EXHIBIT A

US00D602143S

(12) **United States Design Patent** (10) **Patent No.: US D602,143 S**
Gammack et al. (45) **Date of Patent: ** Oct. 13, 2009**

(54) **FAN**

(75) Inventors: **Peter David Gammack**, Malmesbury (GB); **James Dyson**, Malmesbury (GB)

(73) Assignee: **Dyson Limited**, Malmesbury (GB)

(**) Term: **14 Years**

(21) Appl. No.: **29/328,961**

(22) Filed: **Dec. 4, 2008**

(30) **Foreign Application Priority Data**

Jun. 6, 2008 (GB) 4007841

(51) **LOC (9) Cl.** **23-04**
(52) **U.S. Cl.** **D23/370**
(58) **Field of Classification Search** .... D23/382, D23/381, 370, 413, 411, 412; 416/244 R, 416/246, 247 R; D6/309
See application file for complete search history.

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D539,414 S		3/2007	Russak et al.	

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Primary Examiner—Lisa P Lichtenstein
(74) *Attorney, Agent, or Firm*—Morrison and Foerster LLP

(57) **CLAIM**

We claim the ornamental design for a fan, as shown and described.

DESCRIPTION

FIG. **1** is a perspective view of a fan showing our new design;

FIG. **2** is a front view thereof;

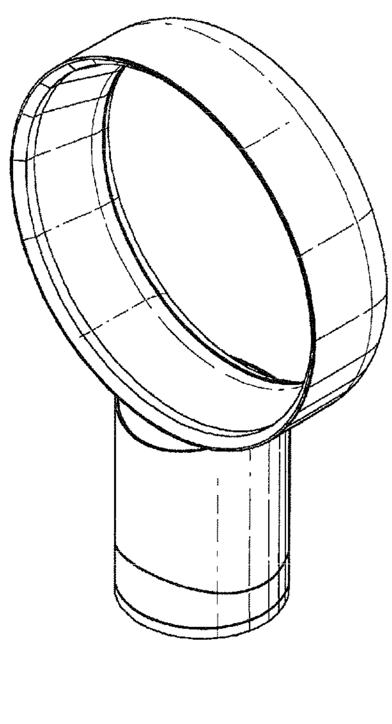
FIG. **3** is a rear view thereof;

FIG. **4** is a side view thereof;

FIG. **5** is a top plan view thereof; and,

FIG. **6** is an underneath plan view thereof.

