

Constricted Convection Cooling System for an Electronic Display

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Technical Field

[0001] This invention generally relates 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 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.

[0003] 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 Invention

[0004] 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.

[0005] 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.

[0006] 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 of the present invention 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.

[0007] An exemplary embodiment of the present invention relates to a constricted convection cooling system and a method of cooling an electronic display. An exemplary embodiment includes an external housing and a convection constriction 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 convection constriction plate is preferably mounted to the posterior display surface. The convection constriction 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.

[0008] The air entering the constricted convection cooling channel may be from a refrigerated air source in communication with the entrance opening. A septum in association with the external housing may be adapted to direct air into the constricted convection cooling channel. A fan may be used to draw the refrigerated air through the constricted convection cooling channel. In other embodiments, a fan may be used to force air through the constricted convection cooling channel.

[0009] 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

[0010] 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:

[0011] FIGURE 1 is a perspective view of a display that may be used in an exemplary embodiment.

[0012] FIGURE 2 is a posterior view of a display that may be used in an exemplary embodiment.

[0013] FIGURE 3 is a perspective view of the convection constriction plate.

[0014] FIGURE 4 is an exploded view of a display that may be used in an exemplary embodiment and an exemplary embodiment of the convection constrictive plate.

[0015] FIGURE 5 is a front perspective view of a fan and display that may be used in an exemplary embodiment of the present invention and a exemplary embodiment of the constrictive convection plate.

[0016] FIGURE 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.

[0017] FIGURE 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.

[0018] FIGURE 8 is an exploded view of an exemplary embodiment of the constricted convection air cooling system for an electronic display.

[0019] **FIGURE 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

[0020] Exemplary embodiments relate to a cooling system for an electronic display and to combinations of the cooling system and the electronic display. Exemplary embodiments of the present invention provide a constrictive convection cooling system for an electronic display.

[0021] Fig. 1 is a perspective view of a display that may be used in an exemplary embodiment of the present invention. As may be appreciated, when the display 10 is exposed to outdoor elements, 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.

[0022] The display 10 shown is equipped with an innovative constricted convection cooling 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, or organic light emitting diodes (OLED) displays. These screens, especially with displays over 24 inches, face significant thermoregulatory issues in outdoor environments.

[0023] 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 outdoor screens in climates normally too cold for liquid crystal or other like technologies.

[0024] Fig. 2 is a posterior view of a display 10 that may be used in an exemplary embodiment of the present invention. In a typical display, the display posterior 22 includes 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).

[0025] Figure 3 is an exemplary embodiment of the constrictive convection plate 30 of the present invention. The constrictive convection plate 30 may have angled side panels 32. The angled side panels 32 are adapted to extend from the constrictive convection plate 30 and make contact with the display posterior 22 and direct air through the constrictive convection channel 50 (shown in Figure 5). The constrictive convection panel 30 may also be constructed to include access apertures 34. The access apertures 34 are defined by the constrictive convection plate 30 and allow access to hardware found on the display posterior 22; without the need to remove the constrictive convection plate 30. The access apertures 34 may be plugged before operation to maintain directed contact between the refrigerated air and the posterior display 10 surface.

[0026] The width of the constrictive convection channel 50 may vary according to the thermal requirements of a particular application. In some embodiments, the constrictive convection channel 50 may be one-half inch or less. In other embodiments, the constrictive convection channel 50 may be between one-half and one inch. In still other embodiments, the constrictive convection channel 50 may be greater than 1 inch.

[0027] Figure 4 is an exploded view showing the relationship of a display 10 that may be used in an exemplary embodiment of the present invention and an exemplary embodiment of the convection constrictive plate 30 of the present invention. As described above, the convection constriction plate 30 may be attached to the display posterior 22 by the mounting brackets 20 (shown in Figure 2). The size of the

convection constriction plate 30 may be of sufficient size to cover the entire posterior display surface 22. In other exemplary embodiments, the size of the convection constriction plate 30 may be adjusted to provide sufficient cooling of the display posterior 22.

[0028] Figure 5 is an exemplary embodiment of the present invention. The constrictive 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 constrictive convection plate 30. The constrictive convection plate 30 and the display posterior 22 define a constricted convection cooling channel 50 immediately behind the display posterior 22. In some exemplary embodiments, constrictive convection cooling channel 50 may run the length and width of the display 10. In other embodiments, the constrictive convection cooling channel 50 may be of sufficient size to provide thermal stability to the display 10.

[0029] The constrictive convection cooling system 54 may include a means for increasing the speed at which air travels through the constrictive convection cooling channel 50. This means may include a fan 52 which may be positioned near an opening of the constriction convection cooling channel 50. The fan 52 may either force the air through the constrictive convection channel 50 or pull the air through the constrictive convection channel 50. The use of a fan 52 may provide increased velocity of the air traveling through the constrictive convection cooling channel 50, thus increasing the efficiency with which heat is transferred from the display posterior 22.

[0030] In other exemplary embodiments, a means for cooling the air (not shown in the Figures) passing through the constrictive 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 constrictive convection plate 30.

