

PROVISIONAL APPLICATION FOR PATENT COVER SHEET – Page 1 of 2

This is a request for filing a PROVISIONAL APPLICATION FOR PATENT under 37 CFR 1.53(c).

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Additional inventors are being named on the _____ separately numbered sheets attached hereto

TITLE OF THE INVENTION (500 characters max):

FAN ASSEMBLY FOR RACK OPTIMIZED SERVER COMPUTER

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OR

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ENCLOSED APPLICATION PARTS (check all that apply)

☐ Application Data Sheet. See 37 CFR 1.76 ☐ CD(s), Number of CDs _____

☒ Drawing(s) Number of Sheets 5 ☐ Other (specify) _____

☒ Specification (e.g. description of the invention) Number of Pages 14

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PTO/SB/16 (07-07)

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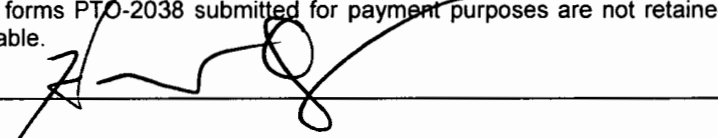


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SIGNATURE



Date 08/05/2011

TYPED or PRINTED NAME Henry C. Query, Jr.

REGISTRATION NO. 35,650
(if appropriate)

TELEPHONE 630-260-8093

Docket Number: XCEL-P012

FAN ASSEMBLY FOR RACK OPTIMIZED SERVER COMPUTERS

BACKGROUND OF THE INVENTION

The present invention relates to a fan assembly for cooling an electronic device comprising a plurality of heat generating electrical components mounted in an enclosure, such as a server computer. In particular, the invention relates to a fan assembly comprising a row of fans which are oriented with their axis of rotation at an angle, such as ninety degrees, to the side walls of the enclosure. The fan assembly enables the required airflow distribution and magnitude through the enclosure with less power, lower noise and fewer fans.

Prior art server computers typically include a number of heat generating electrical components mounted in an enclosure. Such computers commonly employ air to cool the components. Thus, prior art server computers usually include a number of internal fans for generating an airflow over the components. The airflow cools the components through the process of convection by absorbing the heat generated by the components and then dissipating the heat outside the enclosure.

An example of a prior art server computer is shown in Figure 1. This server computer, generally 10, includes a number of electrical components which in this example are housed in a 1u rack enclosure 12. The rack enclosure 12 comprises a front wall 14, a rear wall 16 and two parallel side walls 18. The front and rear walls each comprise a plurality of holes or apertures 20 through which air can pass. Several of the electrical components generate heat during operation of the server computer 10, such as a number of disk drives 22 which are located in a drive bay 24, a plurality of memory modules 26, two processors 28 (each of which is positioned under a

corresponding heat sink 30), and a power supply 32. In order to dissipate the heat generated by these components, the server computer 10 also includes a number of fans 34, in this case six, which are oriented with their axes parallel to the side walls 18.

During operation of the server computer 10, the fans 34 draw air into the enclosure 12

5 through the apertures in the front wall 14 and force the air over the heat generating components and through the apertures in the rear wall 16. As the air flows over the components, the heat generated by the components is absorbed by the air to thereby cool the components.

In order to reduce the power consumed by the server computer, it is desirable to
10 tailor the airflow distribution over the components so that each component will receive the airflow required to cool the component sufficiently. The current state of the art requires that a number of fans be distributed across the enclosure to provide a uniform airflow over all of the components, as well as to provide redundancy in the event one of the fans should stop operating. With the fans oriented parallel to the side walls as
15 shown in Figure 1, this often results in the use of a large number of fans operating at less than peak efficiency in order to generate the required airflows over each of the components.

SUMMARY OF THE INVENTION

The present invention addresses these and other limitations in the prior art by
20 providing a fan assembly which requires fewer fans to achieve a desired airflow distribution over the heat generating components of the server computer while also maintaining redundancy. The fan assembly includes a unique fan tray which is mounted in the enclosure and extends between the side walls. A number of fans are

positioned in the fan tray with their axes of rotation at an angle to the sidewalls, such as ninety degrees. This orientation provides room within the standard envelope for the fan tray to include an exhaust plenum for each fan through which the airflow generated by that fan is directed. In addition, the fan tray includes a number of specially configured guide vanes which are positioned in each exhaust plenum. The exhaust plenum and guide vanes serve to distribute the airflow across a larger portion of the enclosure than would be the case if the fans were oriented with their axes of rotation parallel to the side walls as in the prior art. In addition, should one of the fans stop operating, the airflow distribution generated by one or both of the adjacent fans will be sufficient to cool the components. Thus, the fan assembly of the present invention requires fewer fans than the prior art and therefore results in less power being consumed, as well as less noise being generated, by the server computer.

These and other objects and advantages of the present invention will be made apparent from the following detailed description with reference to the accompanying drawings. In the drawings, the same reference numbers are used to denote similar components in the various embodiments.

BRIEF DESCRIPTION OF THE DRAWINGS

Figure 1 is a perspective view of a prior art computer server;

Figure 2 is a top cross sectional view of one embodiment of the fan assembly of the present invention shown installed in an exemplary server computer, most of the components of which have been removed for clarity;

Figure 3 is a perspective view of the fan assembly shown in Figure 2;

Figure 4 is an exploded perspective view of the fan assembly shown in Figure 2;

Figure 5 is a partial side cross sectional view of one embodiment of means for sealing the fan assembly to the enclosure of the server computer;

Figure 6 is a top cross sectional view of another embodiment of the fan assembly of the present invention which comprises one embodiment of a means for preventing
5 the back flow of air through the fan assembly;

Figure 7 is a top cross sectional view of a further embodiment of the fan assembly of the present invention which comprises an embodiment of a means for adjusting the orientation of the exhaust guide vane components of the invention;

Figure 8A is a partial top cross sectional view of another embodiment of the fan
10 assembly of the present invention which comprises both the guide vane adjustment means of Figure 7 and second embodiment of the backflow prevention means, with the backflow prevention means shown in the open position;

Figure 8B is a view similar to Figure 8A, but showing the backflow preventing means in the closed position; and

15 Figure 9 is a top cross sectional view of yet another embodiment of the fan assembly of the present invention.

DETAILED DESCRIPTION OF THE INVENTION

The present invention provides an integral assembly of a plurality of fans which can be used to dissipate the heat generated by the electrical components of an
20 electronic device, such as a computer. Although the invention has wide application to a variety of electronic devices, it will be described below in the context of a rack mounted server computer.

