

DESCRIPTION

APPARATUS FOR COOLING HEAT GENERATING SPOT OF ELECTRONIC
DEVICE, COOLING METHOD THEREFOR, AND LIQUID CRYSTAL

5 PROJECTOR APPARATUS

TECHNICAL FIELD

The present invention relates to an apparatus for cooling a heat
generating spot (area) of an electronic device, a cooling method therefor, and a
10 liquid crystal projector apparatus, and more particularly, to an apparatus for
cooling a heat generating spot (area) of an electronic device, with two cooling
units which feed air streams that collide with each other on a cooling plane, a
cooling method therefor, and a liquid-crystal projector apparatus which includes
the apparatus for cooling a heat generating spot of an electronic device.

15 BACKGROUND ART

Apparatuses for cooling heat generating spots of electronic devices
have been used in a variety of forms, and cooling apparatuses which rely on air
for cooling have been developed in a variety of configurations for purposes of
simplifying the configuration. A plurality of forced air cooling type cooling
20 apparatuses are provided in projector apparatuses which are projection display
devices currently widely used for business and home applications.

A projection display device projects an image generated on an image
display element of an image display onto a screen under magnification. Among
such projection display devices, a liquid crystal projector apparatus which
25 employs liquid crystal panels for image display elements displays an image on a
screen in the following configuration and operation.

White light from a light source is reflected by a reflector, and is polarized or converted by PBS (Polarization-Beam Splitter) for separation into respective color light of red, green, and blue (R/G/B). Each separated color light is directed into each liquid crystal panel corresponding thereto, and optically modulated by the liquid crystal panel in accordance with a video signal. Each optically modulated color light is combined by a cross dichroic prism and projected onto a screen through a projection optical system.

In this event, a liquid crystal panel which operates in a TN (Twisted Nematic) mode can treat only a particular linearly polarized component, so that each color light is coordinated in a predetermined polarization direction (for example, S-polarization) by a polarizing plate before it impinges on the liquid crystal panel, and then optically modulated by the liquid crystal panel. Subsequently, an S-polarized component is cut by a polarizing plate on the exit side of the liquid crystal panel to extract a P-polarized component alone.

In this way, within a liquid crystal unit which includes an incident-side polarizing plate, a liquid crystal panel, and an exit-side polarizing plate, the incident-side polarizing plate and exit-side polarizing plate disposed before (upstream) and after (downstream) the liquid crystal panel along the optical axis each have functions of passing only polarized light in one axial direction and blocking other polarized light, and therefore generate heat during their operations due to light absorption. Also, the liquid crystal panel internally generates heat during its operations in the same manner because part of the transmitted light is blocked by a black matrix disposed on boundaries of respective pixels.

Organic materials are often used for these liquid crystal panels and polarizing plates, so that if they are irradiated with light at short wavelengths or

are exposed to high temperatures for a long time, their functions will be largely compromised by damaged alignment films of the liquid crystal panels, lower polarization selection characteristics of the polarizing plates, and the like. Accordingly, countermeasures to heat radiation, such as forced air cooling, are
5 required for these components of the liquid crystal unit.

A specially configured cooling apparatus is required for efficiently cooling a plurality of heat generating spots of a plurality of components in an electronic device, each of which has surfaces that oppose each other with a spacing defined therebetween, and includes heat generating spots on the
10 surfaces opposite to each other.

Fig. 1(a) and 1(b) are schematic diagrams of the configuration of a liquid crystal projector apparatus of a background related art, where Fig. 1(a) generally illustrates the appearance of the general liquid crystal projector apparatus, and Fig. 1(b) illustrates the internal structure of the liquid crystal
15 projector apparatus. Fig. 2 in turn is a schematic diagram of the internal configuration of the liquid crystal projector apparatus.

As mainly illustrated in Fig. 2, liquid crystal projector apparatus 1 includes cooling fan 3 for forcedly cooling liquid crystal unit 2, and cooling air duct 4, both of which are mounted in the housing of liquid crystal projector
20 apparatus 1. In addition, lamp cooling fan 7 for cooling light source 5, power supply unit 10 and the like, exhaust fan 9 for exhausting the housing, and the like are provided as required.

Here, a general method of cooling liquid crystal unit 2 of liquid crystal projector apparatus 1 will be described with reference to Figs. 3A and 3B. Figs.
25 3A and 3B are schematic diagrams illustrating the configuration of a cooling unit for cooling the liquid crystal unit in the liquid crystal projector apparatus, where

Fig. 3A is an exploded perspective view, and Fig. 3B is a schematic cross-sectional view for describing a forced air cooling operation.

In Fig. 3B, liquid crystal unit 2 including incident-side polarizing plate 12, liquid crystal panel 13, and exit-side polarizing plate 14 is provided for each color light (R/G/B), and air cooling device 15 including cooling fan 3 and cooling air duct 4 is disposed therebelow.

During the operation of air cooling device 15, air 16 from cooling fan 3 is fed into spaces among incident-side polarizing plate 12, liquid crystal panel 13, exit-side polarizing plate 14, which include each liquid crystal unit 2, from the lower end of liquid crystal unit 2 through discharge port 17 provided in cooling air duct 14 to perform forced air cooling.

In recent years, a reduction in size and an increase in luminance have been increasingly requested for liquid crystal projector apparatuses in accordance with their versatile usages. To respond to such requests, an increase in lamp power and a reduction in size of display device are now under progress, resulting in an increase in flux density of light incident on the liquid crystal unit, and a continuous increase in heat load on each component which forms part of liquid crystal unit 2.

For example, in a liquid crystal projector apparatus (1.0"-XGA) of 2000-lm class, a total amount of heat generated by liquid crystal units is approximately 15 W, while heat flux of an exit-side polarizing plate is approximately 0.6 W/cm². However, with a 5000-lm class, a total amount of heat generated by liquid crystal units amounts to 35 W or more, while heat flux of an exit-side polarizing plate amounts to 1.4 W/cm² or more.

Generally, when forced air cooling is used for cooling liquid crystal units, the amount of air fed by a fan is increased to enhance the air velocity

around a heat generating spot to improve the heat transfer coefficient and heat radiation capabilities, thereby accommodating ever increasing heat loads.

However, as the amount of fed air is increased by increasing the rotational speed of the fan, operation noise will increase. On the other hand, as
5 the amount of fed air is increased by employing a fan of larger size, this mitigates reducing the size of the apparatus.

On the other hand, requests have been gradually increased for longer lifetime of liquid crystal projector apparatus for reducing environmental loads and running cost. Apart from lamps, a factor which dominates the lifetime of the
10 liquid crystal projector apparatus is mainly the lifetime due to degraded optical characteristics in the liquid crystal units. Accordingly, the lifetime can be increased by reducing the operating temperature of the liquid crystal units through improvements on the cooling performance.

However, in a laminar flow region, the average heat transfer coefficient
15 of forced convection is proportional to the square root of the air velocity, while the operating temperature of the panel is reciprocally proportional to the square root of the air velocity. Thus, a reduction in the operating temperature of the panel to some extent will result in a lower sensitivity of a change in panel temperature to a change in air velocity.

20 Fig. 4 is a graph showing the relationship between a panel cooling air velocity and the panel operating temperature in 0.8"-SXGA (5000-lm class, 25°C environment). For reducing the panel operating temperature from 70°C to 60°C ($\Delta T = -10^\circ\text{C}$), the air velocity may be simply increased from 4.5 m/s to 8 m/s ($\Delta V = +3.5$ m/s), whereas for reducing from 60°C to 50°C ($\Delta T = -10^\circ\text{C}$), the air
25 velocity must be increased from 8 m/s to 18 m/s ($\Delta V = +10$ m/s), as can be seen from the graph.

In this way, when forced air cooling is relied on to further reduce the panel operating temperature for prolonging the lifetime, the cooling air velocity is excessively required as the target temperature is lower. Accordingly, the fan operation noise can further increase, or the apparatus can be increased in size,
5 as described above, and in some cases, the limit of cooling capabilities (air cooling limit) can be exceeded, so that the development of a highly efficient liquid crystal unit cooling system is an urgent necessity.

Further, in regard to the liquid crystal panel, another requirement exists for cooling from a viewpoint of image quality. Specifically, since the optical
10 modulation effect to an input signal highly depends on the temperature in the optical modulation of the liquid crystal panel, thermal gradient on the panel plane cause variations in luminance and color, resulting in a degraded quality of projected images. For this reason, in cooling the liquid crystal panel, a cooling method is desired to minimize a temperature gradient and temperature
15 variations which occur on the surface of the panel in operation.

Fig. 5 is a schematic side view illustrating a first related art example of liquid crystal unit cooling, as disclosed in Patent Document 1 (JP-11-295814A). Specifically, an apparatus for improving a liquid crystal panel cooling efficiency is provided with the aid of air directing plate 39 disposed below cross dichroic
20 prism 35 to optimize the direction of air fed from cooling fan 3.

Fig. 6 is a schematic perspective view illustrating a second related art example of liquid crystal unit cooling, as disclosed in Patent Document 2 (JP-2001-318361A). Specifically, an apparatus for improving a cooling efficiency is provided with protrusion 41 for guiding cooling air to liquid crystal
25 holding frame 40 to restrain interstices of air fed from duct discharge port 42.

Fig. 7 is a schematic cross-sectional view illustrating a third related art example of liquid crystal unit cooling, as disclosed in Patent Document 3 (JP-2004-61894A). Specifically, an apparatus is provided for adjusting a cooling air velocity by changing air passage widths (X and Y in the figure) between liquid crystal panel 13 and polarizing plate 14 with the provision of cutout 43 in an air passage of liquid crystal panel holding frame 40.

Figs. 8A and 8B are schematic diagrams illustrating a first example of a fourth related art example of liquid crystal unit cooling, where Fig. 8A is a top plan view, and Fig. 8B is a lateral sectional view. Figs. 9A and 9B are schematic diagrams illustrating a second example of the fourth related art example of liquid crystal unit cooling, where Fig. 9A is a top plan view, and Fig. 9B is a lateral sectional view. This fourth related art example is disclosed in Patent Document 4 (JP-2000-124649A).

In Figs. 8A and 8B, air leading plate 44 having a U-shaped groove form is connected (positioned) between liquid crystal panel 13 and polarizing plate 12, for turning the direction of cooling air blown up from below on the exit side of liquid crystal panel 13 by the U-shaped groove at the upper end by 180° to feed the air from above to below on incident polarizing plate 12, thereby eliminating thermal gradient which occur on the panel surface.

On the other hand, in Figs. 9A and 9B, an apparatus is disclosed for eliminating thermal gradient on a panel plane with the provision of a pair of cooling fans 3a, 3b above and below liquid crystal panel 13, with the liquid crystal panel interposed therebetween, to feed an air stream from below to above on the exit side and from above to below on the incident side.

Fig. 10 is a schematic lateral sectional view illustrating a fifth related art example of liquid crystal unit cooling. This fifth related art example is disclosed

in Patent Document 5 (JP-2001-209126A) which discloses an apparatus which includes a liquid crystal panel cooling unit in a closed internal circulation structure with the use of circulation duct 45, where first cooling fan 3a air-cools a liquid crystal unit, exhaust air heated by received heat is transferred to external
5 air circulation duct 46 shield by circulation duct 45 through a heat sink or the like (not shown, provided on the boundary of circulation duct 45 and air circulation duct 46 in the figure), and the heat of the heat sink is radiated by second cooling fan 3b which is provided outside.

10 DISCLOSURE OF THE INVENTION

PROBLEMS TO BE SOLVED BY THE INVENTION

As described above, when an attempt is made to increase the air velocity of the fan to improve the cooling performance in the cooling of the liquid crystal unit, this will lead to increased fan operation noise and mounting volume.
15 Further, when the liquid crystal unit is desirably cooled to about room temperature to prolong its lifetime, this can be hampered by the air cooling limit (the temperature is not reduced even if the air velocity is increased).

Patent Document 1 (first related art example) discloses a structure which includes an air directing plate below a cross dichroic prism for adjusting
20 the direction of cooling air fed to a liquid crystal panel to improve the efficiency of cooling the liquid crystal panel. However, even if an increased amount of air is fed to impinge the panel exit side by optimizing the angle at which the air is fed to the liquid crystal panel, a reduced air stream is fed to the exit-side polarizing plate positioned on the opposite surface thereof on the contrary, thereby
25 resulting in a lower efficiency of cooling the exit-side polarizing plate.

Patent Document 2 (second related art example) discloses an apparatus which includes a protrusion in a liquid crystal panel holding frame for limiting interstices of fed air stream to efficiently guiding the air stream fed through the duct to the liquid crystal panel without waste. However, since the
5 restraint of leaking air by the protrusion partially causes a reduction in air velocity due to an increased air resistance, and a rise in panel temperature due to stagnation of discharge heat (exacerbation of release of exhaust air) in a downstream region (above the liquid crystal panel), the improvement on the cooling efficiency is canceled out, thus making it difficult to provide sufficient
10 effects.

Patent Document 3 (third related art example) discloses an apparatus which includes a cutout in an air path of a liquid crystal panel holding frame to ensure an air passing area even if a spacing with a polarizing plate is narrow, thereby compensating for the cooling air velocity. However, when the spacing
15 between respective units is narrow at an inflow end, this constitutes an air resistance to reduce the amount of fed air. Also, even if a cutout is provided on the downstream side thereof to increase the air passing area, the air velocity is reduced at cooled components (liquid crystal panels, and light transmission planes of polarizing plates), so that the cooling efficiency is not increased.

20 The first example of Patent Document 4 (fourth related art example) discloses a structure which includes an air guiding plate having a U-shaped groove form connected (positioned) between a liquid crystal panel and a polarizing plate to turn around an air stream fed by a fan at a top end to cool the liquid crystal panel in opposite directions on the incident side and exit side of the
25 liquid crystal panel, thereby alleviating variations in panel temperatures. In this event, however, the air passing area is reduced to one half, and an air traveling

distance is increased twice, as compared with conventional structures, thus exacerbating the air resistance to restrain the amount of air fed by the fan. Also, since the air which has passed by and cooled the panel exit side in the former half of the U-shaped groove is heated by discharged heat, the heat radiation capabilities significantly decrease in the latter half in which the air turns around to pass by the panel incident side. Thus, this structure is not suitable for highly efficient cooling.

On the other hand, in the second example (Figs. 9A and 9B) of the fourth related art example which ventilates the panel incident side and exit side individually in opposite directions using a pair of fans, this is effective in that the heat generation distributions (cooling actions) on the panel surfaces are upside down on the incident side and exit side to balance the temperature within the panel. However, this structure follows a conventional cooling method in that a parallel air flow is directed onto a heat generating plane to radiate heat, and fails to achieve a sufficient cooling efficiency because an air resistance increases due to a reduction of each air passing area to one half while a heat radiation load per fan is reduced.

Patent Document 5 (fifth related art example) forcibly air-cools liquid crystal units by a closed circulation system to transfer heat of exhaust air to the outside through a heat sink and radiate the heat by another air-cooling fan, thereby reducing the temperature of internally circulated air for cooling the liquid crystal units. In this event, however, while effective for preventing dusts being introduced into the liquid crystal units, the transport of discharged heat involves a heat transfer process of gas (internally circulated flow) --> solid (heat sink) --> air (forced air cooling to external air) twice, and therefore the fifth related art example disadvantageously suffers from a poor heat transport efficiency due to

a large heat resistance from the internally circulated air to the external air and cannot be applied to a high luminance model which generates a large amount of heat.

It is an exemplary feature of the present invention to provide a silent
5 cooling apparatus for effectively reducing the operating temperature of an electronic device which includes a plurality of components which include surfaces opposite to each other with a spacing therebetween and have a heat generating spot on at least any of the surfaces opposite to each other, in a small and low-cost configuration.

10 MEANS FOR SOLVING THE PROBLEM

An apparatus for cooling a heat generating spot of an electronic device of the present invention is a cooling apparatus for forcedly air-cooling a heat generating spot of an electronic device which includes a plurality of components which are disposed side-by-side to have the same in-plane direction, and which
15 include heat generating spots within their surfaces. The cooling apparatus further includes first air cooling means for feeding an air stream to the heat generating spot in an orientation of the in-plane direction, and second air cooling means for feeding an air stream to the heat generating spot in the in-plane direction in a different orientation from the air stream by the first air cooling
20 means.

EFFECTS OF THE INVENTION

In the apparatus for cooling a heat generating spot of an electronic device in the present invention, for example, when applied to a cooling mechanism for a liquid crystal image display, a pair of air cooling means
25 disposed in opposition in the vertical direction across a liquid crystal unit interposed therebetween, are used to cause air streams to collide in an

opposing state in a space between a liquid crystal panel and a polarizing plate, thereby generating an impinging jet flow perpendicular to each heat generating plane of the liquid crystal panel and polarizing plate. In this way, the heat transfer coefficient can be significantly improved to promote the heat transfer, as compared with the cooling of a liquid crystal unit according to the background related art which relies on a uniform flow along a parallel plane, thus advantageously providing small-size, low-cost, and low-noise highly efficient cooling.

BRIEF DESCRIPTION OF THE DRAWINGS

10 The foregoing and other exemplary purposes, aspects and advantages will be better understood from the following detailed description of an exemplary embodiment of the invention with reference to the drawings.

Fig. 1(a) and Fig. 1(b) are schematic diagrams of the configuration of a liquid crystal projector apparatus of a background related art, where Fig. 1(a) illustrates the appearance of a general liquid crystal projector apparatus, and Fig. 1(b) illustrates the internal structure of the liquid crystal projector apparatus. Fig. 2 illustrates a schematic diagram illustrating the internal configuration of a liquid crystal projector apparatus.

Fig. 3A illustrates a schematic exploded perspective view illustrating the configuration of a cooling unit for a liquid crystal unit of a liquid crystal projector apparatus.

Fig. 3B illustrates a schematic cross-sectional view for describing a forced air cooling operation of the cooling unit for the liquid crystal unit of the liquid crystal projector apparatus.

Fig. 4 illustrates a graph showing the relationship between a panel cooling air velocity and a panel operating temperature in 0.8"-SXGA (5000-lm class: 25□ environment).

Fig. 5 illustrates a schematic side view illustrating a first related art example of cooling a liquid crystal unit.

Fig. 6 illustrates a schematic perspective view illustrating a second related art example of cooling a liquid crystal unit.

Fig. 7 illustrates a schematic side view illustrating a third related art example of cooling a liquid crystal unit.

Fig. 8A illustrates a schematic top plan view illustrating a first example of a fourth related art example of cooling a liquid crystal unit.

Fig. 8A illustrates a schematic lateral sectional view illustrating the first example of the fourth related art example of cooling a liquid crystal unit.

Fig. 9A illustrates a schematic top plan view illustrating a second example of the fourth related art example of cooling a liquid crystal unit.

Fig. 9B illustrates a schematic lateral sectional view illustrating the second example of the fourth related art example of cooling a liquid crystal unit.

Fig. 10 illustrates a schematic lateral sectional view illustrating a fifth related art example of cooling a liquid crystal unit.

Fig. 11 illustrates a schematic exploded perspective view of an apparatus for cooling a heat generating spot of a liquid crystal image display according to a first exemplary embodiment of the present invention.

Fig. 12 illustrates a schematic cross-sectional view for describing the configuration and operation of the apparatus for cooling a heat generating spot in a liquid crystal image display according to the first exemplary embodiment of the present invention.

Fig. 13 illustrates a schematic partial cross-sectional view and a partially enlarged cross-sectional view showing the flow of an air stream for cooling a liquid crystal unit in Fig. 12.

Fig. 14 illustrates a schematic cross-sectional view for describing the
5 configuration and operation of apparatus for cooling a heat generating spot in a liquid crystal image display according to a second exemplary embodiment of the present invention.

Fig. 15 illustrates a schematic partial cross-sectional view and a partially enlarged cross-sectional view showing the flow of an air stream for cooling a
10 liquid crystal unit in Fig. 14.

Fig. 16A illustrates a schematic cross-sectional view of a cooling structure in the first exemplary embodiment, as viewed from a light transmission plane side.

Fig. 16B illustrates a schematic cross-sectional view of the cooling structure in the first exemplary embodiment, as viewed from a transverse plane side.

15 Fig. 16C illustrates a schematic cross-sectional view of a cooling structure in a third exemplary embodiment, as viewed from a light transmission plane side.

Fig. 16D illustrates a schematic cross-sectional view of a cooling structure in a fourth exemplary embodiment, as viewed from a light transmission plane side.

Fig. 16E illustrates a schematic cross-sectional view of a cooling structure in a
20 fifth exemplary embodiment, as viewed from a light transmission plane side.

Fig. 16F illustrates a schematic cross-sectional view of a cooling structure in a sixth exemplary embodiment, as viewed from a light transmission plane side.

Fig. 17A illustrates a schematic explanatory diagrams of a seventh exemplary embodiment according to the present invention, including a perspective view
25 which describes a duct configuration of a cooling apparatus, and a cross-sectional view which describes operations.

Fig. 17B illustrates a schematic explanatory diagram of the seventh exemplary embodiment according to the present invention, and a top plan view which describes the operation of the cooling apparatus.

Fig. 18 illustrates a schematic explanatory diagrams showing a control method in a cooling apparatus of the present invention, where (i) illustrates a front view of a liquid crystal unit as viewed from a light transmission plane side, and (ii) illustrates a cross-sectional view of the same, and (a), (b), (c) show changes in the amount of air streams of a fan in time series.

Fig. 19 illustrates a schematic diagram for describing impinging jet cooling.

Fig. 20A illustrates a schematic diagram for describing a liquid crystal panel and a light transmission plane of a polarizing plate in a liquid crystal image display, and a front view which depicts a liquid crystal panel and a polarizing plate side by side.

Fig. 20B illustrates a schematic diagram for describing a liquid crystal panel and a light transmission plane of a polarizing plate in a liquid crystal image display, and a side view which displays a liquid crystal panel and a polarizing plate side by side.

BEST MODE FOR CARRYING OUT THE INVENTION

Next, an apparatus for cooling a heat generating spot of an electronic device according to an exemplary embodiment of the present invention will be described in terms of the configuration and operation with reference to the drawings. In this exemplary embodiment, for facilitating the understanding, the electronic device will be described as represented by a liquid crystal image display of a liquid crystal projector apparatus, and components such as an incident-side polarizing plate, a liquid crystal panel, and an exit-side polarizing plate which form a liquid crystal unit. However, the present invention is not

limited to this exemplary embodiment, but may also be applied to a cooling apparatus or the like for an electronic device which includes a plurality of components, each of which includes surfaces opposite to each other with a spacing defined therebetween, where at least any of the surfaces opposite to each other is a heat generating spot, for example, heat generating spots
5 disposed across a narrow gap, such as a rack unit which has a plurality of printed circuit boards mounted therein in parallel, IC chips mounted on a board of a small-size electronic device in a narrow space facing an inner wall of a housing, and the like.

10 Since the liquid crystal projector apparatus has been previously described in the section of Background Art, the description is omitted here.

Fig. 11 is a schematic exploded perspective view of an apparatus for cooling a heat generating spot of a liquid crystal image display according to a first exemplary embodiment of the present invention, Fig. 12 is a schematic
15 cross-sectional view for describing the configuration and operation of the heat generating spot cooling apparatus in the liquid crystal image display according to the first exemplary embodiment of the present invention, and Fig. 13 includes a schematic partial cross-sectional view and a partially enlarged cross-sectional view showing the flow of air for cooling a liquid crystal unit in Fig. 12.

20 Cooling apparatus 26a for a liquid crystal image display (electronic device) of a liquid crystal projector apparatus according to the present invention is formed of first air cooling unit 29a including first cooling fan 27a and first air cooling duct 28a, and like second air cooling unit 33a including second cooling fan 31a and second air cooling duct 32a, disposed at an upper and a lower end
25 of liquid crystal unit 2 which is provided for each of R/G/B color light and

includes incident-side polarizing plate 12, liquid crystal panel 13, and exit-side polarizing plate 14 which are assembled into a unit.

Referring next to Fig. 12, operations for cooling liquid crystal unit 2 by cooling apparatus 26a in this exemplary embodiment, will be described.

5 In this exemplary embodiment, as illustrated in Fig. 12, first air cooling unit 29a is provided at the lower end of liquid crystal unit 2, and first air stream 30a generated from first cooling fan 27a passes through spaces between incident-side polarizing plate 12 and liquid crystal panel 13 of each color light and between liquid crystal panel 13 and exit-side polarizing plate 14 from below to above through first air cooling duct 28a.

10 Additionally, second air cooling unit 33a is provided at the upper end of liquid crystal unit 2, and second air stream 34a generated from second cooling fan 31a passes through spaces between incident-side polarizing plate 12 and liquid crystal panel 13 of each color light and between liquid crystal panel 13 and exit-side polarizing plate 13 from above to below through second air cooling duct 32a in the same manner.

Referring next to Fig. 13, a description will be given of a cooling action by cooling apparatus 26a in this exemplary embodiment. Fig. 13 is a schematic cross-sectional view of liquid crystal unit 2 for one color light alone, extracted from among liquid crystal units 2 in Fig. 12.

20 As described above, first air stream 30a is sent from the lower end of liquid crystal unit 2 into the space between incident-side polarizing plate 12 and liquid crystal panel 13 and the space between liquid crystal panel 13 and exit-side polarizing plate 14 from below to above. Second air stream 34a is sent from the upper end of liquid crystal unit 2 into the space between incident-side polarizing plate 12 and liquid crystal panel 13 and the space between liquid

crystal panel 13 and exit-side polarizing pate 14 from above to below in the same manner. First and second air streams 30a and 34a collide at a central position (impinging plane a in the drawing) in an opposing state in a space between the respective units when first cooling fan 27a and second cooling fan
5 31a have an equivalent amount of fed air, and when first air cooling duct 28a and second air cooling duct 32a have an equal air resistance.

In this event, first air stream 30a and second air stream 34a which collide in an opposing state from directions opposite to each other, generate
evolutional flows which perpendicularly go to polarizing plates 12, 14 on the
10 incident/exit sides and the light transmission plane of liquid crystal panel 13 at positions at which they collide, as illustrated in a detailed view of Fig. 13. Thus, a perpendicular jet stream is formed toward a heat generating plane (light transmission plane) while allowing the transmission of the color light.

In this way, the heat transfer coefficient can be largely increased as
15 compared with a cooling method of the background related art which relies on a parallel flat flow, thus making it possible to cool the liquid crystal units at a high heat radiation efficiency.

Next, a second exemplary embodiment in an apparatus for cooling an electronic device according to the present invention will be described in detail
20 with reference to the drawings. Fig. 14 is a schematic cross-sectional view for describing the configuration and operation of the apparatus for cooling a heat generating spot in a liquid crystal image display according to the second exemplary embodiment of the present invention, and Fig. 15 includes a schematic partial cross-sectional view and a partially enlarged cross-sectional
25 view showing the flow of air for cooling a liquid crystal unit in Fig. 14.

In cooling apparatus 26b in the second exemplary embodiment, and in cooling apparatus 26a in the first exemplary embodiment, second air cooling unit 33b disposed at the upper end of liquid crystal unit 2 includes axial fan 36 alone.

5 Also, in this event, first air flow (stream) 30b sent by first air cooling unit 29b including first cooling fan 27b and first air cooling duct 28b, and second air stream 34b sent from second air cooling unit 33b including axial fan 36 are fed into the space between incident-side polarizing plate 12 and liquid crystal panel 13, which form part of liquid crystal unit 2, and the space between liquid crystal
10 panel 13 and exit-side polarizing plate 14. Hence, the first air flow 30b and the second air stream 34b collide at substantially the central position between the respective elements (collision plane b in Fig. 15) in an opposing state. Thus, a perpendicular jet stream is generated which goes toward incident/exit-side polarizing plates 12, 14 and the light transmission plane of liquid crystal panel
15 13, which are heat generating planes, in a manner similar to the first exemplary embodiment described above.

In this exemplary embodiment, the second air cooling unit includes the axial fan alone, thereby reducing the size and simplifying the mounting.

Next, third to sixth exemplary embodiments in the apparatus for
20 cooling an electronic device according to the present invention will be described with reference to the drawings.

Figs. 16A to 16F are schematic cross-sectional views of cooling structures in the first and third to sixth exemplary embodiments, where Fig. 16A is a schematic cross-sectional view of the first exemplary embodiment as viewed from a light transmission plane side; Fig. 16B is a schematic
25 cross-sectional view of the first exemplary embodiment as viewed from a

transverse plane side; Fig. 16C is a schematic cross-sectional view of a third exemplary embodiment as viewed from the light transmission plane side; Fig. 16D is a schematic cross-sectional view of a fourth exemplary embodiment as viewed from the light transmission plane side; Fig. 16E is a schematic cross-sectional view of a fifth exemplary embodiment as viewed from the light transmission plane side; and Fig. 16F is a schematic cross-sectional view of a sixth exemplary embodiment as viewed from the light transmission plane side. Fig. 16A and 16B are provided for describing a comparison of the first exemplary embodiment with the third to sixth exemplary embodiments.

In the first exemplary embodiment, air streams are fed by independent air cooling units 29a, 33a from the upward and downward directions of liquid crystal unit 2 in opposing directions to cause cooling air streams to collide with each other at the central position on the light transmission plane (collision plane a) of liquid crystal unit 2, thereby generating a perpendicular flow (collision jet stream) toward each heat generating plane.

On the other hand, in the cooling structure in the third exemplary embodiment illustrated in Fig. 16C, first discharge port 37c of first air cooling unit 29c disposed at the lower end of liquid crystal unit 2, and second discharge port 38c of second air cooling unit 33c disposed at the upper end of liquid crystal unit 2 in the same manner are offset to left and right, respectively, from the central axial line of the panel indicated by ax in the figure.

In this way, first air stream 30c by first air cooling unit 29c and like second air stream 34c by second air cooling unit 33c oppositely collide at a position corresponding to a shift of an air velocity distribution, to form evolutonal flows which go perpendicularly to the heat generating planes at positions substantially along a diagonal (collision plane c in the figure) on the light

transmission plane. Consequently, it is possible to accomplish wide and highly efficient cooling of the liquid crystal unit.

In this event, since the air streams flow in an oblique direction after the collision, heated exhaust air can be readily discharged outside of the housing
5 such that the exhaust air will not circulate again into the cooling air.

The cooling structure in the fourth exemplary embodiment illustrated in Fig. 16D includes first discharge port 37d of first air cooling unit 29d and like second discharge port 38d of second air cooling unit 33d being disposed so as to oppose substantially on a diagonal of the light transmission plane.

10 In this way, like the third exemplary embodiment described above, first air stream 30d by first air cooling unit 29d and like second air stream 34d by second air cooling unit 33d are fed into the space between the incident-side polarizing plate and liquid crystal panel, and the space between the liquid crystal panel and exit-side polarizing plate, and collide in opposition to each other at a
15 diagonal position (collision plane d in the figure) on the light transmission plane. Thus, evolutionary flows are formed which go perpendicularly to the heat generating planes on the diagonal of the light transmission planes to produce similar effects to those of the third exemplary embodiment.

The cooling structure in the fifth exemplary embodiment illustrated in
20 Fig. 16E includes in that both first cooling unit 29e and second cooling unit 33e being disposed on both sides of the lower end of the liquid crystal unit. First discharge port 37e of first air cooling unit 29e and like second discharge port 38e of second air cooling unit 33e are set such that air feeding directions intersect on the center line (ax in the figure) of the panel in the vertical direction.

25 In this event, like other exemplary embodiments, the liquid crystal unit can be highly efficiently cooled, and simultaneously, the first and second air

streams can be discharged in the same direction toward above the liquid crystal unit, thus facilitating the heat exhaustion processing.

The cooling structure in the sixth exemplary embodiment illustrated in Fig. 16F includes first discharge port 37f of first air cooling unit 29f and like
5 second discharge port 38f of second air cooling unit 33f being disposed so as to oppose each other on the left and right sides of liquid crystal unit 2.

In this event, mounting spaces must be provided on the left and right sides of the liquid crystal units. However, since evolutionary flows toward the heat generating planes are formed on the center axis (ax in the figure) of the panel,
10 this is effective for a liquid crystal panel which exhibits a large temperature gradient in the vertical direction.

Next, a seventh exemplary embodiment in the cooling apparatus of the present invention will be described with reference to the drawings.

Figs. 17A and 17B are schematic explanatory diagrams of the seventh
15 exemplary embodiment according to the present invention, where Fig. 17A includes a perspective view which describes a duct configuration of the cooling apparatus, and a cross-sectional view which describes the operation, while Fig. 17B is a top plan view which describes the operation in the same manner.

In the seventh exemplary embodiment illustrated in Figs. 17A and 17B,
20 the second cooling fan which forms part of the second air cooling unit is omitted. However, first cooling fan 27g is shared, and second air cooling duct 32g is branched halfway from first air cooling duct 28g, and extended toward the center of liquid crystal unit 2 at a lateral position of liquid crystal unit 2 to discharge second air stream 34g toward the center of the light transmission
25 plane substantially horizontally from a lateral direction of liquid crystal unit 2, in

the cooling apparatus of the first to sixth exemplary embodiments described above.

In this way, first air stream 30g fed by first duct 28g from below to above liquid crystal unit 2, and second air stream 34g fed from one side of liquid crystal unit 2 have two different vectors (orthogonal vectors in this exemplary embodiment) and collide in a space in the unit near the central position on the light transmission plane between incident-side polarizing plate 12 and liquid crystal panel 13 or between liquid crystal panel 13 and exit-side polarizing plate 14. Thus, a high cooling effect can be accomplished in a manner similar to the first to sixth exemplary embodiments described above.

Also, in this event, since first cooling fan 27g is shared by first air cooling duct 28g and second cooling duct 32g, the number of mounted fans can be reduced to lead to a reduction in cost and noise. In addition, since second duct 32g is formed by branching part of first duct 30g, not only the cooling fan but also the cooling apparatus can be reduced in mounting volume, thus facilitating applications to small projector apparatuses.

Further, since either the second cooling fan or the second duct need not be provided as an independent member, an assembling process can be simplified. This additionally allows maintaining the same productivity as the projector apparatus in the configuration of the background related art which employs a single cooling fan, while providing high cooling capabilities.

Next, with reference to the drawings, described is a method of improving the quality of projected image using the cooling apparatus of the present invention by expanding a cooling action area to increase a heat radiation effect and simultaneously mitigating thermal gradient on the surface of the liquid crystal panel.

Fig. 18 includes schematic explanatory diagrams showing a control method in the cooling apparatus of the present invention, where (i) is a front view of a liquid crystal unit as viewed from the light transmission plane side, and (ii) illustrates a cross-sectional view of the same, and (a), (b), (c) indicate
5 changes in time-series fan air amount. The order (a) --> (b) --> (c) --> (b) - > (a) represents fan air amount control in time-series and a ventilation state at the respective instances.

In the explanatory diagrams, the cooling apparatus of the first exemplary embodiment described above is given as an example, but it can be
10 applied to cooling apparatuses of other exemplary embodiments.

First air cooling unit 29a and second air cooling unit 33a provided at the lower end and upper end of liquid crystal unit 2, respectively, include a first cooling fan (not shown) and first air cooling duct 28a, and a second cooling fan (not shown) and second air cooling duct 32a, respectively. From respective duct
15 discharge ports, first air stream 30a and second air stream 34a are fed in opposite directions into spaces between incident-side polarizing plate 12 and liquid crystal panel 13 and between liquid crystal panel 13 and exit-side polarizing plate 14. Streams 30a, 30b collide at midway positions therein to form evolutional flows in a direction perpendicular to the light transmission planes.

20 Thus, the heat generating planes are cooled with perpendicular jet streams.

This cooling method controls the ratio of the amount of air fed by the first cooling fan to the amount of air fed by the second cooling fan to vary the location of the collision over time, and move the perpendicular flows to the light transmission planes in the vertical direction, thereby expanding an area to which
25 the highly efficient cooling acts, and simultaneously mitigating the difference in temperature on the panel surface.

