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(54) **Title**: INFORMATION DISPLAY AND A METHOD FOR COOLING AN INFORMATION DISPLAY

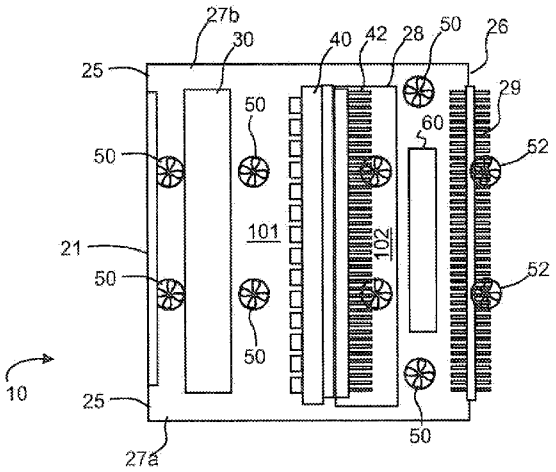

Fig. 3

(57) **Abstract**: The present invention relates to an information display comprising a housing (20), a display panel (30), and a backlight unit (40). The information display (10) further comprises a first air channel (101) between the display panel (30); and the backlight unit (40) adapted to receive a first cooling air flow. In some embodiments the information display (10) comprises a second air channel (102) for a second cooling air flow adapted to conduct at least part of the heat generated by the backlight unit (40) outside the information display. The information display (10) is adapted to keep the first cooling air flow separate from the second cooling air flow. The present application also discloses a method for cooling an information display (10) having a housing (20), a display panel (30); and a backlight unit (40). The method comprises providing a first cooling air flow to a first air channel (101) located between the display panel (30) and the backlight unit (40). In some embodiments the method comprises providing a second cooling air flow to a second air channel (102) for conducting at least part of the heat generated by the backlight unit (40) outside the information display; and keeping the first cooling air flow separate from the second cooling air flow.

WO 2013/182733 A1

Information Display and a Method for Cooling an Information Display

Field of the Invention

The present invention relates in general to information displays and methods for controlling temperature of information displays.

Background of the Invention

Markets for outdoor electronic information displays, capable of showing full colour video information, have increased considerably during the last years. The biggest growth in outdoor display market is estimated to happen in digital signage business, practically meaning advertising and public information display applications. Other typical applications are passenger information systems e.g. railway and city traffic sectors. Giant outdoor information displays have earlier been realized mostly with full colour LED technology, but for application with small viewing distance (starting from 1 m) they are not applicable due to limitation of pixel size. For such displays, thin film transistor liquid crystal displays (TFT LCD) have seen to be an emerging technology.

Concerning the use of TFT LCD technology in outdoor information displays, standard TFT LCD panels have major restrictions concerning brightness and operating temperature range and have been found vulnerable especially in direct sunshine conditions. A typical industrial TFT LCD panel has transmissive brightness of 700 cd/m^2, but the need for brightness of an outdoor digital signage application is estimated to be greater than 3000 cd/m^2. In addition, the operating temperature of a TFT LCD panel is typically limited to +50°C, with temporary absolute maximum temperature being close to +65°C which is the so called clearing temperature of an LCD panel. In the clearing temperature liquid crystal molecules are changing phase from ”liquid crystal” phase to liquid phase and liquid crystal cells stop working as electronically controllable liquid crystals and the display or parts of it becomes black.

Some existing outdoor information displays use cold cathode fluorescent lamps (CCFL) as a light source for the display panel. This light source may

also be called as a backlight. The size of cold cathode fluorescent lamps is quite large and their lifetime is limited approximately to 50000 operating hours. In addition, CCFL technology has high temperature dependency, which decreases efficiency and brightness. This limits the use of CCFL in very cold or high temperature conditions, which are typical for an outdoor information display. In addition, maintenance of CCFL backlight system is difficult due to enclosed structure of TFT panel. Another problem with CCFL is that they contain mercury which may cause environmental pollution. Therefore, used CCFL must be brought to a special waste collection points.

One approach to produce a more efficient backlight is to use a matrix of light emitting diodes (LEDs) as the backlight. The available brightness of LEDs have been increased in recent years wherein LEDs have become a light source to be reckoned with also in information displays for outdoor use. For example, super high brightness LEDs may provide brightness greater than >3000 cd/m^2. However, such light emitting diodes produce considerable amounts of heat in operation. Therefore, this has limited the use of high brightness LED backlight systems.

