

embodiment, heat which accumulates on the rear portion of the electronic image assembly 50 may be transferred throughout the channels 60 and removed by ambient gas 210. Preferably, the channels 60 are metallic and even more preferably aluminum. Further, in an exemplary embodiment the channels 60 are in conductive thermal communication with the electronic image assembly 50.

[0040] **FIGURE 4** provides a perspective sectional view along the B-B section line shown in Figure 1B. In this view, the path of the circulating gas 250 can also be observed. The space between the front plate 10 and the electronic image assembly 50 may define a front channel 251, through which the circulating gas 250 may travel in order to remove any accumulation of heat on the front surface of the electronic image assembly 50. The circulating gas 250 is preferably then directed into the heat exchanger 45 where heat may be transferred from the circulating gas 250 to the ambient gas 200. Upon exiting the heat exchanger 45, the circulating gas 250 may be re-directed into the front channel 251. In this way, the heat exchanger 45 and the front channel 251 are placed in gaseous communication with each other.

[0041] The circulating gas 250 may also be directed over various electronic components 7 so that heat may be transferred from the electronic components 7 to the circulating gas 250. The electronic components 7 could be any one of the following but not limited to: power modules, heat sinks, capacitors, motors, microprocessors, hard drives, AC/DC converters, transformers, or printed circuit boards.

[0042] Also shown in this sectional view is the path of the ambient gas 210 travelling down one of the channels 60 behind the electronic image assembly 50. In this embodiment, the ambient gas 210 is forced out of the first manifold 30, across the channels 60, and into the second manifold 35 by manifold fan assembly 211. In other words, each channel 60 preferably has an inlet which is in gaseous communication with the first manifold 30 as well as an exit which is in gaseous communication with the second manifold 35. As shown in this Figure, the paths of the ambient gas 210 and the circulating gas 250 may cross, but it is preferable to keep the two gases from mixing (as the ambient gas 210 may contain particulate or contaminants while the circulating gas 250 can remain substantially free of particulate and contaminants). It may be preferable to keep the circulating gas 250 from having particulate or contaminants

because it travels in front of the electronic image assembly 50. Thus, to keep the image quality from being impaired, it may be desirable to keep the circulating gas 250 clean and prevent it from mixing with the ambient gas 210.

[0043] FIGURE 5 provides a perspective sectional view of insert C shown in Figure 4. As noted above, if practicing an embodiment which uses ambient gas 210 as well as the circulating gas 250, the pathways of the two gases may need to cross over one another and it may be desirable to prohibit them from mixing to prevent contamination of sensitive portions of the display. Here, cross through plate 500 allows the pathways of the two gases to cross over one another without letting them mix together. The cross through plate 500 in this embodiment contains a series of voids which pass through the plate. A first series of voids 550 passes through the cross through plate 500 and allows ambient gas 210 to travel from the first manifold 30 into the channels 60 which run behind the electronic image assembly 50. A second series of voids 525 pass through the cross through plate 500 in a direction substantially perpendicular to that of the first series of voids 550. The second series of voids 525 allows the circulating gas to exit the front channel 251, cross over the ambient gas 210, and continue towards the heat exchanger 45. In this embodiment, a circulating gas fan assembly 255 is used to draw the circulating gas 250 through the front channel 251 and through the heat exchanger 45. Much like the other fan assemblies shown and described here, the circulating gas fan assembly 255 could be placed anywhere within the display, including but not limited to the entrance/exit of the heat exchanger 45 or the entrance/exit of the front channel 251.

[0044] FIGURE 6 provides a perspective sectional view of one embodiment of the cross through plate 500. In this embodiment, the cross through plate 500 is comprised of a plurality of hollow blocks 503 sandwiched between a top plate 501 and bottom plate 502 with sections of the plates 501 and 502 removed to correspond with the hollow sections of the blocks 503. A portion of the top plate 501 has been removed to show the detail of the hollow blocks 503, first series of voids 550, and second series of voids 525. The cross through plate 500 could take on any number of forms and could be constructed in a number of ways. Some other embodiments may use a solid plate where the first and second series of voids 550 and 525 are cut out of the solid plate.

Other embodiments could use two sets of hollow blocks where the hollow sections are perpendicular to each other and the blocks are fastened together. Still other embodiments could use a design similar to those that are taught below for the heat exchanger 45, for example any type of cross-flow heat exchanger design could be used. Thus, an exemplary cross through plate 500 contains two gaseous pathways where the two pathways do not allow the gaseous matter to mix. Here, the first gas pathway would be 525 while the second gas pathway would be 550.

[0045] FIGURE 7 provides an exploded perspective view of one exemplary embodiment of the heat exchanger 45 and fan assembly 46. In this view, the fan assembly 46 is shown removed from its mounted position within the fan housing 51. In this embodiment, the heat exchanger 45 is divided into two portions 47 and 48 where the fan housing 51 is used to provide a gaseous communication between the two portions 47 and 48. Here, the fan assembly 46 is placed between the two portions 47 and 48. While the fan assembly 46 can be placed anywhere so that it draws ambient gas 200 through the heat exchanger 45, it has been found that placing the fan assembly 46 between the two portions of the heat exchanger can provide a number of benefits. First, the volumetric flow rate of the ambient gas 200 through the heat exchanger is high, which results in better cooling capabilities for the heat exchanger 45. Second, the noise produced by the fan assembly 46 can be reduced because the surrounding portions 47 and 48 of the heat exchanger 45 essentially act as a muffler for the fan assembly 46.

[0046] In this embodiment, portion 48 is thinner and longer than portion 47. This was done in order to free up more space within the housing so that additional electronic components could fit within the housing (adjacent to portion 48). As shown, the fan housing 51 may be used to connect two portions of a heat exchanger which may be of different lengths. As shown, portion 48 of the heat exchanger is thinner than the fan housing 51. In an alternative embodiment, both portions 48 and 47 may be thinner than the fan assembly 46 such that a fan housing 51 may be used to provide a sealed gaseous communication between the two portions, even though they are both thinner than the fan assembly 51. This design may be preferable when it is desirable to create the largest possible heat exchanger 45 (for maximum cooling abilities) even though

space is limited. This is of course not required, and other embodiments may have portions which are of equal width and length. Also, although this embodiment uses the fan assembly 46 to drive the ambient gas 200, other embodiments could use a fan assembly placed within the heat exchanger to drive the circulating gas 250 instead and drive the ambient gas 200 with another fan assembly (possibly placed within the heat exchanger or located at the entrance/exit of the heat exchanger). Some exemplary embodiments may place fans within the heat exchanger 45 to drive both the ambient gas 200 and circulating gas 250.

[0047] The ambient gas 200 travels through a first pathway (or plurality of pathways) of the heat exchanger 45 while the circulating gas 250 travels through a second pathway (or plurality of pathways) of the heat exchanger 45. Although not required, it is preferable that the circulating gas 250 and ambient gas 200 do not mix. This may prevent any contaminants and/or particulate that is present within the ambient gas 200 from harming the interior of the display. In a preferred embodiment, the heat exchanger 45 would be a cross-flow heat exchanger. However, many types of heat exchangers are known and can be used with any of the embodiments herein. The heat exchanger 45 may be a cross-flow, parallel flow, or counter-flow heat exchanger. In an exemplary embodiment, the heat exchanger 45 would be comprised of a plurality of stacked layers of thin plates. The plates may have a corrugated, honeycomb, or tubular design, where a plurality of channels/pathways/tubes travel down the plate length-wise. The plates may be stacked such that the directions of the pathways are alternated with each adjacent plate, so that each plate's pathways are substantially perpendicular to the pathways of the adjacent plates. Thus, ambient gas or circulating gas may enter an exemplary heat exchanger only through plates whose channels or pathways travel parallel to the path of the gas. Because the plates are alternated, the circulating gas and ambient gas may travel in plates which are adjacent to one another and heat may be transferred between the two gases without mixing the gases themselves (if the heat exchanger is adequately sealed, which is preferable but not required).

[0048] In an alternative design for a heat exchanger, an open channel may be placed in between a pair of corrugated, honeycomb, or tubular plates. The open channel may travel in a direction which is perpendicular to the pathways of the adjacent plates. This

open channel may be created by running two strips of material or tape (esp. very high bond (VHB) tape) between two opposite edges of the plates in a direction that is perpendicular to the direction of the pathways in the adjacent plates. Thus, gas entering the heat exchanger in a first direction may travel through the open channel (parallel to the strips or tape). Gas which is entering in a second direction (substantially perpendicular to the first direction) would travel through the pathways of the adjacent plates).

[0049] Other types of cross-flow heat exchangers could include a plurality of tubes which contain the first gas and travel perpendicular to the path of the second gas. As the second gas flows over the tubes containing the first gas, heat is exchanged between the two gases. Obviously, there are many types of cross-flow heat exchangers and any type would work with the embodiments herein.

[0050] An exemplary heat exchanger may have plates where the sidewalls have a relatively low thermal resistance so that heat can easily be exchanged between the two gases. A number of materials can be used to create the heat exchanger. Preferably, the material used should be corrosion resistant, rot resistant, light weight, and inexpensive. Metals are typically used for heat exchangers because of their high thermal conductivity and would work with these embodiments. However, it has been discovered that plastics and composites can also satisfy the thermal conditions for electronic displays. An exemplary embodiment would utilize polypropylene as the material for constructing the plates for the heat exchanger. It has been found that although polypropylene may seem like a poor thermal conductor, the large amount of surface area relative to a small sidewall thickness, results in an overall thermal resistance that is low. Thus, an exemplary heat exchanger would be made of plastic and would thus produce a display assembly that is thin and lightweight. Specifically, corrugated plastic may be used for each plate layer where they are stacked together in alternating fashion (i.e. each adjacent plate has channels which travel in a direction perpendicular to the surrounding plates).

[0051] **FIGURE 8** provides a perspective sectional view of another embodiment which uses a flow of circulating gas 350 through the backlight cavity of a liquid crystal display (LCD) 300. In this embodiment, a LCD 300 and an associated backlight 320 are used

as the electronic image assembly. A backlight wall 330 may enclose the area between the LCD 300 and the backlight 320 in order to create a backlight cavity. Typically, the backlight cavity is closed to prevent contaminants/particulate from entering the backlight cavity and disrupting the optical/electrical functions of the backlight 320. However, as discussed above the exemplary embodiments may use a clean gaseous matter for the circulating gases which could now be used to ventilate the backlight cavity in order to cool the backlight 320 and even the rear portion of the LCD 300. An opening 340 can be placed in the backlight wall 330 to allow circulating gas 350 to flow through the backlight cavity. A fan assembly 360 may be used to draw the circulating gas 350 through the backlight cavity. In an exemplary embodiment there would be an opening on the opposing backlight wall (on the opposite side of the display as shown in this figure) so that circulating gas 350 could easily flow through the backlight cavity. In this way, the backlight cavity is placed in gaseous communication with the heat exchanger 45.

[0052] **FIGURE 9** provides a perspective sectional view of an exemplary embodiment which uses a flow of circulating gas 350 through the backlight cavity in addition to the flow of circulating gas 250 through the front channel 251 (the area defined between the LCD 300 and front plate 10). Circulating fan assembly 255 may be placed so that it can draw circulating gas 350 through the backlight cavity as well as circulating gas 250 through the front channel 251. As discussed above, the circulating gases 250 and 350 are preferably forced through the heat exchanger 45 (not shown in this figure) so that they may be cooled by the ambient gas 200 (also not shown in this figure). In this way, both the front channel 251 and the backlight cavity are placed in gaseous communication with the heat exchanger 45.

[0053] Also shown in Figure 9 is the optional additional flow of ambient gas 210 which may travel immediately behind the electronic image assembly (in this embodiment backlight 320). Once travelling through the first manifold 30, the ambient gas 210 may pass through the channels 60 in order to remove heat from the backlight 320 and even the channels 60 themselves (if they are thermally conductive). The manifold fan assembly 211 may be used to draw the ambient gas 210 into the first manifold 30 and through the channels 60. Again, the cross through plate 500 may be

used to allow the circulating gases 350 and 250 to cross paths with the ambient gas 210 without letting the two gases mix.

[0054] In an exemplary embodiment, the backlight 320 would contain a plurality of LEDs mounted on a thermally conductive substrate (preferably a metal core PCB). On the surface of the thermally conductive substrate which faces the channels 60 there may be a thermally conductive plate which may be in thermal communication with the channels 60. In an exemplary embodiment, the thermally conductive plate would be metallic and more preferably aluminum and the thermal communication between the channels 60 and the backlight 320 would be conductive thermal communication.

[0055] As noted above, many electronic image assemblies (especially LEDs, LCDs, and OLEDs) may have performance properties which vary depending on temperature. When 'hot spots' are present within an image assembly, these hot spots can result in irregularities in the resulting image which might be visible to the end user. Thus, with the embodiments described herein, the heat which may be generated by the image assembly (sometimes containing a backlight assembly) can be distributed (somewhat evenly) throughout the channels 60 and thermally-conductive surfaces to remove hot spots and cool the backlight and/or electronic image assembly.

[0056] The circulating gases 250 and 350, ambient gas 200, and optional ambient gas 210 can be any number of gaseous matters. In some embodiments, air may be used as the gas for all. As well known by those of ordinary skill in the art, air typically contains some amount of water vapor. It should be noted that the use of the term 'gas' herein does not designate pure gas and that it is specifically contemplated that any of the gaseous matters described herein may contain some amount of impurities including but not limited to water vapor. Preferably, because the circulating gases 250 and 350 may travel in front of the image assembly and backlight respectively, they should be substantially clear, so that they will not affect the appearance of the image to a viewer. The circulating gases 250 and 350 should also preferably be substantially free of contaminants and/or particulate in order to prevent an adverse effect on the image quality and/or damage to the internal electronic components. It may sometimes be preferable to keep ambient gases 200 and 210 from having contaminants as well. Filters may be used to help reduce the particulate within ambient gases 200 and 210.

Filters could be placed near the inlet aperture 24 so that ambient gases 200 and/or 210 could be drawn through the filter. However, in an exemplary embodiment the display may be designed so that contaminants could be present within the ambient gases 200 and 210 but this will not harm the display. In these embodiments, the heat exchanger 45, manifolds 30 and 35, channels 60, and any other pathway for ambient or circulating gas should be properly sealed so that any contaminants in the ambient gas would not enter sensitive portions of the display. Thus, in these exemplary embodiments, ambient air may be ingested for the ambient gases 200 and 210, even if the ambient air contains contaminants or particulate. This can be particularly beneficial when the display is used in outdoor environments or indoor environments where contaminants are present in the ambient air.

[0057] The cooling system may run continuously. However, if desired, temperature sensing devices (not shown) may be incorporated within the electronic display to detect when temperatures have reached a predetermined threshold value. In such a case, the various cooling fans may be selectively engaged when the temperature in the display reaches a predetermined value. Predetermined thresholds may be selected and the system may be configured to advantageously keep the display within an acceptable temperature range. Typical thermostat assemblies can be used to accomplish this task. Thermocouples may be used as the temperature sensing devices.

[0058] It is to be understood that the spirit and scope of the disclosed embodiments provides for the cooling of many types of electronic image assemblies. As used herein, the term 'electronic image assembly' is any electronic assembly for creating an image. At this time this, these are LCD (all types), light emitting diode (LED), organic light emitting diode (OLED), field emitting display (FED), light emitting polymer (LEP), organic electro luminescence (OEL), plasma displays, and any thin/flat panel electronic image assembly. Furthermore, embodiments may be used with displays of other types including those not yet discovered. In particular, it is contemplated that the system may be well suited for use with full color, flat panel OLED displays. Exemplary embodiments may also utilize large (55 inches or more) LED backlit, high definition liquid crystal displays (LCD). While the embodiments described herein are well suited for outdoor environments, they may also be appropriate for indoor

applications (e.g., factory/industrial environments, spas, locker rooms) where thermal stability of the display may be a concern.

[0059] As is well known in the art, electronic displays can be oriented in a portrait manner or landscape manner and either can be used with the embodiments herein.

[0060] Having shown and described preferred embodiments, those skilled in the art will realize that many variations and modifications may be made to affect the described embodiments and still be within the scope of the claimed invention. Additionally, many of the elements indicated above may be altered or replaced by different elements which will provide the same result and fall within the spirit of the claimed invention. It is the intention, therefore, to limit the invention only as indicated by the scope of the claims.

CLAIMS

1. An assembly for cooling an electronic image assembly within a housing having an inlet aperture for ambient gas, exit aperture for ambient gas, and internal cavity for circulating gas, the assembly comprising:
 - a first portion of a heat exchanger which accepts ambient gas from the inlet aperture;
 - a second portion of a heat exchanger which accepts ambient gas from the first portion;
 - an first fan positioned between the first and second portions which pulls ambient gas through the first portion and pushes ambient gas through the second portion;
 - a second fan which forces circulating gas through the internal cavity and at least one of the heat exchanger portions;
 - a plurality of channels placed behind the electronic image assembly, each channel having an inlet and exit;
 - a first manifold in gaseous communication with the inlet of each channel;
 - a second manifold in gaseous communication with the exit of each channel; and
 - a third fan positioned to force ambient gas through the channels.
2. A system for cooling an electronic image assembly with ambient gas, the system comprising:
 - a plurality of channels placed behind the electronic image assembly, each channel having an inlet and exit;
 - a first manifold in gaseous communication with the inlet of each channel;
 - a second manifold in gaseous communication with the exit of each channel; and
 - a fan positioned to force ambient gas through the channels.
3. The cooling system of claim 2 wherein:
 - the channels are in thermal communication with the electronic image assembly.
4. The cooling system of claim 2 wherein:

the first and second manifolds are placed along a pair of vertical edges of the electronic image assembly.

5. The cooling system of claim 2 wherein:
the fan is placed within either the first or second manifold.
6. The cooling system of claim 2 wherein:
the channels have a rectangular cross-section.
7. The cooling system of claim 2 wherein:
the channels are arranged in horizontal rows.
8. The cooling system of any one of claims 2-7 wherein:
the cooling channels are metallic.
9. The cooling system of claim 2 further comprising:
a front plate placed in front of the electronic image assembly, the space between the front plate and the electronic image assembly defining a front channel;
a circulating fan position to force circulating gas through the front channel; and
a pass through plate having a first pathway for ambient gas travelling through the plurality of channels behind the electronic image assembly and a second pathway for circulating gas travelling through the front channel.
10. The cooling system of claim 9 wherein:
the first and second gas pathways are substantially perpendicular.
11. The cooling system of claim 9 wherein:
the first and second gas pathways do not allow the ambient gas and circulating gas to mix.
12. The cooling system of claim 9 wherein:

the pass through plate is positioned adjacent to the first manifold.

13. An electronic display assembly comprising:
 - a housing;
 - an electronic image assembly contained within the housing and having a pair of opposing edges;
 - an inlet aperture in the housing for accepting ambient gas;
 - an exhaust aperture in the housing for exhausting ambient gas;
 - a plurality of channels placed behind the electronic image assembly;
 - a first manifold placed along one of the opposing edges which accepts ambient gas from the inlet aperture and distributes ambient gas to the plurality of channels;
 - a second manifold placed along the opposite edge as the first manifold which accepts ambient gas from the channels and directs it towards the exhaust aperture; and
 - a fan which forces the ambient gas through the channels.
14. The electronic display assembly of claim 13 wherein:
 - the fan is placed within the first manifold.
15. The electronic display assembly of claim 13 wherein:
 - the housing contains a top and bottom portion;
 - the inlet aperture is located at the top portion of the housing; and
 - the exhaust aperture is located at the bottom portion of the housing.
16. The electronic display assembly of claim 13 wherein:
 - the first and second manifolds are oriented vertically; and
 - the plurality of channels are oriented horizontally.
17. The electronic display assembly of any one of claims 13-16 wherein:

the channels are in conductive thermal communication with the electronic image assembly.

18. The electronic display assembly of claim 13 further comprising:
- a transparent front plate placed in front of the electronic image assembly, the space between the front plate and the electronic image assembly defining a front channel;
 - a circulating fan position to force circulating gas through the front channel; and
 - a first pass through plate adjacent to the first manifold and a second pass through plate adjacent to the second manifold, each pass through plate having a first pathway for ambient gas travelling through the plurality of channels behind the electronic image assembly and a second pathway for circulating gas travelling through the front channel.
19. The cooling system of claim 18 wherein:
- the first and second gas pathways are substantially perpendicular.
20. An electronic display assembly comprising:
- a housing having a top portion, bottom portion, and a pair of vertical edges;
 - an electronic image assembly contained within the housing;
 - an inlet aperture in the housing for accepting ambient gas;
 - an exhaust aperture in the housing for exhausting ambient gas;
 - a plurality of metallic channels placed behind and in conductive thermal communication with the electronic image assembly;
 - a first manifold placed along one of the vertical edges which accepts ambient gas from the inlet aperture and distributes ambient gas to the plurality of channels;
 - a second manifold placed along the opposite vertical edge as the first manifold which accepts ambient gas from the channels and directs it towards the exhaust aperture; and

a plurality of fans within the first manifold which draw the ambient gas into the inlet aperture and through the channels.

21. The electronic display assembly of claim 20 wherein:
the electronic image assembly is a liquid crystal display.
22. An assembly for cooling an electronic image assembly within a housing having an inlet aperture for ambient gas, exit aperture for ambient gas, and internal cavity for circulating gas, the assembly comprising:
a first portion of a heat exchanger which accepts ambient gas from the inlet aperture;
a second portion of a heat exchanger which accepts ambient gas from the first portion;
an first fan positioned between the first and second portions which pulls ambient gas through the first portion and pushes ambient gas through the second portion; and
a second fan which forces circulating gas through the internal cavity and at least one of the heat exchanger portions.
23. The cooling assembly of claim 22 wherein:
the first fan also draws ambient gas through the inlet aperture.
24. The cooling assembly of claim 23 wherein:
the first fan also pushes ambient gas through the exit aperture.
25. The cooling assembly of claim 22 further comprising:
an electronic component placed within the path of the circulating gas.
26. The cooling assembly of claim 25 wherein:
the electronic component is a power module.

27. The cooling assembly of claim 22 wherein:
the heat exchanger portions are comprised of corrugated layers.
28. The cooling assembly of claim 22 wherein:
the heat exchanger portions are cross-flow heat exchanger portions.
29. An assembly for cooling an electronic image assembly within a housing having an inlet aperture for ambient gas, exit aperture for ambient gas, and internal cavity for circulating gas, the assembly comprising:
a heat exchanger having first and second gas pathways;
an first fan placed within the heat exchanger to draw ambient gas through the inlet aperture and the first gas pathway of the heat exchanger; and
a second fan placed to draw circulating gas through the internal cavity and the second gas pathway of the heat exchanger.
30. The cooling assembly of claim 29 wherein:
the first fan comprises an inlet side and exhaust side such that a portion of the heat exchanger is adjacent to the inlet side and a further portion of the heat exchanger is adjacent to the exhaust side.
31. The cooling assembly of claim 29 wherein:
the internal cavity comprises a front channel defined by the space between the electronic image assembly and a transparent front plate.
32. The cooling assembly of claim 29 wherein:
the first fan also forces the ambient gas out the exit aperture.
33. The cooling assembly of claim 29 further comprising:
an electronic component placed within the path of the circulating gas.
34. The cooling assembly of claim 33 wherein:

the electronic component is a power module.

35. The cooling assembly of claim 29 wherein:

the heat exchanger is comprised of corrugated layers.

36. The cooling assembly of claim 29 wherein:

the heat exchanger is a cross-flow heat exchanger.

37. An electronic display assembly comprising:

a housing having an inlet aperture and exit aperture for ambient gas;

an electronic image assembly within the housing;

a transparent front plate in front of the electronic image assembly, the space between the transparent front plate and the electronic image assembly defining a channel;

a heat exchanger in gaseous communication with the channel, the heat exchanger comprising two portions, each portion having first and second gas pathways, where the first gas pathways are in gaseous communication with the inlet and exit apertures and the second gas pathways are in gaseous communication with the channel;

a first fan assembly placed between the two portions of the heat exchanger to force ambient gas through the first gas pathways; and

a second fan assembly positioned to force gas through the channel and the second gas pathways.

38. The electronic display assembly of claim 37 further comprising:

a power module placed within the path of the circulating gas.

39. The electronic display assembly of claim 37 wherein:

the electronic image assembly is a liquid crystal display.

40. The electronic display assembly of claim 37 wherein:

the electronic image assembly is an OLED display.

41. The electronic display assembly of claim 37 wherein:

the heat exchanger is a cross-flow heat exchanger comprised of corrugated layers.