Referring to Figure 2, one embodiment of the fan assembly of the present

invention, generally 110, is shown installed in a representative server computer 112, such as a 1u enterprise class rack optimized server. The server computer 112 includes a number of heat generating electrical components, such as memory modules, processors and power supplies (represented generally by the rectangle 114a) located downstream of the fan assembly 110, and a number of disk drives 114b located upstream of the fan assembly. These components are mounted in an enclosure 116 which comprises an air permeable front wall 118, an air permeable rear wall 120 and two parallel, generally solid side walls 122. As shown in Figure 2, the fan assembly 110 extends transversely between the side walls 122 between the front wall 118 and the electrical components 114. In operation, the fan assembly 110 generates a flow of air which enters the enclosure 116 through the front wall 118, flows over the electrical components 114 to thereby convectively cool these components, and then exits the enclosure through the rear wall 120.

Referring also to Figures 3 and 4, the fan assembly 110 includes a number of fans 124, in this example three, which are mounted in a generally rectangular fan tray 126. The fans 124 are preferably vane-axial fans, such as the Flurry™ 100 Series vane-axial fan manufactured by Xcelaero Corporation of San Luis Obispo, California. In this example, each fan 124 includes an impeller 128 which is driven by a motor 130 that is supported in a cylindrical fan housing 132 having an inlet end 134 and an outlet end 136. Although not required, the fan housing 132 may also be provided with a generally square inlet end flange 138 which surrounds the inlet end 134 and a generally square outlet end flange 140 which surrounds the outlet end 136.

As shown most clearly in Figure 2, each fan 124 is oriented such that its axis of

rotation A forms an angle α of between about 45° and 90° with the sidewalls 122. In the embodiment of the invention shown in Figure 2, for example, the axis of rotation A of each fan 124 is perpendicular to the side walls 122. In this manner, the depth of the envelope occupied by the fans 124 is significantly smaller than would be the case if the fans were oriented with their axes of rotation A parallel to the side walls 122.

In order to maintain the air flow generated by the fans 124 generally parallel to the side walls 122 of the enclosure 116, each fan is mounted in the fan tray 126 between an inlet plenum 142 and an exhaust plenum 144. Each inlet plenum 142 is defined by a generally concave front facing inlet wall section 146 which extends frontward from a rear edge 148 of the inlet end 134 of the fan housing 132. Similarly, each exhaust plenum 144 is defined by a generally concave rear facing outlet wall section 150 which extends rearward from a forward edge 152 of the outlet end 136 of the fan housing 132. The function of the inlet plenums 142 is to turn the airflow upstream of the fan assembly 110 into the fans 124, and the function of the outlet plenums 144 is to turn the airflow exiting the fans into a direction generally parallel to the sidewalls 122 of the enclosure 116. In this manner, even with the fans 124 mounted with their axis A at an angle α relative to the side walls 122, the fan assembly 110 is still able to achieve a flow distribution which produces a desired degree of cooling for the components 114.

In designing the inlet and outlet plenums 142, 144, the radius R_E of the outlet wall sections 150 is ideally selected so as to obtain a desired pressure recovery in the air flow exiting the fans 124. The radius R_I of the inlet wall sections 146 may then be determined given the radius R_E , the number of fans 124 in the fan assembly 110, and

the length of the fan tray 126 (which in most cases corresponds to the width of the enclosure 116). Finally, the radii R_E and R_I may be adjusted empirically to obtain a desired air flow over the components 114. For example, in an embodiment of a fan assembly which comprises three 1.37-inch diameter Flurry™ Series 100 fans mounted in a fan tray 15.87 inches long and oriented with their axes of rotation perpendicular to the side walls, R_I may be about 1.4 inches and R_E may be about 1.4 inches.

In the exemplary embodiment of the invention shown in the drawings, each inlet plenum 142 is provided with a number of optional inlet guide vanes 154 and each exhaust plenum 144 is provided with a number of exhaust guide vanes 156. The inlet guide vanes 154, if present, assist the inlet plenum 142 in turning the airflow into the fans 124 and also spread the airflow uniformly across the fan inlet 134. The inlet guide vanes 154 also serve as finger guards for the fans 124. In addition to aiding the exhaust plenum 144 in turning the airflow exiting the fans 124 into a direction generally parallel to the side walls 122, the exhaust guide vanes 156 spread the airflow across the components 114. The exhaust guide vanes 156 also serve to inhibit the backflow of air through a corresponding fan 124 which is not operating. The number and configuration of the inlet and exhaust guide vanes 154, 156 may be determined empirically for a given fan assembly 110 and server computer 112.

In addition to the inlet guide vanes 154, the inventors have discovered that the distribution of the airflow forward of the fan assembly 110 and through the inlet plenum 142 may be improved by providing each inlet plenum with a corresponding inlet lip 158. As shown most clearly in Figure 2, each inlet lip 158 comprises a preferably annular projection which extends frontward from a forward edge 160 of the inlet end 134 of the

fan housing 132. The configuration of the inlet lip 158 may be determined empirically for a given fan assembly 110 and server computer 112.

Referring still to Figures 2-4, each fan 124 may be mounted in a respective cavity 162 which is formed in the fan tray 126 between a corresponding pair of generally longitudinal front and rear wall sections 164, 166. In this particular embodiment of the invention, the right end (as viewed in Figure 2) of each front wall section 164 is connected to or formed integrally with the inlet lip 158 of the adjacent inlet plenum 142. In addition, the left end (as viewed in Figure 2) of each front wall section 164 is connected to or formed integrally with the outlet wall section 150 of the adjacent exhaust plenum 144, and the right end (as viewed in Figure 2) of each rear wall section 166 is connected to or formed integrally with the inlet wall section 146 of the adjacent inlet plenum 142. Furthermore, the inlet wall section 146 of the left inlet plenum 142 may be connected to or formed integrally with the outlet wall section 150 of the middle outlet plenum 144, and the inlet wall section of the middle inlet plenum may be connected to or formed integrally with the outlet wall section of the right outlet plenum. In this manner, each cavity 162, together with its adjacent inlet and exhaust plenums 142, 144, defines a continuous flow path through the fan tray 126 in which a corresponding fan 124 is positioned.

