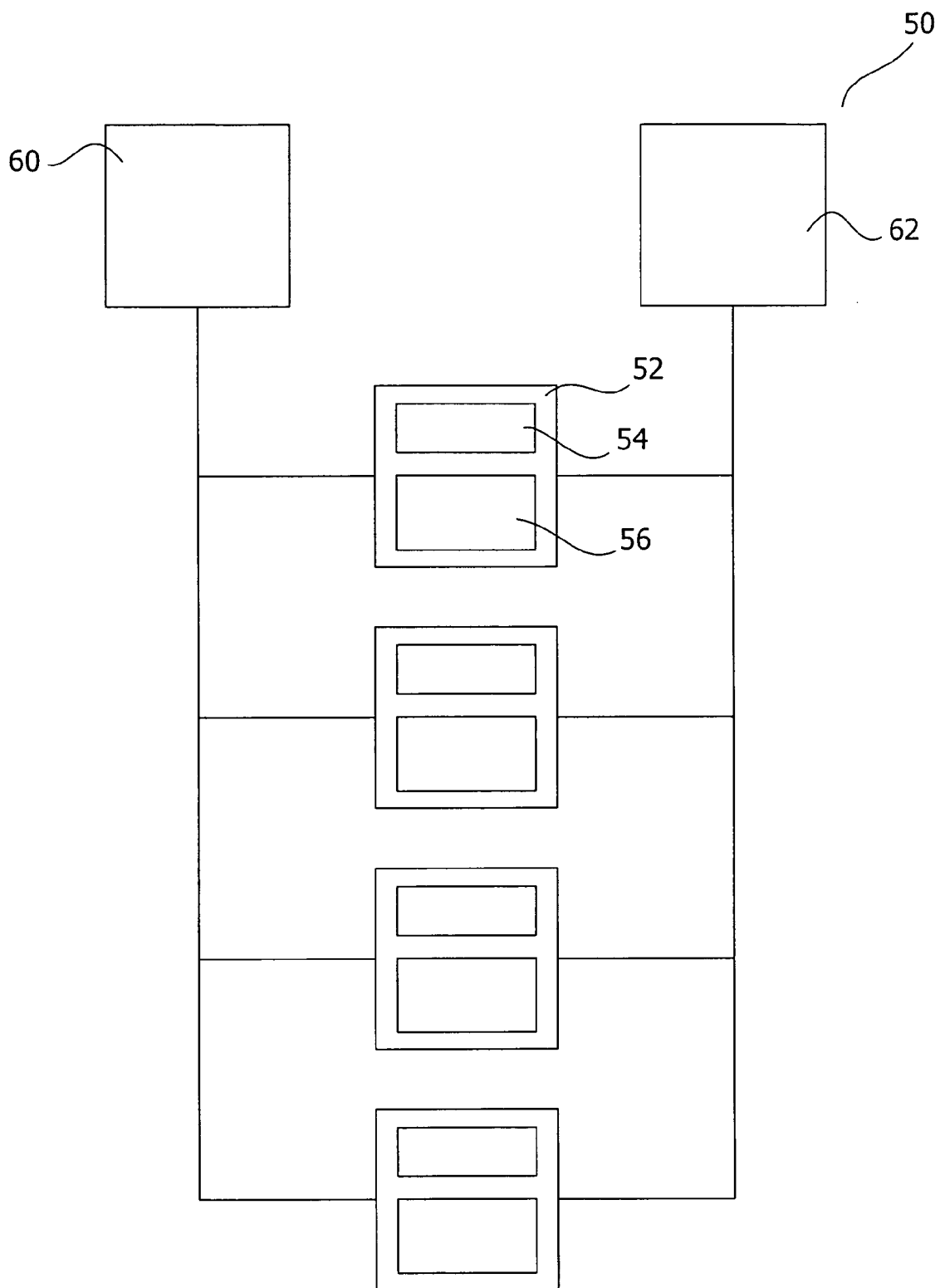


Fig. 7



European Patent
Office

EUROPEAN SEARCH REPORT

Application Number
EP 08 00 0921

DOCUMENTS CONSIDERED TO BE RELEVANT			
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
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Y	* abstract *	4,7	
	* figure 7 *		
	* paragraph [0006] *		
	* paragraph [0038] - paragraph [0039] *		
	* paragraph [0051] - paragraph [0053] *		
	* paragraph [0059] - paragraph [0064] *		

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	* figure 3a *		
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The present search report has been drawn up for all claims			TECHNICAL FIELDS SEARCHED (IPC)
			G09F
Place of search		Date of completion of the search	Examiner
Munich		20 June 2008	Pierron, Christophe
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			

2
EPO FORM 1503 03.02 (P04C01)

**ANNEX TO THE EUROPEAN SEARCH REPORT
ON EUROPEAN PATENT APPLICATION NO.**

EP 08 00 0921

This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report.
The members are as contained in the European Patent Office EDP file on
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