The European patent application EP 1 914 589 describes a liquid crystal display apparatus and control method thereof. The liquid crystal display apparatus includes an LCD panel, a backlight unit, a cooling fan and a controller which selectively controls either the fan driver of the backlight unit to set a rotation speed of the cooling fan to be corresponded with a luminance value of the backlight unit. One problem in this approach is that only the luminance value of the backlight unit is taken into consideration when controlling the rotation speed of the cooling fan. Hence, this approach is not applicable in outdoor information displays in which a direct sunlight can cause extra heat on the LCD panel.

Another European patent application EP 1 647 766 describes a light emitting device package and back light unit for liquid crystal display using the same. The package uses a fan to forcibly cool the LED package to increase the heat radiation efficiency and to prevent degradation of the device. Also this solution is not applicable to outdoor information displays due to *inter alia* the fact that the liquid crystal display is not cooled at all. Hence, a direct sunlight may increase the temperature of the liquid crystal display too high.

Summary of the Invention

One objective of the present invention is to introduce a thermal management system for high brightness TFT liquid crystal displays with LED backlighting, which enables very high brightness backlight system for information display with closed housing. The embodiments of the present invention are based on the idea that cooling air flow is provided in between the display panel and the backlight, and that there is a separate channel for cooling the backlight. To put it more precisely, the information display according to an example embodiment is mainly characterised in that the information display comprises:

- a first air channel between the display panel and the backlight adapted to receive a cooling air flow, and
- a second air channel adapted to conduct at least part of the heat generated by the backlight outside the information display,

wherein the information display is adapted to keep the first cooling air flow separate from the second cooling air flow.

The method for cooling an information display having a housing, a display panel; and a backlight unit, is mainly characterised in that the method comprises:

- providing a first cooling air flow to a first air channel located between the display panel and the backlight unit;
- providing a second cooling air flow to a second air channel for conducting at least part of the heat generated by the backlight unit outside the information display; and
- keeping the first cooling air flow separate from the second cooling air flow.

In some example embodiments a standard TFT display is utilized where a backlight system is integrated to the TFT panel so that the panel backlight form a thin and tight package. In the present invention the panel and the backlight system are separated from each other to discrete sub-systems wherein an extra air channel is formed between the panel and the backlight. This extra air channel can be utilized by directing a cooling air flow to this channel.

Some embodiments of the present invention provide more efficient temperature control of information displays than what has been achieved by prior art information displays for outdoor use. Because the cooling air flows between the display panel and the backlight unit the heat radiated from the backlight unit does not adversely affect to the display panel wherein the temperature of the display panel does not rise too high.

Another reason for more efficient temperature control is due to the fact that the second cooling channel behind the backlight unit is isolated from the first cooling channel wherein airflows in these two cooling channels are not mixed.

Due to more efficient cooling air circulation inside the housing of the information display temperature will be more homogenous inside the housing of the information display and individual hot spots do not occur so easily than in prior art information displays.

Information displays according to the present invention are better able to maintain their operation even in simultaneous high outside air temperature and solar radiation conditions.

Other embodiments of the invention are characterized by what is disclosed in the other claims. Inventive embodiments are also discussed in the description section of the present application. The inventive content of the application can also be defined differently than in the claims below. The inventive content may also consist of several separate inventions, especially if the invention is considered in the light of expressions or implicit sub-tasks or from the point of view of advantages or categories of advantages achieved. Therefore, some of the attributes contained in the claims below may be superfluous from the point of view of separate inventive concepts.

Description of the Drawings

In the following the invention will be described in more detail with reference to the appended drawings, in which

Fig. 1 depicts an information display for outdoor use according to an example embodiment of the present invention;

Fig. 2 depicts a cross-sectional side view of the information display of Fig. 1;

Fig. 3 depicts a horizontal cross-sectional view from top of the information display of Fig. 1;

Fig. 4 depicts examples of cooling air flows inside the information display of Fig. 1 as a side view;

Fig. 5 depicts examples of cooling air flows inside the information display of Fig. 1 as a top view; and

Fig. 6 depicts a cross-sectional side view of an information display according to another embodiment of the present invention.

Detailed Description of the Invention

In Figure 1 an example embodiment of an information display 10 according to the present invention is depicted as a perspective view. Figure 2 depicts a cross-sectional side view of the information display of Figure 1. The information display 10 comprises a housing 20, a display panel 30, a backlight unit 40 and one or more fans 50—54. The housing 20 may comprise a stand 22 so that the information display 10 may freely stand on the ground or the stand 22 may be used to fix the information display 10 to the ground. The housing 10 also comprises channels 101, 102 for guiding cooling air flows within the housing 20 aiming to improve the cooling of parts inside the housing 20 of the information display 10, possibly with the help of the fans 50—54. The housing 20 of the information display 10 also comprises at least a partially transparent front plate 21 through which information shown by the display panel 30 can be seen. The front plate 21 may also provide filtering properties, which reduce the stress of solar radiation while achieving good transmissivity to visible spectrum. A controlling unit 60 is provided to control the operation of the display panel 30, the backlight unit 40 and the fans 50—54. The information display 10 may also comprise

measuring elements (not shown) to measure environmental conditions such as temperatures inside and/or outside the housing 20, lightness in the environment of the information display 10 etc. The controlling unit 60 may use the measured information to control e.g. the operation of the fans and to control the brightness of the backlight unit 40.