Referring to Figure 4, the fan tray 126 may comprise separate top and bottom panels 168, 170 which when connected together lock the fans 124 in position in their corresponding cavities 162. The top and bottom panels 168, 170 may be made of any suitable material, such as plastic, using any appropriate technique, such as injection molding. For the particular shape of fan 124 depicted in the drawings, at least one of

the top and bottom panels 168, 170 may be provided with a rectangular cutout 172 for each fan which comprises the same length as the fan housing 132 and the same width as the end flanges 138, 140. In addition, at least one but preferably both of the top and bottom panels 168, 170 may comprise two longitudinally spaced pairs of struts 174
5 which are configured to engage the fan housing 132 and preferably also the axial inner portions of the end flanges 138, 140 to thereby firmly hold each fan 124 in position in the fan tray 126. In order to ensure that the fan tray 126 provides an airtight boundary between the low pressure side of the enclosure (i.e., the portion of the enclosure upstream of the fan assembly 110) and the high pressure side of the enclosure (i.e., the
10 portion of the enclosure downstream of the fan assembly), the top panel 168 is ideally sealed to the bottom panel 170 using an appropriate number of suitable gaskets 176 positioned between corresponding halves of the wall sections 146, 150, 164, 166 and preferably also the guide vanes 154, 156.

The fan tray 126 is also ideally sealed to the enclosure 116 in order to effectively
15 separate the low pressure side of the enclosure from the high pressure side of the. In order to facilitate this sealing, the fan tray may comprise generally planar ends 178, a generally planar top 180 and a generally planar bottom 182 (Figure 3). In this manner, the sides 178 may be sealed to the side walls 122 of the enclosure 116, the top 180 may be sealed to the top cover of the enclosure and the bottom 182 may be sealed to
20 the bottom of the enclosure using, for example, one or more appropriately configured gaskets (not shown).

An alternative arrangement for sealing the fan tray 126 to the enclosure 116 is shown in Figure 5, which is a side cross sectional view of the fan assembly 110 showing

the inlet end 134 of one of the fans 124. In this embodiment, the top 180 of the fan tray 126 includes a downstream-side lip 184 which is sealed to a removable top cover 186 of the enclosure 116 with a straight seal 188. The seal 188 may be positioned in an elongated seal support bracket 190 which is secured to the top cover 186 by appropriate means, such as a number of rivets 192. In addition, the bottom 182 of the fan tray 126 may be received in a corresponding recess 194 which is formed in a bottom 196 of the enclosure 116.

Figure 5 also illustrates another means for sealing the top panel 168 to the bottom panel 170. In this embodiment, a labyrinth seal is created between these components by forming a projection 198 on the upper edge of the bottom panel 170 which is received in a corresponding groove 200 that is formed on the bottom edge of the upper panel 168, or vice-versa. The projection 198 and groove 200 may be formed on corresponding halves of the wall sections 146, 150, 164, 166 and preferably also the guide vanes 154, 156.

With the fan tray 126 separating the high pressure side of the enclosure 116 from the low pressure side, it is desirably to include means for preventing the backflow of air through the fan assembly 110 should one or more of the fans 124 cease operating. Referring to Figure 6, for example, an embodiment of the fan assembly 110 is shown in which the exhaust guide vanes 156 are configured to function as a one-way valve for their corresponding exhaust plenums 144. In this embodiment, the upstream end of each exhaust guide vane 156 is connected by a corresponding pivot member 202 to the top 178 or bottom 182, or both, of the fan tray 126 to thereby enable the exhaust guide vanes to swing toward and away from the downstream end 136 of a corresponding fan

124. In addition, the fan tray 126 is provided with a corresponding stop member for each exhaust guide vane 156 to prevent the guide vane from swinging past its appropriate position when the fan 124 is operating. For example, the stop members for the exhaust guide vanes 156 located adjacent the outlet wall sections 150 may simply be the outlet wall sections themselves, while the stop members for each of the remaining exhaust guide vanes may comprise a small protrusion 204 which is formed on the top 178 or the bottom 182, or both, of the fan tray 126. Thus, under normal operation of the fans 124, the air flow will force the exhaust guide vanes 156 into their open position against the stop members. However, when one of the fans 124 stops operating, the initial backflow of air will force its corresponding guide vanes 156 into the closed position, which is shown for the right-most fan in Figure 6. In this regard, the closing of the guide vanes 156 may be facilitated by a suitable spring member (not shown), such as a torsion spring which is connected between the pivot 202 and its corresponding guide vane.

In another embodiment of the invention which is shown in Figure 7, the fan assembly 110 is provided with means for enabling the orientation of the exhaust guide vanes 156 to be adjusted. In this embodiment, the upstream end of each exhaust guide vane 156 is connected by a corresponding pivot member 202 to the top 178 or bottom 182, or both, of the fan tray 126. In addition, for each exhaust guide vane 156 the fan tray 126 comprises a series of detents 206 which are formed on the top 178 or the bottom 182, or both, of the fan tray 126. Thus, the orientation of each exhaust guide vane 156 can be adjusted by pivoting the guide vane to a desired position between an adjacent pair of detents 206. In this manner, the orientation of the exhaust guide vanes

156 can be set during installation of the fan assembly 110, which thus allows one set of top and bottom panels 168, 170 to be used in a wide variety of applications.

An embodiment of the fan assembly 110 in which combines backflow prevention means of the present invention is combined with the guide vane adjustment means just described is illustrated in Figures 8A and 8B. In this embodiment, a flexible membrane 208 is attached by suitable means to the upstream end of each exhaust guide vane 156. The membranes may made of polymeric film such as polyimide and comprise a rectangular configuration having a height which is sufficient to extend completely between the top 179 and bottom 182 of the fan tray 126. In normal operation of each fan 124, the membranes 208 are forced by the airflow into the open position shown in Figure 8A against their corresponding guide vanes 156. As shown in Figure 8B, however, when one of the fan 124 stops operating, the backflow of air forces the membranes 208 to fold back against the adjacent guide vanes 156 or the downstream end 136 of the fan to thereby block the backflow. Figures 8A and 8B also illustrate the pivot members 202 and detents 206 which enable each exhaust guide vane to be oriented as desired.

