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(54) **DISPLAY COOLING**

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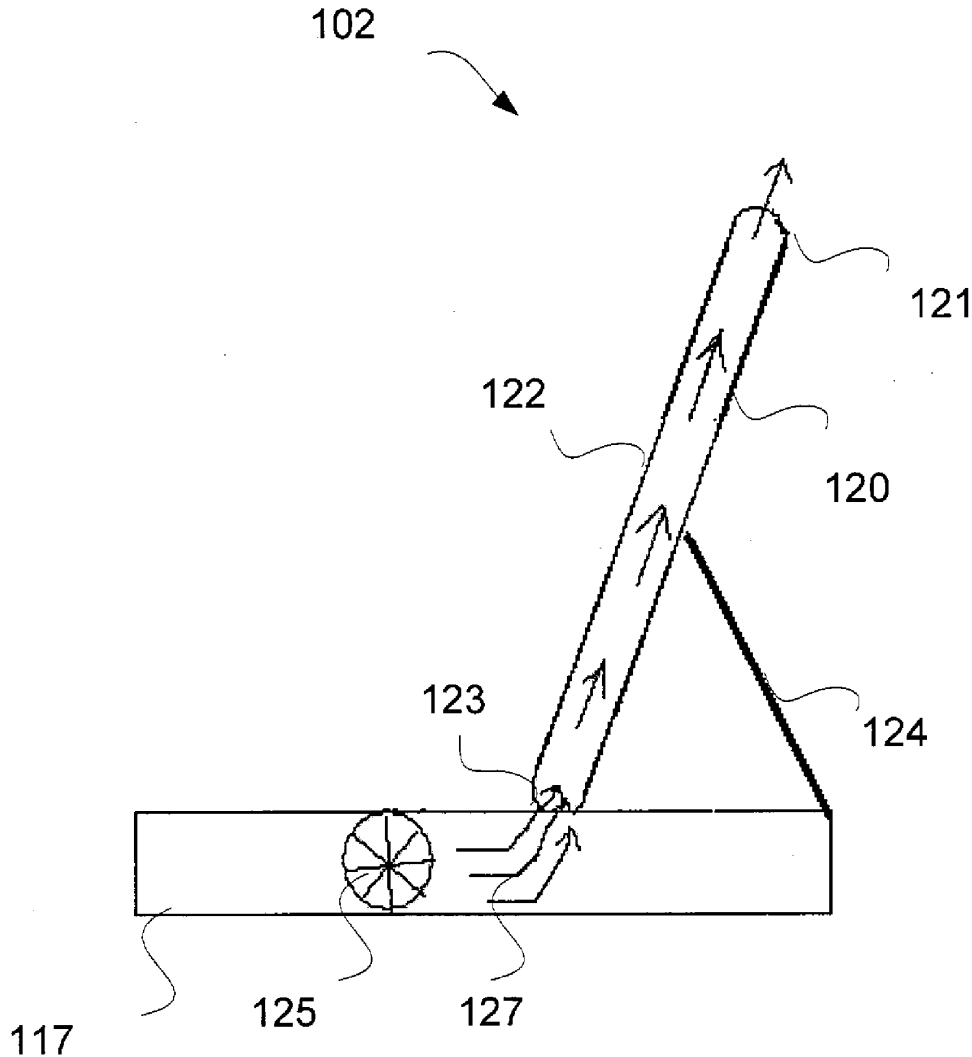
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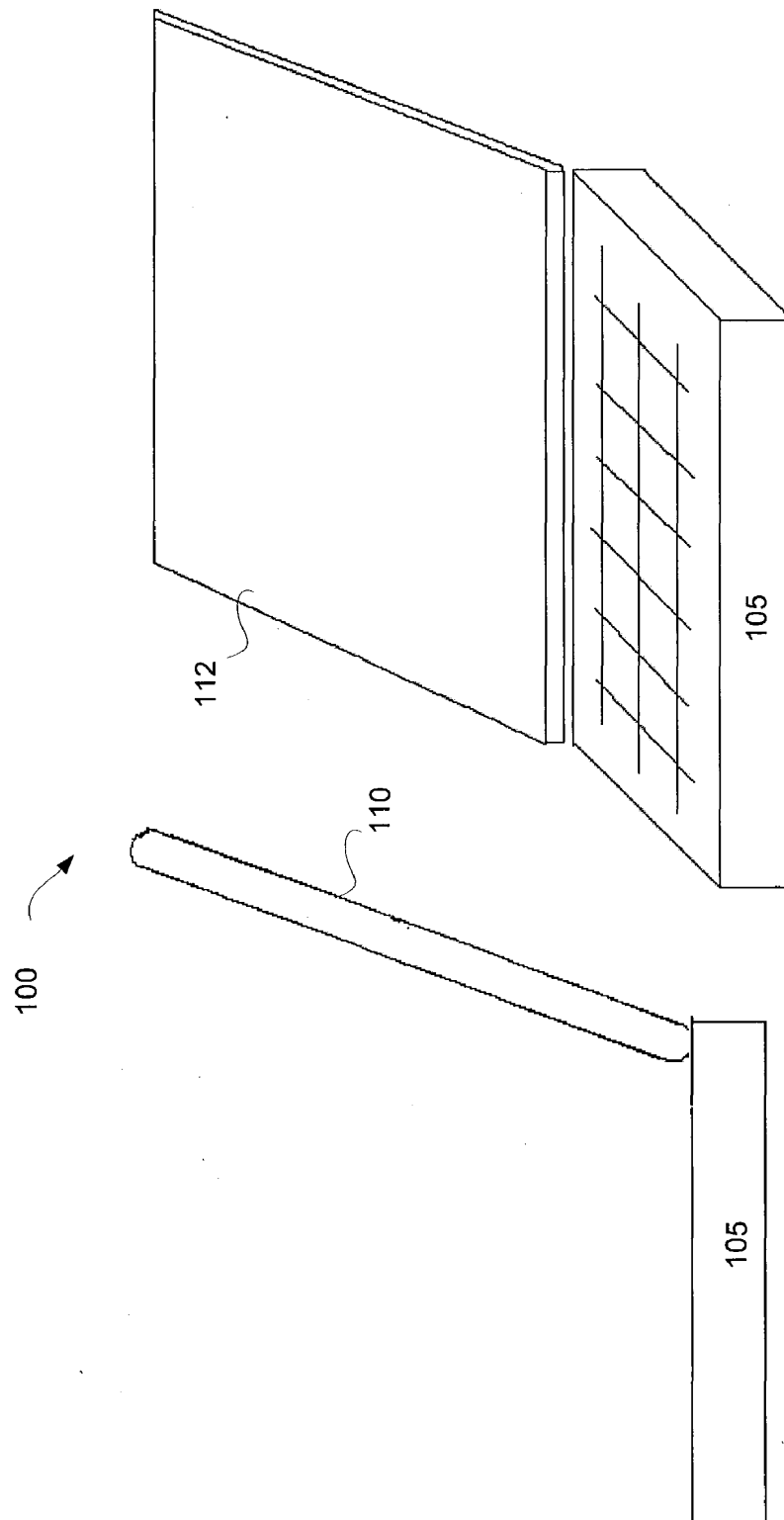
ABSTRACT

