A cooling device having a first fan, a second fan upstream of the first fan, and a flow-conditioner element that includes a housing with a first side having a flow-conditioner plate, a second side opposite the first side that defines an opening, and a duct between the first side and the second side, wherein the flow-conditioner plate is attached to a side of the first fan proximal to the second fan and the second side of the housing is attached to a side of the second fan proximal to the first fan. A method for cooling electronic components and a fan assembly are also disclosed.
**FIG. 9**

![Diagram of a mechanical component with labeled parts: 32, 34, 36, 38, 42, 44.](image)

**TABLE 1**

<table>
<thead>
<tr>
<th>CFM</th>
<th>Static Pressure</th>
</tr>
</thead>
<tbody>
<tr>
<td>PRIOR ART FAN PERFORMANCE</td>
<td></td>
</tr>
<tr>
<td>144.5</td>
<td>0.0</td>
</tr>
<tr>
<td>131.0</td>
<td>1.0</td>
</tr>
<tr>
<td>123.5</td>
<td>1.5</td>
</tr>
<tr>
<td>115.5</td>
<td>2.0</td>
</tr>
</tbody>
</table>

**TABLE 2**

<table>
<thead>
<tr>
<th>CFM</th>
<th>Static Pressure</th>
</tr>
</thead>
<tbody>
<tr>
<td>NEW FAN DUCT PERFORMANCE</td>
<td></td>
</tr>
<tr>
<td>150.3</td>
<td>0.0</td>
</tr>
<tr>
<td>137.4</td>
<td>1.0</td>
</tr>
<tr>
<td>127.0</td>
<td>1.5</td>
</tr>
<tr>
<td>118.4</td>
<td>2.0</td>
</tr>
</tbody>
</table>

**FIG. 10**
FAN AND COOLING DEVICE

BACKGROUND

When in operation, electronic components generate heat which must be dissipated in order to ensure their continued operation and to prevent the build up of heat within the device or cabinet in which the electronic components are located. This is particularly true with respect to computer components used in desktops or servers where the increasing density of components has resulted in increased cooling demands.

The increased cooling demands can be met by supplying higher airflow through the device or system in which the components are located. Due to space limitations in various devices, including desktops and servers, the installation of larger or parallel fans is not practicable. One alternative to the use of parallel fans is to use series stacked fans to provide for higher rates of airflow. Unfortunately, the performance of the stacked series fans is reduced due to the non-ideal i.e., non-uniform entrance flow of air entering the downstream fan.

Various attempts have been made to improve the flow of air entering the downstream fan. These include the use of outlet guide vanes attached to the upstream fan in an attempt to provide uniform airflow to the downstream fan. Additionally, an air gap has been provided between the upstream and downstream fans in an attempt to provide uniform airflow.

Given the need to provide a greater amount of cooling for more concentrated electronic components, a device that could generate a larger amount of cooling air at a reduced noise level would be an important improvement in the art.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a sectional view of a cooling device showing a first and second fan and a flow conditioner.

FIG. 2 is a side view of a flow conditioner.

FIG. 3 is a perspective view of a flow conditioner.

FIG. 3A is a perspective view of a flow-conditioner plate.

FIG. 4 is a graph showing the increase in air flow for a given static pressure.

FIG. 5 is a front view of a flow-conditioner plate.

FIG. 5A is a perspective view of the flow-conditioner plate shown in FIG. 5.

FIG. 6 is a graph showing the increased air flow at a given static pressure using a flow-conditioner plate as shown in FIG. 5.

FIG. 7 is a table showing the decrease in noise level using the flow conditioner.

FIG. 8 is a graph showing the decrease in noise level at various frequencies using the flow conditioner.

FIG. 9 is a side view of a fan assembly.

FIG. 10 is a table showing the increase in flow rate at a given static pressure for an embodiment of the fan assembly.

FIG. 11 is a perspective view of an embodiment of a fan inlet duct.

FIG. 11A is a perspective view showing the fan connection plate of the fan inlet duct shown in FIG. 11.

FIG. 12 is a perspective view of an embodiment of a fan outlet duct.

FIG. 12A is a perspective view showing the fan connection plate of the fan outlet duct shown in FIG. 12.

DETAILED DESCRIPTION OF THE EMBODIMENTS

The apparatus involves a cooling device 10 for use with electronic components (not shown), in particular, computer components within desktops, blade enclosures, and servers. As shown in FIG. 1, the cooling device 10 comprises a first fan 12, a second fan 14 upstream of the first fan 12, and a flow conditioner element 16 that comprises a housing 18 having a first side 20 that includes a flow-conditioner plate 22, a second side 24 opposite the first side 20 that defines an opening 26, and duct 28 between the first side 20 and the second side 24, wherein the flow-conditioner plate 22 is attached to a side of the first fan 12 proximal to the second fan 14 and the second side 24 of the housing 18 is attached to a side of the second fan 14 proximal to the first fan 12.