[0031] Figure 6 is a double display housing 60 utilizing an exemplary embodiment of the constricted convection air cooling system 54 for an electronic display of the present invention. A convection constriction plate 30 is mounted to a display posterior 22. The convection constriction 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 constrictive convection plate 30. An exit opening 64 adapted to expel air from the constrictive convection cooling channel 50 is defined by the convection constriction plate 30 and the display posterior 22. As above, the constrictive convection plate 30 may have access apertures 34. The access apertures 34 allow access to hardware located behind the constrictive convection plate 30. The access apertures 34 may be closed before use using plugs or other similar devices (not shown in the Figures).

[0032] 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 constrictive convection channel 50. The constrictive convection channel 50 directs the air into contact with the display posterior 22 increasing heat transfer from the display. In addition, the narrowing of the air flow path by the constrictive convection channel 50 also increases the effectiveness of the heat transfer. After passing over the display posterior 22, the air exits the constrictive 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.

[0033] As above, a means for cooling the air (not shown in the Figures) forced into the constrictive 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, or any other means to decrease the temperature of the air before entering the constrictive convection cooling channel 50.

[0034] Figure 7 is a double display housing 60 that may use an exemplary embodiment of the constrictive convection air cooling system 54 of the present invention. 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 numbers of mounting brackets 20. The mounting brackets 20 may serve to attach the constrictive convection plate 30 (shown in Figure 3) to the display posterior 22. The height of the mounting brackets 20 extend from the display posterior defines the depth of the constrictive convection cooling channel 50 (shown in Figure 5).

[0035] As with other exemplary embodiments, a means for increasing the speed at which the air travels through the constrictive 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, a fan (shown in Figure 5).

[0036] Figure 8 is an exploded view of the constrictive convection cooling system 54, for use with an electronic display 10, of the present invention. 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. A constrictive convection plate 30 may be mounted to the display posterior 22 (shown in Figure 2) using mounting brackets 20. The constrictive convection plate 30 and the display posterior 22 define a constrictive convection cooling channel 50 immediately behind the display posterior 22. The constrictive convection plate 30 further defines an entrance opening 62 and an exit opening 64 (shown in Figure 6). 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.

[0037] 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.

[0038] 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 constrictive 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 constrictive convection cooling channel 50. as the air passes through the convection constrictive cooling channel heat is transferred away from the display posterior 22.

[0039] After absorbing heat from the display posterior 22, the air may exit the constrictive 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 atmosphere.

[0040] To assist in the movement of air through the constrictive convection channel 50 a means to increase the air speed may be used. Increasing the air speed allows 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 constrictive convection channel 50. In other embodiments, the fan 52 may be associated with the entrance opening 62 and may force air into the constrictive convection channel 50.

[0041] 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, 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.

[0042] Figure 9 is a display 10 housing using the constriction convection cooling system 54 of the present invention. An exemplary display 10 may also be utilized in conjunction with an optional isolated gas cooling system 100 which is the subject matter of co-pending U.S. Application No. 61/033,064, hereby incorporated by reference, in its entirety herein.

[0043] The exemplary embodiment shown in Figure 9 includes three cooling loops. The first cooling loop is comprised of the constrictive convection plate 30 mounted to the display posterior 22. The second cooling loop is comprised of the isolated gas cooling system 100. The third cooling loop is comprised of the ambient air vent system used to cool the refrigeration unit 110. In other exemplary embodiments, all three loops may include refrigerated air. In still other exemplary embodiments, all three loops may contain heated air. The ability to provide cooled and heated air in the loops allows use of an outdoor electronic display across a variety of climates. Other exemplary embodiments may contain any combination of cooling loops.

[0044] In the first cooling loop, a constrictive convection plate 30 may be mounted to the display posterior 22 (shown in Figure 2). Mounting brackets 20 (shown in Figure 2) may be used to fix the constrictive convection plate to the display posterior. A constrictive convection channel 50 is defined by the constrictive convection plate 30, and is immediately against the display posterior 22.

[0045] 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 constrictive convection channel 50. The air may then be expelled into the atmosphere from the constrictive convection channel 50 through the exit opening 64. Optionally, a means for increasing the speed of the air traveling through the constrictive convection channel 50 may be included either associated with the entrance opening 62 or the exit opening 64.

[0046] The second cooling loop 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 housing of the display 10. 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 contaminants that might negatively affect the display image.

[0047] 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 contaminants may not substantially enter the first gas chamber.

[0048] The gas chamber 104 is in gaseous communication with the return air passage 106. A refrigeration unit 108 may be provided within the closed circuit. The refrigeration unit may be any device which cools the air in the isolated gas cooling chamber 102. Along with cooling the air, the refrigeration unit 108 may be utilized to propel the gas around the isolated gas cooling chamber 102. 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 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.

[0049] As the isolated gas in the gas chamber 104 traverses the isolated gas cooling chamber 102 it contacts the display 10 surface. Contacting the cooling gas directly to the display 10 enhances the convective heat transfer way from the display 10. 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.

[0050] 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.

[0051] 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 and exits 116 and 118 carries away heat generated by the refrigeration unit 110.

[0052] An optional air filter (not shown) may be employed within the isolated gas cooling system 100 to assist in preventing contaminants 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.

[0053] The constricted convection cooling system may also be used in conjunction with an air curtain as described in Co-pending Application No. 11/941,728, hereby incorporated by reference in its entirety.

[0054] 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.