Apparatus and method for cooling a display unit includes having a first set of one or more openings to allow pressured air to enter a display unit housing and a second set of one or more openings to allow the air to exit. The pressured air is generated by an air movement device. The air movement device may be internal or external to the display unit housing.

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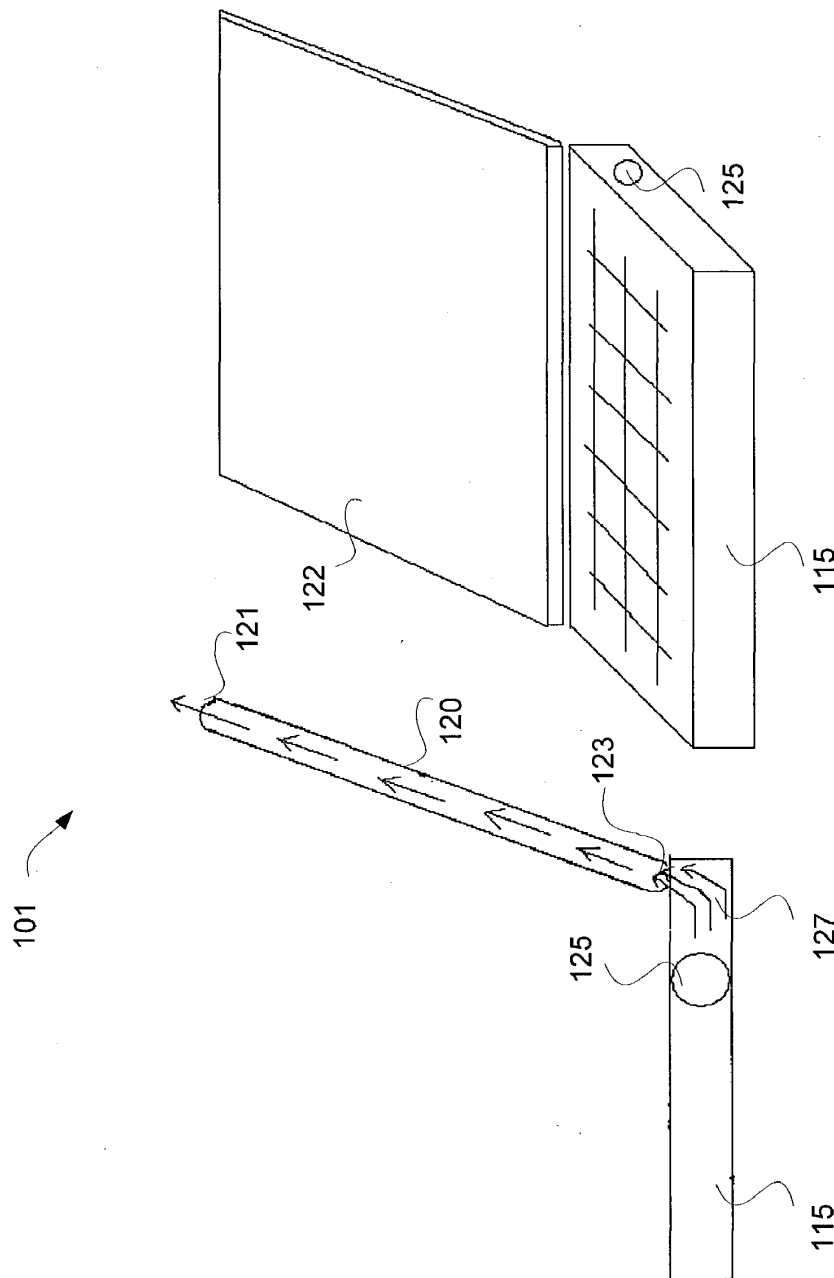


