US011013142B2

(12) **United States Patent**
Dunn et al.

(10) **Patent No.: US 11,013,142 B2**
(45) **Date of Patent: May 18, 2021**

(54) **ELECTRONIC DISPLAY WITH COOLING**

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(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days.

(21) Appl. No.: **16/933,932**

(22) Filed: **Jul. 20, 2020**

(65) **Prior Publication Data**

US 2020/0352049 A1 Nov. 5, 2020

Related U.S. Application Data

(63) Continuation of application No. 16/708,260, filed on Dec. 9, 2019, now Pat. No. 10,721,836, which is a (Continued)

(51) **Int. Cl.**
H05K 7/20 (2006.01)
G02F 1/1333 (2006.01)
(Continued)

(52) **U.S. Cl.**
CPC ***H05K 7/202*** (2013.01); ***G02F 1/133385*** (2013.01); ***H05K 7/20136*** (2013.01);
(Continued)

(58) **Field of Classification Search**
CPC ... G02B 5/30; G02B 6/0055; G02F 1/133528; G02F 2001/133388; G02F 1/133308;
(Continued)

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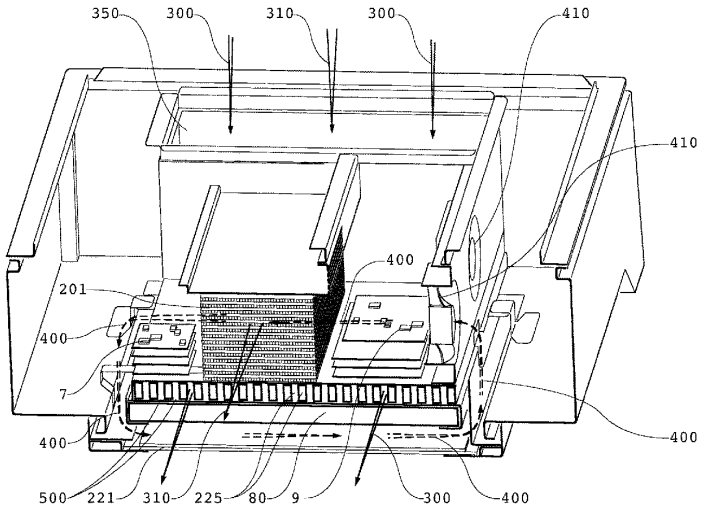
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(57) **ABSTRACT**

Systems and methods for cooling an electronic image assembly are provided. A transparent panel forms a front portion of a housing for the electronic image assembly. The transparent panel is located forward of, and at least some distance from the electronic image assembly. An airflow pathway passes through the housing between said electronic image assembly and said transparent panel. An air circulation device forces air through the airflow pathway. At least one polarizer located at the transparent panel is configured to reduce solar energy entering said airflow pathway.

15 Claims, 4 Drawing Sheets



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SEC Exhibit 1001.0001
IPR2023-00221

Related U.S. Application Data

continuation of application No. 15/789,331, filed on Oct. 20, 2017, now Pat. No. 10,506,740, which is a continuation of application No. 14/834,034, filed on Aug. 24, 2015, now Pat. No. 9,801,305, which is a continuation of application No. 14/050,464, filed on Oct. 10, 2013, now Pat. No. 9,119,325, which is a continuation of application No. 12/641,468, filed on Dec. 18, 2009, now Pat. No. 8,654,302, which is a continuation-in-part of application No. 12/411,925, filed on Mar. 26, 2009, now Pat. No. 8,854,595, and a continuation-in-part of application No. 12/556,029, filed on Sep. 9, 2009, now Pat. No. 8,373,841, and a continuation-in-part of application No. 12/234,307, filed on Sep. 19, 2008, now Pat. No. 8,767,165, and a continuation-in-part of application No. 12/234,360, filed on Sep. 19, 2008, now abandoned, and a continuation-in-part of application No. 12/237,365, filed on Sep. 24, 2008, now Pat. No. 8,879,042, and a continuation-in-part of application No. 12/235,200, filed on Sep. 22, 2008, now abandoned, and a continuation-in-part of application No. 12/620,330, filed on Nov. 17, 2009, now Pat. No. 8,274,622, and a continuation-in-part of application No. 12/556,209, filed on Sep. 9, 2009, now Pat. No. 8,379,182.