1 Claim, 4 Drawing Sheets



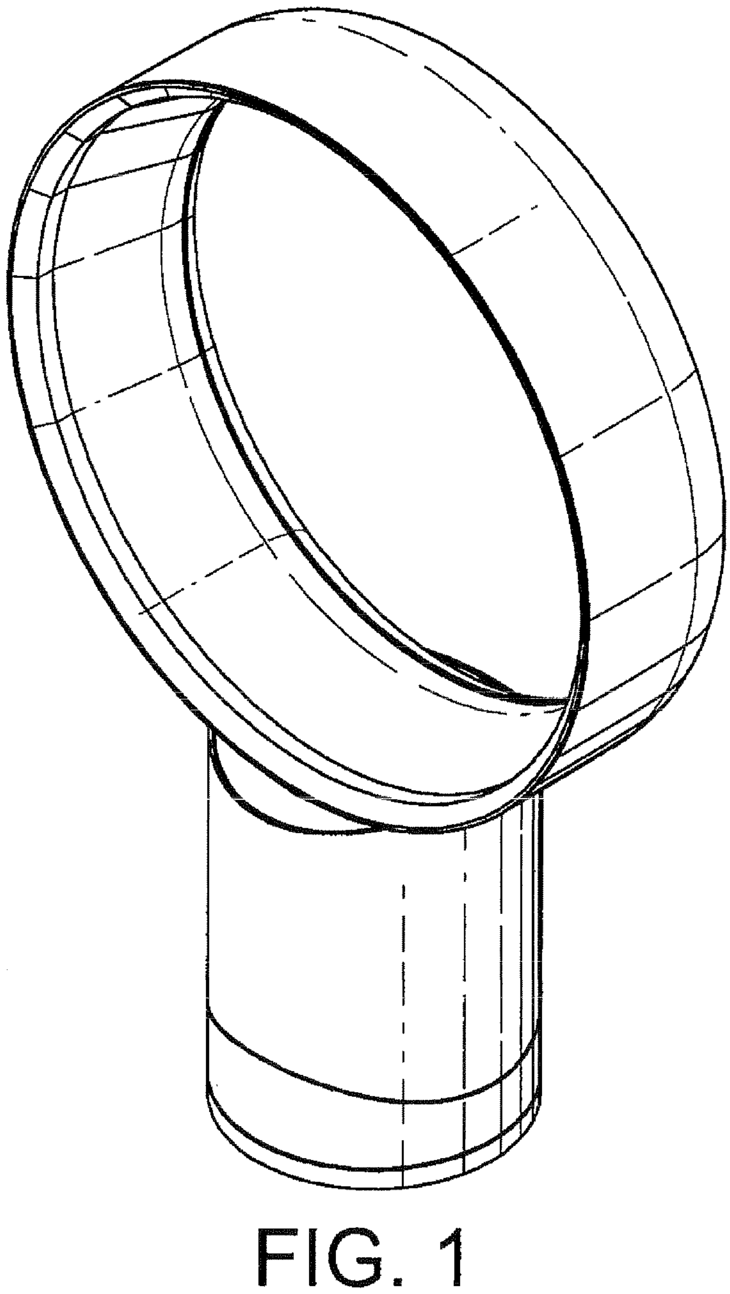


FIG. 1

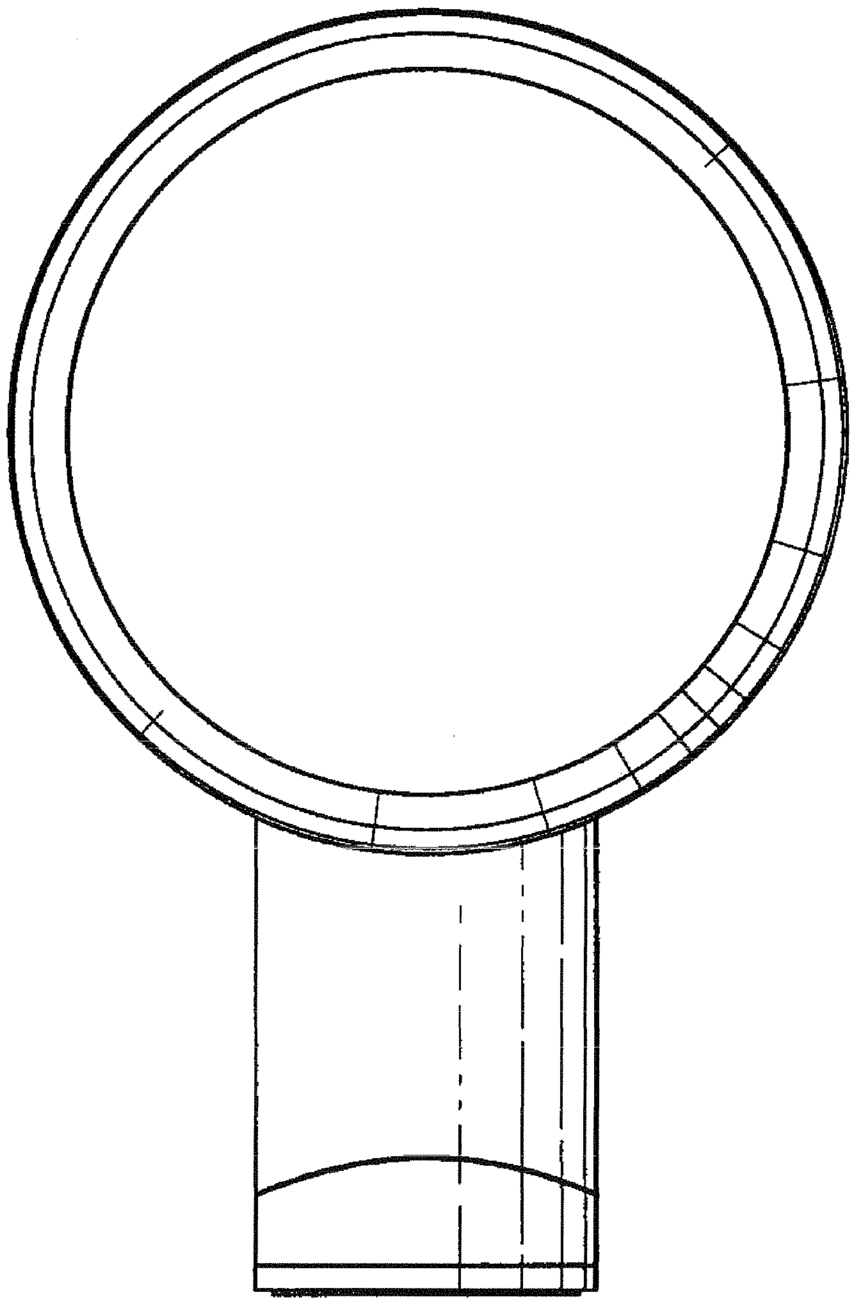


FIG. 2

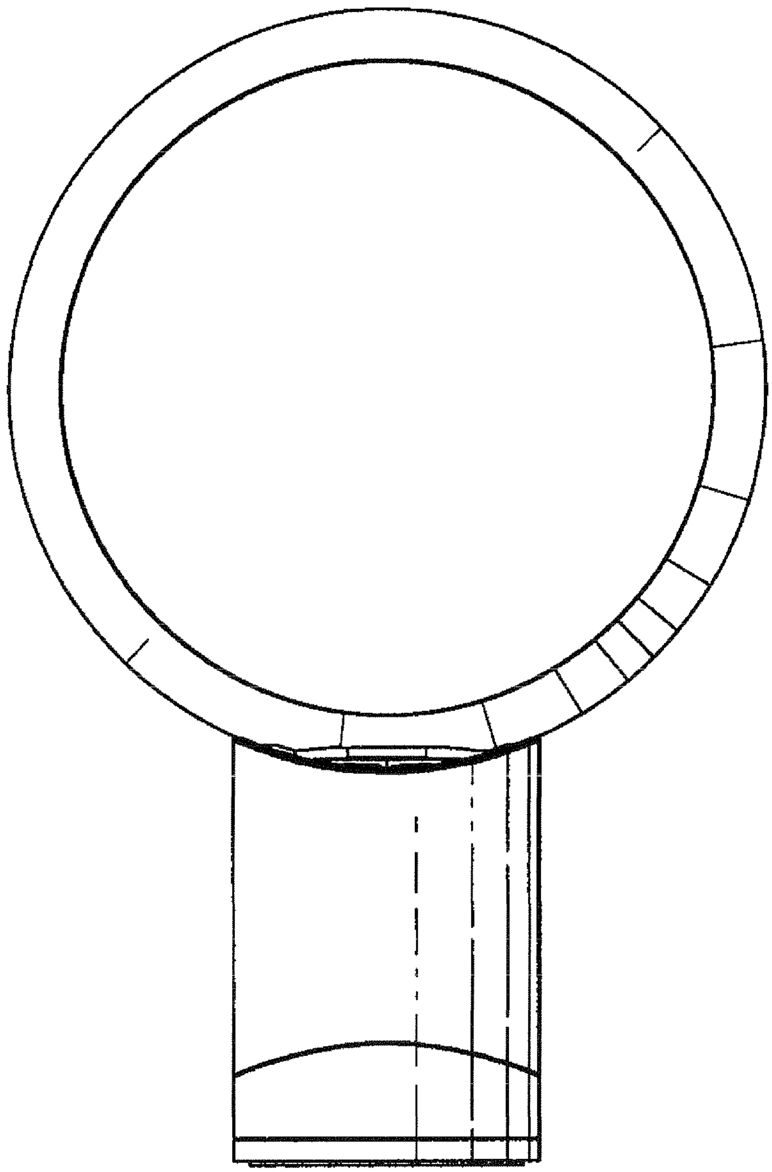


FIG. 3

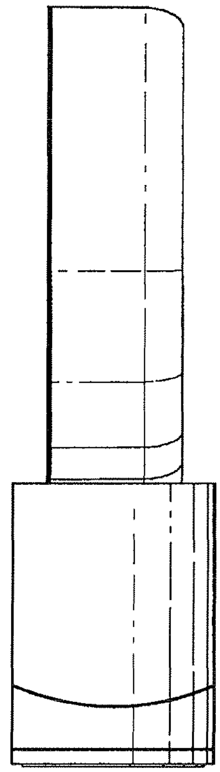


FIG. 4

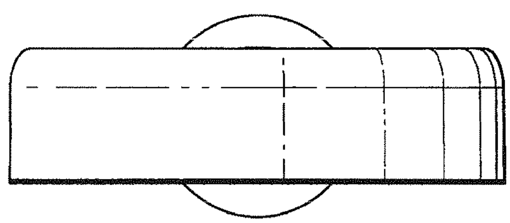


FIG. 5

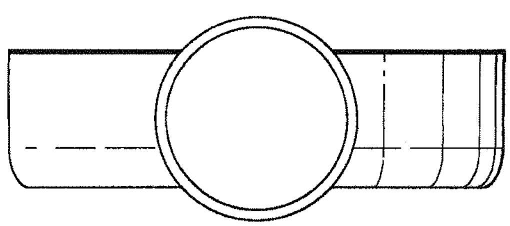


FIG. 6

EXHIBIT B

US00D605748S

(12) United States Design Patent
Gammack et al.