FIG. 2B

FIG. 2A

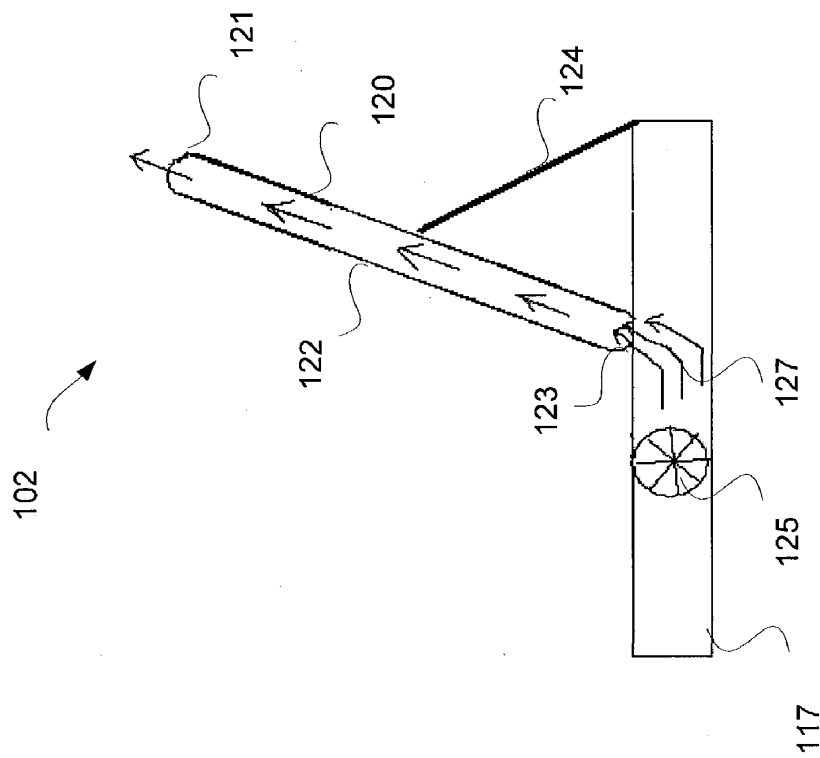


FIG. 3

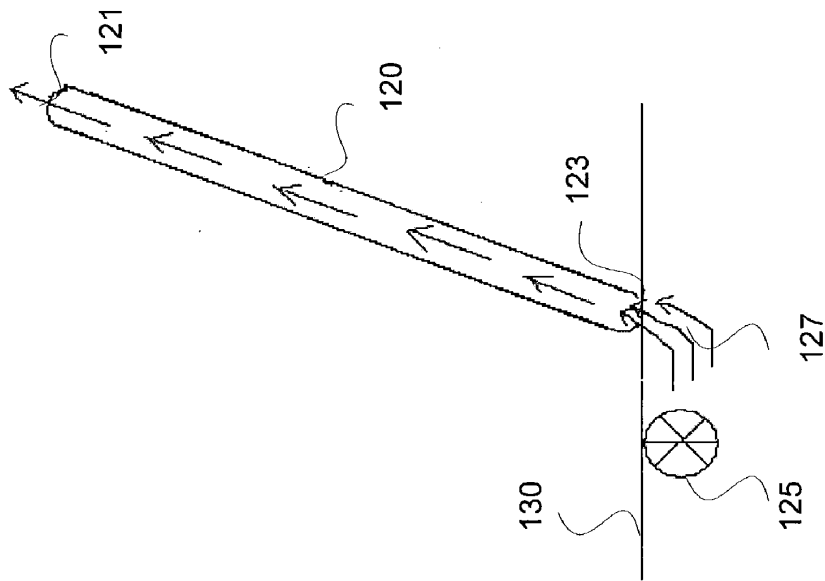


FIG. 4

