US009173322B2

(12) **United States Patent**
Dunn

(10) **Patent No.: US 9,173,322 B2**
(45) **Date of Patent: Oct. 27, 2015**

(54) **CONSTRICTED CONVECTION COOLING SYSTEM FOR AN ELECTRONIC DISPLAY**

(71) Applicant: **Manufacturing Resources International, Inc.**, Alpharetta, GA (US)

(72) Inventor: **William Dunn**, Alpharetta, GA (US)

(73) Assignee: **Manufacturing Resources International, Inc.**, Alpharetta, GA (US)

(*) 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.: **14/508,621**

(22) Filed: **Oct. 7, 2014**

(65) **Prior Publication Data**

US 2015/0055054 A1 Feb. 26, 2015

Related U.S. Application Data

(63) Continuation 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. 12/234,307, filed on Sep. 19, 2008, now Pat. No. 8,767,165, said

(Continued)

(51) **Int. Cl.**

G02F 1/1333	(2006.01)
G02F 1/1335	(2006.01)
H05K 7/20	(2006.01)

(52) **U.S. Cl.**

CPC ***H05K 7/20154*** (2013.01); ***G02F 1/133308*** (2013.01); ***G02F 1/133385*** (2013.01); ***G02F 1/133603*** (2013.01); ***H05K 7/202*** (2013.01); ***H05K 7/20145*** (2013.01); ***H05K 7/20972*** (2013.01); *G02F 2001/133628* (2013.01)

(58) **Field of Classification Search**

CPC G02F 1/133308; G02F 1/133385; G02F 1/133603; H05K 7/20154; H05K 7/20145; H05K 7/202; H05K 7/20972

USPC 349/58, 69, 161; 361/695

See application file for complete search history.

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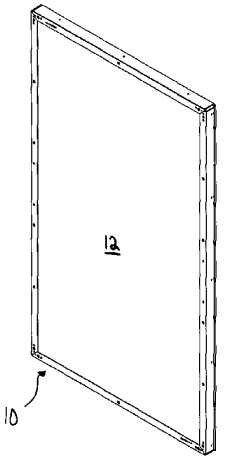
Primary Examiner — Jerry Blevins

(74) *Attorney, Agent, or Firm* — Standley Law Group LLP

(57) **ABSTRACT**

Preferred embodiments provide a cooling system for an electronic display. A constricted convection plate is used to force cooling air against a posterior surface of the electronic display. Fans may be used to propel or pull air between the constricted convection plate and the rear surface of an electronic display. A refrigeration unit or thermoelectric module may be employed to cool or heat the air traveling through the constricted convection channel. Some embodiments include a closed loop which extracts heat (or adds heat) to the front display surface.

16 Claims, 10 Drawing Sheets



SEC et al. v. MRI
SEC Exhibit 1001.001
IPR 2023-00220

Related U.S. Application Data

application No. 12/411,925 is a continuation-in-part of application No. 12/234,360, filed on Sep. 19, 2008, said application No. 12/411,925 is a continuation-in-part of application No. 12/237,365, filed on Sep. 24, 2008, said application No. 12/411,925 is a continuation-in-part of application No. 12/235,200, filed on Sep. 22, 2008.

(60) 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. 61/095,616, filed on Sep. 9, 2008, provisional application No. 61/115,333, filed on Nov. 17, 2008, provisional application No. 61/138,736, filed on Dec. 18, 2008, provisional application No. 61/152,879, filed on Feb. 16, 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.

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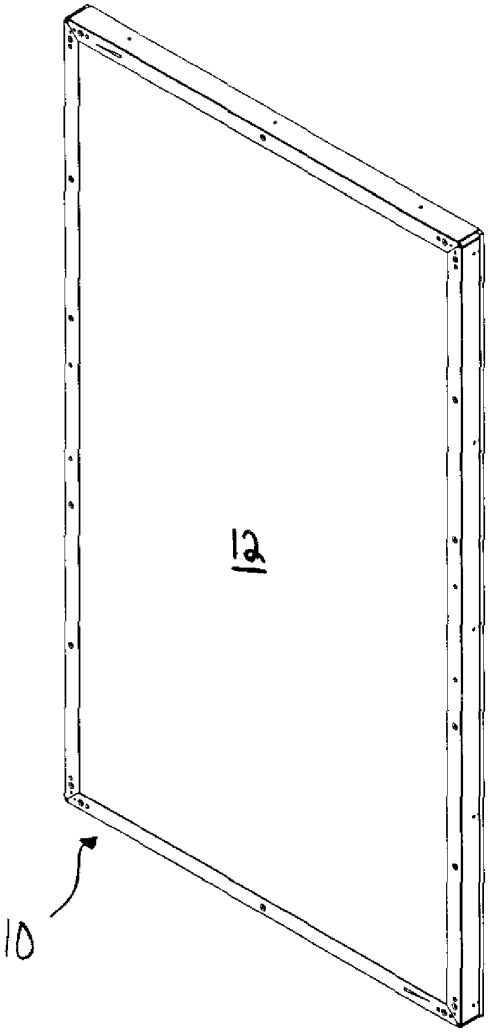


