ABSTRACT

Air turnover in a space achieved by a paddle fan having a plurality of blades is significantly increased by mounting an assembly radially outward from the blades. The assembly has a generally vertical shroud that is substantially impervious to air flow and a directing grid attached to the shroud at a lower end thereof. The directing grid has a plurality of intersecting members to reduce cross-sectional flow area and induce laminar air flow therethrough.
HOUSING FOR PADDLE FAN

CROSS REFERENCES TO RELATED APPLICATIONS

[0001] This application is a non-provisional of U.S. provisional application 60/766,432, filed 19 Jan. 2006, from which a claim of benefit of priority under 35 USC §120 is made and which is incorporated by reference as if fully recited herein.

TECHNICAL FIELD

[0002] The present invention, to the extent disclosed in the exemplary embodiments, relates to a housing for paddle fans and paddle fan assemblies incorporating such a housing.

BACKGROUND OF THE INVENTION

[0003] Ceiling fans are well-known and commonly used in commercial and residential settings to "stir up" the air in a room, especially a room with a high "head space", that is a large volume of empty space above the first six or seven feet above the floor. This is common in warehouses and other commercial settings and is increasingly common in residential units with vaulted or so-called "cathedral" ceilings.

[0004] Ceiling fans as presently known are characterized by several features. They typically have from 4 to 6 blades or paddles, although some may go as low as two blades and others may go as high as 8 blades. The blades or paddles are typically not designed to operate aerodynamically, that is, they would not be classified as propellers. The blades generally are planar or nearly so, although the plane of each blade is usually canted or skewed relative to a plane perpendicular to the axis of rotation. A typical diameter swept out by the blades is in the range of 30 to 60 inches.

[0005] Ceiling fans also tend to be powered by relatively small horsepower electric motors, with a rotational velocity of the motor usually being controlled by a rheostat. The motor usually has two to three velocity settings, but none of these speeds is as high as even the lowest speed that one sees in a floor or box fan, as described in more detail below. The rotational velocity and blade structure are designed to minimize noise and thrust force, especially the latter, since the generation of a thrust force would either pull or push upon a ceiling mount. Many of the ceiling fans are bi-directional, that is, the motor may be set to operate in either direction. The angle of the blades or paddles will therefore be able to direct air in either direction along the axis of rotation.

[0006] In contrast, floor or box fans are intended to circulate the air in a generally horizontal direction. For safety reasons, and due to the relatively high rotational velocity and proximity to people, floor or box fans are housed in a protective structure, which may or may not possess any capability for directing the exit gas flow.

[0007] In the past, ceiling fans have not been very efficient in moving air vertically in an effective manner. By this, we mean that the ceiling fans make little impact on air flow at or near the floor when the paddles are located high enough off the floor to minimize the danger of having them strike occupants in the room.

[0008] In U.S. Pat. No. 4,064,427 to Hansen, an annular ring is provided horizontally proximate to the blades of a ceiling fan. The ring is intended to act as a safety guard and an attachment area for light fixtures. Since no affect upon air circulation is described, and because the fan is positioned low enough that there is concern about the blades striking an occupant of the room, it is reasonable to assume that Hansen understood the annular ring as providing no significant result.

[0009] In U.S. Pat. No. 4,750,863 to Scooggins, another annular ring structure is placed around a ceiling fan, but the annular structure is described primarily as a base for a filter element to remove particulates from the air. The figures in that patent show the annular ring to be positioned slightly above the top surfaces of the blades. In other words, the ring does not even provide the safety features of Hansen's '427. No enhancement of vertical air flow is described or claimed.

[0010] U.S. Pat. No. 5,094,676 to Karbach is similar to the Scooggins '863 patent, but is shows an annular ring for supporting the filter element, but the ring is horizontally proximate to the blades. It claims no enhancement of vertical air flow and there are no features presented that would justify such a claim.