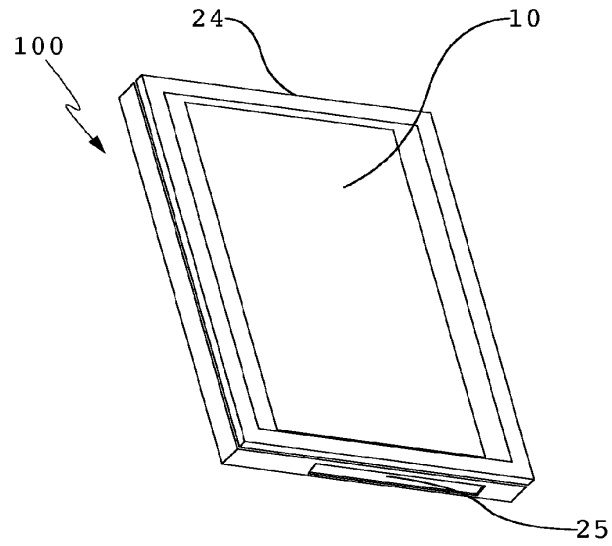


FIG - 1A

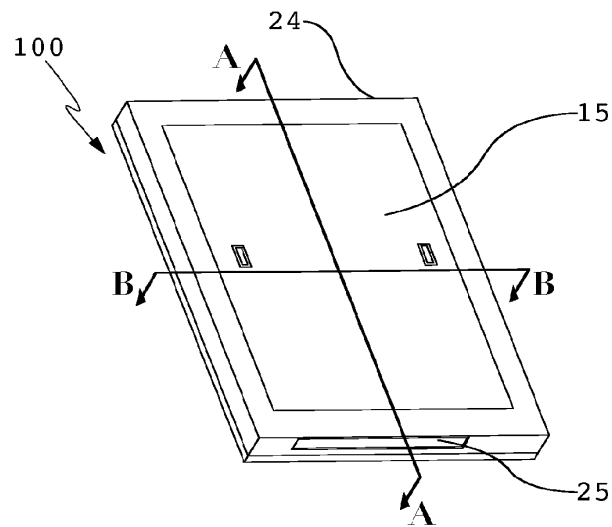


FIG - 1B

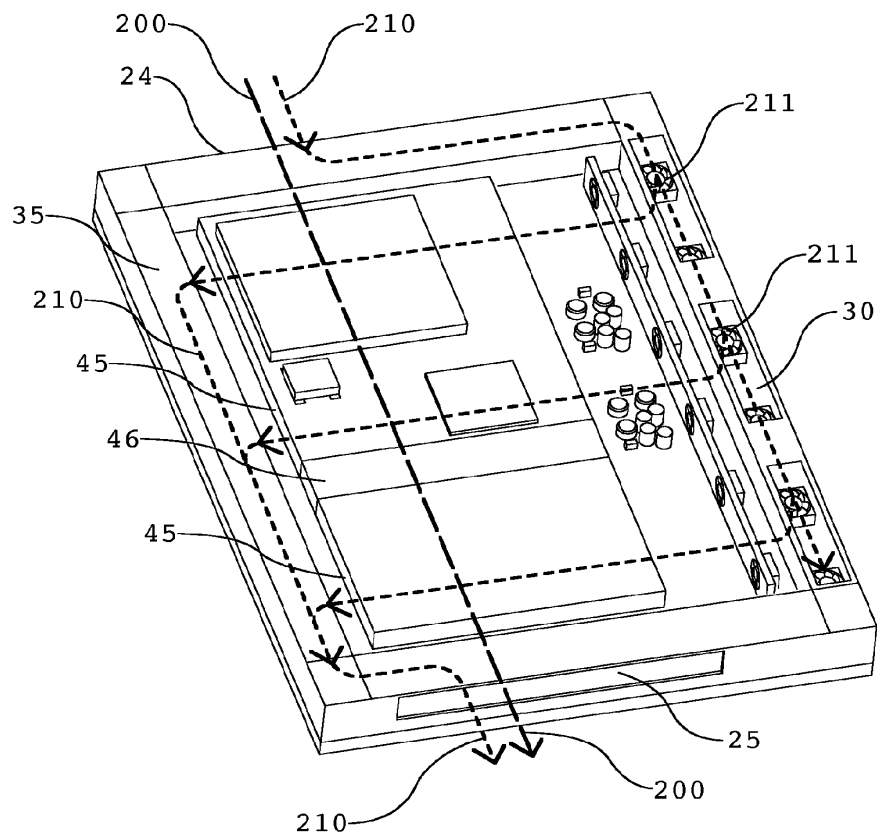


FIG - 2

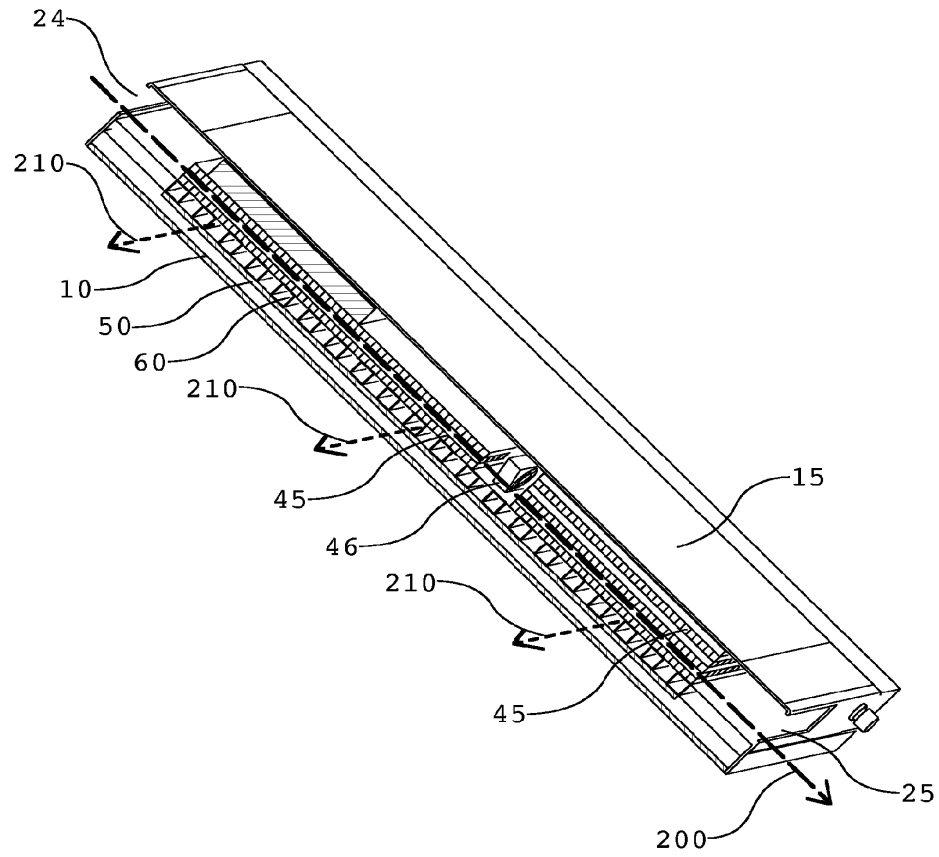


FIG - 3

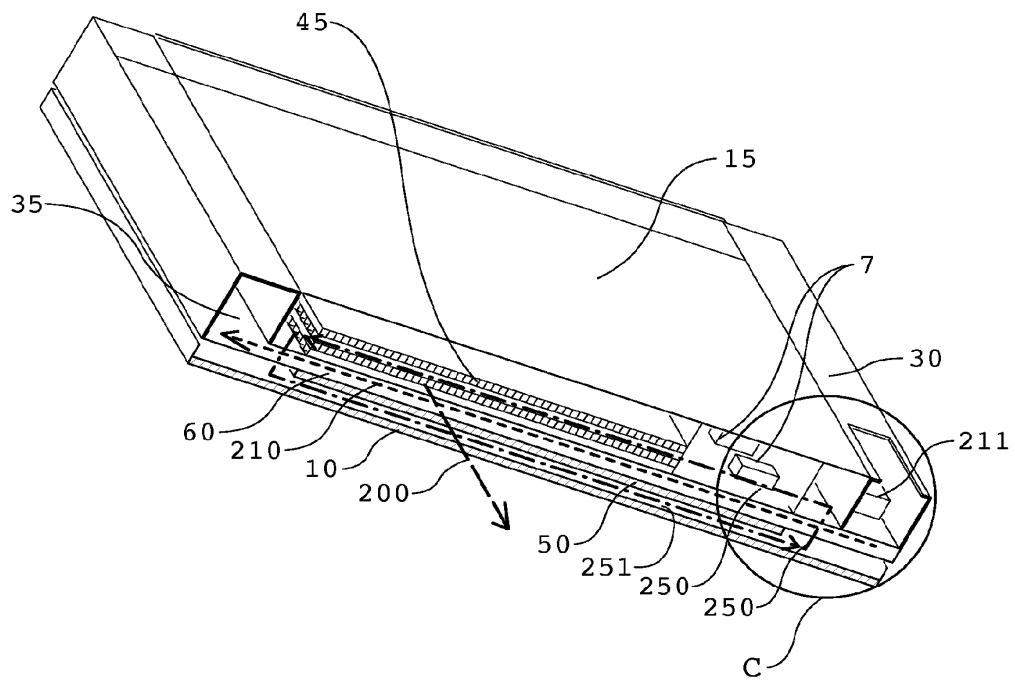


FIG - 4

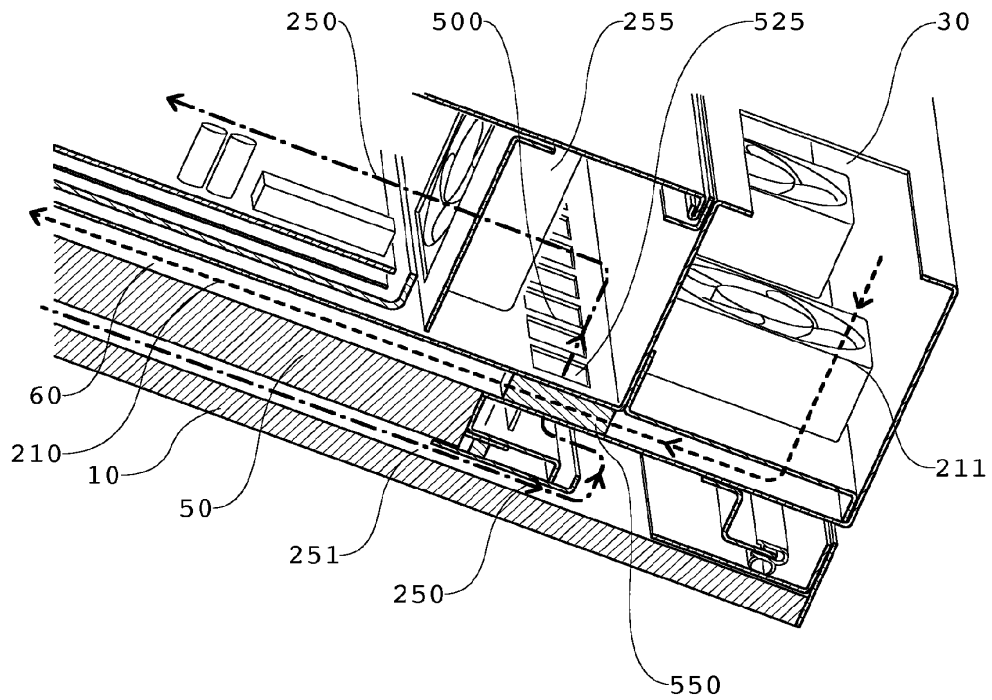


FIG - 5

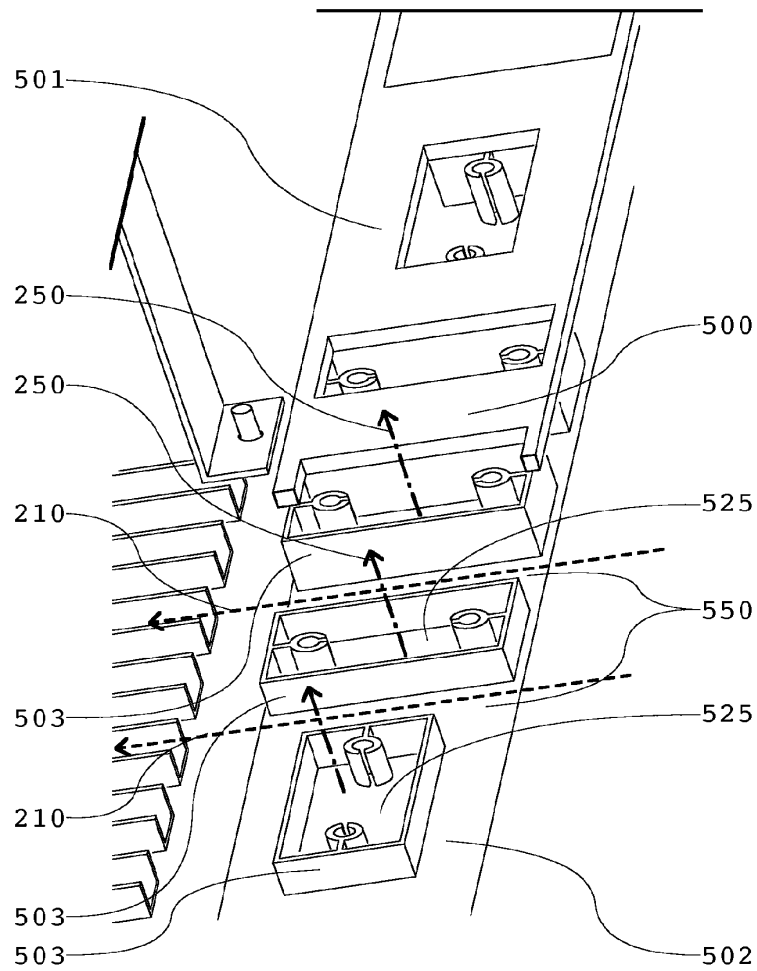


FIG - 6

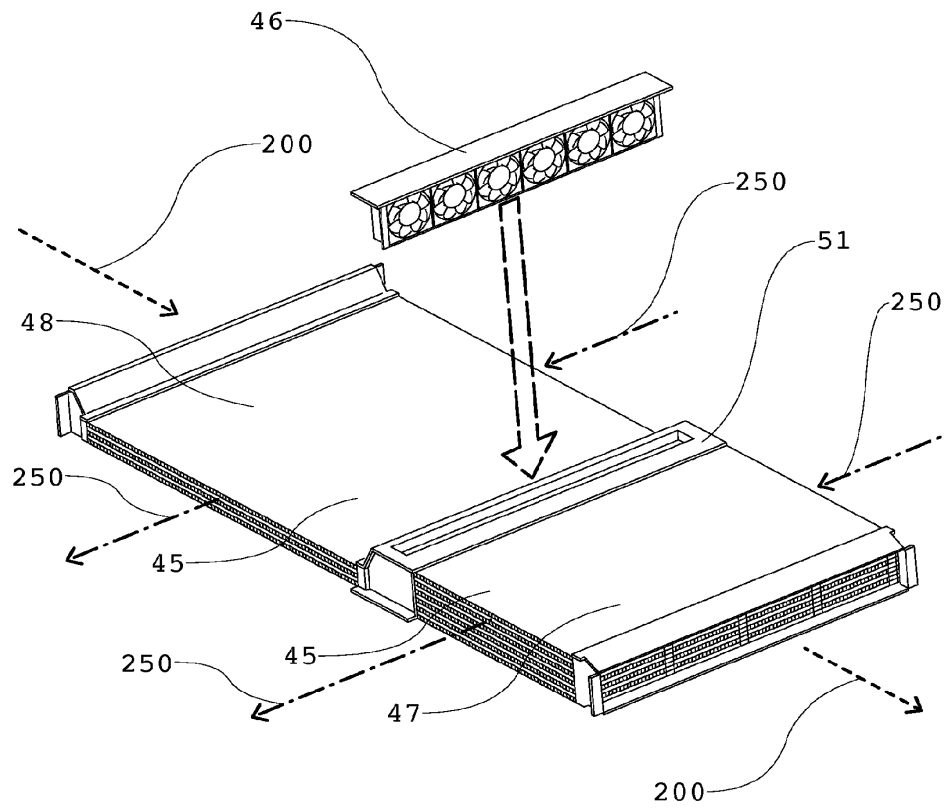


FIG - 7

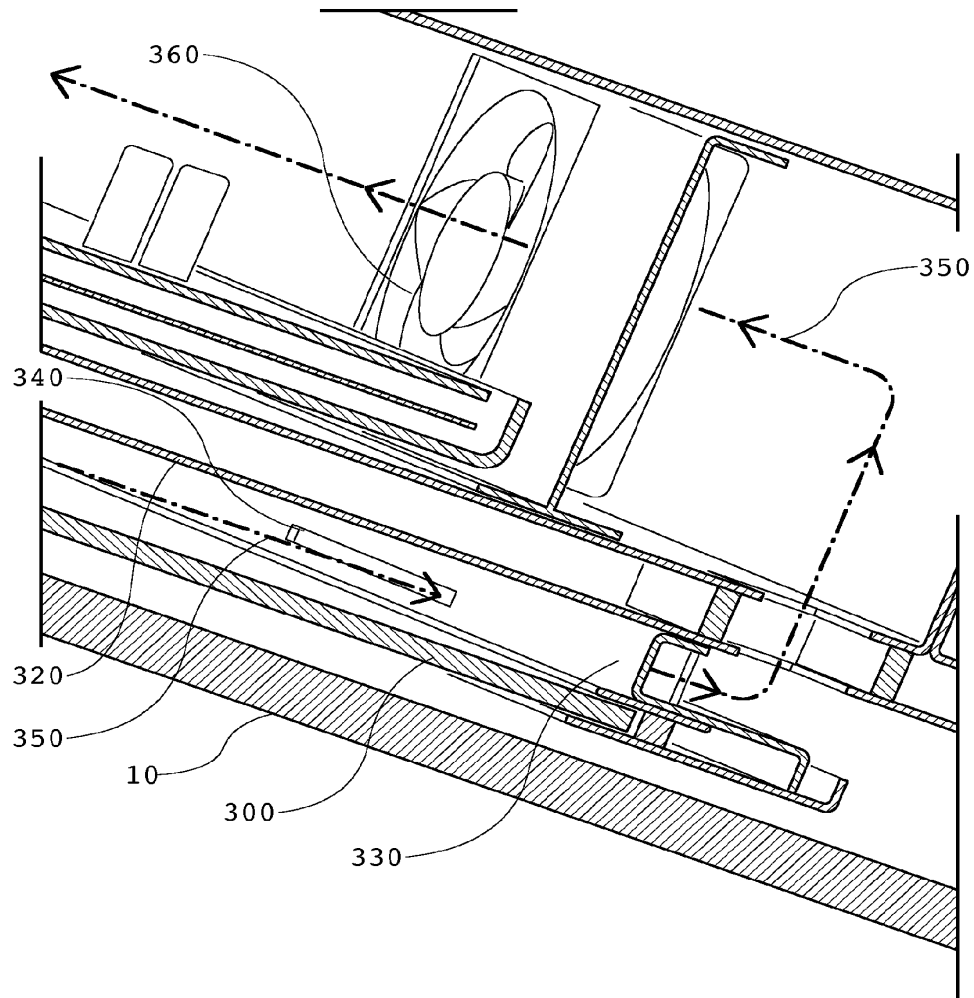


FIG - 8



Espacenet

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Heat radiation module for display card

Inventor(s): XIE XINMAO [CN] ± (XINMAO XIE)
Applicant(s): ADDA CORP [CN] ± (ADDA CORPORATION)
Classification: - **international:** **G06F1/20;** (IPC1-7): G06F1/20
- **cooperative:**
Application number: CN2004259817U 20040521
Priority number(s): CN2004259817U 20040521

Abstract of CN2702363 (Y)

The utility model relates to a heat radiation module for a display card which is a heat radiation module which can effectively decrease the operating temperature of the display card. A first heat radiation fin part and a second heat radiation fin part are arranged on the heat radiation module for a display card. A concave holding fan part is arranged between the first heat radiation fin part and the second heat radiation fin part. At least one radiation fan is vertically arranged in the holding fan part. The height of the heat radiation module can be effectively decreased because the radiation fan is deeply arranged in the heat radiation module. When the radiation fan rotates, the convection current between the thermal current in the first heat radiation fin part and the second heat radiation fin part and the outside air can be accelerated. The heat on the heat radiation module is quickly emitted. The radiation efficiency of the display card is raised.

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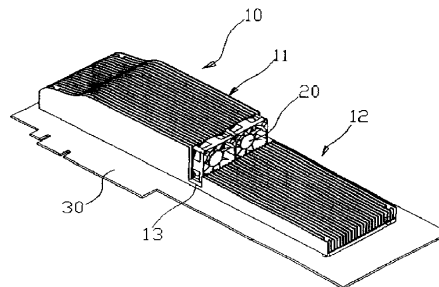
代理人 党晓林

权利要求书 1 页 说明书 5 页 附图 7 页

[54] 实用新型名称 显示卡散热模组

[57] 摘要

本实用新型涉及一种显示卡散热模组，其作为一种能有效降低显示卡作业时温度的散热模组，该显示卡散热模组上设有一第一散热鳍部与一第二散热鳍部，该第一散热鳍部与第二散热鳍部间设有一凹入的置扇部，该置扇部中立设有至少一散热风扇，如此一来，可因散热风扇深入安装在散热模组中，不但能有效减低散热模组的高度，且使散热风扇转动时，可加速第一、二散热鳍部中的热气流与外界的空气对流，而使散热模组上的热迅速散发出去，进而提升该显示卡的散热效率。



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1. 一种显示卡散热模组，包含一散热器及一散热风扇；其特征在于，该散热器，具有一第一散热鳍部与一第二散热鳍部，该第一散热鳍部与该第二散热鳍部由一凹入置扇部相区隔；该散热风扇，立设于该置扇部。
- 5 2. 根据权利要求 1 所述的显示卡散热模组，其特征在于，该第一散热鳍部由一片以上的散热鳍片所构成。
3. 根据权利要求 1 所述的显示卡散热模组，其特征在于，该第二散热鳍部由一片以上的散热鳍片所构成。
4. 根据权利要求 2 或 3 所述的显示卡散热模组，其特征在于，该散
- 10 热鳍片为由铝挤型制法所制得的鳍片结构。
5. 根据权利要求 2 或 3 所述的显示卡散热模组，其特征在于，该散热鳍片为由堆叠法所制得的鳍片结构。
6. 根据权利要求 2 或 3 所述的显示卡散热模组，其特征在于，该散热鳍片为以铝合金材质制成的鳍片结构。
- 15 7. 根据权利要求 2 或 3 所述的显示卡散热模组，其特征在于，该散热鳍片为由铜合金材质制成的鳍片结构。
8. 根据权利要求 1 所述的显示卡散热模组，其特征在于，该第一散热鳍部高于该第二散热鳍部。

显示卡散热模组

技术领域

- 本实用新型涉及一种显示卡散热模组，尤指一种应用于显示卡上的散热模组，其藉由将散热风扇立于相对的第一、二散热鳍部间，而使该散热风扇所产生的气流能有效带走显示卡上所产生的热源。

背景技术

- 在台湾成为举世闻名的电脑王国后，国内各企业无不克尽使命共同创造台湾奇迹，尤其，在电脑硬件的这个领域之中，国内企业也持续加强研发能力与产品竞争力，但是，随着CPU或显示卡的运算能力大增之下，电脑主机内部有关散热元件的提升是否跟得上目前的需求呢？实在难以令所有人百分之百的心服能跟得上，以致于让众多的使用者对电脑内部的散热效率打上一个大问号，其实，针对电脑的散热效率而言，是影响相关机件（如CPU、显示卡或其它适配卡等）的使用寿命、处理效能与稳定性的，因为，当这些相关机件的温度过高时，常会衍生出一些使用寿命降低、处理效能不佳与稳定性锐减的后果，所以，若要相关机件能够正常运作而达到一定的效能时，则对于这些机件的作业温度一定要严加控制，绝不能使作业温度过高而对使用者不利，以下举现有的技术来说明。

- 请参阅图1所示，为习知技术的示意图，如图所示的散热器100包含复数个散热鳍片110、一导热管120与一散热风扇130，其主要是将热源所产生的高温藉由该导热管120传导至不同之处的散热鳍片110，并且，利用该散热风扇130所产生的气流来使该局部的复数个散热鳍片110的温度得以降低。

- 请参阅图2、2a所示，为另一习知技术的示意图，该散热模组200，

其主要包含散热风扇 210 与复数的散热鳍片 220，且该散热鳍片 220 成环状而围绕于该散热风扇 210 的外围，利用该散热风扇 210 所产生的气流来降低散热鳍片 220 的温度。

经由所述先前技术的说明后应可得，设计人认为若是利用一导热管来传导热源至分布不同处的散热鳍片，则会因导热管再次加工使得导热管的品质稳定度降低及散热效率不佳且制作成本增加；或者，将多数的散热鳍片成环状而围绕于该散热风扇的外围时，则该散热风扇必须提供较大的风力，但该散热鳍片的有效散热表面积也相对会缩小，反而不利于整体的散热效率的提升。另外，运用导热管之后，虽能将热能传达至他处并因而增加散热面积，但是，该导热管的管内呈真空状，该导热管经过多次加工后，其导热效能将大为降低，并且，该导热管的制造费用较高。

发明内容

有鉴于此，设计人欲提供一种显卡散热模组来有效降低显卡的作业温度，并且达成先前技术所未提供的功效。

本实用新型的主要目的在于提供一种显卡散热模组，其包含：一散热器，该散热器上设有一第一散热鳍部与一第二散热鳍部，且利用一置扇部将该第一散热鳍部与该第二散热鳍部加以区隔；以及至少一散热风扇，恰固设于该置扇部；藉由上述各元件的连结，令该散热风扇实施运转时，可因散热风扇立于第一、二散热鳍部间凹陷的置扇部中，不但能有效降低整个散热模组的高度，且在散热风扇两侧面对扇叶的第一、二散热鳍部，可藉由风力得到该散热风扇的吸风或排风的气流，进而提高散热效率，降低显卡的温度。

本实用新型的另一目的，在于提供一种显卡散热模组，其散热鳍部可藉由铝挤型制法与堆叠法制得，而该散热鳍部可为铜系合金或铝系合金，以提升热能的传导与热能的消散效率。

本实用新型的功效在于：显示卡的效能提升、显示卡的寿命增加以及使用者的总付出成本减少。以及，藉由本实用新型的功效而衍生的优点在于电脑的整体效率提升、显示卡的购置成本降低。

5 附图说明

图 1 为习知技术的示意图。

图 2 为另一习知技术的示意图。

图 2a 为另一习知技术的实施时的示意图。

图 3 为本实用新型的外观立体图。

10 图 4 为本实用新型的分解立体图。

图 5 为本实用新型的俯视图。

图 6 为本实用新型的右侧示意图。

图 7 为本实用新型的正视图。

图 8 为本实用新型实施状态的风力流向示意图。

15 图号说明：

10. . . 散热器

11. . . 第一散热鳍部

12. . . 第二散热鳍部

13. . . 置扇部

20 14. . . 散热鳍片

20. . . 散热风扇

30. . . 显示卡

D. . . 风向 (Direction of Air)

25 具体实施方式

本实用新型为一种显示卡散热模组，请参阅图 3、4 所示，本实用新

型为一种装置在显示卡 30 上的散热模组 10，该散热模组上设有一第一散热鳍部 11 与一第二散热鳍部 12，并且，利用一凹入的置扇部 13 将该第一散热鳍部 11 与该第二散热鳍部 12 加以区隔；以及至少一散热风扇 20，该散热风扇 20 恰立设于该置扇部 13，在将上述各元件连结之后，使得该散热风扇 20 实施运转时，可因散热风扇立于第一、二散热鳍部间凹陷的置扇部中，不但能有效降低整个散热模组的高度，且在散热风扇两侧面对扇叶的第一、二散热鳍部，可藉由风力得到该散热风扇的吸风或排风的气流，进而提高散热效率，降低显示卡的温度。

请参阅图 5、6 所示，前述本实用新型的散热器 10 是由一第一散热鳍部 11 与一第二散热鳍部 12 所组成的，而该第一散热鳍部 11 与该第二散热鳍部 12 皆是由一片以上的散热鳍片 14 所构成的，该散热鳍片 14 可由铝挤型制法或是堆叠法来制得，但设计人在此并不对铝挤型制法或是堆叠法来详加说明，因为，就同一行业熟习散热器的技术领域的专业人士应可轻易了解，故在此并未多作解释。

请参阅图 7、8 所示，本实用新型的散热鳍片 14 通常是使用高导热度的材质，例如铝系与铜系的金属材料，但并不以此为限，在本实用新型是以铝或铜系的合成金属材料（铝合金、铜合金）来作为实施本实用新型的示范。而在图 8 中说明了该散热风扇 20 运转时所产生的风向 D (Direction of Air) 是由该第二散热鳍部 12 吹向该第一散热鳍部 11，这是因为该第二散热鳍部 12 的高度低于该第一散热鳍部 11，这同时也是申请人考虑到散热效率所作的调整，但并不是要求一定得要如此才能实施本实用新型，因为，无论该第二散热鳍部 12 与该第一散热鳍部 11 之间孰高孰低，皆不影响本实用新型所达成的目的，以及该风向 D 也不限定其是由该第二散热鳍部 12 吹向该第一散热鳍部 11 或由该第一散热鳍部 11 吹向该第二散热鳍部 12。

综上所述，本实用新型的一种显示卡散热模组确实达成显示卡的效能

- 提升、显示卡的寿命增加、降低显示卡的作业温度以及使用者的总付出成本减少的目的，并且，进一步地使得电脑的整体效率提升、显示卡的购置成本降低以及使用者的时间成本降低，而基于本实用新型的原理也可实施于CPU等会产生热源的物品上，故可据以衍生的运用范围广泛，另外，
- 5 因为本实用新型的构造简单、方便使用，所以倍增生产效率也可同时兼顾生产成本，并在使用者的购买费用上可大幅降低，适于大量生产，实具产业利用价值，符合新型专利申请要件的产业利用性(Useful)，再者，本实用新型的一种显示卡散热模组又与最接近的先前技艺(The closest prior art)相较之下，明显具有相当大的进步跨距(Inventive Step)，
- 10 符合新型专利申请要件的进步性(Non-obviousness)，并且，经由本说明书的详细揭露下(如说明书与图式所揭露的技术内容)，足以致使同一行业的专业人士据以实施本实用新型，且其构成结构又未曾见于诸书刊或公开使用，诚符合新型专利申请要件的新颖性(Novelty)，恳请专利局早日核准本实用新型，以利申请人的商品化实施。
- 15 需陈明的，以上所述乃是本实用新型的具体实施例及所运用的技术原理，根据本文的揭露或教导可衍生推导出许多的非实质变更与修正，若依本实用新型的构想所作的等效改变，其所产生的功能作用仍未超出说明书及图式所涵盖的精神，均应属于本实用新型的保护范围。