(60) Provisional application No. 61/138,736, filed on Dec. 18, 2008, provisional application No. 61/039,454, filed on Mar. 26, 2008, provisional application No. 61/095,615, filed on Sep. 9, 2008, provisional application No. 61/033,064, filed on Mar. 3, 2008, provisional application No. 61/053,713, filed on May 16, 2008, provisional application No. 61/057,599, filed on May 30, 2008, provisional application No. 61/076,126, filed on Jun. 26, 2008, provisional application No. 61/115,333, filed on Nov. 17, 2008, provisional application No. 61/095,616, filed on Sep. 9, 2008.

(51) **Int. Cl.**
F28D 9/00 (2006.01)
F28F 3/02 (2006.01)

(52) **U.S. Cl.**
CPC ***H05K 7/20163*** (2013.01); ***H05K 7/20972*** (2013.01); *F28D 9/00* (2013.01); *F28F 3/02* (2013.01)

(58) **Field of Classification Search**
CPC G02F 1/133385; G02F 1/0311; G02F 2001/133334; G02F 2201/08; G02F 2201/36; G07F 17/3211; G09F 13/0413; G09F 13/12; H05K 7/202; H05K 7/206; H05K 7/20972; H05K 7/20136; H05K 7/20163; H05K 9/0081; H01L 51/5234; Y02P 20/133
See application file for complete search history.

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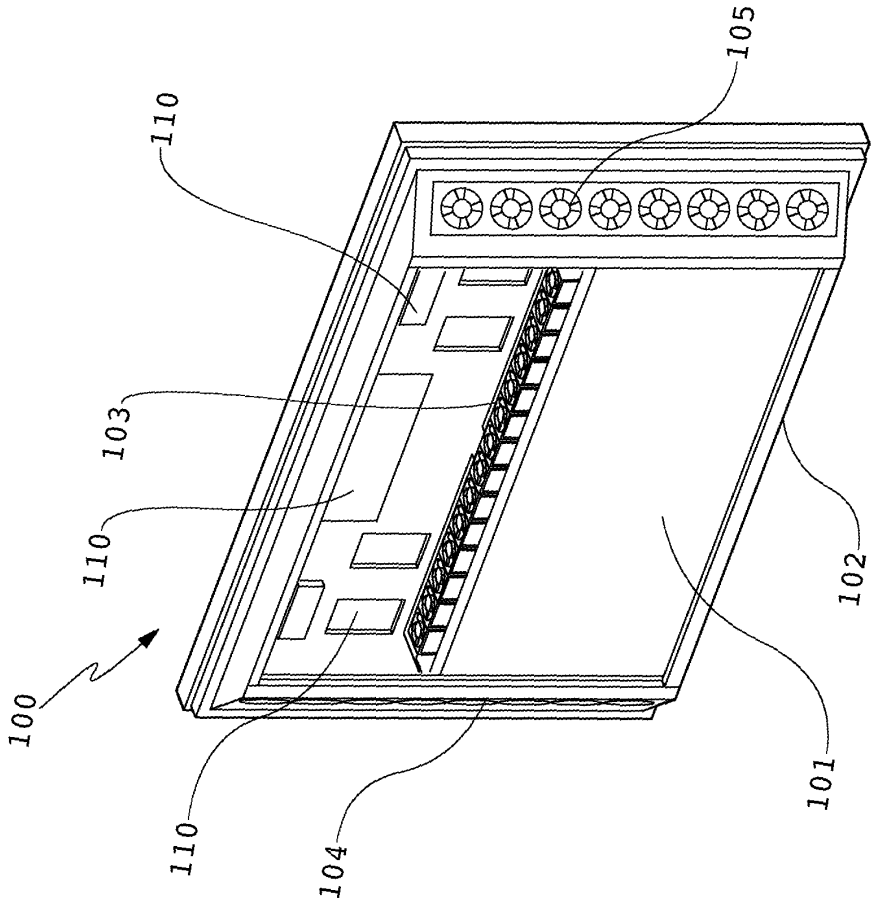
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FIG-1