(10) Patent No.: **US D605,748 S**
(45) Date of Patent: ** ***Dec. 8, 2009**

(54) **FAN**

(75) Inventors: **Peter David Gammack**, Malmesbury (GB); **James Dyson**, Malmesbury (GB)

(73) Assignee: **Dyson Limited**, Wiltshire (GB)

(*) Notice: This patent is subject to a terminal disclaimer.

(**) Term: **14 Years**

(21) Appl. No.: **29/328,939**

(22) Filed: **Dec. 4, 2008**

(30) **Foreign Application Priority Data**

Jun. 6, 2008 (GB) 4007842

(51) **LOC (9) Cl.** **23-04**

(52) **U.S. Cl.** **D23/370**

(58) **Field of Classification Search** .... D23/382, D23/381, 370, 413, 411, 412; 416/244 R, 416/246, 247 R; D6/309

See application file for complete search history.

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D115,344 S	*	6/1939	Chapman	D23/411
2,433,795 A		12/1947	Stokes	
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D206,973 S		2/1967	De Lisio	
5,881,685 A		3/1999	Foss et al.	
D415,271 S	*	10/1999	Feer	D23/411
6,073,881 A		6/2000	Chen	
D429,808 S	*	8/2000	Krauss et al.	D23/411
6,123,618 A		9/2000	Day	
D435,899 S	*	1/2001	Melwani	D23/382
D485,895 S	*	1/2004	Melwani	D23/370
D539,414 S		3/2007	Russak et al.	
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GB	1 501 473	2/1978
GB	2 236 804	4/1991
GB	2 242 935	10/1991
JP	56-167897	12/1981

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* cited by examiner

Primary Examiner—Lisa P Lichtenstein
(74) *Attorney, Agent, or Firm*—Morrison & Foerster LLP

(57) **CLAIM**

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DESCRIPTION

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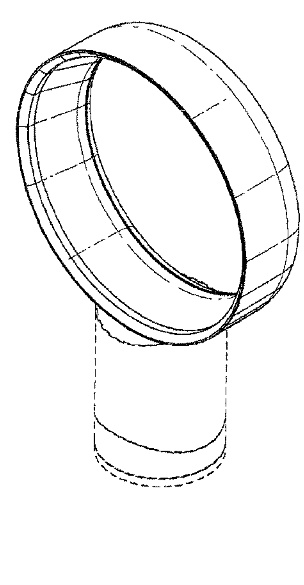
FIG. **5** is a top plan view thereof; and,

FIG. **6** is an underneath plan view thereof.

The features of the design as claimed by applicants are shown in bold lines. The features shown in dotted lines are not claimed and are provided to indicate the context of the design.