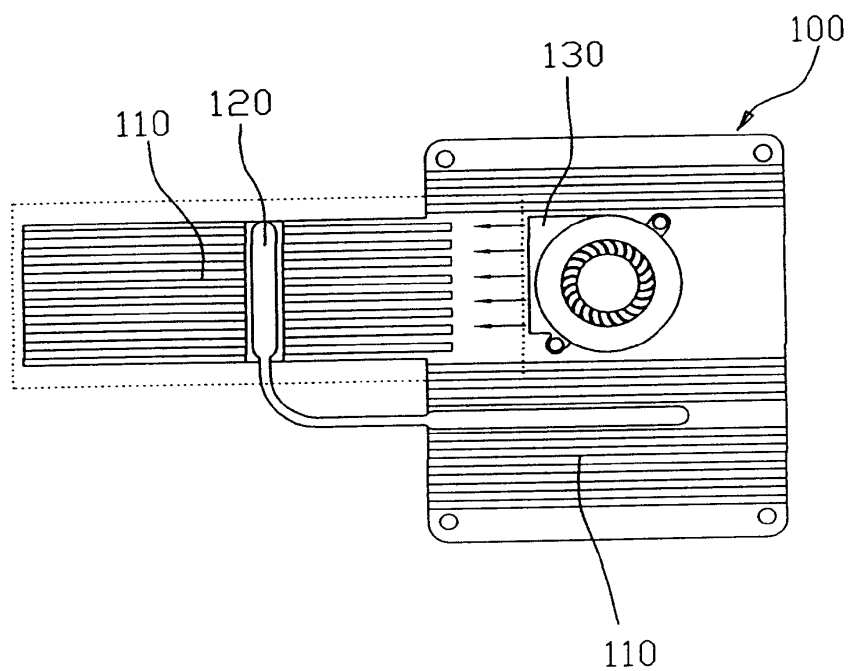


图 1

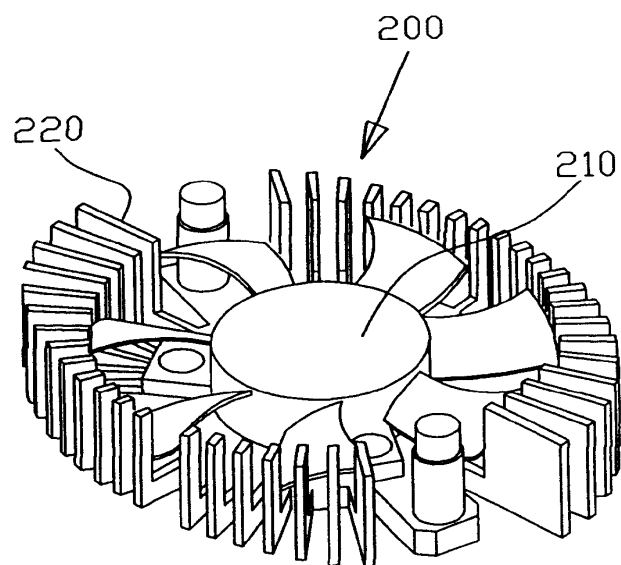


图 2

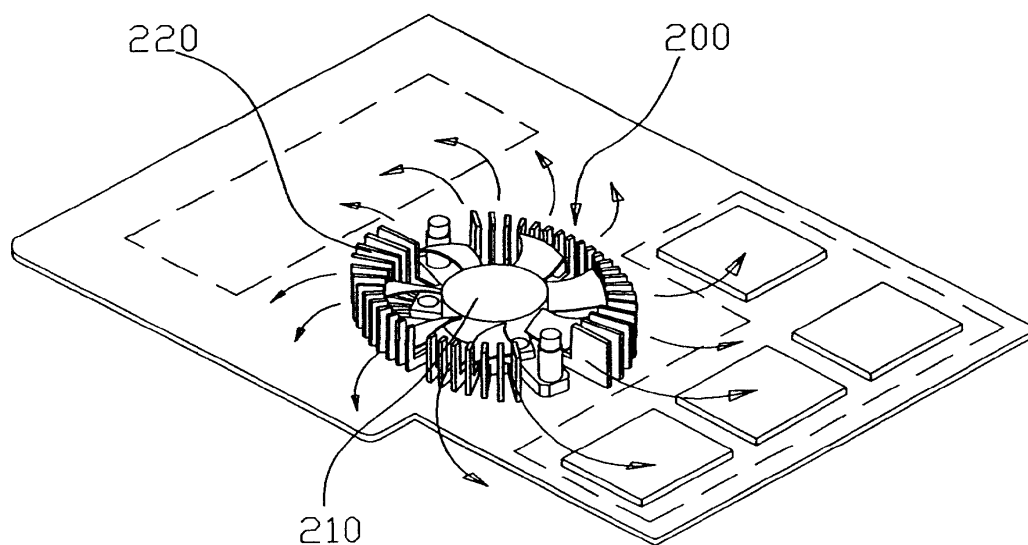


图 2a

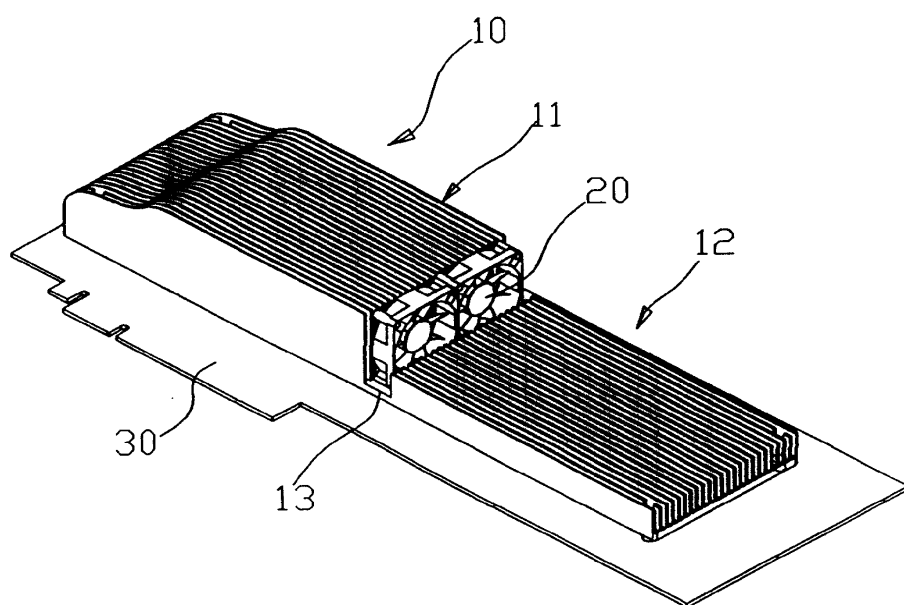


图 3

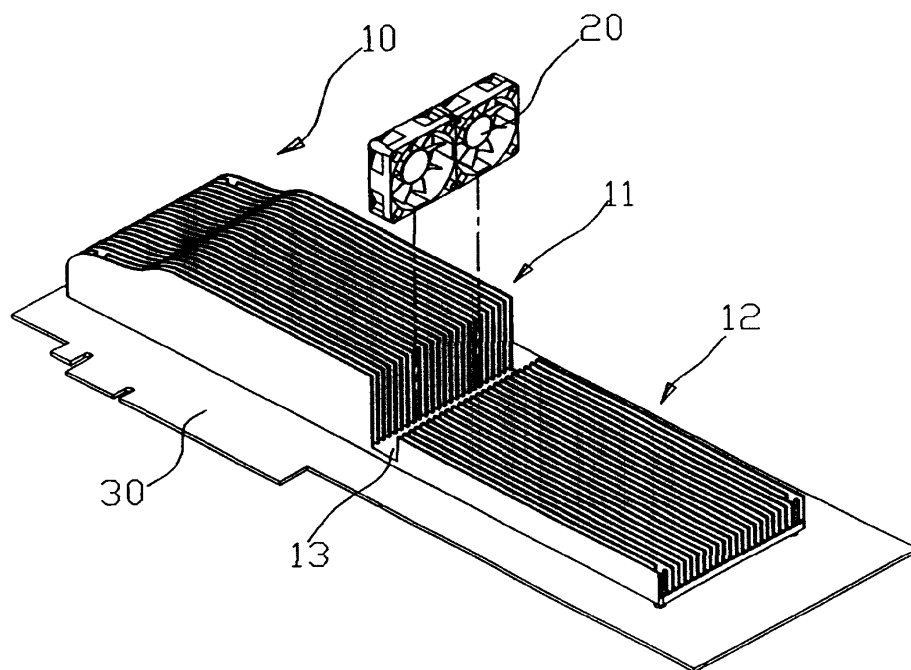


图 4

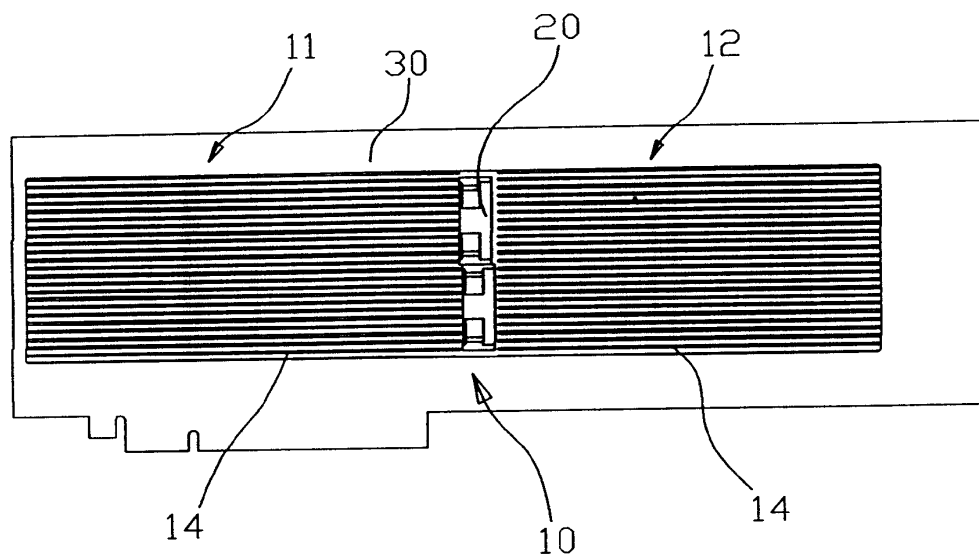


图 5

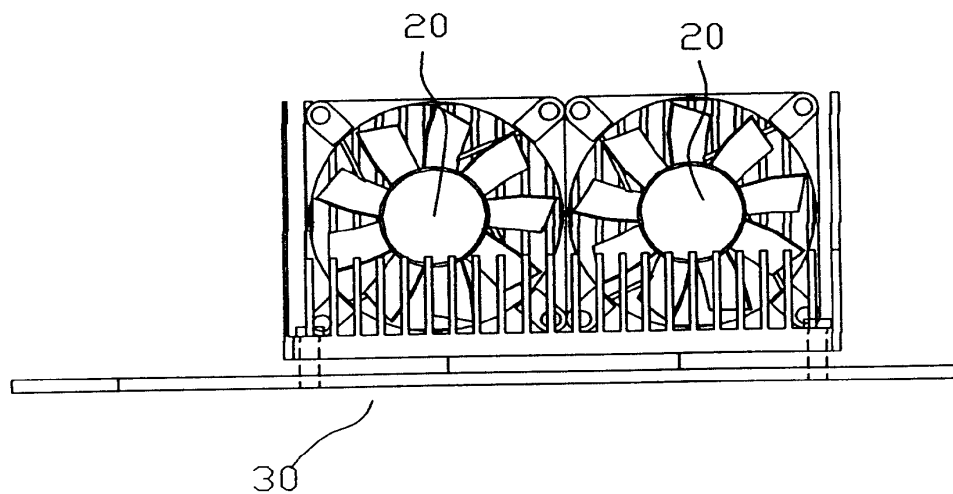


图 6

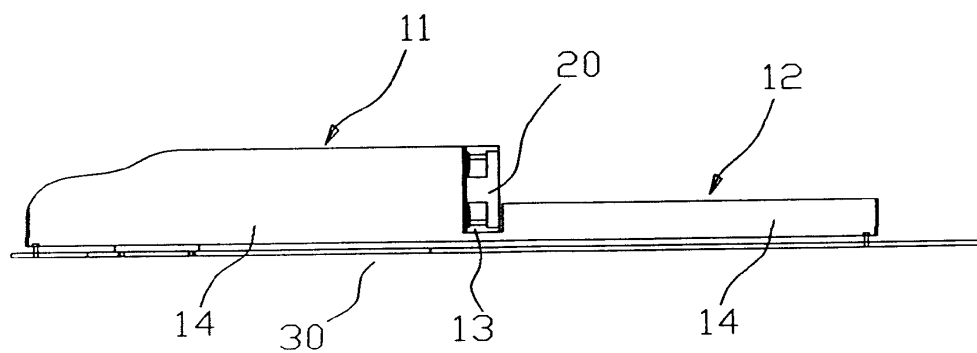


图 7

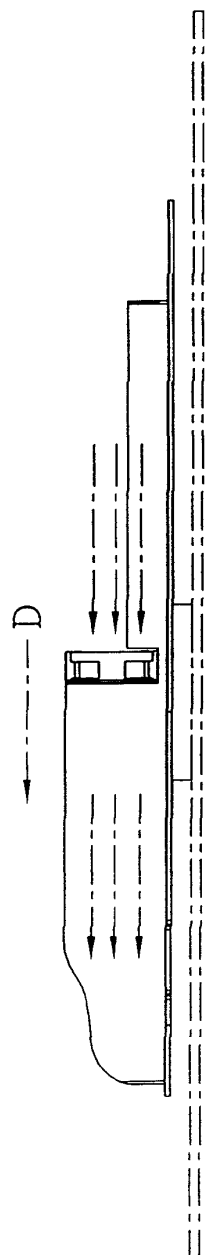


图 8



Espacenet

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THERMAL CONTROL SYSTEM FOR AN ELECTRONIC DISPLAY

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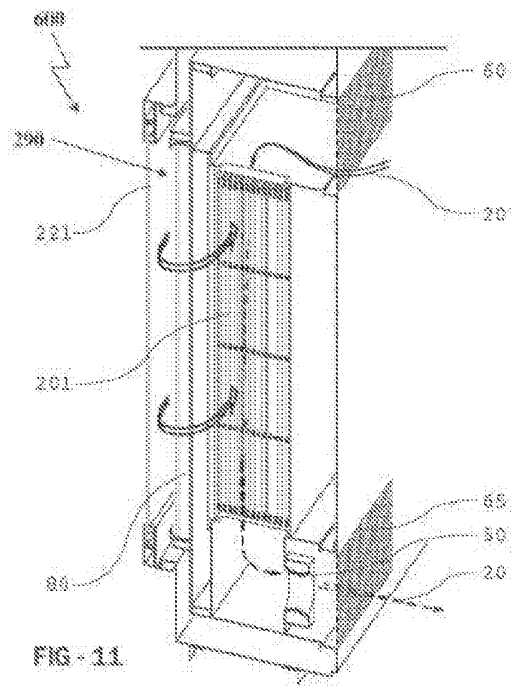
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A cooling assembly for an electronic image assembly and a display assembly containing the same. Some embodiments use ambient gas to cool power modules and/or an image assembly (sometimes backlight). Other embodiments use a closed loop of circulating gas which passes across the front surface of an image assembly and through a heat exchanger. An open loop passes through the heat exchanger and extracts heat from the circulating gas. Ambient air may be used as the ambient gas. An optional additional channel may be used to cool the back portion of the image assembly or backlight with ambient gas. Some embodiments also use thermally conductive plates and ribs to distribute the heat and avoid hot spots in the display. The cooling assembly can be used with any type of electronic assembly for producing an image.



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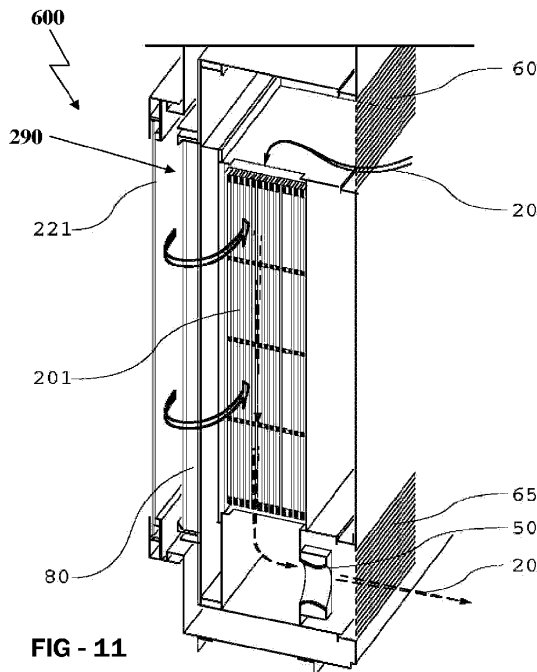
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[Continued on next page]

(54) Title: THERMAL CONTROL SYSTEM FOR AN ELECTRONIC DISPLAY



(57) Abstract: A cooling assembly for an electronic image assembly and a display assembly containing the same. Some embodiments use ambient gas to cool power modules and/or an image assembly (sometimes backlight). Other embodiments use a closed loop of circulating gas which passes across the front surface of an image assembly and through a heat exchanger. An open loop passes through the heat exchanger and extracts heat from the circulating gas. Ambient air may be used as the ambient gas. An optional additional channel may be used to cool the back portion of the image assembly or backlight with ambient gas. Some embodiments also use thermally conductive plates and ribs to distribute the heat and avoid hot spots in the display. The cooling assembly can be used with any type of electronic assembly for producing an image.

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Thermal Control System for an Electronic Display

Inventors: William Dunn, Tim Hubbard, Ware Bedell

Technical Field

[0001] The exemplary embodiments generally relate to cooling systems and in particular to cooling systems for electronic displays.

Background of the Art

[0002] Conductive and convective heat transfer systems for electronic displays generally attempt to remove heat from the electronic components in a display through as many sidewalls of the display as possible. In order to do this, the systems of the past have relied primarily on fans for moving internal air within the housing past the components to be cooled and out of the display. These components are typically power supplies. In some cases, the heated air is moved into convectively thermal communication with fins.

[0003] While such heat transfer systems have enjoyed a measure of success in the past, improvements to displays and new display applications require even greater cooling capabilities. In particular, cooling devices for electronic displays of the past have generally used convective heat dissipation systems that function to cool only the rear interior portion of the display. When used outdoors or in other warm environments, this is not adequate, especially when radiative heat transfer from the sun through a front display surface becomes a major factor. In many applications 200 Watts or more of power through a front display surface is common. Furthermore, the market is demanding larger screen sizes for displays. With increased electronic display screen size and corresponding front display surface size more heat will be generated and more heat will be transmitted into the displays. Also, when displays are used in outdoor environments the ambient air may contain contaminants (dust, dirt, pollen, water vapor, brake dust, sand, smoke, etc.) which, if ingested into the display for cooling the interior can cause damage to the interior components of the display.

[0004] Modern displays (especially those which are used outdoors) have become increasingly brighter, with some backlights producing 1,000-2,000 nits or more. In order to produce this level of brightness, illumination devices such as CCFL assemblies, LEDs, organic LEDs, and plasma assemblies may produce a relatively large amount of heat. Further, the illumination devices require a relatively large amount of power in order to generate the required brightness level. This large amount of power is typically supplied through one or more power supplies for the display. These power supplies may also become a significant source of heat for the display.

[0005] A large fluctuation in temperature is common when devices of the past are used in outdoor environments, direct sunlight, or other difficult thermal environments. Such temperature fluctuation adversely affects both the lifetime and the performance of the electronic components in these devices.

Summary of the Exemplary Embodiments

[0006] While the systems of the past have attempted to remove heat only through the non-display sides and rear components of an electronic display, a preferred embodiment may cause convective heat transfer from the front face of the image assembly as well (the side which faces an intended viewer). These preferred embodiments may comprise two separate flow paths for gas through an electronic display. A first flow path may be a closed loop and a second flow path may be an open loop. The closed loop path travels across the front surface of the image assembly, continues to the rear of the display where it may enter a heat exchanger, finally returning to the front surface of the image assembly. The open loop path draws gas (ex. ambient air) through the rear of the display (possibly through a heat exchanger) and then exhausts it out of the display housing. A heat exchanger may be used to transfer heat from the closed loop to the open loop and exhausted out of the display. Optionally, the open loop may also be forced behind the image assembly (sometimes a backlight other times an OLED or other type of image-producing assembly), in order to cool the image assembly and/or backlight assembly (if a backlight is necessary for the

particular type of display being used). A cross-flow heat exchanger may be used in an exemplary embodiment.

[0007] Other embodiments relate to a system for cooling the following portions of an electronic display, either alone or in combination: (1) power module(s), (2) backlight, and (3) front display surface. Power modules with heat dissipating assemblies (ex. cold plates and/or heat sinks) may be used with some embodiments where the side of the power module containing the heat dissipating assembly is placed in the path of ambient gas while the side of the power module containing sensitive electrical components remains in a separate environment. An isolating structure may provide the necessary gaseous (and sometimes particulate/contaminate) isolation between the two sides of the power modules. The closed loop may or may not be used when cooling the power modules with an open loop of ambient gas.

[0008] Backlights with a front and rear sides may be used with some embodiments for LCD displays where the front side contains the illumination devices and the rear side contains a thermally conductive surface for dissipating the heat from the illumination devices. Ideally, there should be a low level of thermal resistance between the front and rear sides of the backlights.

[0009] Other embodiments may place the power modules in thermal communication with a plurality of thermally conductive ribs where the ribs are placed in the path of cooling air (sometimes ambient gas). The heat from the power modules is distributed throughout the ribs and removed by the cooling air. It has been discovered that forcing air through the relatively narrow channels defined by the ribs improves the ability to remove heat from the power modules.

[0010] In another embodiment, both the power modules and the display backlight (or image assembly) are in thermal communication with the ribs. In this way, a single path of cooling air (sometimes ambient gas) can be used to cool two of the warmest components of a typical electronic display. For example, and not by way of limitation, LED arrays are commonly used as the illumination devices for LCD displays. It has been found that the optical properties of LEDs (and other illumination devices) can vary depending on temperature. Thus, when an LED is exposed to room temperatures, it may output light with a certain luminance, wavelength, and/or color temperature.

However, when the same LED is exposed to high temperatures, the luminance, wavelength, color temperature, and other properties can vary. Thus, when a temperature variation occurs across an LED backlight (some areas are at a higher temperature than others) there can be optical inconsistencies across the backlight which can be visible to the observer. By using the embodiments herein, heat buildup can be evenly distributed across the ribs and removed from the display. This can prevent any potential 'hot spots' in the backlight which may become visible to the observer because of a change in optical properties of the illumination devices (sometimes, but not always LEDs). In other embodiments, the image assembly (rather than a backlight) is in thermal communication with the ribs. The image assembly may comprise any form of electronic assembly for generating an image, including but not limited to: LCD, light emitting diode (LED), organic light emitting diode (OLED), field emitting displays (FED), light-emitting polymers (LEP), plasma displays, and any other flat/thin panel displays.

[0011] The ribs may provide an isolated chamber from the rest of the display so that ambient air can be ingested and used to cool the ribs. This is beneficial for situations where the display is being used in an outdoor environment and the ingested air may contain contaminants (pollen, dirt, dust, water, smoke, etc.) that would damage the sensitive electronic components of the display.

[0012] If a backlight is used with the particular display application, a backlight with front and rear sides may be used where the front side contains the illumination devices and the rear side contains a thermally conductive surface for dissipating the heat from the illumination devices. Ideally, there should be a low level of thermal resistance between the front and rear sides of the backlights. An exemplary embodiment contains a metal core PCB with LEDs on the front side and a metallic surface on the rear side.

[0013] By the aspects described below, the exemplary embodiments herein have made consistent cooling possible for large electronic displays, even in hot climates and placed in direct sunlight. The embodiments also do not require any form of air conditioner (although it may be used if desired), which reduces the space and energy requirements for the display.

[0014] The foregoing and other features and advantages of the exemplary embodiments will be apparent from the following more detailed description of the particular embodiments of the invention, as illustrated in the accompanying drawings.

Brief Description of the Drawings

[0015] A better understanding of an exemplary embodiment will be obtained from a reading of the following detailed description and the accompanying drawings wherein identical reference characters refer to identical parts and in which:

[0016] **FIGURE 1** is a perspective view of a typical power module;

[0017] **FIGURE 2** is a perspective view of two power modules installed within an isolating structure;

[0018] **FIGURE 3** is a perspective view of an embodiment where the cooling air may be used to cool the power modules and a backlight assembly;

[0019] **FIGURE 4** is a perspective view of an embodiment which is similar to that which was shown in Figure 3 with the exception that a heat sink is now being used with the power modules;

[0020] **FIGURE 5** shows a perspective view of an embodiment where a plurality of channels are created between the backlight assembly and the isolating structure;

[0021] **FIGURE 7** shows a perspective section view of another embodiment which uses a thermally-conductive plate and thermally-conductive ribs;

[0022] **FIGURE 8** shows a perspective section view of another embodiment where the ribs are used to distribute heat from and cool a backlight assembly;

[0023] **FIGURE 9** is a rear perspective view of an embodiment where the rear cover of the display has been removed;

[0024] **FIGURE 10A** is a perspective section view of another embodiment showing the closed loop and open loop channels;

[0025] **FIGURE 10B** is a perspective section view similar to the view shown in Figure 10A where the rear and side covers have been removed;

[0026] FIGURE 11 is a perspective section view of another embodiment showing inlet and exhaust apertures for the ambient gas which is used only within the heat exchanger and not within additional optional channels; and

[0027] FIGURE 12 is a perspective section view of an exemplary embodiment where a cross-flow heat exchanger is used to separate high power and low power electrical assemblies.

Detailed Description

[0028] FIGURE 1 shows one embodiment of a typical power module 7 which may be used with some of the embodiment described herein. A printed circuit board 6 may be attached to the power module 7 and may contain a plurality of electronic components 5 which may be necessary to operate and control the power module 7. These electronic components 5 may include, but are no means limited to resistors, capacitors, op-amps, wire harnesses, connectors, and inductors. A baseplate 8 may be attached to the power module 7 and may act as a heat dissipating assembly for the power module 7, such that heat which is generated by the power module 7 is transferred to the baseplate 8. In some embodiments there may be more components used, such as a conductive pad located between the power module and the baseplate 8. Also, as discussed further below, any type of heat sink or fin assembly may be used with the baseplate 8 to further enhance its thermodynamic properties. There may be conductive pads placed between the baseplate 8 and a heat sink assembly also.

[0029] FIGURE 2 shows two power modules installed within an isolating structure 9 which substantially prevents gaseous and contaminate communication between the two sides of the power module. The baseplates 8 of the power modules are shown on the side of the isolating structure 9 where surrounding-environment cooling air 4 is designed to pass over the baseplates 8. Gaskets 11 may be used to provide a gaseous (and/or contaminate) seal between the power modules and the isolating structure 9. Cooling air 4 is sometimes drawn from the environment surrounding the display. This environment may contain harmful contaminants which could damage various electrical components in the display. These harmful contaminants include, but

are not limited to: dust, smoke, pollen, water vapor, other harmful particulate and other harmful gases. Thus, one of the purposes for the isolating structure 9 is to prevent the surrounding-environment cooling air 4 from contacting some of the sensitive electronic components of the display, including but not limited to the electronic components 5 (shown in Figure 1) which are required to operate and control the power modules. By mounting the power modules within the isolating structure 9, surrounding-environment cooling air 4 can be drawn into the display housing and forced over the baseplates 8 (and optional heatsinks and fins) in order to cool the power modules. This can be accomplished without exposing sensitive electronic components to the potentially harmful surrounding-environment cooling air 4.

[0030] FIGURES 3 and 4 show embodiments where the cooling air 4 may be used to cool the power modules and a backlight assembly 140. These embodiments show a backlight assembly 140 which contains a plurality of illumination devices (ex. LEDs) 141 which are mounted to a printed circuit board (PCB). An exemplary embodiment would use a metal core PCB or any other mounting structure which would have a relatively low level of thermal resistance so that heat can transfer from the illumination devices 141 to the rear surface of the backlight assembly 140 where it can be removed by the cooling air 4. The illumination devices 141 could be LED, halogen, CCFL, or any other device which produces light. Further, a backlight assembly may not even be necessary for some embodiments such as plasma, OLED, LEP, or FED displays. However, these display types are also known to generate heat and where backlight cooling is described in this application these methods could also be applied to the cooling of rear surfaces of these electronic image assemblies. Thus, where backlight assemblies are shown, a plasma, OLED, FED, or LEP image assembly could be substituted. The electronic components 5 may be isolated from the cooling air 4 by using the isolating structure 9.

[0031] FIGURE 4 shows an embodiment which is similar to that which was shown in Figure 3 with the exception that a heat sink 12 is now in thermal communication with the power modules in order to further facilitate the transfer of heat away from the power modules. It should of course be noted that many types of heat sinks are available which are made of many different materials and have many different geometry types.

Any form of heat sink is particularly contemplated with various embodiments and may be used to satisfy different operating conditions.

[0032] FIGURE 5 shows another embodiment where a plurality of channels 15 are created between the backlight assembly 140 and the isolating structure 9. Channel separators 16 may be used to separate each channel 15 and provide structural rigidity to the overall assembly. The channel separators 16 would preferably be fabricated out of thermally conductive material so that they may also transfer heat between the backlight assembly 140 and the isolating structure 9. A thermally conductive channel separator 16 can also extract heat from either the backlight assembly 140 or the isolating structure 9 and may dissipate the heat into the air moving through the channel 15. Thus, some channel separators 16 may contain fins or heat sinks in order to facilitate heat transfer to the air moving through the channel 15.

[0033] FIGURE 6 shows a view down a single channel 15 which contains the heat sink 12 for a power module which is mounted within the isolating structure 9. Some channels 15 may contain power modules and others may not. A channel fan 17 may be used to draw air through the channel 15 in order to cool the heat sink 12 (if used) and the channel separators 16 (if thermally conductive) as well as the backlight 140 (or LED assembly for an LED display). Each channel 15 may contain one or more channel fans 17. Some channels may not contain a fan at all, but may rely solely on natural convection to allow heat to rise and exit the channel. As will be discussed at length below, the fans can be placed anywhere in the display assembly and may be used to draw air through the channels, push air through the channels, or a combination of both.

[0034] While the display is in operation, the channel fans 17 may run continuously. Alternatively, temperature sensing devices (not shown) may be placed in each channel and used to measure the temperature within the channel or any of the channel components (backlight or display assembly, isolating structure, or channel separators). Based on data received from these temperature sensing devices, the various fans may be selectively engaged depending on which channel requires cooling. Thus, fans 17 which draw air through channels 15 which contain power modules may run more often or at higher speeds due to the greater amount of heat coming from the power modules.

Also, channels which contain power modules may contain larger fans or a plurality of fans in order to cool the channel.

[0035] **FIGURE 7** shows another embodiment which uses a thermally-conductive plate 10 and ribs 18. In one embodiment, the baseplate 8 of the power module would be in thermal communication with the thermally-conductive plate 10. In other embodiments, a baseplate 8 may not be used and instead, the power module 7 would be in direct thermal communication with the thermally conductive plate 10. Due to the thermally-conductive nature of the plate 10 and ribs 18 and the thermal communication between them, heat which is produced by the power modules would be distributed throughout the plate 10 and ribs 18. In an exemplary embodiment, a path of cooling air 20 (ambient gas) is used to remove the heat which has accumulated on the plate 10 and ribs 18. Alternatively, a natural convection process could also be used to allow the heat to escape the plate 10 and ribs 18.

[0036] A plurality of mounting posts may be used to mount electronic assemblies such as PCBs, hard drives, timing and control boards, inductors, and even the power modules if desired. The mounting posts may also be thermally conductive so that the heat which is generated by these electronic assemblies can also be transferred to the plate 10 and the ribs 18 and removed by the cooling air 20.

[0037] In an exemplary embodiment, the plate 10 would provide a gaseous and contaminate barrier between the side containing the ribs 18 (and cooling air 20) and the side containing the mounting posts, power modules, and any other electronic assemblies. If the plate 10 provides an adequate barrier, ambient air may be ingested as cooling air 20 and the risk of contaminants entering the side of the plate 10 containing the sensitive electronic components may be reduced or eliminated. An inlet aperture 25 may be used to accept the cooling air 20 and direct it along the ribs 18.

[0038] The ribs 18 shown in this embodiment contain a hollow rectangular cross-section, but this is not required. Other embodiments may contain ribs with I-beam cross-sections, hollow square cross-sections, solid rectangular or solid square cross-sections, 'T' cross-sections, 'Z' cross-sections, corrugated or honeycomb cross-section, or any combination or mixture of these. It is preferable that the ribs 18 are thermally conductive. Metal may be used to produce the ribs 18 in some embodiments.

[0039] FIGURE 8 shows another embodiment where the ribs 18 are used to distribute heat from and cool a backlight assembly. The backlight assembly in this embodiment includes a plurality of illumination devices 32 which are mounted on a thermally conductive substrate 30. In an exemplary embodiment, the illumination devices 32 would be LEDs and the thermally conductive substrate 30 would be a PCB and more preferably a metal core PCB. On the surface of the thermally conductive substrate 30 which faces the ribs 18 there may be a thermally conductive surface 35. In an exemplary embodiment, the thermally conductive surface 35 would be metallic and more preferably aluminum. It is preferred that the ribs 18 are in thermal communication with the rear surface 35 and that the rear surface 35 is in thermal communication with the thermally conductive substrate 30. In some embodiments however, the thermally conductive substrate 30 may comprise traditional PCB materials rather than a metal core PCB or any highly thermally conductive materials. It is most preferable that there is a low level of thermal resistance between the illumination devices 32 and the ribs 18. Cooling air 20 may again be forced along the ribs 18 in order to remove heat from the backlight assembly. Of course, this could also occur through natural convection, but more efficient cooling has been typically observed through forced convection. An image assembly (such as an OLED display which may not utilize a backlight) could also be used in place of the backlight assembly in order to cool the image assembly.

[0040] As noted above, many illumination devices (especially LEDs and OLEDs) may have performance properties which vary depending on temperature. When 'hot spots' are present within a backlight or illumination assembly, these hot spots can result in irregularities in the resulting image which might be visible to the end user. Thus, with the embodiments described herein, the heat which may be generated by the backlight assembly can be distributed throughout the various ribs and thermally-conductive surfaces to remove hot spots and cool the backlight.

[0041] In an exemplary embodiment, the ribs 18 may be used to cool both the backlight assembly and the power modules. In a further exemplary embodiment, the ribs 18 can also be used to cool any additional electronic assemblies by placing them in thermal communication with the thermally-conductive plate 10. Thus, with the ribs 18 in a central location, the 'front' would be towards an intended observer of the display while

the 'back' would be on the opposite side of an intended observer. Therefore, the front side of the ribs 18 would be in thermal communication with a backlight assembly (or other illumination or image-producing assembly) and the rear side of the ribs would be in thermal communication with a rear plate (i.e. thermally-conductive plate 10). A single path of cooling air can then be used to cool the interior of the display while the various hot spots can distribute heat throughout the ribs and other thermally conductive surfaces to provide the most efficient cooling. This can be accomplished without having to expose sensitive electrical components to the contaminants and/or particulate of ambient gas.

[0042] FIGURE 9 shows the rear of an exemplary electronic display 100, where the rear cover for the display housing has been removed in order to show the internal components. In this embodiment, fan assemblies 102 and 103 for a closed loop of circulating gas may be placed along two opposing edges of a heat exchanger 101. Preferably, fan assembly 102 is the inlet for the heat exchanger and fan assembly 103 is the exit for the heat exchanger 101. These assemblies can optionally be reversed however, where fan assembly 103 is the inlet and fan assembly 102 is the exit. Further, both assemblies 102 and 103 are not required. Some embodiments may use only one fan assembly for the closed loop of circulating gas. If only one fan assembly is used, it is preferable to place the fan assembly at the inlet of the heat exchanger 101, so that the circulating gas is 'pulled' across the front of the image assembly and pushed through the heat exchanger 101. This is not required however; other embodiments may pull the isolated gas through the heat exchanger 101. Other embodiments may push the isolated gas across the front of the image assembly. Fan assemblies 104 and 105 for an open loop of ambient gas may be placed along two opposing edges of the display housing. Again, both assemblies 104 and 105 are not required as some embodiments may use only one assembly and may use the open loop fan assemblies in a push or pull design. Therefore, when referring to the placement of the various fan assemblies, the terms 'push', 'pull', 'force', and 'draw' will be used interchangeably and any orientation may be used with the various embodiments herein.

[0043] The circulating gas which is being forced by the closed loop fan assemblies is primarily circulating around the display. For example, the circulating gas travels in a

loop where it contacts the front surface of the image assembly (see Figures 10A-10B) and transfers heat from the image assembly to the circulating gas. The circulating gas is then preferably directed (or forced, pulled, etc.) into the heat exchanger 101 in order to transfer heat from the circulating gas to the ambient gas. Afterwards, the circulating gas exits the heat exchanger 101 and may return to the front surface of the image assembly. The circulating gas may also pass over several electronic components 110 in order to extract heat from these devices as well. The electronic components 110 may be any components or assemblies used to operate the display including, but not limited to: transformers, circuit boards, resistors, capacitors, batteries, power modules, motors, inductors, illumination devices, wiring and wiring harnesses, lights, thermo-electric devices, and switches. In some embodiments, the electrical components 110 may also include heaters, when the display assembly might be used in cold-weather environments.

[0044] In order to cool the circulating gas (as well as optionally cooling a backlight assembly or image assembly as taught above) ambient gas is ingested into the display housing by the open loop fan assembly 104 and/or 105. The ambient gas may simply be ambient air which is surrounding the display 100. In some embodiments, the ambient gas may be air conditioned prior to being drawn into the display by one or more air conditioning assemblies (not shown). Once the ambient gas is ingested into the display, it may be directed (or forced) through the heat exchanger 101 and optionally also across the rear surface of the backlight assembly or image assembly (see Figures 10A-10B) or through ribs/channels as shown above or across power modules as shown above. By using the heat exchanger 101, heat is transferred from the circulating gas to the ambient gas. The heated ambient gas is then expelled out of the display housing.

[0045] Although not required, it is preferable that the circulating gas and ambient gas do not mix. In a preferred embodiment, the heat exchanger 101 would be a cross-flow heat exchanger. However, many types of heat exchangers are known and can be used with any of the embodiments herein. The heat exchanger 101 may be a cross-flow, parallel flow, or counter-flow (tube-within-a-tube or otherwise) heat exchanger. In an exemplary embodiment, the heat exchanger 101 would be a cross-flow and would be comprised of a plurality of stacked layers of thin plates. The plates may have a

corrugated or honeycomb design, where a plurality of channels or pathways travel down the plate length-wise. The plates may be stacked such that the directions of the pathways are alternated with each adjacent plate, so that each plate's pathways are substantially perpendicular to the pathways of the adjacent plates. Thus, gas may enter the heat exchanger only through plates whose channels or pathways travel parallel to the path of the gas. Because the plates are alternated, the closed loop and ambient gases may travel in plates which are adjacent to one another and heat may be transferred between the two gases without mixing the gases themselves (if the heat exchanger is adequately sealed, which is preferable but not required).

[0046] In an alternative design, an open gap may be placed in between pairs of channelized or honeycomb plates. The open gap may travel in a direction which is perpendicular to the channels of the plates. This open gap may be created by running two strips of material or tape (esp. very high bond (VHB) tape) between two opposite edges of the plates in a direction that is perpendicular to the direction of the channels in the adjacent plates. Thus, gas may travel through the open gap (parallel to the strips or tape) but would not pass through the open gap in a direction which is perpendicular to the strips or tape (parallel to the channels of the adjacent plates).

[0047] Other types of cross-flow heat exchangers could include a plurality of tubes which contain the first gas and travel perpendicular to the path of the second gas. As the second gas flows over the tubes containing the first gas, heat is exchanged between the two gases. Obviously, there are many types of cross-flow heat exchangers and any type would work with the embodiments herein.

[0048] An exemplary heat exchanger may have plates where the sidewalls are relatively thin so that heat can easily be exchanged between the two paths of gas. A plurality of materials can be used to create the heat exchanger. Preferably, the material used should be corrosion resistant, rot resistant, light weight, and inexpensive. Metals are typically used for heat exchangers because of their high thermal conductivity. However, it has been discovered that plastics and composites can also satisfy the thermal conditions for electronic displays. An exemplary embodiment would utilize polypropylene as the material for constructing the plates for the heat exchanger. It has been found that although polypropylene may seem like a poor thermal conductor, the

large amount of surface area relative to the small material thickness, results in an overall thermal resistance that is low. Thus, an exemplary heat exchanger would be made of plastic and would thus produce a display assembly that is thin and lightweight. Specifically, corrugated or honeycomb plastic may be used for each plate layer.

[0049] As mentioned above, both inlet and exit fan assemblies are not required for the embodiments. Alternatively, only a single fan assembly may be used for each loop. Thus, only an inlet fan assembly may be used with the closed loop and only an exhaust fan assembly may be used with the open loop. Alternatively, one of the loops may have both inlet and exit fan assemblies while the other loop only has either an inlet or exit assembly.

[0050] The gas used in both loops can be any number of gaseous matters. In some embodiments, air may be used as the gas for both loops. Preferably, the gas which travels through the closed loop should be substantially clear, so that when it passes in front of the image assembly it will not affect the appearance of the image to a viewer. The gas which travels through the closed loop should also be substantially free of contaminants and/or particulate (ex. dust, dirt, pollen, water vapor, smoke, etc.) in order to prevent an adverse effect on the image quality and damage to the internal electronic components. It may also be preferable to keep the gas within the open loop from having contaminants. An optional filter (not shown) may be used to ensure that the air (either in the closed or open loop) stays free of contaminants. However, in an exemplary embodiment the open loop may be designed so that contaminants could possibly be present within the ambient gas but this will not harm the display. In these embodiments, the heat exchanger (and the optional path behind the image assembly or backlight or through the ribs) is properly sealed so that any contaminants in the ambient gas would not enter sensitive portions of the display. Thus, in these exemplary embodiments, ingesting ambient air for the ambient gas, even if the ambient air contains contaminants, will not harm the display. This can be particularly beneficial when the display is used in outdoor environments or indoor environments where contaminants are present in the ambient air.

[0051] **FIGURE 10A** shows a cross-section of another embodiment of a display 200. In this figure, the rear cover 250 and side covers 251 and 252 are shown to illustrate

one method for sealing the overall display 200. The image assembly 220 is shown near the front of the display 200. As discussed above, the image assembly 220 may comprise any form of electronic assembly for generating an image, including but not limited to: LCD, light emitting diode (LED), organic light emitting diode (OLED), field emitting displays (FED), light-emitting polymers (LEP), plasma displays, and any other flat/thin panel displays. The front display surface 221 is placed in front of the image assembly 220, defining a channel 290 through which the circulating gas may flow. The front display surface 221 may be any transparent material (glass, plastic, or composite) and may comprise several layers for polarizing light, reducing glare or reflections, and protecting the internal display components. In an exemplary embodiment, the front display surface 221 would comprise two panes of glass which are laminated together with optical adhesive (preferably index-matching). Further, a polarizing layer may be attached to one of the panes of glass in order to reduce the internal reflections and solar loading on the image assembly 220. It is most preferable that the polarizing layer be attached to the inner surface of the front display surface 221 (the one facing the closed loop channel 290) and also contain an anti-reflective (AR) coating.