Yet another embodiment of the fan assembly of the present invention is shown in Figure 9. The fan assembly of this embodiment, generally 210, is similar in many respects to the fan assembly 110 described above. Thus, the fan assembly 210 includes a plurality of fans 124, in this case 4, which are mounted in a fan tray 126 that is positioned in the server computer 112 between the sidewalls 122 of the enclosure 116 (not shown). In this embodiment, however, the fans 124 are oriented such that the inlet ends 134 and outlet ends 136 of adjacent fans face each other. For example, the

first and second fans 124a, 124b (starting from the left side of the fan assembly 210) are oriented with their outlet ends 136 facing each other, the second and third fans 124b, 124c are oriented with their inlet ends 134 facing each other, and the third and fourth fans 124c, 124d are oriented with their outlet ends facing each other.

5 Also, although the inlet plenums 142 for the first and fourth fans 24 are each defined by a generally concave front facing inlet wall section 146 as described above, the inlet plenums for the second and third fans are each defined by a respective generally concave front facing inlet wall section 212 which is formed on a corresponding side of an inlet plenum arm 214 that is positioned approximately midway between the
10 fans. In a similar fashion, the exhaust plenums 144 are each defined by a respective generally concave rear facing outlet wall section 216 which is formed on a corresponding side of one of two exhaust plenum arms 218, one of which is positioned approximately midway between the first and second fans 124a, 124b and the other of which is positioned approximately midway between the third and fourth fans 124c, 124d.

15 Also, each outlet plenum arm 218 may be pivotally connected to the fan tray 126 by a transverse pivot bar 220 or other such means in order to allow it to automatically pivot into a blocking position over the outlet end 136 of one of the adjacent fans 124 to thereby prevent the backflow of air through the corresponding exhaust plenum 144 when that fan is not operating.

20 It should be recognized that, while the present invention has been described in relation to the preferred embodiments thereof, those skilled in the art may develop a wide variation of structural and operational details without departing from the principles of the invention. Therefore, the above description should be construed to cover all

equivalents falling within the true scope and spirit of the invention.