[0011] U.S. Pat. No. 6,193,384 to Stein teaches a frusto-conical background positioned laterally inwardly from the tips of the modified blades of a ceiling fan. LED elements on the generally vertically extending tips are used to display messages as the blades rotate. The background is not described as providing any air flow enhancement and seems to be useful only in enhancing the visual display.

[0012] In U.S. Pat. No. 4,657,485 to Hartwig, an open grill member provides a guard function to the sides of, and below, a set of ceiling fan blades. The open structure would belie any claim of vertical air flow enhancement, although none is made.

[0013] Two US patents, utility U.S. Pat. No. 4,515,538 to Shih and design Pat. D484,887 to Bucher, show an annular ring crowned with a grill structure, but both are shown as being intended for use in association with a high-speed aero-dynamic fan blade set. Shih's '538 shows a front guard structure intended at influencing or directing downward vertical air flow beneath the blades. This front guard is taught as being rotating in the same direction as the fan, but at a much slower speed. Bucher's '887 shows a series of concentric bell-shaped structures located below the blade set.

[0014] While not strictly confined to a ceiling fan, U.S. Pat. No. 4,730,551 to Peladat shows a high speed fan, similar to a bathroom exhaust fan, which has a circular exhaust port that is surrounded by a square or rectangular inlet area. The Peladat '551 is mounted above a suspended ceiling and teaches that ceiling fans are not capable of directing a vertical column of warm air all the way to the floor of a room, especially a high-ceilinged room.

[0015] Accordingly, it is an unmet need of the prior art to provide a ceiling fan system with sufficient vertical air movement to affect an air temperature gradient between the top and bottom of a room in which the fan is located.

SUMMARY OF THE INVENTION

[0016] This and other advantages are achieved, at least in the preferred embodiments, by an assembly for improving the turnover of air in a space by a paddle fan having a plurality of blades extending a first radial distance from a centerline thereof. The assembly comprises a generally vertical shroud, having an internal diameter at least at a top end thereof that is slightly larger than a diameter of the paddle fan. It also comprises a directing grid attached to the shroud at a lower end thereof, the directing grid comprising a plurality of intersecting members to reduce cross-sectional flow area. The assembly is also provided with means for mounting the shroud radially outwardly from the fan blades.
In some embodiments, the shroud is cylindrical, while in other embodiments, the shroud is frustoconical.

In some embodiments the mounting means attaches the shroud to the paddle fan, while in other embodiments, the mounting means attaches the shroud to a ceiling from which the paddle fan is suspended.

In the preferred embodiments, the average airflow velocity at a point between 80 and 100% of the radial distance from the centerline to the blade tip is greater when the paddle fan is operated with the assembly in place relative to identical operation of the paddle fan without the assembly in place.

In the preferred embodiments, a ratio of the average airflow velocity measured at a point between 80 to 100% of the radial distance form the centerline to the blade tip to the average airflow velocity measured at the centerline under the same operating conditions increases by at least a factor of 4.

**BRIEF DESCRIPTION OF THE DRAWINGS**

A better understanding of the invention will be had when reference is made to the appended drawings, wherein identical parts are identified by identical part numbers and wherein:

- FIG. 1 is a perspective view of a room with an embodiment of the paddle fan assembly of the present invention;
- FIG. 2 is a front, enlarged view of the paddle fan assembly of FIG. 1;
- FIGS. 3a and 3b are partial side sectional views of first and second embodiments of a directing grid as used in the paddle fan assembly of FIG. 1;
- FIG. 4 is a graphical presentation of the data presented numerically in Table 1A;
- FIG. 5 is a graphical presentation of the data presented numerically in Table 1B;
- FIG. 6 is a graphical presentation of the data presented numerically in Table 1C;
- FIG. 7 is a graphical presentation of the data presented numerically in Table 1D;
- FIG. 8 is a graphical presentation of the ratio of average airflow velocity at a distance from the fan centerline to the average airflow velocity at the centerline for each of the tested fans, plotted against a normalized radial distance from the centerline to blade tip; and
- FIG. 9 is a graphical presentation of the ratio of average airflow velocity at a distance from the fan centerline for a fan with the assembly to the average airflow velocity at the same distance for the same fan without the assembly, plotted against a normalized radial distance from the centerline to blade tip.