Specifically, the independent cooling fans (first cooling fan and second cooling fan) are controlled to adjust the ratio of the respective amounts of air fed by the fans such that a first air amount is larger than a second air amount at a certain time (Fig. 18(a)); such that the first air amount is equal to the second air amount at the next time (Fig. 18(b)); and such that the first air amount is smaller than the second air amount at the next time (Fig. 18(c)). The air amount control may electrically vary the rotational speeds of the fans, or may be conducted by adjusting the openings of dampers provided in the ducts.

The control is periodically repeated such as (a) --> (b) --> (c) --> (b) --> (a), thereby vertically moving the evolutonal flows (collision jet streams) formed on the input/output polarizing plates and the light transmission plane of the liquid crystal panel to vary the position at which the maximum cooling effect is provided (i.e., the position at which the air streams collide) to expand a region in which the cooling action is high, and mitigate local variations in heat transfer coefficient within the light transmission plane over time, so that the temperature gradient is restrained within the panel surface to improve the quality of projected images.

While the foregoing description has given the first exemplary embodiment as an example, it is obvious that similar effects are also provided by conducting such air amount control in other exemplary embodiments.

In an eighth exemplary embodiment of an apparatus for cooling a heat generating spot of an electronic device of the present invention, a first air stream from first air cooling means and a second air stream from a second air cooling means have different air velocity vectors from each other. The first air cooling means and second air cooling means may be set such that the first air stream and second air stream collide with each other at the positions of heat generating

spots on opposing surfaces of a plurality of components. The first air cooling means may be disposed at the lower end of the opposing planes of the plurality of components, while the second air cooling means may be disposed at the upper end of the opposing planes of the plurality of components. The first air cooling means may include a first cooling fan and a first air cooling duct, while the second air cooling means may include a second air cooling fan and a second air cooling duct. One of the first air cooling means and second air cooling means may include a cooling fan and an air cooling duct, while the other may include a cooling fan alone. The first air cooling means may include a first cooling fan and a first air cooling duct, while the second air cooling means may include the first cooling fan shared by the first air cooling means, and a second air cooling duct branched halfway from the first air cooling duct for feeding air into the plane from a direction different from an air feeding direction of the first air cooling duct. Also, the first cooling fan and second cooling fan may provide variable amounts of air.

The effect of the present invention can also be produced in the cooling of heat generating spots in a plurality of components of an electronic device which have surfaces opposite to each other, at least any of which includes the heat generating spot.

Also, since the position at which fan air streams collide can be arbitrarily set by arbitrarily controlling the ratio of air amounts from a pair of air cooling means, the position at which the collision jet streams are produced can be periodically varied on the basis of the center of the panel to mitigate thermal gradient on the panel surface, thus advantageously improving the image quality.

In a ninth exemplary embodiment of the apparatus for cooling a heat generating spot of an electronic device according to the present invention, the

electronic device may be a liquid crystal image display, and components may include an incident-side polarizing plate, a liquid crystal panel, and an exit-side polarizing plate which form part of the liquid crystal unit.

In a tenth exemplary embodiment of the present invention, a method of
5 cooling a heat generating spot of an electronic device may be a heat generating spot cooling method for the aforementioned apparatus for cooling a heat generating spot of an electronic device. The tenth embodiment may include feeding a first air stream by first air cooling means for components of the electronic device in a first direction in gaps between opposing surfaces of the
10 components. Additionally, a second air stream is fed by second air cooling means in a second direction different from the first direction in gaps between the opposing surfaces of the components to cause the first air stream and second air stream to collide with each other near the central positions of heat generating spots on the opposing surfaces of the component. Thus, evolutional flows are
15 generated which go perpendicularly to one or both of the opposing surfaces of the components.

In a method of cooling a heat generating spot of an electronic device according to an eleventh exemplary embodiment of the present invention, first air cooling means is disposed at a lower end of components of an electronic
20 device, and second air cooling means is disposed at an upper end of the components of the electronic device. A first air stream by the first air cooling means may be fed from below to above in spaces between a plurality of components, while a second air stream by the second air cooling means may be fed cooling below in the spaces between the plurality of components, to cause
25 the first air stream and second air stream to collide with each other near the central positions of heat generating spots on opposing surfaces of the

components. Thus, evolutional flows are generated which go perpendicularly to one or both of the opposing surfaces of the components. By varying, over time, the ratio of air amounts of the first cooling fan which forms part of the first air cooling means to a second cooling fan which forms part of the second air cooling means, the position at which the first air stream and second air stream collide may be periodically moved from the central positions of the heat generating spots on the opposing surfaces of the components. The electronic device may be a liquid crystal image display, and the components may include an incident-side polarizing plate, a liquid crystal panel, and an exit-side polarizing plate which include a liquid crystal unit.

In a twelfth exemplary embodiment of the present invention, a liquid crystal projector apparatus includes any of the aforementioned apparatus for cooling a heat generating spot of an electronic device.

In the apparatus for cooling a heat generating spot of an electronic device according to the present invention, when the electronic device is, for example, a liquid crystal image display of a liquid crystal projector apparatus, a pair of independent air cooling means, each, including a cooling fan and an air cooling duct, are provided above and below a liquid crystal unit. Thus, air streams are fed across the liquid crystal unit therebetween from above and below in opposite directions to pass the air streams through spaces between the incident-side polarizing plate and liquid crystal panel or between the liquid crystal panel and exit-side polarizing plate. The two air streams to collide near the center of a light transmission plane near the central position of a heat generating spot to improve the cooling efficiency.

For cooling a heat generating flat plate such as a polarizing plate and a liquid crystal panel by forced air cooling, collision jets cooling may be given as

one of the methods which provides the highest cooling efficiency. Fig. 19 is a schematic diagram for describing the collision jet cooling. As illustrated in Fig. 19, the collision jet cooling is a method which involves jetting coolant (air, liquid) 20 perpendicularly to heat generating flat plate 18 through nozzle 19 to cause an impinging jet flow to collide with heat generating plate 18, thereby radiating heat from a heat generating plane.

Generally, in the forced air cooling for a heat generating flat plate, two approaches, i.e., a thinning method and a replacement method are contemplated for improving the heat transfer coefficient to promote the heat transfer.

The former is a method which promotes the heat transfer by reducing the thickness (thinning) of a thermal boundary layer formed on the surface of a heat generating body, in which case since the thickness of the thermal boundary layer is reciprocally proportional to the square root of a the velocity in a main stream direction (flow rate along the flat plate), the aforementioned manner of increasing the air velocity to reduce the temperature of the heat generating body is comparable to this.

The latter intends to promote the heat transfer by encouraging the exchange of a fluid near the surface of a solid with a fluid slightly spaced apart therefrom, and is achieved by controlling a turbulent flow which is associated with generation/disappearance of a unsteady vortex.

The collision jet cooling for cooling a heat generating flat plate by causing a jet stream to collide with the heat generating flat plate from a direction perpendicular thereto falls under the latter. The collision jet cooling demonstrates cooling capabilities higher by a factor of five to ten than a

conventional method of feeding air along a heat generating flat plate through a process of:

1) breakage (peeling) of the thermal boundary layer on the surface of the heat generating body due to the collision jet stream;

5 2) exchange of fluids (temperature replacement) due to the evolutionary flow produced on the collision plane; and

3) sliding of the jet stream on the wall due to the Coanda effect (the nature of a fluid by which an object placed in a flow causes a reduction in pressure between a fluid and a wall surface of a solid to attract the flow to the wall surface, thereby changing the direction of the flow along the object).

Incidentally, when such collision jet cooling is applied, for example, to cooling of a liquid crystal image display in a liquid crystal projector apparatus, a nozzle position thereof is a problem to be solved. Specifically, since a liquid crystal panel and a polarizing plate generate heat due to a light absorption effect when each color light passes, the heat generating plane substantially matches with the light transmission plane (panel light transmission plane 22, polarizing plate light transmission plane 25), as illustrated in Figs. 20A and 20B.

Accordingly, it is necessary to generate a perpendicular air flow to the heat generating plane so as not to impede the transmission of each color. Figs. 20A and 20B are schematic diagrams for describing the light transmission planes of the liquid crystal panel and polarizing plate in a liquid crystal image display, where Fig. 20A is a front view which depicts a liquid crystal panel and a polarizing plate placed side by side, and Fig. 20B is a side view.

Thus, in the cooling mechanism for a liquid crystal image display in the present invention, cooling air streams are fed from above and below the liquid crystal unit in directions opposite to each other to cause the cooling air streams

to collide with each other near the center of the light transmission plane in a space between the liquid crystal panel and polarizing plate. Thus, evolution flows are generated which go perpendicularly to heat generating planes of both the liquid crystal panel and polarizing plate to form vertical jet streams, thereby
5 dramatically increasing the heat transfer coefficient to promote the heat transfer and accomplish highly efficient cooling of the liquid crystal unit.

Further, by changing the ratio of air amounts by the fans provided above and below the liquid crystal unit over time, the position at which the air streams collide (position at which the vertical jet streams are generated) can be
10 vertically vibrated from the center of the liquid crystal panel with respect to the liquid crystal panel and polarizing plate. In this way, since a region at which the maximum cooling effect is demonstrated (position of collision) can be periodically varied within the panel surface, it is possible to eliminate thermal gradient on the surface of the liquid crystal panel to improve the quality of
15 projected images.

While the invention has been particularly shown and described with reference to exemplary embodiments thereof, the invention is not limited to these exemplary embodiments. It will be understood by those of ordinary skill in the art that various changes in form and details may be made therein without
20 departing from the spirit and scope of the present invention as defined by the claims.

Further, it is noted that Applicant's intent is to encompass equivalents of all claim elements, even if amended later during prosecution.

This application is based upon and claims the benefit of priority from
25 Japanese patent application No. 2006-287395, filed on October 23, 2006, the disclosure of which is incorporated herein in its entirety by reference.

CLAIMS

1. A cooling apparatus for air-cooling a heat generating spot of an electronic device which comprises a plurality of components which are disposed side by side to have the same in-plane direction, said components including heat generating spots within surfaces thereof, characterized by comprising:

5 first air cooling means for feeding an air stream to said heat generating spot in an orientation of the in-plane direction; and

second air cooling means for feeding an air stream to said heat generating spot in said in-plane direction in a different orientation from the air stream by said first air cooling means.

2. The apparatus for cooling a heat generating spot of an electronic device according to claim 1, wherein:

a first air stream by said first air cooling means and a second air stream by said second air cooling means have air velocity vectors different from
5 each other; and

said first air cooling means and said second air cooling means are set such that said first air stream and said second air stream collide with each other at positions of said heat generating spots on opposing surfaces of a plurality of said components.

3. The apparatus for cooling a heat generating spot of an electronic device according to claim 1 or 2, wherein:

said first air cooling means is disposed at a lower end of a plane opposing a plurality of said components; and

5 said second air cooling means is disposed at an upper end of the plane opposing the plurality of said components.

4. The apparatus for cooling a heat generating spot of an electronic device according to any of claims 1 to 3, wherein:

said first air cooling means comprises a first cooling fan and a first air cooling duct; and

5 said second air cooling means comprises a second cooling fan and a second air cooling duct.

5. The apparatus for cooling a heat generating spot of an electronic device according to any of claims 1 to 3, wherein:

one of said first air cooling means and said second air cooling means comprises a cooling fan and an air cooling duct, and the other one of said first
5 air cooling means and said second air cooling means comprises a cooling fan alone.

6. The apparatus for cooling a heat generating spot of an electronic device according to claim 1 or 2, wherein:

said first air cooling means comprises a first cooling fan, and a first air cooling duct; and

5 said second air cooling means comprises said first cooling fan shared by said first air cooling means, and a second air cooling duct branched halfway from said first air cooling duct for feeding air into a plane from a direction different from an air feeding direction of said first air cooling duct.

7. The apparatus for cooling a heat generating spot of an electronic device according to claim 4 or 5, wherein:

said first cooling fan and said second cooling fan feed variable amounts of air.

8. The apparatus for cooling a heat generating spot of an electronic device according to any of claims 1 to 7, wherein:

said electronic device comprises a liquid crystal image display, and
said components include an incident-side polarizer, a liquid crystal panel, and
5 an exit-side polarizing plate which comprise a liquid crystal unit.

9. A heat generating spot cooling method for the apparatus for cooling a
heat generating spot of an electronic device according to claim 1, said method
characterized by comprising:

feeding a first air stream by said first air cooling means for said
5 components of said electronic device in a first direction in gaps between
opposing surfaces of said components;

feeding a second air stream by said second air cooling means in a
second direction different from the first direction in the gaps between the
opposing surfaces of said components; and

10 causing said first air stream and said second air stream to collide with
each other near central positions of heat generating spots on opposing surfaces
of said components, thereby generating evolutionary flows which go
perpendicularly to one or both of the opposing surfaces of said components.

10. The method of cooling a heat generating spot of an electronic device
according to claim 9, wherein:

said first air cooling means is disposed at a lower end of said
components of said electronic device, and said second air cooling means is
5 disposed at an upper end of said components of said electronic device;

a first air stream by said first air cooling means is fed from below to
above in a space between a plurality of said components;

a second air stream by said second air cooling means is fed from
above to below in the space between the plurality of said components; and

10 said first air stream and said second air stream are caused to collide with each other near central positions of heat generating spots on opposing surfaces of said components, thereby generating evolutionary flows which go perpendicularly to one or both of the opposing surfaces of said components.

11. The method of cooling a heat generating spot of an electronic device according to 9 or 10, wherein:

 the position at which said first air flow collides with said second air flow is periodically moved from the central positions of the heat generating spots on
5 the opposing surfaces of said components by varying, over time, the ratio of the amount of air fed by said first cooling fan which forms part of said first air cooling means to the amount of air fed by said second cooling fan which forms part of said second air cooling means.

12. The method of cooling a heat generating spot of an electronic device according to any of claims 9 to 11, wherein:

 said electronic device comprises a liquid crystal image display, and said components include an incident-side polarizer, a liquid crystal panel, and
5 an exit-side polarizing plate which comprise a liquid crystal unit.

13. A liquid crystal projector apparatus characterized by comprising the apparatus for cooling a heat generating spot of an electronic device according to claim 8.