1 Claim, 4 Drawing Sheets



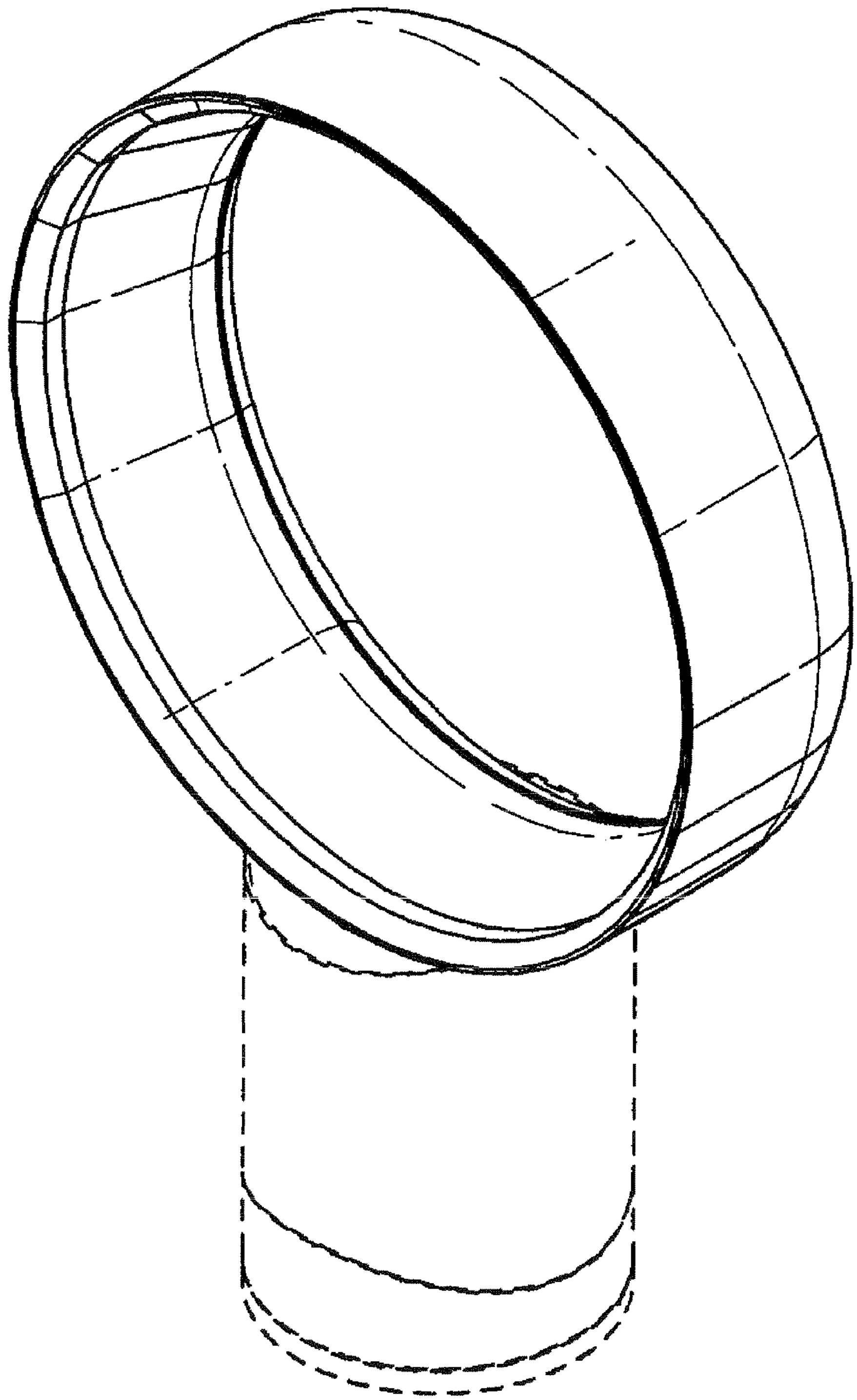


FIG. 1

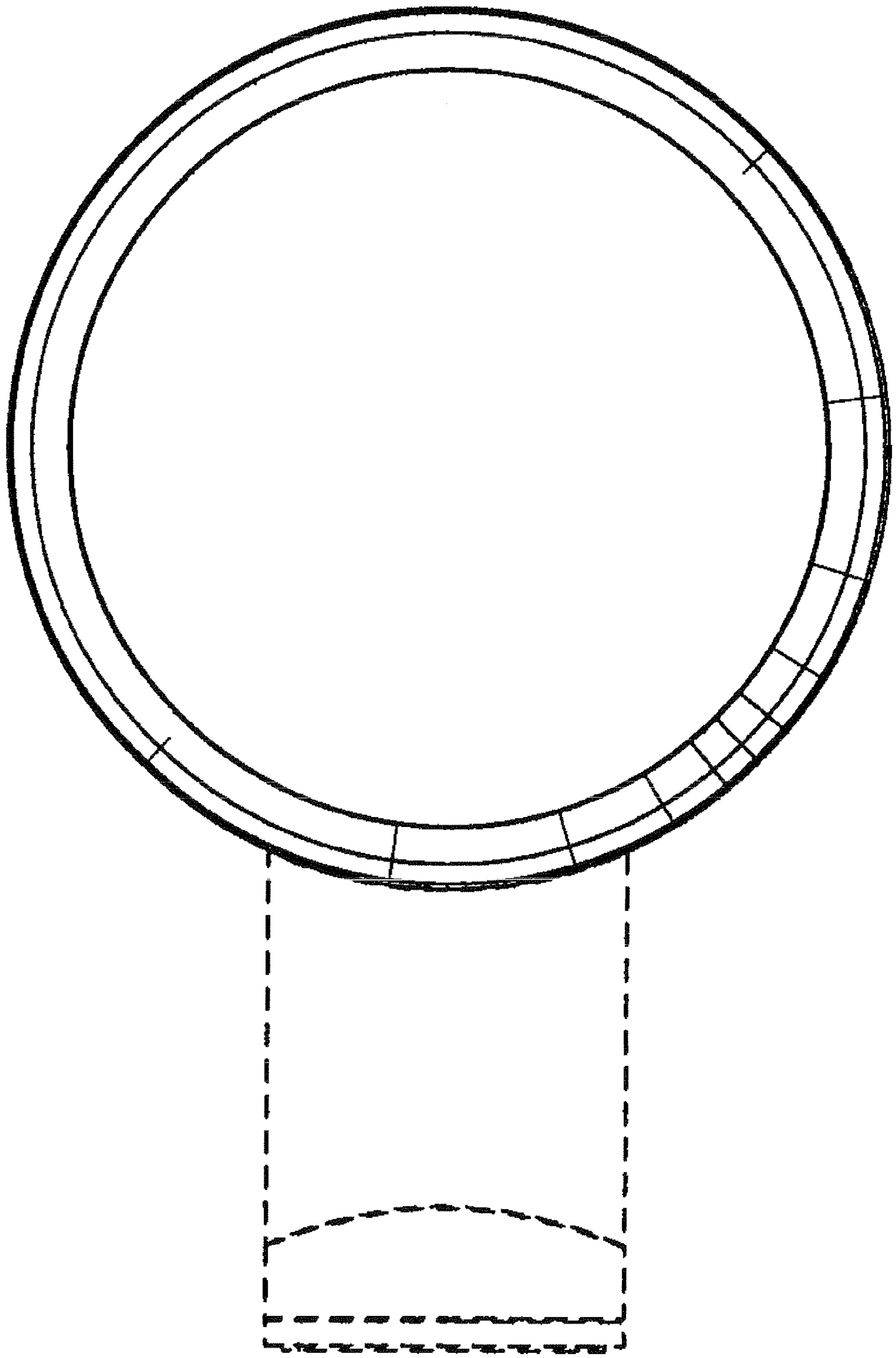


FIG. 2

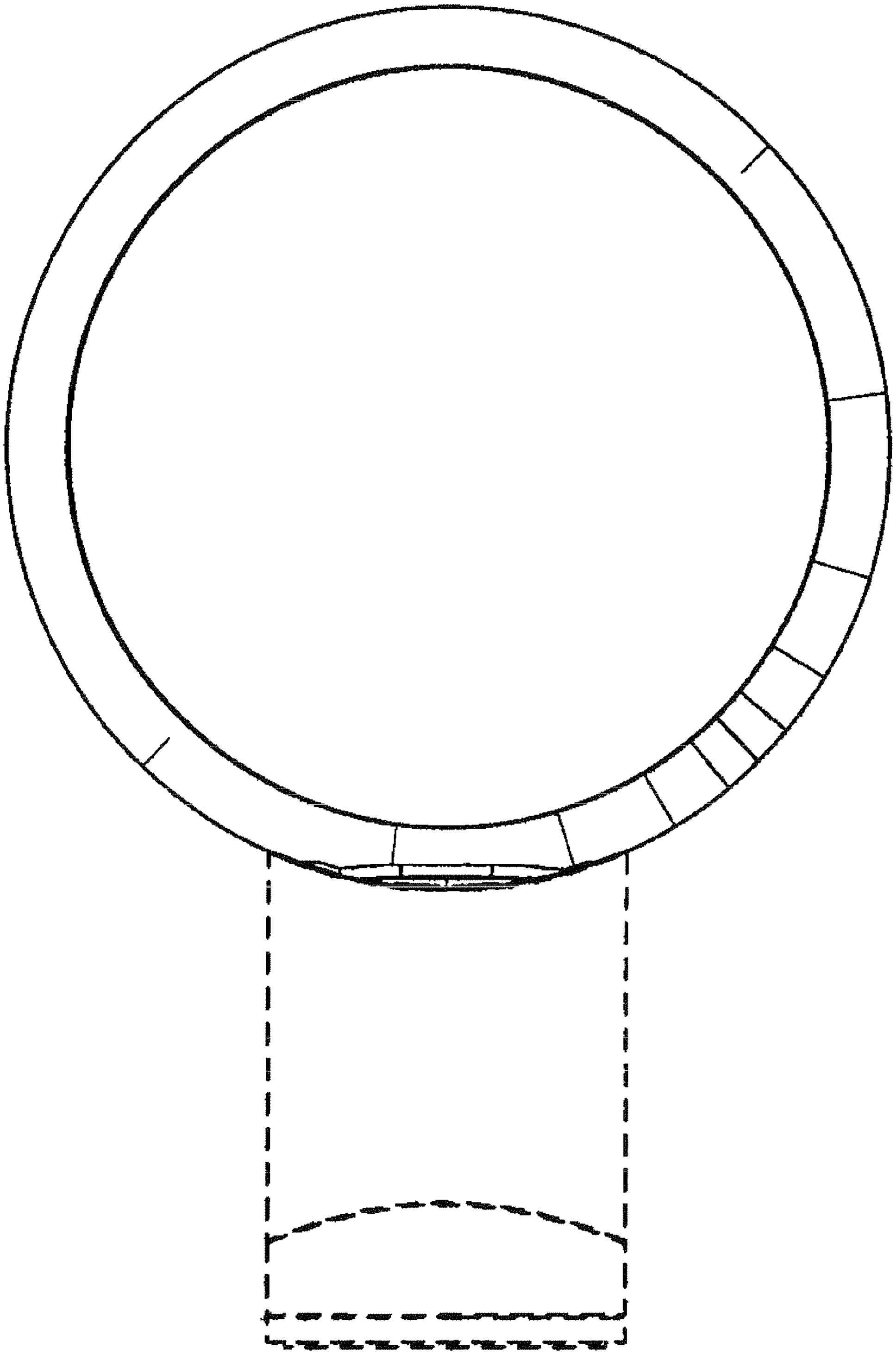
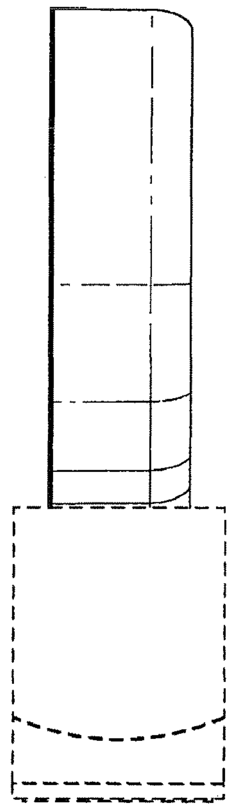


FIG. 3



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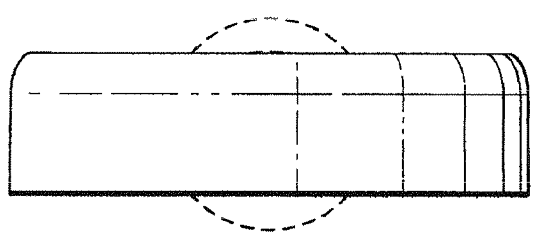

FIG. 5

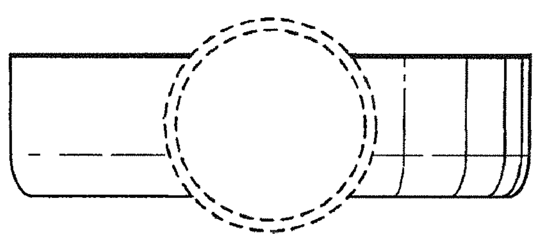

FIG. 6

EXHIBIT C

US008052379B2

(12) **United States Patent**
Gammack

(10) **Patent No.: US 8,052,379 B2**
(45) **Date of Patent: Nov. 8, 2011**

(54) **FAN ASSEMBLY**

(75) Inventor: **Peter David Gammack**, Malmesbury (GB)

(73) Assignee: **Dyson Technology Limited**, Malmesbury (GB)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 21 days.

(21) Appl. No.: **12/716,613**

(22) Filed: **Mar. 3, 2010**

(65) **Prior Publication Data**

US 2010/0226750 A1 Sep. 9, 2010

(30) **Foreign Application Priority Data**