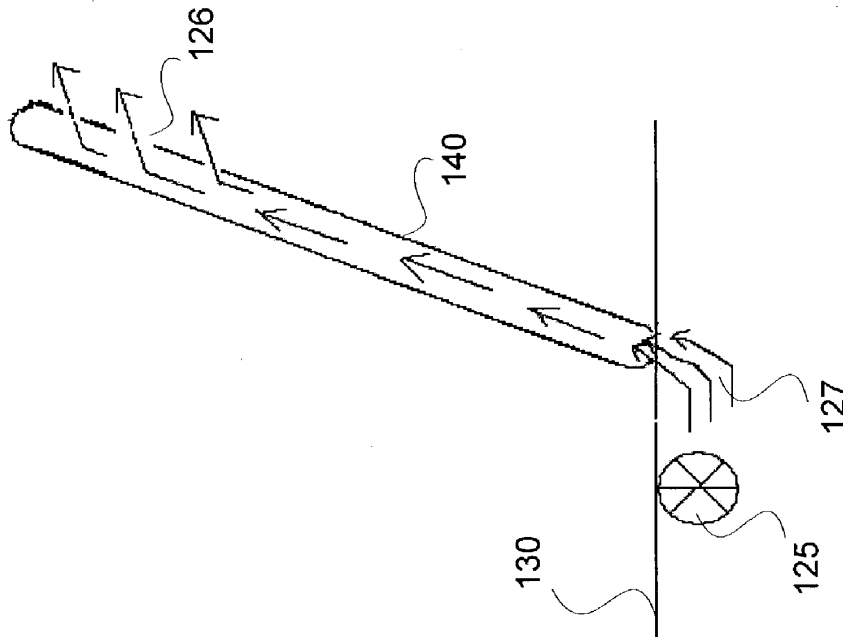


FIG. 5

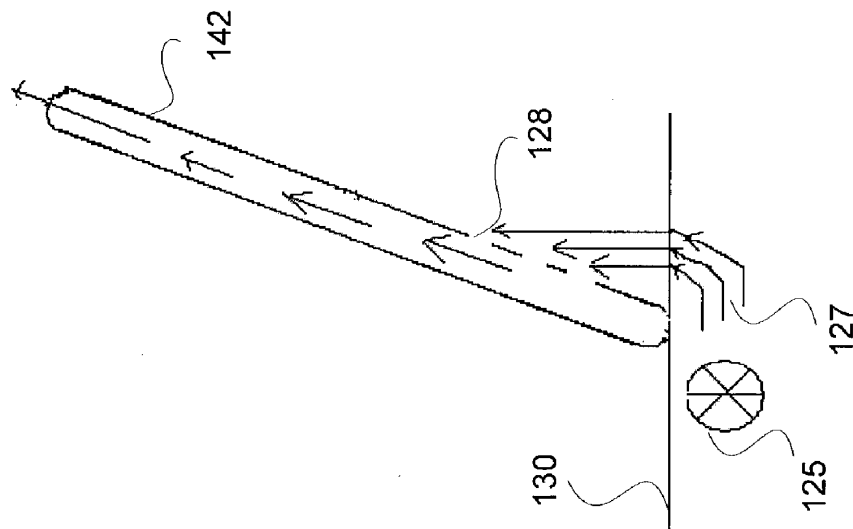
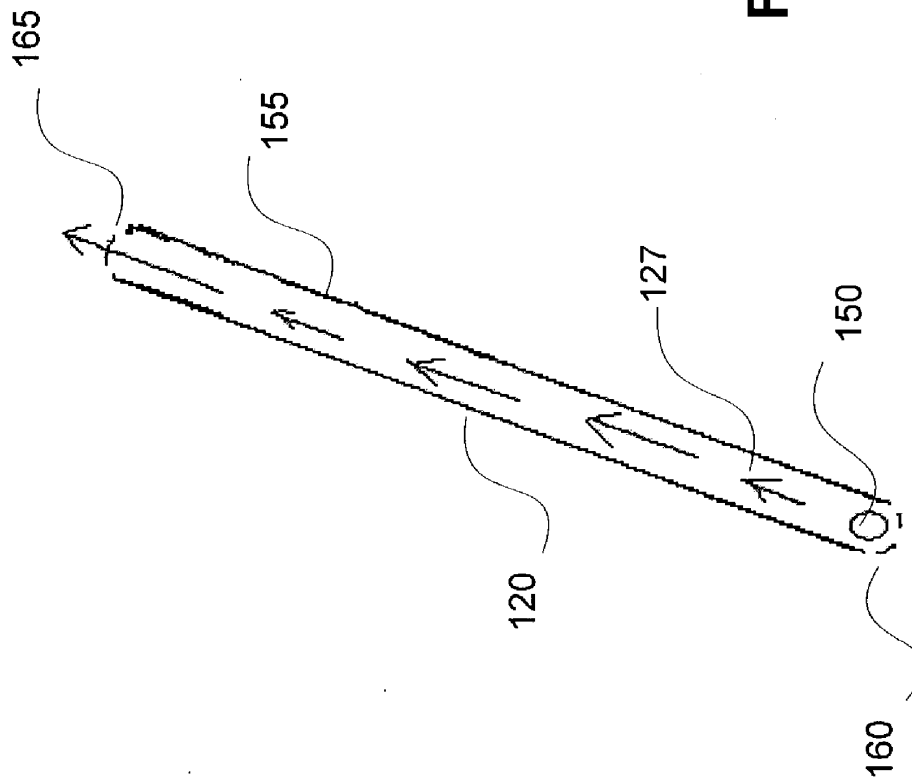