The display panel 30 is, for example, a thin-film transistor liquid crystal display. The display panel 30 may be able to display information in colour or it may display information in so called monochrome form. The display panel 30 may comprise e.g. a front glass plate 32, a liquid crystal layer 34, a back glass plate 36 and a protective transparent plate 38 at the back of the display panel 30. The display panel 30 may also comprise polarizing filters and other elements. However, the detailed structure of the display panels 30 may vary and it is not necessary to describe it in more detail here.

The backlight unit 40 may comprise light emitting diodes arranged, for example, in an array form (i.e. in rows and columns) so that a uniform enough light can be provided by the backlight unit 40 to the display panel 30. The light emitting diodes are preferably super high brightness light emitting diodes so that a high brightness, for example level of 2500 cd/m^2, 3000 cd/m^2 or higher, for example 4000 cd/m^2 can be achieved, when measured from the front surface of TFT panel. It should be noted here that it is also possible to use other kinds of backlight units than backlight units based on light emitting diodes in matrix form. For example, a backlight unit based on plasma technology may be used. The light sources of the backlight unit may also have been positioned differently from the matrix form.

In some example embodiments the display panel 30 and the backlight unit 40 are formed by using an lcd display module which comprises both an lcd display panel and a backlight unit as an airtight module, which may cause that the heat of backlight unit 40 may stress the display panel 30. Thus, in the present invention the display panel and the backlight unit are separate from each other. Then, the protective transparent plate 38 is attached with the display panel so that dust and other impurities can not enter the display panel 30.

The display panel 30 and the backlight unit 40 are fixed to the housing 20 by appropriate means, for example, by screws, clips, and/or adhesive.

Next, some details of the channels 101, 102 for guiding cooling air flows inside the housing 20 will be described with reference to Figures 2 and 3. The housing 20 comprises a top wall 23, a bottom wall 24, a front wall 25, a back wall 26, and two side walls 27a, 27b. These walls 23—27b define the inner space of the housing 20. In the front wall 25 there is an opening for the transparent front plate 21. In some other embodiments the front wall 25 is made of transparent material wherein no openings are needed in the front wall. A first heat sink 29 or other kind of cooling profile or cooling element may have been attached with the back wall 26 of the housing to conduct heat from the inner space of the housing 10 to outside air. The first heat sink 29 may be formed by using a double-sided profile which has fins on both sides of the profile. Thus, when such a heat sink is assembled to the back wall 26, or in an opening of the back wall 26, one side of the profile and the fins of that side are located within the housing 20 and the other side of the profile and the fins of the other side are located outside of the housing 20.

There are also inner walls 28 inside the housing 20. These inner walls 28 form a kind of a conduit 28c or a tubular structure for cooling air. This conduit 28c acts as a second channel 102. The conduit 28c has a first opening 28a (air inlet) through the top wall 24 of the housing and a second opening 28b (air outlet) through the bottom wall 23 of the housing. Therefore, for example, cooling air can enter the conduit 28c through the first opening 28a and exit the conduit 28c through the second opening 28b. Air flow inside the conduit 28c goes at least partially between fins of a second heat sink 42 or other kind of cooling profile or cooling element, which may be attached with the backlight unit 40. Hence, heat dissipation from the backlight unit 40 to the second air channel 102 and further to the outside air can be improved. It should also be noted here that the cooling air flowing through the conduit 28c does not get mixed with the cooling air flows inside the housing 20. Therefore, more efficient cooling can be achieved compared with solutions of prior art. There may be a fan 53 or a set of fans inside the conduit 28c to improve the air flow and to enhance the cooling effect of the air.

In some other embodiments the first opening 28a and the second opening 28b may be located in side walls 27a, 27b and/or in the back wall 26 of the housing 20.

The second heat sink 42 is preferably fastened directly to the backlight unit, wherein one of the inner walls 28 comprise an opening for the second heat sink 42.

Next, air flow circulation inside the housing 20 will be described in more detail with reference to Figures 4 and 5. In some embodiments the air flow circulation inside the housing 20 is closed i.e. the same air circulates and outside air may not enter the housing 20. In some other embodiments there may be one or more inlets for fresh (cool) air intake and one or more outlets for outputting used (warmed) air from the housing 20. In the latter alternative the inlet may need a filter to prevent or at least to restrict impurities such as dust entering the housing 20.