Mar. 4, 2009 (GB) 0903674.0

(51) **Int. Cl.**
F04D 29/62 (2006.01)

(52) **U.S. Cl.** **415/126**

(58) **Field of Classification Search** 415/51, 415/119, 126, 127; 416/9, 13, 16, 117, 118, 416/119

See application file for complete search history.

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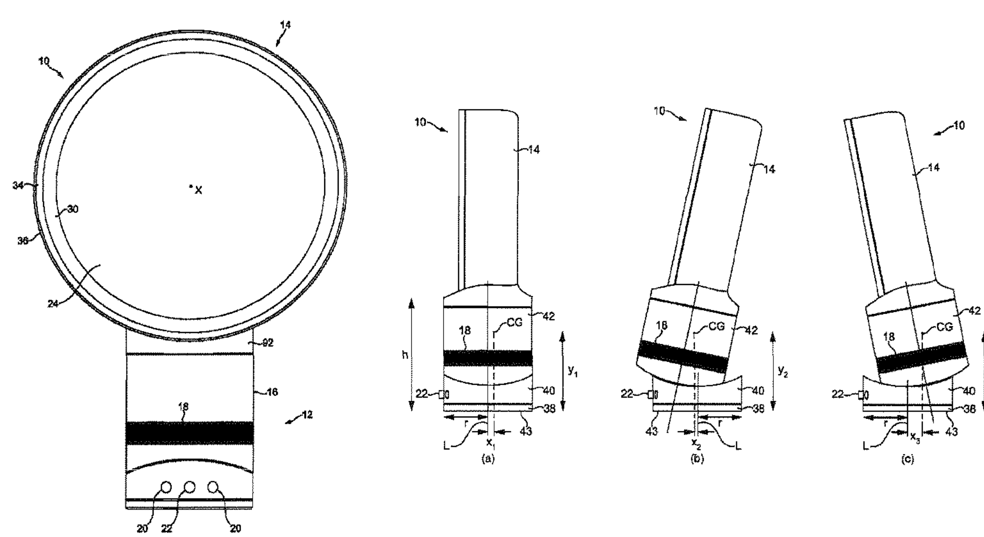
Primary Examiner — Nathaniel Wiehe
(74) *Attorney, Agent, or Firm* — Morrison & Foerster LLP

(57) **ABSTRACT**

A fan assembly for creating an air current includes an air outlet mounted on a stand. The stand includes a base and a body tiltable relative to the base. The fan assembly has a center of gravity located so that when the base is located on a substantially horizontal support surface, the projection of the center of gravity on the support surface is within the footprint of the base when the body is in a fully tilted position.