FIG. 6

FIG. 7



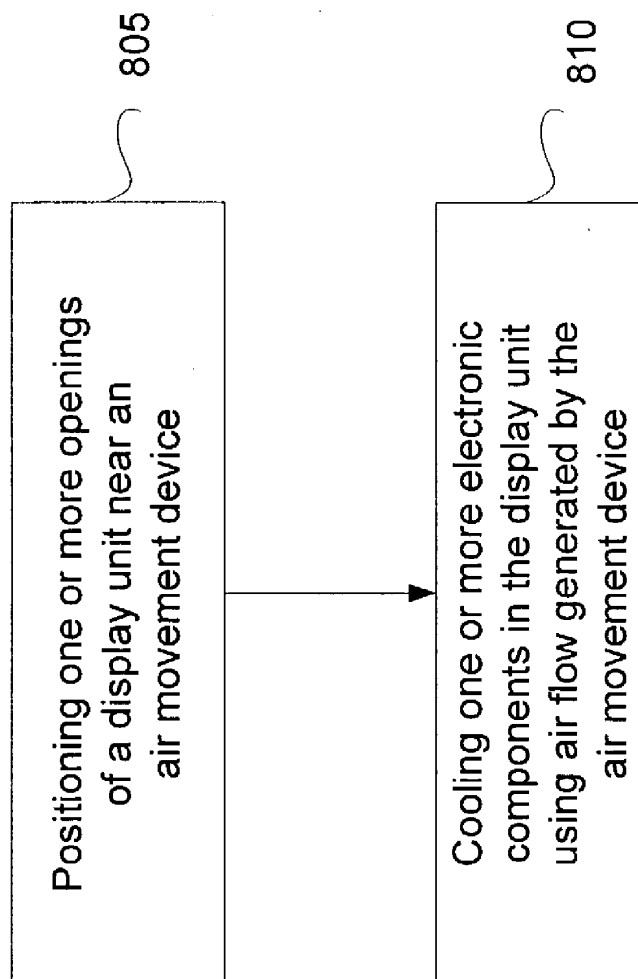


FIG. 8

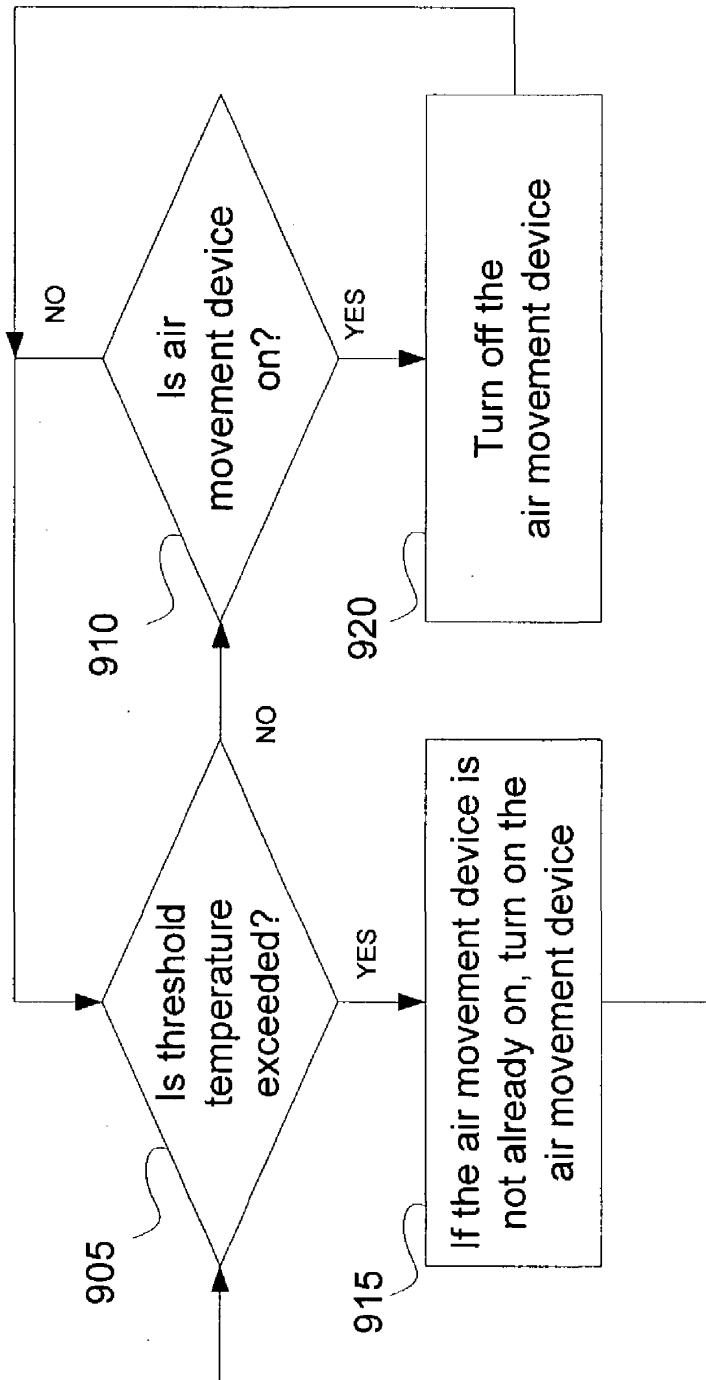


FIG. 9

DISPLAY COOLING

FIELD OF THE INVENTION

[0001] The present invention relates to the field of thermal management, and more particularly, to heat removal from a computing device.

BACKGROUND

[0002] Smaller and more powerful electronic components allow for the design and construction of higher performance portable computing devices (e.g., laptop or notebook computers). Unfortunately, the use of such powerful electronic components often results in increased heat generation. Thus, heat dissipation technology is often used to maintain operating temperatures of the computing devices.

[0003] A portable computing device typically includes a base unit and a display unit. The base unit usually includes an input device (e.g., a keyboard or a touchpad) and a number of electronic components (e.g., processor, disk drive, memory modules, etc.). When in operation, each of these electronic components may generate a different amount of heat. In addition, the display unit may also generate a certain amount of heat when being active for a period of time.

[0004] Maintaining the temperatures of the electronic components and of the display is important to ensure performance, reliability, and safety. Most integrated circuits have specified maximum operating temperatures. When the temperature exceeds a specified maximum, the electronic component may fail. Typically, the base unit may include a fan employed to dissipate heat from the electronic components. The fan may be located in the rear wall of the base unit and may be constructed to induce airflow across the various electronic components in the base unit.

[0005] When the display is integrated into the base unit (e.g., a tablet-like construction), the airflow induced by the fan in the base unit may also help cool the display unit. However, when the display unit is attached to the base unit (e.g., a clamshell-like construction), the airflow in the base unit may have minimal effect on the heat generated by the display unit. In a portable computing device, the display unit is normally thin and display cooling is typically passive. Keeping the display unit cool may help increase its reliability and reduce power consumption of the portable computing device.

BRIEF DESCRIPTION OF THE FIGURES

[0006] The present invention is illustrated by way of example and not limitation in the figures of the accompanying drawings.

[0007] FIGS. 1A and 1B illustrate a side view and a front view of a prior art portable computing device.