Fig. 1

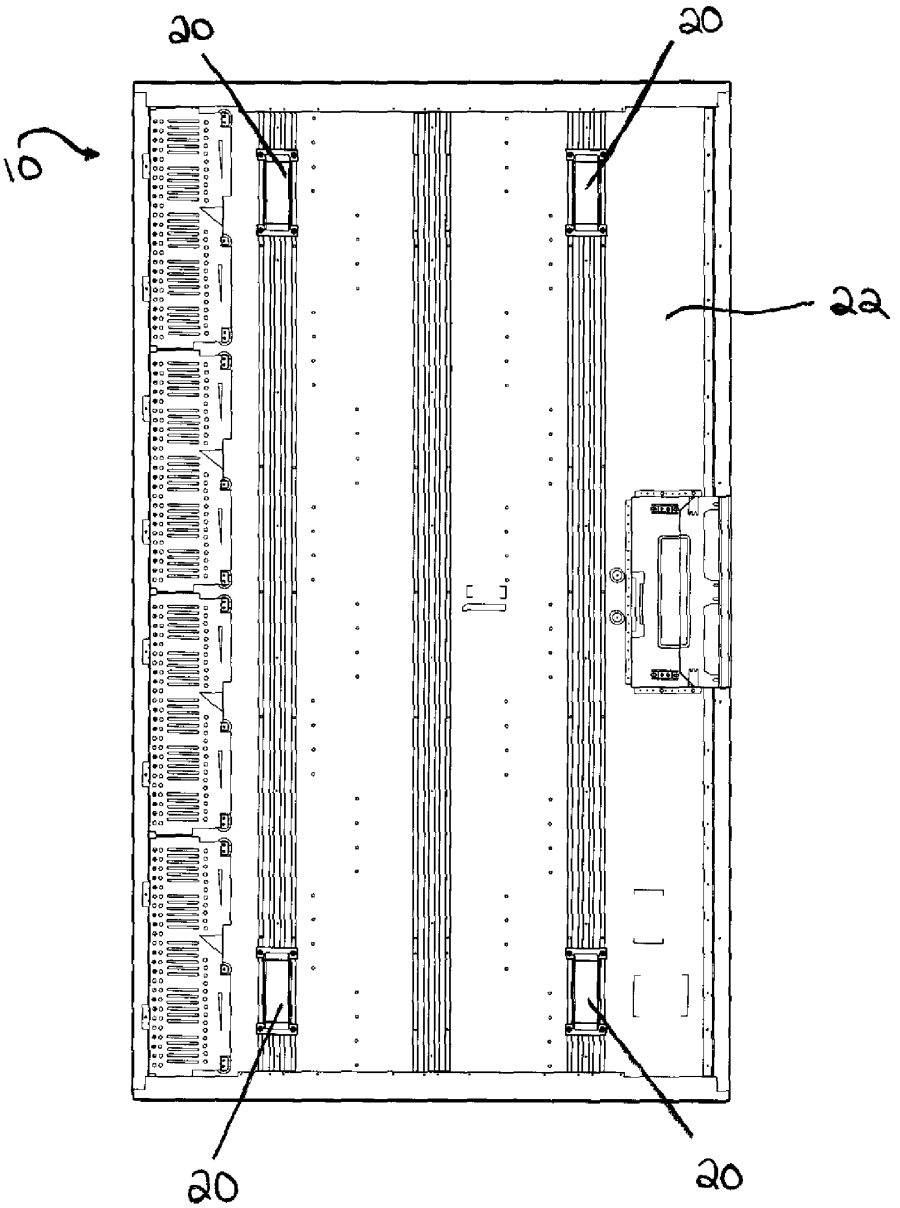


Fig. 2

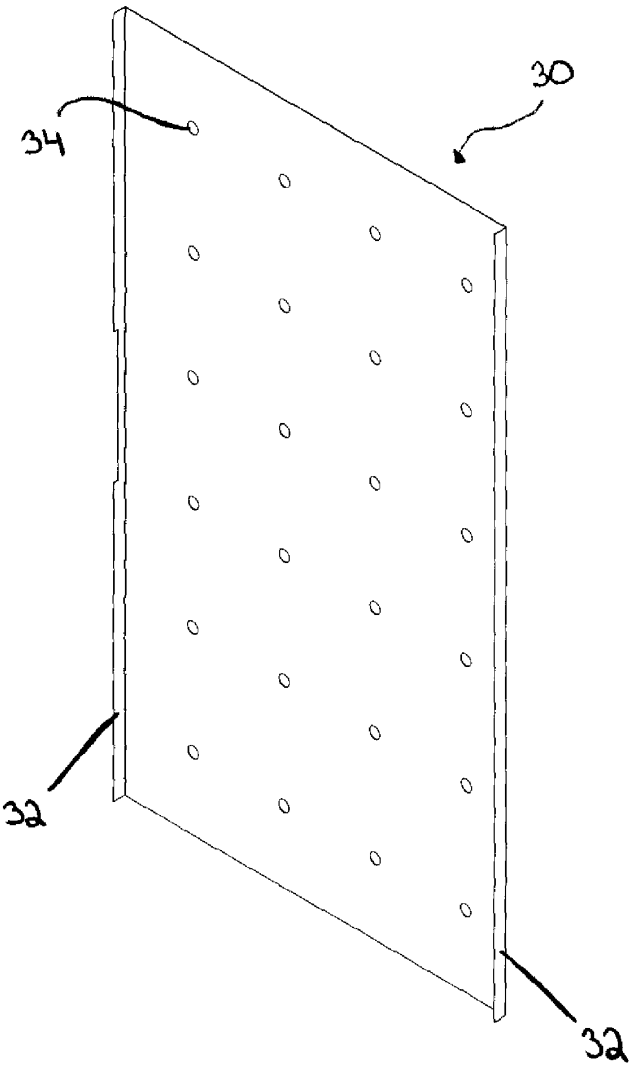


Fig. 3

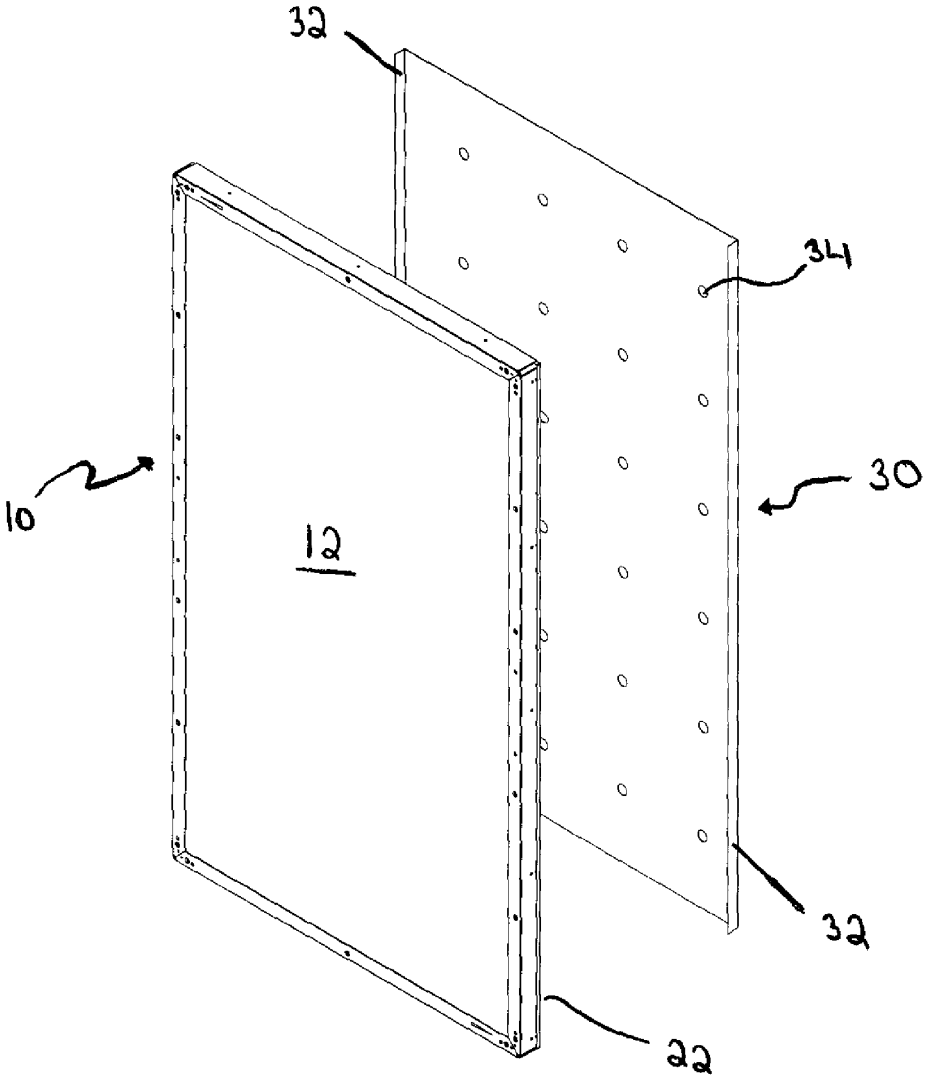


Fig. 4

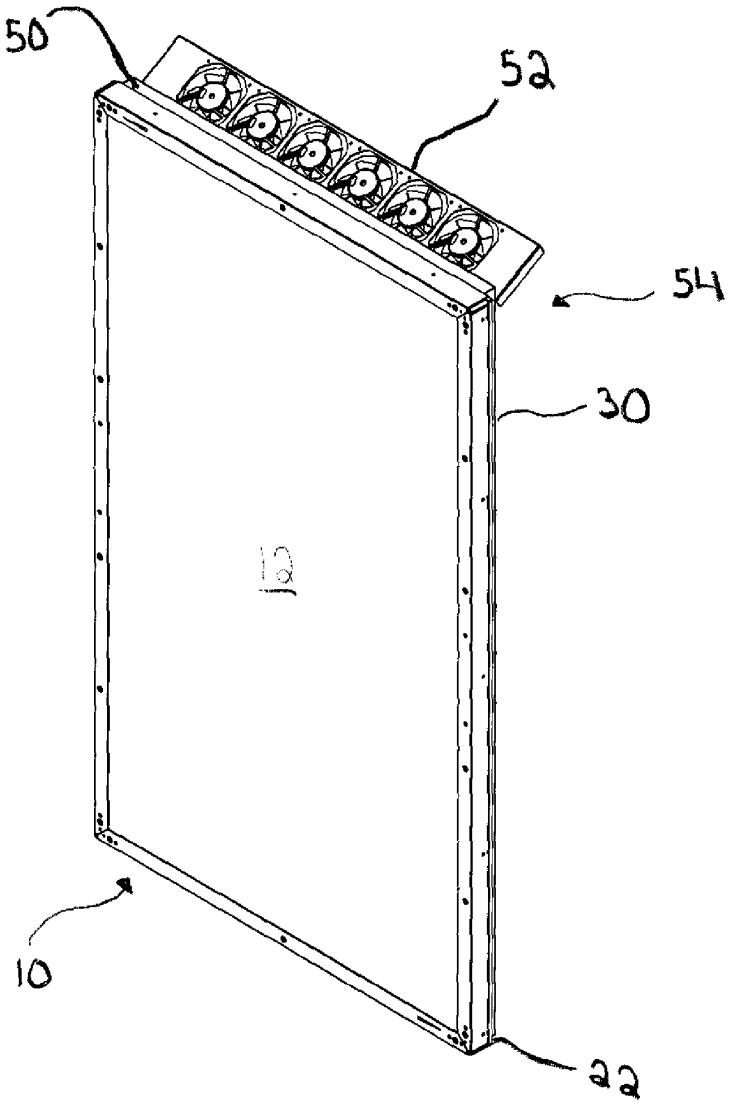


Fig. 5A

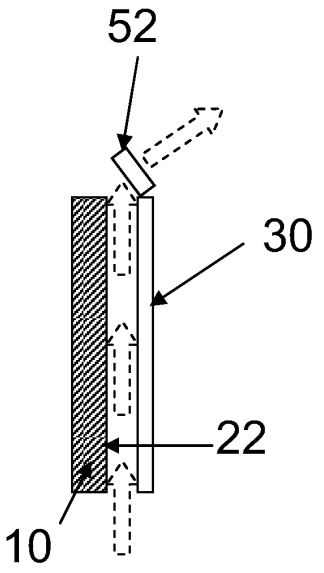


Fig. 5B

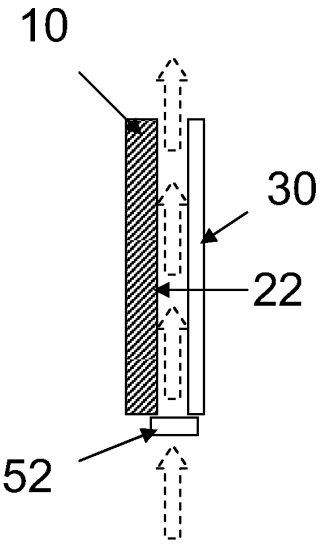


Fig. 5C

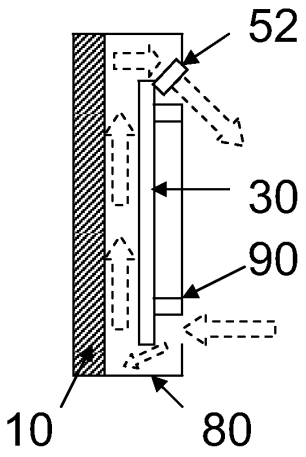


Fig. 5D

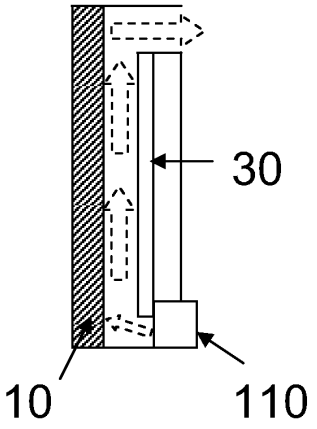


Fig. 5E

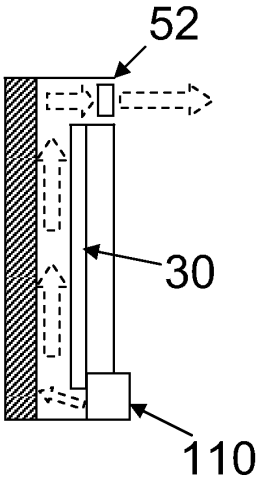


Fig. 5F

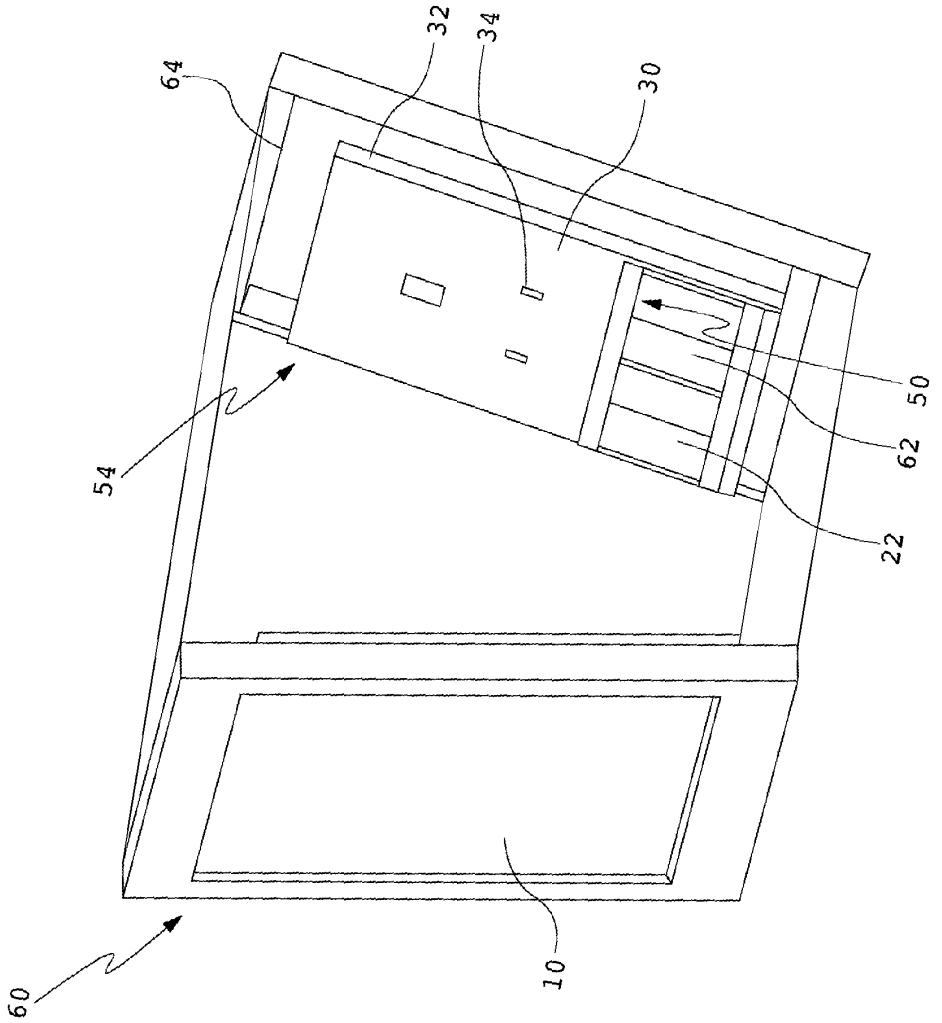


FIG-6

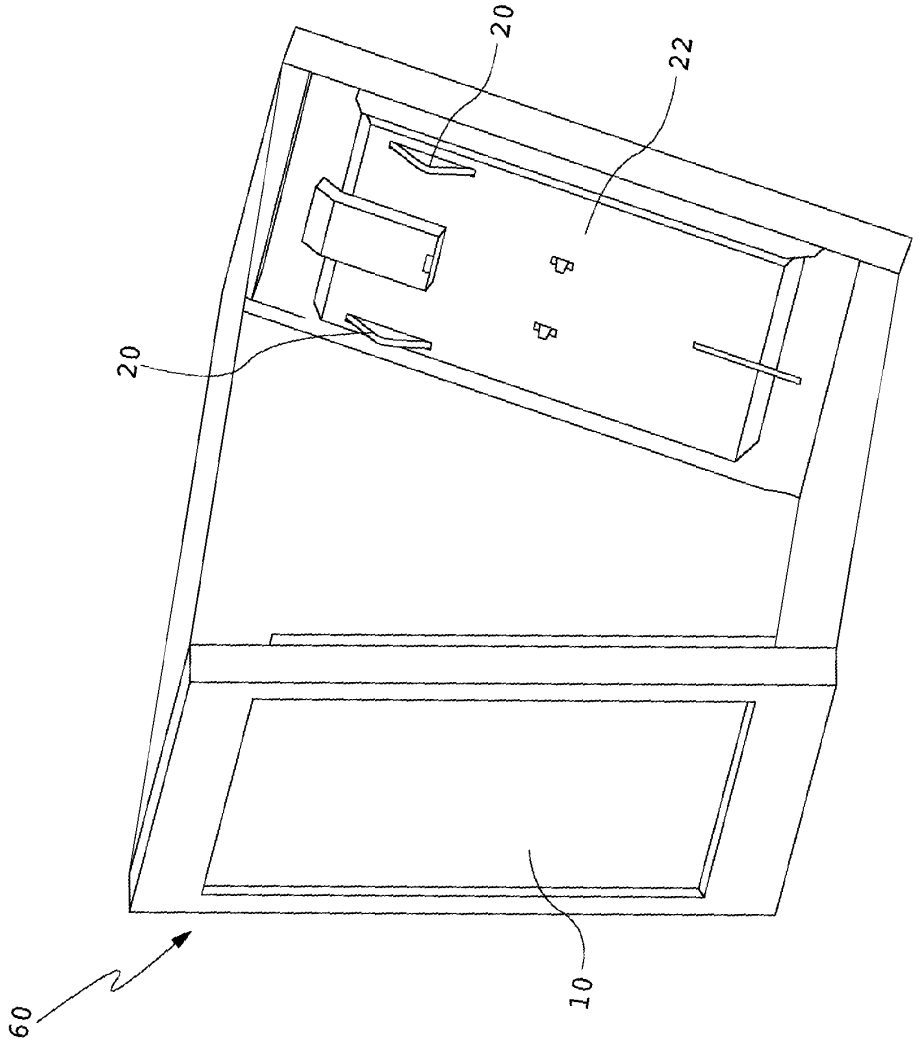


FIG-7

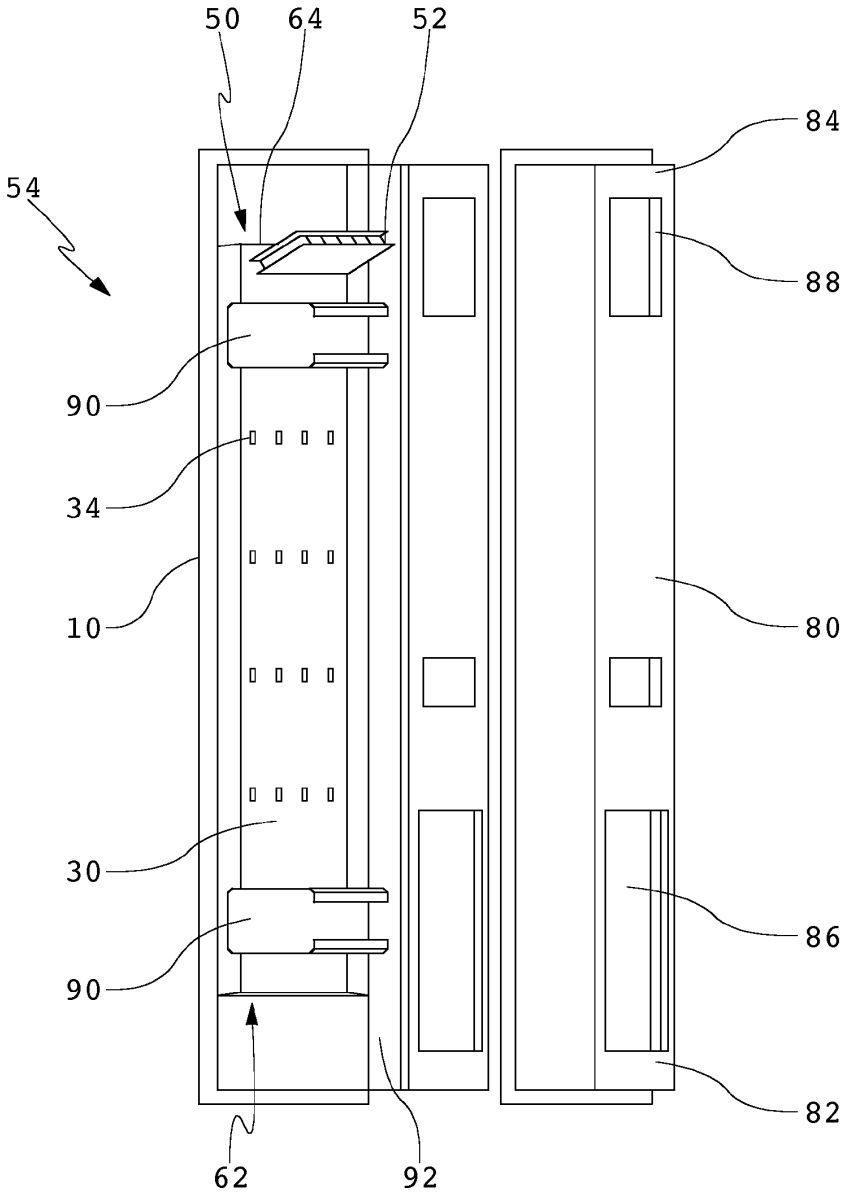


FIG-8

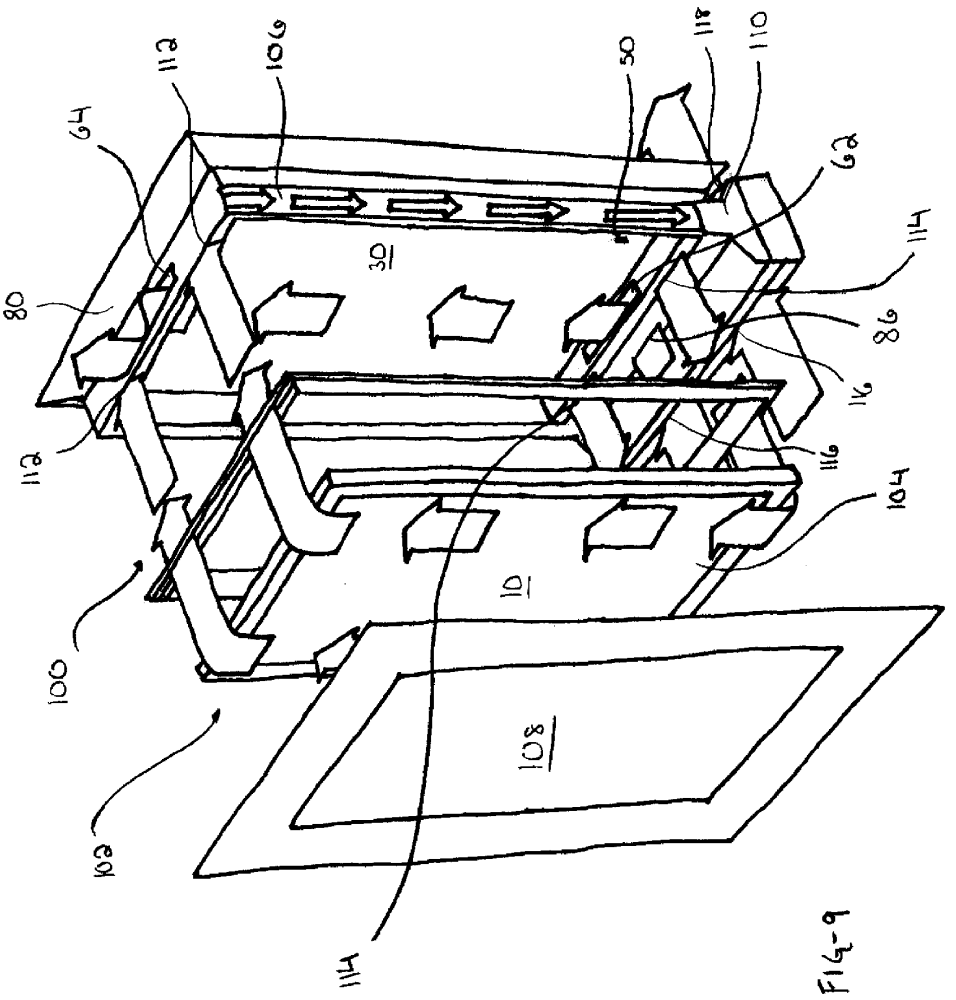

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Fig-9

CONSTRICTED CONVECTION COOLING SYSTEM FOR AN ELECTRONIC DISPLAY

CROSS-REFERENCE TO RELATED APPLICATIONS

This application is a continuation of U.S. application Ser. No. 12/411,925 filed on Mar. 26, 2009, now U.S. Pat. No. 8,854,595 issued Oct. 7, 2014. U.S. application Ser. No. 12/411,925 is a non-provisional application of U.S. Provisional Application No. 61/039,454 filed Mar. 26, 2008. U.S. application Ser. No. 12/411,925 is a non-provisional application of U.S. Provisional Application No. 61/095,615 filed Sep. 9, 2008. U.S. application Ser. No. 12/411,925 is a non-provisional application of U.S. Provisional Application No. 61/095,616 filed Sep. 9, 2008. U.S. application Ser. No. 12/411,925 is a non-provisional application of U.S. Provisional Application No. 61/115,333 filed Nov. 17, 2008. U.S. application Ser. No. 12/411,925 is a non-provisional application of U.S. Provisional Application No. 61/138,736 filed Dec. 18, 2008. U.S. application Ser. No. 12/411,925 is a non-provisional application of U.S. Provisional Application No. 61/142,879 filed Feb. 16, 2009. U.S. application Ser. No. 