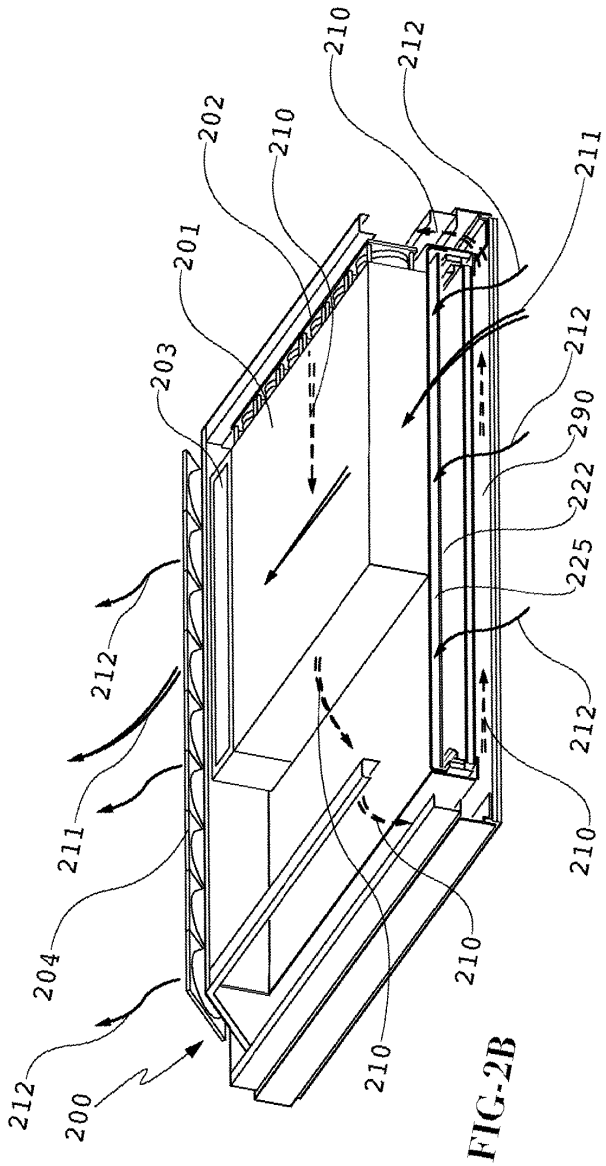

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201
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FIG-2B

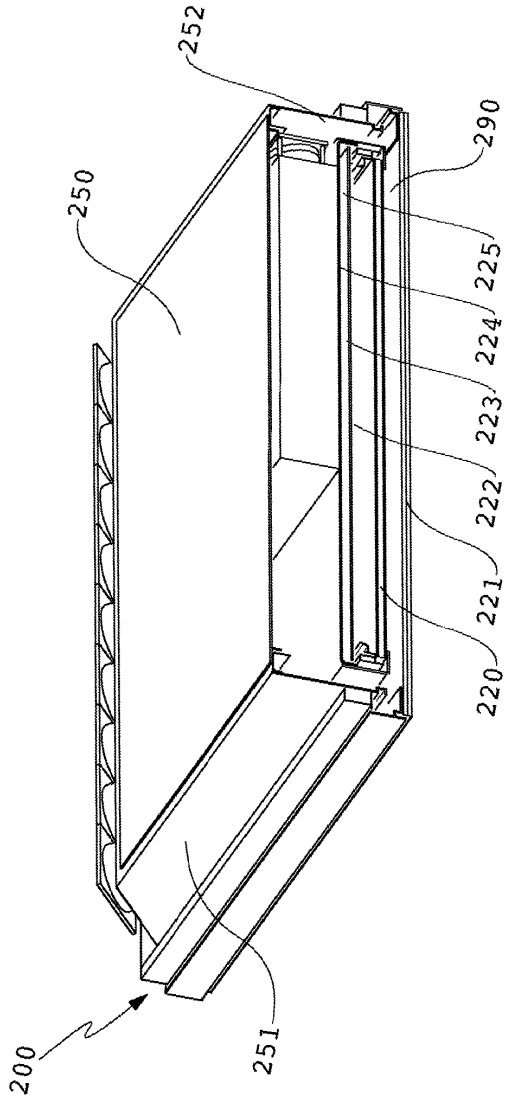
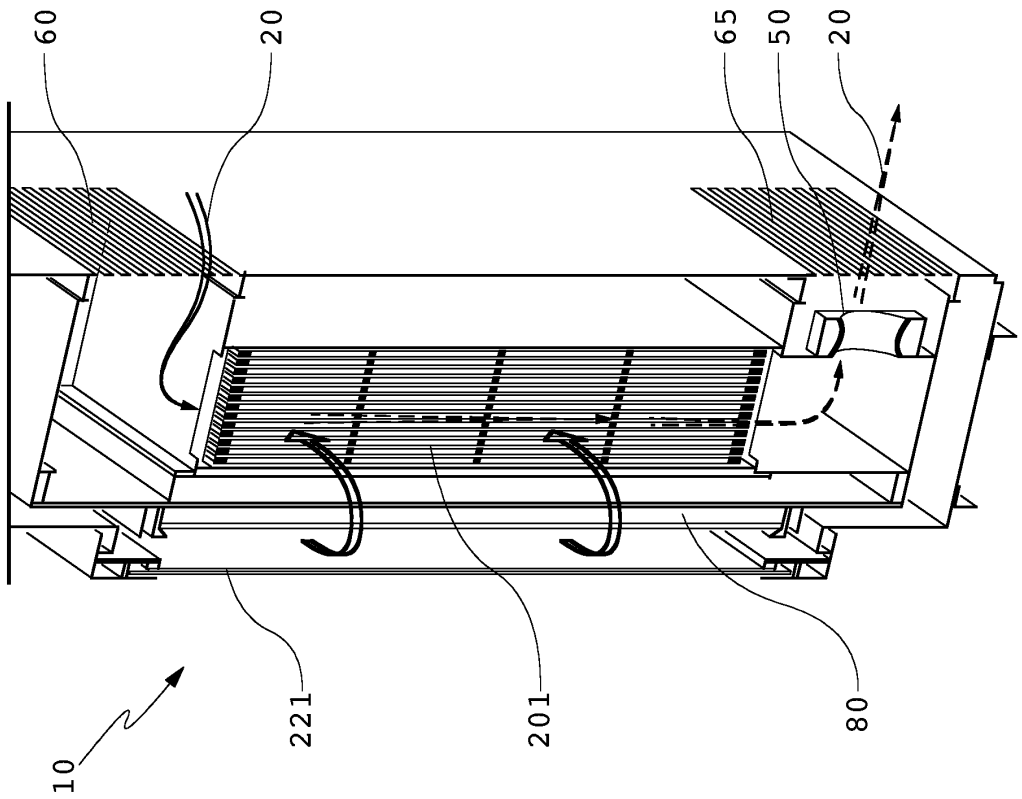