Fig. 1

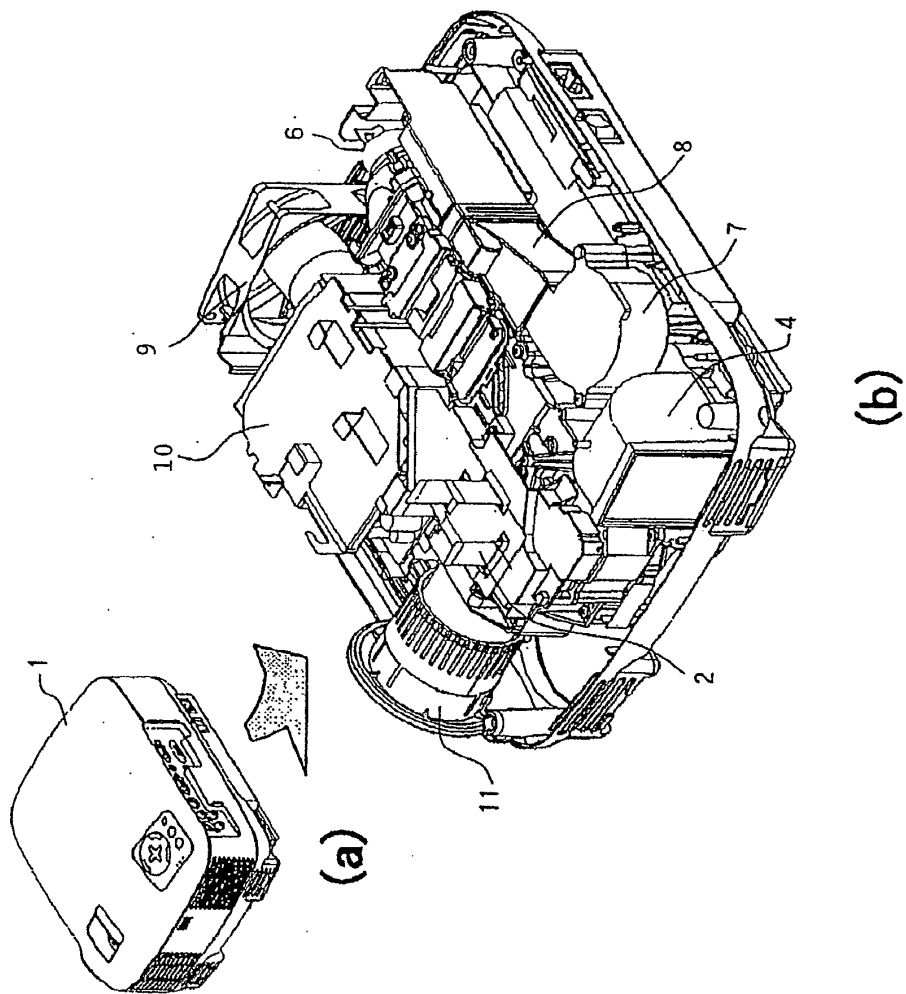


Fig. 2

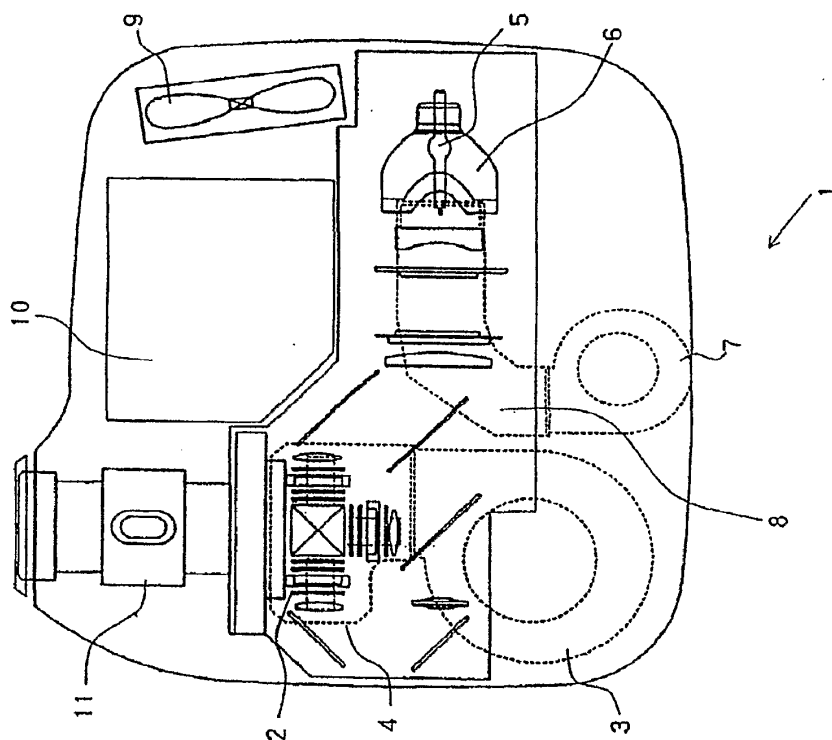


Fig 3A

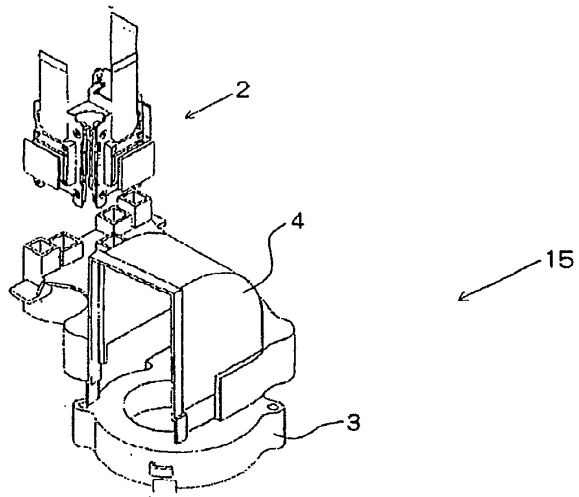


Fig. 3B

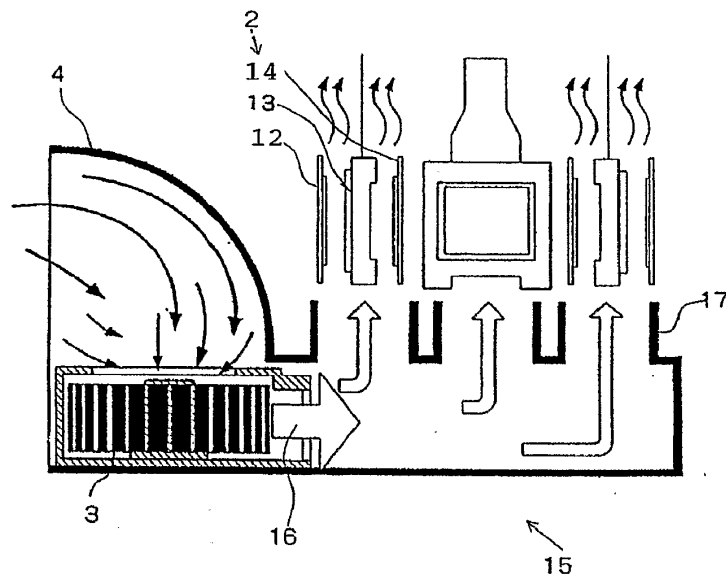


Fig. 4

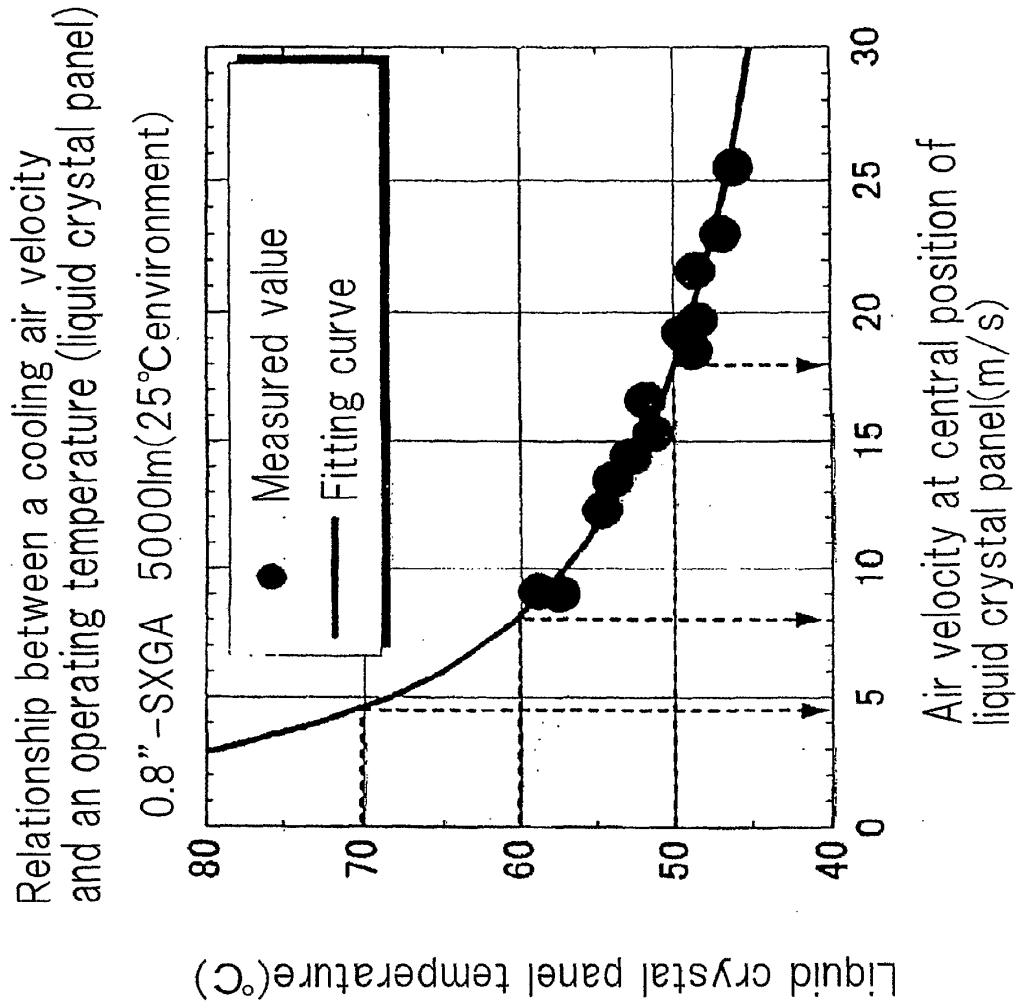


Fig. 5

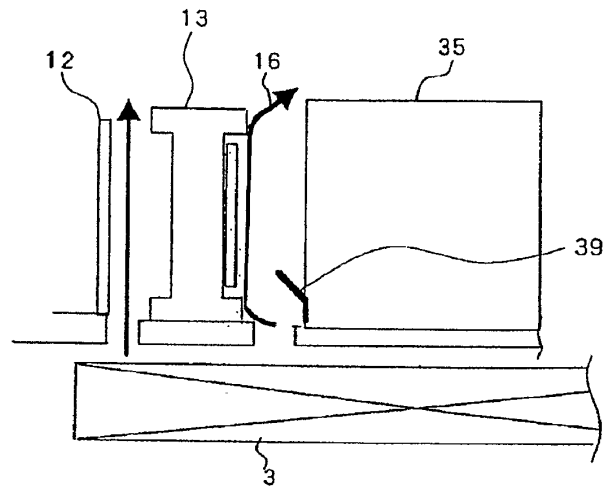


Fig. 6

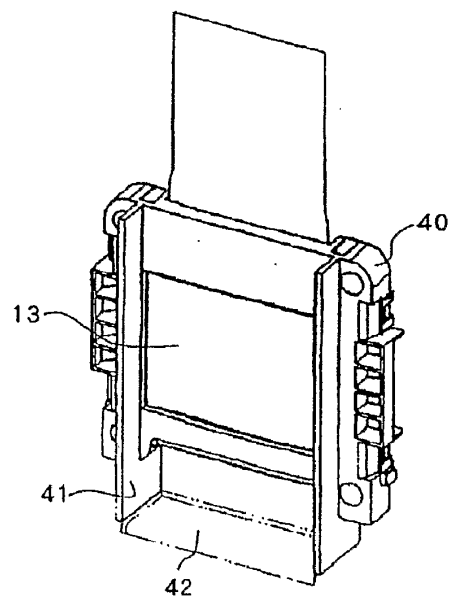


Fig. 7

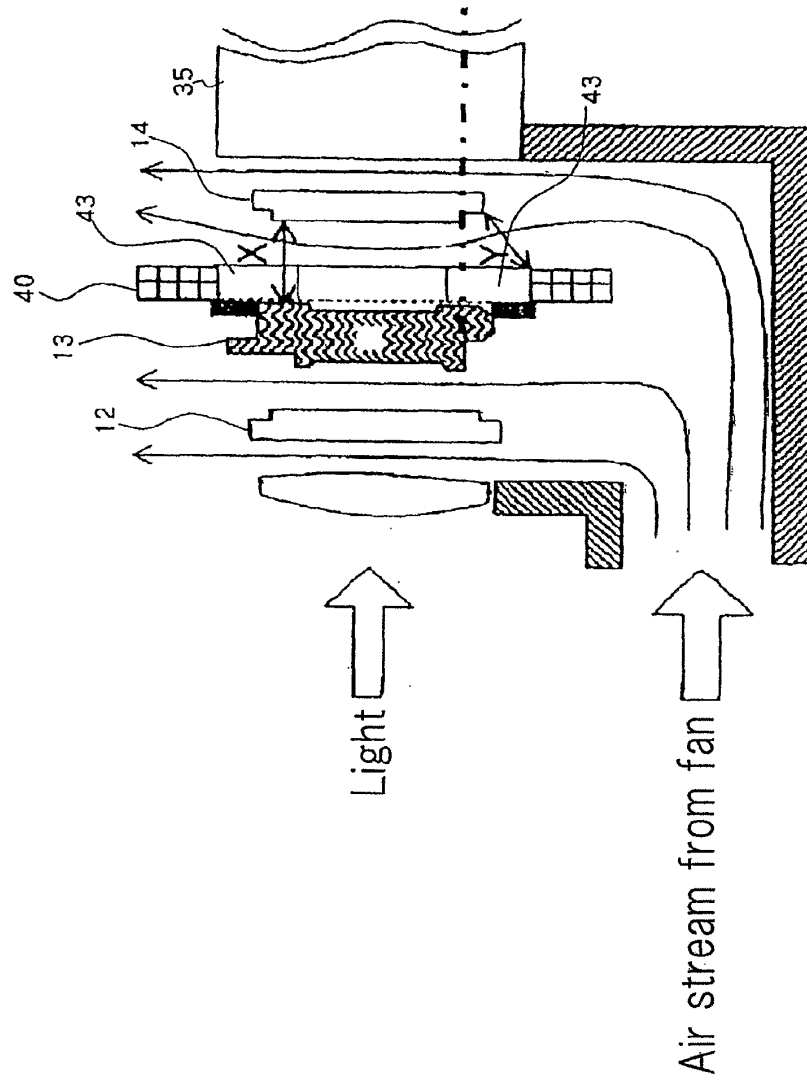


Fig. 8A

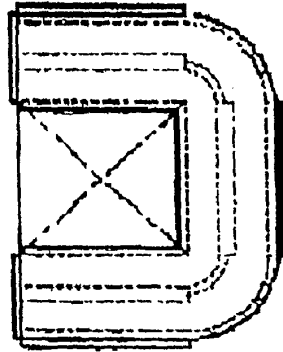


Fig. 8B

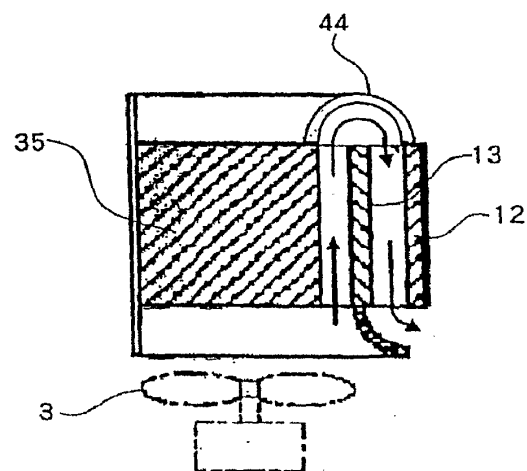


Fig. 9A

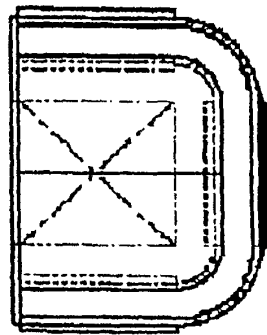


Fig. 9B

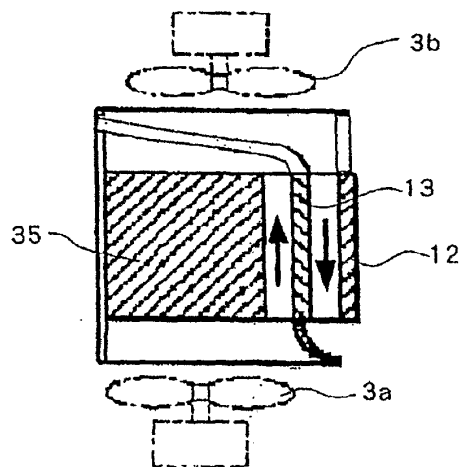


Fig. 10

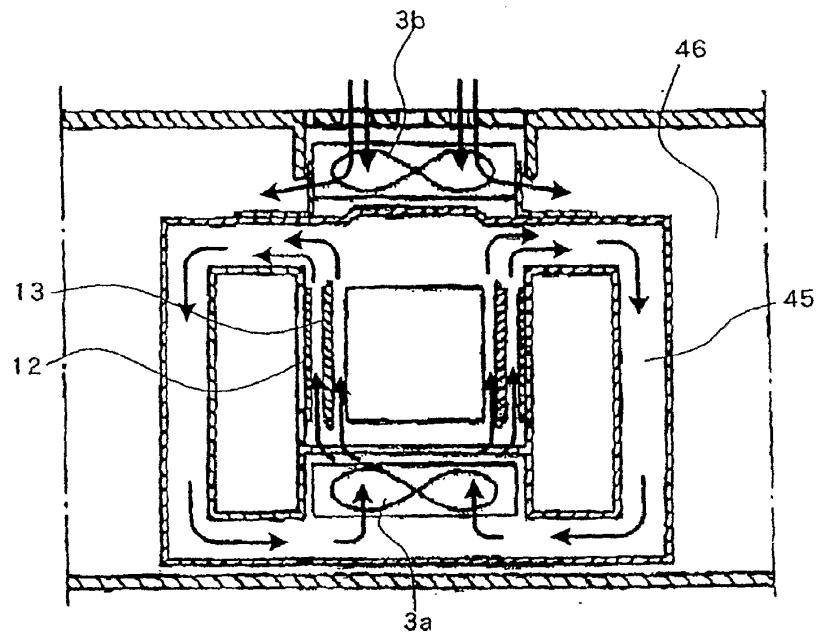


Fig. 11

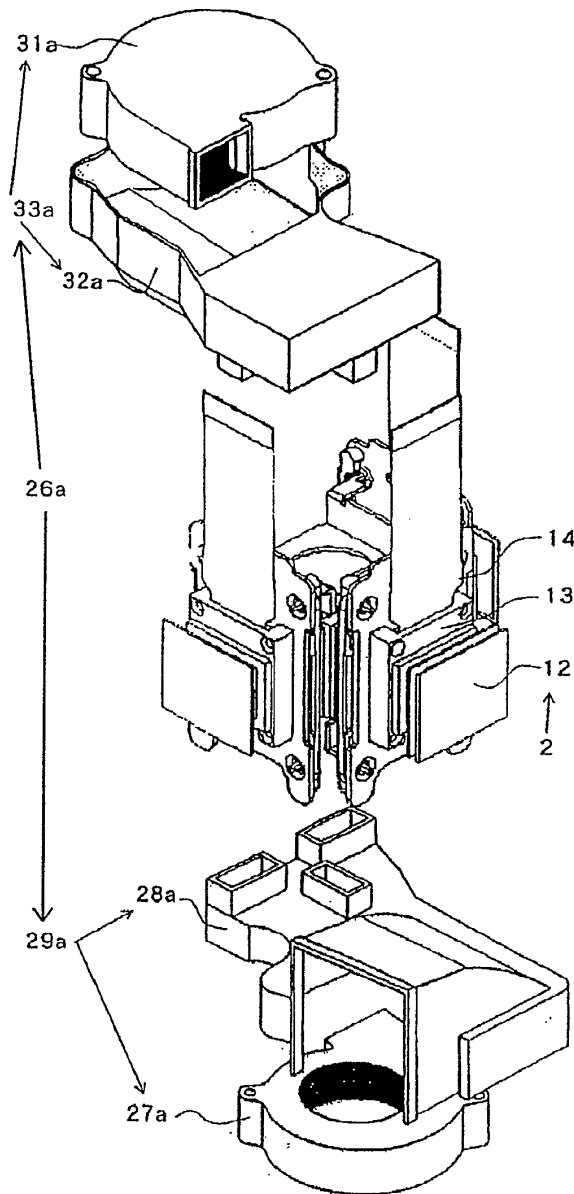


Fig. 12

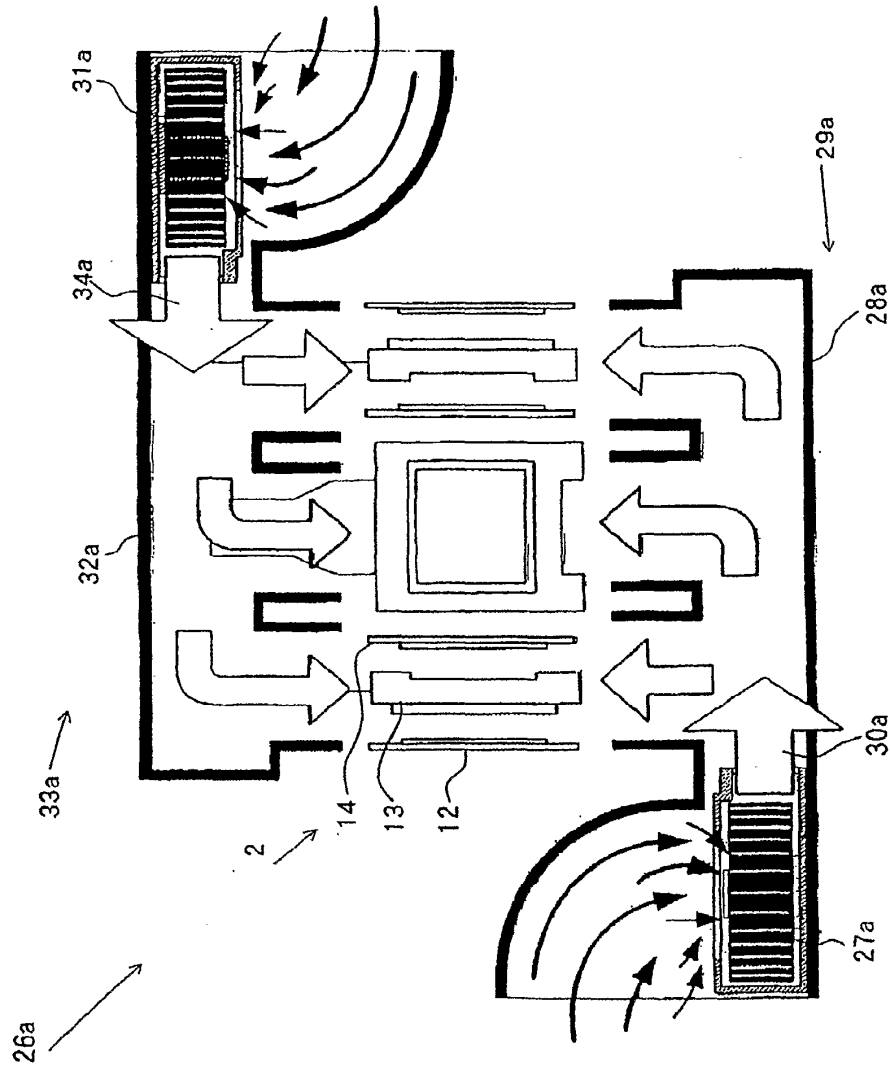


Fig. 13

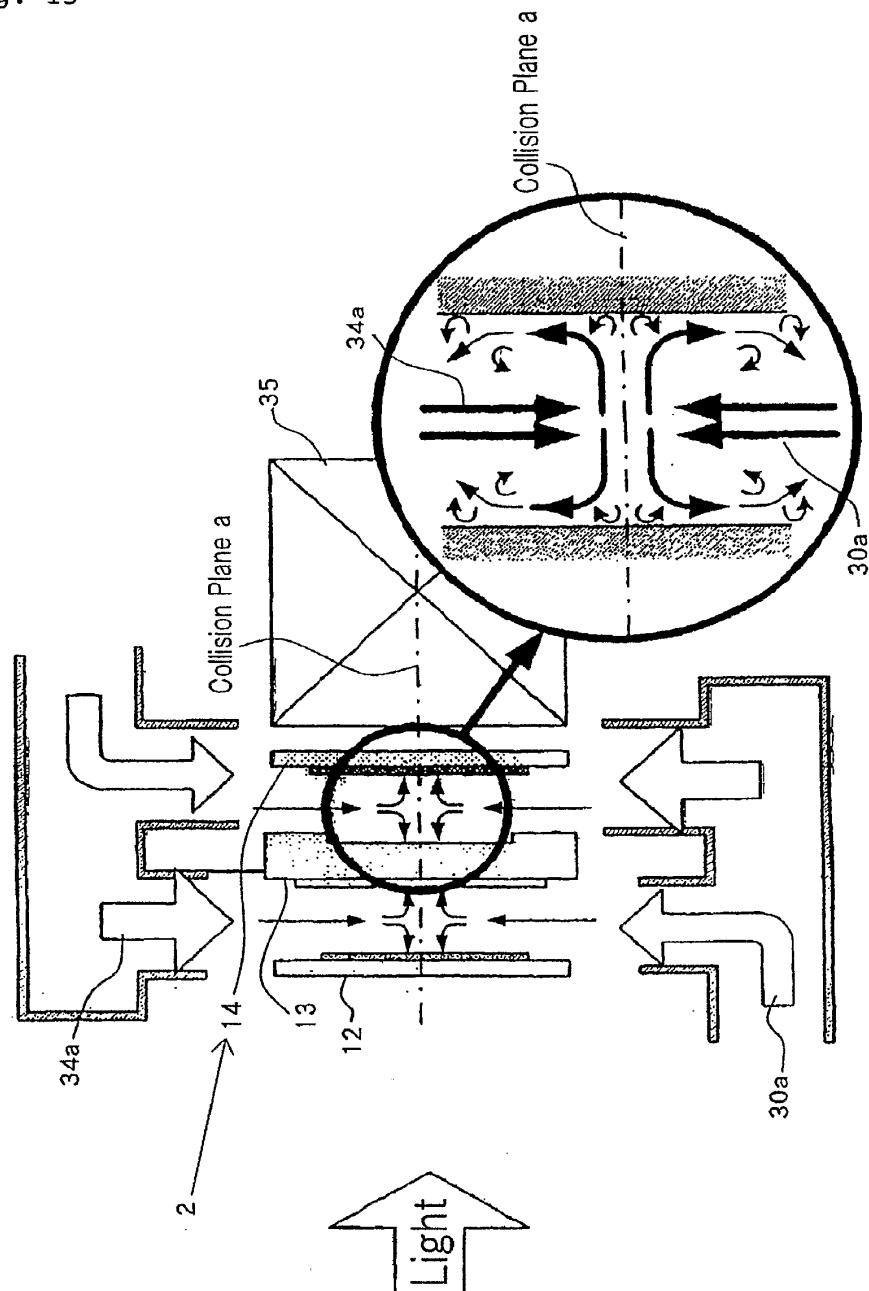


Fig. 14

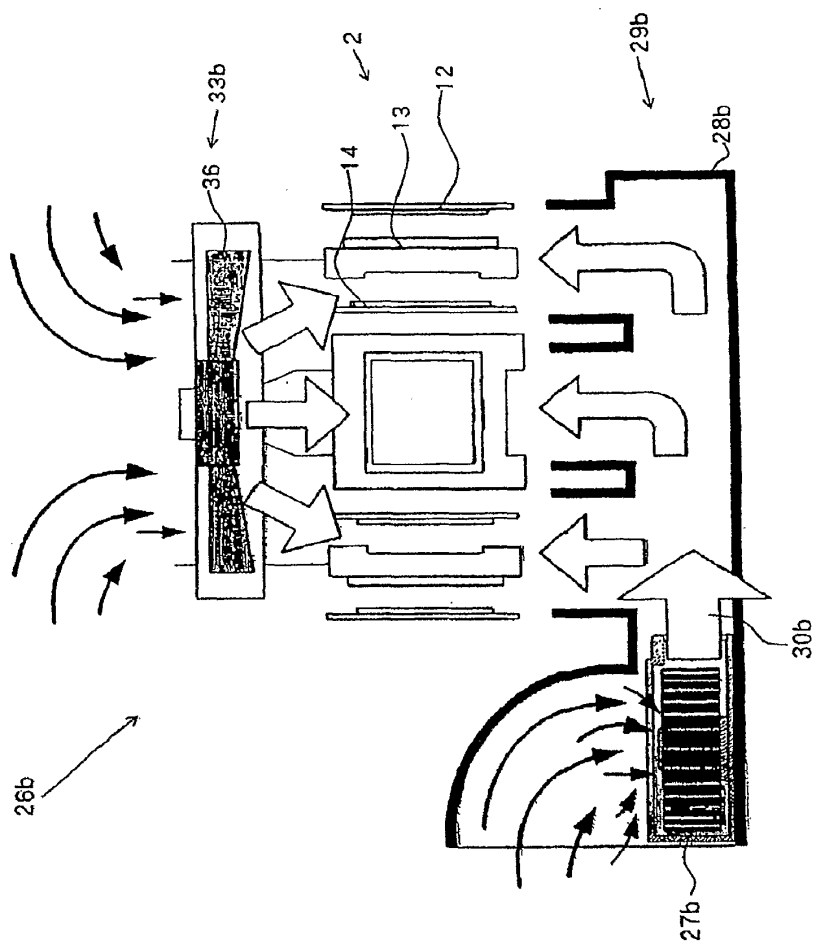


Fig. 15

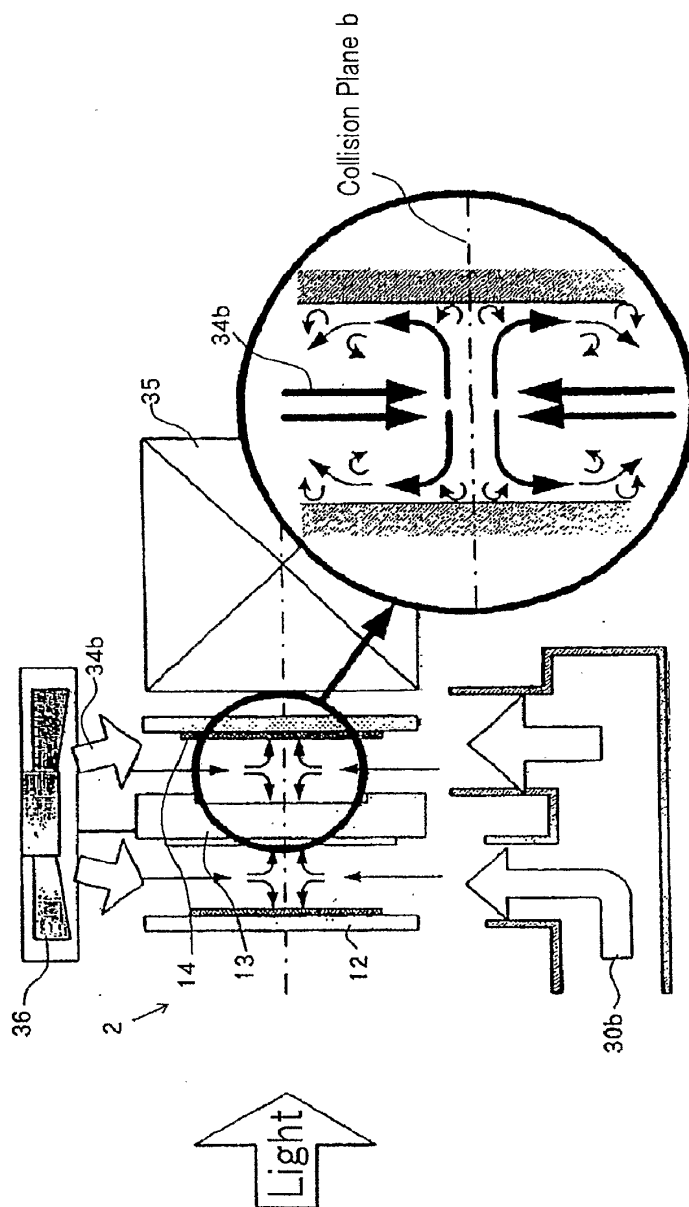


Fig. 16A

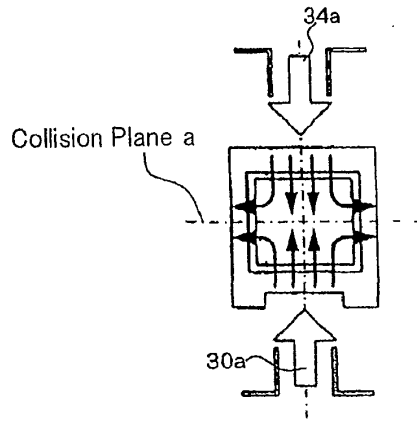


Fig. 16B

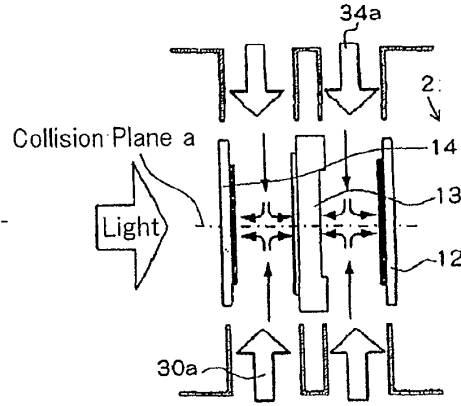


Fig. 16C

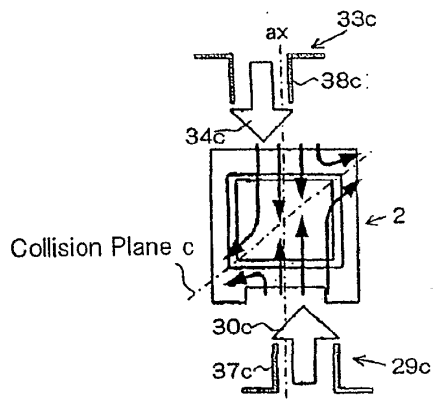


Fig. 16D

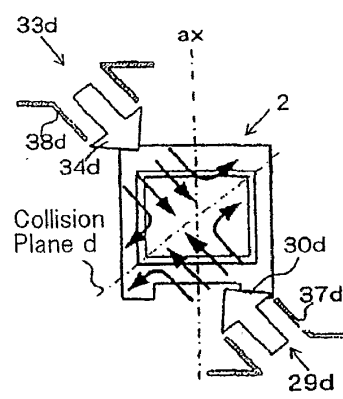


Fig. 16E

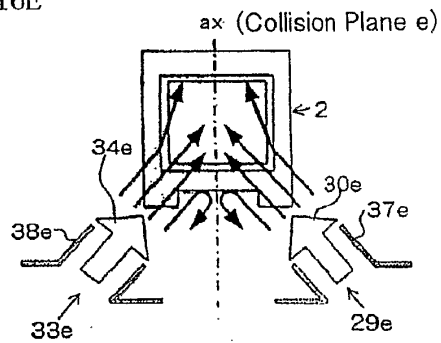


Fig. 16F

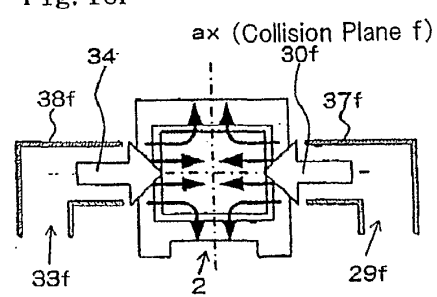


Fig. 17A

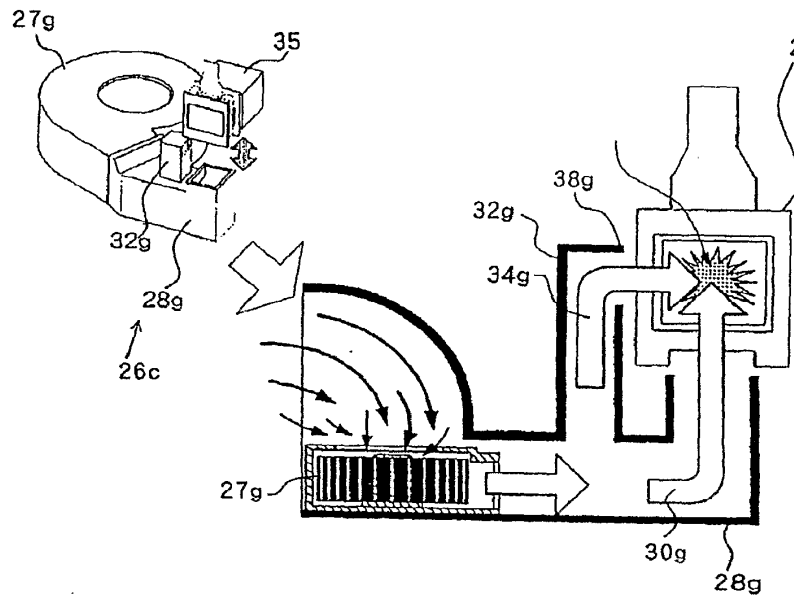


Fig. 17B

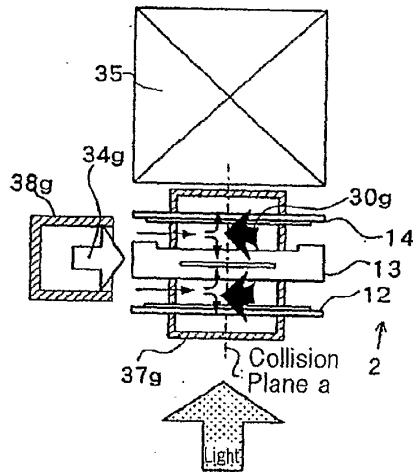


Fig. 18

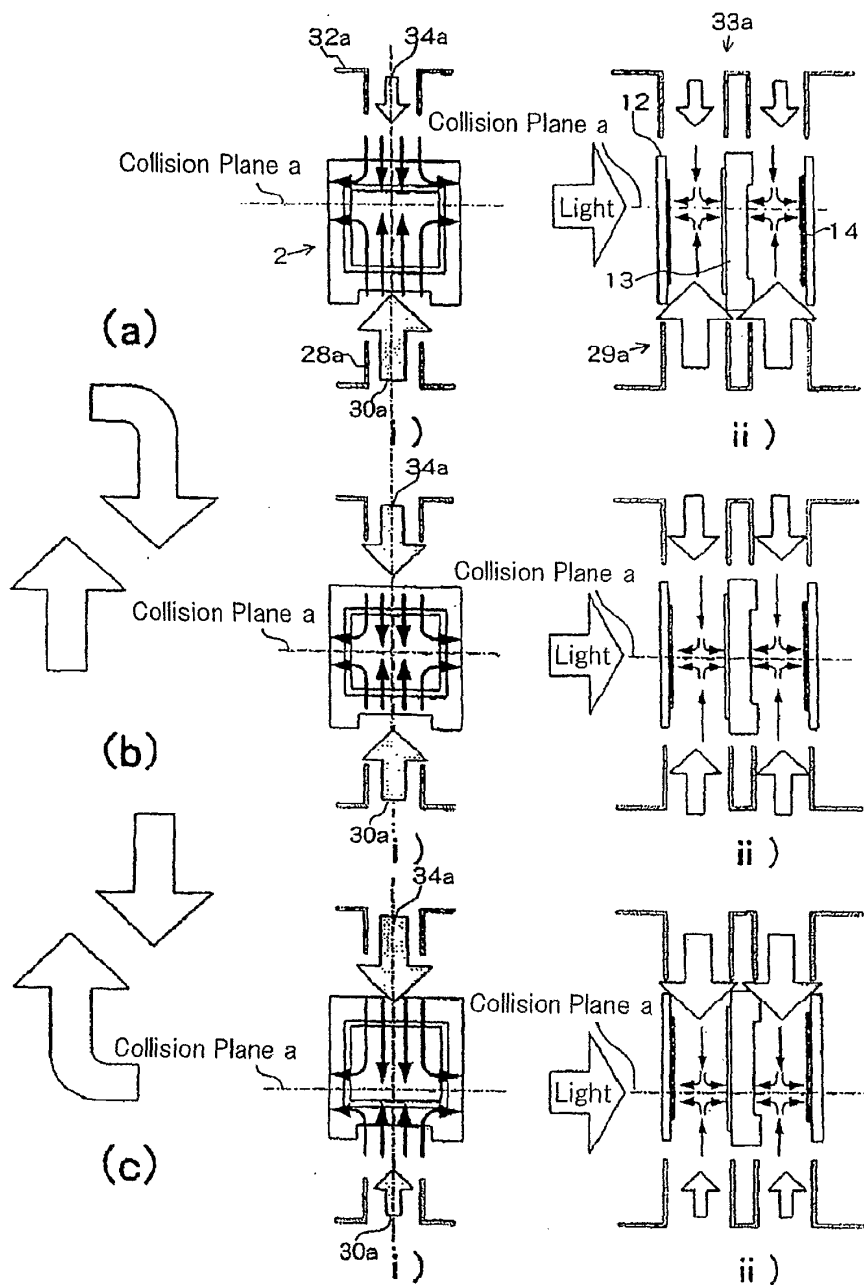


Fig. 19

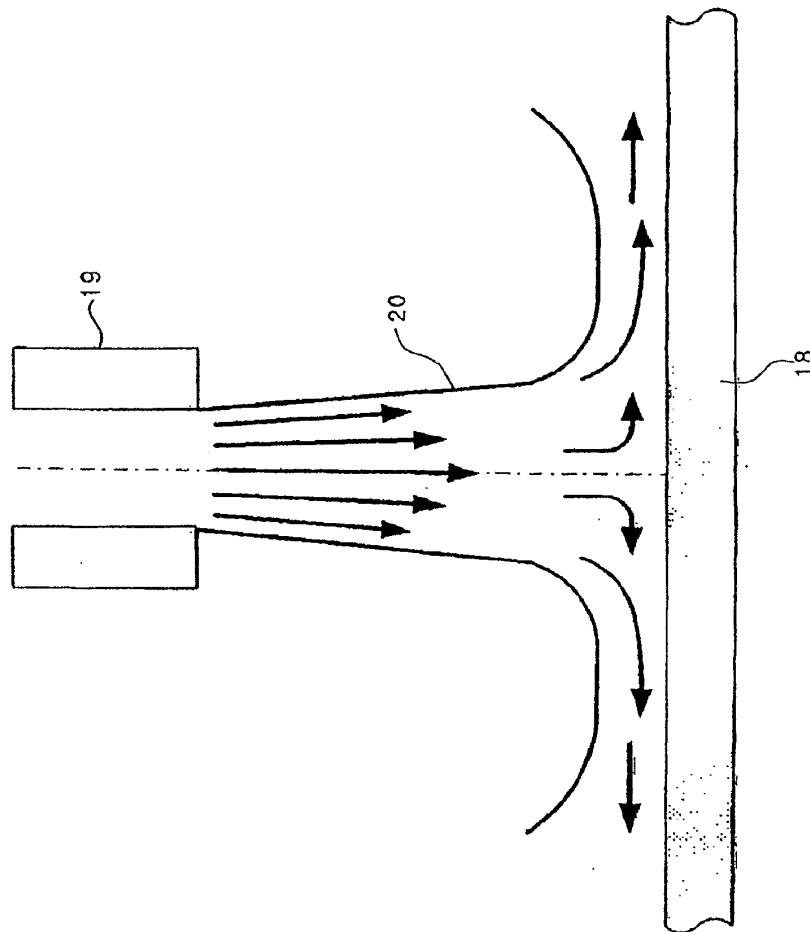


Fig. 20B

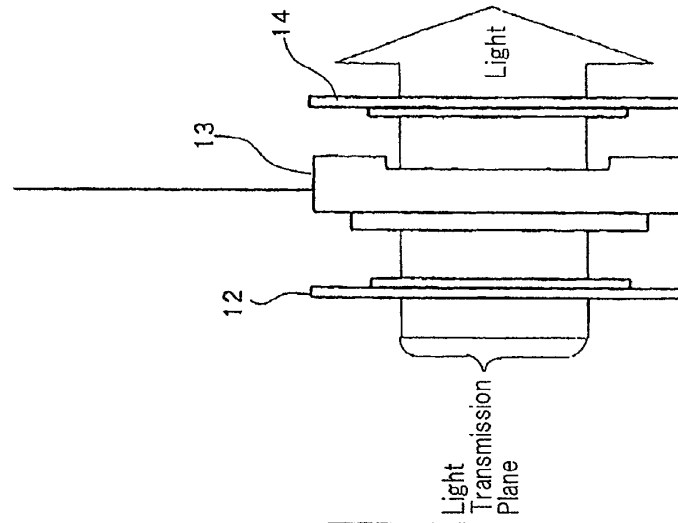
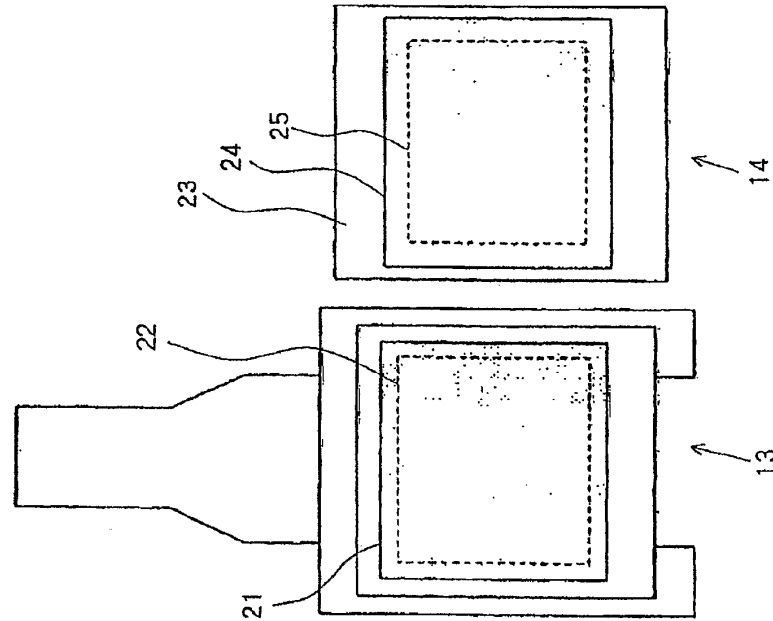


Fig. 20A





Espacenet

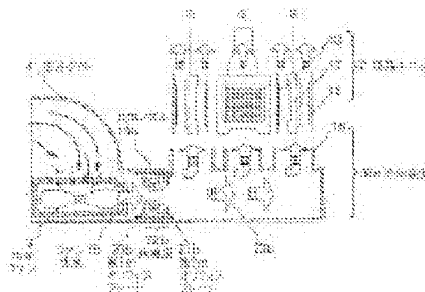
Bibliographic data: JP2008292743 (A) — 2008-12-04

COOLING DEVICE, AND ELECTRONIC EQUIPMENT AND PROJECTION TYPE
DISPLAY DEVICE EQUIPPED WITH COOLING DEVICE

Inventor(s): UTSUNOMIYA MOTOYASU ±
Applicant(s): NEC DISPLAY SOLUTIONS LTD ±
Classification: - **international:** **G02F1/13; G03B21/00;**
G03B21/16
- **European:**
Application
number: JP20070137858 20070524
Priority number(s): JP20070137858 20070524
Also published as: JP4826956 (B2)

Abstract of JP2008292743 (A)

PROBLEM TO BE SOLVED: To improve cooling efficiency further while using a general-purpose fan as a cooling air generation source. ; SOLUTION: The cooling device for air-cooling a heat generation part in electronic equipment includes a cooling fan 3 for generating the cooling air and a resonance nozzle 19b functioning as a means for imparting a pulsation component to the cooling air generated by the cooling fan 3. The resonance nozzle 19b is constituted of a first orifice plate 20b and a second orifice plate 21b arranged to be opposed in an air-cooling duct 4 for guiding the cooling air to the heat generation part, and a resonance chamber 22b formed between the plates. ; COPYRIGHT: (C)2009,JPO&INPIT



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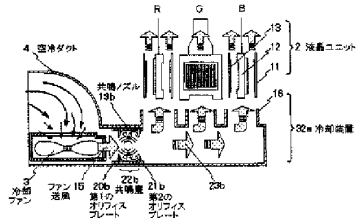
(54) 【発明の名称】 冷却装置、冷却装置を備えた電子機器及び投写型表示装置

(57) 【要約】

【課題】 冷却風の発生源として汎用のファンを用いつつ、冷却効率のさらなる向上を図る。

【解決手段】 電子機器内の発熱部を空冷する冷却装置であって、冷却風を発生させる冷却ファン3と、冷却ファン3が発生させた冷却風に脈動成分を付与する手段としての共鳴ノズル19bとを有する。共鳴ノズル19bは、冷却風を発熱部に導く空冷ダクト4内に対向配置された第1のオリフィスプレート20b及び第2のオリフィスプレート21bと、それらプレート20bと21bとの間に形成された共鳴室22bとから構成されている。

【選択図】 図8



【特許請求の範囲】**【請求項1】**

電子機器内の発熱部を空冷する冷却装置であって、
冷却風を発生させるファンと、前記ファンが発生させた前記冷却風に脈動成分を付与する手段とを有することを特徴とする冷却装置。

【請求項2】

冷却風に脈動成分を付与する前記手段が、前記冷却風を共振させる共鳴ノズルであって、
前記共鳴ノズルは、前記冷却風を前記発熱部に導くダクト内に対向配置された第1のオリフィスプレート及び第2のオリフィスプレートと、それらプレートの上に形成された共鳴室と、から構成されていることを特徴とする請求項1記載の冷却装置。

【請求項3】

前記共鳴ノズルが、前記冷却風を前記発熱部に導くダクトの吐出口に設けられていることを特徴とする請求項1又は請求項2記載の冷却装置。

【請求項4】

冷却風に脈動成分を付与する前記手段が、前記ファンが発生させた前記冷却風を自励振動させる流体素子振動器であることを特徴とする請求項1記載の冷却装置。

【請求項5】

流体素子振動器が、前記冷却風を前記発熱部に導くダクトの吐出口に設けられていることを特徴とする請求項4記載の冷却装置。

【請求項6】

前記流体素子振動器は、前記冷却風を前記発熱部に導くダクトと、前記ダクトを取り囲むように設けられ、該ダクトに少なくとも2箇所で連通する連結ダクトと、前記ダクトと連結ダクトとの連通部から前記冷却風の下流側に向けて次第に径が拡大する吐出ノズルとから構成されていることを特徴とする請求項4又は請求項5記載の冷却装置。

【請求項7】

前記流体素子振動器は、前記冷却風を前記発熱部に導くダクトと、前記ダクトを取り囲むように設けられ、該ダクトに少なくとも1箇所で連通する連結ダクトと、前記連結ダクト内に設けられ、該連結ダクト内に圧力変動を生じさせる圧電素子と、前記ダクトと連結ダクトとの連通部から前記冷却風の下流側に向けて次第に径が拡大する吐出ノズルとから構成されていることを特徴とする請求項4又は請求項5記載の冷却装置。

【請求項8】

前記連結ダクトが、前記冷却風を前記発熱部に導くダクトの途中に設けられていることを特徴とする請求項6又は請求項7記載の冷却装置。

【請求項9】

冷却風に脈動成分を付与する前記手段が、前記冷却風の流路上に設けられた断面形状楔形のブロックであって、
前記ブロックは、その頂点の少なくとも一つが前記冷却風の上流側を向くように前記流路上に配置され、該ブロックに当たった前記冷却風にエッジトーン現象を発生させて、前記冷却風に脈動成分を付与することを特徴とする請求項1記載の冷却装置。

【請求項10】

前記ブロックが、前記冷却風を前記発熱部に導くダクト内に設けられていることを特徴とする請求項9記載の冷却装置。

【請求項11】

前記ブロックが、前記発熱部を挟んで、該発熱部に前記冷却風を導くダクトの吐出口と反対側に配置されることを特徴とする請求項9記載の冷却装置。

【請求項12】

冷却風に脈動成分を付与する前記手段が複数の前記発熱部ごとに設けられていることを特徴とする請求項1乃至請求項11のいずれかに記載の冷却装置。

【請求項13】

請求項1乃至請求項12のいずれかに記載の冷却装置を備えた電子機器。

【請求項14】

入射側偏光板、液晶パネル及び出射側偏光板から構成される液晶ユニットによって形成された画像を拡大投写する投写型表示装置であって、

請求項1乃至請求項12のいずれかに記載の冷却装置を備え、該冷却装置によって前記【発明の詳細な説明】れることを特徴とする投写型表示装置。

【技術分野】

【0001】

本発明は、電子機器内にある発熱部の冷却に関するものである。

【背景技術】

【0002】

従来から電子機器の発熱部を冷却するための手段が多数開発され、そのうちのいくつかは実用化されている。それら冷却手段の一つである空冷方式の冷却手段は、簡易かつ安価な冷却手段として、多くの電子機器に採用されている。例えば、業務用および一般家庭用に広く普及している投写型表示装置（プロジェクタ）においても、空冷方式、特に強制空冷方式の冷却手段が採用されている。

【0003】

投写型表示装置は、画像表示素子上に生成された画像をスクリーンに拡大投影する表示装置である。かかる投写型表示装置のうち、画像表示素子に液晶パネルを用いた液晶プロジェクタ装置は、次のような構成と動作によってスクリーン上に画像を拡大投影する。

【0004】

液晶プロジェクタ装置は、光源を備えている。該光源から発せられた白色光は、リフレクタで反射され、PBS（Polarization Beam Splitter：偏光ビームスプリッタ）により偏光変換された後に、R／G／Bの各色光に分離される。分離された各色光は、各色ごとに用意された液晶パネルに導かれ、対応する液晶パネルに入射する。液晶パネルに入射した各色光は、液晶パネルによってビデオ信号に従った光変調を受ける。光変調された各色光は、色合成プリズムにより合成され、投写光学系を介してスクリーン上に投写される。

【0005】

ここで、TN（Twisted Nematic）モードで動作する液晶パネルは、特定の直線偏光成分しか扱えない。そこで、各液晶パネルの入射側には偏光板が配置され、液晶パネルに入射する色光の偏光方向が所定方向に統一される（ここでは、S偏光に統一されるものとする。）。さらに、液晶パネルの出射側にも偏光板が配置され、液晶パネルで光変調を受けた光のS偏光成分が該偏光板によってカットされ、P偏光成分のみが抽出される。ここで、液晶パネル及びその前後に配置される偏光板は、一体化されてユニット（液晶ユニット）を形成しているのが通常である。また、以下の説明では、液晶パネルの入射側に配置された偏光板を「入射側偏光板」、出射側に配置された偏光板を「出射側偏光板」と呼ぶ場合がある。

【0006】

このように、液晶パネルの前後に、光軸に沿って配置される入射側偏光板及び出射側偏光板は、各々1軸方向の偏光光のみを通過させ、他の偏光光を遮蔽する。入射側偏光板及び出射側偏光板によって遮蔽された光は熱に変換される。すなわち、入射側偏光板及び出射側偏光板は発熱する。また、液晶パネルにおいても、各画素境界にあるブラックマトリクスによって入射光の一部が遮蔽され、遮蔽された光は熱に変換される。従って、液晶パネルも入射側偏光板及び出射側偏光板と同様に発熱する。換言すれば、液晶ユニットは、プロジェクタという電子機器内の発熱部である。

【0007】

一方で、液晶パネルや偏光板には有機材料が用いられることが多い。従って、長時間にわたって波長の短い光が照射されたり、高温に曝されたりすると、液晶パネルの配向膜がダメージを受けたり、偏光板の偏光選択特性が低下したりするなど、その機能が著しく損

なわれてしまう。そこで、液晶プロジェクタには、液晶ユニットを冷却するための冷却手段が設けられている。以下、液晶プロジェクタに設けられている冷却手段について詳しく説明する。

【0008】

図20(a)は、一般的な液晶プロジェクタ1の外観斜視図であり、(b)は内部構造を示す斜視図である。また、図21は、図20(b)に示す内部構造を模式的に示した平面図である。

【0009】

図21に示すように、液晶プロジェクタ1の筐体内には、液晶ユニット2を強制空冷するための冷却ファン3と空冷ダクト4とが設けられている。また、光源5を強制冷却するための冷却ファン7が設けられている。さらに、筐体内の空気を強制的に排気して電源ユニット6等を冷却するための排気ファン8も設けられている。