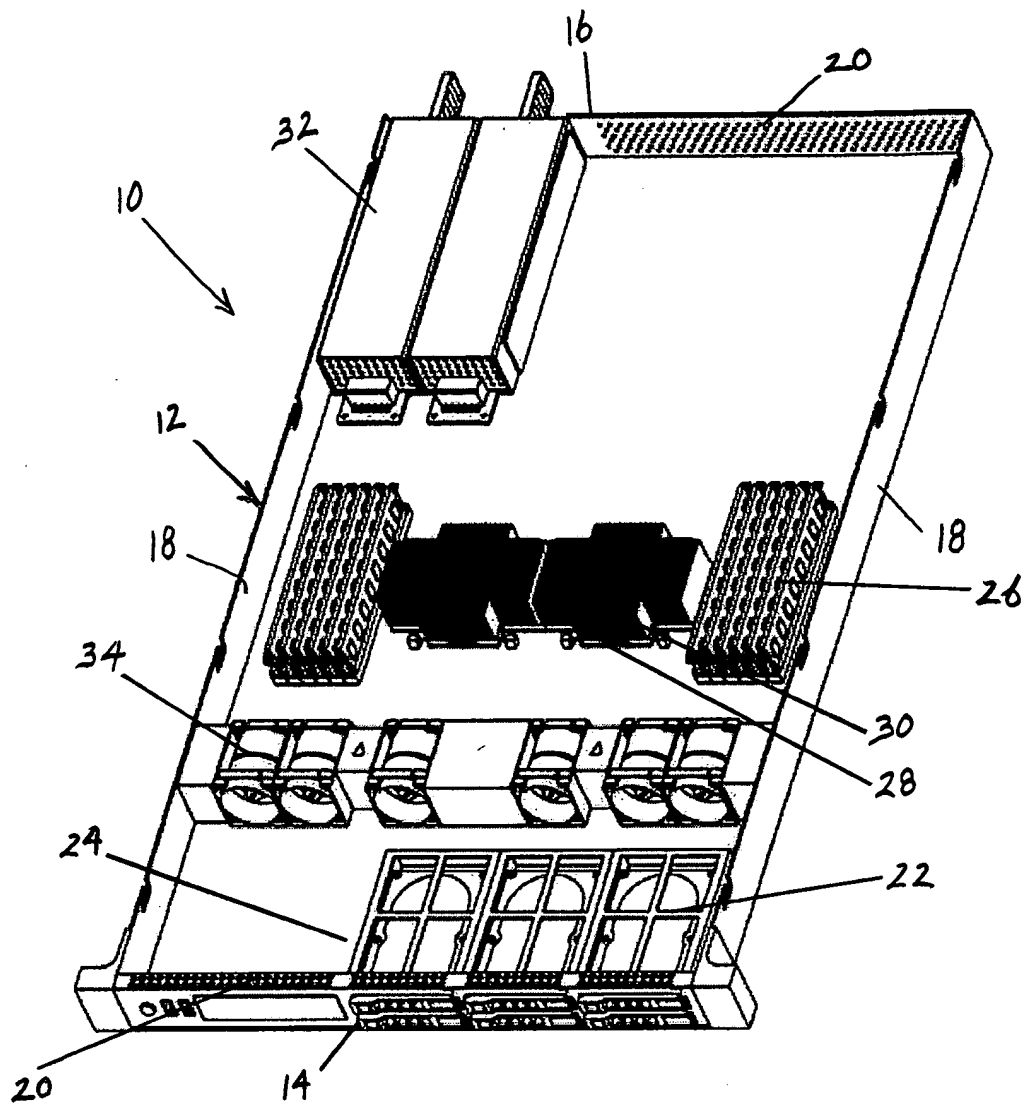


Fig. 1

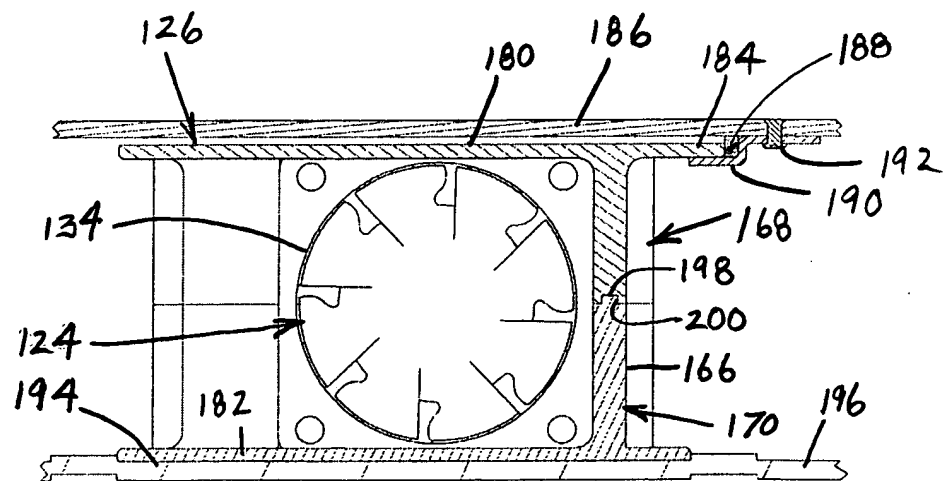


Fig. 5