In the following description the closed air circulation is assumed. There may be one or more fans 50—54 inside the housing to improve the air circulation. Figures 2—5 depict some example locations for the fans but it is obvious that in practical applications the number and the location of the fans 50—54 may differ from the examples given in Figures 2—5. In this example embodiment the rotation direction of the fans is selected so that air flow at the back wall 26 of the housing is upwards and at the front wall 25 of the housing is downwards but it can also be the other way around. In other embodiments the direction of air flows may vary according to an application. Arrows within the housing 20 in Figures 2—5 illustrate air flows according to this example embodiment. When air flows at the back wall 26 upwards, possibly forced by the first set of fans 50, at least some of the heat generated by the controlling unit 60 is conducted to the air wherein the temperature of the air rises accordingly and the heat is transferred away from the controlling unit 60. This phenomenon can be called as convection. The air continues to flow towards the top wall 23 of the housing. Near the top wall 23 the air flow turns towards the front wall 25 of the housing. There may be another set of fans 51 which enhance the air flow. Because the display panel 30 and the backlight unit 40 are separate from each other, there is an air channel (the first air channel 101) between the display panel 30 and the backlight unit 40. Thus, a part of

the cooling air can flow through this air channel and increase heat dissipation from the display panel 30 and also from the surface of the light emitting diodes of the backlight unit 40. Therefore, heat generated by the light emitting diodes does not affect so much to the temperature of the display panel 30 compared to the situation in which the display panel 30 and the backlight unit 40 are constructed as one module, with no air channels in between.

A part of the cooling air can also flow in front of the display panel 30, in other words, between the front glass plate 32 and the transparent front plate 21. This air flow may take some heat due to direct sunlight away from the display panel thus reducing the effects of the direct sunlight on the display panel 30.

In another example embodiment depicted in Figure 6 the space between the transparent front plate 21 of the housing and the front glass plate 32 of the display panel 30 may be filled with a transparent medium 21a. In this embodiment there is no air flow between the transparent front plate 21 of the housing and the front glass plate 32 of the display panel 30 but still the cooling air flowing between the display panel 30 and the backlight unit 40 efficiently keeps the temperature of the display panel 30 low enough to prevent damages.

In some example embodiments there may also be a fan 52 or a set of fans on the backside of the housing 20 so that cooling air flows more efficiently between fins of the first heat sink 20 at the back wall 26 of the housing.

A customised display design aims to guarantee optical appearance and faultless operation in high ambient brightness, high temperature and direct sunshine conditions. The present invention enables to produce e.g. rugged outdoor information high brightness TFT LCD display products with IP65 rating having an effective thermal management system. This display application is capable of surviving in simultaneous high temperature and solar radiation conditions. With the help of the structures presented above it is possible to implement super high brightness LED backlighting or other high brightness light sources and to improve the thermal management system so that the information display can survive in almost all weather conditions without any remarkable limitations in the operation.

Claims:

1. An information display (10) comprising:
- a housing (20);
- a display panel (30); and
- a backlight unit (40);

characterised in that the information display (10) further comprises
- a first air channel (101) between the display panel (30) and the backlight unit (40) adapted to receive a first cooling air flow.

2. The information display (10) according to claim 1, **characterised** in that the information display (10) further comprises a second air channel (102) for a second cooling air flow adapted to conduct at least part of the heat generated by the backlight unit (40) outside the information display; wherein the information display (10) is adapted to keep the first cooling air flow separate from the second cooling air flow.

3. The information display (10) according to claim 1 or 2, **characterised** in that the first air channel (101) is a closed loop providing a closed circulation of the first cooling air flow inside the housing (20).

4. The information display (10) according to claim 1, 2 or 3, **characterised** in that the information display (10) further comprises a first heat sink (29) to conduct heat from the first cooling air flow outside the housing (20).

5. The information display (10) according to claim 1, 2, 3 or 4, **characterised** in that the backlight unit (40) is attached with a second heat sink (42) located at least partly in the second air channel (102).

6. The information display (10) according to any of the claims 1 to 5, **characterised** in that the information display (10) further comprises a front plate (21), which is at least partly transparent.

7. The information display (10) according to claim 6, **characterised** in that the information display (10) further comprises a third air channel between the front plate (21) and the display panel (30).

8. The information display (10) according to claim 6 or 7, **characterised** in that the front plate (21) is adapted to filter solar radiation, and to pass through radiation at a visible spectrum.

9. The information display (10) according to any of the claims 1 to 8, **characterised** in that the backlight unit (30) comprises a set of light emitting diodes.

10. The information display (10) according to any of the claims 1 to 9, **characterised** in that the display panel (30) comprises a thin-film transistor liquid crystal display.