[0008] FIGS. 2A and 2B illustrate a side view and a front view of a portable computing device that includes an air movement device to cool a display unit, according to one embodiment.

[0009] FIG. 3 illustrates a side view of another portable computing device that includes an air movement device to cool a display unit, according to one embodiment.

[0010] FIG. 4 illustrates a tablet computing device, according to one embodiment.

[0011] FIG. 5 illustrates a tablet computing device that includes openings to receive pressured airflow, according to one embodiment.

[0012] FIG. 6 illustrates a third tablet computing device that includes openings to enable pressured airflow to enter, according to one embodiment.

[0013] FIG. 7 illustrates a tablet computing device with an air movement device, according to one embodiment.

[0014] FIG. 8 is a flow diagram illustrating an example of a process used to cool a display unit of a computing device, according to one embodiment.

[0015] FIG. 9 is a flow diagram illustrating another process used to cool a display of a computing device, according to one embodiment.

DETAILED DESCRIPTION

[0016] For one embodiment, a method for cooling a display unit is disclosed. The display unit may include a housing and a display screen. The housing may include one or more openings. Airflow is blown through the one or more openings into the housing of the display unit using an active cooling device external to the display unit.

[0017] In the following description, numerous specific details, such as component types, heat dissipation device sizes, and heat dissipation component mounting structures, and locations are set forth in order to provide a more thorough understanding of the present invention. It will be appreciated, however, by one skilled in the art that the invention may be practiced without such specific details.

[0018] FIGS. 1A and 1B illustrate a side view and a front view of a prior art portable computing device. Portable computing device 100 may be a laptop computer, a notebook computer, or any other portable computing device. The portable computing device 100 may include a base unit 105 and a display unit 110. The display unit 110 may be attached to the base unit 105 using one or more attachment mechanisms (not shown) such as, for example, hinges. The portable computing device 100 may include many electronic components. These electronic components may include a memory system, a disk and/or CD ROM drive, audio and video hardware, connectivity (i.e., network and modem) hardware, a power supply, etc. Most of these electronic components may be in the base unit 105 instead of being in the display unit 110. Typically, the base unit 105 may include one or more cooling devices to reduce temperature. For example, the cooling devices may include heat pipes, heat exchangers, etc. The display unit 110 may include a display screen 112 which may be, for example, liquid crystals display (LCD).

[0019] FIGS. 2A and 2B illustrate a side view and a front view of a portable computing device that includes an air movement device in a base unit, according to one embodiment. Portable computing device 101 may include a base unit 115 and a display unit 120. For one embodiment, the base unit 115 may include an air movement device 125. The air movement device 125 may be, for example, a fan, a blower, etc. The base unit 115 may also include one or more openings (not shown) to allow airflow 127 generated by the

air movement device **125** to flow out of the base unit **115**. In this example, the location of the air movement device **125** is for illustration only and may vary depending on the implementations.

[0020] For one embodiment, the display unit **120** may be an enclosure having a display screen **122** and electronic components associated with the display unit **120**. Depending on the implementations of the portable computing device **101**, the display unit **120** may also include other electronic components such as, for example, circuits, memory chips, batteries, processor, etc. The electronic components may be located behind the display screen **122**. The display unit **120** may include one or more openings or vents **123** (may be referred to as entry openings) located at or near its bottom edge. The display unit **120** may also include one or more openings **121** located at or near its top edge (may be referred to as exit openings).

[0021] For one embodiment, when the entry openings **123** at or near the bottom edge of the display unit **120** is placed in a location having pressured airflow, the entry openings **123** may allow the pressured airflow to flow into the display unit **120** behind the display screen **122** to cool the electronic components in the display unit **120**. In this example, the entry openings **123** is placed near the one or more openings (not shown) of the base unit **115** to receive the airflow **127** flowing out of the base unit **115**.

[0022] For one embodiment, the airflow **127** generated by the air movement device **125** may have a pressure higher than the air released by the display unit **120**. This may allow the airflow **127** to flow (in the direction illustrated by the arrows) into the display unit **120** at the entry openings **123** and out of the display unit **120** at the exit openings **121**. For one embodiment, the air movement device **125** is positioned such that the pressured air that flows into the display unit **120** is of a lower temperature than the ambient air within the display unit **120**. As the air flows toward the exit openings **121**, the air temperature may rise.

[0023] FIG. 3 illustrates a side view of another portable computing device that includes an air movement device, according to one embodiment. Portable computing device **102** may include a base unit **117** and a display unit **120**. For one embodiment, the display unit **120** of the portable computing device **102** may be detachable from the base unit **117**. In this example, the display unit **120** of the portable computing device **102** may be attached to the base unit **117** using attachment **124**. The attachment **124** may also enable the display unit **120** to stay upright with respect to the base unit **117**, as illustrated. Note that in this example, the air movement device **125** of the portable computing device **102** may be positioned at a different location comparing to the location illustrated in FIGS. 2A and 2B. This may allow the airflow **127** to enter the display unit **120** when the display unit **120** is positioned as shown in FIG. 3.

[0024] It may be noted that, in this example, because the display unit **120** may be detached from the base unit **117**, the display unit **120** may include hardware logic to enable it to perform as a tablet computing device. The hardware logic may include, for example, memory subsystem, I/O subsystem, processor, etc. In this example, the base unit **117** may not include the same hardware logic as the base unit **105** of the portable computing device **100** illustrated in FIG. 1. For example, the base unit **117** may include a keyboard, one or more hard drives, etc.