【0010】

図22を参照して、冷却ファン3及び空冷ダクト4による液晶ユニット2の冷却方法について具体的に説明する。図22(a)は、冷却ファン3及び空冷ダクト4の分解斜視図、同図(b)は冷却風の流れを示す模式図である。

【0011】

図22(a)(b)に示すように、入射側偏光板11、液晶パネル12及び出射側偏光板13から構成される液晶ユニット2は、R/G/Bの色光ごとに設けられており、それら液晶ユニット群の下方に、空冷ダクト4の吐出口16が配置されている。

【0012】

主に図22(b)に示すように、冷却ファン3によって生み出されたファン送風(冷却風)15は、空冷ダクト4を通過して該空冷ダクト4の吐出口16から吹き出す。吐出口16から吹き出した冷却風15は、各液晶ユニット2の下から各液晶ユニット2に供給される。各液晶ユニット2に供給された冷却風15は、各ユニット2の入射側偏光板11、液晶パネル12及び出射側偏光板13の間の空間を通過して上方に抜ける。

【0013】

ここで、近年のプロジェクタの利用形態の多様化に応じて、小型化・高輝度化の要求が高まっている。このような要求に応えるために、ランプ出力の向上と表示デバイス(液晶ユニット)の小型化が進められている。その結果、液晶ユニットへ入射する光の光束密度が増大し、液晶ユニットを構成する液晶パネル、入射側偏光板及び出射側偏光板の熱負荷は上昇の一途をたどっている。

【0014】

一方で、環境負荷の低減とランニングコストの削減を目的に、プロジェクタの長寿命化の要求も次第に高まりつつある。ランプ交換部品を除けば、液晶プロジェクタの寿命は、主に液晶ユニットの寿命に依存する。液晶ユニットの冷却手段の冷却能力を高めて液晶ユニットの寿命を延ばすことができれば、液晶プロジェクタ自体の寿命を延ばすことができる。

【0015】

一般に、液晶ユニットの冷却手段として空冷方式を採用する場合、その冷却能力を高めるためには、冷却ファンの送風量を増加させて、冷却風の風速を上げる必要がある。しかしながら、冷却ファンの回転数を上昇させて送風量を増加させると、冷却ファンの動作騒音も増加する。また、冷却ファンを大径化して送風量を増加させると、装置が大型化してしまう。

【0016】

また、冷却風が冷却対象に沿って平行に流れる場合(層流)、平均熱伝達率は風速の平方根に比例し、冷却対象の温度上昇は風速の平方根に反比例する。従って、冷却対象の温度がある程度まで低下すると、風速増加に対する冷却対象の温度低下の感度が鈍くなる。

【0017】

図23に、0.8"サイズの液晶パネル(5000lm-25℃環境)の動作温度の風速依存曲線の

一例を示す。図23より、液晶パネル動作温度を70℃から60℃まで下げる場合には、冷却風の風速を4.5m/sから8m/sへ増速させるだけでよいが、60℃から50℃まで下げる場合には、冷却風の風速を8m/sから18m/sまで増速させなければならないことがわかる。

【0018】

従って、液晶ユニットの長寿命化を図るために、液晶ユニットの動作温度（特に液晶パネルの動作温度）のさらなる低減を目指す場合、冷却風の風速を極めて高速化しなければならない。しかし、冷却風の風速を高速化すると、冷却ファンの動作騒音の増大や装置の大型化を招く虞があることは上述のとおりである。さらには、冷却ファンの動作騒音の増大や装置の大型化を許容したとしても、冷却能力の向上には限界（空冷限界）がある。

【0019】

これまでは、プロジェクト、特に液晶プロジェクトを例にとって電子機器の冷却に関して説明してきた。しかし、プロジェクト以外にも発熱部を持った電子機器は多数存在しており、当該電子機器の性能向上や使用態様の多様化に伴って効率的な冷却手段が求められている。例えば、近年のパーソナルコンピュータは高性能な中央演算処理装置を内蔵しており、その中央演算処理装置は、その動作中に熱を発する。一方、中央演算処理装置の安定した動作を確保するためには、該処理装置を冷却して動作温度を所定範囲内に維持する必要がある。

【0020】

以上のような状況の下、電子機器を高効率で冷却するための手段の開発が急務となっている。そこで、特許文献1には、発熱デバイスの発熱面に冷却流体を供給する手段を振動させることによって、冷却流体の噴流を上記発熱面に供給する冷却装置が記載されている。

【0021】

また、特許文献2には、液晶ユニットを構成するパネル間の隙間に乱流発生手段を設け、該隙間を流れる冷却風に乱流を発生させて冷却効率の向上を図ることが記載されている。

【0022】

また、特許文献3には、電子機器を冷却するための冷却風の発生源として、容積変化型のポンプが示されている。さらに、同文献3には、容積変化型ポンプの駆動周波数を最適化することによって放熱効率を向上させることが指摘されている。

【特許文献1】特開2000-252669号公報

【特許文献2】特開2001-125057号公報

【特許文献3】特開2006-299962号公報

【発明の開示】

【発明が解決しようとする課題】

【0023】

冷却流体の供給手段を振動させて冷却風を噴流とするためには、供給手段を振動させる駆動機構が必要となる。しかし、新たな駆動機構を追加すれば、装置の大型化や高コスト化を招く。また、メカニカルな駆動機構を追加することによって、装置全体の信頼性が低下する虞もある。

【0024】

液晶ユニットを構成するパネル間の隙間に乱流発生手段を設けると、通風抵抗が増加し、冷却効率が低下する虞がある。理論的には、乱流発生手段の大きさ、形状、配置などを最適化することによって、上記冷却効率の低下を回避できる可能性はある。しかし、上記のような最適設計は実際には非常に困難であり、非現実的である。

【0025】

冷却風の発生源としての容積変化型ポンプは、ファンに比べて静圧が大きいというメリットがある一方で、送風量が少なく、騒音が大きいというデメリットがある。また、多くの電子機器では、冷却風の発生源として従来からファンが多用されている。よって、冷却風の発生源をファンからポンプに変更するには、抜本的な設計変更が必要になる場合が多

いと予想される。

【0026】

電子機器の冷却に空冷方式を採用する場合、冷却能力や冷却効率以外の重要な課題の1つに塵埃の問題がある。具体的には、冷却対象に吹き付けられる冷却風に塵埃が混入していると、その塵埃が冷却対象の表面に付着する。電気機器が液晶プロジェクタである場合を例によって具体的に説明すれば、次のとおりである。冷却風に塵埃が混入していると、混入した塵埃が液晶パネルの表面に付着する。特に、図24に示すように、液晶パネル12の表面17のうち、光透過領域18に塵埃が付着すると、塵埃の影がスクリーン上に結象されてしまい画像品質を著しく劣化させる虞がある。

【0027】

そこで、通常の液晶プロジェクタでは、液晶ユニットの冷却に用いる冷却ファンの吸気部に、空冷ダクト内へ塵埃の混入を回避するための防塵フィルタが設置されている。しかしながら、筐体の他の通気口や隙間などから塵埃が空冷ダクト内に侵入する場合も多々あり、使用環境によっては防塵が不十分なケースも予想される。

【0028】

本発明は上記課題に鑑みてなされたものであり、その目的の一つは、冷却風の発生源として汎用のファンを用いつつ、冷却効率のさらなる向上を図ることである。目的の他の一つは、冷却対象の表面に付着した塵埃を冷却風によって効果的に除去することである。

【課題を解決するための手段】

【0029】

上記目的を達成する本発明は、冷却対象に対して脈動成分が付与された冷却風を供給することを課題解決手段の基本原理とするものである。空気噴流（冷却送風）に脈動成分を与えた脈動噴流により生成される周期的な流れが流体中を通過すると、その周囲流体に高周波の小スケールの乱れ（乱流渦）が誘起されるため、脈動周波数や振幅によって独特の熱伝達特性を示し、広い領域で熱伝達効率が増進する。また、脈動成分が付与された、すなわち、周期的な速度変動と圧力変動とが与えられた冷却風を冷却対象に供給することで、冷却対象の表面に付着した塵埃が効果的に除去される。

【0030】

そこで、本発明の冷却装置は、電子機器内の発熱部を空冷する冷却装置であって、冷却風を発生させるファンと、前記ファンが発生させた前記冷却風に脈動成分を付与する手段とを有する。

【発明の効果】

【0031】

本発明によれば、電子機器内の発熱部に脈動噴流化された冷却風が供給されるので、熱伝達効率が向上し、冷却効果が高まる。また、冷却風を脈動噴流化するために、メカニカルな可動部や摺動部を必要としないので、信頼性の高い安価な冷却装置を提供することができる。さらに、脈動噴流化された冷却風が発熱部に供給される結果、冷却風によって、発熱部に付着している塵埃を除去することもできる。

【発明を実施するための最良の形態】

【0032】

（実施形態1）

次に本発明の冷却装置の実施形態の一例について説明する。本実施形態の冷却装置は、冷却風を発生させるファンと、ファンによって生み出された冷却風を電子機器内の発熱部またはその近傍に導くダクトとを少なくとも有する。そして、上記ダクトに、該ダクト内を通過する冷却風（以下「ファン送風」と呼ぶ場合もある。）に脈動を与えて脈動噴流（Pulsed Jet flow）とする手段が設けられていることを特徴とする。

【0033】

本実施形態では、ファン送風に脈動成分を付与する第1の手段として、ダクトの出口に共鳴ノズルが設けられている。共鳴ノズルは、特定の周波数でファン送風を共振させることにより、攪乱成分が増幅した共鳴噴流を生成する。図1、図2を参照して上記共鳴ノズル

ルについて詳細に説明する。

【0034】

図1は、共鳴ノズル19aの構成を示す模式図であり、(a)は断面図、(b)は斜視断面図である。また、図2は、共鳴ノズル19aの作用を示す模式図であり、(a)は比較のために用意した通常のノズルの断面図、(b)は共鳴ノズル19aの断面図である。

【0035】

共鳴ノズル19aは、ダクト31aの出口内部に設けられた第1のオリフィスプレート20aと、第1のオリフィスプレート20aよりも下流側に設けられた第2のオリフィスプレート21aと、対向する2枚のオリフィスプレート20a、21aの間に設けられた共鳴室(空洞容積)22aとから構成されている。尚、共鳴室22aの直径及び高さ(2枚のオリフィスプレート20a、21aの間隔)は、共鳴室22aの容積が所定容積となるように設定されている。

【0036】

共鳴ノズル19aにファン送風15を流入させると、図2(b)に示すように、風速や第1のオリフィスプレート20aおよび第2のオリフィスプレート21aの開口径、あるいは共鳴室22aの空洞容積により規定される周波数で送風が共振(共鳴)し、第2のオリフィスプレート21aの下流側で、攪乱成分が増幅された間欠的な共鳴噴流23a(resonance jet flow)が生成される。このような脈動噴流(=共鳴噴流23a)は、周囲流体との混合・拡散特性を改善・促進するため、熱伝達効率を改善する。

(実施形態2)

以下、本発明の冷却装置の実施形態の他例について説明する。本実施形態の冷却装置も、冷却風を発生させるファンと、ファンによって生み出された冷却風を電子機器内の発熱部またはその近傍に導くダクトとを少なくとも有する。そして、上記ダクトに、該ダクト内を通過する冷却風(ファン送風)に脈動成分を付与して脈動噴流とする手段が設けられていることを特徴とする。

【0037】

本実施形態では、ファン送風に脈動成分を付与する第2の手段として、ファン送風を自励振動させる流体素子振動器がダクトに設けられている。図3、図4を参照して上記流体素子振動器について詳細に説明する。

【0038】

図3は、流体素子振動器24aの構成を示す模式図であり、(a)は斜視断面図、(b)は横断面図である。また図4は、流体素子振動器24aの作用を示す模式的断面図である。

【0039】

流体素子振動器24aは、ファン送風15の下流側に向けて次第に開口径が縮小するダクトの出口部と、該出口部に連設され、下流側に向けて次第に開口径が拡大するノズル部と、出口部とノズル部との連設部分を取り囲むように形成された矩形のダクトとによって構成されている。以下の説明では、上記出口部を「ダクト排気口25a」、ノズル部を「吐出ノズル27a」、矩形のダクトを「連結ダクト26a」と呼ぶ。

【0040】

ダクト排気口25aは、ダクト31bの一部であって、下流側に向けて次第に開口径が縮小するように、少なくとも対向する2つの内壁が下流側に向けて次第に近接するように傾斜している。吐出ノズル27aは、下流側に向けて次第に開口径が拡大するように、少なくとも対向する2つの内壁が下流側に向けて次第に離間するように傾斜している。吐出ノズル27aは、ダクト31bの一部であっても、ダクト31bと別部材であってもよい。連結ダクト26aと、ダクト排気口25a及び吐出ノズル27aの間には、2つの制御口28a、28bが用意されている。連結ダクト26aは、制御口28a、28bを介してダクト排気口25a及び吐出ノズル27aと連通している。

【0041】

このとき、後述する流体自励振動が発生するためには、図3(b)に示すダクト排気口

25aの射出開口幅aと、吐出ノズル27aの喉部開口幅bとの寸法比が $b > 3a$ となることが条件となる。

【0042】

次に図4を参照して、流体素子振動器24aの作用（流体自励振動の発生メカニズム）について説明する。

(1) ダクト排気口25aから流出した噴流（ファン送風15）は、コアンダ効果によって、吐出ノズル27aの傾斜した内壁の一方に沿って屈曲する（図4（a））。ここで、コアンダ効果とは、流れの中に物体を置くと、流体と物体の壁面との間の圧力が低下し、流体が壁面に吸い寄せられ、その物体に沿って流れの向きが変わる流体の性質をいう。

(2) このときファン送風15が屈曲した側に、エントレインメント（巻き込み）が発生し、ファン送風15の屈曲起点（制御口28a）に近い連結ダクト26aの左半分の圧力が低下する（図4（b））。以下の説明では、図4に示す連結ダクト26aの左半分を「左側領域A」、右半分を「右側領域B」と呼ぶ。

(3) 連結ダクト26aの左右で圧力差が発生すると、連結ダクト26a内の空気は、正圧側（右側領域B）から負圧側（左側領域A）へ流れ込む（図4（c））。

(4) 空気が右側領域Bから左側領域Aへ流入すると、これまで負圧であった左側領域Aが正圧となる。すると、コアンダ効果により屈曲していたファン送風15の流れが吐出ノズル27aの内壁から引き剥がされる（図4（d））。

(5) 次に、連結ダクト26aの右側領域Bが低圧になっているので、ファン送風15が吸引され、同じくコアンダ効果により、ファン送風15が吐出ノズル27aの反対側の内壁に沿って屈曲する（図4（e））。

(6) 以後、上記現象の繰り返しにより、ファン送風15は振り子のように揺動し、ファン送風15の供給が継続する限り自励振動が持続される（図4（f））。

【0043】

このような動作原理に基づいて、流体素子振動器24aを通過するファン送風15には、流体自励振動が発生し、これによりファン送風15に脈動成分が付与される。

【0044】

尚、連結ダクト26aの形状は、連結ダクト26a内の空気が該ダクト26a内の圧力差に起因して移動可能な形状であればよく、矩形に限定されない。例えば、連結ダクト26aは、円弧状その他の形状であってもよい。

【0045】

ところで、図5に示すように、図3などに示す連結ダクト26aの代わりに、圧電素子29を用いて左右の制御口の気圧を制御する流体素子振動器24bが知られている。このような流体素子振動器24bは、図3などに示す流体素子振動器24aよりもコスト高になるというデメリットがあるが、小型化が可能であるというメリットもある。

【0046】

このように流体素子振動器を用いて流体自励振動を発生させる機構は、フリップフロップノズルとして知られており、クリーンルームのエアシャワーなどとして実用化されている。

（実施形態3）

以下、本発明の冷却装置の実施形態の他例について説明する。本実施形態の冷却装置も、冷却風を発生させるファンと、ファンによって生み出された冷却風を電子機器内の発熱部またはその近傍に導くダクトとを少なくとも有する。そして、上記ダクトに、該ダクト内を通過する冷却風（ファン送風）に脈動成分を付与して脈動噴流とする手段が設けられていることを特徴とする。

【0047】

本実施形態では、ファン送風に脈動成分を付与する第3の手段として、ファン送風の流路上に、エッジトーン現象を発生させる断面形状楔形（三角形）のブロックが配置されている。ここで、エッジトーン現象とは、流体が鋭い角部に衝突するときに流体がその流れと直交する方向に周期的に変動する現象をいう。尚、ブロックはファン送風の流路上に配

置されていればよく、ダクトの内外は問わない。

【0048】

図6、図7を参照してエッジトーン現象を利用したファン送風の脈動化について説明する。図6に示すように、断面形状楔形のブロック30aをダクト31cの開口中心軸上に、エッジ（頂点）をダクト31c側に向けて配置する。また、ダクト31cの開口面とブロック30aの頂点とを距離Lだけ離間させる。すると、ダクト31cの開口面から射出されるファン送風15は、ブロック30aの頂点に衝突する。

【0049】

次に、図7を参照して、エッジトーン現象の発生メカニズムについて説明する。

(1) ダクト31cの開口面から、噴流として射出されたファン送風15は、ブロック30aの頂点に衝突する（図7(a)）。

(2) ファン送風15がブロック30aの頂点に衝突すると、擾乱（圧力変動）が発生し、それが距離Lを上流側へ伝播していく（図7(b)）。

(3) 上記擾乱の伝播が、ブロック30aとダクト31cとの間の離間した空間内において、局所的な渦変動を励起／増幅させる（図7(c)）。

(4) このようにして、ブロック30aとダクト31との間の衝突領域間において、周期的な擾乱が形成されるため、ダクト31cから射出されるファン送風15（噴流）は、ダクト31cの開口面を節とし、ブロック30aを間に挟んで、うねるように発振する（図7(d)）。

【0050】

このようなエッジトーン現象による噴流の発振により、ファン送風15に脈動成分が付与される。この場合の噴流の振動モードは、噴流の速度（レイノルズ数）や距離Lに依存することが知られている。

（実施形態4）

以下、本発明の電子機器の実施形態の一例について説明する。本実施形態における電子機器は、液晶プロジェクタであって、上記実施形態1～3のいずれかに係る冷却装置を備えていることを特徴とする。

【0051】

具体的には、液晶ユニットの下方にファンとダクトとが配置され、液晶ユニットに、脈動成分が付与された冷却風（ファン送風）が供給される。換言すれば、周期的な速度変動と圧力変動とが付与されたファン送風が冷却風として液晶ユニットに供給される。この結果、液晶ユニットにおける熱伝達が促進され、冷却効率が改善される。また、液晶パネルの表面に付着した塵埃が効果的に除去される。

【実施例】

【0052】

次に、実施例を挙げて本発明についてさらに詳しく説明する。ここでは、実施形態1に係る冷却装置を備えた液晶プロジェクタの一例について説明する。図8は、本例の液晶プロジェクタの冷却装置32a及びその近傍の構成を示す模式的断面図である。

【0053】

本例の液晶プロジェクタの基本構成は、背景技術の欄で既に説明した一般的な液晶プロジェクタと同一である。すなわち、R/G/Bの色光ごとに用意された液晶ユニット2を備え、各液晶ユニット2は、入射側偏光板11、液晶パネル12及び射出側偏光板13から構成されている。

【0054】

本例の液晶プロジェクタが備える冷却装置32aは、冷却ファン3と、空冷ダクト4と、共鳴ノズル19bとから形成され、液晶ユニット2の下方に設置されている。共鳴ノズル19bは、図1に基づいて既に説明したように、上流側の第1のオリフィスプレート20bと、下流側の第2のオリフィスプレート21bと、その間に形成された共鳴室（空洞容積）22bとを有する。冷却ファン3及び共鳴ノズル19bは、空冷ダクト4の内部に配置されている。また、共鳴ノズル19bは、冷却ファン3よりも下流側に配置されてい

る。より具体的には、冷却ファン3がファン送風15を送り出す吐出口の近傍に共鳴ノズル19bが設置されている。

【0055】

次に、本例の液晶プロジェクトにおける液晶ユニット2の冷却動作について説明する。冷却ファン3によって生み出されたファン送風15は、空冷ダクト4内に設置された共鳴ノズル19bの、第1のオリフィスプレート20bを通過して、共鳴室22bに流入する。ファン送風15が共鳴室22bに流入すると、ファン送風15の風速と共鳴室22bの空洞容積、および第1のオリフィスプレート20bと第2のオリフィスプレート21bの開口径に応じた特定の周波数で共振（共鳴）し、下流側に配置された第2のオリフィスプレート21bから、攪乱成分が増幅された共鳴噴流として射出される。例えば、ファン風速20m/s、空洞容積（共鳴室）8cm³の場合、送風は約4kHzの卓越周波数（共鳴周波数）で速度変動を発生させる。

【0056】

以上のようにして共鳴室22b内で共振が生じると、第2のオリフィスプレート21bよりも下流側のファン送風15に共鳴噴流が形成され、ファン送風15に大きな脈動成分が付与される。

【0057】

次に、図9を参照して冷却装置32aによる冷却効果について説明する。図9は、図8に図示されている3つの液晶ユニット2のうちの1つを抽出した模式図である。より具体的には、図9（a）は、入射側偏光板11と液晶パネル12との間におけるファン送風15の様相を示した模式的正面図である。図9（b）は、入射側偏光板11と液晶パネル12との間、および液晶パネル12と出射側偏光板13との間のファン送風15の様相を示した模式的側面図である。

【0058】

上述のように、空冷ダクト4内の共鳴ノズル19bによって脈動成分が付与されたファン送風15は、卓越周波数で速度変動する脈動噴流（共鳴噴流23b）となって、ダクト吐出口16から液晶ユニット2の各板間へ供給される。

【0059】

この場合、板間を通過するファン送風15は、高い乱流性（キャビテーション渦）を保持しつつ、共鳴周波数で間欠的にダクト吐出口16から高速で噴射される。従って、入射側偏光板11、液晶パネル12及び出射側偏光板13といった発熱部の発熱面上に形成される温度境界層の発達を抑制、あるいは破壊（剥離）しながら進行する。これにより、従来の平行平板流れ（層流）による空冷に比べて、熱伝達率が大幅に改善され、各液晶ユニット2が高効率で冷却される。

【実施例】

【0060】

次に、本発明の実施例の他例について説明する。ここでは、実施形態1に係る冷却装置を備えた液晶プロジェクトの他例について説明する。図10は、本例の液晶プロジェクトの冷却装置32b及びその近傍の構成を示す模式的断面図である。

【0061】

本例の液晶プロジェクトの基本構成は、実施例1の液晶プロジェクトと同一であり、相違点は冷却装置の構成のみである。よって、実施例1の液晶プロジェクトと同一の構成については、同一の符号を付して説明を省略する。

【0062】

本例の冷却装置32bでは、R/G/Bの各液晶ユニット2ごとに共鳴ノズルが設けられている点が実施例1と異なる。より具体的には、ファン送風15を各液晶ユニット2に分配すべく、各液晶ユニット2ごとに設けられたダクト吐出口16に、共鳴ノズル19cが設けられている。

【0063】

冷却ファン3によって生み出されたファン送風15は、空冷ダクト4内で分岐され、各

ダクト吐出口1 6から対応する液晶ユニット2に向けて噴射される。このとき各ダクト吐出口1 6に共鳴ノズル1 9 cが用意されているので、各液晶ユニット2を構成する入射側偏光板1 1と液晶パネル1 2の間、および液晶パネル1 2と出射側偏光板1 3の間に供給されるファン送風1 5は、卓越周波数で速度変動する脈動噴流（共鳴噴流2 3 c）となる（図1 1参照）。

【0064】

従って、実施例1と同様に、従来の平行平板流れ（層流）による空冷に比べて、熱伝達率が大幅に改善され、各液晶ユニット2が高効率で冷却される。

【実施例】

【0065】

次に、本発明の実施例のさらに他例について説明する。ここでは、実施形態2に係る冷却装置を備えた液晶プロジェクタの一例について説明する。図1 2は、本例の液晶プロジェクタの冷却装置3 2 c及びその近傍の構成を示す模式的平面断面図である。

【0066】

本例の液晶プロジェクタの基本構成は、実施例1の液晶プロジェクタと同一であり、相違点は冷却装置の構成のみである。よって、実施例1の液晶プロジェクタと同一の構成については、同一の符号を付して説明を省略する。

【0067】

本例の冷却装置3 2 cは、上記冷却装置3 2 a、3 2 bと同様に、液晶ユニット2の下方に配置されており、冷却ファン3、空冷ダクト4及び流体素子振動器2 4 bから構成されている。図示されている流体素子振動器2 4 bでは、連結ダクト2 6 b及び吐出ノズル2 7 cが空冷ダクト4と一体に形成されている。また、流体素子振動器2 4 bは、空冷ダクト4内に設けられた冷却ファン3の吐出口の近傍に配置されている。

【0068】

次に、図1 2、図1 3を参照して冷却装置3 2 cによる液晶ユニット2の冷却動作について説明する。図1 3に示すように、液晶ユニット2の下方に冷却装置3 2 cが設けられており、冷却ファン3によって生み出されたファン送風1 5は、空冷ダクト4内に設けられた流体素子振動器2 4 bを通過する。このとき、下流側に向かって拡大傾斜する吐出ノズル2 7 cと、連結ダクト2 6 b内を移動する空気的作用とにより、ファン送風1 5に流体自励振動が発生する。流体自励振動が発生させる具体的メカニズムについては、実施形態2において詳細に説明したので、ここでの説明は省略する。

【0069】

ファン送風1 5に流体自励振動が発生する結果、ファン送風1 5は、流体素子振動器2 4 bの下流側において周期的（1 0～2 0 Hz）な揺動を示し、空冷ダクト4の各ダクト吐出口1 6へのファン送風1 5の供給が時間的に切り替えられる。

【0070】

このようにして発生した流体自励振動は、空冷ダクト4内において、ファン送風1 5を高速で左右にスイングさせるため、その下流側に位置する各ダクト吐出口1 6からは、一定の時間周期でファン送風1 5が断続的に射出される。

【0071】

例えば、ファン送風1 5の風速が5～2 0 m/s、スイング角を1 2度前後に設定した場合、自励振動数は5～3 0 Hz程度になる。仮に、自励振動数が2 0 Hzとなるように、風速及びスイング角を設定した場合、往路と復路の折り返し点に位置するダクト吐出口（本例では、R用の液晶ユニット及びB用の液晶ユニットに対応するダクト吐出口）では、ファン送風1 5の吐出周期は5 0 m s間隔となる。一方、その中間に位置するダクト吐出口（本例では、G用の液晶ユニットに対応するダクト吐出口）では、その半分の2 5 m s間隔でファン送風1 5が射出される。

【0072】

このようにしてダクト吐出口1 6から射出されるファン送風1 5は、時間周期による間欠送風となるため、ファン送風1 5に大きな脈動成分が付与される。

【0073】

また、本例の冷却装置は、空冷ダクトの内部空間を分離して、各ダクト吐出口へファン送風を分配する従来の冷却方法に対し、空冷ダクトの内部空間を分離するのではなく、ファン送風を時間的に分割し、各ダクト吐出口から順次射出させる。従って、液晶ユニットの各板間を通過する送風（冷却風）は、高い乱流エネルギーを保持しつつ、間欠的に高速で噴射される。よって、熱伝達率が大幅に改善され、液晶ユニットが効率良く冷却される。

【実施例】

【0074】

次に、本発明の実施例のさらに他例について説明する。ここでは、実施形態2に係る冷却装置を備えた液晶プロジェクタの他例について説明する。図14は、本例の液晶プロジェクタの冷却装置32d及びその近傍の構成を示す模式的断面図である。

【0075】

本例の液晶プロジェクタの基本構成は、実施例1の液晶プロジェクタと同一であり、相違点は冷却装置の構成のみである。よって、実施例1の液晶プロジェクタと同一の構成については、同一の符号を付して説明を省略する。

【0076】

本例の冷却装置32dでは、R/G/Bの各液晶ユニット2ごとに流体素子振動器が設けられている点が実施例3と異なる。より具体的には、ファン送風15を各液晶ユニット2に分配すべく、各液晶ユニット2ごとに設けられたダクト吐出口16に、流体素子振動器24cが設けられている。

【0077】

冷却ファン3によって生み出されたファン送風15は、空冷ダクト4内で分岐され、各ダクト吐出口16から対応する液晶ユニット2に向けて噴射される。このとき各ダクト吐出口16に流体素子振動器24cが設けられているので、各液晶ユニット2を構成する入射側偏光板11と液晶パネル12との間、および液晶パネル12と出射側偏光板13との間で、ファン送風15に流体自励振動を発生させ、固有の自励振動数で送風を左右に揺動させることができる（図15参照）。

【0078】

上記のように、狭い板間内において送風を周期的に左右へ揺動させる場合、そのスイング角領域において、送風に高い乱流成分（送風ベクトルの転回による攪拌作用）が発生する。従って、ファン送風15は、入射側偏光板11、液晶パネル12及び出射側偏光板13といった発熱部の発熱面上に形成される温度境界層の発達を抑制し、あるいは破壊（剥離）しながら、放熱を行うことになる。この結果、従来の平行平板流れ（層流）による空冷方法に比べ、冷却効率が大幅に改善される。

【0079】

ところで、本例及び実施例3の流体素子振動器を、圧電素子を用いて連結ダクト内の気圧を制御するタイプの流体素子振動器（図5参照）で置換可能なことは既述のとおりであり、また、その際のメリット及びデメリットも既述のとおりである。

【実施例】

【0080】

次に、本発明の実施例のさらに他例について説明する。ここでは、実施形態3に係る冷却装置を備えた液晶プロジェクタの一例について説明する。図16は、本例の液晶プロジェクタの冷却装置32e及びその近傍の構成を示す模式的断面図である。

【0081】

本例の液晶プロジェクタの基本構成は、実施例1の液晶プロジェクタと同一であり、相違点は冷却装置の構成のみである。よって、実施例1の液晶プロジェクタと同一の構成については、同一の符号を付して説明を省略する。

【0082】

本例の冷却装置32eは、液晶ユニット2の下方に配置されており、冷却ファン3と、

空冷ダクト4と、断面形状が楔形（三角形）のブロック30bとから構成されている。ブロック30bは、空冷ダクト4内であって、かつ、冷却ファン3よりも下流側に配置されている。さらに、ブロック30bは、冷却ファン3の吐出口にその頂点を向け、かつ、その頂点が吐出口から所定の距離だけ離れた位置に配置されている。

【0083】

次に、図16、図17を参照して冷却装置32eによる液晶ユニット2の冷却動作について説明する。図17に示すように、冷却装置32eは液晶ユニット2の下方に配置されている。冷却ファン3によって生み出されたファン送風15は、空冷ダクト4内に配置されたブロック30bに衝突する。すると、衝突部（ブロック30bの頂点）で発生した擾乱が上流側に伝播し、局所的な渦変動が励起される。励起された渦変動は、冷却ファン3とブロック30bとの間の衝突空間において増幅され、周期的な圧力変動を形成するエッジトーン現象を発生させる。より厳密に言えば、冷却ダクト4は、冷却ファン3とブロック30bとの間の領域でその径が絞られて細くなっており、この径が絞られた部位とブロック30bの頂点との間の空間領域において渦変動が増幅される。

【0084】

これにより、ファン送風15は、ブロック30bよりも下流側において周期振動を示す（図16参照）。この結果、各R/G/Bごとに設けられたダクト吐出口16へのファン送風15の供給が時間的に切り替えられる。

【0085】

以上のようにして発生した流体自励振動によって、ファン送風15が各ダクト吐出口16から一定の時間周期で断続的に射出され、ファン送風15に大きな脈動成分が付与される。

【0086】

実施例3と同様に、冷却風は、空間的に分離されるのではなく、時間的に分割され、各ダクト吐出口から順次射出される。従って、各液晶ユニットの各板間を通過する冷却風は、高い乱流エネルギーを保持しつつ、間欠的に高速で噴射される。よって、熱伝達率が大幅に改善され、液晶ユニットが効率良く冷却される。

【実施例】

【0087】

次に、本発明の実施例のさらに他例について説明する。ここでは、実施形態3に係る冷却装置を備えた液晶プロジェクタの他例について説明する。図18は、本例の液晶プロジェクタの冷却装置32f及びその近傍の構成を示す模式的断面図である。

【0088】

本例の液晶プロジェクタの基本構成は、実施例1の液晶プロジェクタと同一であり、相違点は冷却装置の構成のみである。よって、実施例1の液晶プロジェクタと同一の構成については、同一の符号を付して説明を省略する。

【0089】

本例の冷却装置32fでは、R/G/Bの各液晶ユニットごとにブロックが設けられている点が実施例5と異なる。より具体的には、各液晶ユニット2を間に挟んで、各ダクト吐出口16と反対側にブロック30cが配置されている。

【0090】

冷却ファン3によって生み出されたファン送風15は、空冷ダクト4内で分岐され、R/G/Bの各液晶ユニット2ごとに設けられた各ダクト吐出口16から射出される。このとき、各液晶ユニット2を挟んで各ダクト吐出口16の反対側にブロック30cが用意されていることによって、液晶ユニット2を構成する入射側偏光板11と液晶パネル12の間、および液晶パネル12と出射側偏光板13の間で、ファン送風15がエッジトーン現象により自励振動し、送風が左右に周期的に揺動される（図19参照）。

【0091】

この場合も、実施例4と同様に、狭い板間内において送風が周期的に左右に揺動することによって、送風に高い乱流成分（送風ベクトルの転回による攪拌作用）が付与され、冷

却効率が大幅に改善される。

【0092】

ところで、本例及び他の実施例の冷却装置では、液晶ユニットを構成する入射側偏光板と液晶パネルの間、および液晶パネルと出射側偏光板の間に供給される冷却風に、各々の手段によって脈動成分を付与することで、熱伝達率を改善し、冷却性能の向上を図っている。この場合、冷却風の脈動は速度変動とともに圧力変動を伴うため、送風による「はたき」の効果も、副次的に得ることができる。

【0093】

従って、冷却ファンによる外気導入の際に、フィルタを通過して空冷ダクト内に侵入した塵埃が、仮に液晶パネルの表面に付着した場合でも、脈動する冷却風によって、塵埃を液晶パネルの表面からはたいて除去することが可能である。この結果、液晶パネルの光透過面を常にクリーンに保ち、投写画像品質を保証することができる。