12/411,925 is also 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 Jul. 1, 2014, which is a non-provisional application of U.S. Provisional Application No. 61/033,064 filed Mar. 3, 2008. U.S. application Ser. No. 12/411,925 is also 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. Provisional Application No. 61/053,713 filed May 16, 2008. U.S. application Ser. No. 12/411,925 is also a continuation-in-part of U.S. application Ser. No. 12/237,365 filed Sep. 24, 2008, which is a non-provisional application of U.S. Provisional Application No. 61/057,599 filed May 30, 2008. U.S. application Ser. No. 12/411,925 is also a continuation-in-part of U.S. application Ser. No. 12/235,200 filed Sep. 22, 2008, which is a non-provisional application of U.S. Provisional Application No. 61/076,126 filed Jun. 26, 2008. All aforementioned applications are hereby incorporated by reference in their entirety as if fully cited herein.

TECHNICAL FIELD

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

BACKGROUND OF THE ART

Conductive and convective heat transfer systems for electronic displays are known. These systems of the past 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 air past the components to be cooled and out of the display. In some cases, the heated air is moved into convectively thermal communication with fins. Some of the past systems also utilize conductive heat transfer from heat producing components directly to heat conductive housings for the electronics. In these cases, the housings have a large surface area, which is in convective communication with ambient air outside the housings. Thus, heat is transferred convectively or conductively to the housing and is then transferred into the ambient air from the housing by natural convection.