[0025] For one embodiment, when the display unit **120** is detached, cooling of the electronic components in the display unit **120** may be achieved by placing the display unit **120** on a surface that provides pressured air. FIG. 4 illustrates a tablet computing device, according to one embodiment. For one embodiment, the display unit **120** may include electronic components to enable it to perform as a tablet computing device. Surface **130** may have one or more openings (not shown) and an air movement device **125** underneath. The air movement device **125** may generate pressured air which may flow through the one or more openings of the surface **130**. The display unit **120** may be positioned such that the pressured air **127** may enter the display unit **120** at the entry openings **123** near the bottom of the display unit **120**.

[0026] The entry openings **123** and the exit openings **121** on the display unit **120** may be positioned based on concentration of heat inside the display unit **120**. For example, depending on how the electronic components are arranged in the display unit **120**, certain areas (e.g., hot spots) may be warmer than others. Thus, it may be desirable to allow the airflow to flow past these areas when the air is still cool. This may help increase the overall cooling effectiveness of the airflow. FIG. 5 illustrates a tablet computing system that includes exit openings, according to one embodiment. Note that display unit **140** (which may perform as a tablet computing device) may include exit openings **126** on upper part of the back of the display unit **140**, as compared to the exit openings **121** located at the top edge of the display unit **140**. FIG. 6 illustrates a tablet computing device that includes entry openings, according to one embodiment. Note that display unit **142** (which may perform as a tablet computing device) may include entry openings **128** on lower part of the back of the display unit **142**, as compared to the entry openings **123** being at the bottom edge of the display unit **142**.

[0027] FIG. 7 illustrates a tablet computing device with an air movement device, according to one embodiment. For one embodiment, display unit **155** (which may perform as a tablet computing device) may include a display screen **120** and an air movement device **150** in an enclosure that makes up the display unit **155**. The air movement device **150** may be positioned behind the display screen **120** and toward the bottom of the display unit **155**. The display unit **155** may also include one or more openings **160** to enable the air movement device **150** to pull cool air from outside of the display unit **155**. Air flow **127** generated by the air movement device **150** may cause an increase in pressure in the bottom region of the display unit **155** enabling the air to flow toward the exit openings **165** located toward the top of the display unit **155**. This may help with heat dissipation of the electronic components in the display unit **155**.

[0028] FIG. 8 is a flow diagram illustrating one process used to cool a display of a computing device, according to one embodiment. In this example, the display unit does not have its own air movement device and may rely on an external air movement device to help with its heat dissipation. At block **805**, the display unit is positioned near an air movement device. To increase the amount of pressured air received from the air movement device, it may be desirable to position the entry openings of the display unit near the air movement device. At block **810**, the electronic components in the display unit are cooled by the pressured air that enters

the display unit at the entry openings and flows behind the display screen toward the exit openings of the display unit.

[0029] For one embodiment, when the display unit has its own air movement device or when it is attached to a base unit that has an air movement device, the display unit may include a temperature sensor that measures the temperature of the ambient air inside the display unit. The temperature sensor may be coupled to a temperature manager which manages the operation of the air movement device. One or more predetermined temperature thresholds may be used by the temperature manager to control the operation of the air movement device to provide more efficient thermal management.

[0030] FIG. 9 is a flow diagram illustrating another process used to cool a display of a computing device, according to one embodiment. In this example, the display unit may have its own air movement device or it may be attached to a base unit that has an air movement device. At block 905, a test is made to determine if the temperature of the ambient air exceeds a threshold temperature. When the threshold is exceeded, the air movement device is turned on, as shown in block 915. It may be possible that the air movement device is already on but the temperature of the ambient air may still exceed the temperature threshold. From block 915, the process continues at block 905.

[0031] From block 905, when the temperature threshold is not exceeded, the process flow to block 910 where a test is made to determine if the air movement device is on. When the air movement device is on, the process flows from block 910 to block 920 where the air movement device is turned off to save power. From block 920, the process then continues to block 905. From block 910, when the air movement device is not on, the process flows from block 910 to block 905.

[0032] The operations of these various methods may be implemented by a processor in a computing device, which executes sequences of computer program instructions which are stored in a memory which may be considered to be a machine-readable storage media. For example, the computing device may be the portable computing device 102 illustrated in FIG. 3. The memory may be random access memory (RAM), read only memory (ROM), a persistent storage memory, such as mass storage device or any combination of these devices. Execution of the sequences of instruction may cause the processor to perform operations according to one embodiment the present invention such as, for example, the operations described in FIGS. 8-9.

[0033] This invention has been described with reference to specific exemplary embodiments thereof. It will, however, be evident to persons having the benefit of this disclosure that various modifications and changes may be made to these embodiments without departing from the broader spirit and scope of the invention. The specification and drawings are, accordingly, to be regarded in an illustrative rather than a restrictive sense.

What is claimed is:

1. A system, comprising:
 - a base unit having a cooling device; and
 - a display unit attached to the base unit and adapted to receive airflow generated by the cooling device.

2. The system of claim 1, wherein the display unit includes a first housing, the first housing including a first set of one or more openings to receive the airflow generated by the cooling device.

3. The system of claim 2, wherein the display unit further includes a display screen, the airflow generated by the cooling device flowing behind the display screen.

4. The system of claim 1, wherein the cooling device is a fan.

5. The system of claim 1, wherein the base unit includes a second housing, the cooling device located inside the second housing.

6. The system of claim 5, wherein the second housing includes a second set of one or more openings, the airflow generated by the cooling device flowing through the second set of one or more openings and the first set of one or more openings.