**DETAILED DESCRIPTION OF A PREFERRED EMBODIMENT**

Referring first to FIGS. 1 and 2, a paddle fan assembly 10 of an exemplary embodiment is shown. The embodiment comprises a paddle fan 20, having a plurality of paddles 22 radially extending from a drive shaft 24. An electric motor (not shown), housed in motor housing 26, is operatively engaged with drive shaft 24. As this type of paddle fan 20 is well-known, additional features such as the electrical supply, a rheostat or other control means for controlling the electricity provided to the motor, and a control switch, typically wall-mounted, are not specifically illustrated. In the illustrated embodiment, an extension tube 28, concentric with drive shaft 24, serves the purposes of suspending the motor housing 26 away from ceiling C, spacing the fan 20 away from the ceiling and providing a conduit through which the electric supply is communicated to the motor. While the exemplary embodiment anticipates suspending additional features from this extension tube, it will be understood that the invention is not limited to such an extension means. It will also be readily understood that, in many embodiments of the invention, the paddle fan 20 and the foregoing features may be already in place. In other words, the paddle fan assembly 10 may be built around a paddle fan 20 that has been previously installed.

A housing 30 is positioned around, and laterally adjacent to, the paddles 22 in the exemplary embodiment. This housing 30 is characterized by a shroud 32. As illustrated, the shroud 32 is provided in two semi-circular pieces that may be fastened together in the field to encompass an existing paddle fan 20. In most embodiments of the invention, the shroud 32 is cylindrical, with an upper end 34 having the same diameter as a lower end 36. In some instances, though, the upper end 34 can have a diameter X1 and the lower end has a diameter X2. If the upper and lower ends are vertically separated by a height Y, then the shroud 32 can be described as having a cone angle A, where A = sin(2Y/(X1−X2)). The shroud 32 will be designed for use with a paddle fan 20 having a blade diameter X3 such that X1 is greater than X3. In some situations, X3 will be between X1 and X2, but in other situations, X3 may be smaller than X2. If X3 is greater than X2, then the shroud needs to be mounted so that a diameter X4 of the shroud, measured at the horizontal level of the paddles 22, is at least as large as X3. In other words, the paddles 22 fit inside the shroud 32 so that they may freely rotate without striking the shroud.

Shroud 32 is constructed from a continuous sheet of material that has no substantial penetrations that would permit air flow through the sheet, either from within or from without. A sheet of a metal, especially galvanized steel or aluminum, would be useful in this application, although a polymeric material may also suffice, provided that it gives the necessary mechanical strength to support the weight of other parts of the assembly.

A further parameter that may be important in designing or selecting a housing for a particular paddle fan 20 is the vertical spacing of the paddles 22 from the ceiling surface, or, perhaps more importantly, the vertical spacing of the upper end 34 of shroud 32 from the ceiling. This is because the product of the circumference of the upper end 34 and the vertical spacing of the upper end from the ceiling defines an effective collection area through which air expelled out of the lower end 36 of the shroud must pass.

As shown in FIGS. 1 and 2, it is expected that many embodiments of the housing 30 will be light enough that they may be suspended directly from extension tube 28 without requiring further reinforcement or support in the ceiling or any mounting structures already in the ceiling. However, if required or desired, the housing 30 may be suspended from the ceiling, independent of the paddle fan 20 or any portion thereof. The exact details of the suspension of the housing are, in either case, well within the skills of one of ordinary skill in this art without further instruction.