【図面の簡単な説明】

【0094】

【図1】実施形態1に係る冷却装置の模式的断面図である。

【図2】(a)は通常のダクトの模式的断面図、(b)は図1に示す共鳴ノズルの模式的断面図である。

【図3】実施形態2に係る冷却装置の模式的断面図である。

【図4】実施形態2に係る冷却装置の動作原理を示す模式的断面図である。

【図5】実施形態2に係る冷却装置の他例を示す模式的断面図である。

【図6】実施形態3に係る冷却装置の模式的断面図である。

【図7】実施形態3に係る冷却装置の動作原理を示す模式的断面図である。

【図8】実施例1に係る液晶プロジェクタの冷却装置及びその近傍の構成を示す模式的縦断面図である。

【図9】図8に示す液晶ユニットに供給された冷却風の挙動を示す模式図である。

【図10】実施例2に係る液晶プロジェクタの冷却装置及びその近傍の構成を示す模式的縦断面図である。

【図11】図10に示す液晶ユニットに供給された冷却風の挙動を示す模式図である。

【図12】実施例3に係る液晶プロジェクタの冷却装置及びその近傍の構成を示す模式的横断面図である。

【図13】実施例3に係る液晶プロジェクタの冷却装置及びその近傍の構成を示す模式的縦断面図である。

【図14】実施例4に係る液晶プロジェクタの冷却装置及びその近傍の構成を示す模式的縦断面図である。

【図15】図14に示す液晶ユニットに供給された冷却風の挙動を示す模式図である。

【図16】実施例5に係る液晶プロジェクタの冷却装置及びその近傍の構成を示す模式的横断面図である。

【図17】実施例5に係る液晶プロジェクタの冷却装置及びその近傍の構成を示す模式的縦断面図である。

【図18】実施例6に係る液晶プロジェクタの冷却装置及びその近傍の構成を示す模式的縦断面図である。

【図19】図18に示す液晶ユニットに供給された冷却風の挙動を示す模式図である。

【図20】一般的な液晶プロジェクタの外観及び内部構造を示す斜視図である。

【図21】一般的な液晶プロジェクタの内部構造を示す模式図である。

【図22】従来の液晶プロジェクタが備える冷却装置を示す模式図である。

【図23】液晶パネルに供給される冷却風の風速と動作温度との関係を示す図である。

【図24】液晶パネル及び偏光板の光透過面を示す模式図である。

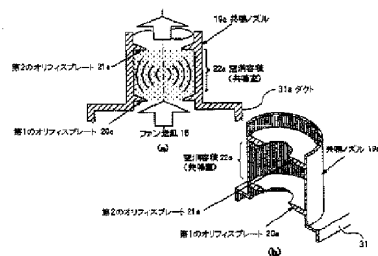
【符号の説明】

【0095】

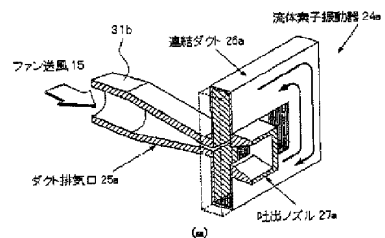
1 液晶プロジェクタ

- 2 液晶ユニット
- 3 冷却ファン
- 4 空冷ダクト
- 11 入射側偏光板
- 12 液晶パネル
- 13 出射側偏光板
- 15 ファン送風
- 16 吐出口
- 19a、19b 共鳴ノズル
- 20a、20b、20c 第1のオリフィスプレート
- 21a、21b、21c 第2のオリフィスプレート
- 22a、22b、22c 共鳴室
- 23a、23b、23c 脈動噴流（共鳴噴流）
- 24a、24b、24c 流体素子振動器
- 25a、25b ダクト排気口
- 26a、26b、26c 連結ダクト
- 27a、27b、27c 吐出ノズル
- 28a、28b、28c 制御口
- 29 圧電素子
- 30a、30b ブロック
- 31 ダクト
- 32a、32b、32c、32d、32e、32f 冷却装置

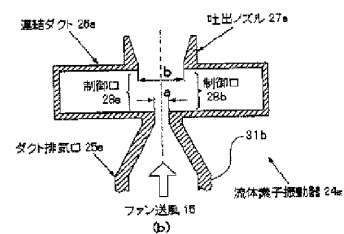
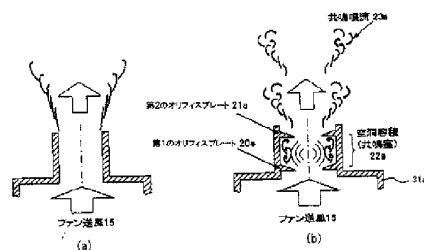
【図1】



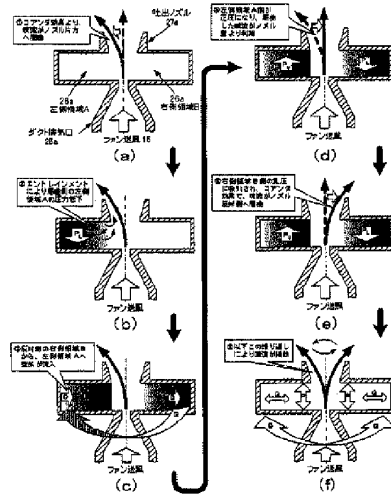
【図3】



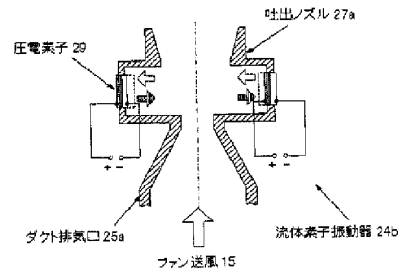
【図2】



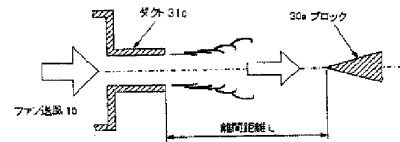
【図4】



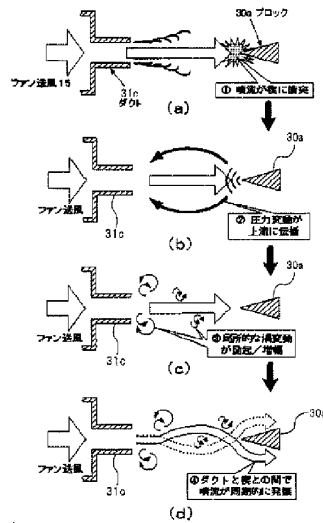
【図5】



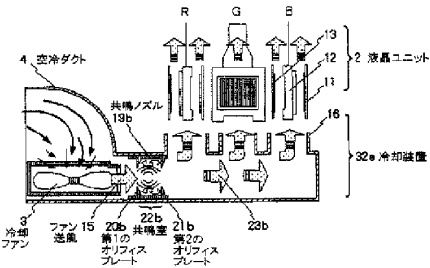
【図6】



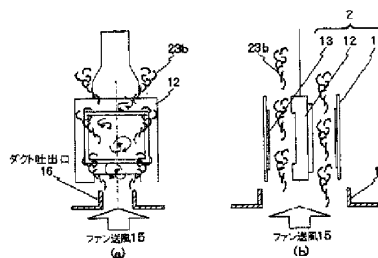
【図7】



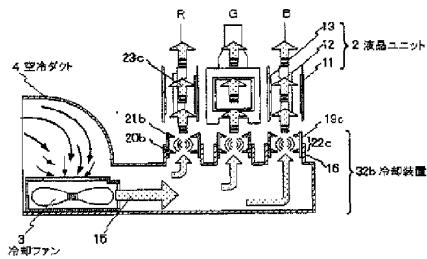
【図8】



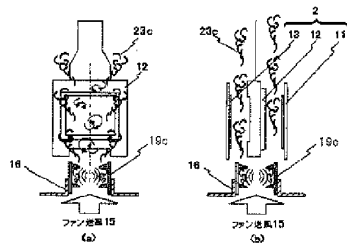
【図9】



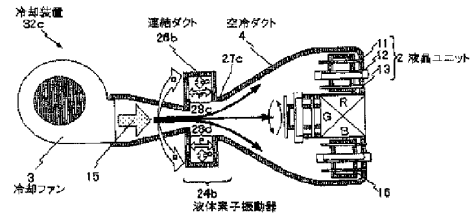
【図10】



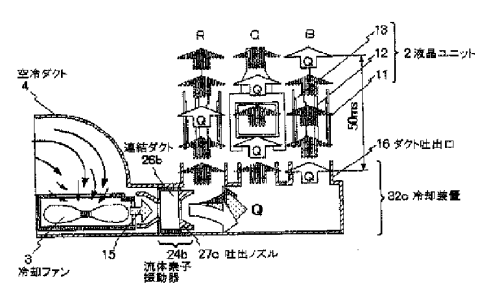
【図11】



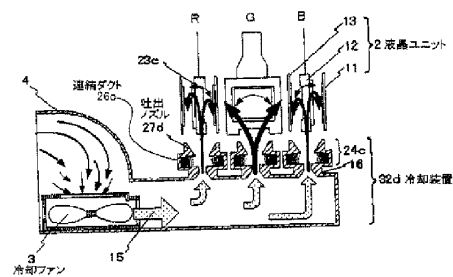
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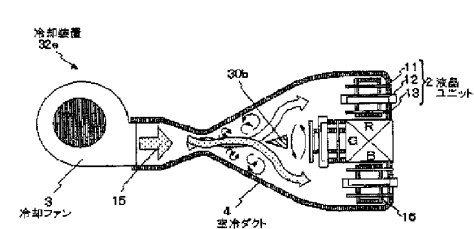
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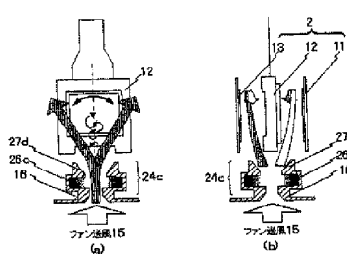
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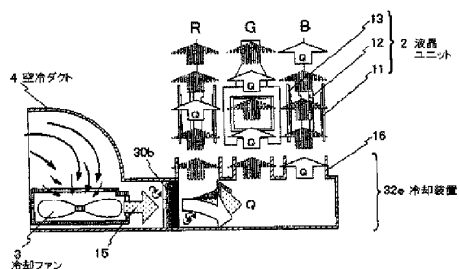
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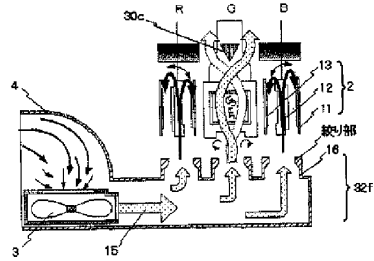
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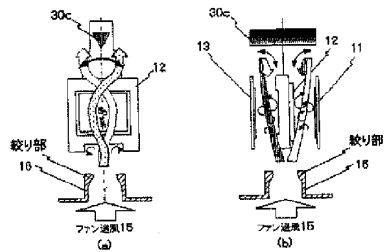
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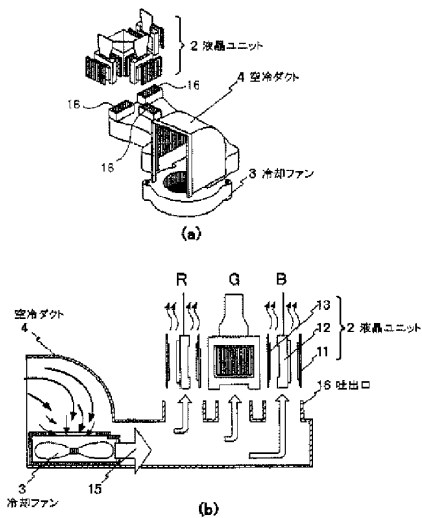
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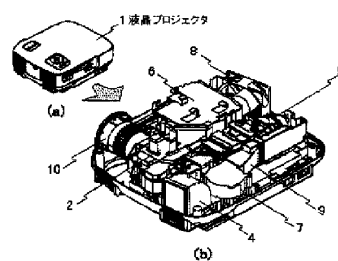
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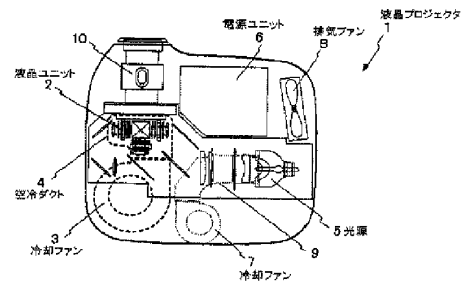
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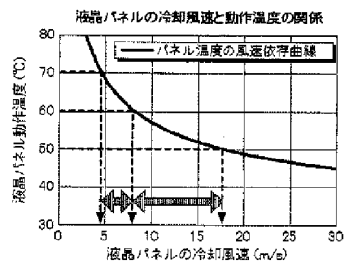
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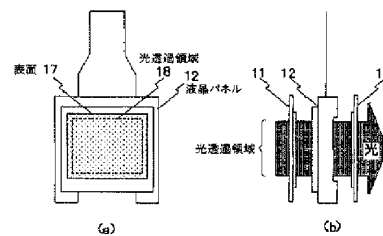
【図21】



【図23】



【図24】



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(54) Title: SYSTEM AND METHOD FOR THERMALLY CONTROLLING AN ELECTRONIC DISPLAY

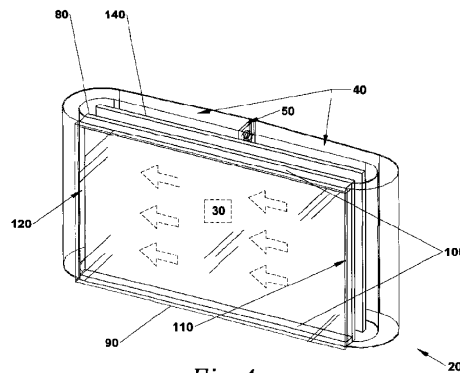


Fig. 4

(57) Abstract: Embodiments relate generally to various thermal control features for electronic displays. One feature comprises a closed loop isolated gas chamber, where a first chamber is in contact with the display surface and transfers heat between the isolated gas and the display surface. A second chamber is in gaseous communication with the first chamber and is adapted to heat or cool the isolated gas and reintroduce the isolated gas into the first chamber. Another feature uses constricted convection to facilitate the cooling of the backlight assembly for the electronic display. Another feature uses an air curtain to further heat or cool the exterior viewing surface of the display. Another feature uses a linear polarizer with an insulating gap to reduce the solar loading of the display stack and provide insulation from the ambient air temperature. Another feature uses a fluid system to contact fluid coolant with the display surface in order to cool the display. Each of the features may be used alone, or in combination to provide the proper operating temperature for the display depending on its desired operating environment.

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System and Method for Thermally Controlling an Electronic Display

Technical Field

[0001] Exemplary embodiments generally relate to heating/cooling systems for electronic displays.

Background of the Art

[0002] Electronic displays are typically used in indoor, temperature-controlled environments. Although the temperature surrounding the display might be relatively stable (near room temperature), the components of the display may generate a large amount of heat. If not properly removed, this heat could damage the display or shorten its lifetime. Conductive and convective heat transfer systems have traditionally been used to remove heat from the electronic components in a display through as many sidewalls of the display as possible. While such heat transfer systems have enjoyed a measure of success in the past, today's electronic displays require even greater cooling (and in some case heating) capabilities.

[0003] Modern electronic displays are now being used in outdoor environments as well as other situations where the surrounding temperature may extend above and below room temperature. In addition to heat transfer from the surrounding air, radiative heat transfer from the sun through a display surface may also become a major factor. In some applications and locations, 200 Watts or more of power through such a display surface is common. Furthermore, the market is demanding larger and brighter, sometimes high definition displays. With increased electronic display size more heat will be absorbed from the sun and more heat will be transmitted into the displays. To compete with the ambient light from the sun as well as reflections off surrounding surfaces, displays must produce more light, which also typically results in more heat generated by the display and/or its backlight assembly.

[0004] Further, in some applications the temperature may drop well below room temperature. Some components of an electronic display may malfunction or may be permanently destroyed by exposure to such low temperatures. For example, the performance of the liquid crystal material in a liquid crystal display (LCD) may be effected by low temperatures.

Summary of the Exemplary Embodiments

[0005] Exemplary embodiments may contain one or more of the thermal control features disclosed herein. A plurality of thermal control features are disclosed and these features may be utilized alone or in any combination. The precise combination of features would depend upon the particular cooling/heating needs of the display at issue, which would depend upon the type of display, size of the display, and its particular environment. The embodiments may be practiced with any form of electronic display, including but not limited to: LCD, light emitting diode (LED), organic light emitting diode (OLED), field emitting display (FED), cathode ray tube (CRT), plasma, and projection displays. An exemplary embodiment would be practiced with LCD displays.

[0006] One thermal feature relates to an isolated gas cooling system. The gas cooling system is preferably a closed loop which includes a first gas chamber comprising a transparent anterior plate and a second gas chamber comprising a cooling plenum. The first gas chamber is anterior to and coextensive with the viewable face of the electronic display. The transparent anterior plate may be set forward of the electronic display surface, defining the depth of the first gas chamber. A cooling chamber fan, or equivalent means, may be located within the cooling plenum and may be used to propel gas around the isolated gas cooling chamber loop. As the gas traverses the first gas chamber it contacts the electronic display surface, absorbing heat from the display surface. Because the gas and the relevant surfaces of the first gas chamber are transparent, the image quality remains excellent. After the gas has traversed the transparent first gas chamber, the gas may be directed into the rear cooling plenum where it is cooled.

[0007] Another thermal feature may utilize the isolated gas system as a heating device, either instead of or in addition to its cooling abilities. An isolated gas heating system would also be a closed loop system with a first gas chamber anterior to the display surface and a second chamber comprising a heating plenum or cooling/heating plenum. Heating elements may be placed within the plenum in order to heat the gas within the second chamber. As the gas is forced into the first chamber it may transfer its heat to the display surface. The gas may then return to the plenum for another heating cycle. The plenum may function as a cooling plenum only, heating plenum only, or a combination heating/cooling plenum; all depending upon the particular display and its particular operating environment.

[0008] Some embodiments may place electronic components used to operate the electronic display within the plenum of the isolated gas chamber. The electronic components may include, but are not limited to: transformers, circuit boards, processors, resistors, capacitors, batteries, motors, power supplies, illumination devices, wiring and wiring harnesses, and switches. If the plenum is being utilized as a cooling plenum, the cool gas within the plenum can further aid in the cooling of the electronic components, which will naturally generate heat during operation. Further, if the plenum is being utilized as a source of heat for the display, the natural heat from the electronic components can also heat the gas in the plenum, reducing the amount of energy which needs to be applied to the heating elements.

[0009] A linear polarizer may be used in some embodiments to further reduce the solar loading on the electronic display. This polarizer can be used in combination with the isolated gas chamber, or may simply be placed anterior to the electronic display with an insulating gap between the polarizer and the display. The insulating gap reduces the amount of heat that is transferred between the polarizer and the display.

[0010] Some electronic displays, such as LCDs for example, require a backlight assembly to produce an image upon the display surface. The backlight assemblies are typically a large source of heat for the display. Thus, some embodiments may utilize a constricted convection system to cool the backlight unit for the display. The constricted convection system may comprise a constricted convection plate which is placed in close proximity to the backlight assembly in order to define a gap. Gas is forced

through the gap in order to facilitate more efficient cooling of the backlight assembly. In some embodiments a wall of the plenum may constitute the constricted convection plate.

[0011] Some embodiments may also utilize an air curtain device which forces air (either warm or cold) over the exterior surface of the display assembly.

[0012] Finally, some embodiments may use a fluid assembly which contacts a fluid against the display surface in order to cool it. The fluid may be a substantially clear form of coolant fluid which is pumped through an anterior cavity which includes the display surface.

Brief Description of the Drawings

[0013] A better understanding of the exemplary embodiments 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:

[0014] **FIGURE 1** is a perspective view of an exemplary embodiment in conjunction with an exemplary electronic display.

[0015] **FIGURE 2** is an exploded perspective view of an exemplary embodiment showing components of the isolated gas cooling system.

[0016] **FIGURE 3** is top plan view of an exemplary embodiment of the cooling chamber.

[0017] **FIGURE 4** is a front perspective view of an embodiment of the isolated cooling chamber, particularly the transparent anterior surface of first gas chamber.

[0018] **FIGURE 5** is a rear perspective view of an embodiment of the isolated cooling chamber, showing optional electrical components placed in the plenum.

[0019] **FIGURE 6** is a rear perspective view of an embodiment of the isolated cooling chamber showing surface features that may be included on the plenum

[0020] **FIGURE 7** is a top plan view of an exemplary embodiment of the cooling chamber showing surface features that may be included on the plenum.

[0021] **FIGURE 8** is a front perspective view of an embodiment of the isolated cooling chamber with included thermoelectric modules.

- [0022] **FIGURE 9** is a top plan view of an exemplary embodiment of the cooling chamber with included thermoelectric modules.
- [0023] **FIGURE 10** is an exploded perspective view of an exemplary embodiment showing components of the isolated gas cooling system.
- [0024] **FIGURE 11** is a top plan view of an exemplary embodiment of the heating chamber.
- [0025] **FIGURE 12** is a rear perspective view of an embodiment of the heating chamber, showing optional electrical components and heating elements.
- [0026] **FIGURES 13 and 14** are cross-sectional views of exemplary embodiments for utilizing a linear polarizer with the isolated gas system or an insulating gap.
- [0027] **FIGURES 15A and 15B** are side views of exemplary embodiments of the constricted convection cooling system with a constricted convection plate.
- [0028] **FIGURE 16** is a top plan view of an exemplary embodiment where the cooling plenum is utilized as the constricted convection plate.
- [0029] **FIGURES 17A-17C** are cross-sectional views of embodiments where the cooling plenum is utilized as the constricted convection plate.
- [0030] **FIGURE 18** is a front plan view of a display utilizing an air curtain device.
- [0031] **FIGURE 19** is a cross-sectional view of a display utilizing an air curtain device.
- [0032] **FIGURE 20** is an illustration showing the components for a liquid cooled display.

Detailed Description

[0033] It is to be understood that the spirit and scope of the disclosed embodiments includes thermally controlling displays including, but not limited to LCDs. For simple explanation purposes, embodiments may be described with respect to the components for LCD displays. By way of example and not by way of limitation, embodiments may be used in conjunction with displays selected from among LCD, light emitting diode (LED), organic light emitting diode (OLED), field emitting display (FED), cathode ray tube (CRT), plasma, and projection displays. Furthermore, embodiments may be used

with displays of other types including those not yet discovered. In particular, it is contemplated that embodiments may be well suited for use with full color, flat panel OLED displays. Further, it is particularly contemplated that embodiments may be used with relatively large, high definition LCD displays. While the embodiments described herein are well suited for outdoor environments, they may also be appropriate for indoor applications (e.g., factory environments, coolers/freezers, etc.) where thermal stability of the display may be at risk.

Isolated Gas Cooling System

[0034] As shown in FIGURE 1, when the display 10 is exposed to outdoor elements, the temperatures inside the display 10 may vary greatly without some kind of cooling device. As such, the display 10 may not function properly or may have a greatly reduced life span. Direct sunlight is especially problematic in causing increases in the internal temperature of the display 10.

[0035] In Figure 1, the display area of the electronic display shown includes a narrow gas chamber that is anterior to and coextensive with the electronic display surface. The display shown is also equipped with an optional air curtain device 114. The air curtain device 114 is discussed in detail below. Optionally, the display may have a reflection shield 119, to mitigate reflection of the sunlight on the display surface. Additionally, in outdoor environments, housing 70 is preferably a color which reflects sunlight.

[0036] As shown in FIGURE 2, an exemplary embodiment of the electronic display 10 includes an isolated gas cooling chamber 20 contained within a display housing 70. A transparent first gas chamber is defined by spacers 100 and transparent front plate 90. A second transparent front plate 130 may be laminated to front plate 90 to help prevent breakage of front plate 90 and protect the interior of the display. Cooling chamber 20 surrounds a display stack 80 and associated backlight assembly 140.

[0037] The display 10 may include means for cooling gas contained within the second gas chamber. This means may include one or more fans 60 which may be positioned at the base of the display housing 70. The fans 60 may ingest cool air and force the cooler ingested air over at least one external surface of a posterior cooling plenum 45. If desired, an air conditioner (not shown) may also be utilized to cool the air which

contacts the external surface of plenum 45. Alternatively, the fans 60 may simply ingest ambient air.

[0038] Referring to FIGURE 3, embodiments of the isolated gas cooling chamber 20 may comprise a closed loop which includes a first gas chamber 30 and a second gas chamber 40. The first gas chamber includes a transparent plate 90. The second gas chamber comprises a cooling plenum 45. The term "isolated gas" refers to the fact that the gas within the isolated gas cooling chamber 20 is essentially isolated from external air in the housing of the display. Because the first gas chamber 30 is positioned in front of the electronic display surface 85, the gas should be substantially free of dust or other contaminants that might negatively affect the display image. An optional filter (not shown) may be utilized to assist in preventing contaminants and dust from entering the first gas chamber 30.

[0039] The isolated gas may be almost any transparent gas, for example, 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 20 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.

[0040] In the closed loop configuration shown in Fig. 3, the first gas chamber 30 is in gaseous communication with the second gas chamber 40. A cooling chamber fan 50 may be provided within the cooling plenum 45 and utilized to propel gas around the isolated gas cooling chamber 20. The first gas chamber 30 includes at least one front glass 90 mounted in front of an electronic display surface 85.

[0041] Referring to FIGURE 4, the front plate 90 may be set forward from the electronic display surface 85 by spacing members 100. The spacing members 100 define the depth of the narrow channel passing in front of the electronic display surface 85. The spacing members 100 may be independent or alternatively may be integral with some other component of the device (e.g., integral with the front plate 90). The electronic display surface 85, the spacing members 100, and the transparent front plate 90 define a first gas chamber 30. The chamber 30 is in gaseous communication with plenum 45 through entrance opening 110 and exit opening 120.

[0042] As shown in Fig. 3, a posterior surface of the first gas chamber 30 preferably comprises the electronic display surface 85 of the display stack 80. As the isolated gas in the first gas chamber 30 traverses the display it contacts the electronic display surface 85. Contacting the cooling gas directly to the electronic display surface 85 enhances the convective heat transfer away from the electronic display surface 85. In exemplary embodiments the electronic display surface 85 comprises the posterior surface of the first gas chamber 30. Accordingly, the term “electronic display surface” refers to the front surface of a typical electronic display (in the absence of the embodiments disclosed herein).

[0043] In an exemplary embodiment, the electronic display surface 85, front plate 90, and optional second front plate 130 may be comprised of a glass substrate. However, neither display surface 85, nor transparent front plate 90, nor optional second transparent front plate 130 need necessarily be glass. Thus, the term “glass” may be used herein interchangeably with the term plate, but a glass material is by no means required. Further, electronic display surface 85 does not have to comprise the posterior surface wall of the front gas compartment 30. An additional plate may be used. However, by utilizing the electronic display surface 85 as the posterior surface wall of the gas compartment 30, there may be fewer surfaces to impact the visible light traveling through the display. Furthermore, the device will be lighter and cheaper to manufacturer.

[0044] Although the embodiment shown utilizes the electronic display surface 85, certain modifications and/or coatings (e.g., anti-reflective coatings) may be added to the electronic display surface 85, 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 electronic display surface 85 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 first gas chamber 30 to contact the electronic display surface 85 directly. In this way, the convective transfer of heat from the display components to the circulating gas will be maximized.

[0045] Referring to Fig. 4, the front plate 90 of the first gas chamber 30 is transparent and is positioned anterior to the electronic display surface 85. The arrows shown represent the movement of the isolated gas through the first gas chamber 30. As shown, the isolated gas traverses the first gas chamber 30 in a horizontal direction. Although cooling system 20 may be designed to move the gas in either a horizontal or a vertical direction, it is preferable to propel the gas in a horizontal direction. In this way, if dust or contaminants do enter the first gas chamber 30, they will tend to fall to the bottom of chamber 30 outside of the viewable area of the display. The system may move air left to right, or alternatively, right to left. After the gas traverses the first gas chamber 30 it exits through exit opening 120. Exit opening 120 defines the entrance junction into the rear cooling plenum 45.

[0046] FIGURE 5 shows a schematic of the rear cooling plenum (illustrated as transparent for explanation). One or more fans 50 within the plenum may provide the force necessary to move the isolated gas through the isolated gas cooling chamber. Whereas the first gas chamber 30 was designed to collect heat from the surface 85 of the display, the second gas chamber 40 is designed to extract the heat from the gas and remove the heat from the cooling chamber 20. The second chamber 40 may have various contours and features to accommodate the internal structures within a given electronic display application.

[0047] If desired, various electronic components 200 can be placed anywhere throughout the second gas chamber 40. The electronic components 200 may include, but are not limited to: transformers, circuit boards, processors, resistors, capacitors, batteries, motors, power supplies, illumination devices, wiring and wiring harnesses, and switches. These components can be mounted directly on the walls of the chamber or supported on rods or posts 209. Thus, the cooling plenum can be designed to not only extract heat from the first gas chamber 30 but also to cool these various electronic components 200. (Additionally, as discussed below, if the isolated gas system is used to heat the display, the electronic components can assist in heating the isolated gas.)

[0048] Referring now to FIGURES 6 and 7, various surface features 150 may be added to improve heat dissipation from the plenum 45. These surface features 150 provide more surface area to radiate heat away from the gas within the second gas

chamber 40. These features 150 may be positioned at numerous locations on the surface of the plenum 45.

[0049] Referring now to FIGURES 8 and 9, one or more thermoelectric modules 160 may be positioned on at least one surface of the plenum 45 to further cool the gas contained in the second gas chamber 40. The thermoelectric modules 160 may be used independently or in conjunction with surface features 150. Alternatively, thermoelectric modules 160 may be used to heat the gas in the plenum if the isolated gas system is utilized to heat a display in a cold environment.

[0050] FIGURE 10 shows an exemplary method for removing heat in the gas contained in the rear plenum 45. Fan 60 may be positioned to ingest air and blow that air across the anterior and posterior surfaces of the plenum 45. Again, fan 60 may ingest air conditioned air into the display housing 70 or may simply ingest ambient surrounding air. Furthermore, in this configuration, fan 60 may also force air past the heat generating components of the electronic display (e.g., the display stack 80 and the backlight assembly 140) to further improve the ability to cool the entire display. It should be noted that this embodiment can be combined with the constricted convection cooling method discussed in detail below. The heated exhaust air may exit through one or more apertures 179 located on the display housing 70.

Isolated Gas Heating System

[0051] As mentioned above, the isolated gas system can be utilized to also heat the electronic display. Referring to FIGURES 11 and 12, heating elements 220 may be located within the second gas chamber 40 and operate to warm the gas as it passes through the second gas chamber 40. These heating elements can be any one of the many commonly available heating elements or thermoelectric modules. Many times, these elements are simply a material which contains a high electrical resistance, and thus generates heat when current flows through it. The heating elements can be, but are not limited to, any one of the following: nichrome wire or ribbon, screen printed metal/ceramic tracks deposited on ceramic insulated metal (generally steel) plates, CalRod (typically a fine coil of nichrome wire in a ceramic binder, sealed inside a tough metal shell), heat lamp, and Positive Thermal Coefficient (PTC) of resistance ceramic.

[0052] As discussed above, the plenum 45 may contain electrical components 200 which power and control the electronic display. The electrical components may be any one of the following: transformers, microprocessors, printed circuit boards, power supplies, resistors, capacitors, motors, wiring harnesses, and connectors. The electrical connections for the electrical components 200 may pass through a wall of the plenum 45. The electrical components 200 can be located anywhere within the plenum 45. The electrical components 200 may be mounted on the posterior or anterior surface of the plenum and may be mounted directly on the surface of the plenum or may be suspended by mounting posts so that gas may pass all around the component.

[0053] While the display is operational, the isolated gas cooling system may run continuously. However, if desired, a temperature sensor (not shown) and a switch (not shown) may be incorporated within the electronic display. Thus, a thermostat may be used to detect when temperatures have reached a predetermined threshold value and the isolated gas system may be selectively engaged when the temperature in the display reaches a predetermined value. Predetermined temperature thresholds may be selected and the system may be configured to heat, cool, or both heat and cool the display to advantageously keep the display within an acceptable temperature range.

Linear Polarizer with Optional Insulator Gap

[0054] FIGURE 13 is a cross-sectional view of another exemplary embodiment for another thermal control feature. In the arrangement shown, the front plate 90 and a second front plate 130 may be comprised of glass and may be laminated together. The first and second front panels 130 and 90 may be fixed to one another with a layer of index matched optical adhesive 201 to form a front glass unit 206. The display stack 80 may comprise a liquid crystal assembly 212 interposed between a front polarizer 216 and a rear polarizer 214. In other embodiments, the display stack 80 may be any other type of assembly for any other type of electronic display. The space between the display stack 80 and the front glass unit 206 defines an insulator gap 300. The insulator gap 300 serves to thermally separate the front glass unit 206 from the LCD stack 80. This thermal separation localizes the heat on the front glass unit rather than allowing solar loading of the LCD stack. If used in combination with the isolated gas system, the insulator gap 300 may comprise the first gas chamber 30. In other

embodiments, the insulator gap 300 may be used without the isolated gas system simply as a layer of insulation from both the ambient air as well as solar loading.

[0055] The second front panel may have a first surface 202 and a second surface 208. The first surface 202 may be exposed to the elements; while the second surface 208 may be fixed to the first front plate 90 by the index matched optical adhesive 201. The first front plate 90 may have a third surface 209 and a fourth surface 204. The third surface 209 may be fixed to the second front plate 130 by the index matched optical adhesive 201; while the fourth surface may be directly adjacent to the insulator gap 300. In some embodiments, to decrease the solar loading of the display stack 80 and improve the viewable image quality, an anti-reflective coating may be applied to the first surface 202 and the fourth surface 204. In other embodiments, the anti-reflective coating may only be applied to at least one of the first, second, third, or fourth surface 202, 208, 209, and 204, respectively.

[0056] FIGURE 14 is a cross-sectional view of another exemplary embodiment of the front glass unit 206. In the arrangement shown, the front glass unit 206 comprises a second front plate 130, a layer of index matched optical adhesive 201, a linear polarizer 400, and a first front plate 90. The linear polarizer 400 may be bonded to at least one of the first, second, third or fourth surfaces 202, 208, 209, and 204, respectively. Again, anti-reflective layers may be applied to at least one of the first, second, third or fourth surfaces 202, 208, 209, and 204, respectively. The linear polarizer 400 may be aligned with the front polarizer 209 found in the LCD stack 85. The inclusion of a linear polarizer 400 in the front glass unit 206, further decreases the solar load on the display stack 80. The reduction in solar loading may significantly reduce the internal temperature of the electronic display. The linear polarizer 300 may also cause a reduction in specular reflection of the front glass unit 206 and the display stack 80. As discussed above, if used in combination with the isolated gas system, the insulator gap 300 may comprise the first gas chamber 30. In other embodiments, the insulator gap 300 may be used without the isolated gas system simply as a layer of insulation from both the ambient air as well as solar loading. Again, it should be noted that the display stack 80 may be an LCD stack, but it can also be any other type of electronic display.

[0057] It should also be noted that the second front plate 130 is not required. Embodiments may utilize only the first front plate 90 with a linear polarizer attached to either the posterior or anterior surface of the front plate 90. An anti-reflective layer may also be attached to either the anterior or posterior surface of the front plate 90. The front plate 90 may be tempered for additional strength if using only the front plate 90 without the second front plate 130.

Constricted Convection

[0058] Some types of electronic displays require a backlight assembly in order to generate an image upon a viewable screen. LCDs are one type of display that requires a backlight assembly. Other types of displays, such as plasma displays and OLEDs, do not require a backlight assembly as they generate light themselves. However, these types of displays still generate a significant amount of heat. Thus, in the foregoing description, the constricted convection system will be described with regard to a backlight assembly, but it should be noted that the embodiments can be practiced with other types of displays. Therefore, when a backlight or backlight assemblies are discussed, these assemblies could also be the rear surfaces of other heat-generating displays and the constricted convection system would facilitate more efficient cooling of these alternate displays. It should also be noted that Figures 15A-15B and Figures 17A-17C are not necessarily drawn to scale. The relationship between the elements may be exaggerated for explanatory purposes.

[0059] FIGURE 15A shows a cross-sectional view of the backlight 140 with the constricted convection plate 300, the space between the two features defines a narrow gap 305. The dimensions of the gap may vary depending on several factors including the size of the display, its operating conditions, the type of backlight assembly and its posterior surface material, and the number and power applied to the various constricted convection fans. Some exemplary embodiments may utilize a gap distance of approximately 0.25-3.5 inches. Other embodiments may utilize a slightly larger gap. It has been found that forcing air through this gap 305 increases the ability to cool the backlight 140. One or more constricted convection fans 310 may be used to pull air through the gap 305. FIGURE 15B shows a cross-sectional view of another

embodiment for the constricted convection system where one or more constricted convection fans 310 push air through the gap 305.