16 Claims, 9 Drawing Sheets



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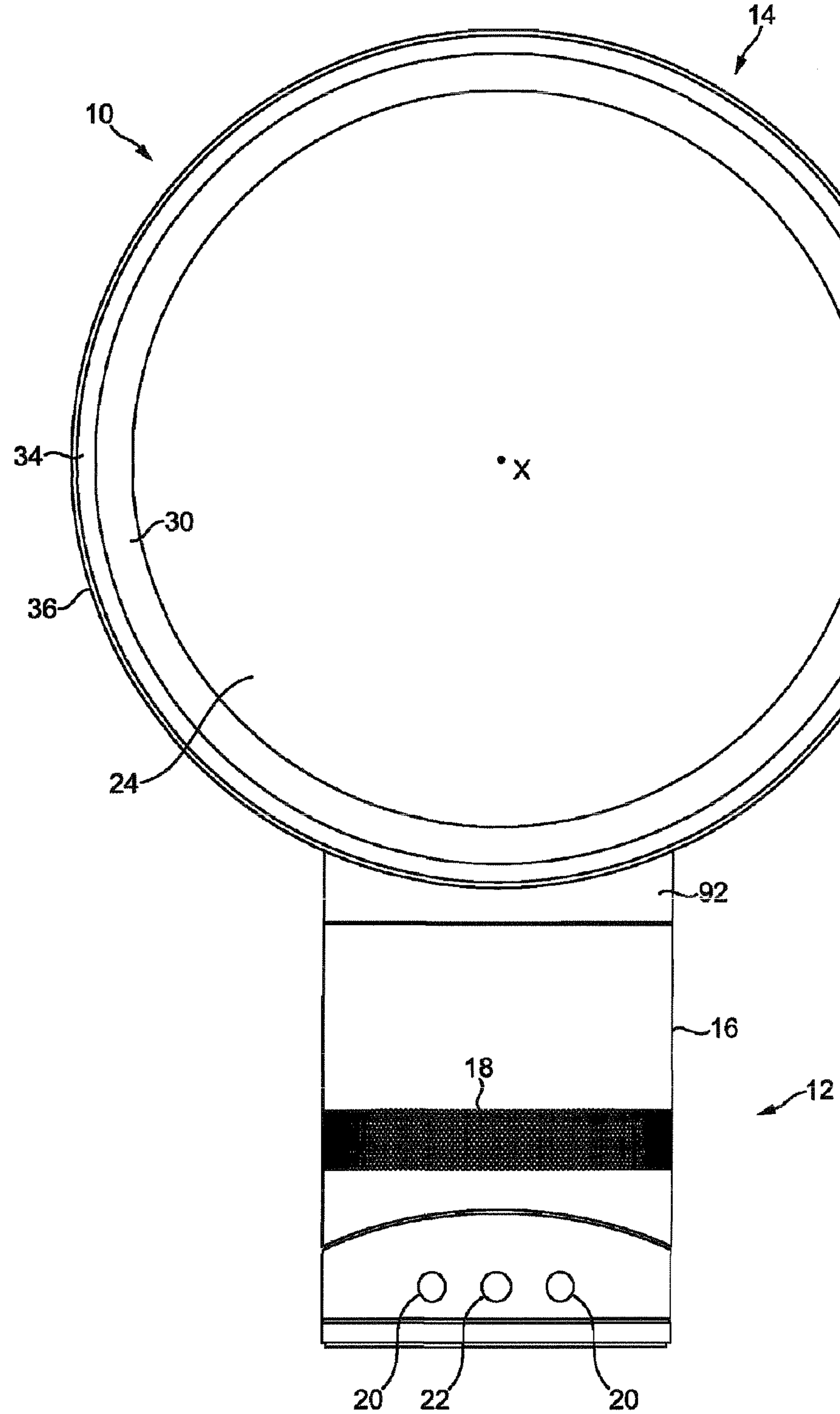