7. The system of claim 6, wherein the second set of one or more openings is positioned near the first set of one or more openings.

8. The system of claim 6, wherein the second set of one or more openings is positioned relative to the first set of one or more openings to increase the airflow received by the display unit.

9. The system of claim 6, wherein the cooling device is positioned relative to the second set of one or more openings to increase pressure of the airflow received by the display unit.

10. The system of claim 6, wherein the first housing includes a third set of one or more openings, wherein the airflow received by the display unit exits the display unit at the third set of one or more openings.

11. The system of claim 11, wherein the third set of one or more openings is positioned relative to the first set of one or more openings to increase heat dissipation of the display unit.

12. An apparatus, comprising:

- a first enclosure, the first enclosure including an air movement device; and

- a second enclosure coupled to the first enclosure, the second enclosure including heat-generating electronic components associated with a display screen, the second enclosure further including a first opening to receive airflow generated by the air movement device, the airflow is to cool the heat-generating electronic components in the second enclosure.

13. The apparatus of claim 12, wherein the second enclosure further includes a second opening to release the air received at the first opening.

14. The apparatus of claim 13, wherein the second opening is positioned away from the first opening to enable the airflow to cool more heat-generating electronic components.

15. The apparatus of claim 14, wherein the airflow flows from the first opening to the second opening behind the display screen.

16. The apparatus of claim 12, wherein the display screen is a liquid crystal display (LCD).

17. The apparatus of claim 12, wherein the airflow generated by the air movement device further cools heat-generating electronic components in the first enclosure.

18. An apparatus, comprising:

- a housing, the housing including an air movement device, a first opening, a second opening, and electronic com-

ponents associated with a display screen, the air movement device is to cause airflow to enter the housing through the first opening and to flow behind the display screen toward the second opening.

19. The apparatus of claim 18, wherein the housing further includes a processor and electronic components associated with the processor, the processor coupled to the display screen, wherein the airflow is to cool the electronic components associated with the display screen and the electronic components associated with the processor.

20. The apparatus of claim 18, wherein the air movement device is a fan, and the display screen is a liquid crystal display (LCD).

21. A display unit in a mobile computing device, comprising:

a display screen; and

a first set of one or more openings to receive pressured air caused by a cooling device, the air is to flow behind the display screen to a second set of one or more openings.

22. The display unit of claim 21, further comprising electronic components associated with the display screen, and wherein the pressured air is to cool the electronic components.

23. The display unit of claim 22, wherein the first set of one or more openings is positioned at a location where there is a high concentration of heat generated by the electronic components associated with the display screen.

24. The display unit of claim 22, wherein the second set of one or more openings is positioned relative to the first set of one or more openings to enable more cooling of the electronic components associated with the display screen.

25. A computer system, comprising:

a base unit, the base unit including an air movement unit to generate airflow; and

a display unit coupled to the base unit, the display unit including a display screen and a first opening, wherein the first opening is positioned close to the air movement unit to receive the airflow generated by the air movement unit.

26. The system of claim 25, wherein heat generated by electronic components associated with the display screen is cooled by the airflow received at the first opening.

27. The system of claim 25, wherein the display unit further includes a second opening to allow cross ventilation of the airflow received at the first opening.

28. The system of claim 25, wherein the base unit further includes a processor and electronic components associated with the processor, and wherein heat generated by the electronic components associated with the processor is cooled by the airflow generated by the air movement unit.

29. A method, comprising:

forcing air through a first set of one or more openings of a display unit housing into the display unit housing, the air generated by an air movement device external to the display unit housing and is to dissipate heat generated by one or more electronic components included in the display unit housing.

30. The method of claim 29, wherein the air exits the display unit housing through a second set of one or more openings.

31. The method of claim 29, wherein the display unit housing includes a display screen and electronic components associated with the display screen.

32. The method of claim 31, wherein the display unit housing further includes a processing unit.

33. The method of claim 29, wherein the air movement device is included in a base unit housing coupled to the display unit housing.

34. A method, comprising:

determining if temperature of ambient air inside a display unit housing exceeds a predetermined temperature threshold; and

when the temperature of the ambient air exceeds the predetermined temperature threshold and an air movement device associated with the display unit housing is not turned on, turning on the air movement device, wherein air generated by the air movement device is to enter the display unit housing through a first set of one or more openings, to flow behind a display screen of the display unit housing, and is to exit the display unit housing through a second set of one or more openings.

35. The method of claim 34, further comprising:

when the temperature of the ambient air does not exceed the predetermined temperature threshold and the air movement device is not turned off, turning off the air movement device.

36. The method of claim 34, wherein the air movement device is external to the display unit housing.

37. The method of claim 34, wherein the air movement device is internal to the display unit housing.

38. A computer readable medium containing executable instructions which, when executed in a processing system, causes the processing system to perform a method comprising:

determining if temperature of ambient air inside a display unit housing exceeds a predetermined temperature threshold; and

when the temperature of the ambient air exceeds the predetermined temperature threshold and an air movement device associated with the display unit housing is not turned on, turning on the air movement device, wherein are generated by the air movement device is to enter the display unit housing through a first set of one or more openings, to flow behind a display screen of the display unit housing, and is to exist the display unit housing through a second set of one or more openings.

39. The computer readable medium of claim 38, further comprising:

when the temperature of the ambient air does not exceed the predetermined temperature threshold and the air movement device is not turned off, turning off the air movement device.

40. The computer readable medium of claim 38, wherein the air movement device is external to the display unit housing.

41. The computer readable medium of claim 38, wherein the air movement device is internal to the display unit housing.

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