[0060] FIGURE 16 shows a top view of the isolated gas system as discussed above. The cross-section line 17-17 is shown passing through the isolated gas system.

[0061] FIGURES 17A-17C show cross-sectional views of the 17-17 section that is shown in Figure 16. Referring first to Figure 17A, towards the front of the display is the first gas chamber 30 which abuts against the electronic display 80. Anterior to the first gas chamber 30 is the front plate 90. Towards the rear of the display, the backlight 140 is placed in close proximity to the second gas chamber 40. In this arrangement, the outer wall of the second gas chamber 40 may function as the constricted convection plate. This embodiment does not utilize a constrictive convection fan, but instead uses the fan 60 which ingest air from outside the display housing and forces it over the surfaces of the second gas chamber 40. As noted above, this air may simply be ambient air or alternatively this air may come from a conditioning unit (not shown). To facilitate the flow of air between the backlight 140 and the cooling chamber 40, a guiding device 320 may be used.

[0062] Referring now to Figure 17B, the cooling chamber 40 contains a guiding feature 41, which is used in combination with the guiding device 320 to facilitate the flow of air between the backlight and the cooling chamber. Figure 17C shows another embodiment, where both the external fan 60 and the constrictive convection fan 310 is used. This embodiment could also utilize a version of the guiding devices shown in Figures 17A and 17B.

[0063] The backlight 140 may comprise a printed circuit board (PCB) with a plurality of lights mounted to the side facing the electronic display 80. The lights in the backlight may be any one of the following: LED's, organic light emitting diodes (OLED), field emitting display (FED), light emitting polymer (LEP), or organic electro-luminescence (OEL) lights. In an exemplary embodiment, the backlight 140 would ideally have a low level of thermal resistance between the side facing the electronic display 80 and the side facing the second gas chamber. To accomplish this low level of thermal resistance, the backlight 140 may be built using metal printed circuit board (PCB) technology to further transfer heat away from the lights. The rear surface of the

backlight 140 may also be metallic, or some other thermally conductive material, to further enhance the convective heat transferring properties. The surface may even have a plurality of surface features such as fins to further enhance the convective heat transferring properties. The constrictive convective fan 310 may then send the warm air out of an exhaust 179 (shown in Figure 2) so that it may exit the display housing entirely.

[0064] While the display is operational, the external fan 60 and the constrictive convection fan 310 may run continuously. However, if desired, a temperature sensor (not shown) and a switch (not shown) may be incorporated within the electronic display. This effective thermostat may be used to detect when temperatures have reached a predetermined threshold value. In such a case, the various 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 with a thermostat (not shown) to advantageously keep the display within an acceptable temperature range. This would save on both energy costs as well as the useful lifetime of the devices.

Air Curtain

[0065] In addition to the various thermal control features discussed above, an air curtain device can also be used. The air curtain device may be used alone, or in combination with any of the other thermal control features discussed above.

[0066] FIGURE 18 shows an electronic display 10, having a housing 70 and a front plate 90. The air baffles 114 for the air curtain can be seen as a broken line in the figure. Cross-section line 19-19 can also be seen in this figure.

[0067] FIGURE 19 shows the cross-sectional view from the line 19-19 shown in Figure 18. This figure shows the circulation of air through the housing 70 when fans 60 are actuated. As discussed above, fans 60 ingest air into the housing 70 through entrance 51. This air may be ambient air or alternatively may be air conditioned air. The flow of ingested air is shown as arrow 111. Once inside the display housing 70, the air may flow upwards along flow arrow 121. This air may be utilized with any of the above mentioned thermal control features. For example, this air may be used to cool

the isolated gas within the second chamber (plenum) or may be used with the constricted convection system described above.

[0068] For explanatory purposes, the details of the internal components of the display have been omitted from this figure and only a cavity 61 is shown. It should be noted, that the air curtain can be practiced with any type of electronic display and with any combination of the thermal control features described above. Various internal features (not shown) may be placed within the cavity 61 to direct the air towards the baffles 114. The ingested air may continue through the cavity 61 along arrow 121 until it reaches the baffles 114 which may direct the air against the exterior display surface. This exterior surface may be the first front plate 90, or alternatively, any of the additional front plates which are described in detail above (ex. second front plate 130).

[0069] Thus, the air curtain can be used as an exhaust for the cooling of internal components of the display. Alternatively, the cool air from the air curtain can be used to further cool the exterior front surface of the display which may be subjected to significant solar loading or heat transfer from ambient hot air.

Fluid Cooling System

[0070] FIGURE 20 is an explanatory schematic illustrating another thermal control feature. As may be appreciated from the drawing, the cooling system 22 includes various components in fluid communication. Preferably, this may be accomplished by connecting the components with a series of tubes or pipes (illustrated conceptually as dotted lines). The cooling system 22 components include a reservoir tank 37, a pump 47, and a cooling chamber 4 in fluid communication. Preferably, the system also includes a filter 83 and a radiator 72, also in fluid communication. Optionally, the system may also include a fan unit 94. However, the optional fan unit is preferably not in fluid communication with the other components.

[0071] Reservoir tank 37 holds the primary volume of coolant fluid and provides surface area to conduct heat away from the fluid while it is contained in the tank 37. The tank has at least two openings, an exit port 13 and a return port 14. Optionally, the reservoir tank includes a ventilation port 66. Pump 47 causes the coolant fluid to move through the system 22. As may be appreciated by those skilled in the art, pump 47 may be located at a number of locations along the coolant fluid pathway with suitable

results. However, in order to minimize curvature of plates 44 and 128, it is preferable to position pump 47 after the cooling chamber 4 so that the pump actually pulls liquid coolant from the bottom to the top of cooling chamber 4. If the pump is so positioned, engaging the pump creates an area of low pressure at the top of the cooling chamber 4. In this way fluid flows through the cooling chamber 4 according to the arrows. Due to the "slipperiness" of some coolant fluids, pump 47 is preferably a positive displacement pump.

[0072] In order to regulate the flow of coolant fluid through the cooling chamber, a bypass line with a valve 634 may be provided. The bypass line provides a bypass route for coolant fluid to bypass the cooling chamber 4. The valve 634 is adapted to facilitate control over the amount of coolant fluid diverted through the bypass line. The bypass line and valve 634 allow a predetermined portion of coolant fluid to be diverted away from the flow directed to the cooling chamber 4 and thereby facilitate control over the flow rate through the cooling chamber itself. In this way, the flow rate through the cooling chamber may be regulated.

[0073] As one skilled in the art will appreciate, other methods and devices may also be used to regulate the flow through the cooling chamber. For example, the size and pump speed of pump 47 may be optimized for a given application. Alternatively, a variable speed pump may also be used. Preferably, the variable speed pump may be in electrical communication with at least one pressure transducer (not shown). Preferably, a pressure transducer may be placed upstream of the cooling chamber 4 and another pressure transducer may be placed downstream of the cooling chamber 4. The pressure information provided by the at least one pressure transducer may be utilized to set the operating speed of the variable speed pump. In that way, the flow rate through the cooling chamber 4 may be adjusted to maintain appropriate pressures in the device. Maintaining appropriate pressures in the cooling chamber 4 is important for preventing deformation or breakage of the display glass.

[0074] An optional filter 83 may be added to remove contamination in the fluid. Preferably, a radiator 72 and fan unit 94 may also be included to provide even greater thermal stability. Optionally, a spigot (not shown) may be provided to facilitate the process of filling and emptying the coolant fluid from the system.

[0075] In operation, fluid exits the reservoir tank 37 from an output port 13 which may be located beneath the tank 37. On its way to the cooling chamber 4, the fluid passes through optional filter 83. From the filter 83, the fluid next enters the cooling chamber 4 through inlet 98 of manifold 59. The fluid coolant travels up through the fluid compartment of the cooling chamber 4 in the direction indicated (dash arrows). The coolant fluid exits cooling chamber 4 through outlet 99 of the upper manifold 60. Preferably, the fluid is then received by an optional radiator 72. While traveling through the optional radiator 72, an optional fan unit 94 may force air past the radiator 72 to assist in transferring heat away from the coolant fluid. Pump 47, which may be positioned after the radiator 72, can pull the fluid toward the reservoir tank. The fluid is received into the reservoir tank 37 through return port 14. Preferably, return port 14 may be disposed at a location that is relatively distant from exit port 13 so as to allow the returning fluid the maximum opportunity to cool before it exits the reservoir tank 37 through port 13.

[0076] If desired, fan units may be located at the base of the housing 75 just behind the cooling chamber 4 of display 15. Fan units may provide a laminar flow of air through the interior of the housing 75. Preferably, the airflow will be directed across at least one external surface of reservoir tank 37. As described above, the air exhaust flow may ultimately be redirected onto the cooling chamber surface 44 by way of an optional air curtain system 114.

[0077] If desired, a temperature sensor (not shown) and a switch (not shown) may be incorporated within the electronic display. The temperature sensor may be used to detect when temperatures have reached a predetermined threshold value. In such a case, the pump can be selectively engaged when the temperature in the display meets a predetermined value. Predetermined thresholds may be selected and the system may be configured with a thermostat (not shown) to advantageously keep the display at a relatively constant temperature, or at least within a range of acceptable temperatures. Alternatively, to avoid the need for a thermostat, the pump 47 may run continuously when the electronic display is operational.

CLAIMS

1. A thermal control system for an electronic display having a display surface and a backlight assembly, the system comprising:

a first gas chamber positioned anterior to the electronic display surface, said first gas chamber having an entrance, exit, and exterior surface;

a second gas chamber in gaseous communication with the entrance and exit of said first gas chamber and positioned posterior to the electronic display surface, said second gas chamber having interior and exterior surfaces;

one or more chamber fans within said second gas chamber to propel gas around the first and second gas chambers; and

means for cooling the isolated gas which is contained within the second gas chamber.

2. The system of claim 1, wherein the means for cooling the isolated gas comprises:

one or more exterior fans adapted to force air over the exterior surfaces of the second gas chamber.

3. The system of claim 1, further comprising:

one or more of the electronic components for operating the electronic display, contained within said second gas chamber.

4. The system of claim 2, further comprising:

one or more surface features on the exterior surfaces of the second gas chamber.

5. The system of claim 1, further comprising:
a means for heating the gas which is contained within the second gas chamber.
6. The system of claim 5, wherein:
the means for heating the gas which is contained within the second gas chamber
comprises one or more heating elements within the second gas chamber.
7. The system of claim 1, wherein:
an exterior surface of the second gas chamber is placed in close proximity to the
backlight assembly, the space between the backlight assembly and the
exterior chamber surface defining a gap, the system further comprising:
one or more constricted convection fans adapted to draw air through said gap.
8. The system of one of claims 1-4, and 7, further comprising:
an air curtain device adapted to force air across the exterior surface of said first
gas chamber.
9. The system of one of claims 1-4 and 7-8 further comprising:
a linear polarizer placed anterior to said first gas chamber.
10. The system of one of claims 2-9, further comprising:
a temperature sensing device adapted to measure the temperature of the display
surface;

a switch in communication with said temperature sensing device and said chamber and exterior fans; and

wherein the fans are switched on when the temperature of the display surface reaches a threshold value.

11. The system of one of claims 1-10 further comprising:

a filter within the second gas chamber.

12. The system of one of claims 2-4 and 7-11 wherein:

said one or more exterior fans are forcing air over the exterior surfaces of the second gas chamber which has been air conditioned.

13. A thermally controlled electronic display comprising:

a display stack;

a backlight assembly positioned posterior to said display stack and having a posterior surface;

a constricted convection plate in close proximity to the posterior surface of said backlight assembly, the space between the convection plate and the posterior surface of the backlight assembly defining a gap;

one or more constricted convection fans adapted to draw air through said gap;

a first plate of anti-reflective glass positioned anterior to said display stack, the space between said anti-reflective glass and said display stack defining an insulating gap;

a linear polarizer positioned anterior to said first plate; and

a second plate of anti-reflective glass positioned anterior to said linear polarizer.

14. The display of claim 13 further comprising:

an air curtain device adapted to force air upon the second plate of anti-reflective glass.

15. The display of one of claims 13 and 14 wherein said backlight assembly comprises:

a printed circuit board (PCB) with an anterior and posterior surface;

a plurality of LEDs attached to the anterior surface of said PCB; and

a metallic coating applied to the posterior surface of said PCB.

16. The display of one of claims 13-15 the display further comprising:

a first gas chamber comprising said insulating gap and having an entrance and exit,

a second gas chamber in gaseous communication with the entrance and exit of said first gas chamber and positioned posterior to the electronic display surface, said second gas chamber having interior and exterior surfaces;

one or more chamber fans within said second gas chamber to propel gas around the first and second gas chambers; and

means for cooling the gas contained within the second gas chamber.

17. A method for thermally controlling an electronic display having a display surface and a backlight assembly, comprising the steps of:

providing an isolated gas system comprising a first gas chamber which is in contact with the electronic display surface and a second gas chamber in gaseous communication with said first gas chamber;

forcing isolated gas into the first gas chamber;

transferring heat from the electronic display surface to the isolated gas;

directing the isolated gas into the second gas chamber;

cooling the isolated gas in the second gas chamber if cooling is desired; and

reintroducing the isolated gas into the first gas chamber.

18. The method of claim 17, wherein the cooling step comprises the steps of:

transferring heat from the isolated gas to the walls of the second chamber;

forcing air over the walls of the second chamber; and

transferring heat from the walls of the second chamber to the air.

19. The method of claim 17, further comprising the step of:

heating the isolated gas within the second chamber if heating is desired.

20. The method of claims 17-19, further comprising the steps of:

providing a constrictive convection plate posterior to the backlight assembly, the area between the constrictive convection plate and the backlight assembly defining a gap;

forcing air through said gap in order to cool the backlight assembly.