[0052] For the embodiment shown in Figure 10A, the image assembly 220 may be an LCD stack with a backlight assembly 222. Some backlights may use cold cathode fluorescent lamps (CCFLs) to produce the illumination necessary for generating an image. In an exemplary embodiment, the backlight assembly 222 would comprise a printed circuit board (PCB) with a plurality of LEDs (light emitting diodes) on the front surface. As discussed above, an exemplary embodiment would have a low level of thermal resistance between the front surface of the backlight assembly 222 and the rear surface 223 of the backlight. A metallic PCB may be used for this purpose. The rear surface 223 of the backlight may contain a thermally conductive material, such as a metal. Aluminum may be an exemplary material for the rear surface 223. A second surface (or plate) 224 may be placed in close proximity behind the rear surface 223 of the backlight assembly 222. The space between the rear surface 223 of the backlight and the second surface 224 may define an additional optional open loop channel 225 through which ambient gas may travel in order to cool the backlight assembly 222. This

open loop channel 225 may be similar to the channel 15 shown above, except open loop channel 225 may be narrower.

[0053] FIGURE 10B shows the same cross section from Figure 10A with the rear cover 250 and side covers 251 and 252 removed and the closed and open loop air flows shown for explanatory purposes. The closed loop fan assembly 202 is used to propel the circulating gas 210 around the closed loop. A first open loop fan assembly 203 may be used to draw ambient gas 211 through the heat exchanger 201. Optionally, a second open loop fan assembly 204 may be used to draw ambient gas 212 through the optional channel 225 for cooling the backlight assembly 222. The optional second open loop fan assembly 204 can also be used to exhaust ambient gas which has traveled through the heat exchanger 201 and through the channel 225. If a second open loop fan assembly 204 is not used, the first open loop fan assembly 203 may be used to exhaust the ambient gas 211 that has traveled through the heat exchanger 201.

[0054] As noted above, in an exemplary embodiment the ambient gas does not mix with the circulating gas. It may be important for the image quality that the circulating gas remains free of particulate and contaminates as this gas travels in front of the image assembly 220. Since gas for the open loop may contain various contaminates, a preferable embodiment should be adequately sealed to prevent the gas from the two loops from mixing. This is not necessary however, as filters (either removable or permanent) may be used to minimize the effect of particulate for both the open and closed loops.

[0055] FIGURE 11 is a perspective section view of another embodiment of a display assembly 600 showing inlet 60 and exhaust 65 apertures for the ambient gas 20. The inlet aperture 60 may contain a screen or filter (removable or permanent) to remove any particulate (although this may not be necessary). One or more fans 50 may be used to draw the ambient gas 20 into the inlet aperture 60 and through the heat exchanger 201. In this embodiment, the ambient gas 20 is only drawn through the heat exchanger 201 and not through any additional optional channels or ribs. This embodiment may be used when the display assembly 80 (or backlight assembly) does not require the additional cooling of an additional channel. For example, and not by way of limitation,

this embodiment 600 may be used when an OLED is used as the image assembly 80. Further, this embodiment 600 may be used when the LCD backlight is not generating large amounts of heat because it is not required to be extremely bright (perhaps because it is not used in direct sunlight). Still further, this embodiment may be used when the ambient gas 20 contains particulate or contaminants which may damage the display. In these situations, it may be desirable to limit the exposure of the display to the ambient gas 20. Thus, in these situations it may be desirable to only ingest ambient gas 20 into the heat exchanger 201 and not through any additional cooling channels.

[0056] In some embodiments, the ambient gas 20 may be air conditioned (or otherwise cooled) before it is directed into the heat exchanger 201. A front display surface 221 may be used to create an anterior (front) wall of the channel 290 and/or protect the image assembly 80 from damage. An exemplary front display surface 221 may be glass. Another embodiment for the front display surface 221 may be two panes of glass which are laminated together using optical adhesive. Solar loading (radiative heat transfer from the sun through the front display surface 221 may result in a heat buildup on the image assembly 80 (ex. OLED or LCD assembly). This heat may be transferred to the circulating gas, where this heat may then be transferred to the ambient gas 20 and expelled from the display. The image assembly could be any one of the following: LCD, plasma display assembly, OLED, light emitting polymer (LEP) assembly, organic electro luminescence (OEL) assembly, or LED display assembly.

[0057] FIGURE 12 shows an exemplary embodiment where a circulating gas 400 is forced between a front display surface 221 and an image assembly 80 and then through a heat exchanger 201 in order to remove at least a portion of the heat absorbed from the image assembly 80 and front display surface 221. The circulating gas 400 may be propelled by a closed loop fan assembly 410. The heat exchanger 201 may accept circulating gas 400 in one direction while accepting ambient gas 310 in a substantially perpendicular direction such that heat may transfer between the two gases.

[0058] In this embodiment, an optional additional flow of ambient gas 300 is accepted through the inlet aperture 350 and directed along channel 225 in order to cool the rear portion of the image assembly 80 (possibly a backlight). This embodiment uses a set of ribs 18, similar to the designs shown above in Figures 7 and 8. This embodiment also

uses a thermally-conductive plate 10, similar to the one shown in Figure 7. When this optional additional flow of ambient gas 300 is used, it is preferable that the anterior (front) surface 500 of the channel 225 be thermally conductive and preferably in thermal communication with at least a portion (preferably the rear portion) of the image assembly 80. Inlet aperture 350 may accept both ambient gas 310 and 300, or there may be separate inlet apertures for each flow of gas 310 and 300.

[0059] Similar to some of the previously described embodiments, the circulating gas 400 also passes over electronic assemblies in order to accept heat from these electronic assemblies. In this exemplary embodiment, the electronic assemblies have been separated by the heat exchanger 201 into two groups. The first group of electronic assemblies 900 may be considered the high power assemblies and may include but are not limited to: power modules, inductors, transformers, and other power-related devices. The second group of electronic assemblies 910 may be considered the low power assemblies and may include but are not limited to: timing and control boards, hard drives and other storage devices, video cards, software drivers, microprocessors, and other control devices. It is known to those skilled in the art that some high power electronic assemblies can cause electrical interference with other electronic assemblies that may be sensitive to electrical interference. Thus, in the exemplary embodiment shown, the heat exchanger 201 is used to separate the lower power electronic assemblies 910 from the high power electronic assemblies 900 to ensure a minimum amount of interference between the two. Further, some high power electronic assemblies 900 are known to also generate heat. This heat may be transferred to the circulating gas 400 prior to introducing this gas into the heat exchanger 201. In the exemplary embodiment shown, ambient air can be ingested as the ambient gas 310 and there is little risk of damage to the electrical assemblies 910 and 900 because the ambient gas 310 would preferably never contact these electrical assemblies. However, the electrical assemblies 910 and 900 will remain cool (as well as clean and dry) because of the cross-flow from the circulating gas 400.

[0060] The cooling system described herein may run continuously. However, if desired, temperature sensing devices (not shown) may be incorporated within the electronic display to detect when temperatures have reached a predetermined

threshold value. In such a case, the various cooling fans may be selectively engaged when the temperature in the display reaches a predetermined value. Predetermined thresholds may be selected and the system may be configured to advantageously keep the display within an acceptable temperature range. Typical thermostat assemblies can be used to accomplish this task. Thermocouples may be used as the temperature sensing devices. The speed of the various fan assemblies can also be varied depending on the temperature within the display.

[0061] It should be particularly noted that the spirit and scope of the disclosed embodiments provides for the cooling of any type of electronic display. By way of example and not by way of limitation, embodiments may be used in conjunction with any of the following: LCD (all types), light emitting diode (LED), organic light emitting diode (OLED), field emitting display (FED), light emitting polymer (LEP), organic electro luminescence (OEL), plasma displays, and any other type of thin/flat panel display. Furthermore, embodiments may be used with displays of other types including those not yet discovered. In particular, it is contemplated that the system may be well suited for use with large LED backlit, high definition (1080i or 1080p or greater) liquid crystal displays (LCD). While the embodiments described herein are well suited for outdoor environments, they may also be appropriate for indoor applications (e.g., factory/industrial environments, spas, locker rooms, kitchens, bathrooms) where thermal stability of the display may be at risk.

[0062] It should also be noted that the variety of cooling channels that are shown in the figures may be shown in a horizontal or vertical arrangement but it is clearly contemplated that this can be reversed or changed depending on the particular embodiment. Thus, the closed loop may run horizontally or vertically and in a clockwise or counter-clockwise direction. Further, the open loop may also be horizontal or vertical and can run left to right, right to left, and top to bottom, or bottom to top.

[0063] Having shown and described preferred embodiments, those skilled in the art will realize that many variations and modifications may be made to affect the described invention and still be within the scope of the claimed invention. Additionally, many of the elements indicated above may be altered or replaced by different elements which

will provide the same result and fall within the spirit of the claimed invention. It is the intention, therefore, to limit the invention only as indicated by the scope of the claims.

CLAIMS

1. A cooling system for an electronic image assembly having a front and back portion, the system comprising:

a front display surface spaced apart from the front portion of the electronic image assembly;

a channel defined by the space between the front display surface and the front portion of the electronic image assembly;

a heat exchanger in gaseous communication with the channel, the heat exchanger having first and second gas pathways, where the first gas pathway is in gaseous communication with the channel;

a first fan assembly positioned so as to force circulating gas through the channel and the first gas pathway; and

a second fan assembly positioned so as to force ambient gas through the second gas pathway.

2. The cooling system of claim 1 wherein:

the heat exchanger is a cross-flow heat exchanger.

3. The cooling system of claim 1 further comprising:

a plate spaced apart from the rear portion of the electronic image assembly;

a second channel defined by the space between the plate and the rear portion of the electronic image assembly; and

wherein the second fan assembly is further positioned so as to force ambient gas through the second channel.

4. The cooling system of claim 3 further comprising:
- a power module in electrical communication with the electronic image assembly;
 - and
 - a heat sink in thermal communication with the power module and placed within the second channel.
5. The cooling system of any one of claims 3 or 4 further comprising:
- a plurality of ribs placed within the second channel.
6. An electronic display assembly comprising:
- an electronic image assembly;
 - an isolating structure space apart from the electronic image assembly;
 - a channel defined by the space between the isolating structure and the electronic image assembly;
 - a power module having electronic components on a first side and a heat sink on the second side, where the power module is attached to the isolating structure so that the heat sink is within the channel and the electronic components are outside the channel; and
 - a fan positioned so as to draw ambient gas through the channel.
7. The electronic display assembly of claim 6 further comprising:

a rib placed within the channel and in thermal communication with the isolating structure.

8. The electronic display assembly of claim 7 further comprising:

a surface placed within the channel and in thermal communication with the electronic image assembly and the rib;

9. The electronic display assembly of any one of claims 6, 7, or 8 wherein:

the electronic image assembly is a liquid crystal display.

10. The electronic display assembly of any one of claims 6, 7, or 8 wherein:

the electronic image assembly is an OLED display.

11. An electronic display assembly comprising:

an electronic image assembly having a front and rear portion;

a surface on the rear portion of the electronic image assembly and in thermal communication with the electronic image assembly;

a plate spaced apart from the surface;

a first channel defined by the space between the plate and the surface;

a power module in electrical communication with the electronic image assembly and in thermal communication with the plate; and

a first fan positioned so as to draw ambient gas through the first channel.

12. The electronic display assembly of claim 11 further comprising:

a rib placed within the first channel and in thermal communication with the plate and the surface.

13. The electronic display assembly of claim 12 further comprising:

a front display surface spaced apart from the front portion of the electronic image assembly;

a second channel defined by the space between the front display surface and the front portion of the electronic image assembly;

a heat exchanger in gaseous communication with the second channel, the heat exchanger having first and second gas pathways, where the first gas pathway is in gaseous communication with the second channel;

a second fan positioned so as to force ambient gas through the second gas pathway; and

a third fan positioned so as to force circulating gas through the second channel and the first gas pathway.

14. The electronic display assembly of any one of claims 11 through 13 wherein:

the electronic image assembly is a LCD.

15. The electronic display assembly of any one of claims 11 through 13 wherein:

the electronic image assembly is an OLED.

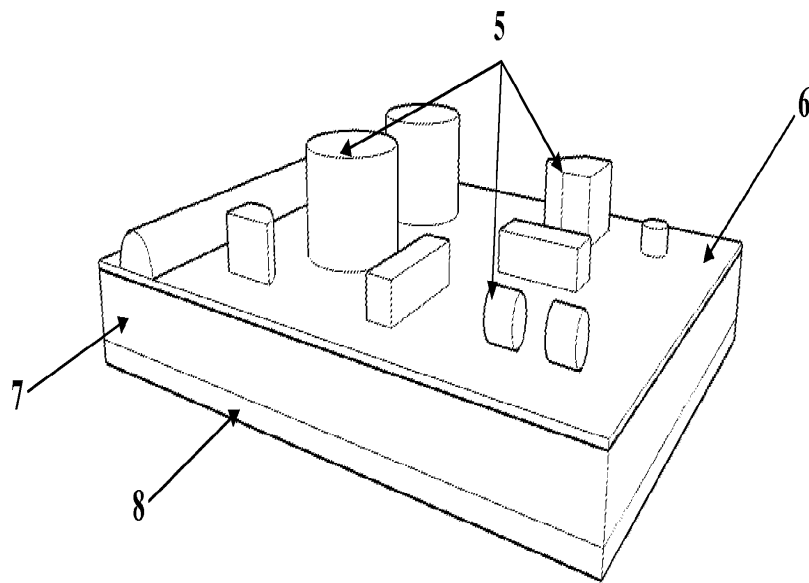


FIG-1

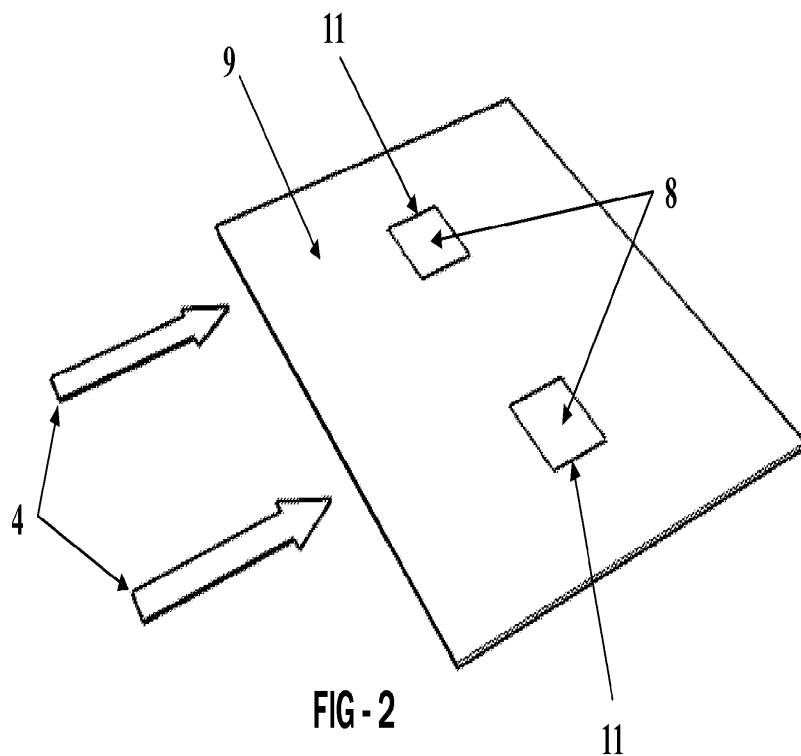


FIG-2

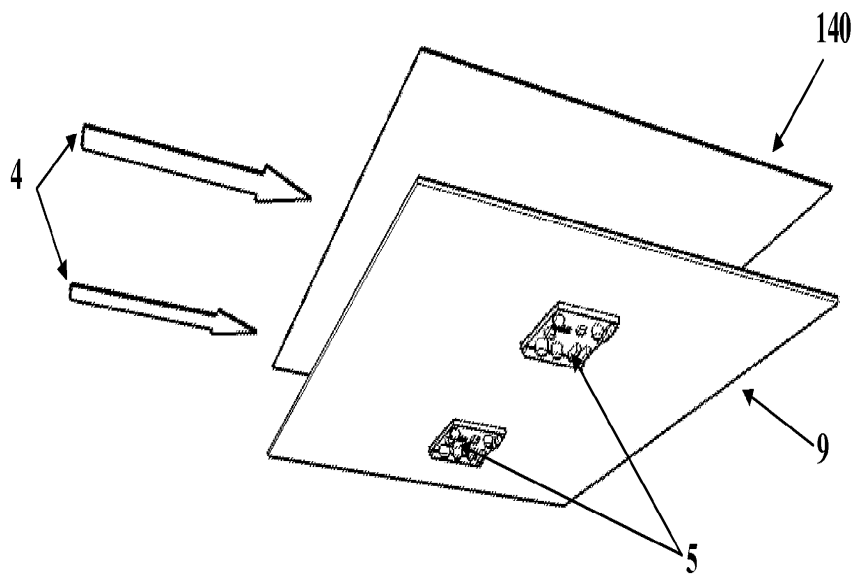


FIG - 3

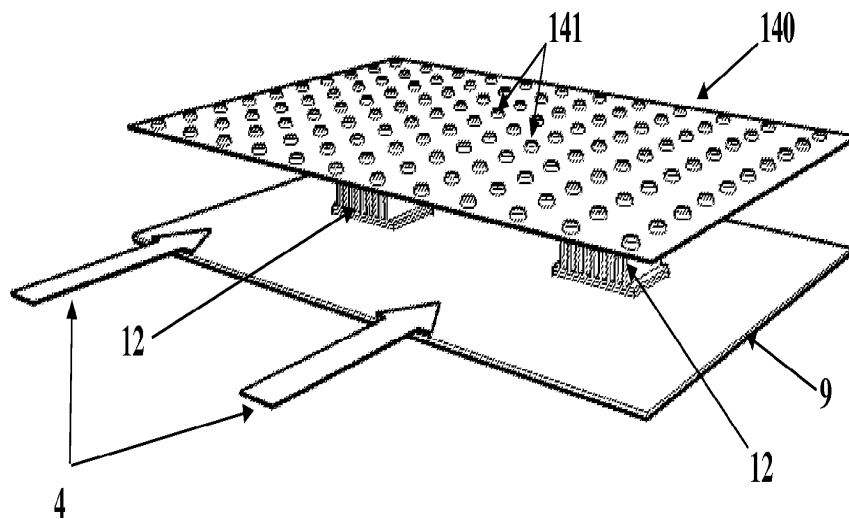
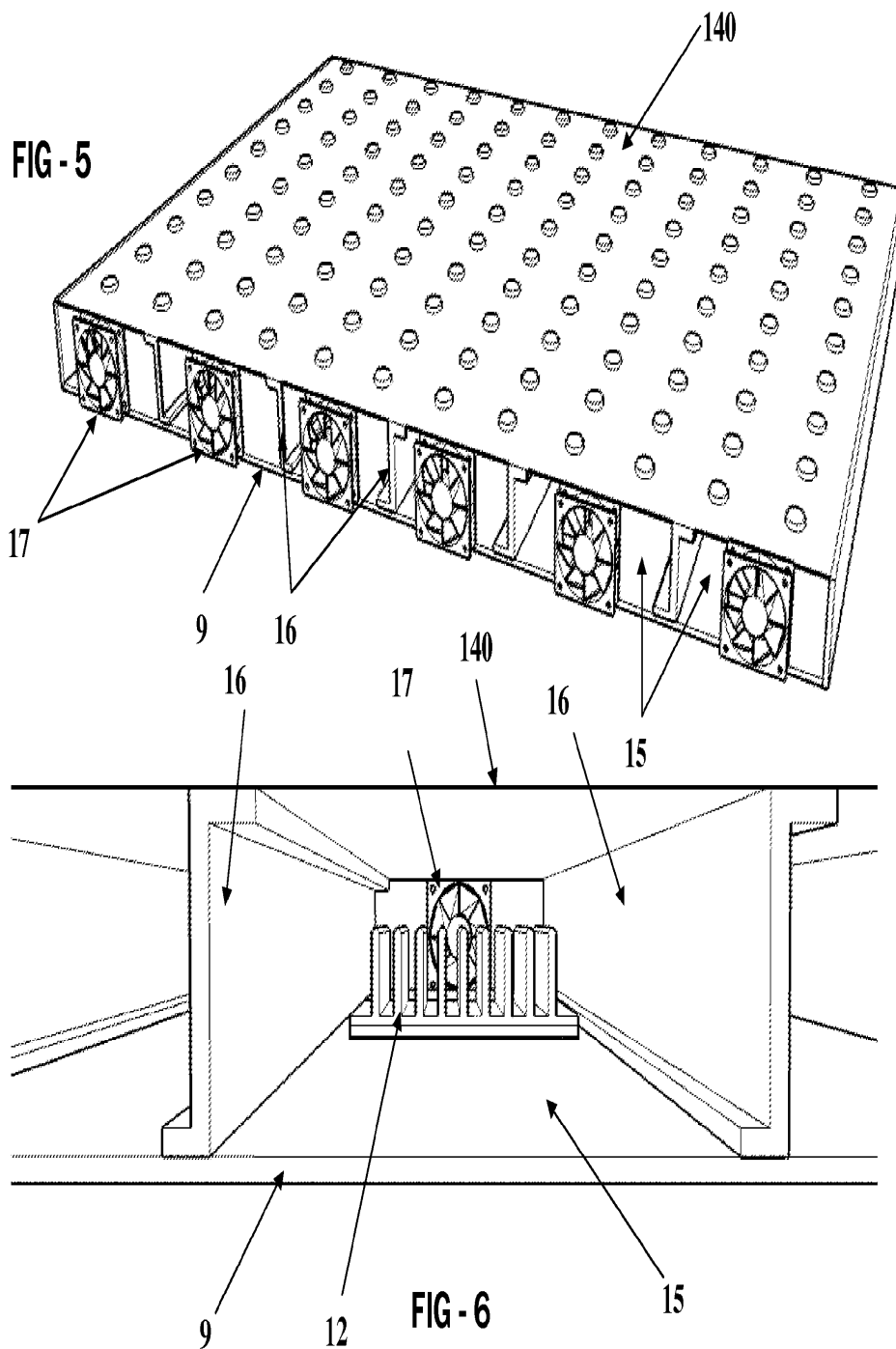
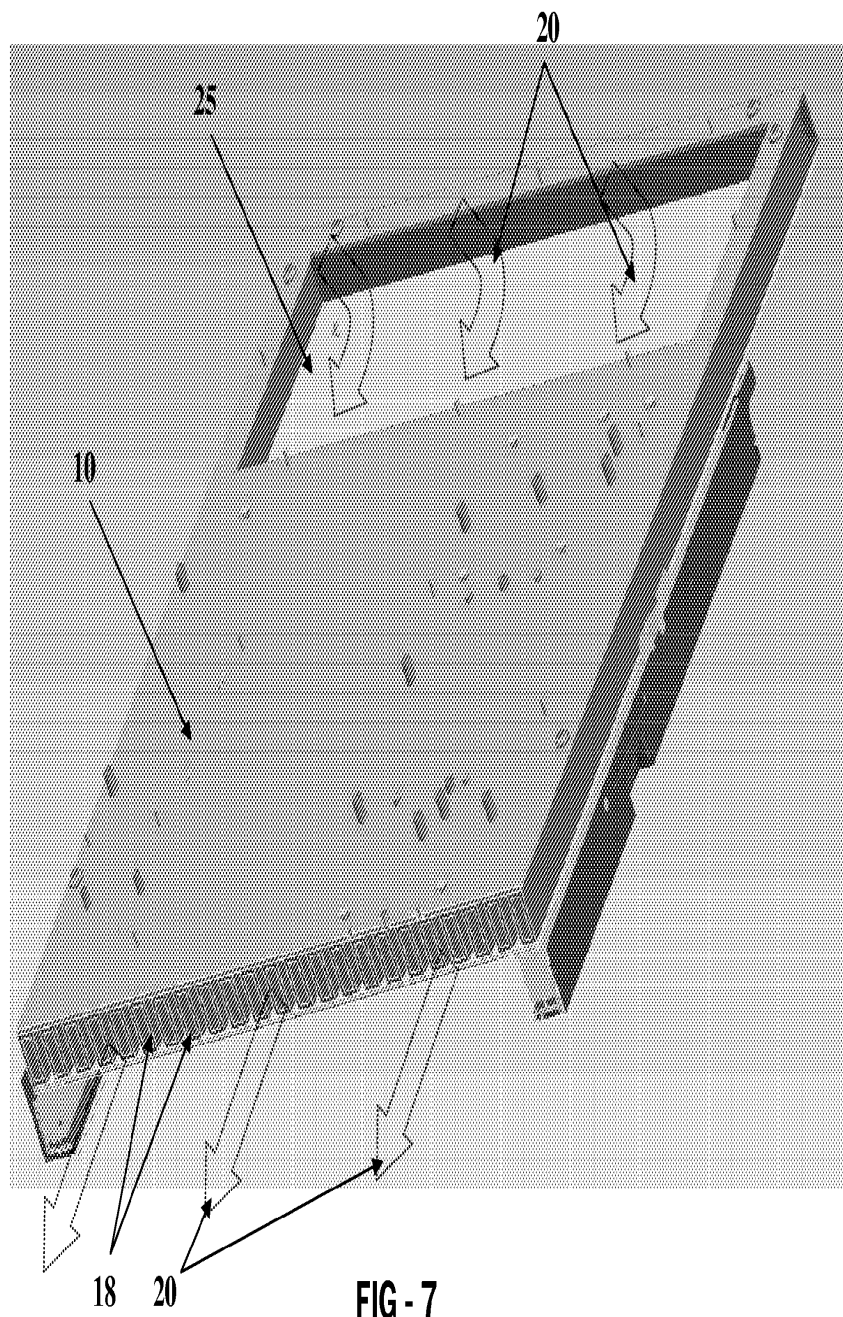
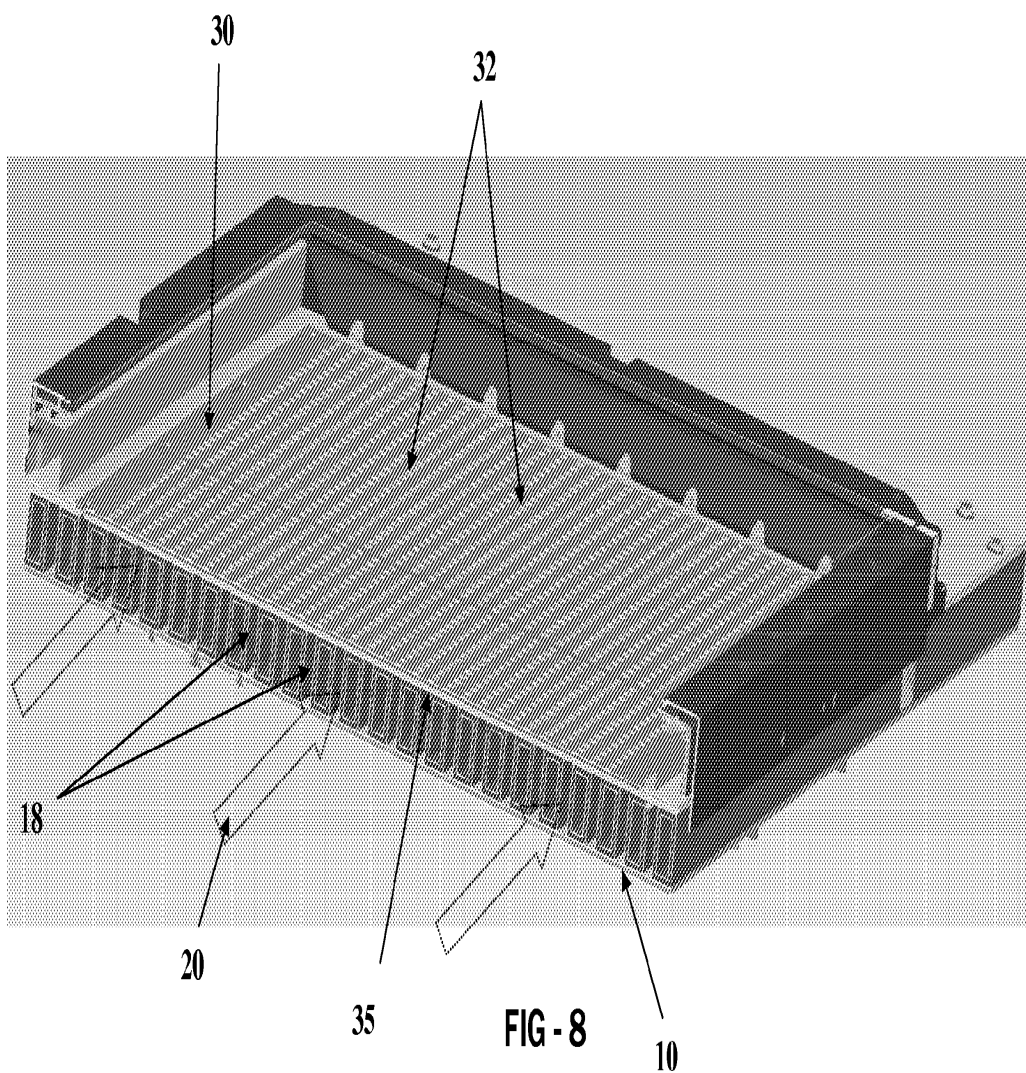