A further feature of the disclosed embodiment is disclosed in FIGS. 3a and 3b. It has already been noted that the upper diameter X1 of the shroud 32 and the vertical spacing of the upper end 34 from the ceiling define a cylin-
drical surface area through which air must pass. Similarly, the maximum area through which air is expelled from the housing 30 is the area of the lower end 36, which is readily calculated from diameter X2. It is the inventor’s experience that this area is, and probably should be, further reduced by the use of a directing grid 40. This directing grid 40, in the disclosed embodiment, comprises a circular piece formed from a plurality of intersecting grid members 42. In the disclosed embodiment, the grid members 42 intersect in a manner to provide a plurality of square openings 44, although other arrangements will be known. For example, another arrangement will provide a plurality of triangular openings.

As best seen in the side sectional views of FIGS. 3a and 3b, the directing grid 40 can be constructed of grid members 42 which have a rectangular cross-section (defined by height H and constant width W1 in FIG. 3a) or it can be constructed of grid members 142 which have a triangular cross section (defined by height H and a maximum width W3 in FIG. 3b). In either case, it will be seen that the total flow area through the lower end is decreased. In FIG. 3a, the open areas 44 have a constant width, but in FIG. 2b, the open areas have a decreasing area. From these illustrations, it will be clear to those of ordinary skill how to adjust the available flow area in a manner that promotes either parallel flow (FIG. 3a) or converging flow (FIG. 3b). From the inventor’s experience, it is believed that a filter element, and particularly a fibrous filter element that requires a tortuous flow path therethrough, is counterproductive to the effort of aligning a directed laminar flow of air downwardly through the directing grid 40.

While it is recognized that many paddle fans 20 will possess bi-directional capability, as described above, this feature may not be necessary. The primary object of the housing embodiment disclosed herein is to enhance vertical downflow of air directly under the paddles, rather than enhancing vertical upflow of air onto the ceiling above the paddles, so the paddle fan 20 preferably can provide such downflow.

Since an objective of the disclosed embodiment is to provide increased turnover of room air, particularly in enclosed spaces with high overhead volume, a commercial testing laboratory was engaged to confirm the efficiency of the paddle fan assembly 10 described above. Two different tests were performed.

In a first test, a series of paddle fans were tested to determine the effect of the paddle fan assembly 10 on a series of fans, operating with and without the assembly 10.

**Test 1A**

A paddle fan, manufactured by Dayton Electric Manufacturing Company of Niles, Ill., was mounted from a ceiling. The paddle fan, Model 4C852B, has a 36 inch blade diameter, comprising 3 blades, and is rated by the manufacturer as operating at an airflow rating of 12,500 cubic feet per minute (“CFM”) and a blade speed, as stated by the manufacturer, in the range of 370-395 revolutions per minute (“rpm”). The motor was rotated in a direction to cause downward airflow. Measurements of the average air velocity were taken below the fan, starting at the axial centerline and moving radially outward, while the fan was in stable operation. The shroud was effectively cylindrical with an internal diameter about two inches larger than the blade diameter. The discharge diameter to the adaptor was 35.75 inches. The directing grid at the lower end of the assembly, with the fan blades positioned close to the top of the directing grid, had 0.5 inch square grid openings. Data were collected with and without the assembly in place, as follows:

<table>
<thead>
<tr>
<th>Distance from center (inches)</th>
<th>Average velocity without assembly (ft per min)</th>
<th>Average velocity with assembly (ft per min)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>496</td>
<td>231</td>
</tr>
<tr>
<td>4</td>
<td>580</td>
<td>272</td>
</tr>
<tr>
<td>8</td>
<td>688</td>
<td>378</td>
</tr>
<tr>
<td>12</td>
<td>592</td>
<td>407</td>
</tr>
<tr>
<td>16</td>
<td>599</td>
<td>291</td>
</tr>
<tr>
<td>20</td>
<td>185</td>
<td>129</td>
</tr>
<tr>
<td>24</td>
<td>105</td>
<td>67</td>
</tr>
<tr>
<td>28</td>
<td>89</td>
<td>54</td>
</tr>
</tbody>
</table>

These data are shown graphically at FIG. 4, with velocity plotted against distance from centerline. Because the distance data are based on distance from centerline, the plotted data are indicated as “18W/O” and “18W”, as blade radius is more appropriate when reviewing the data. In this test, data taken beyond 18 inches from the centerline were outside the vertical projection of the shroud.