11. The information display (10) according to any of the claims 1 to 10, **characterised** in that the information display (10) is adapted for outdoor information display applications.

12. A method for cooling an information display (10) having a housing (20), a display panel (30); and a backlight unit (40), **characterised** in that the method comprises:

- providing a first cooling air flow to a first air channel (101) located between the display panel (30) and the backlight unit (40).

13. The method according to claim 12, **characterised** by

- providing a second cooling air flow to a second air channel (102) for conducting at least part of the heat generated by the backlight unit (40) outside the information display; and
- keeping the first cooling air flow separate from the second cooling air flow.

14. The method according to claim 12 or 13, **characterised** in that the first cooling air flow is provided as a closed circulation inside the housing (20).

15. The method according to claim 12, 13 or 14, **characterised** in that the method further comprises using a first heat sink (29) to conduct heat from the first cooling air flow outside the housing (20).

16. The method according to any of the claims 12 to 15, **characterised** in that the information display (10) further comprises an at least partly

transparent front plate (21), wherein the method further comprises using the space between the front plate (21) and the display panel (30) as a third air channel.

17. The method according to any of the claims 12 to 15, **characterised** in that a set of light emitting diodes is used as the backlight unit (30).

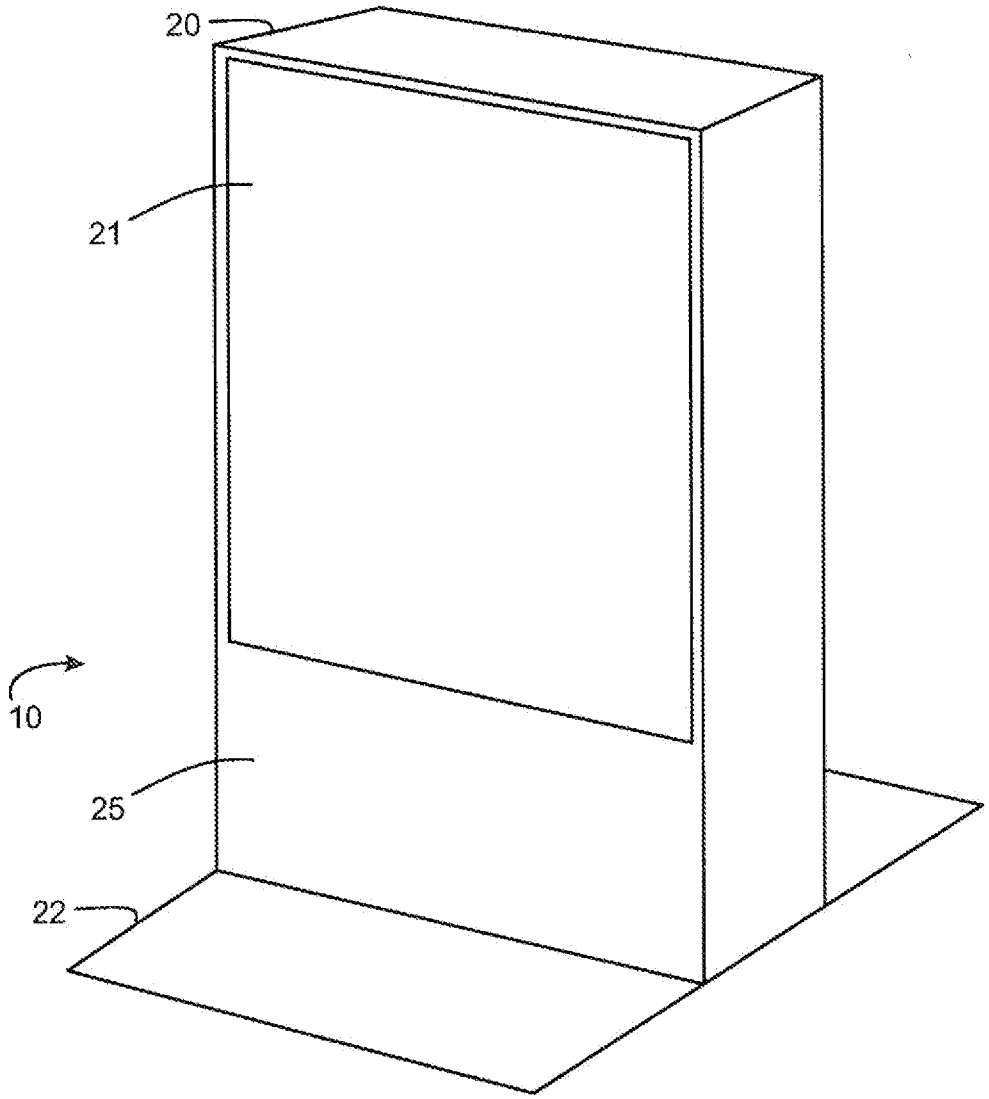

Fig. 1

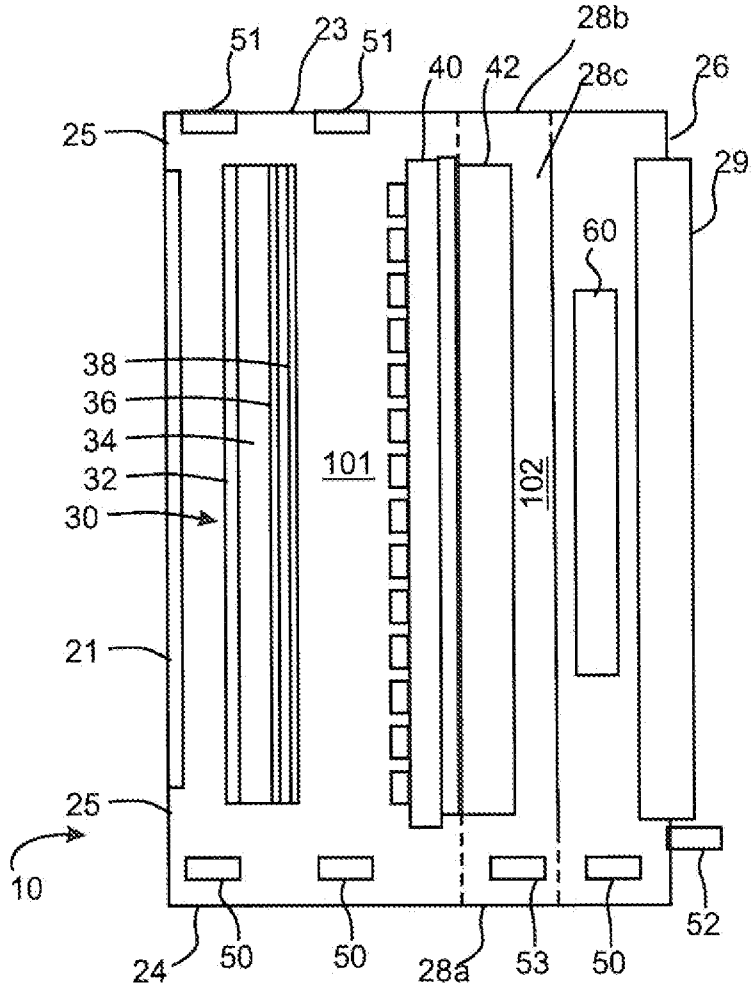
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Fig. 2

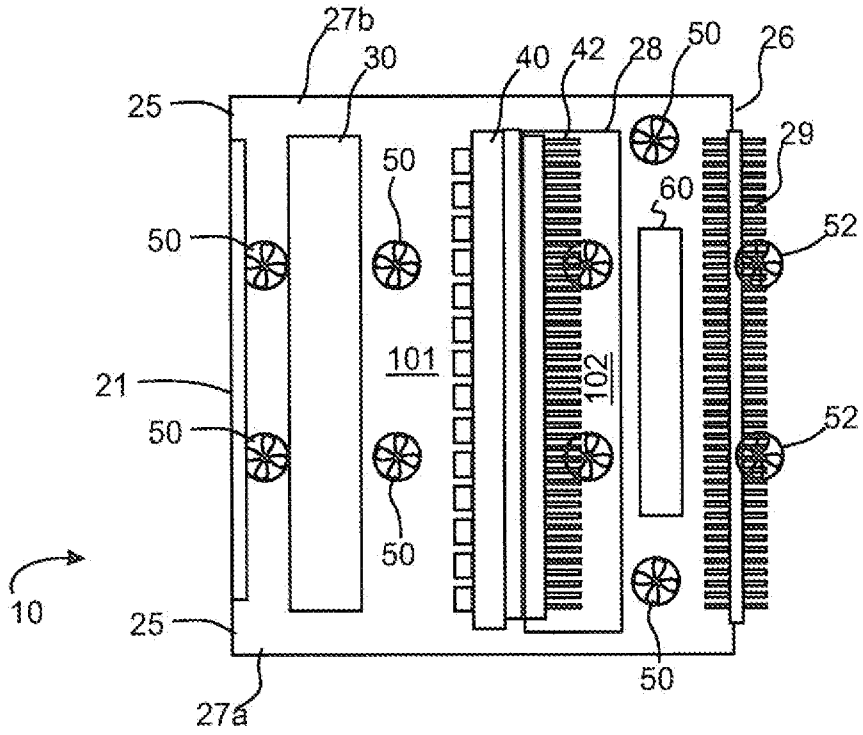
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Fig. 3