In an embodiment, the first 12 and second 14 fans are axial fans.

In an embodiment, the flow-conditioner plate 22 has a thickness "t" as shown in FIG. 2, of approximately 4 mm. This flow-conditioner plate 22 may be perforated, as is shown in FIG. 3A. Such a plate defines a plurality of openings 30, each one of which may be circular with a diameter of approximately 5 mm, in a particular embodiment. In an embodiment, the flow-conditioner plate 22 may have a circular grating that is divided into multiple sections as is shown in FIGS. 5 and 5A.

In still another embodiment, the length and width of the side of the first fan 12 proximal to the second fan 14 is equal to the length and width of the flow-conditioner plate 22. The duct 28, defined by the housing 18 between the flow-conditioner plate 22 and the second side 24, may be an elongated duct 28 having a length "L" of at least 13 mm, as shown in FIG. 2. The duct 28 provides for an air gap that exists between the flow-conditioner plate 22 and the second fan 14, as shown in FIGS. 1, 2, and 3.

The flow conditioner element 16 may be manufactured of plastic or any like material.

When in operation, the flow conditioner 16 is aligned axially between the first and second fan 12, 14, downstream of the second fan 14, as shown in FIG. 1. Air flow "A" exits the second fan 14 and proceeds through the opening 26 in the second end 24 of the flow conditioner housing 18, through the air duct 28 to the flow-conditioner plate 22 on the first end 20 of the housing 18 adjacent to the first fan 12. The air "A" is then drawn through the flow-conditioner plate 22 into the first fan 12.

In an embodiment, the cooling device 10 is used to cool computer components (not shown) that may be located in a desktop computer or a server. The flow conditioner 16 improves the flow of air entering the downstream or first fan 12 by generating a more uniform flow of air. As can be seen in FIG. 4, using the flow conditioner results in a higher flow rate in cubic feet per minute ("CFM") being generated by a fan at a given static pressure. This results in an increase in the airflow through the electronic components resulting in greater cooling while the spacing of the fans 12, 14 reduce the noise associated with the airflow through the fans 12, 14. This increase in airflow allows for an increase of the density of components in a given compartment as greater cooling is achieved at a given static pressure than without the use of the flow conditioner 16. Likewise, the flow conditioner 16 results...
in an increase in energy savings and noise reduction as it allows for a particular static pressure to be achieved using a lower CFM, and thus a lower fan RPM, than a cooling system utilizing cooling fans arranged in series without a flow conditioner 16.

[0028] FIGS. 5 and 5A show another embodiment of the flow-conditioner plate 22 used with the cooling device 10. FIG. 6 is a graph showing the increase in flow rate for a given static pressure that result from the use of a flow conditioner 16 with the flow-conditioner plate 22 shown in FIG. 5.

[0029] As shown in FIGS. 7 and 8, at low operating frequencies, the greater the air gap between the two fans 12, 14, the lower the noise level. At higher frequencies, an air gap of at least 13 mm results in a more effective level of noise reduction.

[0030] Also disclosed is a method of cooling electronic components within an enclosure, the method comprises: (1) generating an air flow from a second fan 14; (2) drawing the air flow from the second fan 14 through an opening 26 in a housing 18 positioned downstream of the second fan 14; (3) pulling the air flow through a flow-conditioner plate 22 on a side of the housing 18 distal to the second fan 14 into a first fan 12 attached to the flow-conditioner panel 22; and (4) generating the air flow downstream from the first fan 12.

[0031] In an embodiment, the flow-conditioner plate is a perforated plate.

[0032] A fan assembly 32 for cooling electronic components is also disclosed. In an embodiment, as shown in FIG. 9, the fan assembly 32 comprises a fan 34, an inlet duct 36 having a first end 38 upstream of the fan 34, said first end 38, as shown in FIGS. 11 and 11A, defines a first opening 40 having a first diameter d1 and a second end 42 downstream of the first end 38, said second end 42 attached to a first side 44 of the fan 34 and defining a second opening 46 having a second diameter d2 that is smaller than the first diameter d1.

An outlet duct 48, as shown in FIGS. 12 and 12A, has a first end 50 attached to a second side 52 of the fan 34 opposite the first side 42, said first end 50 of the outlet duct 48 defining an opening 54 having a first diameter d3 and a second end 56 downstream of the first end 50, said second end 56 defining a second opening 58 having a second diameter d4 that is greater than the first diameter d3.

[0033] The inlet duct 36, as shown in FIG. 11, used in the assembly 32 creates a nozzle effect that allows for a smoother flow of air into the fan 34. The outlet duct 48, as shown in FIG. 12, acts as a diffuser expanding the air flow out of the fan 34. As shown in FIG. 10, the use of the inlet and outlet duct 36, 48 allows for a greater flow of air at a given static pressure, as shown in FIG. 10, thereby increasing the cooling effect of the fan 34.