FIG - 4







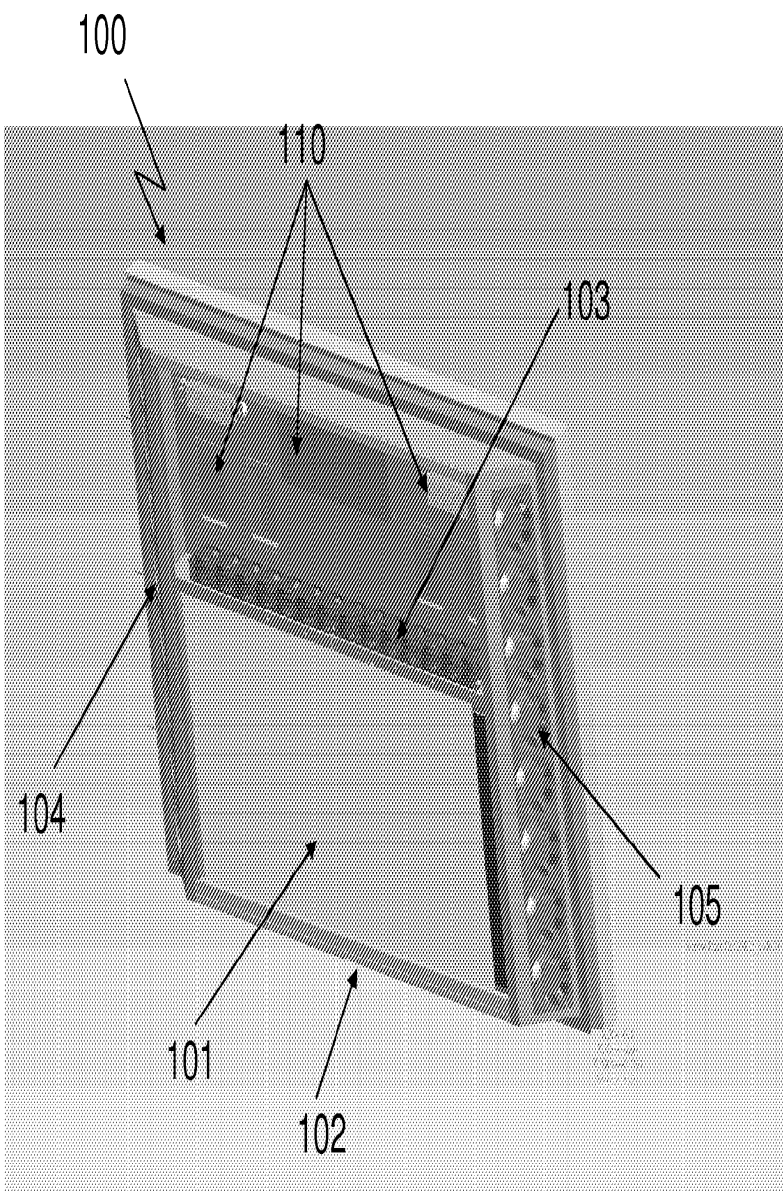


FIG - 9

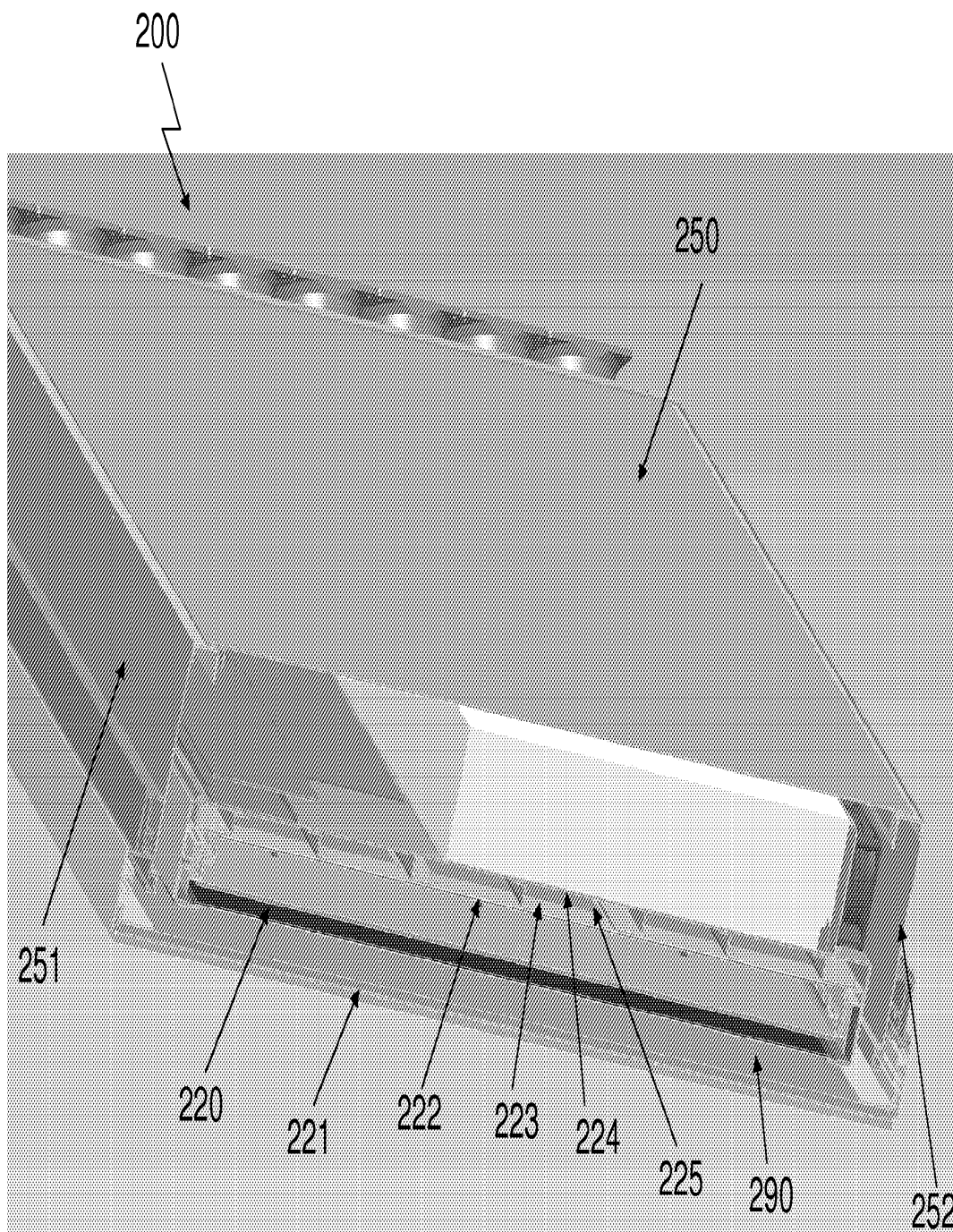


FIG - 10A

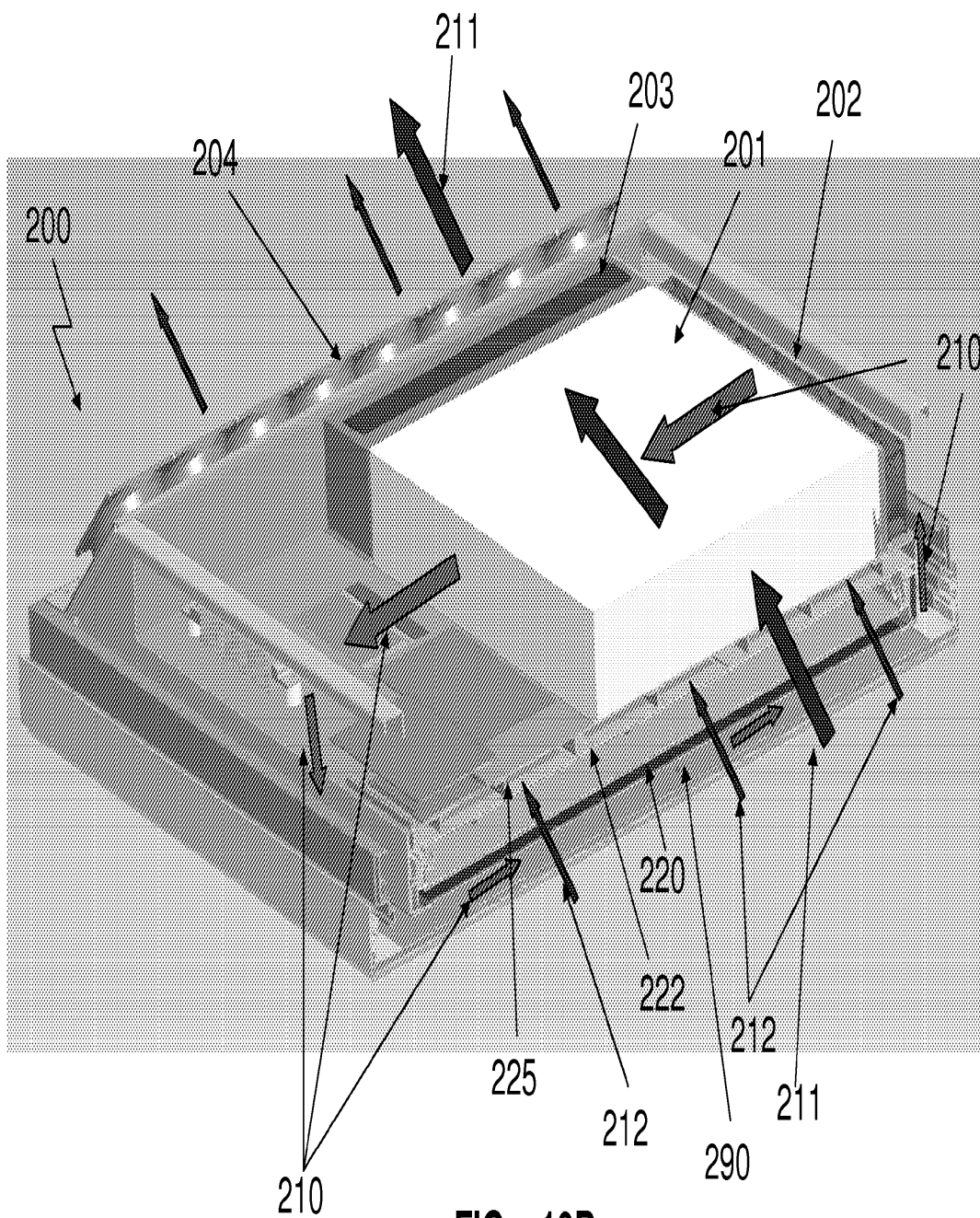


FIG - 10B

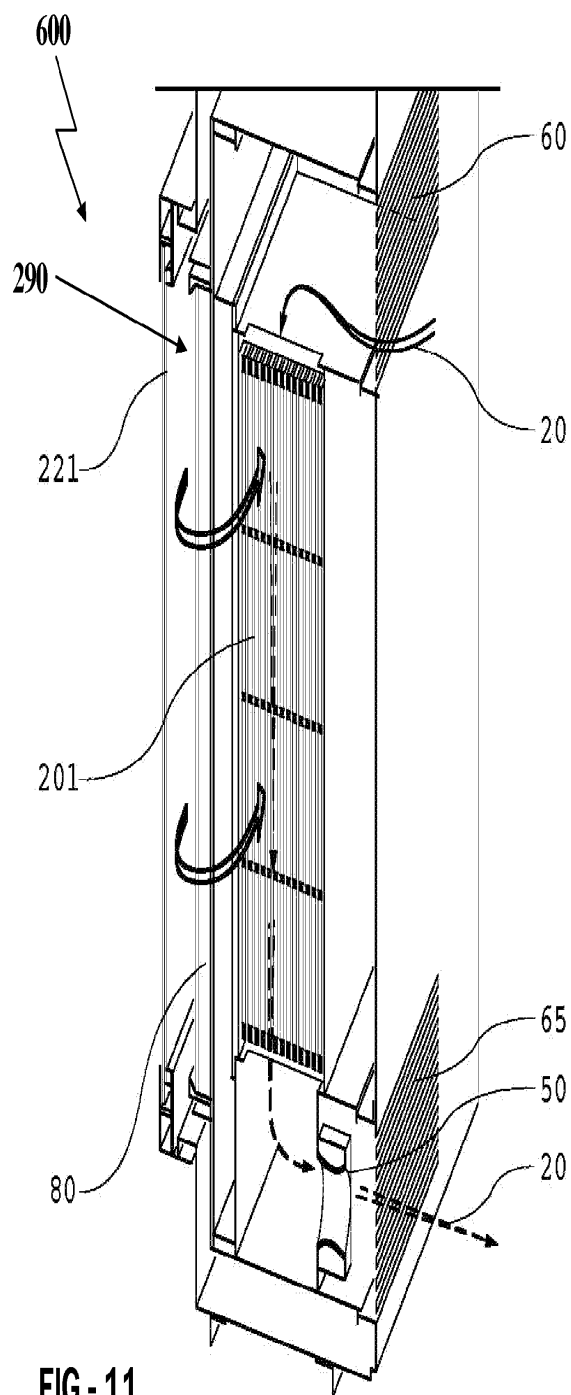
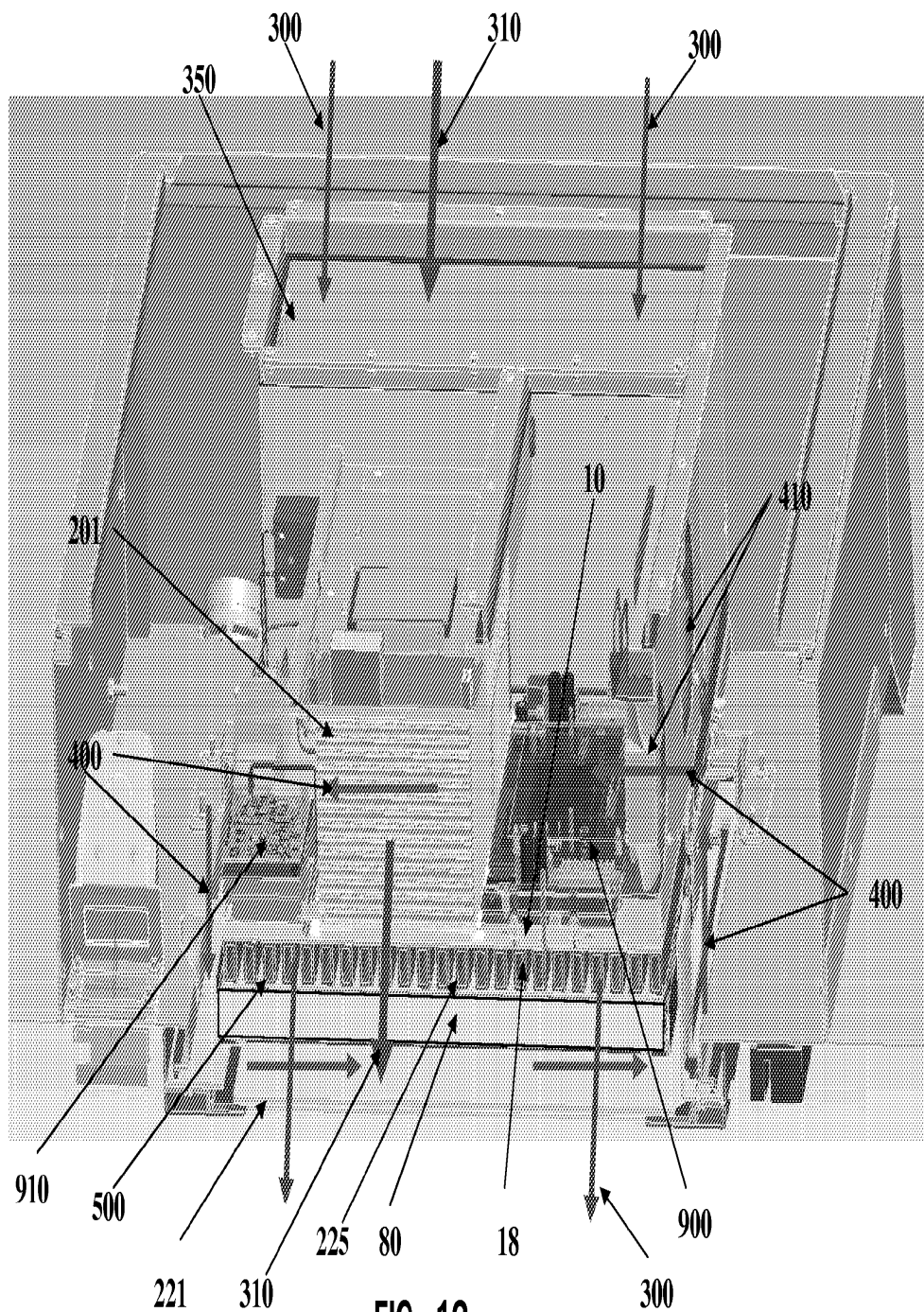


FIG - 11





Espacenet

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EXPANDED HEAT SINK FOR ELECTRONIC DISPLAYS AND METHOD OF PRODUCING THE SAME

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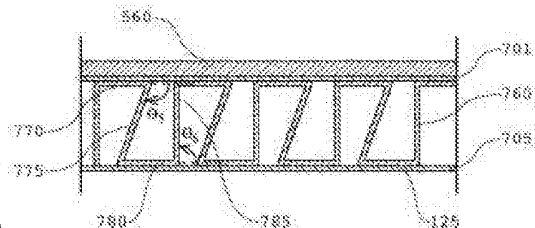
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Abstract not available for EP2603831 (A2)

Abstract of corresponding document: US2012038849 (A1)

An expanded heat sink for transferring heat from an electronic display component to a path of cooling air is disclosed. A continuous sheet may define a series of channels where the cooling air is blown through the channels and along the continuous sheet. When viewed along

the path of the cooling air and oriented horizontally, the continuous sheet may define a series of four-sided polygons having top, bottom, left side, and right side portions where either the top or bottom portions are absent from each polygon. The absent top portions may be supplied by a front plate or the rear portion of an electronic display. The absent bottom portions maybe supplied by a rear plate. One or more components of the electronic display may be placed in thermal communication with the sheet and/or front/rear plates to transfer heat from the components to the cooling air.



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[Continued on next page]

(54) Title: EXPANDED HEAT SINK FOR ELECTRONIC DISPLAYS AND METHOD OF PRODUCING THE SAME

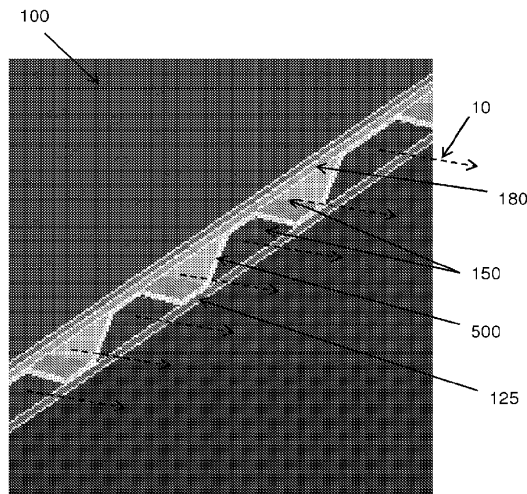


FIG - 1B

(57) Abstract: An expanded heat sink for transferring heat from an electronic display component to a path of cooling air is disclosed. A continuous sheet may define a series of channels where the cooling air is blown through the channels and along the continuous sheet. When viewed along the path of the cooling air and oriented horizontally, the continuous sheet may define a series of four-sided polygons having top, bottom, left side, and right side portions where either the top or bottom portions are absent from each polygon. The absent top portions may be supplied by a front plate or the rear portion of an electronic display. The absent bottom portions may be supplied by a rear plate. One or more components of the electronic display may be placed in thermal communication with the sheet and/or front/rear plates to transfer heat from the components to the cooling air.

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Expanded Heat Sink for Electronic Displays and Method of Producing the Same

Inventors: William Dunn, Bill Swatt, and Tim Hubbard

Cross-Reference to Related Applications

[0001] This application claims priority to U.S. Application No. 61/372,942, filed on August 12, 2010, herein incorporated by reference in its entirety. This application claims priority to U.S. Application No. 13/206,596 filed on August 10, 2011, herein incorporated by reference in its entirety.

Technical Field

[0002] Exemplary embodiments generally relate to cooling systems and in particular to cooling systems for electronic displays.

Background of the Art

[0003] Conductive and convective heat transfer systems for electronic displays generally attempt to remove heat from the electronic components in a display through the sidewalls of the display. Components such as power modules, which are known for producing a large amount of heat may have a 'heat sink' attached to the component which provides an expanded surface area so that heat may be transferred away from the component. These heat sinks have previously been limited to only the size of the power module itself.

[0004] Modern displays have become extremely bright, with some LCD backlights producing 1,000-2,000 nits or more. Sometimes, these illumination levels are necessary because the display is being used outdoors, or in other relatively bright areas where the display illumination must compete with other ambient light. In order to produce this level of brightness, illumination devices (ex. fluorescent lamps, LED, organic LED (OLED), light emitting polymer (LEP), organic electro luminescence (OEL), and plasma assemblies) may produce a relatively large amount of heat. Further, the illumination devices require a relatively large amount of power in order to generate the

required brightness level. This large amount of power is typically supplied through one or more power supplies for the display. These power supplies may also become a significant source of heat for the display.

[0005] Further, previous electronic displays were primarily designed for operation near room temperature. However, it is now desirable to have displays which are capable of withstanding large surrounding environmental temperature variations. For example, some displays are designed for operation at temperatures as low as -22F and as high as 113 F or higher. When surrounding temperatures rise, the cooling of the internal display components can become even more difficult.

[0006] Still further, in some situations radiative heat transfer from the sun through the front portion of the display can also become a source of heat. Furthermore, the market is demanding larger screen sizes for displays. With increased electronic display screen size and corresponding front display surfaces, more heat will be generated and more heat will be transmitted into the displays.

Summary of the Exemplary Embodiments

[0007] Exemplary embodiments relate to a system for cooling various components of an electronic display. The exemplary embodiments may be used to cool the power module(s) or power transformer(s), backlight (if used in the particular display), and other internal components of an electronic display, either alone or in combination. The component(s) may be placed in thermal communication with a continuous conductive sheet which may be placed in the path of cooling air. The heat from the components are distributed throughout the continuous conductive sheet and removed by the cooling air. Some embodiments may place the continuous conductive sheet between a pair of substantially parallel plates (which may also be conductive and may be in thermal communication with the continuous conductive sheet and one or more components).

[0008] In one embodiment where the electronic display is a liquid crystal display, power modules and the display backlight may be placed in thermal communication with the continuous conductive sheet. In this way, a single path of cooling air can be used to cool two of the most heat-producing components of a typical LCD. For example, and not by way of limitation, LED arrays are commonly used as the illumination devices for LCD backlights. It has been found that the optical properties of LEDs (and other illumination devices) can vary depending on temperature. Thus, when an LED is exposed to room temperatures, it may output light with a certain luminance, wavelength, and/or color temperature. However, when the same LED is exposed to high temperatures, the luminance, wavelength, color temperature, and other properties can vary. Thus, when a temperature variation occurs across an LED backlight (some areas are at a higher temperature than others) there can be optical inconsistencies across the backlight which can be visible to the observer. By using the exemplary embodiments herein, heat buildup can be evenly distributed across the continuous conductive sheet and removed from the display. This can prevent any potential 'hot spots' in the backlight which may become visible to the observer because of a change in optical properties of the LEDs.

[0009] The continuous conductive sheet may provide an isolated chamber from the rest of the display so that ambient air can be ingested and used to cool the continuous conductive sheet. This is beneficial for situations where the display is being used in an

outdoor environment and the ingested air may contain contaminants (pollen, dirt, dust, water, smoke, etc.) that would damage the sensitive electronic components of the display.

[0010] The foregoing and other features and advantages will be apparent from the following more detailed description of the particular embodiments of the invention, as illustrated in the accompanying drawings.

Brief Description of the Drawings

[0011] A better understanding of an exemplary embodiment will be obtained from a reading of the following detailed description and the accompanying drawings wherein identical reference characters refer to identical parts and in which:

[0012] FIGURE 1A is a front perspective section view of an exemplary embodiment used to cool an LED backlight;

[0013] FIGURE 1B is a detailed front perspective section view of insert B from Figure 1A;

[0014] FIGURE 2 is a rear perspective view of an embodiment using fans to draw cooling air through the channels;

[0015] FIGURE 3A is a rear perspective section view of an embodiment where the cooling fans are placed within the continuous conductive sheet and several components are placed within thermal communication with the continuous conductive sheet;

[0016] FIGURE 3B is a rear perspective section view of insert B from Figure 3A;

[0017] FIGURE 4 is a perspective view of one embodiment for the continuous conductive sheet;

[0018] FIGURE 5A is a side view of one embodiment for the continuous conductive sheet used within an LED-backlit liquid crystal display;

[0019] FIGURE 5B is a side view of another embodiment for the continuous conductive sheet used to cool a backlight as well as other electrical components; and

[0020] FIGURE 5C is a side view of another embodiment for the continuous conductive sheet used within an electronic display.

Detailed Description

[0021] The invention is described more fully hereinafter with reference to the accompanying drawings, in which exemplary embodiments of the invention are shown. This invention may, however, be embodied in many different forms and should not be construed as limited to the exemplary embodiments set forth herein. Rather, these embodiments are provided so that this disclosure will be thorough and complete, and will fully convey the scope of the invention to those skilled in the art. In the drawings, the size and relative sizes of layers and regions may be exaggerated for clarity.

[0022] It will be understood that when an element or layer is referred to as being "on" another element or layer, the element or layer can be directly on another element or layer or intervening elements or layers. In contrast, when an element is referred to as being "directly on" another element or layer, there are no intervening elements or layers present. Like numbers refer to like elements throughout. As used herein, the term "and/or" includes any and all combinations of one or more of the associated listed items.

[0023] It will be understood that, although the terms first, second, third, etc., may be used herein to describe various elements, components, regions, layers and/or sections, these elements, components, regions, layers and/or sections should not be limited by these terms. These terms are only used to distinguish one element, component, region, layer or section from another region, layer or section. Thus, a first element, component, region, layer or section discussed below could be termed a second element, component, region, layer or section without departing from the teachings of the present invention.

[0024] The terminology used herein is for the purpose of describing particular embodiments only and is not intended to be limiting of the invention. As used herein, the singular forms "a", "an" and "the" are intended to include the plural forms as well, unless the context clearly indicates otherwise. It will be further understood that the terms "comprises" and/or "comprising," when used in this specification, specify the presence of stated features, integers, steps, operations, elements, and/or components, but do not preclude the presence or addition of one or more other features, integers, steps, operations, elements, components, and/or groups thereof.

[0025] Embodiments of the invention are described herein with reference to cross-section illustrations that are schematic illustrations of idealized embodiments (and intermediate structures) of the invention. As such, variations from the shapes of the illustrations as a result, for example, of manufacturing techniques and/or tolerances, are to be expected. Thus, embodiments of the invention should not be construed as limited to the particular shapes of regions illustrated herein but are to include deviations in shapes that result, for example, from manufacturing.

[0026] For example, an implanted region illustrated as a rectangle will, typically, have rounded or curved features and/or a gradient of implant concentration at its edges rather than a binary change from implanted to non-implanted region. Likewise, a buried region formed by implantation may result in some implantation in the region between the buried region and the surface through which the implantation takes place. Thus, the regions illustrated in the figures are schematic in nature and their shapes are not intended to illustrate the actual shape of a region of a device and are not intended to limit the scope of the invention.

[0027] Unless otherwise defined, all terms (including technical and scientific terms) used herein have the same meaning as commonly understood by one of ordinary skill in the art to which this invention belongs. It will be further understood that terms, such as those defined in commonly used dictionaries, should be interpreted as having a meaning that is consistent with their meaning in the context of the relevant art and will not be interpreted in an idealized or overly formal sense unless expressly so defined herein.

[0029] Herein the terms 'front' and 'rear' may be used to describe the relationship between the various elements shown in the various embodiments. The term 'front' is used herein to denote a direction towards the intended observer of the electronic display. The term 'rear' is used herein to denote a direction away from the intended observer of the electronic display.

[0030] **FIGURE 1A** is a front perspective section view of an exemplary embodiment used to cool an LED backlight 100 (or an LED display). In this embodiment, the continuous conductive sheet 500 is placed adjacent to the LED backlight 100 and used to create a plurality of channels 150. Preferably, the LED backlight 100 is in thermal

communication with the continuous conductive sheet 500. Thus, heat which is generated by the LED backlight 100 is transferred to the continuous conductive sheet 500 and removed by cooling air 10.

[0031] FIGURE 1B is a detailed front perspective section view of insert B from Figure 1A. In this embodiment, the continuous conductive sheet 500 is placed between a front plate 180 and a rear plate 125 in order to create the channels 150. The front plate 180 is preferably in thermal communication with the LED backlight 100 and the continuous conductive sheet 500. The rear plate 125 may also be in thermal communication with the continuous conductive sheet 500. The thermal communication may be conductive, convective, radiative, or any combination of these. Preferably, the thermal communication is at least conductive.

[0032] The LED backlight 100 and front plate 180, front plate 180 and continuous conductive sheet 500, and the continuous conductive sheet 500 and rear plate 125 may be fastened to one another using any number of different techniques, including but not limited to: mechanical fasteners, adhesives, double-sided tape, welding, or other similar techniques. Each component may be attached to one another using similar or different methods. It is preferable that the chosen technique permits thermal communication between the components (if desired). In some embodiments the thermal communication between components may be accomplished by simply placing the components in contact with one-another or in close proximity to one another. Some embodiments may use a combination of the fastening techniques above. Thus, an exemplary embodiment may use both mechanical fasteners as well as an adhesive (preferably a thermally conductive adhesive) or double-sided tape. An exemplary type of double-sided tape would be Very High Bond (VHB™) tape commercially available from 3M™ Saint Paul, MN. www.3M.com An exemplary form of mechanical fasteners would be rivets or screws/bolts.

[0033] FIGURE 2 is a rear perspective view of an embodiment using fans 225 to draw cooling air 10 through the channels 150. Inlet apertures 200 allow the fans 225 to draw cooling air 10 in between the rear plate 125 and front plate 180 and along the channels 150. The cooling air 10 can then be exhausted out of the exit apertures 210. A single fan may be used in some embodiments, while several fans (even more than shown in

Figure 2) could be used in other embodiments. Of course, the fans 225 could instead be placed at the inlet apertures 200 and used to 'push' the cooling air 10 through the channels 150 rather than 'pull' (as shown in Figure 2). Further, fans could be placed at both the inlet apertures 200 and exit apertures 210 to both push and pull the cooling air 10 through the system.

[0034] FIGURE 3A is a rear perspective section view of an embodiment where the cooling fans 300 are placed within the continuous conductive sheet 500 and electronic components 800 are placed in thermal communication with the continuous conductive sheet 500. In this embodiment, cooling air 10 is drawn into the inlet apertures 310 by fans 300 which are placed along the length of the continuous conductive sheet 500. Thus, in this embodiment the fans 300 perform both a 'pull' and 'push' of the cooling air 10 through the channels 150. Electronic components 800 may be placed in thermal communication with the continuous conductive sheet 500 by establishing thermal communication between the electronic components 800 and the rear plate 125 (which is preferably in thermal communication with the continuous conductive sheet 500 in this embodiment).

[0035] The electronic components 800 may be any electronic component used in an electronic display which generates heat. The electronic components 800 are preferably in electrical communication with the electronic display assembly. Some embodiments may use power supplies/modules or power transformers as the electronic components 800.

[0036] FIGURE 3B is a rear perspective section view of insert B from Figure 3A. In this embodiment, the continuous conductive sheet 500 is placed between a front plate 180 and a rear plate 125 in order to create the channels 150. As discussed further below, a front plate 180 may not be necessary in some embodiments. Thus, in some embodiments the continuous conductive sheet 500 may be directly fastened to the rear portion of the LED backlight 100 (or another rear portion of an electronic display, especially an OLED assembly).

[0037] In this embodiment, a portion of the front plate 180 overlaps a portion of the rear plate 125 to create an overlap section 350. Here, heat is permitted to transfer directly between the edges of the rear plate 125 and front plate 180 and allows the

thermal energy to quickly and evenly spread throughout the plates and the continuous conductive sheet 500.

[0038] FIGURE 4 is a perspective view of one embodiment for the continuous conductive sheet 500.

[0039] FIGURE 5A is a side view of one embodiment for the continuous conductive sheet 500 used within an LED-backlit liquid crystal display. In this embodiment, the LED backlight 100 is attached to and in thermal communication with the front plate 180; which is attached to and in thermal communication with the continuous conductive sheet 500. A liquid crystal assembly 550 is placed in front of the LED backlight 100. The liquid crystal assembly 550 may contain several layers and is well known in the art. Typically, the liquid crystal assembly 550 contains two transparent plates with liquid crystal material sandwiched in between the two plates. An electrode of some type is typically used to orient the liquid crystal material. Additional layers may also be used to orient/polarize light, color filter the light, and provide anti-reflective or protective properties. These layers have not been shown as they are well-known in the art and are not critical to these embodiments of the invention.

[0040] Here, the rear plate 125 may not be in thermal communication with the continuous conductive sheet 500 but may only provide structure for the channels and/or structural support to the assembly. Of course, it is preferable that the rear plate 125 and the continuous conductive sheet 500 are in thermal communication so that heat can be more effectively and evenly distributed and removed. Ideally, there should be a low level of thermal resistance between the front and rear sides of the backlight 100. An exemplary embodiment may utilize a metal core PCB with LEDs on the front side and a metallic surface (or otherwise thermally conductive surface) on the rear side.

[0041] Generally, the continuous conductive sheet 500 may be described as four continuous portions, which are generally repeated to create the overall structure. For this embodiment, the first portion 600 runs parallel to and adjacent with the front plate 180. The second portion 610 extends from the first portion 600 at angle Θ_1 towards the rear plate 125. The third portion 620 extends from the second portion 610 and runs parallel to and adjacent with the rear plate 125. The fourth portion 630 extends from the third portion 620 at angle Θ_2 towards the front plate 180. The four portions may

then be repeated to create the continuous conductive sheet 500. Thus, the fourth portion 630 may continue to a second series of portions, starting with another portion similar to the previous first portion 600. In some embodiments, angle Θ_1 may be substantially equal to angle Θ_2 . While in other embodiments, angle Θ_1 may be different than angle Θ_2 .

[0042] In other words, when oriented horizontally and viewed along the direction of the cooling air (the side view shown in Figure 5A) the continuous conductive sheet 500 may be formed to create a series of four-sided polygons, each one having a bottom side (portion 620), left side (portion 610), right side (portion 630), and a top side (in this polygon supplied by front plate 180) where either the top or bottom side is absent from each polygon. For the embodiment shown in Figure 5A, the absent side of the polygon alternates between the top side and bottom side for each adjacent polygon. An exemplary version of the embodiment shown in this figure may be formed of stamped or bent sheet metal.

[0043] FIGURE 5B is a side view of another embodiment for the continuous conductive sheet 750 used to cool a backlight 700 as well as other electrical components 800. In this embodiment, the continuous conductive sheet 750 is attached to and in thermal communication directly with the backlight 700 (thus, there is no separate front plate used). A liquid crystal assembly 550 is placed in front of the backlight 700, which may be LED driven or may be any other means for illuminating the rear portion of the liquid crystal assembly 550. An additional electrical component 800 is placed in electrical communication with the backlight 700 and/or liquid crystal assembly 550 and is in thermal communication with the rear plate 705. Here, heat which is produced by the electrical component 800 may be transferred to the rear surface 704 of the rear plate 705, where it may then be transferred to the front surface 706 of the rear plate 705. The cooling air can remove the heat from the front surface 706 of the rear plate 705. Additionally, the heat may be transferred from the front surface 706 of the rear plate 705 to the continuous conductive sheet 750 where it may spread throughout the continuous conductive sheet 750 and ultimately removed by the cooling air.