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FIG-2A

FIG-3



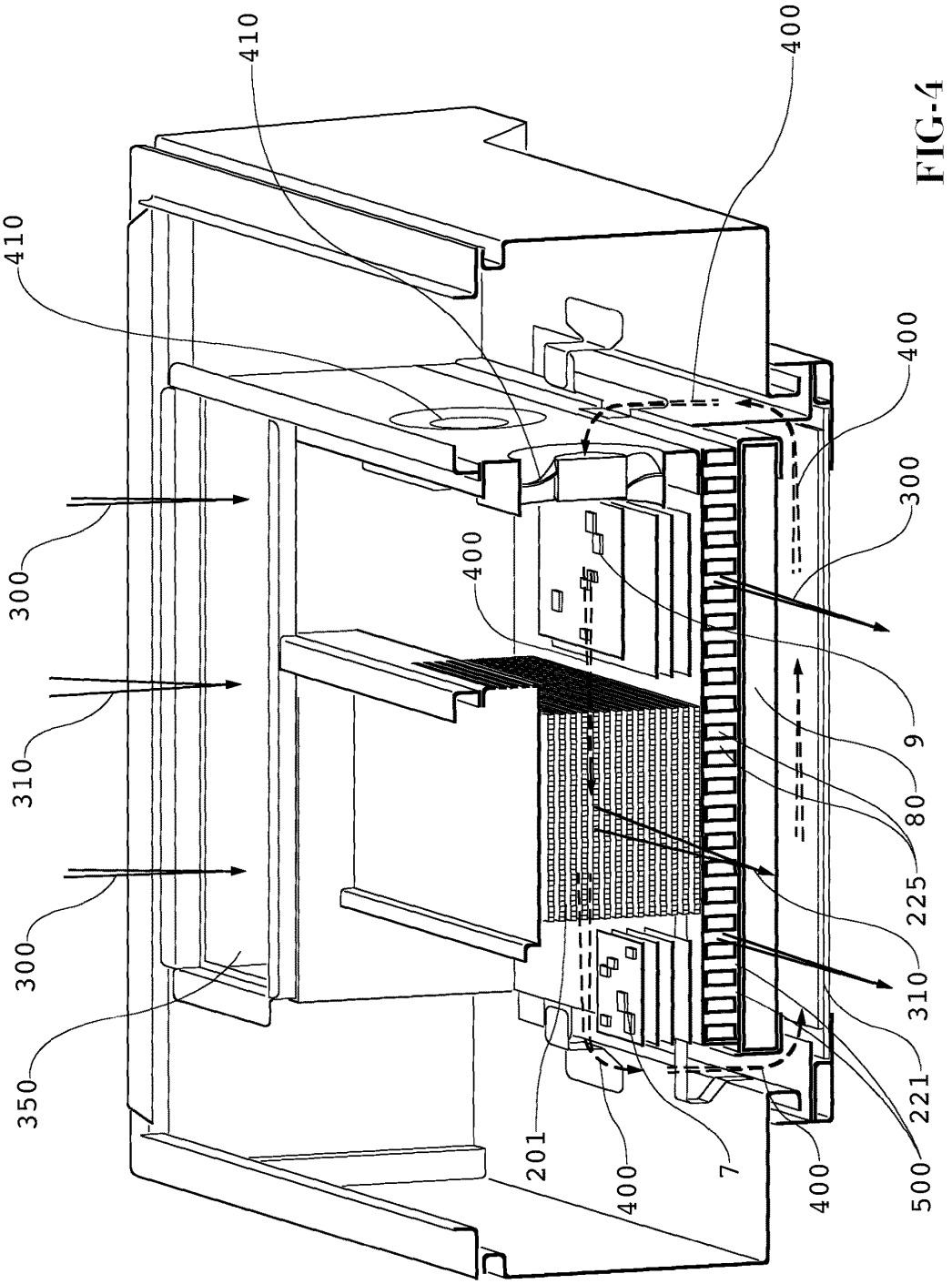

410
400
410
400
300
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310
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80
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FIG-4

ELECTRONIC DISPLAY WITH COOLING

CROSS-REFERENCE TO RELATED APPLICATIONS

This application is a continuation of U.S. application Ser. No. 16/708,260 filed on Dec. 9, 2019. U.S. application Ser. No. 16/708,260 is a continuation of U.S. application Ser. No. 15/789,331 filed on Oct. 20, 2017, now U.S. Pat. No. 10,506,740 issued on Dec. 10, 2019. U.S. application Ser. No. 15/789,331 is a continuation of U.S. application Ser. No. 14/834,034 filed on Aug. 24, 2015, now U.S. Pat. No. 9,801,305 issued on Oct. 24, 2017. U.S. application Ser. No. 14/834,034 is a continuation of U.S. application Ser. No. 14/050,464 filed on Oct. 10, 2013, now U.S. Pat. No. 9,119,325 issued on Aug. 25, 2015. U.S. application Ser. No. 14/050,464 is a continuation of U.S. application Ser. No. 12/641,468 filed Dec. 18, 2009, now U.S. Pat. No. 8,654,302 issued on Feb. 18, 2014, which is a non-provisional of U.S. Application No. 61/138,736 filed Dec. 18, 2008. U.S. application Ser. No. 12/641,468 is a continuation-in-part of U.S. application Ser. No. 12/411,925 filed Mar. 26, 2009, now U.S. Pat. No. 8,854,595 issued on Oct. 7, 2014, which is a non-provisional application of U.S. Application No. 61/039,454 filed Mar. 26, 2008. U.S. application Ser. No. 12/641,468 is a continuation-in-part of U.S. application Ser. No. 12/556,029 filed Sep. 9, 2009, now U.S. Pat. No. 8,373,841 issued on Feb. 12, 2013, which