While such heat transfer systems have enjoyed a measure of success in the past, improvements to displays require even greater cooling capabilities.

SUMMARY OF THE EXEMPLARY EMBODIMENTS

In particular, cooling devices for electronic displays of the past have generally used convective heat dissipation systems that function to cool an entire interior of the display by one or more fans and fins, for example. 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.

In the past, many displays have functioned satisfactorily with ten or twelve inch screens. Now, many displays are in need of screens having sizes greater than or equal to twenty-four inches that may require improved cooling systems. For example, some outdoor applications call for seventy inch screens and above. With increased heat production with the larger screens and radiative heat transfer from the sun through the display window, heat dissipation systems of the past, which attempt to cool the entire interior of the display with fins and fans, are no longer adequate.

A large fluctuation in temperature is common in the devices of the past. Such temperature fluctuation adversely affects the electronic components in these devices. Whereas the systems of the past attempted to remove heat from the entire interior of the display, a preferred embodiment causes directed convective heat transfer from the anterior of the display. By the aspects described below, the present invention has made consistent cooling possible for electronic displays having screens of sizes greater than or equal to twelve inches. For example, cooling of a seventy inch screen can be achieved, even in extremely hot climates. Greater cooling capabilities are provided by the device and method described and shown in more detail below.

An exemplary embodiment relates to a constricted convection cooling system and a method of cooling an electronic display. An exemplary embodiment includes an external housing and a constricted convection plate. The external housing preferably includes an air entrance end and an exhaust end. The air entrance end defines an entrance aperture; while the exhaust end defines an exit aperture. The constricted convection plate is preferably mounted to the posterior display surface. This posterior display surface may be the posterior surface of the backlight assembly or the posterior surface of any other thin panel display assembly (OLED, plasma, etc.). The constricted convection plate further defines a constricted convection cooling channel immediately behind the posterior display surface. The convection cooling channel may be adapted to receive air entering the entrance aperture and adapted to expel air through the exit aperture.

The air entering the constricted convection cooling channel may be from a refrigerated air source in communication with the entrance opening, or alternatively may be ambient air from the display surroundings. A septum in association with the external housing may be adapted to direct air into the constricted convection cooling channel. One or more fans may be used to draw the cooling air through the constricted convection cooling channel. In other embodiments, one or

SEC et al. v. MRI
SEC Exhibit 1001.013
IPR 2023-00220

more fans may be used to force air through the constricted convection cooling channel. In exemplary embodiments, a plurality of fans are used to draw a substantially uniform flow of air through the constricted convection cooling channel. This helps to cool the display assembly in a uniform manner. This is particularly beneficial with an LED backlight, as individual LEDs may fail prematurely if exposed to high levels of heat for an extended period of time.