[0044] Again, this embodiment of the continuous conductive sheet 750 may be described as four continuous portions, which are generally repeated to create the overall structure. For this embodiment, the first portion 710 runs parallel to and adjacent with the backlight 700. The second portion 715 extends from the first portion 710 at angle Θ_3 towards the rear plate 705. The third portion 720 extends from the second portion 715 and runs parallel to and adjacent with the rear plate 705. The fourth portion 725 extends from the third portion 720 at angle Θ_4 towards the backlight 700. The four portions may then be repeated to create the continuous conductive sheet 750. Thus, the fourth portion 725 may continue to a second series of portions, starting with another portion similar to the previous first portion 710. In some embodiments, angle Θ_3 may be substantially equal to angle Θ_4 . While in other embodiments, angle Θ_3 may be different than angle Θ_4 . In this particular embodiment, both angles Θ_3 and Θ_4 are near 90 degrees, or perpendicular to the backlight 700 and rear plate 705 and/or first portion 710 and third portion 720.

[0045] In other words, when oriented horizontally and viewed along the direction of the cooling air (the side view shown in Figure 5B) the continuous conductive sheet 750 may be formed to create a series of four-sided polygons, each one having a bottom side (portion 720), left side (portion 715), right side (portion 725), and a top side (in this polygon supplied by backlight 700) where either the top or bottom side is absent from each polygon. For the embodiment shown in Figure 5B, the absent side of the polygon alternates between the top side and bottom side for each adjacent polygon. An exemplary version of the embodiment shown in this figure may be formed of stamped or bent sheet metal.

[0046] **FIGURE 5C** is a side view of another embodiment for the continuous conductive sheet 760 used within an electronic display. Here, the continuous conductive sheet 760 is attached to and in thermal communication with the front plate 701 which is attached to and in thermal communication with an electronic display assembly 560. In this embodiment, the continuous conductive sheet 760 may be used to cool a type of electronic display that does not require a backlight device. Thus, the electronic display assembly 560 could be, but is not limited to any one of the following types of displays: OLED, LED, light emitting polymer (LEP), organic electro

luminescence (OEL), and plasma. The heat which is generated by the electronic display assembly 560 can be transferred to the front plate 701 where it can be transferred to the continuous conductive sheet 760 and removed by the cooling air. Additionally, radiative heat transfer from sunlight can also cause a heat buildup upon the electronic display assembly 560. This heat can also be transferred to the continuous conductive sheet 760 and removed by the cooling air. Here, the rear plate 705 may not be in thermal communication with the continuous conductive sheet 760 but may only provide structure for the channels and/or structural support to the assembly. Of course, it is preferable that the rear plate 705 and the continuous conductive sheet 760 are in thermal communication so that heat can be more effectively and evenly distributed and removed.

[0047] Again, this embodiment of the continuous conductive sheet 760 may be described as four continuous portions, which are generally repeated to create the overall structure. For this embodiment, the first portion 770 runs parallel to and adjacent with the front plate 701. The second portion 775 extends from the first portion 770 at angle Θ_5 towards the rear plate 705. The third portion 780 extends from the second portion 775 and runs parallel to and adjacent with the rear plate 705. The fourth portion 785 extends from the third portion 780 at angle Θ_6 towards the front plate 701. The four portions may then be repeated to create the continuous conductive sheet 760. Thus, the fourth portion 785 may continue to a second series of portions, starting with another portion similar to the previous first portion 770. In some embodiments, angle Θ_5 may be substantially equal to angle Θ_6 . While in other embodiments, angle Θ_5 may be different than angle Θ_6 .

[0048] In other words, when oriented horizontally and viewed along the direction of the cooling air (the side view shown in Figure 5C) the continuous conductive sheet 760 may be formed to create a series of four-sided polygons, each one having a bottom side (portion 780), left side (portion 775), right side (portion 785), and a top side (in this polygon supplied by front plate 701) where either the top or bottom side is absent from each polygon. For the embodiment shown in Figure 5C, the absent side of the polygon alternates between the top side and bottom side for each adjacent polygon. An

exemplary version of the embodiment shown in this figure may be formed of bent sheet metal.

[0049] Electronic displays are produced in a variety of sizes and orientations, including but not limited to both landscape and portrait orientations. Any of the embodiments herein can be used to cool the various types, sizes, and orientations of electronic displays. Further, the channels may be oriented in a vertical manner, and the cooling air may travel from top to bottom or from bottom to top. Still further, the channels may be oriented in a horizontal manner, and the cooling air can travel left to right or right to left.

[0050] While the embodiments of the continuous conductive sheet have been generally described as containing four portions which repeat themselves, other embodiments could use a mixture of different designs. Thus, some embodiments may not repeat the same four portions over and over. Some embodiments could use four portions from the continuous conductive sheet 750 of Figure 5B, followed by four portions from the continuous conductive sheet 500 of Figure 5A. Of course, any number of different combinations could be used, depending on the materials and manufacturing process used to construct the particular continuous conductive sheet.

[0051] It should be noted that the embodiments herein do not require that a singular continuous conductive sheet is used to cool the entire electronic display. A plurality of smaller continuous conductive sheets may be used in order to cool the display. The smaller continuous conductive sheets may be connected to each other and in thermal communication with one another or they may be spaced apart from one another. Thus, as used herein the term 'continuous' does not require that the entire display is cooled with a single conductive sheet. The term 'continuous' as used herein defines a single element that can be placed between two substantially planar objects to create at least two channels.

[0052] Further, the term 'thermal communication' as used herein does not require direct thermal communication, i.e. there may be intermediate devices or layers in-between the two components which are still considered to be in 'thermal communication.' Conductive heat transfer is one type of thermal communication and is preferable with the exemplary embodiments herein. Convective thermal communication

is one type of thermal communication which is preferable between the continuous conductive sheet and the cooling air.

[0053] The continuous conductive sheets have been shown herein with relatively constant cross-sectional thicknesses but this is also not required. Some portions of the continuous conductive sheets may be thicker or thinner than other portions and some may even contain fins or additional extended surface areas for removing the absorbed heat.

[0054] It is preferable that the front plate, rear plate, and continuous conductive sheet are comprised of materials which are thermally conductive. Metals have been found to be exemplary materials for these components. More specifically, sheet metals and even more specifically aluminum sheet metals are preferable. However, many thermally conductive plastics and composite materials can also perform adequately. Specifically, polypropylene sheets would be within the scope of the various embodiments.

[0055] In an exemplary embodiment, the front and rear plates would provide a gaseous and contaminate barrier between the space between them (containing the continuous conductive sheet) and the rest of the display. If the plates provide an adequate barrier, ambient air may be ingested as cooling air 10 and the risk of contaminants entering the portions of the display containing the sensitive electronic components may be reduced or eliminated.

[0056] As noted above, many illumination devices (especially LEDs and OLEDs) may have performance properties which vary depending on temperature. When 'hot spots' are present within a backlight or illumination assembly, these hot spots can result in irregularities in the resulting image which might be visible to the end user. Thus, with the embodiments described herein, the heat which may be generated by the backlight assembly can be distributed (somewhat evenly) throughout the various ribs and thermally-conductive surfaces to remove hot spots and cool the backlight.

[0057] The cooling system may run continuously. However, if desired, temperature sensing devices (not shown) may be incorporated within the electronic display to detect when temperatures have reached a predetermined threshold value. In such a case, the various cooling fans may be selectively engaged when the temperature in the display

reaches a predetermined value. Predetermined thresholds may be selected and the system may be configured to advantageously keep the display within an acceptable temperature range. Typical thermostat assemblies can be used to accomplish this task. Thermocouples may be used as the temperature sensing devices.

[0058] It is to be understood that the spirit and scope of the disclosed embodiments provides for the cooling of many types of displays. By way of example and not by way of limitation, embodiments may be used in conjunction with any of the following: LCD (all types), light emitting diode (LED), organic light emitting diode (OLED), field emitting display (FED), light emitting polymer (LEP), organic electro luminescence (OEL), plasma displays, and any other type of flat panel electronic display. Furthermore, embodiments may be used with displays of other types including those not yet discovered. In particular, it is contemplated that the system may be well suited for use with full color, flat panel OLED displays. Exemplary embodiments may also utilize large (55 inches or more) LED backlit, high definition (1080i or 1080p or greater) liquid crystal displays (LCD). While the embodiments described herein are well suited for outdoor environments, they may also be appropriate for indoor applications (e.g., factory/industrial environments, spas, locker rooms) where thermal stability of the display may be at risk.

[0059] Although fans are shown with some of the embodiments herein, they are not required for all embodiments. While forced convection (using fans) is preferable, natural or un-forced convection (no fans) may also produce acceptable results and is within the scope of the invention.

[0060] The relative sizing of each component shown in the figures is not to be interpreted as a requirement of the invention or that they are accurately drawn to scale. Some components have been enlarged for clarity. Other components have been simplified for clarity.

[0061] Having shown and described preferred embodiments, those skilled in the art will realize that many variations and modifications may be made to affect the described embodiments and still be within the scope of the claimed invention. Additionally, many of the elements indicated above may be altered or replaced by different elements which

will provide the same result and fall within the spirit of the claimed invention. It is the intention, therefore, to limit the invention only as indicated by the scope of the claims.

CLAIMS

1. An expanded heat sink for transferring heat from an electronic display component to a path of cooling air, the expanded heat sink comprising:

a continuous sheet when viewed along the path of the cooling air and oriented horizontally, defines a series of four-sided polygons having top, bottom, left side, and right side portions where either the top or bottom portions are absent from each polygon.

2. The heat sink of claim 1 wherein:

the absent portion of the polygon alternates between the top and bottom portion for each adjacent polygon.

3. The heat sink of claim 1 wherein:

the four-sided polygons are trapezoids.

4. The heat sink of any one of claims 1-3 wherein:

the top and bottom portions are substantially parallel.

5. The heat sink of claim 1 wherein:

the four-sided polygons are rectangles.

6. The heat sink of any claim 1 further comprising:

a front plate placed above the continuous sheet; and

a rear plate place below the continuous sheet.

7. The heat sink of claim 6 wherein:

the front plate is placed so as to supply the missing top portion of the polygons;
and

the rear plate is placed so as to supply the missing bottom portion of the
polygons.

8. A liquid crystal display (LCD) comprising:

the heat sink of claim 6;

an LED backlight placed above and in thermal communication with the front
plate; and

a liquid crystal assembly placed above the LED backlight.

9. The LCD of claim 8 further comprising:

a fan positioned to draw cooling air between the front plate and rear plate and
along the continuous sheet.

10. The LCD of any one of claims 8-9 wherein:

the LED backlight is placed in conductive thermal communication with the front
plate.

11. An expanded heat sink for transferring heat from an electronic display component to a path of cooling air, the expanded heat sink comprising:

- a substantially planar front plate;
- a substantially planar rear plate placed parallel to the front plate; and
- a continuous sheet placed between the front and rear plates to define a series of channels for accepting the cooling air.

12. The heat sink of claim 11 wherein:

- the continuous sheet contains a series of four portions:
 - the first portion running substantially parallel to the front plate,
 - the second portion extending from the first portion and towards the rear plate at a first angle,
 - the third portion extending from the second portion and substantially parallel to the rear plate, and
 - the fourth portion extending from the third portion and towards the front plate at a second angle.

13. The heat sink of claim 12 wherein:

- the first portions are in contact with the front plate, and
- the third portions are in contact with the rear plate.

14. The heat sink of claim 12 wherein:

- the first and second angles are substantially equal.

15. The heat sink of claim 12 wherein:

the first and second angles are each less than ninety degrees.

16. An electronic display comprising:

the heat sink of claim 11;

an electronic display assembly placed in front of and in thermal communication
with the front plate; and

a fan positioned to draw cooling air through the channels.

17. The electronic display of claim 16 further comprising:

an electrical component in conductive thermal communication with the rear plate.

18. The electronic display of claim 17 wherein:

the electrical component is any one of the following: power module, power
supply, and power transformer.

19. A liquid crystal display (LCD) comprising:

the heat sink of claim 1;

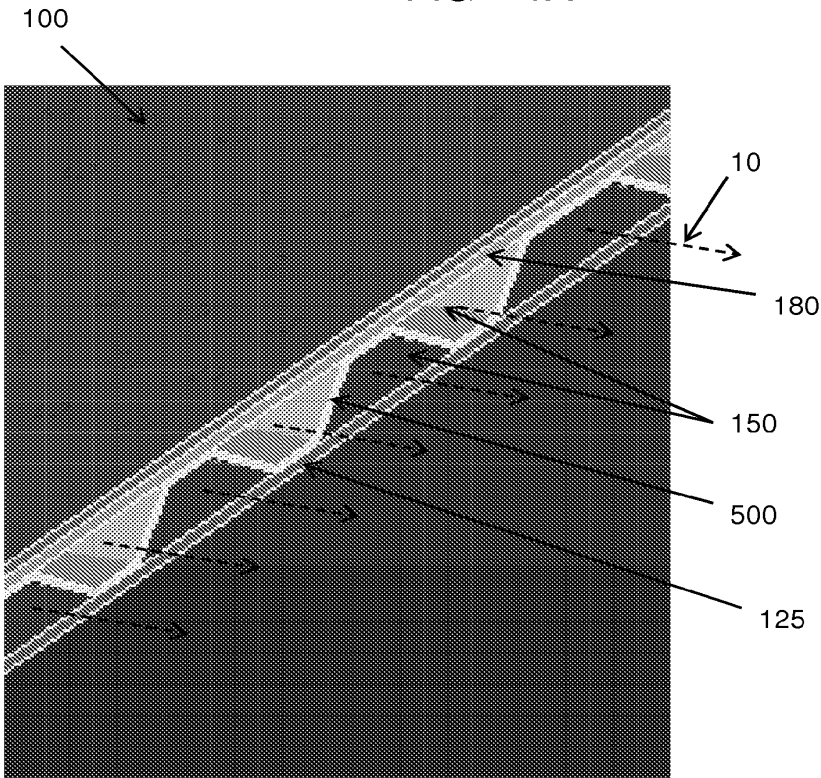
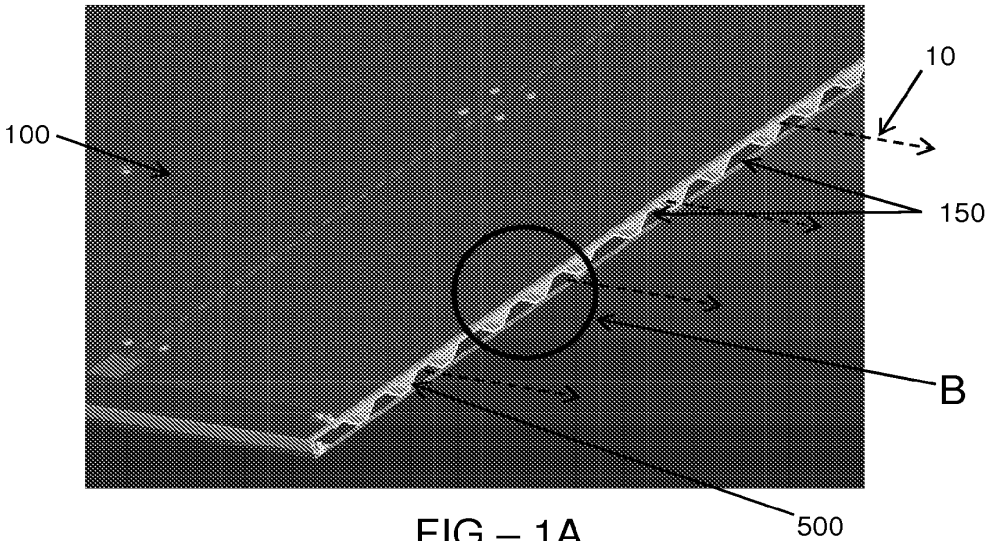
an LED backlight placed above and in thermal communication with the
continuous sheet;

a liquid crystal assembly placed above the LED backlight;

a rear plate placed behind and in thermal communication with the continuous
sheet; and

a fan positioned to draw cooling air between the LED backlight and rear plate
and along the continuous sheet.

20. The LCD of claim 19 further comprising:
an electrical component in conductive thermal communication with the rear plate.



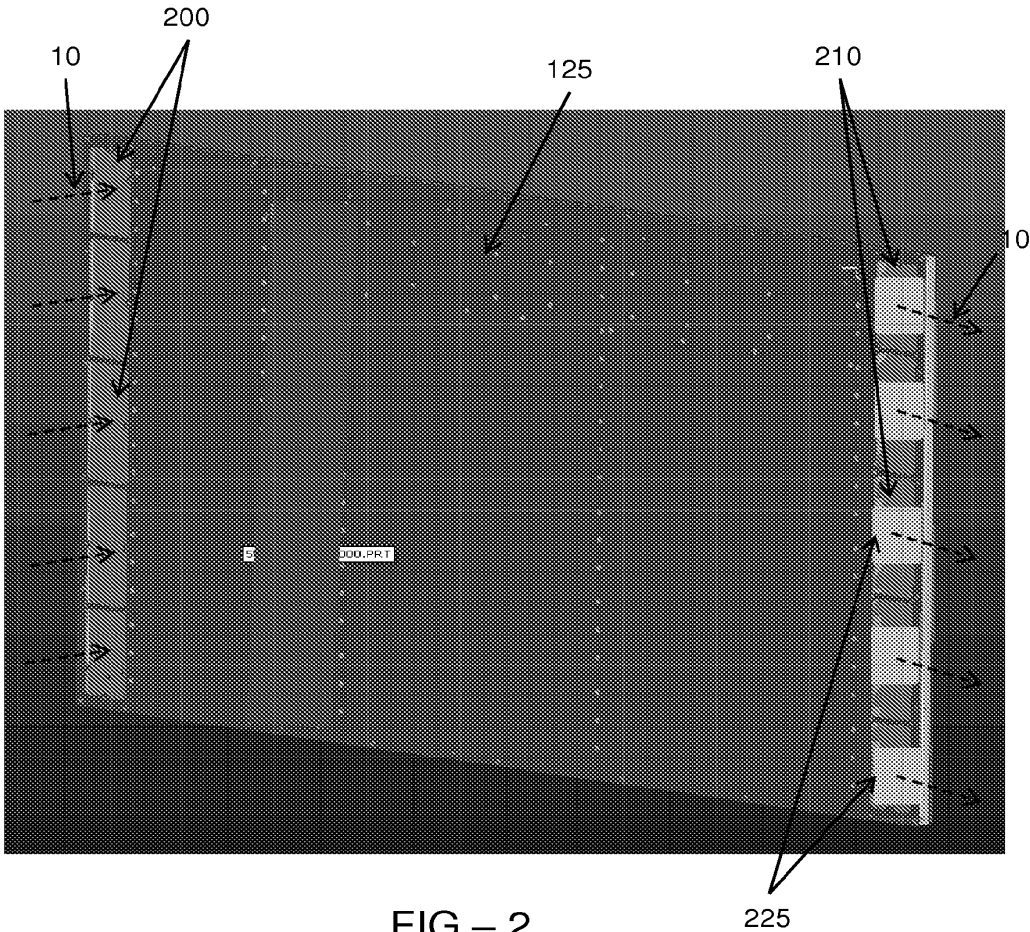
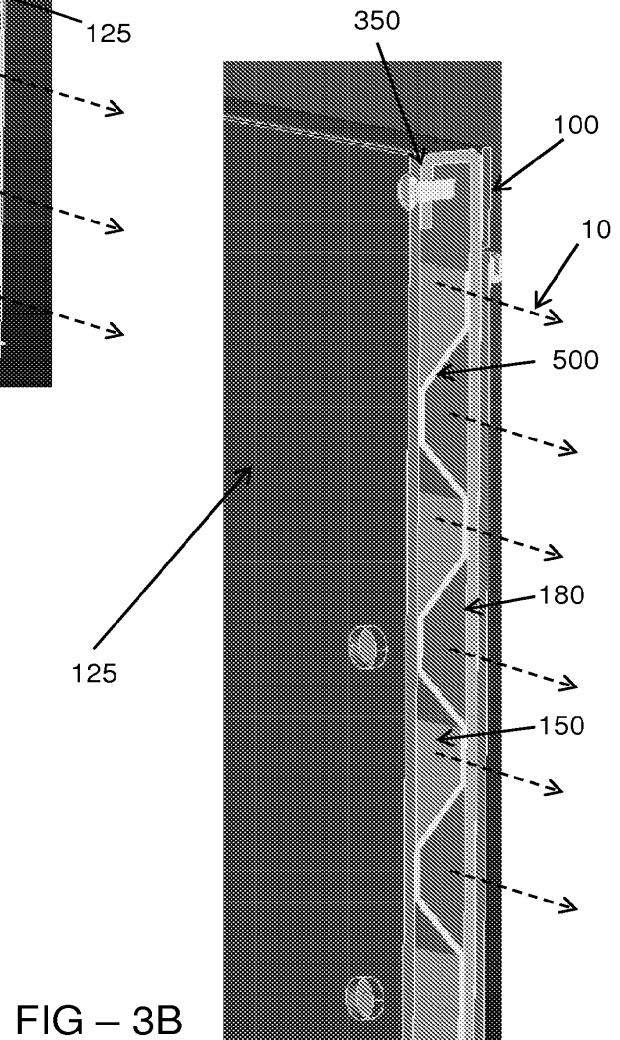
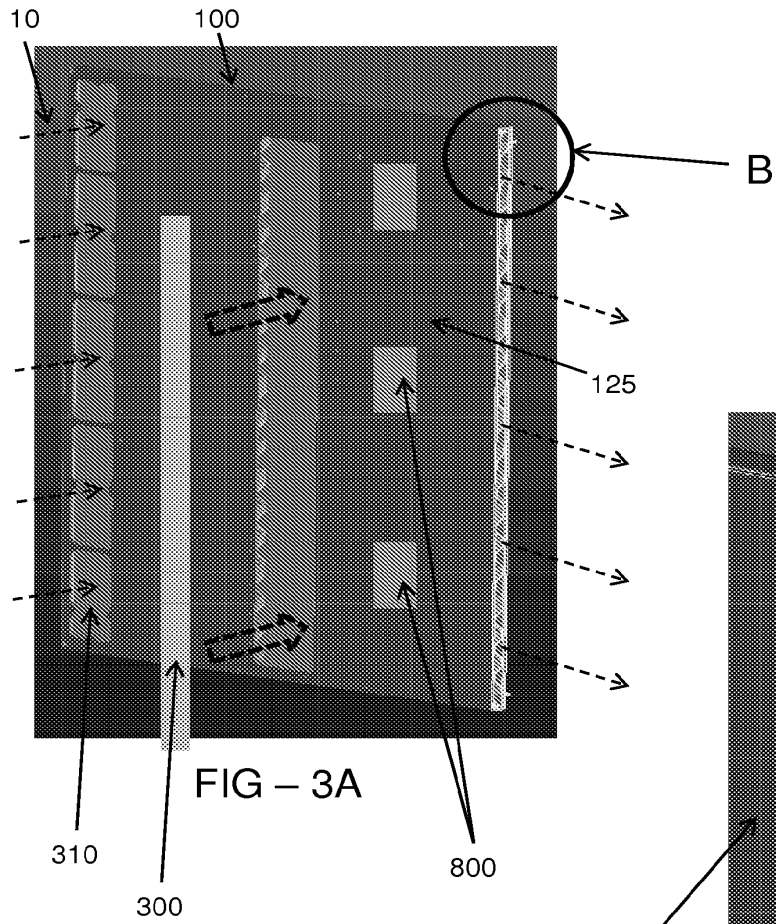


FIG - 2



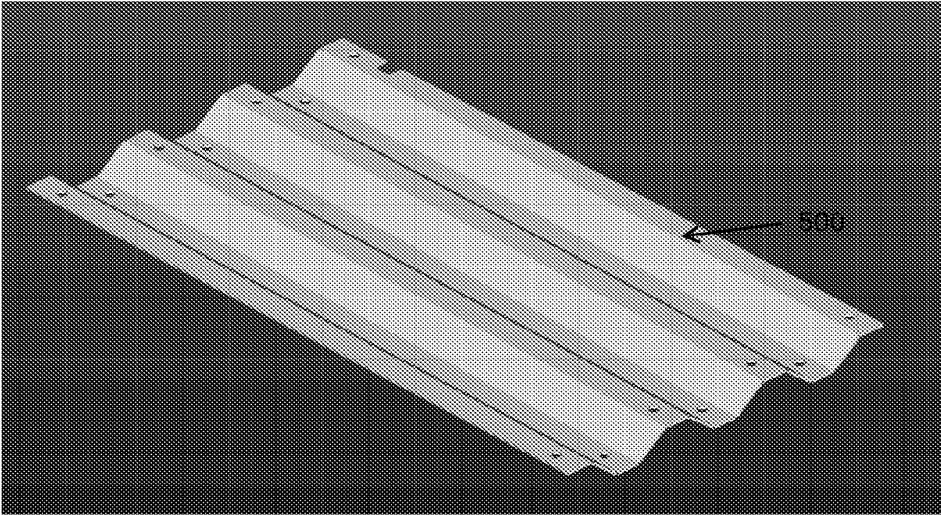
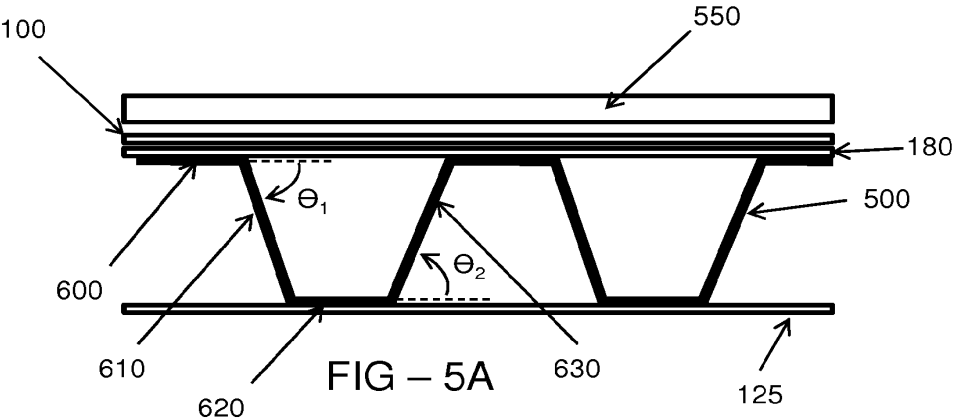
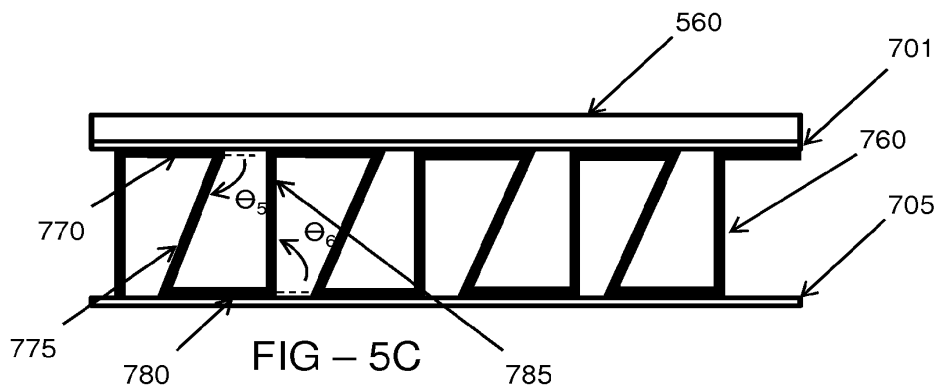
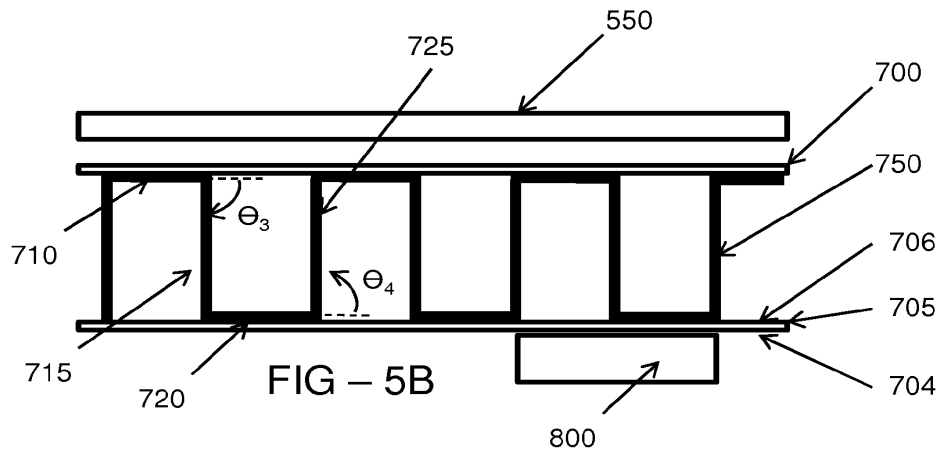


FIG - 4







Espacenet

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BACK PAN COOLING ASSEMBLY FOR ELECTRIC DISPLAY

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Exemplary embodiments disclosed herein provide a back pan cooling assembly for an electronic display having a rear pan. A cooling back pan is preferably positioned behind the rear pan, the space between the cooling back pan and the rear pan defining a gap. A fan is positioned to cause a flow of ambient air through the gap. An electronic component for driving the electronic display may be placed in conductive thermal communication with the cooling back pan. A rear cover can be placed against the cooling back pan to define a sealed compartment which does not permit ambient air to enter. A port can be provided within the rear cover which allows ambient air to travel between the surroundings, the fan, and the gap.

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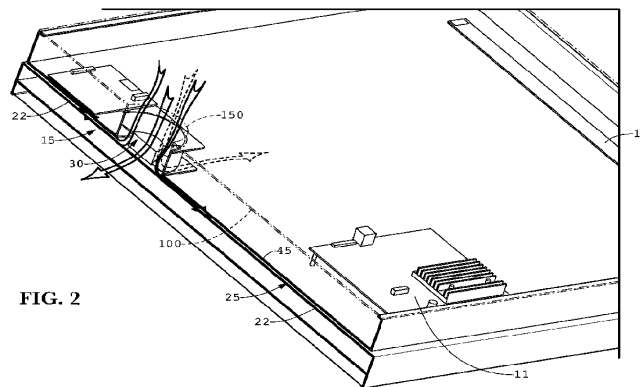


FIG. 2

(57) Abstract: Exemplary embodiments disclosed herein provide a back pan cooling assembly for an electronic display having a rear pan. A cooling back pan is preferably positioned behind the rear pan, the space between the cooling back pan and the rear pan defining a gap. A fan is positioned to cause a flow of ambient air through the gap. An electronic component for driving the electronic display may be placed in conductive thermal communication with the cooling back pan. A rear cover can be placed against the cooling back pan to define a sealed compartment which does not permit ambient air to enter. A port can be provided within the rear cover which allows ambient air to travel between the surroundings, the fan, and the gap.

WO 2014/062815 A1

Back Pan Cooling Assembly for Electronic Display

Cross-Reference to Related Applications

[0001] This application claims priority to US Application No. 61/714,381 filed on October 16, 2012 and is herein incorporated by reference in its entirety.

Technical Field

[0002] Embodiments generally relate to a cooling assembly for the back pan of an electronic display.

Background of the Art

[0003] Electronic displays are now being used for a variety of applications, in addition to the traditional in-home viewing applications. It is now desirable for electronic displays to be used as restaurant menu boards, advertising, and general informational purposes. Each application may require a different set of electronic assemblies, in order to drive the electronic display and provide any ancillary services related to the electronic display and its purpose. Electronic displays are typically manufactured in standard sizes, shapes, and with standard electronic components.

Summary of the Exemplary Embodiments

[0004] One exemplary embodiment provides a cooling back pan that is positioned behind the rear pan of an electronic display, where the space between the cooling back pan and the rear pan defines a gap. A fan is preferably positioned so as to cause a flow of ambient air through the gap, cooling the rear pan and the cooling back pan. Electronic components for operating the electronic display can be mounted to the cooling back pan and preferably are placed in conductive thermal communication with the cooling back pan.

[0005] The foregoing and other features and advantages of the present invention will be apparent from the following more detailed description of the particular embodiments, as illustrated in the accompanying drawings.

Brief Description of the Drawings

[0006] A better understanding of an exemplary embodiment will be obtained from a reading of the following detailed description and the accompanying drawings wherein identical reference characters refer to identical parts and in which:

[0007] FIGURE 1 is a rear perspective view of an exemplary back pan cooling assembly.

[0008] FIGURE 2 is a sectional view of the embodiment shown in Figure 1.

Detailed Description

[0009] The invention is described more fully hereinafter with reference to the accompanying drawings, in which exemplary embodiments of the invention are shown. This invention may, however, be embodied in many different forms and should not be construed as limited to the exemplary embodiments set forth herein. Rather, these embodiments are provided so that this disclosure will be thorough and complete, and will fully convey the scope of the invention to those skilled in the art. In the drawings, the size and relative sizes of layers and regions may be exaggerated for clarity.

[0010] The terminology used herein is for the purpose of describing particular embodiments only and is not intended to be limiting of the invention. As used herein, the singular forms "a", "an" and "the" are intended to include the plural forms as well, unless the context clearly indicates otherwise. It will be further understood that the terms "comprises" and/or "comprising," when used in this specification, specify the presence of stated features, integers, steps, operations, elements, and/or components, but do not preclude the presence or addition of one or more other features, integers, steps, operations, elements, components, and/or groups thereof.