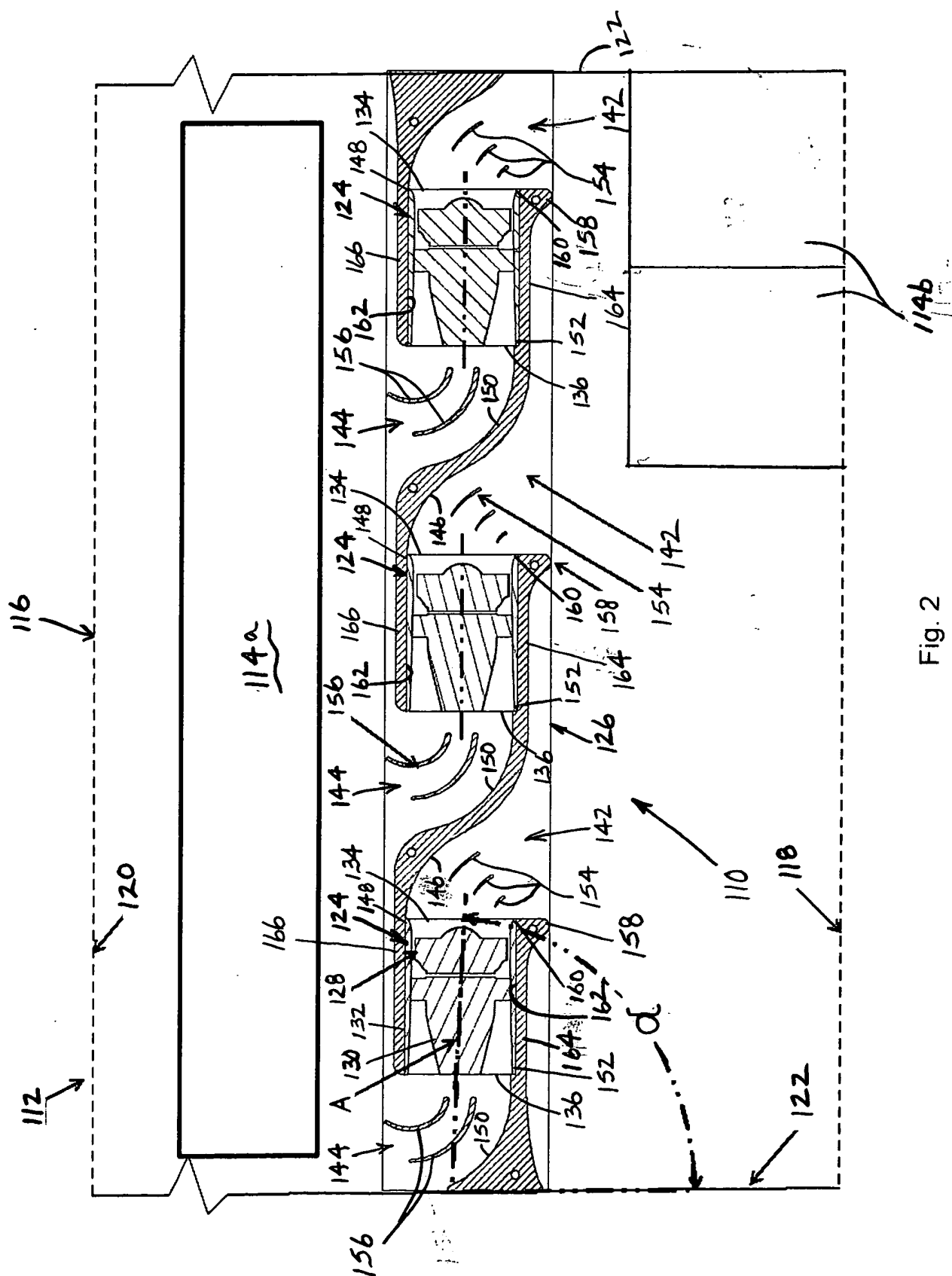
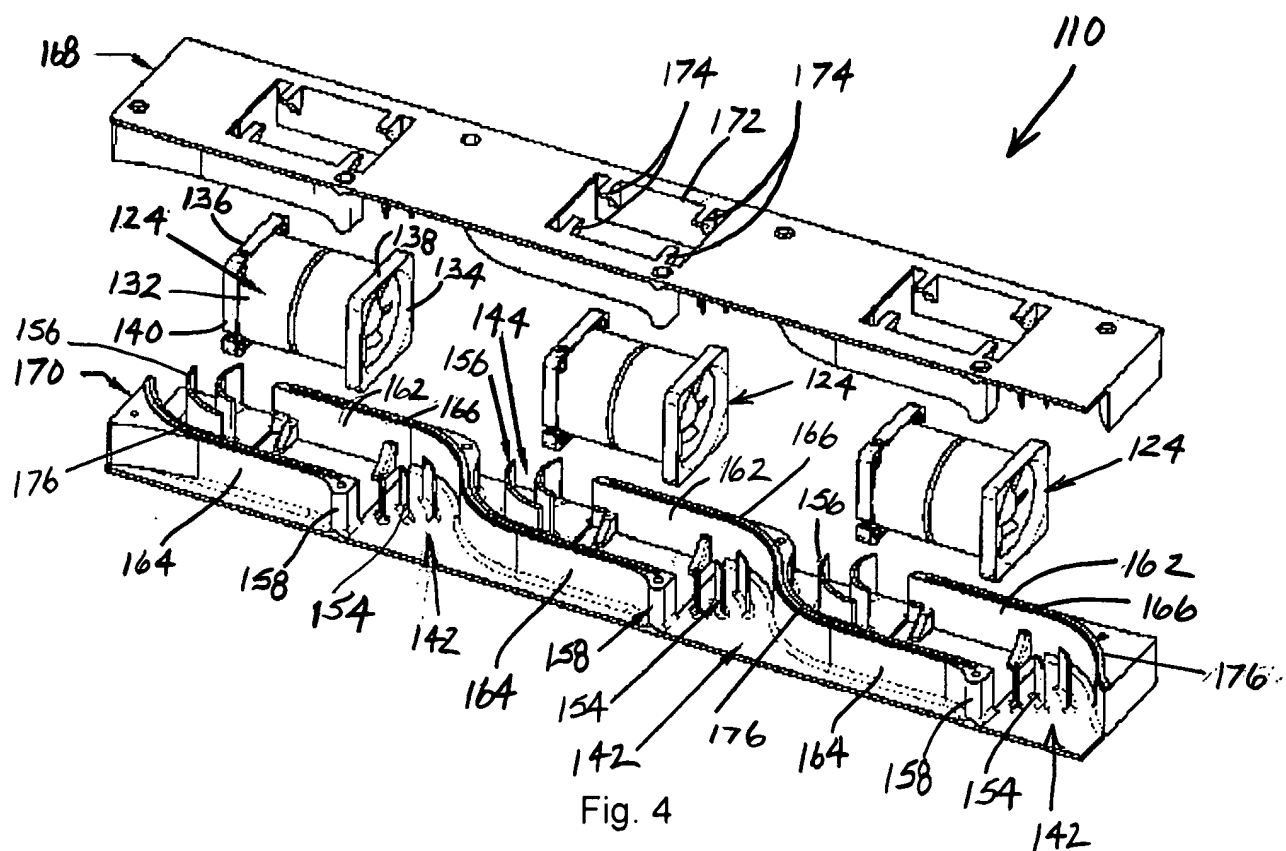
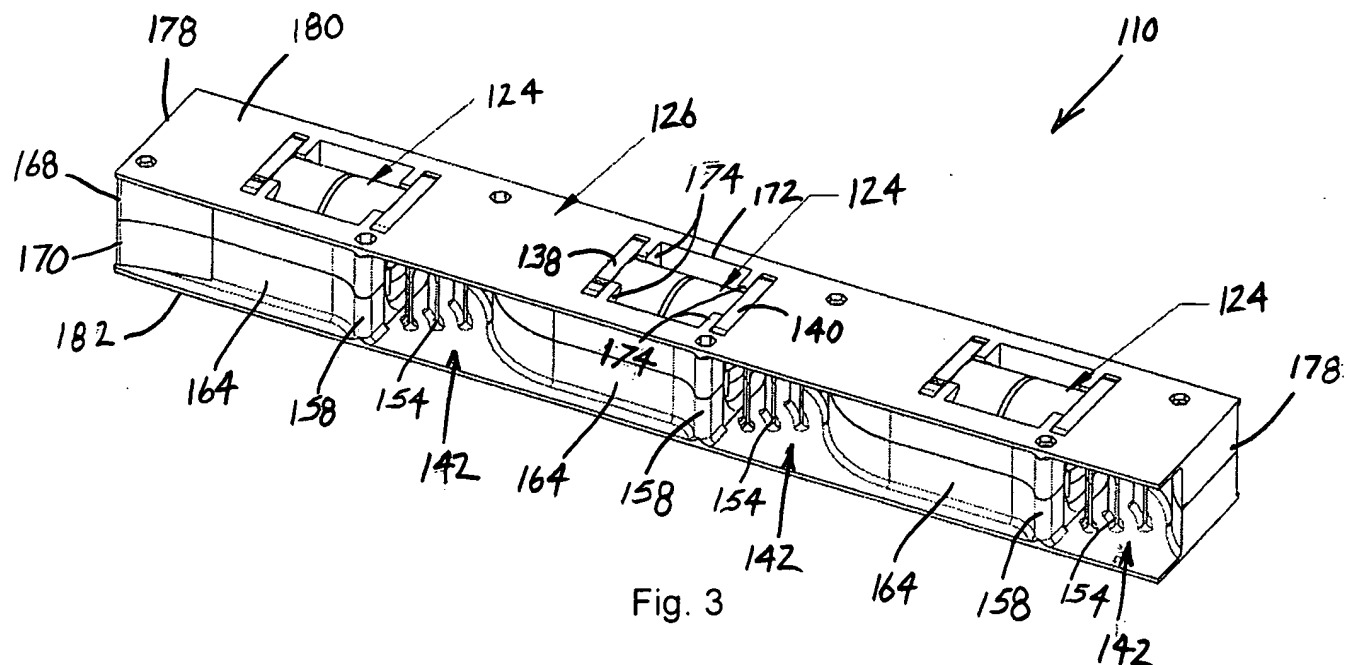