**Test 1B**

The same test as in Test 1A was performed, with a Dayton Model 4C853B paddle fan used instead of the prior fan. The fan has a 48 inch blade diameter, comprising 3 blades, and is rated by the manufacturer as operating at an airflow rating of 21,000 cubic feet per minute (“CFM”) and a blade speed, as stated by the manufacturer, in the range of 285-315 revolutions per minute (“rpm”). Measurements were taken as in the prior test. A larger shroud was substituted, to provide an internal diameter about two inches larger than the blade diameter. The discharge diameter to the adaptor was 46.75 inches. The directing grid at the lower end of the assembly, with the fan blades positioned close to the top of the directing grid, had 0.562 inch square grid openings. Data were collected with and without the assembly in place, as follows:

<table>
<thead>
<tr>
<th>Distance from center (inches)</th>
<th>Average velocity without assembly (ft per min)</th>
<th>Average velocity with assembly (ft per min)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>443</td>
<td>41</td>
</tr>
<tr>
<td>4</td>
<td>486</td>
<td>59</td>
</tr>
<tr>
<td>8</td>
<td>558</td>
<td>126</td>
</tr>
<tr>
<td>12</td>
<td>587</td>
<td>243</td>
</tr>
<tr>
<td>16</td>
<td>617</td>
<td>413</td>
</tr>
<tr>
<td>20</td>
<td>412</td>
<td>432</td>
</tr>
<tr>
<td>24</td>
<td>225</td>
<td>283</td>
</tr>
<tr>
<td>28</td>
<td>136</td>
<td>127</td>
</tr>
</tbody>
</table>

These data are shown graphically at FIG. 5, with velocity plotted against distance from centerline. Because the distance data are based on distance from centerline, the plotted data are indicated as “24W/O” and “24W”, as blade radius is more appropriate when reviewing the data. In this test, data taken beyond 24 inches from the centerline were outside the vertical projection of the shroud.

**Test 1C**

The same test as above was performed, with a Dayton Model 4C854B paddle fan used instead of the prior fan.
The fan has a 56 inch blade diameter, comprising 3 blades, and is rated by the manufacturer as operating at an airflow rating of 27,500 cubic feet per minute (“CFM”) and a blade speed, as stated by the manufacturer, in the range of 245-265 revolutions per minute (“rpm”). Measurements were taken as in the prior test. A larger shroud was substituted, to provide an internal diameter about two inches larger than the blade diameter. The discharge diameter to the adaptor was 53 inches. The directing grid at the lower end of the assembly, with the fan blades positioned close to the top of the directing grid, had 0.625 inch square grid openings. Data were collected with and without the assembly in place, as follows:

<table>
<thead>
<tr>
<th>Distance from center (inches)</th>
<th>Average velocity without assembly (ft per min)</th>
<th>Average velocity with assembly (ft per min)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>373</td>
<td>52</td>
</tr>
<tr>
<td>4</td>
<td>411</td>
<td>55</td>
</tr>
<tr>
<td>8</td>
<td>464</td>
<td>71</td>
</tr>
<tr>
<td>12</td>
<td>488</td>
<td>124</td>
</tr>
<tr>
<td>16</td>
<td>548</td>
<td>229</td>
</tr>
<tr>
<td>20</td>
<td>460</td>
<td>315</td>
</tr>
<tr>
<td>24</td>
<td>311</td>
<td>367</td>
</tr>
<tr>
<td>28</td>
<td>183</td>
<td>272</td>
</tr>
</tbody>
</table>

These data are shown graphically at FIG. 6, with Velocity plotted against distance from centerline. Because the distance data are based on distance from centerline, the plotted data are indicated as “28W/O” and “28W”, as blade radius is more appropriate when reviewing the data.