The foregoing and other features and advantages will be apparent from the following more detailed description of the particular embodiments, 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 description and the accompanying drawings wherein identical reference characters refer to identical parts and in which:

FIG. **1** is a perspective view of a display that may be used in an exemplary embodiment.

FIG. **2** is a posterior view of a display that may be used in an exemplary embodiment.

FIG. **3** is a perspective view of the constricted convection plate.

FIG. **4** is an exploded view of a display that may be used in an exemplary embodiment and an exemplary embodiment of the constricted convection plate.

FIG. **5**A is a front perspective view of a fan and display that may be used in an exemplary embodiment and an exemplary embodiment of the constricted convection plate.

FIGS. **5**B through **5**F show side views of additional embodiments for the constricted convection system.

FIG. **6** is a perspective view of a double display housing utilizing an exemplary embodiment of the constricted convection air cooling system for an electronic display.

FIG. **7** is a posterior view of a display the may be found in a double display housing utilizing an exemplary embodiment of the constricted convection air cooling system for an electronic display.

FIG. **8** is an exploded view of an exemplary embodiment of the constricted convection air cooling system for an electronic display.

FIG. **9** is a perspective view of an exemplary embodiment of the constricted air cooling system for an electronic display of the present invention with an optional isolated gas cooling system.

DETAILED DESCRIPTION

Exemplary embodiments relate to a cooling system for an electronic display and to combinations of the cooling system and the electronic display. Exemplary embodiments provide a constricted convection cooling system for an electronic display.

FIG. **1** is a perspective view of a display that may be used in an exemplary embodiment. As may be appreciated, when the display **10** is exposed to heat and/or sunlight, the temperatures inside the display **10** will vary greatly without some kind of cooling device. As such, the electronics including the display screen **12** (e.g., LCD screen) will have a greatly reduced life span. By implementing certain embodiments of the cooling system disclosed herein, temperature fluctuation is greatly reduced. This cooling capability has been achieved in spite of the fact that larger screens generate more heat than smaller screens.

The display **10** shown may be equipped with a backlight assembly. Modern displays are required to be extremely bright and this is especially true with displays that are intended for use in bright environments, especially outdoor environments which see direct or indirect sunlight. Accordingly, the backlight assembly may be required to be very bright and as such may generate a significant amount of heat. Exemplary embodiments provide excellent cooling of the backlight assembly, through the use of the constricted convection system. Accordingly, it may be placed in direct sunlight. Although the cooling system may be used on smaller displays, it is especially useful for larger LCD, LED, plasma, or organic light emitting diodes (OLED) displays. These screens, especially with displays over 24 inches, face significant thermoregulatory issues in outdoor environments.

It is to be understood that the spirit and scope of the disclosed embodiments includes cooling of displays including, but not limited to LCDs. By way of example and not by way of limitation, the present invention may be used in conjunction with displays selected from among LCD (including TFT or STN type), light emitting diode (LED), organic light emitting diode (OLED), field emitting display (FED), cathode ray tube (CRT), and plasma displays. Furthermore, embodiments of the present invention may be used with displays of other types including those not yet discovered. In particular, it is contemplated that the present invention may be well suited for use with full color, flat panel OLED displays. While the embodiments described herein are well suited for outdoor environments, they may also be appropriate for indoor applications (e.g., factory environments) where thermal stability of the display may be at risk. Furthermore, while most of this disclosure is written in terms of cooling, embodiments enclosed herein may be utilized for heating in particular applications. The means for cooling the air in the cooling systems may be replaced with a means for heating the air. A heating system for an electronic display would allow usage in climates/environments normally too cold for liquid crystal or other like technologies.

FIG. **2** is a posterior view of a display **10** that may be used in an exemplary embodiment. In a typical display, the display posterior **22** may include four mounting brackets **20**. The four mounting brackets **20** are shown by way of example and not by way of limitation, exemplary embodiments may be used with various numbers of mounting brackets **20**. The mounting brackets **20** serve to attach the constricted convection plate **30** (shown in FIG. **3**) to the display posterior **22**. The height that the mounting brackets **20** extending from the display posterior **22** define the depth of the constricted convection cooling channel **50** (shown in FIG. **5**). This may also be described as the gap distance between the display posterior **22** and the constricted convection plate.

In an exemplary embodiment, the display posterior **22** may be the posterior surface of a backlight assembly. The backlight assembly may comprise a printed circuit board (PCB) with a plurality of LEDs mounted to the anterior surface. The PCB may have a low level of thermal resistance between the anterior and posterior surfaces such that heat which is generated by the LEDs may be transferred to the posterior surface of the of the backlight assembly, and subsequently removed by air within the constricted convection channel. The PCB may comprise a metal core PCB and the posterior surface of the PCB may be metallic so that air within the constricted convection channel may cool the metallic posterior surface (and subsequently the backlight assembly) more easily and efficiently.

FIG. **3** is an exemplary embodiment of the constricted convection plate **30**. The constricted convection plate **30** may

SEC et al. v. MRI
SEC Exhibit 1001.014
IPR 2023-00220

have angled side panels **32**. The angled side panels **32** are adapted to extend from the constricted convection plate **30** and make contact with the display posterior **22** and direct air through the constricted convection channel **50** (shown in FIG. **5**). The constricted convection panel **30** may also be constructed to include access apertures **34**. The access apertures **34** are defined by the constricted convection plate **30** and allow access to hardware found on the display posterior **22**; without the need to remove the constricted convection plate **30**. The access apertures **34** may be plugged before operation to maintain directed contact between the refrigerated air and the posterior display surface **22**.

The width of the constricted convection channel **50** may vary according to the thermal requirements of a particular application. In some embodiments, the constricted convection channel **50** may be one-half inch or less. In other embodiments, the constricted convection channel **50** may be between one-half inch and one inch. In still other embodiments, the constricted convection channel **50** may be between one and five inches.

FIG. **4** is an exploded view showing the relationship of a display **10** that may be used in an exemplary embodiment and an exemplary embodiment of the constricted convection plate **30**. As described above, the constricted convection plate **30** may be attached to the display posterior **22** by the mounting brackets **20** (shown in FIG. **2**). The size of the constricted convection plate **30** may be of sufficient size to cover the entire posterior display surface **22**. In other exemplary embodiments, the constricted convection plate **30** may only cover a portion of the posterior display surface **22**. Therefore, the size of the constricted convection plate **30** may be adjusted to provide sufficient cooling of the display posterior **22**.

In FIG. **5**A, the constricted convection plate **30** is shown mounted to the display posterior **22**. The mounting brackets **20** (shown in FIG. **2**) may be used to secure the constricted convection plate **30**. The constricted convection plate **30** and the display posterior **22** define a constricted convection cooling channel **50** immediately behind the display posterior **22**. As discussed above, in some embodiments the constricted convection cooling channel **50** may run the length and width of the display **10**. In other embodiments, the constricted convection cooling channel **50** may be only of sufficient size to provide thermal stability to the display **10**.

The constricted convection cooling system **54** may include a means for increasing the speed at which air travels through the constricted convection cooling channel **50**. This means may include one or more fans **52** which may be positioned near an opening of the constricted convection cooling channel **50**. The fans **52** may either force the air through the constricted convection channel **50** or pull the air through the constricted convection channel **50**. Alternatively, a plurality of fans may be used to both push and pull air through the constricted convection cooling channel **50**. The use of one or more fans **52** may provide increased velocity of the air traveling through the constricted convection cooling channel **50**, thus increasing the speed with which heat is transferred from the display posterior **22**.