is a non-provisional application of U.S. Application No. 61/095,615 filed Sep. 9, 2008. U.S. application Ser. No. 12/641,468 is a continuation-in-part of U.S. application Ser. No. 12/234,307 filed Sep. 19, 2008, now U.S. Pat. No. 8,767,165 issued on Jul. 1, 2014, which is a non-provisional application of U.S. Application No. 61/033,064 filed Mar. 3, 2008. U.S. application Ser. No. 12/641,468 is a continuation-in-part of U.S. application Ser. No. 12/234,360 filed Sep. 19, 2008, which is a non-provisional application of U.S. Application No. 61/053,713 filed May 16, 2008. U.S. application Ser. No. 12/641,468 is a continuation-in-part of U.S. application Ser. No. 12/237,365 filed Sep. 24, 2008, now U.S. Pat. No. 8,879,042 issued Nov. 4, 2014, which is a non-provisional application of U.S. Application No. 61/057,599 filed May 30, 2008. U.S. application Ser. No. 12/641,468 is a continuation-in-part of U.S. application Ser. No. 12/235,200 filed Sep. 22, 2008, which is a non-provisional of U.S. Application No. 61/076,126 filed Jun. 26, 2008. U.S. application Ser. No. 12/641,468 is a continuation-in-part of U.S. application Ser. No. 12/620,330 filed Nov. 17, 2009, now U.S. Pat. No. 8,274,622 issued Sep. 25, 2012, which is a non-provisional of U.S. Application No. 61/115,333 filed Nov. 17, 2008. U.S. application Ser. No. 12/641,468 is a continuation-in-part of U.S. application Ser. No. 12/556,209 filed Sep. 9, 2009, now U.S. Pat. No. 8,379,182 issued Feb. 19, 2013, which is a non-provisional of U.S. provisional application No. 61/095,616 filed Sep. 9, 2008. All of said aforementioned applications are hereby incorporated by reference in their entirety as if fully recited herein.