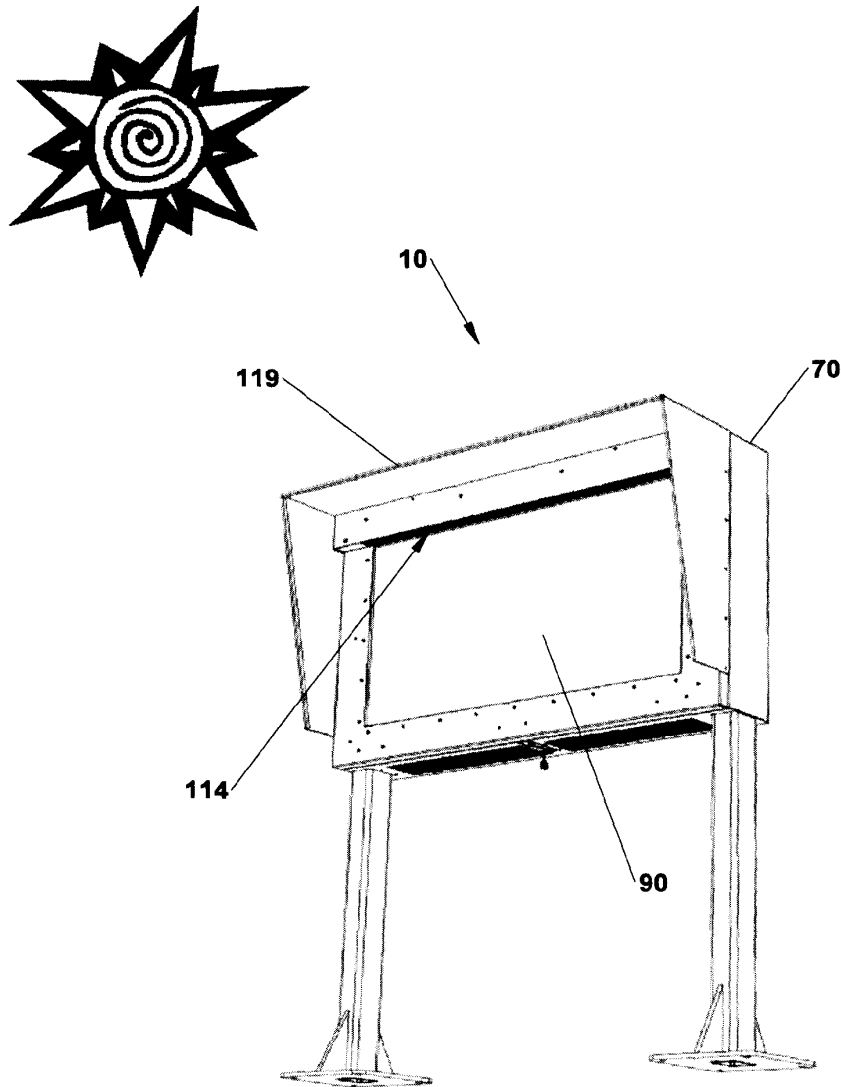


Fig. 1

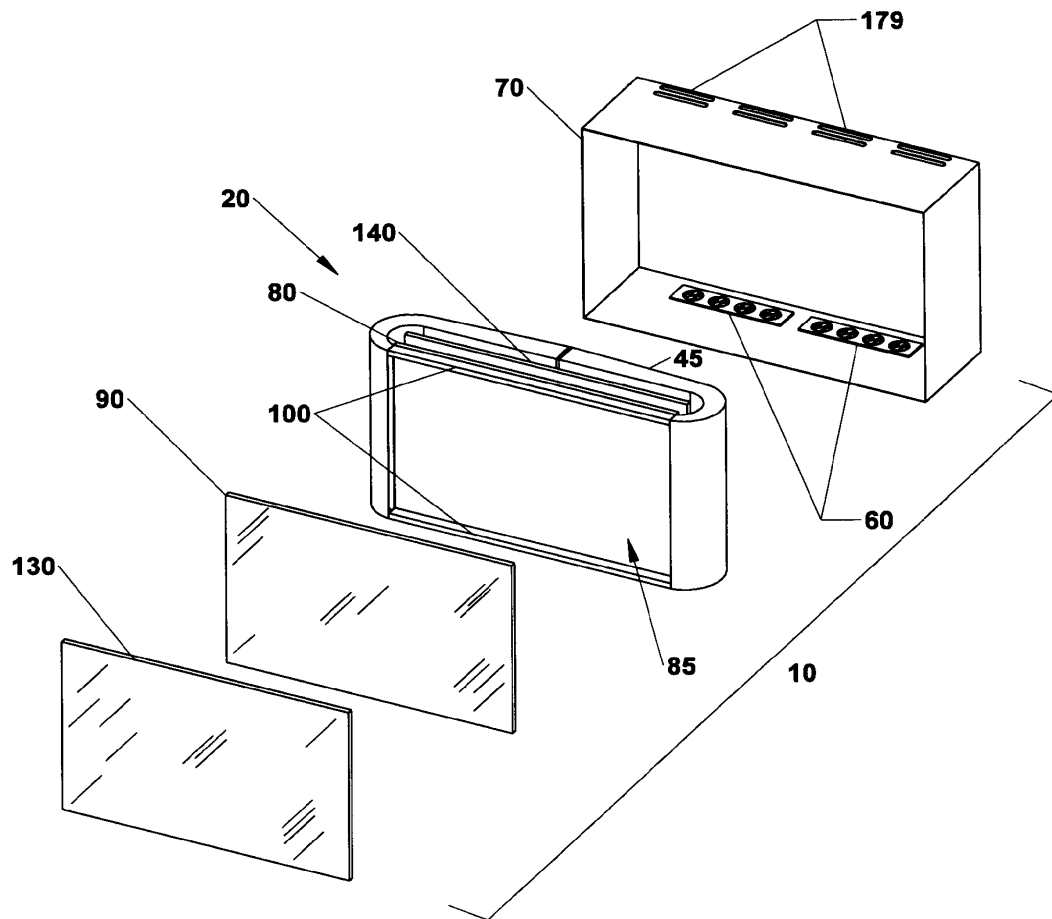


Fig.2

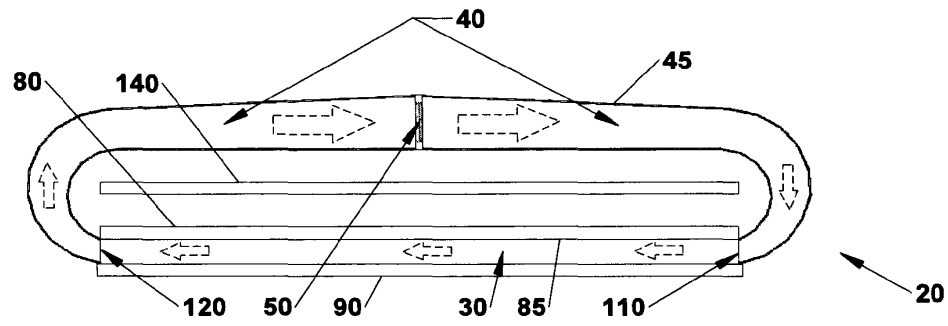


Fig. 3

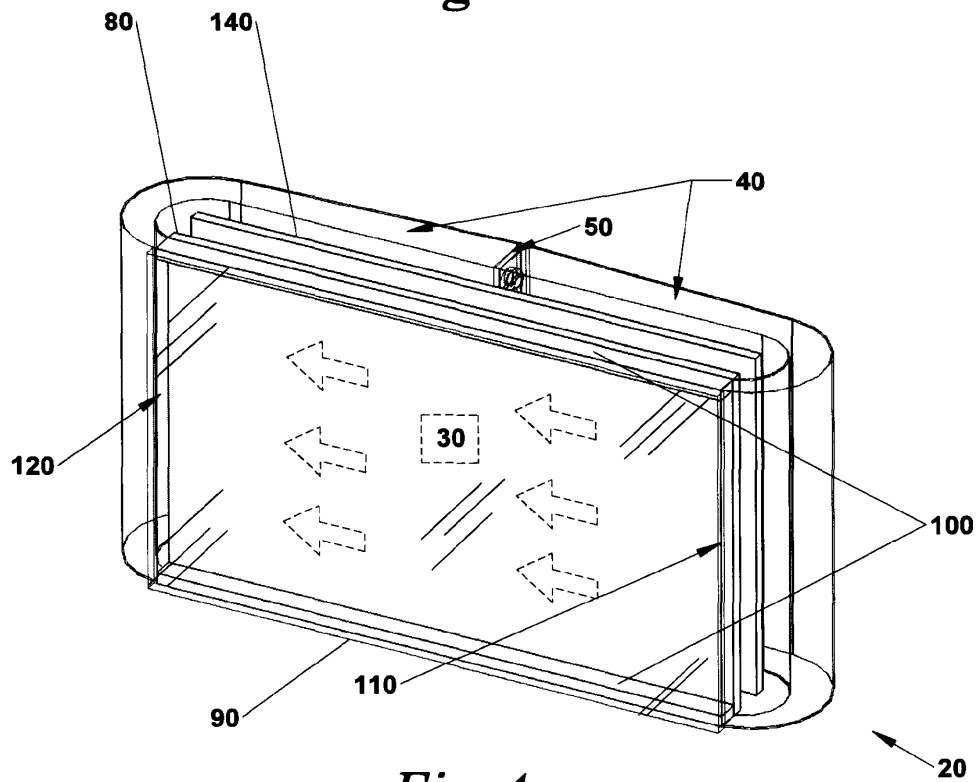


Fig. 4

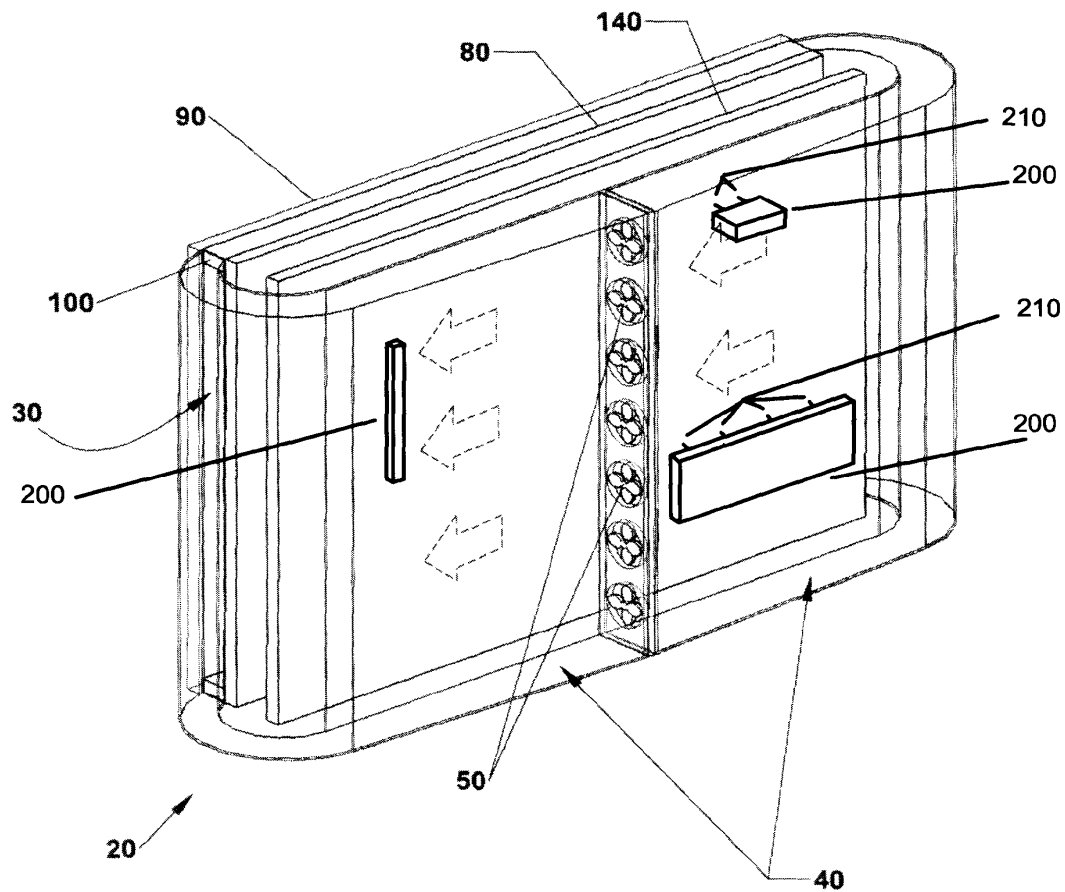


Fig. 5

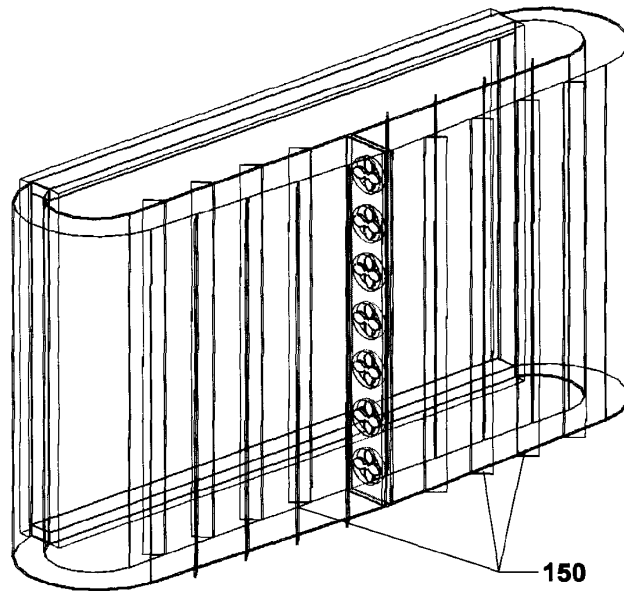


Fig. 6

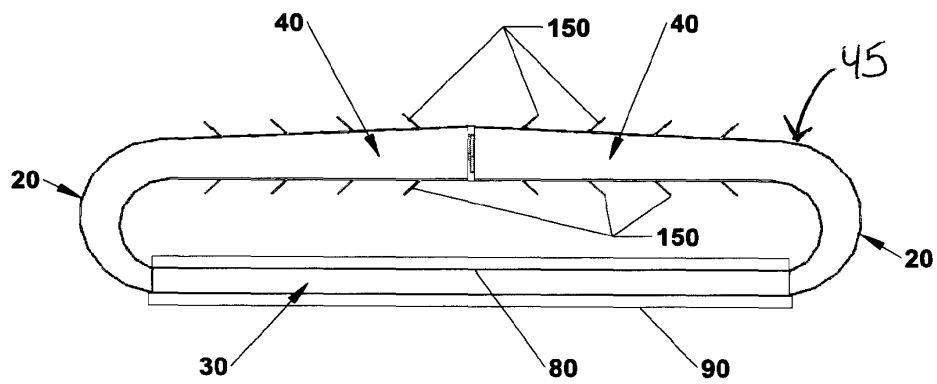


Fig. 7

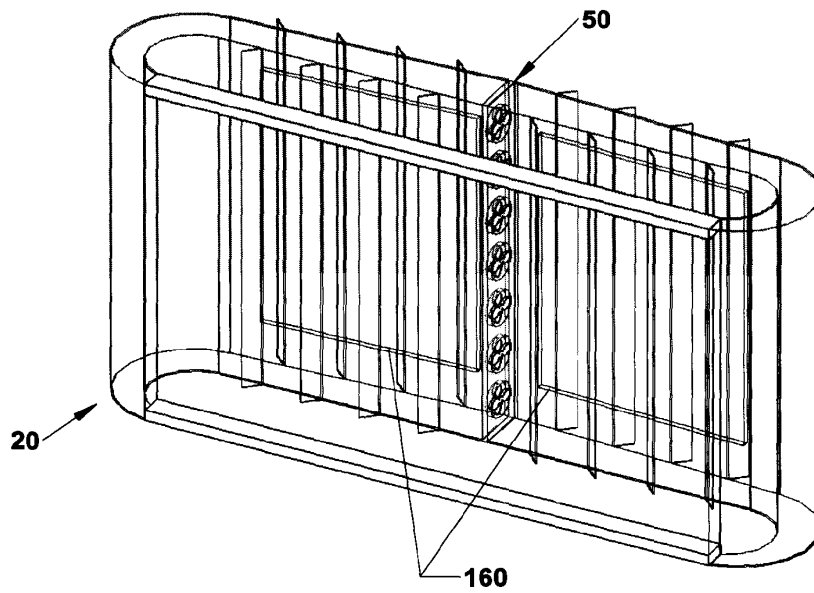


Fig. 8

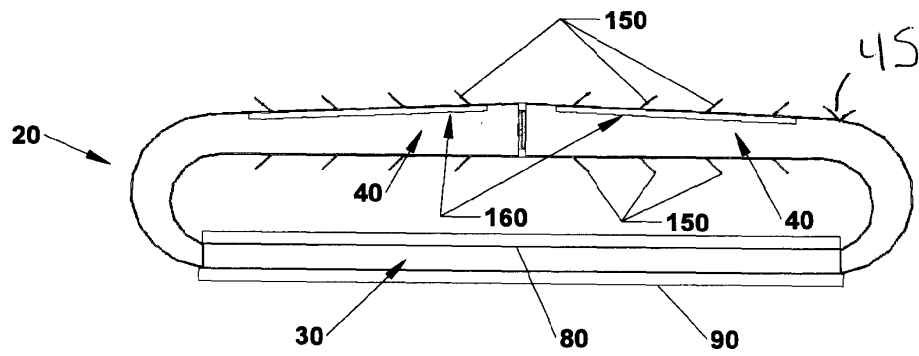


Fig. 9

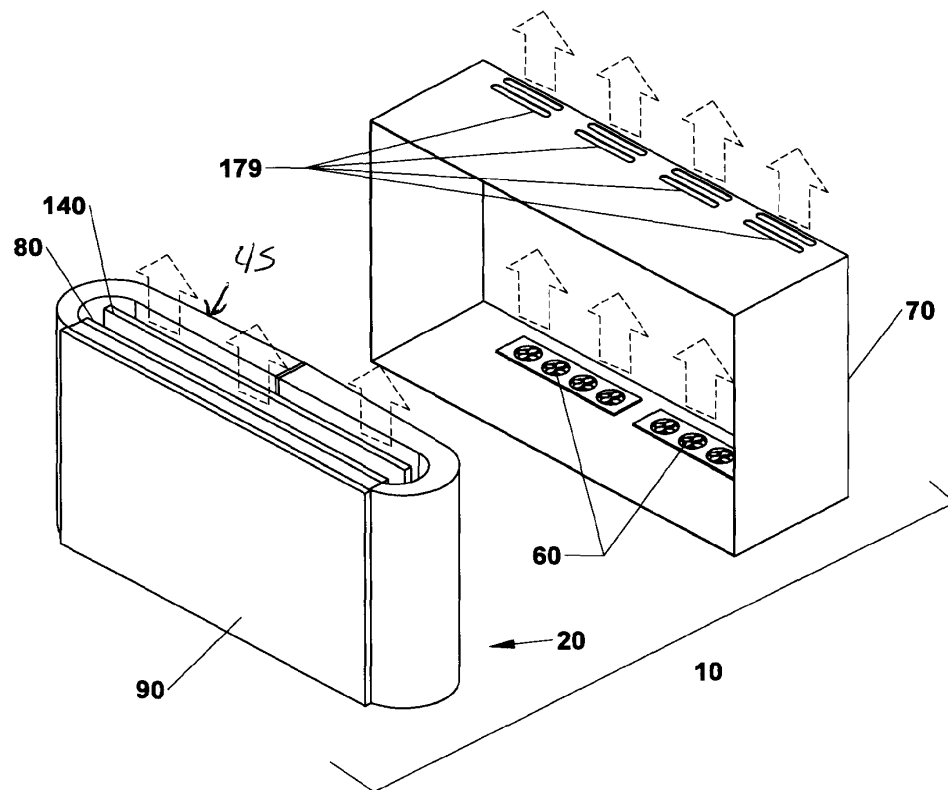


Fig. 10

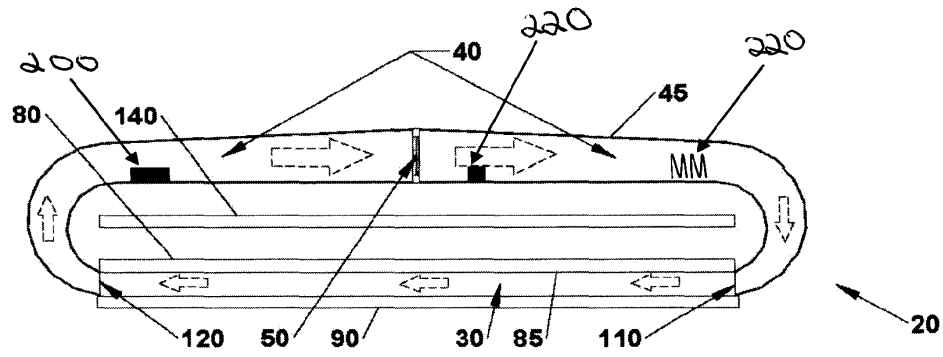


Fig. 11

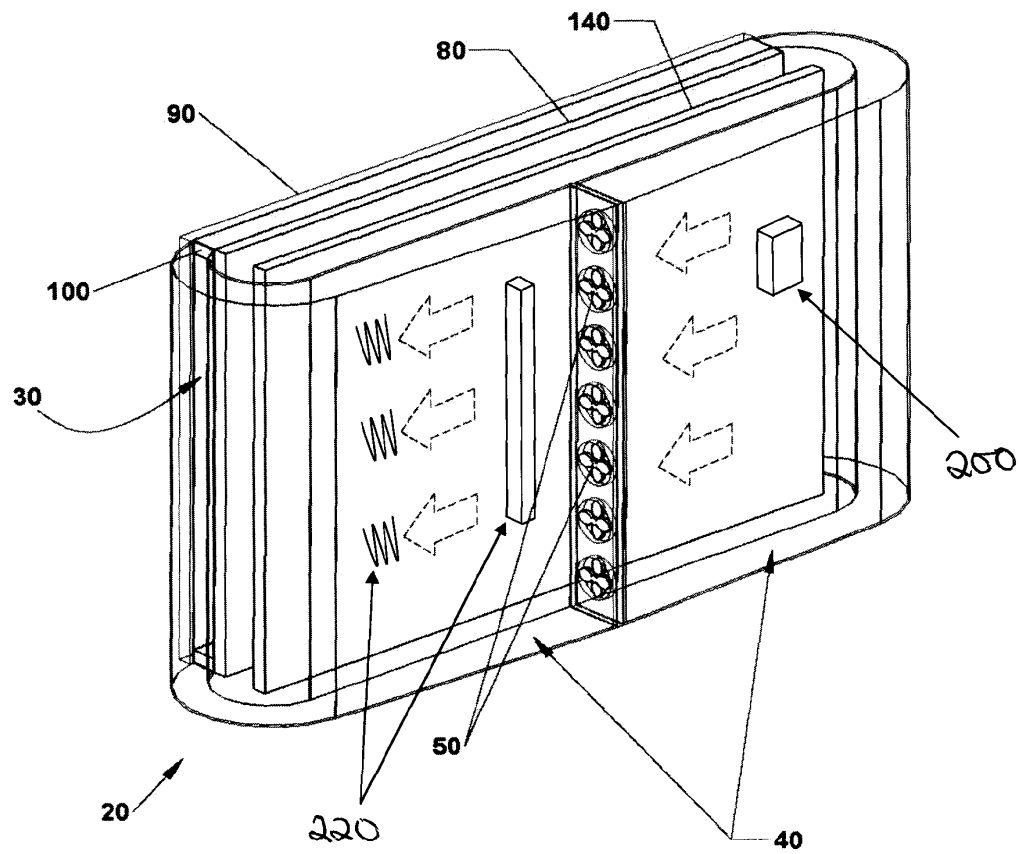


Fig. 12

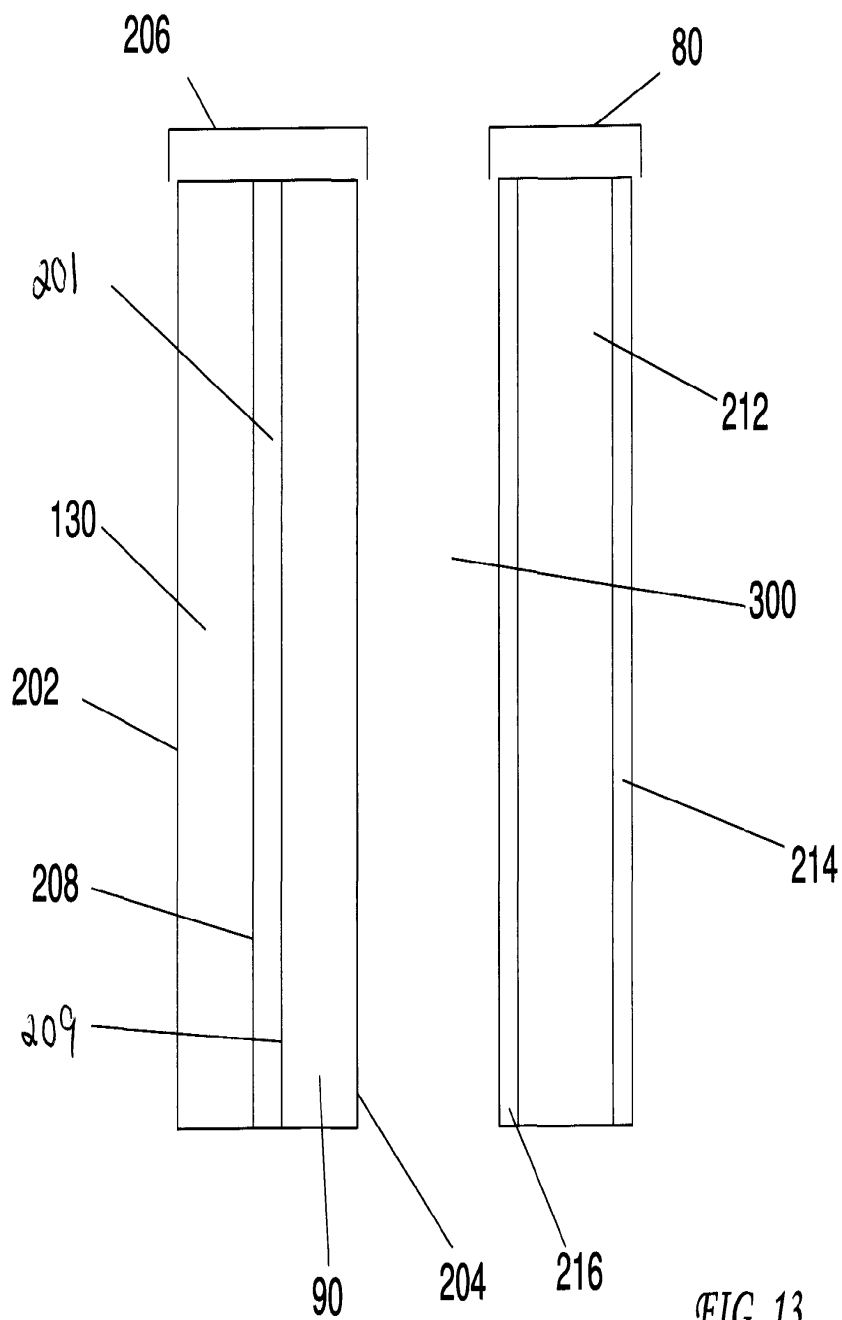
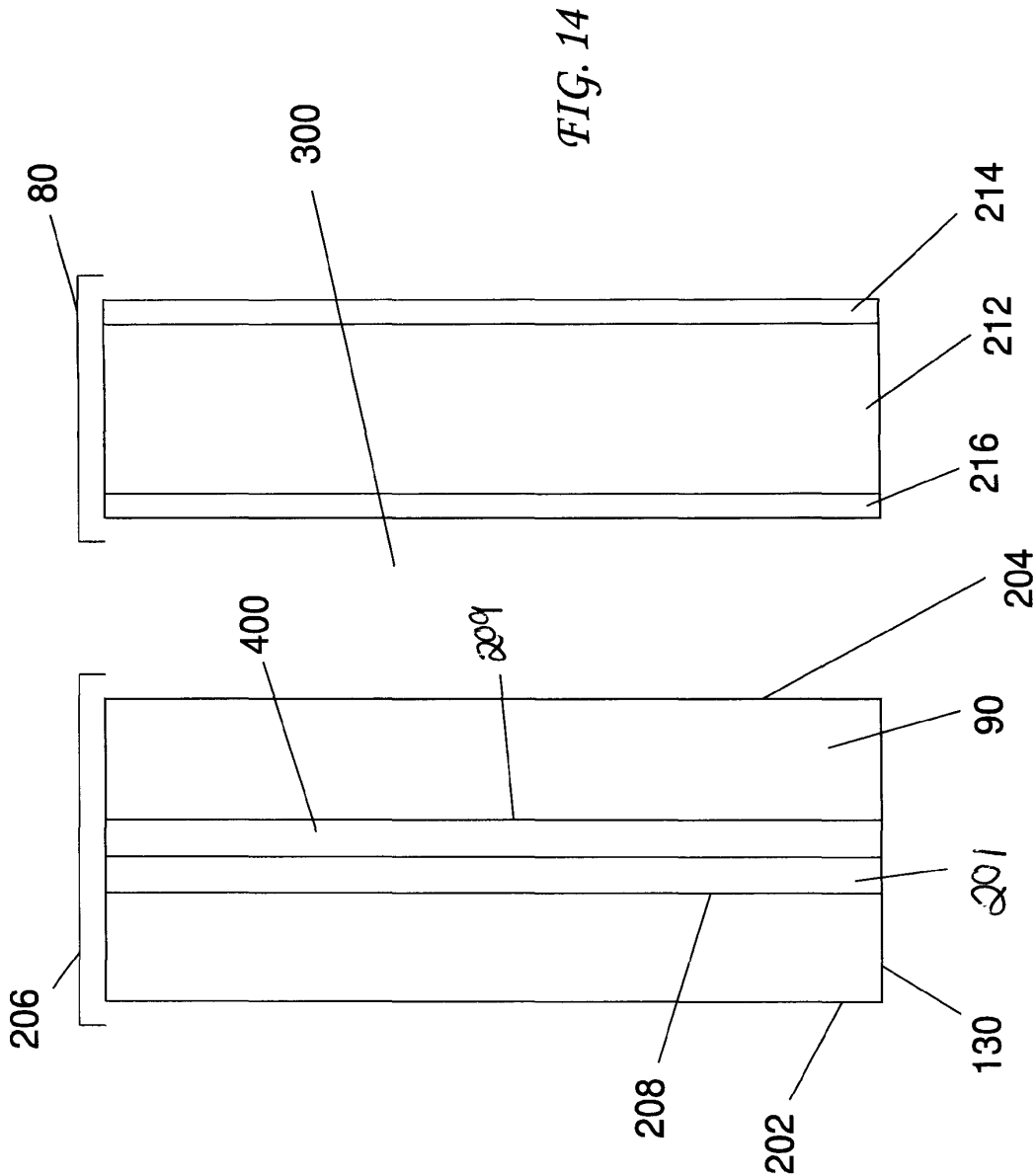


FIG. 13



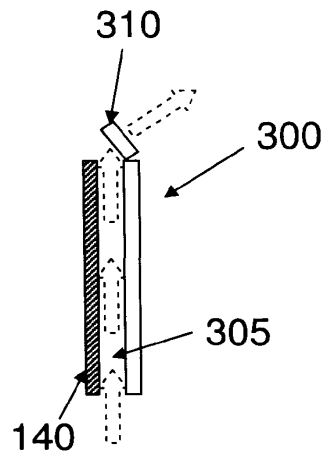


Fig. 15A

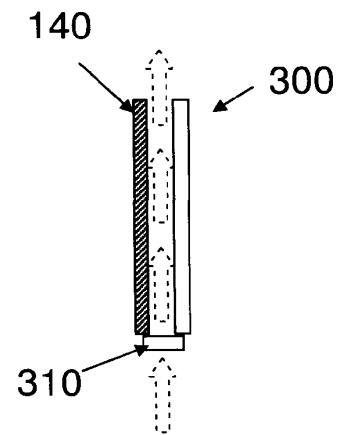


Fig. 15B

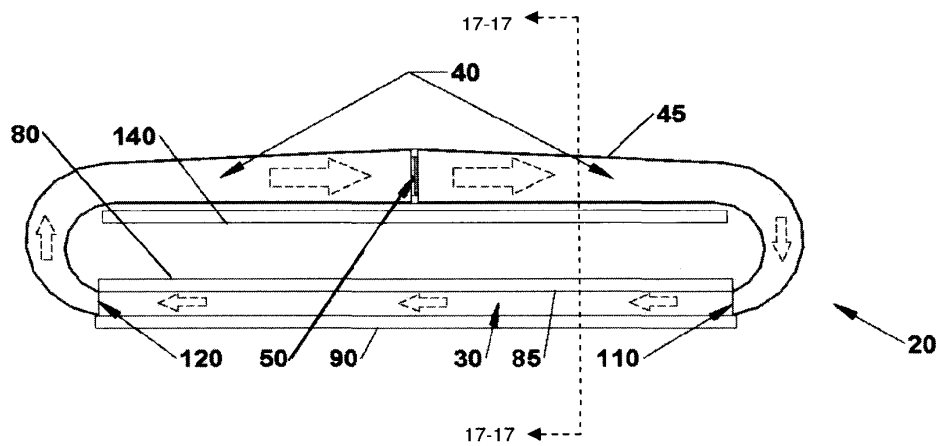


Fig. 16

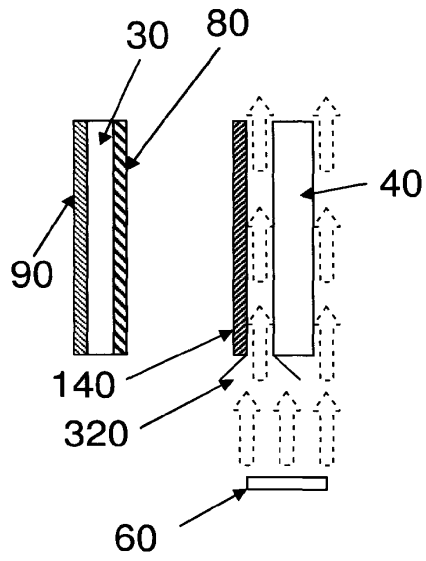


Fig. 17A

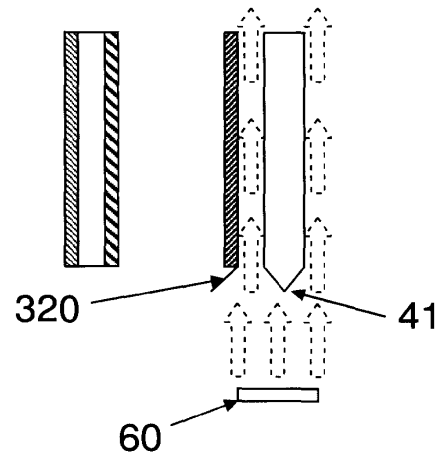


Fig. 17B

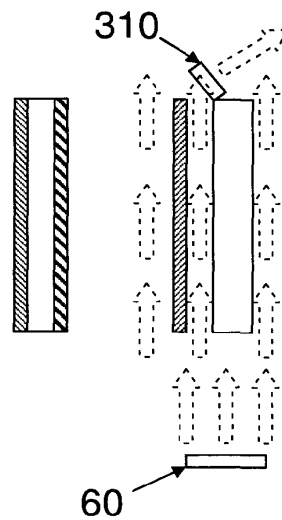
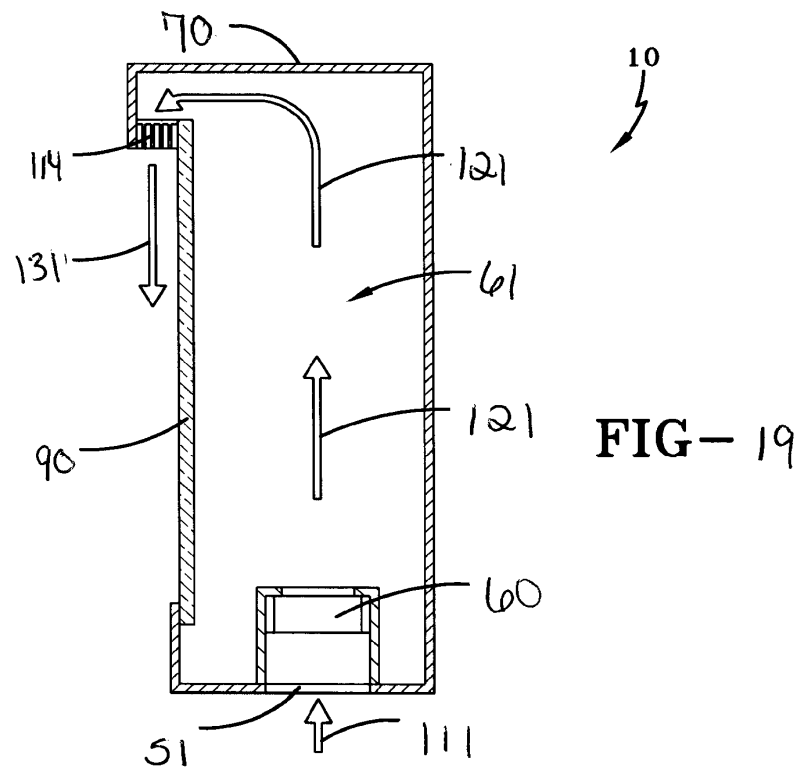
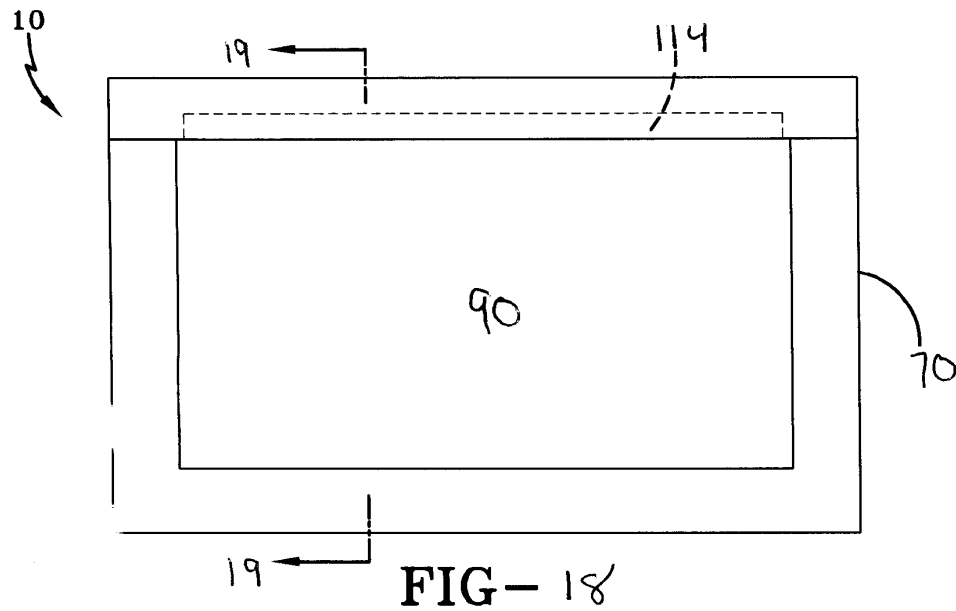


Fig. 17C



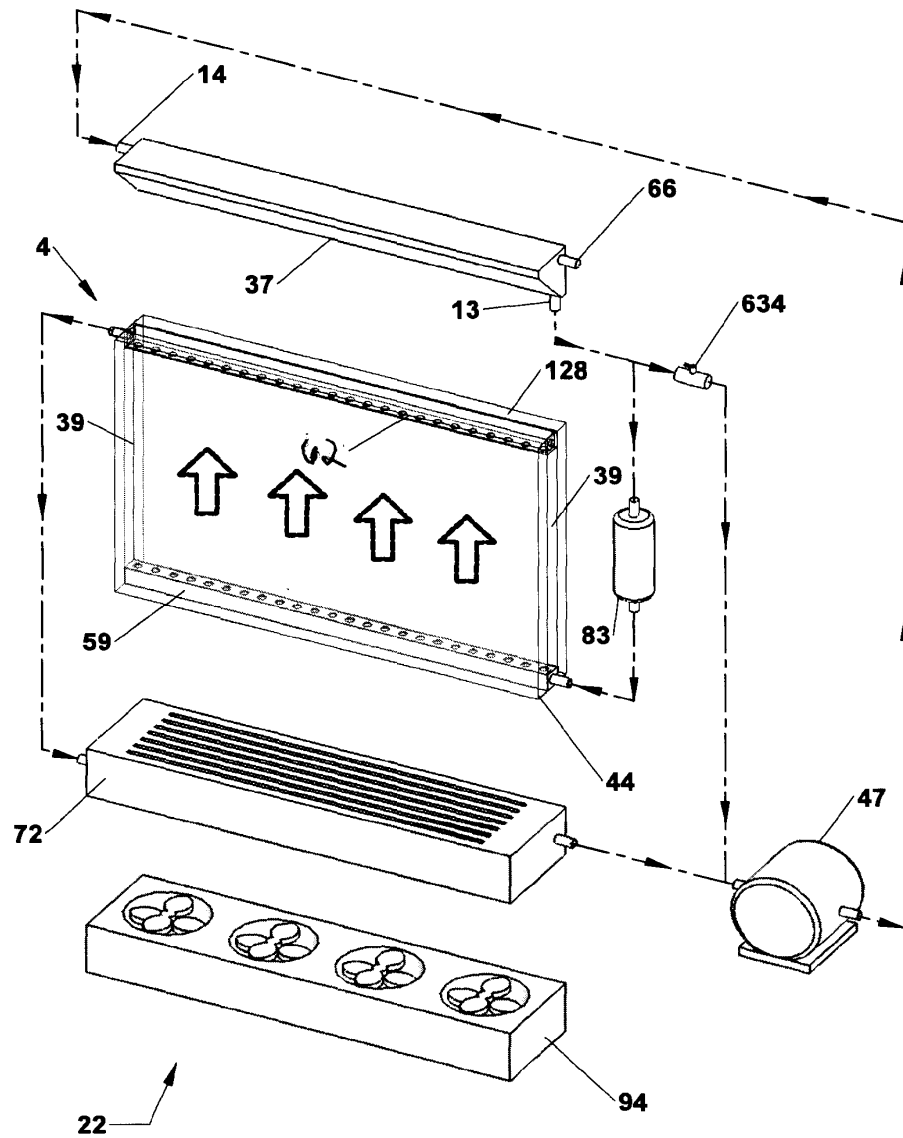


FIG. 20



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(54) Title: SYSTEM AND METHOD FOR THERMALLY CONTROLLING AN ELECTRONIC DISPLAY

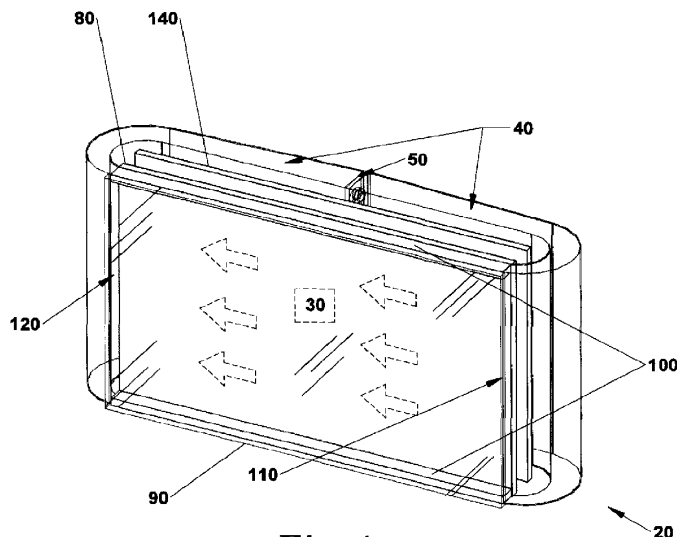


Fig.4

(57) Abstract: Embodiments relate generally to various thermal control features for electronic displays. One feature comprises a closed loop isolated gas chamber, where a first chamber is in contact with the display surface and transfers heat between the isolated gas and the display surface. A second chamber is in gaseous communication with the first chamber and is adapted to heat or cool the isolated gas and reintroduce the isolated gas into the first chamber. Another feature uses constricted convection to facilitate the cooling of the backlight assembly for the electronic display. Another feature uses an air curtain to further heat or cool the exterior viewing surface of the display. Another feature uses a linear polarizer with an insulating gap to reduce the solar loading of the display stack and provide insulation from the ambient air temperature. Another feature uses a fluid system to contact fluid coolant with the display surface in order to cool the display. Each of the features may be used alone, or in combination to provide the proper operating temperature for the display depending on its desired operating environment.

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MC, MT, NL, NO, PL, PT, RO, SE, SI, SK, TR), OAPI
(BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR,
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B. FIELDS SEARCHED

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IPC G02F, G09F

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

Korean Utility models and applications for Utility models since 1975

Japanese Utility models and applications for Utility models since 1975

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

eKOMPASS (KIPO internal) & keywords: air, gas, cool, temperature, control

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	JP 08-194437 A (MATSUSHITA ELECTRIC WORKS LTD.) 30 July 1996 See figure 1 and paragraph [0010] - paragraph [0012].	1-4
A	JP 2005-134849 A (NAGOYA ELECTRIC WORKS CO., LTD.) 26 May 2005 See abstract, figures 1-4, and their corresponding descriptions.	1-8,13-15,17-20
A	JP 2002-158475 A (FUJITSU GENERAL LTD.) 31 May 2002 See abstract, figures 1-5, and their corresponding descriptions.	1-8,13-15,17-20
A	KR 10-2007-0070675 A (NAUTILUS HYOSUNG INC.) 04 July 2007 See abstract, figures 1-3, and their corresponding descriptions.	1-8,13-15,17-20

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

* Special categories of cited documents:

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

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

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

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

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

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

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

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

"&" document member of the same patent family

Date of the actual completion of the international search

29 JULY 2009 (29.07.2009)

Date of mailing of the international search report

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Name and mailing address of the ISA/KR

Korean Intellectual Property Office
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Form PCT/ISA/210 (second sheet) (July 2008)

INTERNATIONAL SEARCH REPORT

International application No.

PCT/US2008/083792**Box No. II Observations where certain claims were found unsearchable (Continuation of item 2 of first sheet)**

This international search report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. ☐ Claims Nos.:
because they relate to subject matter not required to be searched by this Authority, namely:
2. ☐ Claims Nos.:
because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:
3. ☒ Claims Nos.: 9-12,16
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

Box No. III Observations where unity of invention is lacking (Continuation of item 3 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:

1. ☐ As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims.
2. ☐ As all searchable claims could be searched without effort justifying an additional fee, this Authority did not invite payment of any additional fee.
3. ☐ As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims for which fees were paid, specifically claims Nos.:
4. ☐ No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

Remark on Protest

- ☐ The additional search fees were accompanied by the applicant's protest and, where applicable, the payment of a protest fee.
- ☐ The additional search fees were accompanied by the applicant's protest but the applicable protest fee was not paid within the time limit specified in the invitation.
- ☐ No protest accompanied the payment of additional search fees.

Form PCT/ISA/210 (continuation of first sheet (2)) (July 2008)

SEC et al. v. MRI
SEC Exhibit 1031.0869
IPR2023-00254

INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.
PCT/US2008/083792

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
JP 08-194437 A	30.07.1996	None	
JP 2005-134849 A	26.05.2005	None	
JP 2002-158475 A	31.05.2002	None	
KR 10-2007-0070675 A	04.07.2007	None	

Form PCT/ISA/210 (patent family annex) (July 2008)

WO 2009/135308 A1



— *as to applicant's entitlement to apply for and be granted
a patent (Rule 4.17(ii))*

Published:

— *with international search report (Art. 21(3))*

TITLE OF THE INVENTION**VIDEO DISPLAY SYSTEM****FIELD OF THE INVENTION**

[0001] The present invention relates to video display systems for use in public spaces, and in particular to an enclosure for holding a flat panel video display, environmental control systems for controlling the interior environment of such enclosures, and display structures incorporating such enclosures.

BACKGROUND OF THE INVENTION

[0002] Advertising and marketing displays often consist of non-static images, such as video images and other digital displays. For example, large-scale digital displays are widely used in major urban centers, as well as in stadiums, arenas, exterior walls of buildings and other applications. There exists an increasing need for smaller scale displays that are capable of displaying a static or dynamic video image so as to better attract the attention of onlookers. Displays of this nature may be used for advertising, public service information, and the like. As used in this patent specification, the terms "video display" or "flat panel display" encompasses any type of image display, whether for commercial advertising or other purposes. Preferably, such a display is a digital static or dynamic video display, but other video display types are known.

[0003] There is a need to provide video display systems that are suitable for use as a street or floor-level display for use in a harsh environment, such as outdoor use in locations where the units may be exposed to direct sun, and other situations of extreme heat or cold. Flat panel display screens, such as LCD panels, provide a high degree of resolution and are well-suited for displaying advertising and other images on a smaller scale, for example street-level displays. As well, advances in LCD and other flat panel screen technologies have permitted very bright display capabilities, making this technology in principal suitable for outdoor use in direct or near-direct sunlight. However, apart from certain closely monitored environments such as airports and retail stores,

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exposed video units can be exposed to vandalism and theft. As well, outdoor use of an exposed screen is usually difficult as a result of exposure to moisture and extreme temperature conditions. One solution is to enclose a video screen within a housing or enclosure. An enclosure may also find uses in indoor settings, where for security or other reasons it is desired to encase the video display unit within a robust enclosure.

[0004] Conventional LCD monitors are suitable for operation in a temperature range of approximately 5°C to 40°C. At temperatures above this range, the screen may not function and may be temporarily or permanently damaged, while below this range the display may also not function properly. This presents a drawback for outdoor usage of LCD displays (and other flat panel digital monitors) that are enclosed within a housing, since temperatures can exceed this range. The interior of such an enclosure can experience a greatly elevated temperature, resulting from the combination of internally-generated heat from the video monitor, as well as absorbing of heat from the sun. There is therefore a need to provide a system which includes a secure enclosure for a flat panel digital display unit, but which is capable of maintaining a suitable temperature range for a video unit. Thermal management of the system should be provided in a manner which is efficient, reasonably quiet and reliable within a range of conditions.

SUMMARY OF THE INVENTION

[0005] There is a need for a free-standing display system such as a kiosk, which may be placed in a variety of locations such as public plazas, sidewalks and the like. Such a system offers a high degree of flexibility for marketers and is desirable for modern marketing techniques.

[0006] It is an object of this invention to provide an enclosure for a digital display unit, such as a video display, that is suitable for a street-level or indoor display and which may be incorporated in a variety of display systems such as free-standing kiosks and other displays. For this purpose, it is an object to provide an enclosure that provides a degree of thermal regulation and control to permit the device to operate in harsh outdoor environments.

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[0007] According to one aspect, the invention relates to a video display system which includes an enclosure suitable for use in a range of conditions including outdoor street-level use, and a display unit such as a video flat panel display. The video unit preferably comprises an LCD unit. However, it will be understood that the "flat panel display" (herein referred to as an "FPD") may include essentially any video display means such as a flat screen LCD, LED, plasma or OLED display, as well as other video systems whether currently in use or which may be developed in the future, whether based on analogue or digital video signals.

[0008] The enclosure comprises a substantially sealed housing that contains an FPD, an environmental control unit ("ECU") to regulate the internal temperature within the enclosure, and other components. A clear front panel permits viewing of the FPD. The enclosure is openable, preferably by opening of the housing portion which contains the front panel. To prevent unauthorized access to the enclosure, the housing is securely lockable. Preferably, the housing is configured to permit multiple enclosures to be joined together in various configurations. For example, multiple enclosures may be configured to be combined to form a self-supporting triangular display structure.

[0009] The enclosure includes means to mount the FPD within its interior. The FPD is located to provide an air gap, to permit airflow around the FPD to provide efficient cooling thereof or, in some circumstances, heating. The enclosure also includes means to circulate air through the air gap.

[0010] The ECU may include a heat exchanger such as an air conditioner. According to this aspect of the invention, the enclosure is effectively sealed against ambient air circulation, with interior air being recirculated through the enclosure. According to this aspect, the system is configured to provide a closed-loop, system-level approach to cooling which reduces or eliminates the need to provide individual component-level cooling, thereby permitting the system to operate in a diverse range of conditions including at least some outdoor environments. It is contemplated that units installed in less extreme or sheltered outdoor environments, such as transit shelters or the like, can utilize smaller air conditioners or heat-exchangers. Optionally, a heater may be

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provided to maintain a selected minimum temperature, depending on the environment in which the enclosure is to be installed. Units to be installed in indoor controlled environments could be equipped with only circulating fans. The ECU is responsive to sensors which detect conditions such as the temperature within the enclosure, the power requirements of the system, tampering or movement of the system, and other conditions. The ECU includes a control system which responds to such parameters and conditions by controlling the fan speed (thereby controlling internal air circulation), depowering the FPD, transmitting an alarm signal to a remote operator, and other responsive measures.

[0011] According to another aspect of the invention, the enclosure and ECU are configured to permit the system to maintain the desired temperature range by circulation of ambient (exterior) air through the enclosure. Optionally, a heater may be provided to maintain a selected minimum temperature.

[0012] Another aspect relates to an enclosure in which the housing consists of a rear portion which houses the FPD and ECU, and a front portion which includes a clear panel. The FPD is retained within a structure which is in turn pivotally mounted to the rear portion of the housing. The front portion and FPD are both releasably mounted to the rear housing portion with pivotal engagement means configured to permit the front portion and said FPD to independently pivot outwardly from said housing along parallel axes of rotation to permit access into the interior of said housing. At least one of said pivotal engagement means comprises mutually engaging surfaces projecting from said means to mount said FPD and said housing respectively, configured to oppose each other and rest one upon the other. The mutually engaging surfaces comprise upwardly and downwardly projecting surfaces respectively, configured to interlock when engaged.

[0013] Another aspect relates to a locking mechanism for locking the openable cover to the housing in a secure fashion.

[0014] According to another aspect, the invention relates to a display system comprising a plurality of enclosures as described above incorporated into

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a display system. The enclosures are mounted within a frame, which may be free-standing to form a kiosk-like structure, or alternatively incorporated into a structure such as bus shelter. Preferably, the enclosures are disposed at an angle relative to each other. For example, the system may comprise a rectangular or triangular cross-sectional configuration, with two or more outwardly-facing surfaces of the system comprising video display surfaces. In a preferred version, the systems has a triangular cross-sectional configuration with vertical side walls, with two of the faces comprising outwardly-facing video displays disposed at an angle to each other. The third face comprises a sealed panel, which is openable for access to the interior. An alternative configuration is to provide two enclosures in back-to-back arrangement. This arrangement may be ceiling-mounted. A still-further alternative is to provide a single enclosure for wall mounting. The display system may form a substantially enclosed structure, in which the FPD enclosures form some or all of the side panels, with the upper and lower faces being covered with panels. Active or passive ventilation within the interior may be provided via suitable ventilation ducts.

BRIEF DESCRIPTION OF THE DRAWINGS

[0015] Figure 1 is perspective view of a video display module in accordance with the present invention.

[0016] Figure 2 is a plan view, from above, of the display module of the first embodiment.

[0017] Figure 3 is an exploded view, in perspective, of the first embodiment.

[0018] Figure 4 is a plan view, from above, of an enclosure according to the first embodiment.

[0019] Figure 5 is a rear elevational view of the enclosure.

[0020] Figure 6 is a side elevational view of the enclosure.

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[0021] Figure 7 is a schematic cross-sectional view along line 7-7 of Fig. 4, showing the interior of the enclosure.

[0022] Figure 8 is a perspective view from the front, showing the interior of the rear housing portion with a FPD installed therein and the front housing portion removed.

[0023] Figure 9 is a perspective view of a second embodiment of the invention, depicting a transit shelter incorporating the present invention.

[0024] Figures 10 through 12 are perspective views of third, fourth and fifth embodiments of the present invention.

[0025] Figure 13 is a rear plan view of a sixth embodiment of the invention.

[0026] Figure 14 is a cross section view of the embodiment of figure 13, along line 14-14 of Fig. 13.

[0027] Figure 15 is a sectional view of the embodiment of Figure 13 showing the airflow pattern through the enclosure.

[0028] Figure 16 is a perspective view, from the front, showing internal components of the embodiment of Figure 13.

[0029] Figure 17 is a perspective view of the ECU portion of the system.

[0030] Figure 18 is a perspective view of the FPD holder portion of the sixth embodiment of the invention.

[0031] Figure 19 is a detailed view of the circled portion of Figure 18.

[0032] Figure 20 is a side elevational view of the FPD holder according to the sixth embodiment.

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[0033] Figure 21 is a perspective view of the sixth embodiment.

[0034] Figure 22 is a perspective view, with components separated to show details, of the sixth embodiment.

[0035] Figure 23 is a perspective view of the FPD holder according to a seventh embodiment of the invention.

[0036] Figure 24 is a front elevational view of the enclosure according to the seventh embodiment.

[0037] Figure 25 is an exploded view, in perspective, of the seventh embodiment.

[0038] Fig. 26 is a block diagram showing operation of the environmental control system of the present invention.