[0034] In an embodiment, the diameter d1 of the first end 38 of the inlet duct 36 is equal to the diameter d3 of the second end 56 of the outlet duct 48, and the diameter d2 of the second end 42 of the inlet duct 36 is equal to the diameter d4 of the first end 50 of the outlet duct 48.

[0035] In still another embodiment, the second end of the outlet duct 56 is attached to a flow conditioner element 16.

[0036] The use of the terms “a” and “an” and “the” and similar referents in the context of describing the claimed apparatus, device, system, or method (especially in the context of the following claims) are to be construed to cover both the singular and the plural, unless otherwise indicated herein or clearly contradicted by context. Recitation of ranges of values herein are merely intended to serve as a shorthand method of referring individually to each separate value falling within the range, unless otherwise indicated herein, and each separate value is incorporated into the specification as if it were individually recited herein. All methods described herein can be performed in any suitable order unless otherwise indicated herein or otherwise clearly contradicted by context. The use of any and all examples, or exemplary language (e.g., “such as”) provided herein, is intended merely to better illuminate the claimed apparatus, device, system, or method and does not impose a scope limitation unless otherwise claimed. No language in the specification should be construed as indicating any non-claimed element as essential to the practice of the claimed apparatus, device, system, or method.

[0037] Preferred embodiments of the claimed apparatus, device, system, or method are described herein, including the best mode known to the inventors for practicing the claimed apparatus, device, system, or method. It should be understood that the illustrated embodiments are exemplary only, and should not be taken as limiting the scope of the claimed apparatus, device, system, or method.

What is claimed is:

1. A cooling device comprising:
a first fan;
a second fan upstream of the first fan; and
a flow conditioner element located between the first and second fans, the flow conditioner element comprising:
a housing having a first side that includes a flow-conditioning plate;
a second side opposite the first side that defines an opening; and
ducts between the first side and the second side, wherein the flow-conditioning plate is attached to a side of the first fan proximal to the second fan and the second side of the housing is attached to a side of the second fan proximal to the first fan.

2. The cooling device of claim 1, wherein the first and second fans are axial fans.

3. The cooling device of claim 1, wherein the flow-conditioning plate has a thickness of approximately 4 mm.

4. The cooling device of claim 3, wherein the flow-conditioning plate is a perforated plate.

5. The cooling device of claim 4, wherein the perforated plate has a plurality of circular openings, each having a diameter of approximately 5 mm.

6. The cooling device of claim 4, wherein:
the side of the first fan proximal to the second fan has a length and a width; and
the flow-conditioning plate has a length that is equal to the length of the side of the first fan and a width that is equal to the width of said side.

7. The cooling device of claim 4, wherein the duct between the flow-conditioning plate and the second side is an elongated duct having a length of at least 13 mm.

8. The cooling device of claim 4, wherein the flow conditioner is manufactured from a rigid plastic or like material.

9. The cooling device of claim 4, wherein an air gap exists between the flow-conditioning plate and the second fan.

10. A method of cooling electronic components within an enclosure, the method comprising:
generating an air flow from a second fan;
drawing the air flow from the second fan through an opening in a housing positioned downstream of the second fan;
pulling the air flow through a flow-conditioner plate on a side of the housing distal to the second fan into a first fan attached to the flow-conditioner plate; and generating the air flow downstream from the first fan.

11. The method of claim 10, comprising providing the flow-conditioner plate with a plurality of perforations.

12. The method of claim 10, comprising locating the flow-conditioner plate adjacent the first fan.

13. The method of claim 10, comprising providing the flow-conditioner plate having a thickness of approximately 4 mm.

14. A fan assembly for cooling electronic components, the fan assembly comprising:
   a fan;
   an inlet duct having:
     a first end upstream of the fan, said first end defining a first opening having a first diameter; and
     a second end downstream of the first end, said second end attached to a first side of the fan and defining a second opening having a second diameter that is smaller than the first diameter;
   an outlet duct having:
     a first end attached to a second side of the fan opposite the first side, said first end of the outlet duct defining an opening having a first diameter, and
     a second end downstream of the first end, said second end defining a second opening having a second diameter that is greater than the first diameter.

15. The fan assembly of claim 14, wherein:
   the diameter of the first end of the inlet duct is equal to the diameter of the second end of the outlet duct; and
   the diameter of the second end of the inlet duct is equal to the diameter of the first end of the outlet duct.

16. The fan assembly of claim 14, wherein the second end of the outlet duct is attached to a flow conditioner element, the flow conditioner element comprising:
   a housing having a first side that includes a flow-conditioning plate;
   a second side opposite the first side that defines an opening; and
   a duct between the first side and the second side, wherein the flow-conditioning plate is attached to a side of the first fan proximal to the second fan and the second side of the housing is attached to a side of the second fan proximal to the first fan.

17. The fan assembly of claim 14 wherein the fan is an axial fan.