Test 1D

The same test as above was performed, with a Dayton Model 4C721B paddle fan used instead of the prior fan. The fan has a 60 inch blade diameter, comprising 3 blades, and is rated by the manufacturer as operating at an airflow rating of 46,000 cubic feet per minute (“CFM”). The manufacturer’s stated blade speed is not known. Measurements were taken as in the prior test. A larger shroud was substituted, to provide an internal diameter about two inches larger than the blade diameter. The discharge diameter to the adaptor was 58.5 inches. The directing grid at the lower end of the assembly, with the fan blades positioned close to the top of the directing grid, had 0.625 inch square grid openings. Data were collected with and without the assembly in place, as follows:

<table>
<thead>
<tr>
<th>Distance from center (inches)</th>
<th>Average velocity without assembly (ft per min)</th>
<th>Average velocity with assembly (ft per min)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>300</td>
<td>36</td>
</tr>
<tr>
<td>4</td>
<td>338</td>
<td>38</td>
</tr>
<tr>
<td>8</td>
<td>392</td>
<td>52</td>
</tr>
<tr>
<td>12</td>
<td>430</td>
<td>93</td>
</tr>
<tr>
<td>16</td>
<td>503</td>
<td>178</td>
</tr>
<tr>
<td>20</td>
<td>493</td>
<td>261</td>
</tr>
<tr>
<td>24</td>
<td>428</td>
<td>336</td>
</tr>
<tr>
<td>28</td>
<td>268</td>
<td>334</td>
</tr>
</tbody>
</table>

These data are shown graphically at FIG. 7, with velocity plotted against distance from centerline. Because the distance data are based on distance from centerline, the plotted data are indicated as “30W/O” and “30W”, as blade radius is more appropriate when reviewing the data.

Discussion of Test 1 Data

These data show that the placement of the assembly around the paddle fan moves the maximum average airflow velocity radially outwardly from where the maximum velocity occurs without the assembly. It is believed that a further effect is a more laminar flow of air in the column of air pushed downwardly.

A first alternate view of these data is presented in FIG. 8. In that graph, the data in both axes of the graph is normalized, so that data for each fan configuration are directly comparable. The y-axis shows a normalization of the average velocity by dividing the average velocity at each radial distance by the average velocity at the centerline. For example, from Table 1A, the normalized velocity at 12 inches from the centerline for the 36 inch diameter fan without the assembly in place is 592/496, or 1.194. The distance from the centerline, that is, the data presented along the x-axis, is also normalized, so the distance of 12 inches from centerline in a 36 inch diameter (18 inch radius) fan is 0.667. Thus the x,y coordinate pair (12, 592) of Table 1A becomes the pair (0.667, 1.194) in FIG. 8. FIG. 8 has the immediately notable feature that the 24, 28 and 30 inch radius fans adapted with the assembly are operating under a different regime than the other tested configurations.

A second alternate view of these data is shown in FIG. 9. In that graph, the ratio of the average velocity with the assembly to the average velocity without the assembly for each specific fan size is determined at each distance from the centerline. For example, Table 1A shows an average velocity of 407 ft/min with the assembly and an average velocity of 592 ft/min without the assembly, at the same distance of 12 inches from centerline. The ratio is therefore 407/592, or 0.688. The distances from the centerline are normalized in the same manner as in FIG. 8. This graph also seems to show that the 18 inch radius fan is operating under a different regime than the other three fans tested. Although not investigated in more depth, the 36 inch fan was operating at a significantly higher blade rotation speed.

Test 2

The same independent commercial testing laboratory that conducted the tests reported above as Test 1 performed a second test to verify that the air turnover in a room is increased by the presence of the assembly as described above. The test was conducted using the 36 inch diameter fan of Test 1, both with and without the assembly. The fan was mounted 16 feet above the floor in a room having 80 feet of clear lateral space from the projection of the fan centerline on to the floor. Temperatures were measured at the floor level. Temperature levels were measured at 2 foot intervals from the fan centerline projection onto the floor in a room that was allowed to stratify to develop a natural convective air turnover. Once the fan was turned on, temperature measurements were made to determine the effective radial distance the air was moved. Some definitions are in order here. “Delta Temperature” refers to difference between the measured temperature and the ambient temperature. “Effective Range” is the
distance across the floor from the fan centerline at which the Delta Temperature drops to zero. “Stable Air Flow” is established when the measured temperature first levels off from the initial temperature drop. The “Stabilized Temperature Range” is the distance between which Stable Air Flow is established and the Effective Range.