In other exemplary embodiments, a means for cooling the air which passes through the constricted convection cooling channel **50** may be used. A means for cooling the air may include, but is not limited to, a conditioning unit, a refrigeration unit, or any other means to decrease the temperature of the air passing through the constricted convection plate **30**. Alternatively, ambient air from the surroundings may be drawn in and forced within the constricted convection channel **50**.

FIGS. **5**B through **5**F show side views of additional embodiments for the constricted convection system. In FIG. **5**B, one or more fans **52** are used to draw ambient air between the posterior display surface **22** and the constricted convection plate **30**. In FIG. **5**C, one or more fans **52** are used to force ambient air between the posterior display surface **22** and the constricted convection plate **30**. FIG. **5**D is similar to FIG. **5**B except that the housing **80** and the septum **90** are used to direct the flow of air. In FIG. **5**E, an air conditioning unit **110** is used to both cool the air and to force the cooled air between the posterior display surface **22** and the constricted convection plate **30**. Finally in FIG. **5**F, an air conditioning unit **110** is used in combination with one or more fans **52**.

FIG. **6** is a double display housing **60** utilizing an exemplary embodiment of the constricted convection air cooling system **54**. A constricted convection plate **30** is mounted to a display posterior **22**. The constricted convection plate **30** and the display posterior **22** define a constricted convection cooling channel **50** immediately behind the display posterior **22**. An entrance opening **62** adapted to receive air is defined by the constricted convection plate **30**. An exit opening **64** adapted to expel air from the constricted convection cooling channel **50** is defined by the constricted convection plate **30** and the display posterior **22**. As above, the constricted convection plate **30** may have access apertures **34**. The access apertures **34** allow access to hardware located behind the constricted convection plate **30**. The access apertures **34** may be closed before use using plugs or other similar devices (not shown in the Figures).

An air source (not shown in the Figures) may be in communication with the entrance opening **62**. Air is forced through the entrance opening **62** and into the constricted convection channel **50**. The constricted convection channel **50** directs the air into contact with the display posterior **22** increasing the heat transfer from the display. After passing over the display posterior **22**, the air exits the constricted convection channel **50** through the exit opening **64**. The expelled air may then pass through a portion of the double display housing **60** into the atmosphere.

As above, a means for cooling the air (not shown in the Figures) forced into the constricted convection cooling channel **50** may be employed. The means for cooling the air may include, but is not limited to, a conditioning unit, a refrigerating unit, a thermoelectric unit, or any other means to decrease the temperature of the air before entering the constricted convection cooling channel **50**.

FIG. **7** is a double display housing **60** that may use an exemplary embodiment of the constricted convection air cooling system **54**. The display posterior **22** may include mounting brackets **20**. The mounting brackets **20** are shown by way of example and not by way of limitation. The present invention may use various shapes and numbers of mounting brackets **20**. The mounting brackets **20** may serve to attach the constricted convection plate **30** (shown in FIG. **3**) to the display posterior **22**. The height of the mounting brackets **20** extend from the display posterior defines the depth of the constricted convection cooling channel **50** (shown in FIG. **5**). Further embodiments may not utilize mounting brackets as they are not necessary to practice the invention.

As with other exemplary embodiments, a means for forcing air within the system and increasing the speed at which the air travels through the constricted convection cooling channel **50** may be used. The means for increasing the air speed may be in association with either the entrance opening **62** or the exit opening **64**. The means for increasing the air speed may include, but is not limited to, one or more fans (shown in FIG. **5**).

SEC et al. v. MRI
SEC Exhibit 1001.015
IPR 2023-00220

FIG. **8** is an exploded view of another embodiment of the constricted convection cooling system **54**. The display **10** may be encased in an external housing **80**. The external housing **80** may have an air entrance end **82** and an exhaust end **84**. The air entrance end **82** defines an entrance aperture **86**. The exhaust end **84** defines an exit aperture **88**. The constricted convection plate **30** and the display posterior **22** (not shown in FIG. **8**) define a constricted convection cooling channel **50**. The constricted convection plate **30** further defines an entrance opening **62** and an exit opening **64**. The entrance opening may be adapted to receive air entering the entrance aperture **86**. The exit opening may be adapted to expel air through the exit aperture **88**.

Septa **90** are associated with the external housing **80**. The septa **90** may be adapted to prevent air from evading the constricted convection channel **50**. The septa **90** may also be adapted to provide support and an attachment port for the external housing **80**.

Air or another appropriate gas may be in gaseous communication with the entrance opening **86**. The air then passes through the entrance opening **86** into a middle chamber **92**. The middle chamber **92** is defined by the external housing **80** and the constricted convection plate **30**. Once the air enters the middle chamber it may be directed through the entrance opening **62**. A septum **90** may be positioned to direct air into the entrance opening **62** and prevent the air evading the entrance opening **62**. After passing through the entrance opening **62**, the air may enter the constricted convection cooling channel **50**. As the air passes through the constricted convection cooling channel heat is transferred from the display posterior to the air.

After absorbing heat from the display posterior, the air may exit the constricted convection channel **50** through the exit opening **64**. A septum **90** may be used to prevent the exiting air from evading the exit aperture **88**, and to direct the air towards the exit aperture **88**. The air is then expelled through the exit aperture **88** in to the surrounding atmosphere.

To assist in the movement of air through the constricted convection channel **50**, a means to force the air into the channel and increase the air speed may be used. Increasing the air speed and the volumetric flow rate of the air may allow for increased heat removal. The means to increase the air speed may include, but is not limited to, a fan **52**. The fan **52** may be associated with the exit opening **64** and may draw air from the constricted convection channel **50**. In other embodiments, the fan **52** may be associated with the entrance opening **62** and may force air into the constricted convection channel **50**. Other embodiments may utilize a combination of both drawing the air from the channel and forcing the air into the channel. In an exemplary embodiment, a plurality of fans would be distributed across the entire exit opening **64** (or entrance opening **62**, or both) in order to produce a uniform flow of air across the posterior display surface to facilitate uniform cooling.

In other exemplary embodiments, a means for cooling air in gas communication with the entrance opening **62** may be employed. The means for cooling the air may include, but is not limited to, a conditioning unit, a refrigerating unit, a thermoelectric unit, or any other device that decreases the temperature of the air. Cooling the air further increases the air's ability to transfer heat from the display posterior **22**. The means for cooling air may be housed within the external housing **80**, or it may be an external unit.

FIG. **9** is a display **10** using and exemplary embodiment of the constricted convection cooling system, where three cooling pathways are used. The first cooling pathway is comprised of the constricted convection plate **30** immediately behind the display posterior. The second cooling pathway is a closed loop and is comprised of the isolated gas cooling system **100**. The third cooling pathway is comprised of the ambient air vent system used to cool the refrigeration unit **110**. In some embodiments, the first and/or second pathways may include refrigerated air. In still other exemplary embodiments, the first and/or second pathways may contain heated air. The ability to provide cooled and heated air in the pathways allows use of an outdoor electronic display across a variety of climates. Other exemplary embodiments may contain any combination of cooling/heating pathways. For applications which require both heating and cooling, a thermoelectric module may be used as the refrigeration unit **110**. Thermoelectric modules are commonly available which can run in both cooling and heating modes.

In the first cooling pathway, a constricted convection plate **30** may be mounted immediately behind the display posterior. A constricted convection channel **50** is defined by the gap between the constricted convection plate **30**, and the display posterior.