FIG. 1

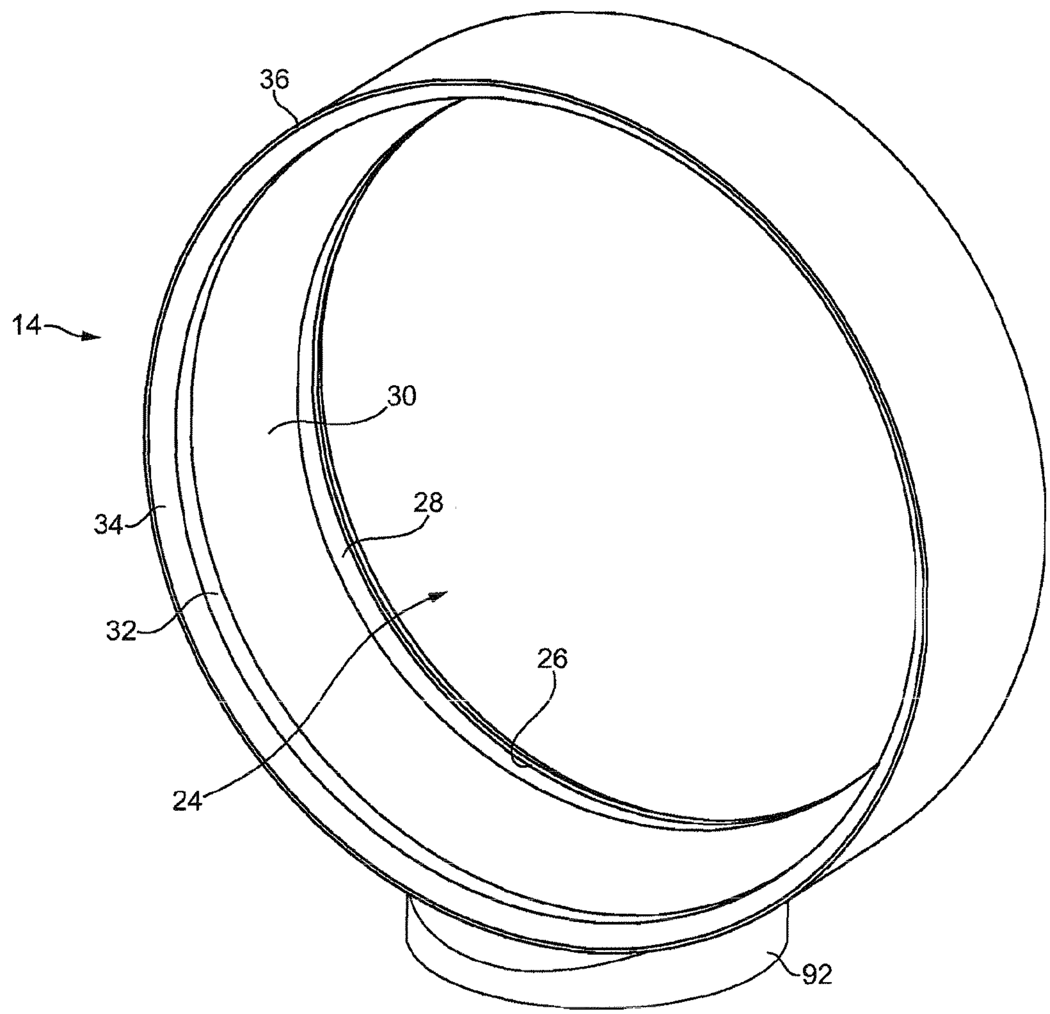

FIG. 2

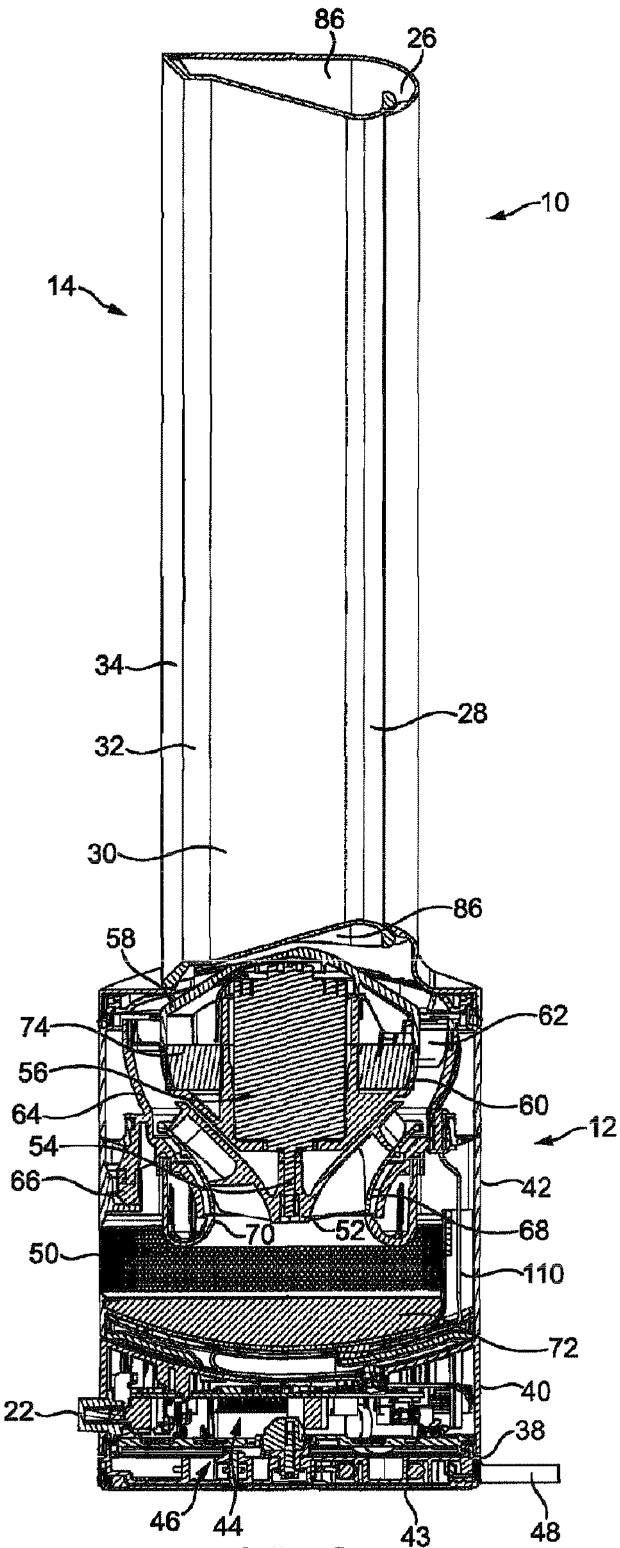

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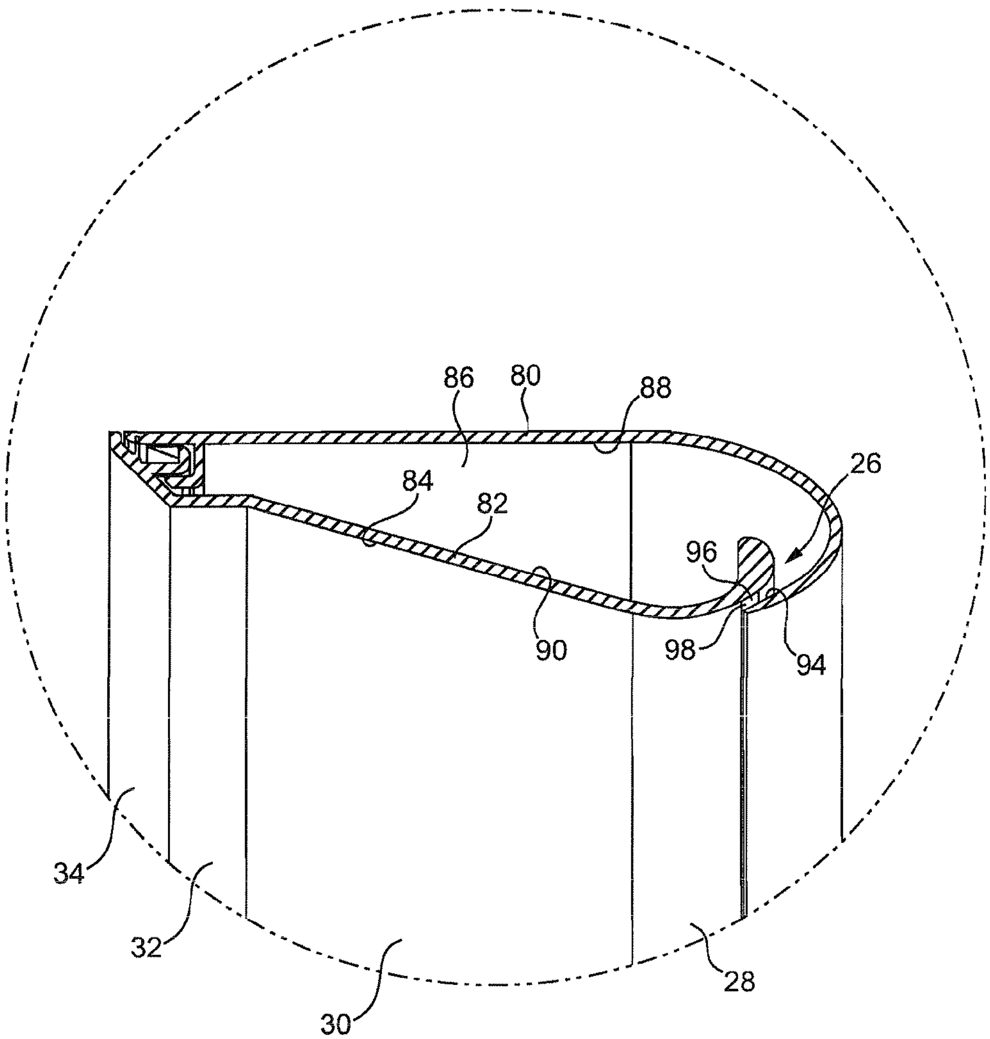
FIG. 3