Fig. 2



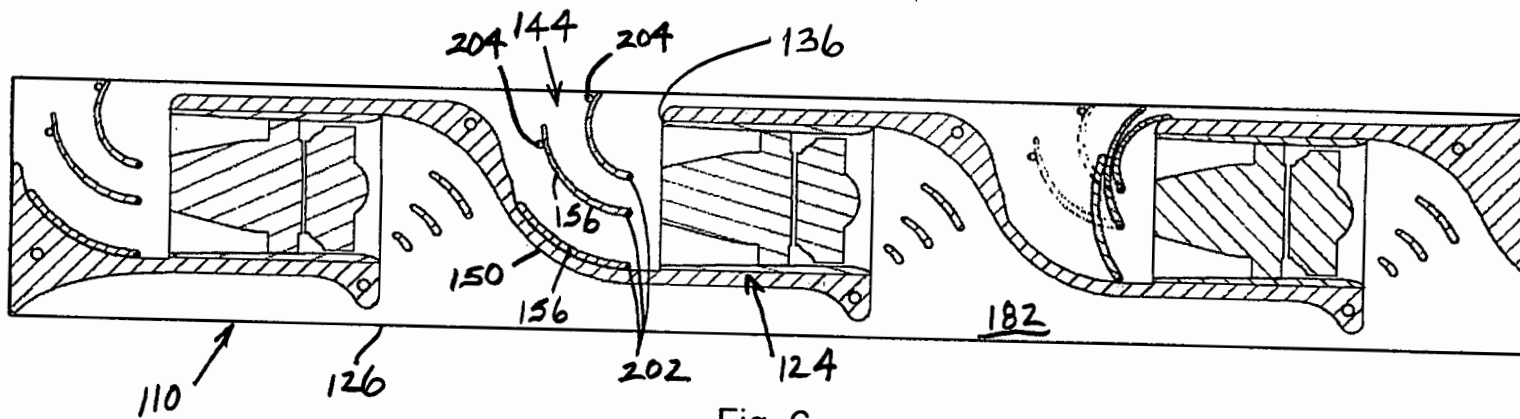


Fig. 6

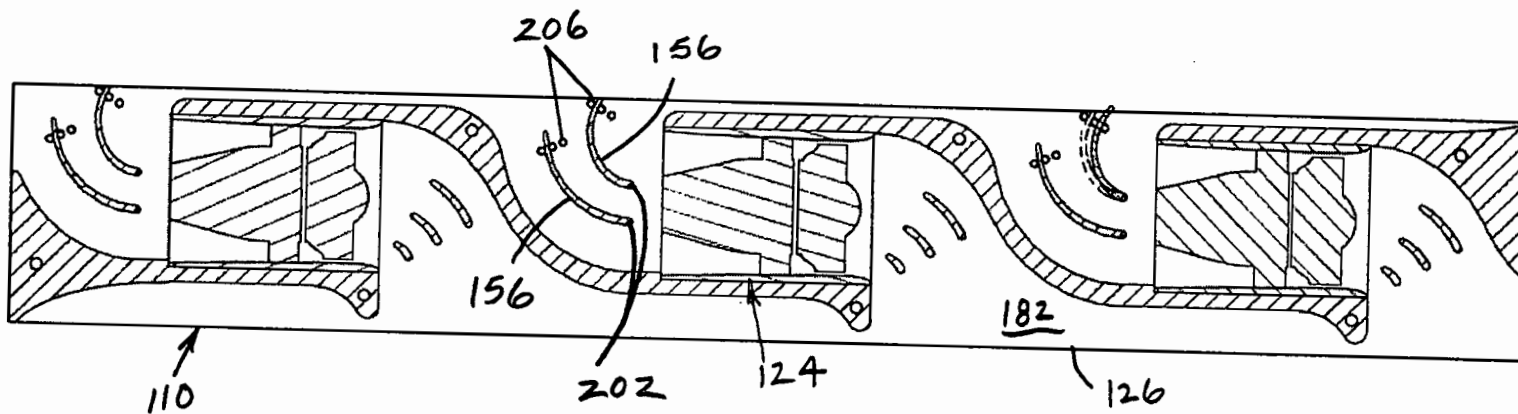


Fig. 7

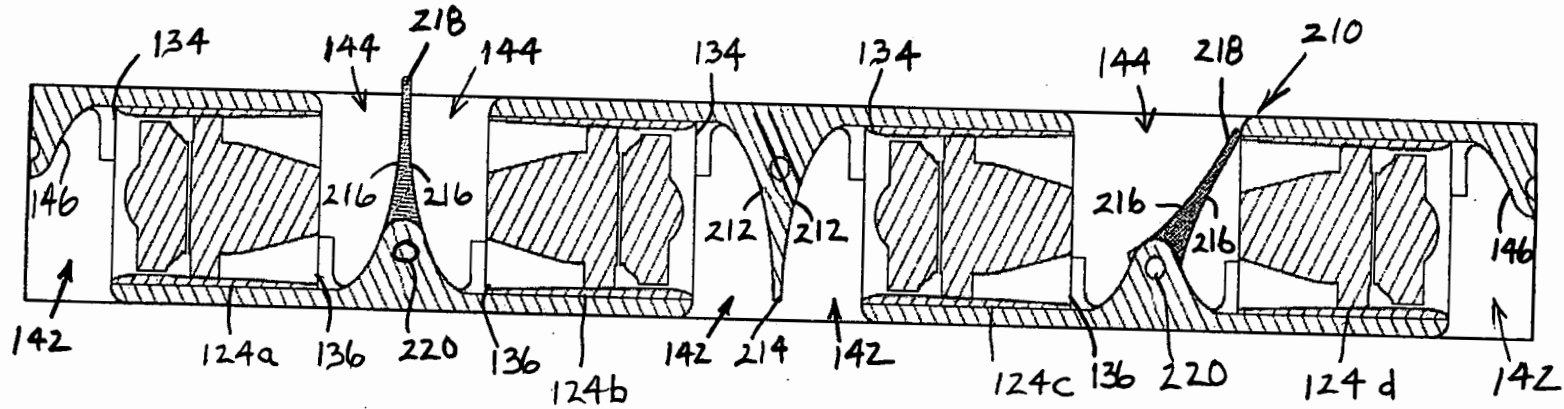
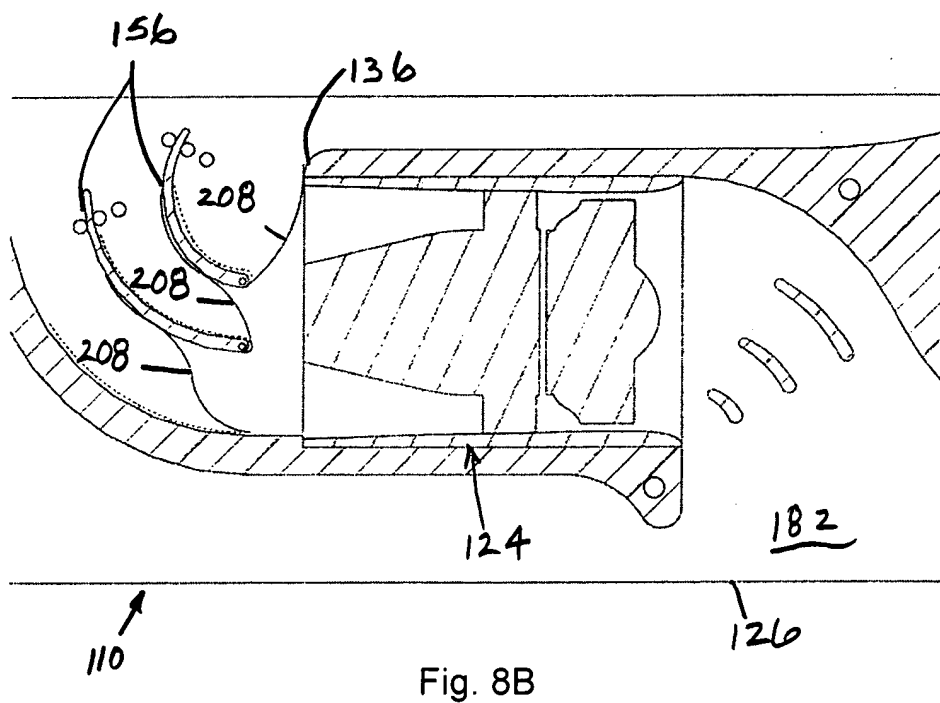
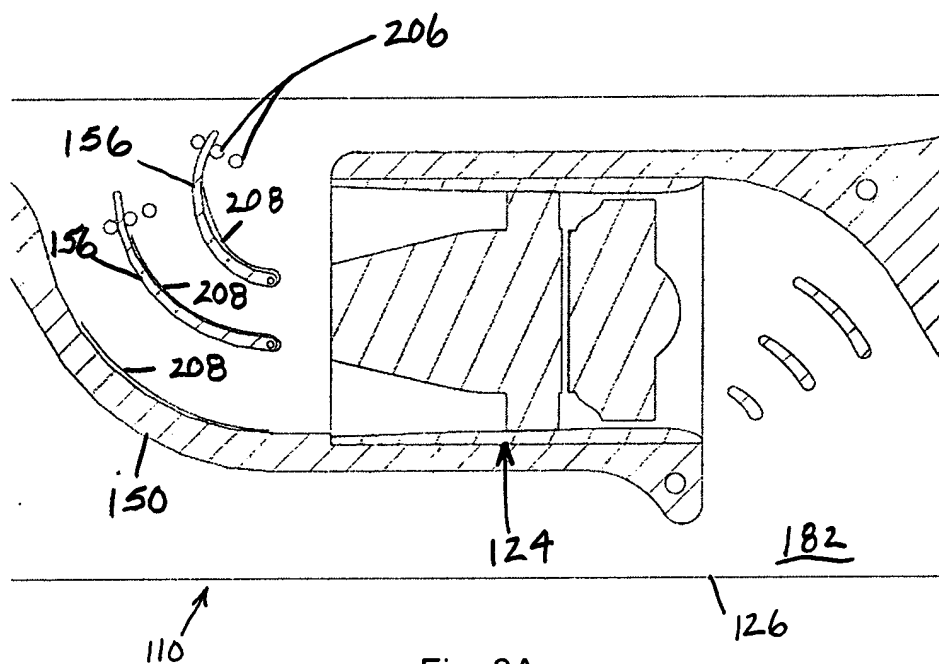


Fig. 9



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APPLICATION NUMBER	FILING or 371(c) DATE	GRP ART UNIT	FIL FEE REC'D	ATTY. DOCKET NO	TOT CLAIMS	IND CLAIMS
61/574,593	08/05/2011		220	XCEL-P012		

CONFIRMATION NO. 7946

Henry C. Query, Jr.
504 S. Pierce Avenue
Wheaton, IL 60187

FILING RECEIPT



Date Mailed: 08/22/2011

Receipt is acknowledged of this provisional patent application. It will not be examined for patentability and will become abandoned not later than twelve months after its filing date. Any correspondence concerning the application must include the following identification information: the U.S. APPLICATION NUMBER, FILING DATE, NAME OF APPLICANT, and TITLE OF INVENTION. Fees transmitted by check or draft are subject to collection. Please verify the accuracy of the data presented on this receipt. **If an error is noted on this Filing Receipt, please submit a written request for a Filing Receipt Correction. Please provide a copy of this Filing Receipt with the changes noted thereon. If you received a "Notice to File Missing Parts" for this application, please submit any corrections to this Filing Receipt with your reply to the Notice. When the USPTO processes the reply to the Notice, the USPTO will generate another Filing Receipt incorporating the requested corrections**

Applicant(s)

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John J. Decker, Cypress, TX;

Power of Attorney:

Henry Query Jr--35650

If Required, Foreign Filing License Granted: 08/18/2011

The country code and number of your priority application, to be used for filing abroad under the Paris Convention, is **US 61/574,593**

Projected Publication Date: None, application is not eligible for pre-grant publication