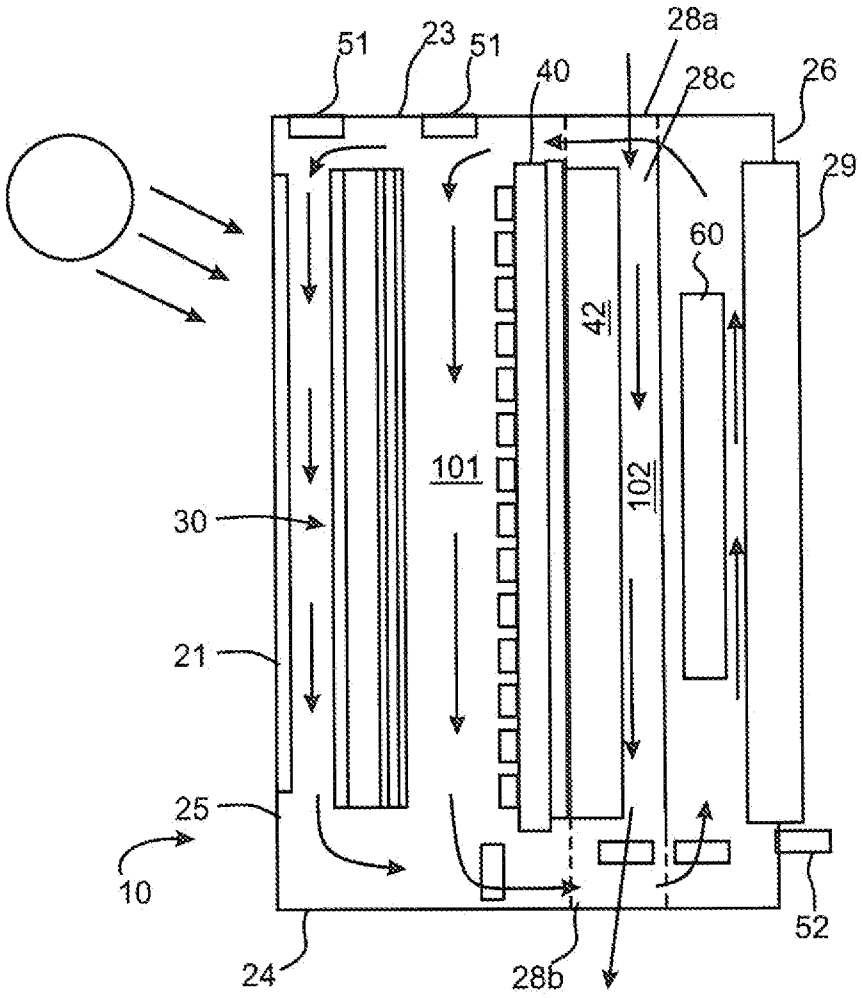
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Fig. 4

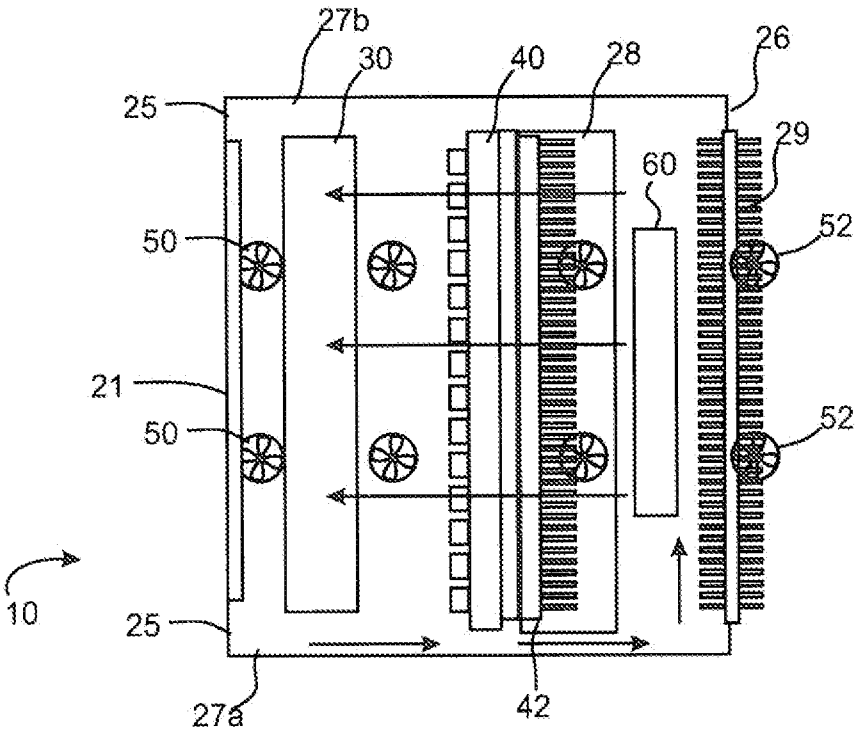
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Fig. 5