[0011] Embodiments of the invention are described herein with reference to illustrations that are schematic illustrations of idealized embodiments (and intermediate

structures) of the invention. As such, variations from the shapes of the illustrations as a result, for example, of manufacturing techniques and/or tolerances, are to be expected. Thus, embodiments of the invention should not be construed as limited to the particular shapes of regions illustrated herein but are to include deviations in shapes that result, for example, from manufacturing.

[0012] Unless otherwise defined, all terms (including technical and scientific terms) used herein have the same meaning as commonly understood by one of ordinary skill in the art to which this invention belongs. It will be further understood that terms, such as those defined in commonly used dictionaries, should be interpreted as having a meaning that is consistent with their meaning in the context of the relevant art and will not be interpreted in an idealized or overly formal sense unless expressly so defined herein.

[0013] FIGURE 1 is a rear perspective view of an exemplary back pan cooling assembly where the rear cover 100 has been removed. An electronic display 15 is provided on the bottom with an exemplary cooling back pan 45 positioned on the top. The electronic display 15 contains a rear pan 22 on the rear surface of the electronic display 15 (i.e. on the side opposing an intended observer). The rear pan 22 is often a component in mass-manufactured electronic displays and typically provides mounts for electronic subassemblies or housings to go with the electronic display. In some embodiments, the rear pan 22 is metallic. As used herein, the term 'rear pan' does not require that the pan is actually the one that came with the originally mass-manufactured display, as this component may be upgraded from its originally mass-manufactured form by downstream manufacturers.

[0014] Here, electronic components 10 and 11 for driving the electronic display 15 are fastened to the cooling back pan 45. In an exemplary embodiment, the electronic components 10 and 11 may be placed in conductive thermal communication with the cooling back pan 22. The electronic components 10 and 11 may contain any one of the following: timing and control boards (TCON), power supplies, video cards/drivers/players, input/output interfaces, antennas, wireless receivers, modems, local electronic storage, and CPU/microprocessors.

[0015] The space between the rear pan 22 and the exemplary cooling back pan 45 defines an air gap 25. The fan 30 is positioned so as to cause a flow of ambient cooling air through the gap 25, in order to cool both the rear pan 22 and the cooling back pan 45. The fan 30 preferably draws ambient air from around the display housing, without letting the air enter other portions of the display housing, especially the portions of the cooling back pan 45 which contain the electronic components 10 and 11 (i.e. the portions sealed off between the cooling back pan 45 and the rear cover 100). In other words, the fan 30 is preferably placed in sealed gaseous communication with the surrounding ambient air and the gap 25 such that ambient air can pass through the fan 30 and gap 25 without entering the area sealed by the cooling back pan 45 and rear cover 100.

[0016] In at least one embodiment, a port 150 is provided which provides sealed gaseous communication between the ambient air surrounding the display housing and the fan 30. Once forced through the gap 25, the cooling air can exit any portion of the perimeter of the rear pan 22 and cooling back pan 45 assemblies, and eventually is exhausted out of the edges of the display housing. In other words, the gap 25 preferably extends to all four edges of the display housing and allows ambient air to enter/exit the gap 25 along all four edges of the rear pan 22 and cooling back pan 45.

[0017] **FIGURE 2** is a sectional view of the embodiment shown in Figure 1.

[0018] As can be observed, the cooling back pan 45 can be used to mount any number of specialized electrical components 10 and 11 which may be required for the end-use of any electronic display. At the same time, the cooling back pan 45 can help remove heat from the electronic components 10 and 11 as well as the rear pan 22, without exposing the sensitive components to ambient air (which may contain dirt, dust, or contaminants).

[0019] It should be noted that although a single fan 30 is shown, this is not required by any embodiment as there can be multiple fans positioned on the cooling back pan 45 in other embodiments. Also, although an exemplary embodiment uses the fan 30 to push the cooling air into the gap 25, alternative embodiments could also be used to draw air from the edges of the display housing, through the gap 25, and exhaust the air through the port 150. It should also be noted that additional fans may be positioned

within the cooling back pan 45 in order to circulate air around the interior of the cooling back pan 45, without mixing with the ambient air.

[0020] It should also be noted that it is preferable to place the fan 30 near the center of the cooling back pan 45, although this is not required. It may be preferable in some instances to place the fan 30 closer to the horizontal top edge of the cooling back pan 45 (as shown in Figure 2), as the heat generated by the display assembly tends to rise where additional flow rates of cooling air would be beneficial in this area. In most cases, if using only one fan 30, it may be preferable to place the fan near the vertically-drawn centerline of the cooling back pan 45.

[0021] As used herein, the term 'electronic display' is any electronic assembly for generating an image to a viewer. The term specifically includes, but is not limited to: liquid crystal displays (all types), OLED, light emitting diode (LED), field emitting display (FED), light emitting polymer (LEP), organic electro luminescence (OEL), plasma displays, and any other type of thin/flat panel display. In an exemplary embodiment, the electronic display 15 comprises an LED edge lit LCD display where the LED backlight is placed in conductive thermal communication with the rear pan 22. In another exemplary embodiment, the electronic display 15 comprises an LED direct backlit LCD display where the rear pan 22 is provided as the rear surface of the direct LED backlight.

[0022] Having shown and described a preferred embodiment of the invention, those skilled in the art will realize that many variations and modifications may be made to affect the described invention and still be within the scope of the claimed invention. Additionally, many of the elements indicated above may be altered or replaced by different elements which will provide the same result and fall within the spirit of the claimed invention. It is the intention, therefore, to limit the invention only as indicated by the scope of the claims.

CLAIMS

We claim:

1. A back pan cooling assembly for an electronic display having a rear pan, the assembly comprising:
 - a cooling back pan positioned behind the rear pan, the space between the cooling back pan and the rear pan defining a gap;
 - a fan positioned to cause a flow of ambient air through the gap; and
 - an electronic component for driving the electronic display, placed in conductive thermal communication with the cooling back pan.
2. The cooling assembly of claim 1 wherein:
 - the fan is sealed within the cooling back pan such that ambient air is not permitted to contact the electronic component.
3. The cooling assembly of claim 1 wherein:
 - the electronic display is in conductive thermal communication with the rear pan.
4. The cooling assembly of claim 1 further comprising:
 - an LED backlight within the electronic display and placed in thermal communication with the rear pan.
5. The cooling assembly of claim 1 wherein:
 - the rear pan and cooling back pan each contain four perimeter edges which are substantially aligned with one another.
6. The cooling assembly of claim 5 wherein:
 - the gap extends to all four perimeter edges of the rear pan and cooling back pan.
7. The cooling assembly of claim 5 wherein:
 - ambient air is permitted to enter the gap along all four perimeter edges.

8. The cooling assembly of claim 1 wherein:
the rear pan comprises the rear surface of a direct-lit LED backlight.
9. The cooling assembly of claim 1 further comprising:
a port in gaseous communication with the fan such that ambient air is drawn through the port and exhausted out of the gap.
10. The cooling assembly of claim 1 further comprising:
a port in gaseous communication with the fan such that ambient air is drawn through the gap and exhausted out of the port.
11. A back pan cooling assembly for an electronic display having a rear pan, the assembly comprising:
a cooling back pan positioned behind the rear pan, the space between the cooling back pan and the rear pan defining a gap;
a rear cover positioned on the cooling back pan to define a rear compartment which is sealed to prevent ambient air from entering the rear compartment;
a port which accepts ambient gas;
an open loop gaseous pathway defined by gaseous communication between the port, fan, and gap; and
a fan positioned to cause a flow of ambient air through the open loop gaseous pathway.
12. The cooling assembly of claim 11 further comprising:
an electronic component for operating the electronic display, placed within the compartment and mounted to the cooling back pan.
13. The cooling assembly of claim 11 wherein:

the rear pan and cooling back pan each contain four perimeter edges which are substantially aligned with one another.

14. The cooling assembly of claim 13 wherein:
the gap extends to all four perimeter edges of the rear pan and cooling back pan.
15. The cooling assembly of claim 11 wherein:
the fan is oriented such that ambient air is drawn through the port and exhausted out of the gap.
16. The cooling assembly of claim 11 wherein:
the fan is oriented such that ambient air is drawn through the gap and exhausted out of the port.
17. A back pan cooling assembly for an electronic display having a rear pan with a pair of vertical edges and a pair of horizontal edges, the assembly comprising:
a cooling back pan having a pair of vertical edges substantially aligned with the vertical edges of the rear pan and a pair of horizontal edges which are substantially aligned with the horizontal edges of the rear pan;
a gap defined between the cooling back pan and rear pan which extends to each horizontal edge to define a pair of horizontal edge gaps and to each vertical edge to define a pair of vertical edge gaps; and
a fan positioned to cause ambient air to flow through the vertical edge gaps and the horizontal edge gaps.
18. The cooling assembly of claim 17 wherein:
the fan is positioned near a center of the cooling back pan.
19. The cooling assembly of claim 17 further comprising:
an LED backlight within the electronic display which is placed in conductive thermal communication with the rear pan.

20. The cooling assembly of claim 17 further comprising:
- a rear cover positioned on the cooling back pan to define a rear compartment which is sealed to prevent ambient air from entering the rear compartment;
 - a port within the rear cover; and
 - an open loop gaseous pathway defined by gaseous communication between the port, fan, and the edge gaps.

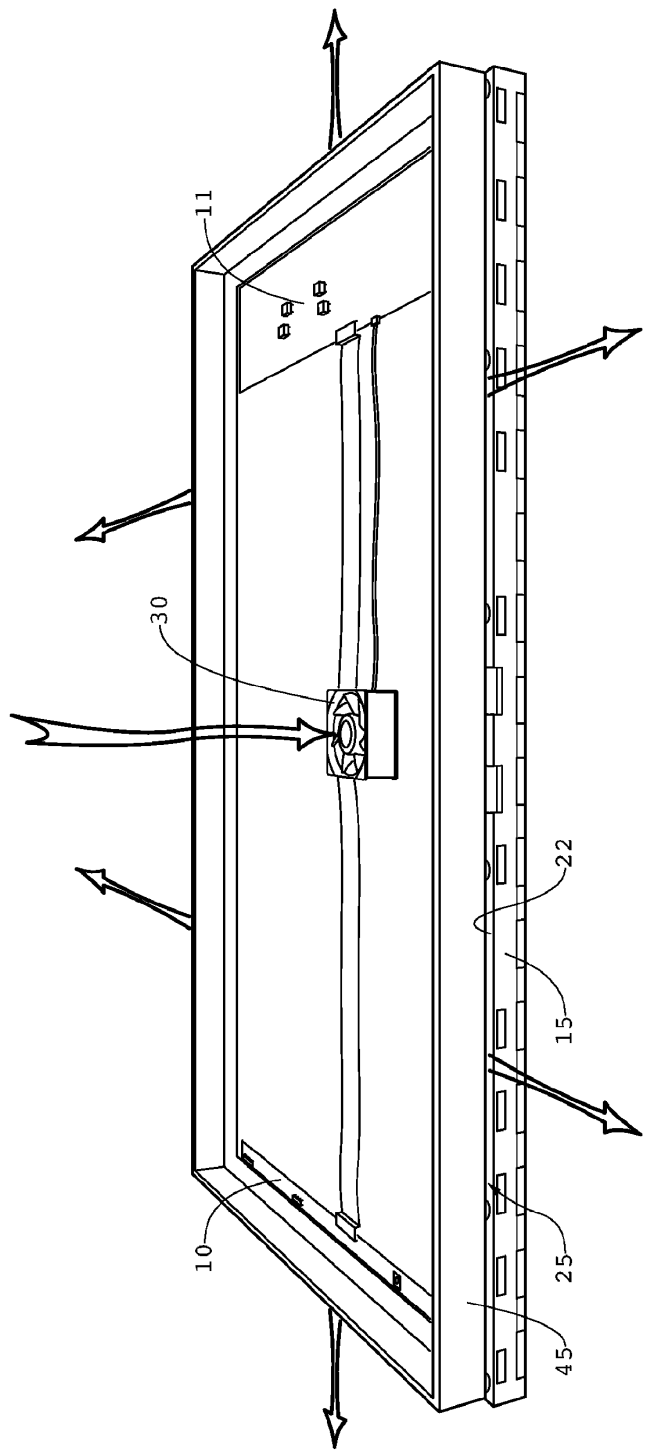


FIG. 1

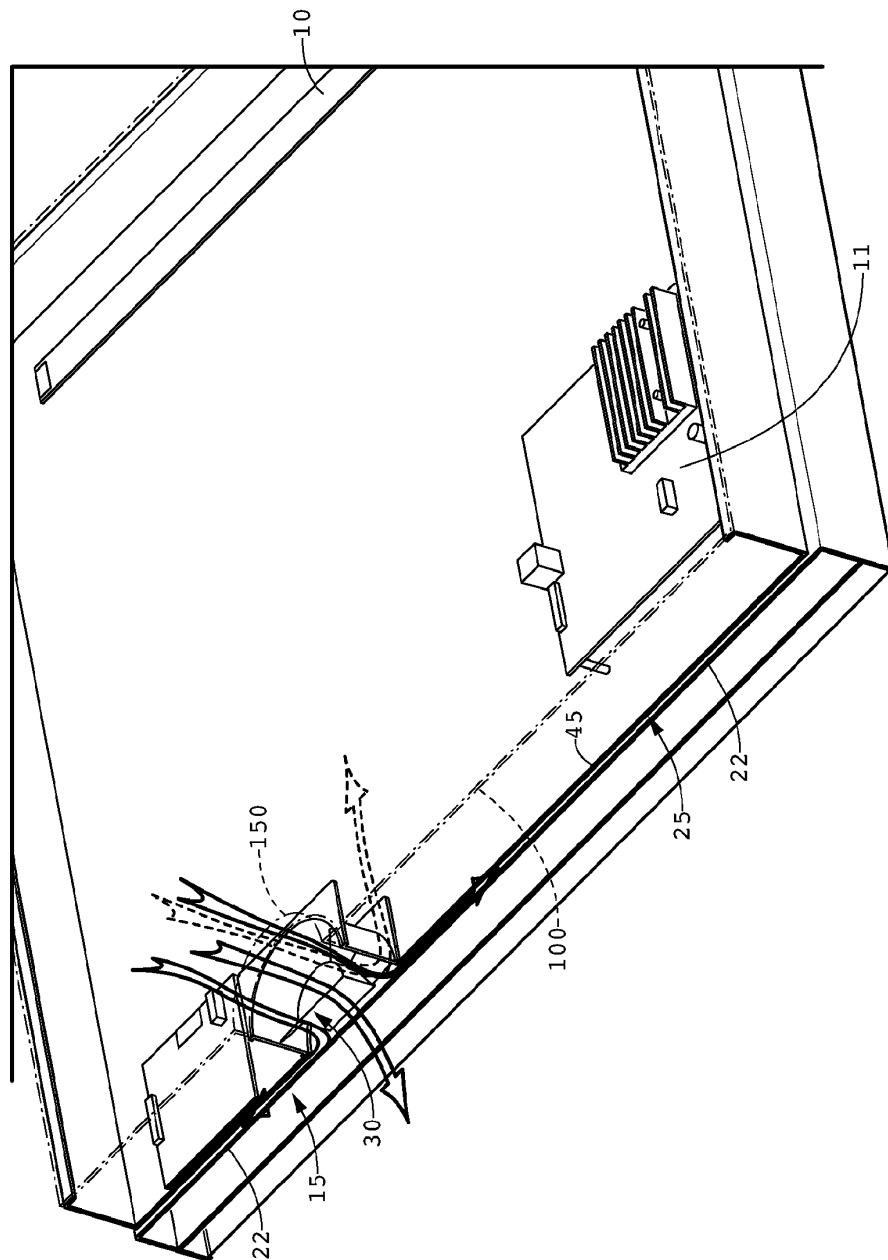


FIG. 2

INTERNATIONAL SEARCH REPORT

International application No.

PCT/US2013/065264

A. CLASSIFICATION OF SUBJECT MATTER

IPC(8) - G09F 9/00 (2014.01)

USPC - 362/612

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

B. FIELDS SEARCHED

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IPC(8) - F21V 29/00; G09F 9/00; G09G 3/20, 5/00, 5/10; H01J 17/28; H05K 7/20 (2014.01)

USPC - 174/547; 345/55, 87, 204; 361/692, 695, 697; 362/97.3, 612

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

CPC - F21V 29/00; G09F 9/00; G09G 3/20, 5/00, 5/10; H01J 17/28; H05K 7/20 (2014.01)

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

Orbit, Google Patents, Google, Google Scholar

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	JP 11296094 A (IRIE et al) 29 October 1999 (29.10.1999) entire document	1, 3, 5-7, 9, 10, 17, 18
Y		2, 4, 8, 11-16, 19, 20
Y	US 2012/0020114 A1 (MIYAMOTO et al) 26 January 2012 (26.12.2012) entire document	2, 4, 8, 11-16, 19, 20
A	US 2012/0044217 A1 (OKADA et al) 23 February 2012 (23.02.2012) entire document	1-20

☐ Further documents are listed in the continuation of Box C.

* Special categories of cited documents:

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier application or patent but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

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FIGURE EIGHT CLOSED LOOP COOLING SYSTEM FOR ELECTRONIC DISPLAY

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The exemplary embodiments herein provide a figure eight closed loop of circulating gas pathways wrapping around an electronic display. One or more open loop ambient air pathways may pass through the figure eight but do not allow the circulating gas and the ambient air to mix. In some embodiments, the open loop ambient air pathway travels along a rear surface of the electronic display. In some embodiments, the circulating gas pathways contain a front channel placed in front of the electronic display, a rear channel placed behind the electronic display, and a center channel placed between the front and rear channels. Pass-through apertures may be placed within the path of the circulating gas and/or the ambient air to allow the paths of the two gaseous matters to cross without allowing them to mix with one another.

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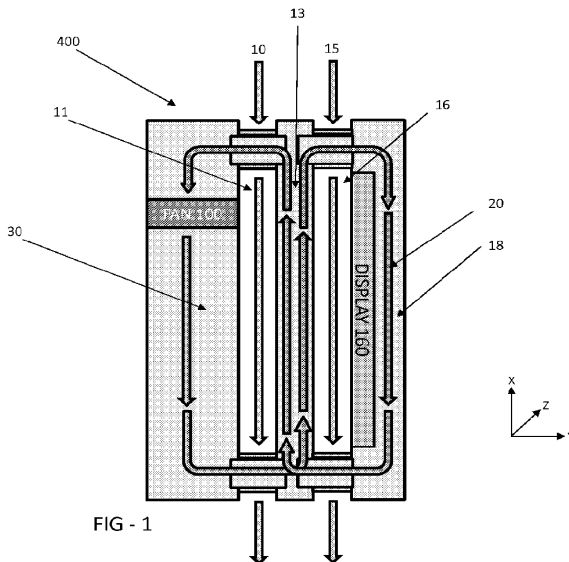
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[Continued on next page]

(54) Title: FIGURE EIGHT CLOSED LOOP COOLING SYSTEM FOR ELECTRONIC DISPLAY



(57) Abstract: The exemplary embodiments herein provide a figure eight closed loop of circulating gas pathways wrapping around an electronic display. One or more open loop ambient air pathways may pass through the figure eight but do not allow the circulating gas and the ambient air to mix. In some embodiments, the open loop ambient air pathway travels along a rear surface of the electronic display. In some embodiments, the circulating gas pathways contain a front channel placed in front of the electronic display, a rear channel placed behind the electronic display, and a center channel placed between the front and rear channels. Pass-through apertures may be placed within the path of the circulating gas and/or the ambient air to allow the paths of the two gaseous matters to cross without allowing them to mix with one another.

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FIGURE EIGHT CLOSED LOOP COOLING SYSTEM FOR ELECTRONIC DISPLAY

Inventors: William Dunn and Kevin O'Conner

Cross-Reference to Related Applications

[0001] This application claims priority to US Provisional Application No. 61/843,706 filed on July 8, 2013 which is herein incorporated by reference in its entirety.

Technical Field

[0002] Embodiments generally relate to cooling systems for electronic displays.

Background of the Art

[0003] Electronic displays are sometimes used in outdoor environments or other areas where the surrounding temperatures may be high or there may be other sources of heat such as solar loading causing the temperatures within the display to rise. However, some portions of the display can be difficult to cool as simply ingesting ambient air into some portions of the display can introduce dust and contaminants into sensitive portions of the display, which can lead to premature failures.

Summary of the Exemplary Embodiments

[0004] Exemplary embodiments provide a figure eight closed loop circulating gas path which defines a center channel for the closed loop of circulating gas. A pair of open loop ambient air channels may be placed on opposite sides of the center channel, in order to remove heat from at least the center channel and the closed loop circulating

gas. One or more open loop ambient air pathways may pass through the figure eight but do not allow the circulating gas and the ambient air to mix. In some embodiments, the open loop ambient air pathway travels along a rear surface of the electronic display. In some embodiments, the circulating gas pathways contain a front channel placed in front of the electronic display, a rear channel placed behind the electronic display, and a center channel placed between the front and rear channels. Pass-through apertures may be placed within the path of the circulating gas and/or the ambient air to allow the paths of the two gaseous matters to cross without allowing them to mix with one another.

[0005] The foregoing and other features and advantages of the present invention will be apparent from the following more detailed description of the particular embodiments, as illustrated in the accompanying drawings.

Brief Description of the Drawings

[0006] A better understanding of an exemplary embodiment will be obtained from a reading of the following detailed description and the accompanying drawings wherein identical reference characters refer to identical parts and in which:

[0007] FIGURE 1 is a simplified illustration of an exemplary embodiment of the figure eight closed loop cooling system.

[0008] FIGURE 2 is a side rear perspective view showing the overall assembly of the display with the rear cover removed and indicating the section line 3-3.

[0009] FIGURE 3 is a perspective section view taken from the section line 3-3 and indicating the locations for Detail 4 and Detail 5.

[0010] **FIGURE 4** is a detailed perspective section view of Detail 4.

[0011] **FIGURE 5** is a detailed perspective section view of Detail 5.

[0012] **FIGURE 6** is a bottom rear perspective view showing the overall assembly of the display and indicating the section line 7-7.

[0013] **FIGURE 7** is a perspective section view taken from the section line 7-7.

Detailed Description

[0014] The invention is described more fully hereinafter with reference to the accompanying drawings, in which exemplary embodiments of the invention are shown. This invention may, however, be embodied in many different forms and should not be construed as limited to the exemplary embodiments set forth herein. Rather, these embodiments are provided so that this disclosure will be thorough and complete, and will fully convey the scope of the invention to those skilled in the art. In the drawings, the size and relative sizes of layers and regions may be exaggerated for clarity.

[0015] The terminology used herein is for the purpose of describing particular embodiments only and is not intended to be limiting of the invention. As used herein, the singular forms "a", "an" and "the" are intended to include the plural forms as well, unless the context clearly indicates otherwise. It will be further understood that the terms "comprises" and/or "comprising," when used in this specification, specify the presence of stated features, integers, steps, operations, elements, and/or components, but do not preclude the presence or addition of one or more other features, integers, steps, operations, elements, components, and/or groups thereof.

[0016] Embodiments of the invention are described herein with reference to illustrations that are schematic illustrations of idealized embodiments (and intermediate structures) of the invention. As such, variations from the shapes of the illustrations as a result, for example, of manufacturing techniques and/or tolerances, are to be expected. Thus, embodiments of the invention should not be construed as limited to the particular shapes of regions illustrated herein but are to include deviations in shapes that result, for example, from manufacturing.

[0017] Unless otherwise defined, all terms (including technical and scientific terms) used herein have the same meaning as commonly understood by one of ordinary skill in the art to which this invention belongs. It will be further understood that terms, such as those defined in commonly used dictionaries, should be interpreted as having a meaning that is consistent with their meaning in the context of the relevant art and will not be interpreted in an idealized or overly formal sense unless expressly so defined herein.

[0018] **FIGURE 1** is a simplified illustration of an exemplary embodiment of the figure eight closed loop cooling system 400. This exemplary embodiment contains a plurality of channels in the assembly. The front channel 18 is placed in front of the display 160 and preferably allows closed loop circulating gas 20 to remove heat from the front of the display 160. The front open loop channel 16 is positioned behind the display 160 and preferably allows open loop air 15 to pass behind the display 160, removing heat at least from the rear portion of the display 160 and the center channel 13. The center channel 13 is preferably positioned between the front open loop channel 16 and the rear open loop channel 11 and allows closed loop circulating gas 20 to cross paths with itself

(creating the figure eight) and to cross paths with the open loop air 10 and 15 without allowing the closed loop circulating gas and open loop air to mix.

[0019] The rear open loop channel 11 is preferably positioned immediately adjacent to the center channel 13, and allows open loop air 10 to flow through, thereby removing heat from the center channel 13 (and/or the closed loop circulating gas 13 contained within) and the rear channel 30. The rear channel 30 is positioned near the rear of the display and may contain various electronic components 35 for operating the overall display assembly, fans, or the display 160 itself.

[0020] In an exemplary embodiment, the front channel 18, center channel 13, and rear channel 30 are in sealed gaseous communication with each other. In other words, these channels do not permit closed loop circulating gas 20 to substantially escape or to allow ambient air or open loop air to enter these channels. Also in an exemplary embodiment, open loop air 10 and 15 is simply ambient air surrounding the display assembly. However, in some embodiments the open loop air 10 and 15 may be treated in some way (ex. filtered, air conditioned, or pre-cooled in some way) prior to being ingested into the display assembly. In this particular embodiment, the closed loop fan 100 is positioned within the rear channel 30, although this is not required. All that is required is that the closed loop fan 100 is positioned to force the closed loop circulating gas 20 through the front channel 18, center channel 13, and rear channel 30. The closed loop circulating gas 20 can be any gaseous matter that preferably does not contain large amounts of particulate. However, it does not have to be pure gas of any type; simple clean air works fine with the exemplary embodiments.

[0021] FIGURE 2 is a side rear perspective view showing the overall assembly of the display with the rear cover removed and indicating the section line 3-3. In this particular embodiment, the display assembly is designed for a portrait orientation with the closed loop fans 100 positioned at the top of the assembly and the open loop fans 200 positioned at the bottom of the assembly. This is of course not required however, as the embodiments herein can be flipped or oriented for a landscape orientation if desired. Further, the open loop fans 200 do not have to be placed at the bottom of the assembly, but could be positioned anywhere so that the open loop air travels in the paths specified in these exemplary embodiments. It of course goes without saying that additional fans could also be used to increase flow rates and/or pressure.

[0022] FIGURE 3 is a perspective section view taken from the section line 3-3 and indicating the locations for Detail 4 and Detail 5. Here, the front channel 18 is defined between the front transparent plate 150 and the electronic display 160. In an exemplary embodiment the electronic display 160 may be an LED backlit liquid crystal display (LCD), but this is not required. Alternative embodiments may utilize any type of flat panel electronic display, including but not limited to plasma, OLED, electroluminescent polymers, or similar. In some embodiments, the various electrical components 35 (power supplies, printed circuit boards, microprocessors, electronic storage, etc.) may be attached and in thermal communication with a plate 31 which may form the rear portion of channel 11 for open loop air 10. In this way, heat that is generated by the electrical components 35 may be transferred to the plate 31, where it can be removed by open loop air 10.

[0023] FIGURE 4 is a detailed perspective section view of Detail 4. Closed loop circulating gas 20 is permitted to pass through the rear open loop channel 11 without mixing with the open loop air 10 by use of pass-through apertures 200, which provide sealed gaseous communication between the rear channel 30 and the center channel 13, without permitting open loop air 10 to enter the channels 30 and 13. In an exemplary embodiment, rear open loop channel 11 may also contain cooling fins 400 for distributing heat from the adjacent channels (30 and 13) and/or electronic components 35 in order to be efficiently removed by the open loop air 10. Similarly, front open loop channel 16 may also contain cooling fins 450 for distributing heat from the adjacent channels (30 and 18) and/or the rear surface of the display 160 in order to be efficiently removed by the open loop air 15. In an exemplary embodiment, the display 160 contains a direct lit LED backlight where the cooling fins 450 are placed in thermal communication with the LED backlight. The cooling fins 450 and 400 may be comprised of any thermally conductive material, but would preferably be comprised of metal and in an exemplary embodiment would be a thin sheet (or multiple thin sheets) of metal.

[0024] FIGURE 5 is a detailed perspective section view of Detail 5. Closed loop circulating gas 20 is permitted to pass through the front open loop channel 16 without mixing with the open loop air 15 by use of pass-through apertures 205, which provide sealed gaseous communication between the front channel 18 and the center channel 13, without permitting open loop air 15 to enter the channels 18 and 13.

[0025] FIGURE 6 is a bottom rear perspective view showing the overall assembly of the display and indicating the section line 7-7.

[0026] **FIGURE 7** is a perspective section view taken from the section line 7-7. The center channel 13 is preferably divided into a plurality of subchannels 300 and 305. On this end of the overall assembly, subchannels 300 are in gaseous communication with the pass-through apertures 200 (which connects the subchannel 300 with the rear channel 30) while subchannels 305 are in gaseous communication with the pass-through apertures 205 (which connects the subchannel 305 with the front channel 18). However, on the opposite end of the assembly (see Figure 3) subchannels 300 are in gaseous communication with the pass-through apertures 205 (which connects the subchannel 300 with the front channel 18) while subchannels 305 are in gaseous communication with the pass-through apertures 200 (which connects the subchannel 305 with the rear channel 30). In this way, the closed loop of circulating gas 20 travels through the front channel 18, through a pass-through aperture to travel along subchannel 305, through another pass-through aperture to travel along the rear channel 30, through another pass-through aperture to travel along the subchannel 300, and finally through another pass-through aperture to return to the front channel 18. In this way, the closed loop of circulating gas 20 performs the 'figure eight' through the assembly, as it weaves its way across the front channel 18, through the center channel 13, across the rear channel 30, again through the center channel 13, and returning to the front channel 18.

[0027] It should be noted that subchannels 300 and 305 may not be required in some embodiments as the center channel 13 could be completely open. It should also be noted that other embodiments may use the subchannels 300 and 305 but would not allow a single subchannel to communicate gaseously with both the front channel 18 and

the rear channel 30. In other words, when viewing the end of the assembly as shown in Figure 7, the opposing end of the assembly would be substantially similar. Thus, subchannels 300 would only communicate with pass-through apertures 200 and the rear channel 30, while the subchannels 305 would only communicate with pass-through apertures 205 and front channel 18. Thus, in this embodiment there would be two separate closed loops.

[0028] Although there is preferably gaseous communication throughout the figure eight, subchannel 300 directs the flow of closed loop circulating gas 20 through rear channel 30 and center channel 13 while subchannel 305 directs the flow of closed loop circulating gas 20 through the center channel 13 and front channel 18. In this preferred embodiment, the subchannels 300 and 305 allow separate flow paths for closed loop circulating gas 20 within the center channel 13, without requiring additional fans. These separate flow paths which cross through the center and loop around the display in a single continuous flow, define the figure eight path for the closed loop circulating gas 20 (seen also in Figure 1). Further, in this preferred embodiment, the flow direction of closed loop circulating gas 20 through the center channel 13 is opposite the flow direction of open loop air 15 and 10, creating a counter-flow heat exchanger between the center channel 13 and the front/rear open loop channels 11 and 16. However, this is not required, as a parallel flow or a cross flow design would work as well.

[0029] In an exemplary embodiment, the rear channel 30 would share a plate with the rear open loop channel 11, such that one side of the plate would be within the rear channel 30 while the opposing side of the plate would be within the rear open loop channel 11. This arrangement is illustrated in Figure 3 with the rear plate 31. Similarly,

it may be preferable for the center channel 13 and the rear open loop 11 to share a plate, such that one side of the plate is within the center channel 13 while the other side of the plate is within the rear open loop 11. Similarly, it may be preferable for the center channel 13 and the front open loop 16 to share a plate. Finally, it may also be preferable for the rear surface of the display 160 to form the front wall of the front open loop 16, such that open loop ambient air 15 can remove heat from the electronic display 160. In some embodiments the rear surface of the display 160 would be the rear surface of a metallic PCB holding a plurality of LEDs for the backlight.

[0030] Having shown and described a preferred embodiment of the invention, those skilled in the art will realize that many variations and modifications may be made to affect the described invention and still be within the scope of the claimed invention. Additionally, many of the elements indicated above may be altered or replaced by different elements which will provide the same result and fall within the spirit of the claimed invention. It is the intention, therefore, to limit the invention only as indicated by the scope of the claims.

CLAIMS

We claim:

1. A cooling assembly for an electronic display comprising:
 - a figure eight closed loop of circulating gas pathways wrapping around the electronic display; and
 - an open loop ambient air pathway passing through the figure eight which does not allow circulating gas to mix with ambient gas.
2. The cooling assembly of claim 1 further comprising:
 - a front channel defined between a front surface of the electronic display and a transparent plate;
 - wherein the figure eight closed loop of circulating gas pathways includes the front channel.
3. The cooling assembly of claim 2 further comprising:
 - a rear channel containing electronic components which are mounted to a rear plate;
 - wherein the figure eight closed loop of circulating gas pathways includes the rear channel.
4. The cooling assembly of claim 3 further comprising:
 - a center channel placed between the front channel and rear channel;

wherein the figure eight closed loop of circulating gas pathways includes the center channel.