Air may enter the entrance aperture **86**, which is defined by external housing **80**. The air passes through the entrance aperture **86** to the entrance opening **62**, and into the constricted convection channel **50**. The air may then be expelled into the atmosphere from the constricted convection channel **50** through the exit opening **64**. Optionally, a means for increasing the speed of the air traveling through the constricted convection channel **50** may be included either associated with the entrance opening **62** or the exit opening **64** or both.

The second cooling pathway may be an exemplary embodiment of an isolated gas cooling system **100**. The isolated gas cooling chamber **102** comprises a closed loop which includes a gas chamber **104** and return air passage **106**. The gas chamber **104** includes a transparent plate **108**. The term "isolated gas" refers to the fact that the gas within the isolated gas cooling chamber **102** is essentially isolated from the external air. In the embodiment shown, the isolated gas cooling system **100** comprises refrigerated air. Because the gas chamber **102** is positioned in front of the display **10**, the gas should be substantially free of dust or other contaminates that might negatively affect the display image.

The isolated gas may be almost any transparent gas, including, but not limited to, normal air, nitrogen, helium, or any other transparent gas. The gas is preferably colorless so as not to affect the image quality. Furthermore, the isolated gas cooling chamber **102** need not necessarily be hermetically sealed from the external air. It is sufficient that the gas in the chamber is isolated to the extent that dust and contaminates may not substantially enter the first gas chamber.

The gas chamber **104** is in gaseous communication with the return air passage **106**. A refrigeration unit **110** may be provided within the exemplary embodiments. The refrigeration unit may be any device which cools the isolated gas which travels around the isolated gas cooling chamber and sometimes through the constricted convection channel. Along with cooling the air, the refrigeration unit **110** may be utilized to propel the gas around the isolated gas cooling chamber **102** or through the constricted convection channel. The gas chamber **104** includes at least one front glass **108** mounted in front of the display **10**. The front glass **108** may be set forward from the display **10** by spacers (not shown in the Figures). The spacing members define the depth of the narrow channel passing in front of the display **10**. The spacing members may be independent of alternatively may be integral with some with some other component of the device (i.e., integral with the front plate). The display **10**, the spacing members, and the

SEC et al. v. MRI
SEC Exhibit 1001.016
IPR 2023-00220

front glass **108** define the narrow gas chamber **104**. The gas chamber **104** may be gaseous communication with the return air passage **106** through entrance openings **112** and exit openings **114**.

As the isolated gas in the gas chamber **104** traverses the isolated gas cooling chamber **102** it contacts the display **10** surface. Contacting the isolated gas directly to the display **10** allows convective heat transfer from the display **10** to the isolated gas. By utilizing the display **10** as the posterior surface wall of the gas chamber **104**, there are fewer surfaces to impact the visible light traveling through the display **10**. Furthermore, the device will be lighter and cheaper to manufacture.

Although the embodiment shown utilizes the display **10**, certain modifications and/or coatings (e.g., anti-reflective coatings) may be added to the display **10**, or to other components of the system in order to accommodate the coolant gas or to improve the optical performance of the device. In the embodiment shown, the display **10** may be the front glass plate of a liquid crystal display (LCD) stack. However, almost any display surface may be suitable for embodiments of the present cooling system. Although not required, it is preferable to allow the cooling gas in the gas chamber **104** to contact the display **10** directly. In this way, the convective effect of the circulating gas will be maximized. Preferably the gas, which has absorbed heat from the display **10** may then be diverted to the refrigeration unit **110** by way of the return air passage **106**.

To maintain efficiency of the refrigeration unit **110**, a third cooling loop may be utilized, wherein ambient air may be passed through the external housing **80**. The ambient air enters the external housing through vent openings **116** and exits through vent exits **118**. The ambient air passing through the vent openings **116** and exits **118** carries away heat generated by the refrigeration unit **110**.

The refrigeration unit may also cool the air which travels within the constricted convection channel **50**. The refrigeration unit may also contain a means to force the cooled air into the constricted convection channel **50**. This means may include one or more fans and one or more septa.

An optional air filter (not shown) may be employed within the isolated gas cooling system **100** to assist in preventing contaminates and dust from entering the gas chamber **104**. It is also understood that any cooling loop may include cooled air, and as stated above the cooling loop may also provide heated air.

The constricted convection cooling system may also be used in conjunction with an air curtain as described in Copending application Ser. No. 11/941,728, hereby incorporated by reference in its entirety.

Having shown and described the 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.

The invention claimed is:

1. A system for cooling an electronic display having a posterior display surface and contained within a housing, the system comprising:

a constricted convection plate placed posterior to the posterior display surface covering the majority of the posterior display surface;

at least one bracket which connects the posterior display surface with the constricted convection plate; and

a fan placed to draw ambient air between the constricted convection plate and the rear posterior.

2. The cooling system from claim **1** wherein:

the posterior display surface comprises the rear surface of a backlight assembly.

3. The cooling system from claim **1** wherein:

the constricted convection plate is substantially parallel to the posterior display surface.

4. A liquid crystal display (LCD) comprising:

a liquid crystal stack;

a backlight assembly behind the liquid crystal stack and comprising:

a printed circuit board (PCB) having front and back sides;

a plurality of LEDs mounted on the front side of the PCB;

a posterior surface on the rear side of the PCB;

a constricted convection plate placed behind and substantially parallel with the posterior surface of the PCB; and

a fan positioned to draw air between the constricted convection plate and the posterior surface.

5. The LCD from claim **4** further comprising:

at least one bracket which connects the posterior surface with the constricted convection plate.

6. The LCD from claim **4** further comprising:

a thermoelectric unit in gaseous communication with the air being drawn by the fan.

7. The LCD from claim **4** further comprising:

a housing which contains the liquid crystal stack, backlight assembly, constricted convection plate, and fan; and

an entrance aperture within the housing which permits external ambient air to enter the housing and flow between the constricted convection plate and the posterior surface of the PCB.

8. The LCD from claim **4** further comprising:

a plurality of access apertures on the constricted convection plate.

9. A system for cooling an electronic display comprising:

an electronic display comprising a front display surface and a posterior surface where no electronics are mounted to the posterior surface of the electronic display;

a constricted convection plate behind the posterior surface of the display covering a majority of the posterior display surface; and

a means for forcing air between the constricted convection plate and the posterior surface of the electronic display.

10. The cooling system from claim **9** further comprising:

a plurality of apertures on the constricted convection plate.

11. The cooling system from claim **9** further comprising:

at least one bracket which connects the posterior surface with the constricted convection plate.

12. The cooling system from claim **9** further comprising:

a housing which contains the electronic display, constricted convection plate, and means for forcing air; and

an entrance aperture within the housing which permits external ambient air to enter the housing and flow between the constricted convection plate and the posterior surface.

13. The cooling system from claim **12** wherein:

the means for forcing air between the constricted convection plate and the posterior surface of the electronic display comprises a plurality of fans placed near the entrance aperture.

SEC et al. v. MRI
SEC Exhibit 1001.017
IPR 2023-00220

14. The cooling system from claim **9** further comprising:

a gaseous closed loop traveling across the front display surface, behind the constricted convection plate, and returning to the front display surface;

a means for propelling gas around the closed loop; and

a means for cooling the gas in the closed loop.

15. The cooling system from claim **14** wherein:

the means for propelling the gas around the closed loop comprises a plurality of fans within the closed loop.

16. The cooling system from claim **9** wherein:

the electronic display comprises an LED backlight LCD display where the posterior surface is the rear surface of a backlight assembly.

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SEC et al. v. MRI
SEC Exhibit 1001.018
IPR 2023-00220