TECHNICAL FIELD

The exemplary embodiments described herein generally relate to cooling systems and in particular to cooling systems for electronic displays.

BACKGROUND

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. In order to do this, the systems of the past have relied primarily on fans for moving internal air (or ingested ambient 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.

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. Electronic displays are now being used in outdoor environments and other applications where they may be exposed to high ambient temperatures and even direct sunlight. 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. By itself, this is not adequate in many climates, especially when radiative heat transfer from the sun through a display window becomes a major factor. In many applications and locations 200 Watts or more of power through such a display window is common. Furthermore, the market is demanding larger screen sizes for displays. With increased electronic display screen size and corresponding display window 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 contaminates (dust, dirt, pollen, water vapor, smoke, etc.) which, if ingested into the display for cooling the interior can cause damage to the interior components of the display.

A large fluctuation in temperature is common in the devices of the past. Such temperature fluctuation adversely affects the electronic components in these devices; both performance and lifetime may be severely affected. Thus, there exists a need for a cooling system for electronic displays which are placed within environments having high ambient temperatures, possibly contaminates present within the ambient air, and even placed in direct sunlight.

SUMMARY

Exemplary 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 may draw ambient gas (ex. ambient air) through the rear of the display (sometimes through a heat exchanger, behind an image assembly, or both) and then exhausts it out of the display housing. A heat exchanger may be used to transfer heat from the circulating gas to the ambient gas. In alternative embodiments, the ambient gas may also be forced behind the image assembly (sometimes a backlight), 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.

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

A better understanding of an exemplary embodiment will be obtained from a reading of the following detailed descrip-

tion and the accompanying drawings wherein identical reference characters refer to identical parts and in which:

FIG. **1** is a rear perspective view of an embodiment where the rear cover of the display has been removed.

FIG. **2**A is a perspective section view of another embodiment showing the closed loop and open loop channels.

FIG. **2**B is a perspective section view similar to the view shown in FIG. **2**A where the rear and side covers have been removed.

FIG. **3** is a perspective section of another embodiment where ambient gas is ingested only into the heat exchanger and not into optional additional channels.

FIG. **4** 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 OF THE EXEMPLARY EMBODIMENTS

FIG. **1** shows the rear of an embodiment for an electronic display **100**, where the rear cover for the display housing has been removed in order to show the internal components. In this embodiment, the fan assemblies **102** and **103** for the closed loop 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. If only one fan assembly is used, it may be 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 the open loop 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. Because the various fan assemblies described herein can be placed in multiple orientations, 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.

The circulating gas which is being forced by the closed loop fan assemblies is primarily circulating around the display. For example, the gas travels in a loop where it passes through a channel, contacting the front surface of the image assembly (see FIGS. **2**A-**2**B) and absorbs heat from the image assembly. The circulating gas is then preferably directed (or forced) 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 eventually return to the channel and contact 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.

In order to cool the circulating gas (as well as optionally cooling a backlight assembly or image assembly) 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. In some embodiments, the ambient gas may be air conditioned (or otherwise cooled) prior to being drawn into the display. 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 FIGS. **2**A-**2**B). By using the heat exchanger **101**, heat may be transferred from the circulating gas to the ambient gas. The heated ambient gas may then be expelled out of the display housing.

Although not required, it is preferable that the circulating gas and ambient gas do not mix. This may prevent any contaminates and/or particulate that is present within the ambient gas from harming the interior of the display. 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 heat exchanger. In an exemplary embodiment, the heat exchanger **101** 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, 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).

In an alternative design, 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).

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.

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 paths of gas. 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

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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 the small material thickness, results in an overall thermal resistance that is very 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.

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.

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 would also preferably be substantially free of contaminates 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 contaminates. An optional filter may be used to ensure that the air (either in the closed or open loop) stays free of contaminates. However, in an exemplary embodiment the open loop may be designed so that contaminates 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) is properly sealed so that any contaminates 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 contaminates, will not harm the display. This can be particularly beneficial when the display is used in outdoor environments or indoor environments where contaminates are present in the ambient air.