5. The cooling assembly of claim 1 wherein:

the open loop ambient air pathway travels along a rear surface of the electronic display.

6. The cooling assembly of claim 3 wherein:

the open loop ambient air pathway travels along a side of the rear plate which is opposite the side containing the electronic components.

7. The cooling assembly of claim 1 further comprising:

a plurality of pass-through apertures placed within the figure eight closed loop of circulating gas pathways.

8. The cooling assembly of claim 7 wherein:

the pass-through apertures are arranged such that the circulating gas travels through the center of the aperture while the open loop ambient air passes around the aperture.

9. The cooling assembly of claim 7 wherein:

the pass-through apertures are arranged to prevent the circulating gas from mixing with the open loop ambient air.

10. A cooling assembly for an electronic display comprising:
- a closed loop of gas pathways for circulating gas comprising
 - a front channel placed in front of the electronic display,
 - a rear channel placed behind the electronic display, and
 - a center channel placed between the front and rear channels;
 - a first open loop pathway for ambient air positioned between the electronic display and the center channel; and
 - a second open loop pathway for ambient air positioned between the center channel and the rear channel.
11. The cooling assembly of claim 10 further comprising:
- a closed loop fan positioned to force circulating gas through the closed loop of gas pathways; and
 - an open loop fan positioned to force ambient air through the first and second open loop pathways.
12. The cooling assembly of claim 10 further comprising:
- a rear plate having a posterior and anterior side and placed within the rear channel;
 - a plurality of electronic components attached to the posterior side of the rear plate; and
 - wherein the anterior side of the rear plate forms a portion of the second open loop pathway.

13. The cooling assembly of claim 10 further comprising:

a plurality of pass-through apertures positioned within the first open loop pathway.

14. The cooling assembly of claim 13 wherein:

the pass-through apertures contain a hole in the center and are arranged such that the circulating gas travels through the hole in the center while the ambient air travels around the pass-through aperture.

15. The cooling assembly of claim 10 wherein:

the second open loop pathway and the rear channel share a plate such that a side of the plate is within the rear channel while an opposing side of the plate is within the second open loop pathway.

16. The cooling assembly of claim 10 wherein:

the center channel is placed between the first and second open loop pathways.

17. A cooling assembly for an electronic display comprising:

a front channel defined by the space between a front surface of the electronic display and a transparent plate;

a first open loop pathway defined by the space between a rear surface of the electronic display and a front plate;

a rear plate positioned behind the electronic display and having a first side forming part of a rear channel and an opposing side forming part of a second open loop pathway;

a center channel placed between the first and second open loop pathways;

a closed loop fan positioned to force circulating gas through the front channel, rear channel, and center channel; and

an open loop fan positioned to force ambient air through the first and second open loop pathways.

18. The cooling assembly of claim 17 further comprising:

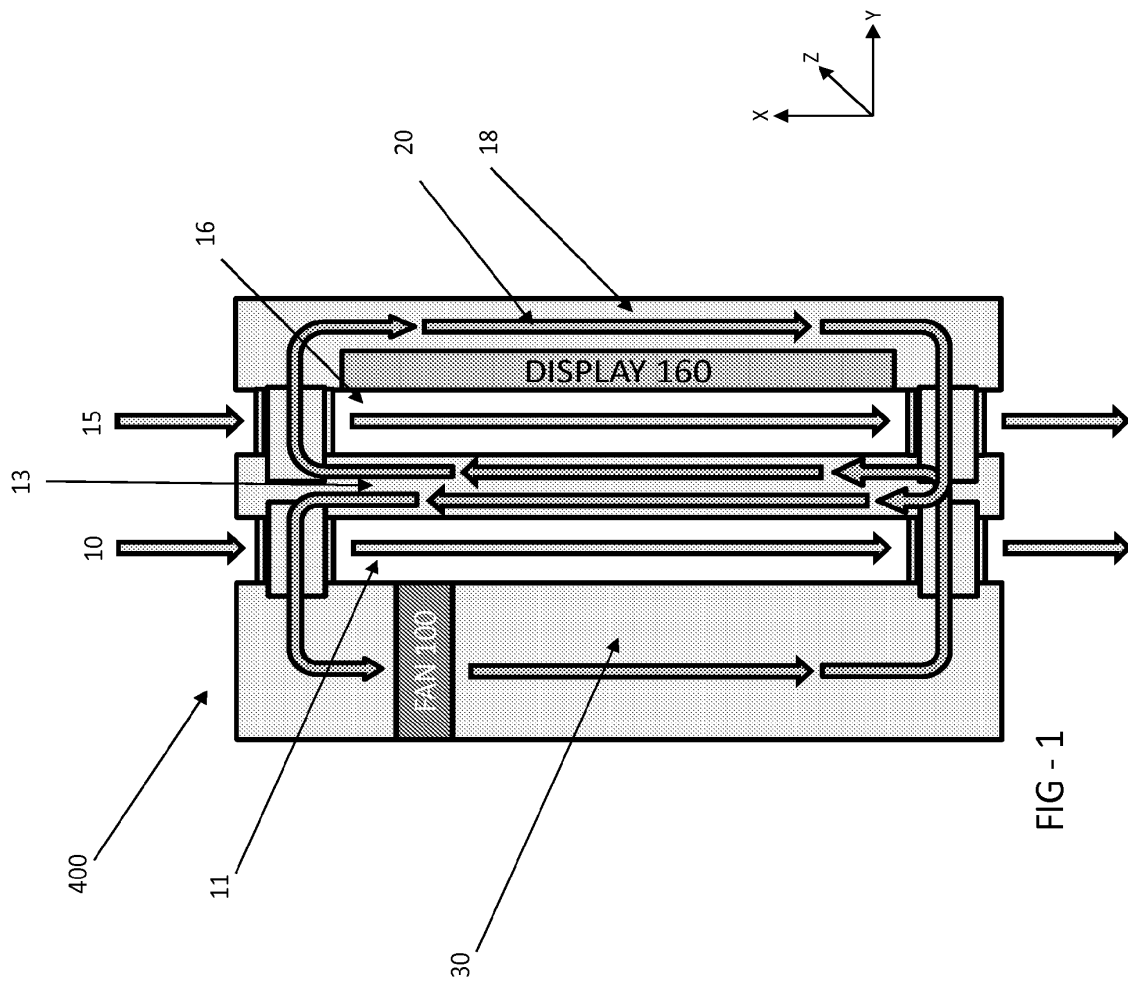
a plurality of pass-through apertures placed within the path of the circulating gas.

19. The cooling assembly of claim 17 further comprising:

a plurality of electronic components attached to the side of the rear plate forming part of the rear channel.

20. The cooling assembly of claim 17 further comprising:

a plurality of cooling fins placed within the first and second open loop pathways.



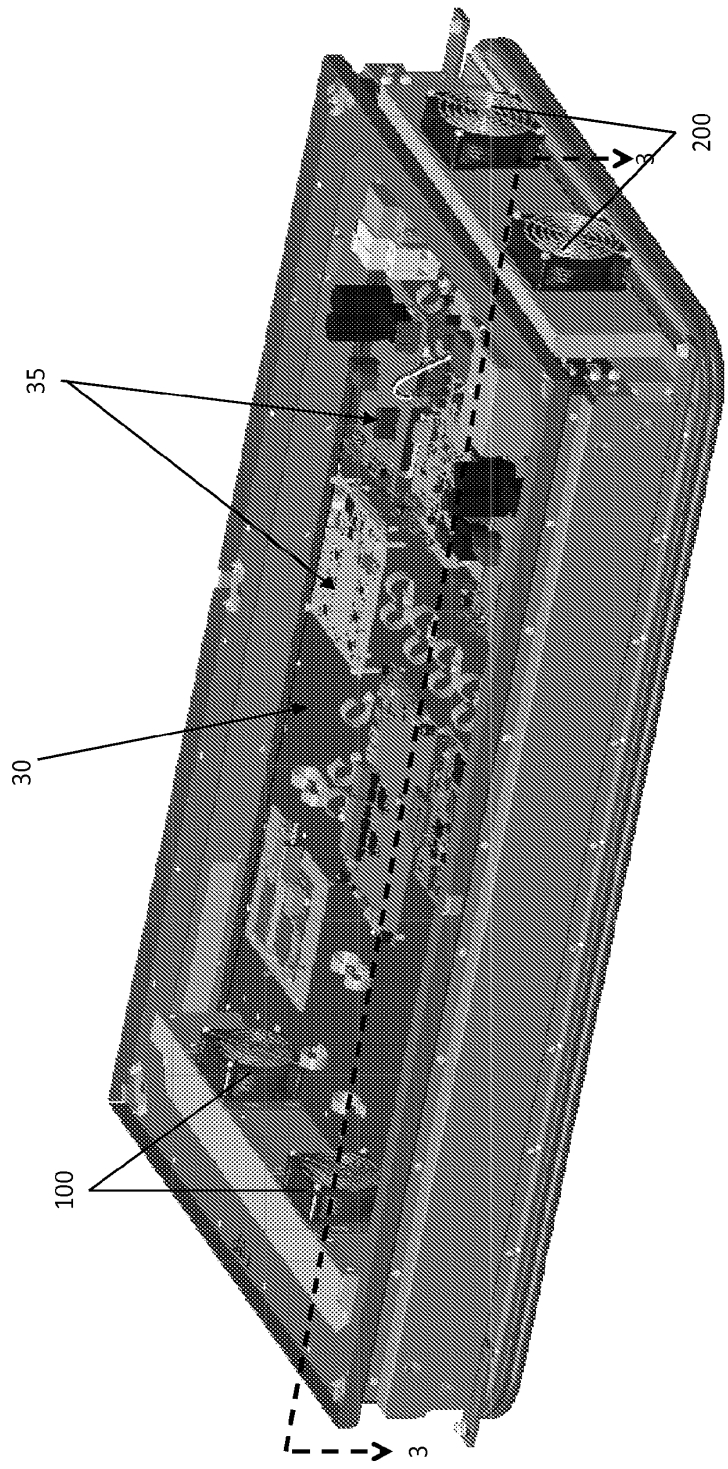


FIG - 2

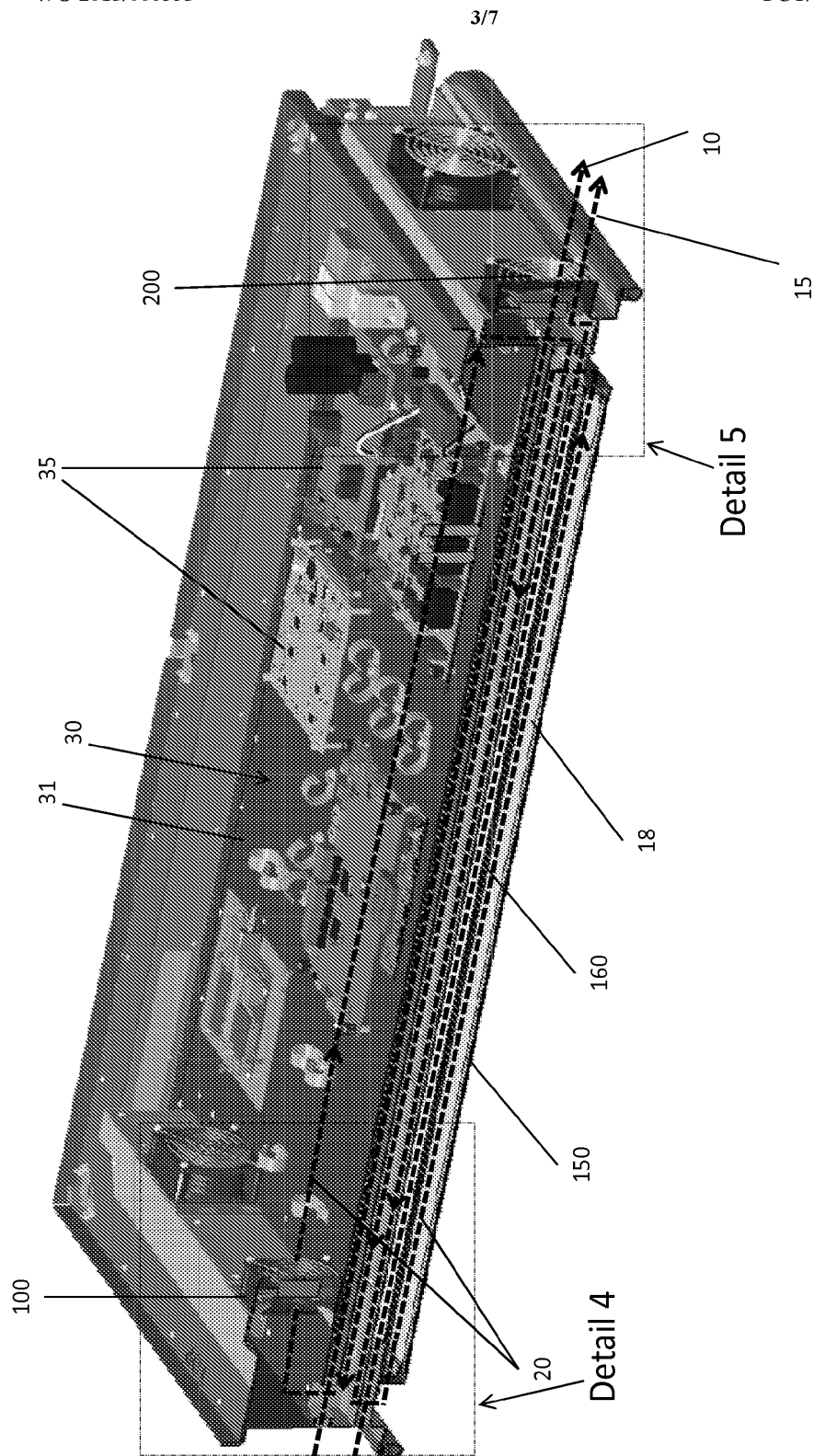


FIG - 3

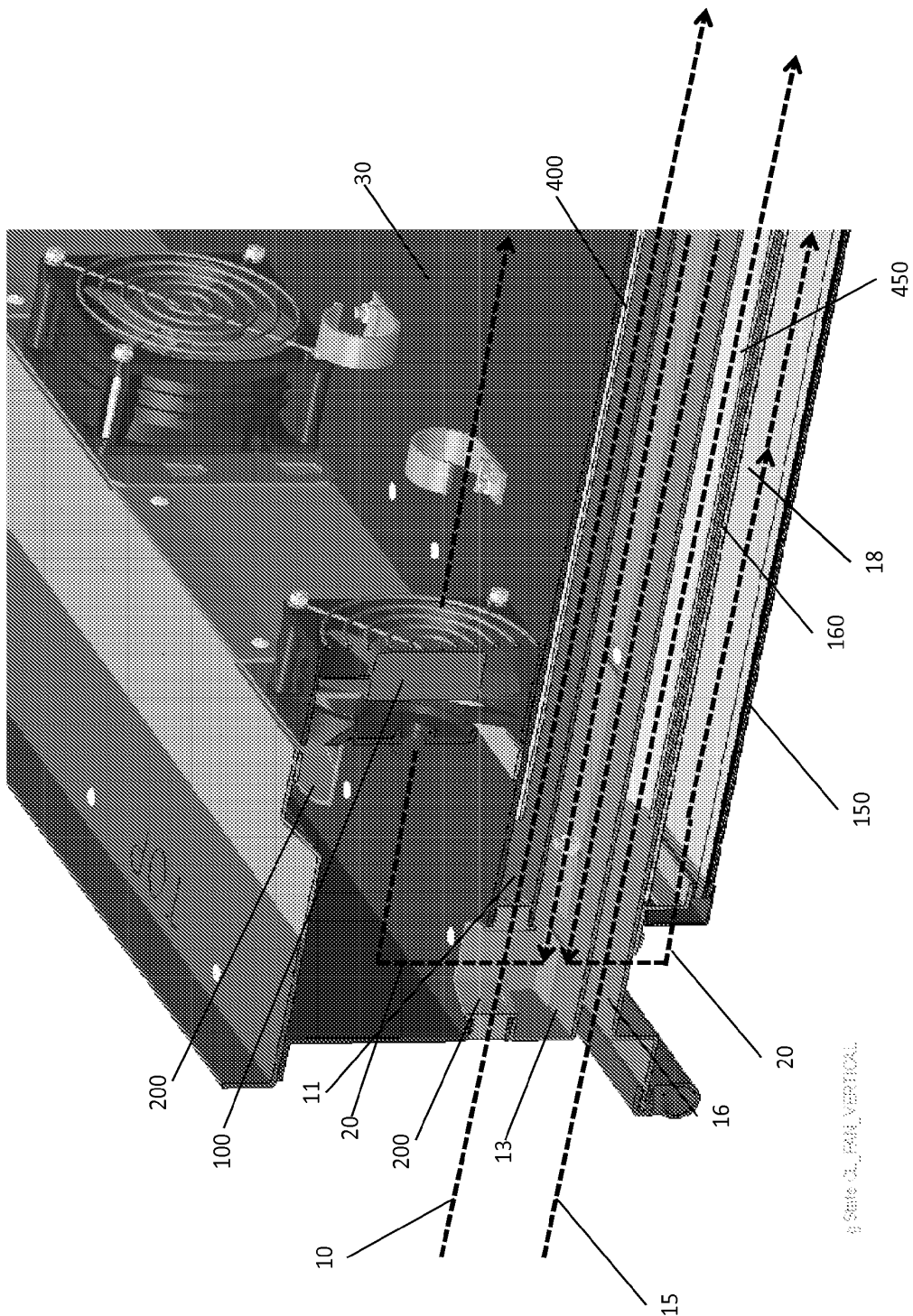


FIG - 4

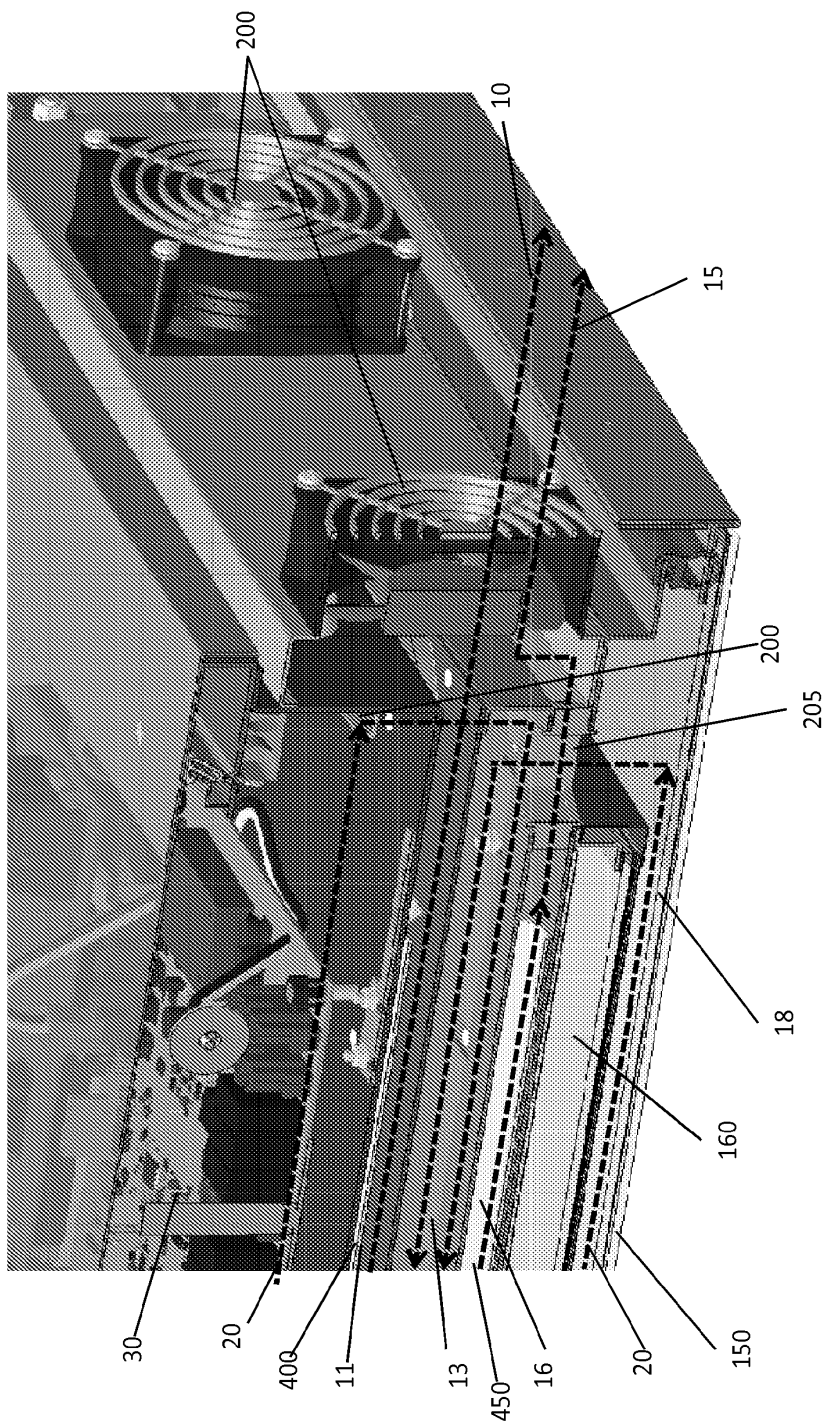


FIG - 5

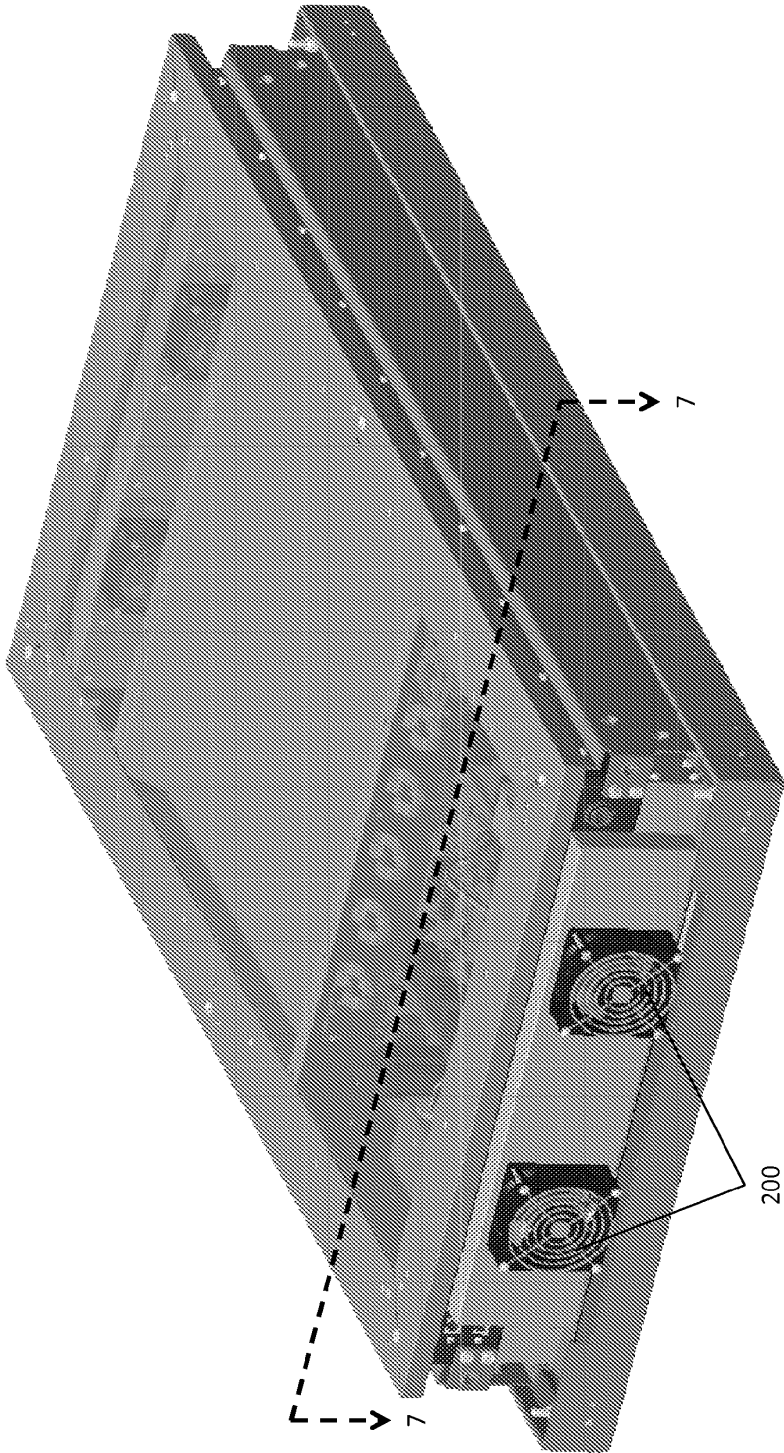
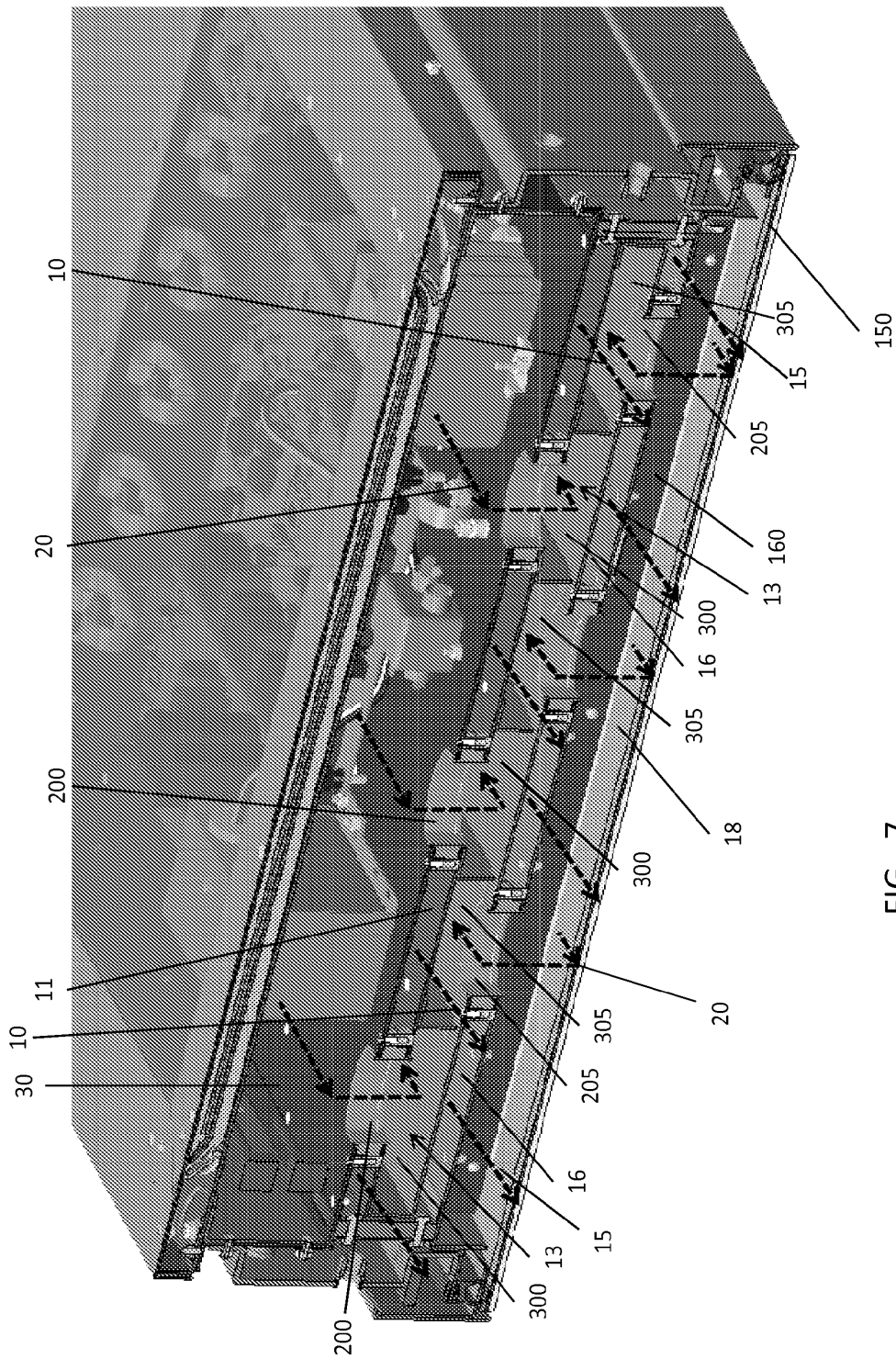


FIG - 6





Espacenet

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HYBRID REAR COVER AND MOUNTING BRACKET FOR ELETRONIC DISPLAY

Inventor(s): DUNN WILLIAM [US]; DIAZ MARCOS [US]; AZEVEDO KYLE [US] ± (DUNN, William, ; DIAZ, Marcos, ; AZEVEDO, Kyle)

Applicant(s): MFG RESOURCES INT INC [US] ± (Manufacturing Resources International, INC)

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Abstract not available for EP3117693 (A2)

Abstract of corresponding document: US2015264826 (A1)

A system and method for mounting an electronic display is disclosed herein. A rear cover mounting bracket may contain a rear plate and a sidewall which surrounds a perimeter of the plate. A plurality of mounting holes may be placed within the plate to allow fastening the rear plate to a vertical surface. An electronic display assembly module may contain a thermal plate where the attachment of the rear cover mounting bracket to the module creates a plenum which can house one or more electronic components. In a preferred embodiment, the rear plate contains a pair of hooks and the module contains a pair of corresponding cylinders which can be engaged with the hooks so that the module can hang from the hooks.

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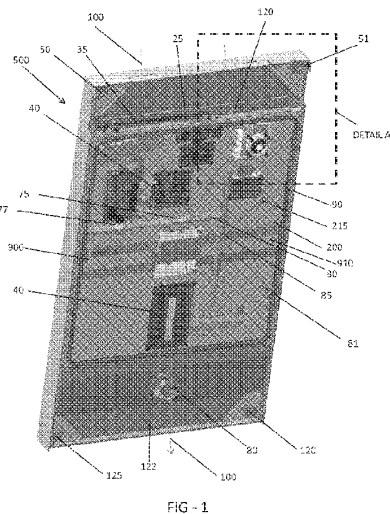
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(57) Abstract: A system and method for mounting an electronic display is disclosed herein. A rear cover mounting bracket may contain a rear plate and a sidewall which surrounds a perimeter of the plate. A plurality of mounting holes may be placed within the plate to allow fastening the rear plate to a vertical surface. An electronic display assembly module may contain a thermal plate where the attachment of the rear cover mounting bracket to the module creates a plenum which can house one or more electronic components. In a preferred embodiment, the rear plate contains a pair of hooks and the module contains a pair of corresponding cylinders which can be engaged with the hooks so that the module can hang from the hooks.

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B. FIELDS SEARCHED Minimum documentation searched (classification system followed by classification symbols) IPC(8): H05K 5/00, 7/14, 7/16, 7/18, 7/20; G06F 1/20 (2015.01); CPC: H05K 7/20136, 7/20145, 7/20154, 7/20172, 7/202, 7/20954, 7/20972; G02F 1/1333, 1/133385; F28D 9/00, 9/0062; F26F 3/02; F21V 29/02 Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched Electronic data base consulted during the international search (name of data base and, where practicable, search terms used) PatSeer (US, EP, WO, JP, DE, GB, CN, FR, KR, ES, AU, IN, CA, INPADOC Data); Google; Google Scholar; EBSCO, SEARCG STRINGS: ((mount* W4 bracket) OR (mount* W4 support) OR (mount* W4 plate) OR (mount* W4 frame) OR bracket OR support OR plate OR frame) AND ((electronic W4 display W4 assembly) OR monitor OR tv OR television OR (video W4 screen)) AND (thermal W4		
C. DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X ---	US 5,748,269 A (HARRIS, D. et al.) May 05, 1998; figures 1-3, 4B, 5 and 6; column 3, lines 14-18, 37-38, 53-59; column 4, lines 33-37; column 5, lines 15-40; column 6, lines 21-31	1-6 ---
X ---	US 2013/0270975 A1 (MANUFACTURING RESOURCES INTERNATIONAL, INC.) October 17, 2013; figures 1-4; paragraphs [0016], [0018], [0020] and [0023]	10, 12, 13, 16-20 ---
Y		7-9, 11, 14, 15 ---
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Name and mailing address of the ISA/ Mail Stop PCT, Attn: ISA/US, Commissioner for Patents P.O. Box 1450, Alexandria, Virginia 22313-1450 Facsimile No. 571-273-8300		Authorized officer: Shane Thomas PCT Helpdesk: 571-272-4300 PCT OSP: 571-272-7774

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