[0053] Working in this system, the fan operating without the assembly was observed to have an Effective Range of 22 feet from centerline, but when operating with the assembly, the Effective Range increased to 40 feet. The increase in floor area coverage by the fan with the assembly is therefore the ratio of the squares of the Effective Ranges, that is, \(40^2/22^2\), or 3.31. In economic terms, this means that a fan operating with the assembly of this embodiment greatly increases the air turnover in a room that would be provided by the same fan in the same room without the assembly installed. This increase in turnover is achieved without increasing the power consumption of the fan, so any energy savings in heating or cooling realized by the additional turnover are achieved at a constant cost. It is noted that the 36 inch fan, as demonstrated above, while marginally better with the assembly than without it, triples the floor coverage. The data show that the 36 inch diameter fan with the assembly operates similarly to a 60 inch diameter fan without the assembly, as shown in FIG. 8. Accordingly, it is expected that repeating the test protocol of Test 2 using the larger diameter fans will show an even more pronounced effect, and such tests are scheduled to be done.

[0054] While the foregoing examples describe the use of the assembly in conjunction with a paddle fan that is suspended from a ceiling, the beneficial effects of increased air turnover described in the foregoing are not expected to be limited to situations where a ceiling is present. Accordingly, it is expected that a paddle fan used on a patio or similar open space, or even under a portable covering such as a tent, will have its performance increased substantially by the use of an embodiment of the assembly. It is known that increasing air turnover in such a space deters insects such as mosquitoes from landing on and biting humans.

[0055] The inventor believes that the object of the invention is to maximize the vertical distance of the room through which the air is effectively turned over. Since any vertical downflow will be balanced out by a corresponding upflow, it is believed that the primary objects are best achieved by using the paddle fan 20 in a downflow mode with the disclosed embodiment.

1. An assembly for improving the turnover of air in a space by a paddle fan having a plurality of blades extending a first radial distance from a centerline thereof, comprising:
   a generally vertical shroud, having an internal diameter at least at a top end thereof that is slightly larger than a diameter of the paddle fan;
   a directing grid attached to the shroud at a lower end thereof, the directing grid comprising a plurality of intersecting members to reduce cross-sectional flow area;
   means for mounting the shroud radially outwardly from the fan blades.
2. The assembly of claim 1, wherein:
   the shroud is cylindrical.
3. The assembly of claim 1, wherein:
   the shroud is frustoconical.
4. The assembly of claim 2, wherein:
   the mounting means attaches the shroud to the paddle fan.
5. The assembly of claim 2, wherein:
   the mounting means attaches the shroud to a ceiling from which the paddle fan is suspended.
6. The assembly of claim 1, wherein:
   the average airflow velocity at a point between 80 and 100% of the radial distance from the centerline to the blade tip is greater when the paddle fan is operated with the assembly in place relative to identical operation of the paddle fan without the assembly in place.
7. The assembly of claim 1, wherein:
   a ratio of the average airflow velocity measured at a point between 80 to 100% of the radial distance from the centerline to the blade tip to the average airflow velocity measured at the centerline under the same operating conditions increases by at least a factor of 4.
8. The assembly of claim 1, wherein:
   the internal diameter of the shroud is at least about 30 inches.
9. The assembly of claim 3, wherein:
   the mounting means attaches the shroud to the paddle fan.
10. The assembly of claim 3, wherein:
    the mounting means attaches the shroud to a ceiling from which the paddle fan is suspended.

* * * * *