FIG. **2**A 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 optionally 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 index-matching optical adhesive. 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. The front display surface may be a durable display panel as disclosed in co-pending U.S. application Ser. No. 12/330,041 filed on Dec. 8, 2008, herein incorporated by reference in its entirety.

For the embodiment shown in FIG. **2**A, 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. 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 **224** may be placed 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** (or image assembly **220** if no backlight is used).

FIG. **2**B shows the same cross section from FIG. **2**A 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** may be 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 additional optional channel **225** for cooling the backlight assembly **222** (or image assembly **220** if no backlight is used). 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 (perhaps because the additional optional channel **225** 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**.

As noted above, in an exemplary embodiment the ambient gas **211** and **212** does not mix with the circulating gas **210**. 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.

FIG. **3** is a perspective section view of another embodiment of a display assembly **10** 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).

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One or more fans **50** may be positioned so as 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. This embodiment may be used when the image 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 **10** may be used when an OLED is used as the image assembly **80**. Further, this embodiment **10** 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 contaminates 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.

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 as it passes through the channel between the front display surface **221** and the image assembly **80**, 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, LED display assembly, or any other flat/thin panel electronic display.

FIG. **4** shows another 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**. Here, 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.

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). 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 of the image assembly **80**. In this arrangement, the ambient gas **300** may also be used to absorb heat from the image assembly **80**. In some embodiments, the image assembly may be an LCD with an LED backlight. Here, the LED backlight may be in thermal communication with surface **500** so that heat can be transferred form the LED backlight to the ambient gas **300**. Alternatively, the image assembly **80** may be an OLED assembly and the surface **500** may be in thermal communication with the OLED assembly. 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**.

For the embodiment shown in FIG. **4**, a plurality of ribs are shown placed within channel **225**. These ribs may be thermally conductive and in thermal communication with surface **500**. Thus, heat from surface **500** may be distributed throughout the ribs and removed by the ambient gas **300**. It has been found, that this arrangement can provide improved cooling abilities for the image assembly **80** and/or backlight (if necessary). It can also provide greater structural rigidity to the overall assembly. It has been found that some image assemblies (especially LEDs and OLEDs) may have performance properties which vary depending on temperature. Thus, as the temperature of the image assembly increases, the luminance, color temperature, and other optical properties can vary. 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 some of the embodiments described herein, the heat which may be generated by the backlight assembly or image assembly can be distributed throughout the ribs and thermally-conductive surfaces to remove hot spots and cool the backlight or image assembly.

The ribs 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. Metal may be used to produce the ribs in some embodiments.

In other embodiments, additional heat-producing electronic assemblies may be placed in thermal communication with the ribs so that heat can be removed from these assemblies as well. In an exemplary embodiment, power modules may be placed in thermal communication with the ribs so that the heat from the power modules can be distributed throughout the ribs and removed by the ambient gas **300**.

The circulating gas **400** may also pass 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 **9** 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 **7** 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 **7** from the high power electronic assemblies **9** to ensure a minimum amount of interference between the two. Further, some high power electronic assemblies **9** 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 **7** and **9** because the ambient gas **310** would preferably never contact these electrical assemblies. However, the electrical assemblies **7**

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and **9** will remain cool (as well as clean and dry) because of the cross-flow from the circulating gas **400**.

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.

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 (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, kitchens, bathrooms) where thermal stability of the display may be at risk.

It should also be noted that the variety of open and closed cooling loops 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 clock-wise 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.

Having shown and described various exemplary embodiments, those skilled in the art will realize that many variations and modifications may be made thereto without departing from the scope of the inventive concept. Additionally, many of the elements indicated above may be altered or replaced by different elements that will provide a like result and fall within the spirit of the inventive concept. It is the intention, therefore, to limit the inventive concept only as indicated by the scope of the claims.

What is claimed is:

1. A cooling system for an electronic image assembly, the cooling system comprising:

a housing for the electronic image assembly;

a cover panel forming a forward portion of the housing, wherein the cover panel is located forward of, and at least some distance from, the electronic image assembly and is configured to permit viewing of images displayed at the electronic image assembly through said cover panel;

a closed loop airflow pathway passing through the housing, wherein said closed loop airflow passes around said electronic image assembly and is configured to accommodate circulating gas, and wherein at least a portion of said closed loop airflow pathway extends between said electronic image assembly and said cover panel;

an open loop airflow pathway for ambient air passing through said housing and behind said electronic image assembly;

at least one air circulation device positioned to force the circulating gas through the closed loop airflow pathway when activated; and

at least one polarizer located at an inward facing surface of said cover panel and configured to prevent at least some sunlight striking said cover panel from traveling beyond said at least one polarizer.