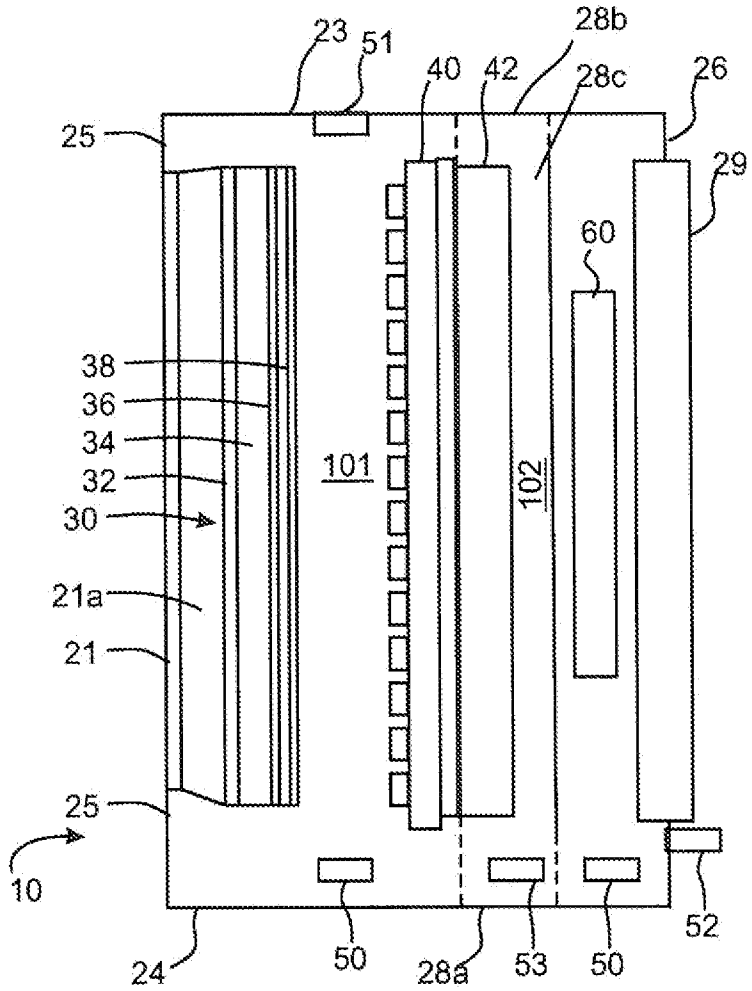
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Fig. 6

INTERNATIONAL SEARCH REPORT

International application No.
PCT/FI2012/050574

A. CLASSIFICATION OF SUBJECT MATTER

See extra sheet

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC: G02F, G09F, H05K

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

FI, SE, NO, DK

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

EPO-Internal, WPI, TXTWOT, TXTJPT, TXTJPS, TXTKRT, INSPEC, XPAIP, XPIEE, XPESP, XPESP2, XPRD, XPI3E, XPIOP

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 2012012300 A1 (DUNN WILLIAM et al.) 19 January 2012 (19.01.2012) abstract; pars. [0003]-[0004], [0008]-[0012], [0027]-[0054]; figs.	1-17
X	WO 2009065125 A2 (MFG RESOURCES INTERNATIONAL IN et al.) 22 May 2009 (22.05.2009) abstract; pars. [0003], [0005]-[0009], [0033]-[0077]; claims; figs. 1-2, 4, 6-9, 16, 17c.	1-2, 5-13, 16-17
X	US 2011019363 A1 (VAHLSING SCOTT et al.) 27 January 2011 (27.01.2011) abstract; pars. [0025]-[0079]; figs. 9, 9a.	1, 4, 6, 8-12, 15, 17
X	US 2012131936 A1 (YOSHIDA TOMONORI et al.) 31 May 2012 (31.05.2012) pars. [0005], [0006], [0020]-[0025]; figs. 1-2.	1, 3-4, 6-12, 14-17
X	EP 1253459 A2 (GILBARCO INC) 30 October 2002 (30.10.2002) abstract; pars. [0001]-[0004], [0007]-[0010], [0015]-[0031]; claims; fig. 1.	1, 3-4, 6-12, 14-17

☒ Further documents are listed in the continuation of Box C. ☒ See patent family annex.

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Date of the actual completion of the international search	Date of mailing of the international search report
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INTERNATIONAL SEARCH REPORT

International application No.
PCT/FI2012/050574

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International application No.
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CLASSIFICATION OF SUBJECT MATTER

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