Non-Publication Request: No

Early Publication Request: No

Title

Fan assembly for rack optimized server computer

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of patent applications on the same invention in member countries, but **does not result** in a grant of "an international patent" and does not eliminate the need of applicants to file additional documents and fees in countries where patent protection is desired.

Almost every country has its own patent law, and a person desiring a patent in a particular country must make an application for patent in that country in accordance with its particular laws. Since the laws of many countries differ in various respects from the patent law of the United States, applicants are advised to seek guidance from specific foreign countries to ensure that patent rights are not lost prematurely.

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Applicants may wish to consult the USPTO booklet, "General Information Concerning Patents" (specifically, the section entitled "Treaties and Foreign Patents") for more information on timeframes and deadlines for filing foreign patent applications. The guide is available either by contacting the USPTO Contact Center at 800-786-9199, or it can be viewed on the USPTO website at <http://www.uspto.gov/web/offices/pac/doc/general/index.html>.

For information on preventing theft of your intellectual property (patents, trademarks and copyrights), you may wish to consult the U.S. Government website, <http://www.stopfakes.gov>. Part of a Department of Commerce initiative, this website includes self-help "toolkits" giving innovators guidance on how to protect intellectual property in specific countries such as China, Korea and Mexico. For questions regarding patent enforcement issues, applicants may call the U.S. Government hotline at 1-866-999-HALT (1-866-999-4158).

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