DETAILED DESCRIPTION

[0039] In a first embodiment, shown in Figures 1- 8, the system comprises a free-standing display structure 10 having a substantially triangular cross-sectional configuration, with generally vertical rectangular sides. Structure 10 includes a rigid support frame 18, composed of three upright corner posts 20, each of which terminates in a foot 22. Feet 22 may be bolted to a substrate to minimize the risk of theft or movement. One or more of posts 20 are adjustable in length. Preferably, posts 20 are partly or fully covered with a decorative covering, such as powder coated sheet metal or a stainless steel tube 24. Posts 20 are connected together with cross bars 26, seen in Figure 3. Triangular floor and roof panels 14 and 16 cover the upper and lower open ends of the module, and are mounted to cross bars 26. The floor and roof panels include ventilation openings 30, to permit ventilation of the assembly by convection. Optionally, ventilation fans 32 may be provided to vent the interior of the module. Preferably, ventilation openings 30 are louvered and covered with filter members.

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[0040] The system is supplied with power, and optionally external video and audio signals, which may be supplied via a conventional subsurface conduit which terminates in a GFCI-equipped junction box located within the interior of the system. A multiple outlet UL listed power bar is used to distribute power to all of the electrical devices contained within the system.

[0041] Structure 10 includes at least one video screen display enclosure 40, composed of separable front and rear housings 48 and 60. Enclosure 40 is fabricated from a robust material, such as stainless steel or aluminum. Each enclosure forms an independent video display unit, and it will be seen that one or more such enclosures may be arranged in various combinations or configurations to form a wide variety of display modules and systems. Structure 10 comprises two enclosures 40, forming two walls of the triangular structure, and a wall 42 forming the third side thereof and composed of one or more solid panels 44, openable to provide access to the interior of the structure. Conveniently, wall 42 comprises a pair of panels 44 which swing open, and which are securely lockable in the closed position. It is evident that variations of the above are possible, including all three sides of the structure comprising video enclosures, or only a single side, or the third side comprising another type of display, or the display structure having a different number of side walls other than three.

[0042] As seen in Figure 7, a video flat panel display unit ("FPD") 100 is housed within enclosure 40. In the present embodiment, FPD 100 is a high-output LCD digital monitor, although essentially any video monitor may be housed within the enclosure, provided it dimensionally fits therein and has sufficient screen brightness and other desired characteristics.

[0043] Referring to Figures 4-6, enclosure 40 comprises a self-contained substantially sealed unit. Enclosure 40 includes a front housing 48 which holds a transparent glazed front panel 50. Panel 50 is essentially inert to heat and chemicals, and has significant impact resistance, while allowing substantially no flexibility across its surface. If broken, it will shatter to form non-abrasive beads and remain intact and in place until removed for replacement. To provide sufficient security, the inventors have found that a suitable panel consists of a

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laminated composite of two tempered glass plates, each about 6 mm in thickness, bonded with a 1.5 mm thick optical bonding resin adhesive, resulting in a finished thickness of about 13.5 mm. It will be evident that these specifications are non-limiting, and are provided merely by way of example. The front layer is clear with an anti-reflective finish on the outside, with polished edges and a printed border matching the view dimensions of a screen of a selected maximal size. In one example, the enclosure is intended for use with a maximum screen size of 82 inches (measured diagonally), although it is evident that this is merely an illustrative example and is based on economically feasible technology as of the date of this patent specification. It is understood that rapid advances in video technology may soon result in economically viable screen sizes larger than this. In general, the structure may be scaled up or down within a range commensurate with available technology and appropriateness to the desired use of the device.

[0044] According to one embodiment, the enclosure is configured to be similar to a conventional "6 sheet" size, namely a panel size of about 4X6 feet (1200mm W x 1750mm H). This is a conventional size used for poster-type displays incorporated into public furniture. Since conventional FPD's sized above 20" diagonal are in a ratio of 16:9, the most appropriate to this size of FPD would be a 70" LCD screen.

[0045] Front housing 48 is hinged to rear housing 60, preferably with a top-mounted hinge to permit front housing 48 to open by swinging upwardly, to permit replacement of the FPD, if required. Front housing 48 is sealed to rear housing 60, for example with a gasket or the like, and is securely latched and locked to prevent unauthorized access.

[0046] Front housing 48 may include a frame or mask 62, which may be mounted to the interior of the front panel to selectively form an opaque border around the clear front panel (see Figure 1). This reduces the effective clear viewing area of the panel, to permit smaller screens to be mounted within the enclosure, while blocking the clear area of the panel surrounding the video screen.

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[0047] Rear housing 60 comprises tapered side walls 64, converging rearwardly to permit adjacent enclosures 40 to be mounted within a display structure at an acute angle of about 60 degrees (in the case of a triangular structure) relative to each other. The angle will depend on the desired display module configuration. Upper and lower panels 66 and 68 of rear housing 60 are optionally horizontal or sloped. The enclosure includes a vertical rear panel 70, within which is mounted an openable rear access panel 72 to permit access to the interior of the enclosure, for example to access the electronic components.

[0048] An environment control unit (ECU) 74 or other air tempering unit is housed within an ECU enclosure 75, which projects rearwardly from rear panel 70. Preferably, ECU enclosure 75 is located towards the top of the unit 40 to enhance its cooling capabilities. In this embodiment, enclosure 40 is substantially sealed, and ECU 74 effectively re-circulates the air within the enclosure interior. A heat exchanger or air conditioner 76 within ECU 74 discharges waste heat to the exterior of the enclosure. For example, ECU 74 may include a 7,000 BTU a/c unit.

[0049] As seen in Figure 7, ECU housing 75 comprises an ambient air compartment 79 open to the exterior of enclosure 40 and a closed loop compartment 81 open to the interior of enclosure 40. The respective compartments 79 and 81 form separate manifolds that are sealed relative to each other. A heat exchanger or a/c unit 76 cools the air within closed loop compartment 81, and exhausts the excess heat through ambient air compartment 79, via vents 83 within housing 75, which are open to the external environment. Vents 83 permit ambient air to circulate through the ambient air compartment 79 of ECU housing 75.

[0050] ECU 74 includes a control system which is responsive to signals from various monitors and sensors, including a monitor which measures power consumption of the electrical systems associated with the enclosure and temperature within the enclosure. ECU 74 provides thermal management of the internal environment within enclosure 40, in response to inputs from said monitors and sensors and pre-programmed values including the operating temperature range of the video screen, the expected solar heating of the

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enclosure, which depends in part on the relative size and thermal characteristics of the glazed front panel, as well as the characteristics of the enclosure material, and the expected outdoor temperatures in the selected environment.

[0051] ECU 74 controls the air circulation components of the system to provide thermal control within a selected range. With known conventional LCD screens, a suitable operating temperature range is about 10-40°C or 5-40°C. It is also contemplated that the circulation fans 84 and/or 90 may be left permanently on, with the air conditioner and optionally the heater being switchable in response to the temperature within the enclosure. In extreme environments, a UPS is included to maintain the operation of air circulation fans to return the internal temperature of the enclosure to ambient in the event of a power failure. Thermal interlocks are also provided to prevent the opening of the doors before the internal temperature of the unit has returned to ambient to prevent the formation of condensation.

[0052] ECU 74 controls the environment inside the enclosure 40 so that FPD 100 is protected from variations in local weather conditions. For cooling in hot weather, or high solar loading, the ECU controls the removal of heat, for example by switching or controlling of the speed of heat modulating components including fans, air conditioners, heat exchangers, heat pipes, thermo-electric modules, motorized vents, or motorized solar shields. For heating in cold weather the ECU controls the addition of heat from electric heaters, or other sources of heat. In addition it may delay the application of power to other modules in the digital display until they have been heated to an acceptable temperature for reliable operation, referred to as "cold start" control. The ECU may also control the timing of power to other units, such as display backlights, so they are energized in an orderly and acceptable manner. The other functions of the ECU are to signal alarm conditions, such as but not limited to, intrusion alarm, high or low internal temperature, failure of cooling or heating devices, high shock or vibration, water ingress, smoke, display failure, or failure of the ECU controller itself. ECU 74 operates relatively quietly, in order to minimize the noise generated by the device.

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[0053] FPD 100 is mounted within the rear housing 60. FPD 100 is mounted to maintain an air gap between its front face and front panel 50, and its rear face and the rear panel 70, and also around the upper and lower edges of the FPD. The air gap is essentially unobstructed across the full height of the FPD, to permit an air flow to pass over both sides of the FPD. FPD 100 is mounted within enclosure 40 by any suitable mounting means. For example, FPD 100 may be rear mounted by means of a Vesa™ mount, or mounting means may attach the periphery of FPD 100 in the case of open frame monitors. The gap between the FPD and front panel 50 may be approximately 1 inch, and the upper and lower gaps may be approximately 3 inches.

[0054] One or more fan banks 84 and 90 circulate air within the interior of enclosure 40. Fan bank 84 draws air through the space between front surface of FPD 100 and front panel 50, while fan bank 90 draws air through the space between the rear surface of FPD 100 and the rear wall of enclosure 40. Each fan bank 84 and 90 consists of at least one electrical fan, mounted within a fan housing. The combined airflow from fan banks 84 and 90 are directed through opening 92 within the rear of enclosure 40, and enters into closed loop compartment 81. The airflow is cooled by heat exchanger 76, and the cooled airflow then exits through discharge vent 101. A wedge-shaped baffle 88 protruding from the backside of the video monitor splits the air current into upper and lower streams, both of which flow over and chill the backside of FPD 100. The upper air stream is drawn through fans 90 for recirculation. The lower air stream flows downwardly, and contacts baffle 86, which serves as a cold air turning vane, at the base of enclosure 40. The lower stream flows downwardly towards the base of the enclosure, where baffle 86 channels the cool airflow through the lower gap between the base of the FPD 100 and the enclosure. This air current then flows upwardly through the gap between FPD 100 and the front panel 50. As the airflow passes over the upper edge of FPD 100, it is drawn through circulation fans 84, to be recirculated through ECU 74.

[0055] The present system is modular in structure, wherein each enclosure 40 may be separately assembled off site and shipped, along with the frame members and other systems components, for on-site assembly. Assembly is

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relatively simple, with each individual enclosure 40 comprising a "plug and play" unit which need only be plugged into the power and video signal lines or a wireless network.

[0056] Optionally, the display module 10 may be configured as a cubical or rectangular structure or alternately individual video screen enclosures may be mounted to a ceiling or floor. Other variations include back to back or side by side mounting, or surrounding a structural column.

[0057] Optionally, the enclosure includes an audio system (not illustrated). In order to provide a clear audio output without the need for external speakers, a transducer is provided to effectively transform front panel 50 into a sound driver. This may be provided, for example, with a Panasonic™ ambient speaker system, in which a full range transducer type mechanism is attached directly to the front glass panel with an adhesive pad, attached directly to the internal glass face of the display. This permits a clear audio capability without the need for openings in the sealed enclosure.

[0058] Both open frame and finished commercial screens can be housed in the enclosure. In one aspect, a high output LCD monitor, such as an MRI brightness-enhanced open-frame 70" Samsung™ monitor is used, which is effective in direct or near-direct sunlight. However, any suitable digital screen may be used in the system, and the existing screen within a unit may be replaced or upgraded.

[0059] The present system may include hardware and software that permits local or remote (web enabled) monitoring, control, and populating the FCD with user selectable advertising material, which may include material presented in display formats that are universally accepted and commonly used in the outdoor advertising industry.

[0060] The video and audio signals for the display structure 10 may originate from a common source, to permit identical video images to be displayed on all screens, or alternatively the displays and speakers may be separately controlled. The signals may comprise pre-programmed signals, which

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may be provided by way of audio visual playback devices mounted within the individual enclosures or within the interior of the display systems. Alternatively, the audio and/or audio-visual signals may be transmitted remotely, by wireless or non-wireless means. The programming may be either pre-programmed, for example displaying advertisements on a continuous loop, or may be remotely programmed by manual or automatic control. Remotely sourced signals may be transmitted to the displays by any suitable means including wireless transmission or fibre optic transmission means. All such means for supplying visual or audio-visual signals to the system are contemplated within the scope of this invention and would be known to persons of ordinary skill in the art.

[0061] The structure 10 may include a player module 600, comprising a hardened computer unit and associated hard drive which together control the digital content displayed on the FPD's 100. The player module communicates with a remote command centre. This enables content selected at one or more remote centres to be displayed on the screen. The player module may store such data temporarily. The player module also functions as a monitoring unit, to signal local conditions and data back to the command centres, such as the correct functioning of the display screen. By way of non-limited examples, the system permits users to customize the display of advertising content which can be controlled with user selectable criteria, such as the physical location of the device, the time and date, point of sale data, and product inventory information. In addition the player can be used to facilitate local communication with devices, such as, but not limited to, hand-held IR remotes, for local data input or for set-up or maintenance purposes. Further, it may also be used to relay audience conditions at the local site to the command centres. The remote command may be situated at one or more locations, or from sites on the Internet or a private data network, or even from mobile sites with access to such computer networks. The communication method between the Player and the remote command centre can be any high speed digital communication media, such as but not limited to, hard-wired Ethernet, wireless Internet, broadband-over-power, fiber, etc. The communication interface may be a separate module, or may be incorporated into the player module.

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[0062] Optionally, at least one of the sides of the system consists of or includes a backlit poster-type display in place of an enclosure 40.

[0063] According to a second embodiment, shown in Figure 9, one or more enclosures 40 can be incorporated within a transit shelter 102. In this aspect, posts 20 may provide structural support for the shelter, thus integrating the video display with the shelter. The video system thus provides both structural support and shelter from the elements, in addition to the video display.

[0064] Figure 10 illustrates a third embodiment consisting of a single or double-sided floor-standing (street-level) display 104 composed of either a single enclosure 40, or dual enclosures 40 arranged back-to-back. Figure 11 illustrates a fourth embodiment, consisting of a one-sided, wall-mounted display 106. Figure 12 illustrates a fifth embodiment, consisting of a two-sided, ceiling mounted display 108. The preceding systems of Figures 10-12 comprise one or two enclosures 40 as generally described above, wherein the enclosures are mounted within a frame 110 which supports the enclosure(s) in a suitable configuration.

[0065] A sixth embodiment is shown in Figures 13-22. In this version, enclosure 40 is adapted for maintaining a suitable operating temperature within its interior without the need for active cooling by an air conditioner or other heat exchanger, by generating a flow of ambient air through the enclosure. The enclosure consists of front and rear housings 200 and 210 which open like a clamshell, connected together with a removable hinged connection means, described below in more detail. Rear housing 210 encloses the FPD 100 and the ventilation components described herein, and front housing 200 includes the clear viewing panel 50. A pliable gasket where housings 200 and 210 meet provides a watertight seal.

[0066] The hinged connection means between the housings 200 and 210 is disposed horizontally along their respective upper edges to permit the front housing to swing away from the rear housing. The connection consists of opposed mutually engaging flanges 212 and 214. A first flange 212 extends forwardly from rear housing 210 with an outer portion which projects upwardly.

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Flange 214 extends rearwardly from the front housing 200 with an outer portion which projects downwardly. The respective flanges engage each other to suspend front housing 200 in a manner that permits front housing 200 to pivot outwardly from rear housing 210 about a horizontal axis. The respective flanges interlock to prevent the housings from coming apart, and to lock the housings together when the enclosure is closed. When enclosure 40 is open, the respective flanges may be disengaged from each other by lifting the front housing 200, thereby disengaging the mating flanges.

[0067] The front housing 200 is further attached to the rear housing 210 with a pair of gas spring struts 216, one on either side of the front housing 200 (see Figure 21). Struts 216 are provided with quick release attachment members 218 where they join to the front housing, so that the front housing 200 can be fully disconnected from the rear housing 210, for example to replace the glass panel 50. Struts 216 are telescoping to permit the front housing to open, and are provided with sufficient resistance to hold to the front housing in the open position when required.

[0068] FPD 100 is retained within a screen holder 220, seen in more detail in Figures 18-20, which in turn is mounted within the rear housing 210. The screen holder is configured to also channel airflow within the enclosure for ventilation of the FPD. Screen holder 220 comprises the following components:

a) a rectangular inner frame 222 dimensioned to fit a selected FPD. The inner frame comprises four frame members 222a-d consisting of inwardly-facing channel shaped members to receive the edges of the FPD. The frame members are assembled together with corner brackets 223 that fasten to frame members 222 with screws or other fastening means, to permit assembly around FPD 100. Frame members 222a-d effectively wrap around the periphery of FPD 100, slightly overlapping the front face thereof. Each frame member 222 also overlaps the rear face of FPD 100, and terminates in a flange 224 which protrudes rearwardly and includes a vertical portion.

b) a rear panel 226, having ventilation slots 228 extending horizontally therethrough. The rear panel 226 is mounted to flanges 224 so as to space the rear panel from the rear face of FPD 100.

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c) an outer frame 230 which fastens to the rear panel 226, and when mounted to the inner frame 222 via the attachment of the rear panel is spaced from the inner frame. The outer frame 230 is composed of four outer channel-shaped outer frame members 230a-d (only 230a-c are shown). The outer faces 232 of frame members 230 contact panel 50 when the enclosure is closed. As well, the outer frame is configured to channel an airflow around FPD 100 to provide ventilation.

[0069] As seen in Figure 22, screen holder 220 is retained within rear housing 210 in a fashion which permits it to pivot outwardly from the rear housing to permit access to the interior of the rear housing. The axis of rotation of screen holder 220 is horizontal and is parallel to the axis of rotation of the front housing. The retention of screen holder 220 is via mutually engaging surfaces which operate in a fashion similar in principle to the engaging flanges holding the front and rear housings together, whereby the screen holder is suspended from the rear housing by means of mutually engaging flanges 240 and 242. Flange 240 projects forwardly from the rear housing and upwardly, and flange 424 projects rearwardly from the front housing and downwardly. The respective flanges engage each other to suspend screen holder 220 in a pivotal engagement with the rear housing 210, while permitting release of the screen holder by lifting the screen housing to disengage the respective flanges.

[0070] When front housing 200 is opened, FPD 100 may be swung outwardly for access to the rear of the housing. The screen is further fastened to rear housing 210 with a pair of gas spring struts 244 which connect the rear panel 226 of screen holder 220 to rear housing 210. Struts 244 attach to screen holder 220 with quick-release mounts 246 to permit FPD 100 to be readily detached for replacement.

[0071] Front housing 200 locks to the rear housing 210 in the closed position to prevent unauthorized access, with a robust lock that resists tampering.

[0072] The system includes an environmental control unit ("ECU") 300, which is shown together with its associated components in Figures 13-17, 21

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and 22. ECU 300 is housed in the rear compartment 210 behind the FPD, within an ECU compartment 302. ECU compartment 302 is defined by a wall 303 which maintains airflow separation between the incoming air entering the ECU compartment, and the outgoing exhaust air exiting the enclosure 40. Wall 303 extends horizontally across the interior of the enclosure 40 so as to effectively surround the ECU. Exterior (ambient) air enters compartment 303 through perforations 304 within the rear panel 306 of the enclosure. An inlet manifold 307 within ECU compartment 302 covers the perforated region. Inlet manifold 307 houses a semi-permeable membrane 308, such as a Gore [™] membrane that filters the incoming air to block liquid, particulates, etc., while permitting the inflow of air, thereby limiting the intake of moisture and contaminants into the enclosure.

[0073] The enclosure is configured to permit air circulation around the FPD to control its temperature within a useable range. As seen in particular in Figures 14 and 15, internal air circulation is driven in part by the venting of exhaust air from the enclosure, by exhaust fans 310 mounted within the rear housing, located near the top thereof to take advantage of heat stratification within the enclosure. Exhaust fans 310 are each housed within an exhaust manifold 311 located at an upper corner of the rear housing. Internal air circulation is further driven by an air circulation fan 312 located within a heater/blower unit 320, which in turn is mounted within the ECU compartment 302. The heater/blower unit 320 includes an air intake 324 adjacent to the intake manifold 306 to draw air into the enclosure. Air is discharged from the heater/blower unit 320 through an air outlet 326 adjacent to the rear panel 226 of screen holder 220 to discharge air into the interior thereof. The heater/blower unit 320 comprises a variable speed, high capacity unit, which when operating draws air into the ECU enclosure from the intake manifold 306.

[0074] A portion of the incoming airflow enters the heater/blower unit while the remainder of the airflow is directly circulated into the enclosure 40 without entering the heater/blower unit. Exhaust fans 310 provide additional air circulation by withdrawing heated air from the enclosure. The airflow from both paths is then channeled into screen holder 220, through the openings in the rear

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panel thereof. The airflow within the screen holder follows two paths, the first being under and around the front of FPD 100, and the second path being upwardly along the rear face of the FPD. Both air streams are channeled between the inner and outer FPD frames 222 and 230, which are spaced apart to provide an airflow channel. Outer frame members 230a-d effectively form baffles which channel the airflow around FPD 100.

[0075] ECU enclosure compartment 302 includes an exhaust manifold 311. The air streams circulating around FPD 100 are channeled out of enclosure 40 through outlet openings 330 within rear panel 226, which feeds into manifold 311. Exhaust fans 310 discharge the heated air from the exhaust manifold 311 into the ambient air.

[0076] Air circulation through enclosure 40 is shown by the arrows in Figure 14, wherein ambient air enters the inlet manifold 306, and passes through membrane 308 into ECU compartment 302. A portion of the ambient air exits compartment 302 directly through openings 228 in the screen enclosure 220, and the remaining portion passes through heater/blower unit 320, where the air is optionally heated (if required) and accelerated by fan 312. The combined airstreams enter the screen enclosure 220, where a portion travels upwardly within the space between the rear surface of the FPD 100 and the rear panel 226 of the screen enclosure. The remaining ambient airflow is deflected around the bottom edge of the FPD and travels upwardly across the front face of the FPD. The respective airflows then enter the exhaust manifold 311, where they are vented by fan 310 out of the enclosure. Figure 15 represents airflow through the enclosure, showing in particular the laminar flow achieved across the front and rear faces of FPD 100.

[0077] The heater component within the heater/blower unit 320 is a variable electrical resistance heater, and is particularly useful if the unit is intended to operate in a cold climate. For use in a consistently warm environment (such as an indoor or temperature environment) the heater may be dispensed with.

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[0078] Operation of the control system of ECU 300 is illustrated schematically in Figure 26. ECU derives AC current from the mains feed. AC power passes from ECU 300 and is supplied as both DC and AC power, to components in the system. ECU 300 includes processor 500 that comprises firmware responsive to integral and attached external sensors. The ECU firmware includes integrated charts with user changeable fields to set the temperatures at which the system elements are switched. The firmware charts control the following components:

- a) the on/off temperatures of equipment connected to the AC outputs
- b) the on/off temperature of heating elements in the system
- c) the on/off temperature settings and run-speed of exhaust cooling fans.

[0079] ECU 300 includes a data connection to the content player, preferably a Mini IPX PC, with the data connection comprising an RS232 port for the transfer of data signals from the processor.

[0080] ECU 300 can be interrogated, remotely via the data connection, from the content player, using a "read ECU" command to view firmware charts controlling the operation of the system.

[0081] According to a preferred control setting, the firmware is programmed to control the heater and fans in response to the internal temperature within the enclosure as follows:

Temp	-40C	-30C	-20C	-10C	0C	10C	20C	30C	40C
Heater	ON	ON	ON	ON	ON	OFF	OFF	OFF	OFF
Fans	OFF	OFF	OFF	OFF	OFF	OFF	ON 20%	ON 50%	ON 100%

[0082] The firmware is programmed to turn power to the FPD off if the internal temperature is outside the above range.

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[0083] According to one embodiment, the architecture of the ECU and electronic componentry is as follows:

1. Power Input
 - AC mains supply feed 110V to 250V
 - Main power switch – system disconnect
 - Convenience outlet for peripheral equipment - optional
2. ECU – System Control Board
 - AC Power feed from system disconnect switch
 - AC Power distribution to all integrated equipment power supplies
 - System sensors on the board, and connections for remote sensors by cable to various positions within the enclosure (temperature, shock/acceleration; ambient light, enclosure intrusion/security), with ECU being responsive to signals from said sensors to shut down power to said FPD or transmit an alarm signal to a remote recipient
 - AC power distribution and (on/off) control, heating elements
 - DC power distribution and (speed) control system (exhaust) fans
 - Alarm reporting function to content player
3. Power Supply or Supplies
 - Integrated player board AC/DC
 - LCD backlight AC/DC
4. Environmental Control – System Enclosure
 - Fan heater appliance to maintain enclosure internal ambient temperature within given parameters, determined by ECU firmware
 - Speed controlled high capacity exhaust fans to remove excess heat and maintain enclosure internal ambient temperature within given parameters, determined by ECU firmware
5. Electronic Equipment
 - Content player - Mini IPX format, ruggedized PC board, with video output to display(s) and network connection
 - Data storage device(s)
 - Wireless adapter (optional)
 - Network device(s)

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6. Display(s)

- LCD module with integrated backlight and T-con board LVDS connection
- Screen driver board with video feed from content player [may be eliminated if LVDS direct feed from player is available]

[0084] A seventh embodiment is shown in Figures 23-25, in which the enclosure 400 includes vertical spaced apart lateral sidewalls 401, having downwardly extending feet 402 (seen in Figs. 24 and 25). Opposed bottom and top walls 404 and 406 and a rear panel 408 are fastened to the sidewalls 401 to define an interior space. The rear panel 408 is removable, and gasket 409 seals rear panel 408 to walls 404 and 406 and sidewalls 406. An FPD housing 410 installed within enclosure 400, with a gasket 414 providing a resilient seal where the FPD housing contacts the enclosure. The FPD housing 410 is hinged to enclosure 400 with mutually engaging flanges 500 and 502 in the same manner as described above in connection with the 6th embodiment hereof. When closed, the FPD housing fits within the interior of enclosure 400.

[0085] The FPD housing 410 includes a bottom wall 405. An air inlet 418, provides air access to the FPD housing through a slotted portion of the bottom wall. The air inlet is covered with an inlet plenum 422, which houses a semi-permeable membrane 420 to filter the incoming air as described above. The inlet plenum 422 is retained by a removable clamp 423. An air outlet 424 is provided within the upper wall 407 in a location opposed to inlet plenum 422 to receive the outflow of air from the enclosure.

[0086] A battery of exhaust fans 426 is mounted to the top wall 406 of enclosure 400. Top wall 406 includes an array of outlet openings 430 aligned with exhaust fans 426. Outlets 430 are aligned with and directly above outlet 424, to exhaust air from the interior of FPD housing 410. A heater core 432 is mounted to the rear panel 408 within the interior of outer enclosure 400 to provide additional heat, when necessary. Heater core 432 comprises an electrical resistance heater, as described above. Airflow within enclosure 400 is further driven by a battery of circulation fans 440, mounted in a vertical row within the interior of the enclosure. Circulation fans 440 are mounted on a

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vertical fan bracket 442, which mounts to the heater core 432. Circulation fans 440 function in a similar fashion to circulation fans 84 described above.

[0087] The airflow entering the enclosure is directed to flow over and around the FPD so as to maintain its temperature within the desired operating range. The fans, heating system and other active system components are controlled by the EDU as described above.

[0088] One or more FPD power supplies 450, system controller 452, and other electrical components are mounted to the rear panel within the interior of the enclosure.

[0089] The enclosure 400 of the seventh embodiment may be fitted within a video display module of any of the embodiments described above, including without limitation a multi-sided free standing display that incorporates multiple enclosures, or a mounted display unit. An audio system may be incorporated, as described above, and the images on FPD may be supplied by an on-site source or supplied remotely in the manner described above.

[0090] The present invention encompasses variations and departures from the detailed embodiments described herein. The full scope of the invention includes the present disclosure of the invention, including the detailed description of embodiments, as well as the invention as set forth in the accompanying claims, and all functional and mechanical equivalents of any elements described herein.

CLAIMS

1. A video screen enclosure system for displaying a flat panel video display unit ("FPD"), comprising a housing, a front panel member mounted to said housing with an airtight seal, said front panel member including a clear viewing panel, means to mount said FPD within said enclosure to provide an air gap at least partially surrounding said FPD, an air inlet to permit exterior air to enter into said enclosure, an air outlet to exhaust air from said enclosure, air circulation means to draw exterior air into said enclosure through said inlet and circulate ambient air within said enclosure around said FPD, a temperature sensor and an environmental control unit ("ECU") responsive to said temperature sensor and configured to control said air circulation means to maintain the interior temperature within said enclosure within a selected range suitable for operation of said FPD.
2. A system as defined in claim 1 further comprising a heater to heat air within said enclosure.
3. A system as defined in claim 2 further comprising airflow diversion means whereby a portion of said ambient air is directed initially through said heater and the remainder of said ambient air is directed around said FPD.
4. A system as defined in claim 1 wherein said front panel member and said FPD are engaged to said housing with independent pivotal engagement means configured to permit said panel member and said FPD to independently pivot outwardly from said housing along parallel axes of rotation to permit access into the interior of said housing.
5. A system as defined in claim 4 wherein at least one of said pivotal engagement means comprises mutually engaging surfaces projecting from said means to mount said FPD and said housing respectively, configured to oppose each other and rest one upon the other.

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6. A system as defined in claim 5 wherein said mutually engaging surfaces comprise upwardly and downwardly projecting surfaces respectively, configured to interlock when engaged.
7. A system as defined in any one of claims 4-6 further comprising struts connecting said panel member and said FPD to said housing to retain said panel member and FPD in an open position, said struts having releasable mounts to permit rapid disconnection of said FPD and panel member from said housing.
8. A system as defined in any one of claims 1-7 further comprising a semi-permeable membrane mounted to said enclosure to filter air entering said enclosure through said inlet, said membrane having a pore size dimensioned to admit air while blocking liquid water.
9. A system as defined in any one of claims 1-8 further comprising means to shut down power to said FPD when said temperature is outside said range.
10. A system as defined in any one of claims 1-9 wherein said ECU comprises an AC power inlet, at least one AC power outlet, and at least DC power outlet.
11. A system as defined in any one of claim 1-10 further comprising one or more sensors to detect intrusion into said enclosure, breakage of said front panel, or movement of said enclosure, said ECU comprising means responsive to said sensors to shut down power to said FPD or transmit an alarm signal to a remote recipient.
12. A video screen enclosure system for displaying a flat panel video display unit ("FPD"), comprising a housing, a front panel member mounted to said housing with an airtight seal, said front panel member including a clear viewing panel, means to mount said FPD within said enclosure to provide an air gap at least partially surrounding said FPD, means to circulate air within said enclosure around said FPD, a temperature sensor and an environmental control unit ("ECU") responsive to said temperature sensor configured to control said means

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to circulate air to maintain the interior temperature within said enclosure within a selected range suitable for operation of said FPD.

13. A system as defined in claim 12 wherein said enclosure forms a sealed unit wherein essentially only interior air is recirculated through said ECU, and said ECU comprises a heat exchanger or air conditioner to selectively chill said recirculated air to maintain the interior temperature within said selected range.

14. A system as defined in claim 12 wherein said means to circulate air includes at least one baffle configured to direct an air current around the front and rear faces of said FPD within said enclosure.

15. A system as defined in any one of claims 12-14 wherein said means to circulate air includes at least one blower configured to circulate air within said enclosure.

16. A system as defined in claim 12 wherein said ECU includes a heater.

17. A system as defined in claim 12 further comprising an audio system for projecting sound from said enclosure, said audio system comprising at least one audio transducer in contact with said front panel whereby said front panel forms an audio driver.

18. A system as defined in any one of claims 1-17 further comprising a flat panel FPD.

19. A system as defined in any one of claims 1-18 further comprising a source of digital image signals and signal transmission means to transmit said signals to said digital display unit.

20. A display system comprising a support frame and at least one video screen enclosure system as defined in any of claims 1-19 mounted to said frame configured to form a multi-sided display module wherein said video screen enclosure system forms comprises at least one side of said module.

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21. A system as defined in claim 20 wherein said frame is configured to retain at least two of said enclosures in angled relationship to each other.

22. A system as defined in claim 21 comprising a substantially enclosed structure defining an interior space, wherein said enclosures face outwardly from said structure.

23. A system as defined in any one of claims 20-22 configured to form a component of a transit shelter.

24. A system as defined any one of claims 20-23 further comprising a backlit poster display configured to form a side of said display module.

25. A system as defined in any one of claims 20-24 configured as a triangular structure having three generally vertically oriented rectangular sidewalls at least one of which comprises said video screen enclosure system.

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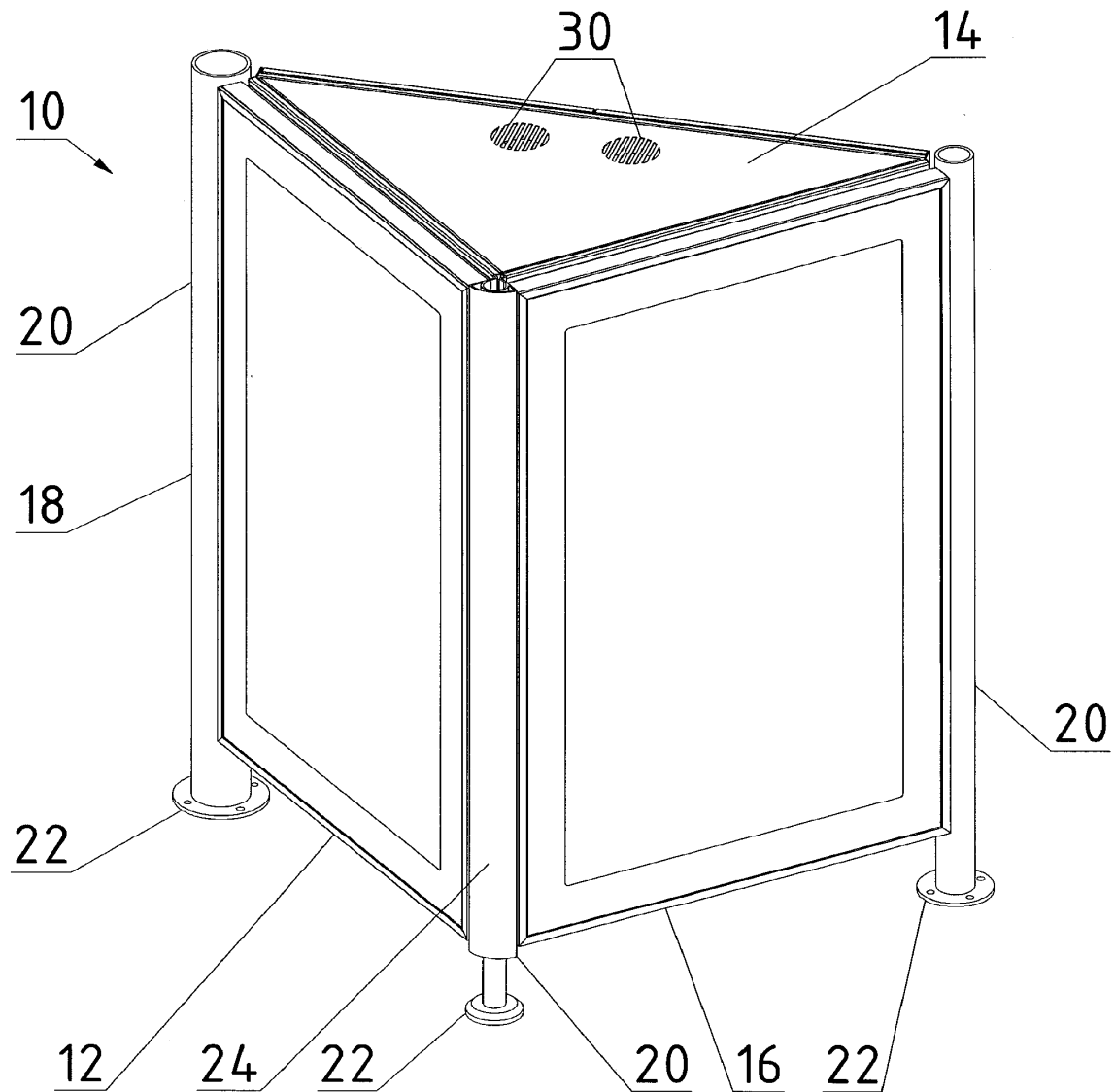


FIG. 1

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