2. The cooling system of claim **1** further comprising:

at least one film having anti-reflection properties located at said cover panel.

3. The cooling system of claim **1** further comprising:

a heat exchanger located rearward of the electronic image assembly, wherein a first portion of said heat exchanger forms part of said open loop airflow pathway, and wherein a second portion of said heat exchanger forms part of said closed loop airflow pathway.

4. The cooling system of claim **3** further comprising:

an inlet located at a first portion of said housing for ingesting said ambient air into said open loop airflow pathway; and

an exhaust located at a second portion of said housing for exhausting said ambient air from said open loop airflow pathway.

5. The cooling system of claim **1** wherein:

said at least one polarizer comprises a linear polarizer.

6. A cooling system for an electronic image assembly, the cooling system comprising:

a housing for the electronic image assembly;

a transparent cover panel forming a front portion of the housing, the transparent cover panel located forward of, and at least some distance from, the electronic image assembly;

an open loop airflow pathway passing through the housing behind the electronic image assembly;

a closed loop gas circulation pathway contained within the housing, wherein a portion of said closed loop gas circulation pathway passes between said transparent cover panel and said electronic image assembly;

an inlet located at a first portion of said housing for ingesting ambient air into said open loop airflow pathway;

an exhaust located at a second portion of said housing for exhausting said ambient air from said open loop airflow pathway;

an air circulation device positioned along said open loop airflow pathway between said inlet and said exhaust, wherein said air circulation device is configured to force said ambient air through the open loop airflow pathway when activated;

a gas circulation device positioned along said closed loop gas circulation pathway to force circulating gas around the closed loop gas circulation pathway when activated;

a heat exchanger located rearward of the electronic image assembly, wherein a first portion of said heat exchanger forms part of said open loop airflow pathway, and wherein a second portion of said heat exchanger forms part of said closed loop gas circulation pathway; and

one or more solar energy reduction layers located at said transparent cover panel, wherein each of said one or more solar energy reduction layers is configured to prevent a portion of solar energy entering said trans-

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parent cover panel from thermally interacting with the circulating gas at said portion of said closed loop gas circulation pathway passing between said transparent cover panel and said electronic image assembly or thermally interacting with said electronic image assembly.

7. The cooling system of claim **6** wherein:

said air circulation device comprises one or more fan assemblies; and

said gas circulation device comprises one or more fan assemblies.

8. The cooling system of claim **6** wherein:

at least one of said one or more solar energy reduction layers comprise a polarizer.

9. The cooling system of claim **8** wherein:

said polarizer comprises a linear polarizer.

10. The cooling system of claim **6** wherein:

at least one of said one or more solar energy reduction layers comprise a film having anti-reflection properties.

11. The cooling system of claim **6** wherein:

at least a first one of said one or more solar energy reduction layers comprise a polarizer; and

at least a second one of said one or more solar energy reduction layers comprise a film having anti-reflection properties.

12. A method for cooling an electronic image assembly, said method comprising the steps of:

placing said the electronic image assembly within a housing;

forcing circulating air through a closed loop airflow pathway within said housing, wherein at least a portion of said closed loop airflow pathway extends between an electronic image assembly and a cover panel forming a front portion of said housing and spaced apart from said electronic image assembly, wherein said cover panel is configured to permit viewing of images displayed at the electronic image assembly through said cover panel;

forcing ambient air through a second airflow pathway within said housing, wherein said second airflow pathway extends behind said electronic image assembly; and

providing one or more solar energy reduction layers at an inward facing surface of said cover panel, wherein each of said one or more solar energy reduction layers is configured to reduce an amount of solar energy transferred to said circulating air in at least said portion of said closed loop airflow pathway.

13. The cooling method of claim **12** wherein:

at least one of said one or more solar energy reduction layers comprise a polarizer.

14. The cooling method of claim **13** wherein:

at least one of said one or more solar energy reduction layers comprise a film having anti-reflection properties.

15. The cooling method of claim **12** further comprising the steps of:

thermally transferring heat between said circulating air in said closed loop airflow pathway and said ambient air in said second airflow pathway at a heat exchanger common to said closed loop airflow pathway and said second airflow pathway.

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