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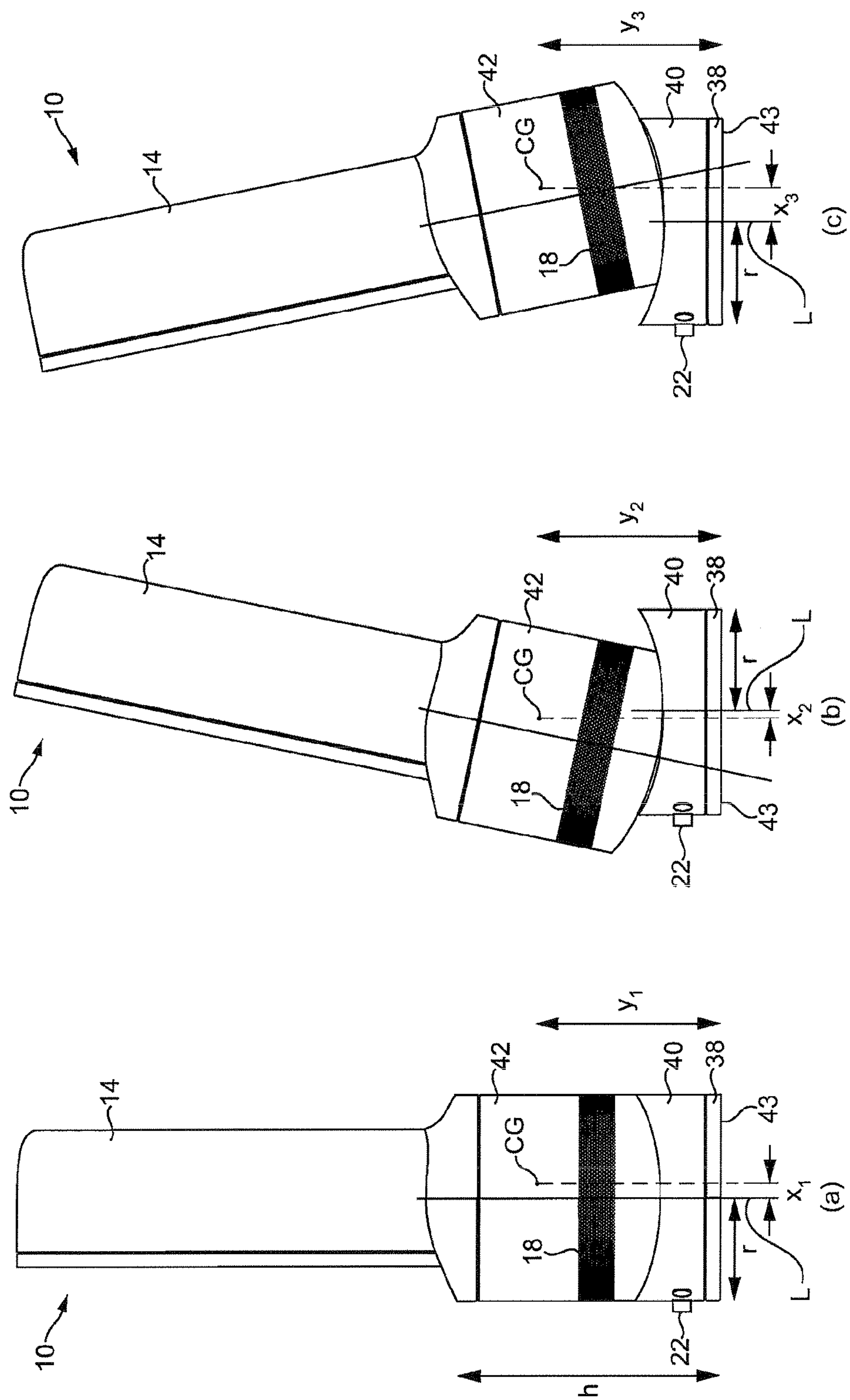
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FIG. 5

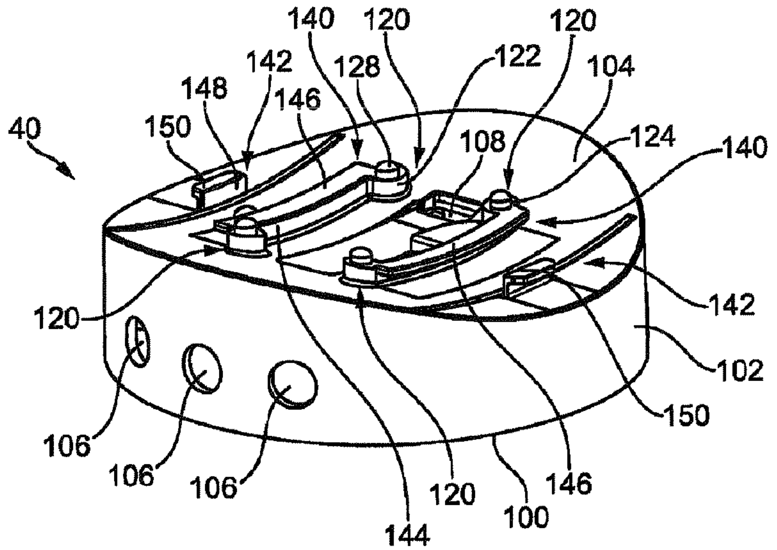
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FIG. 6

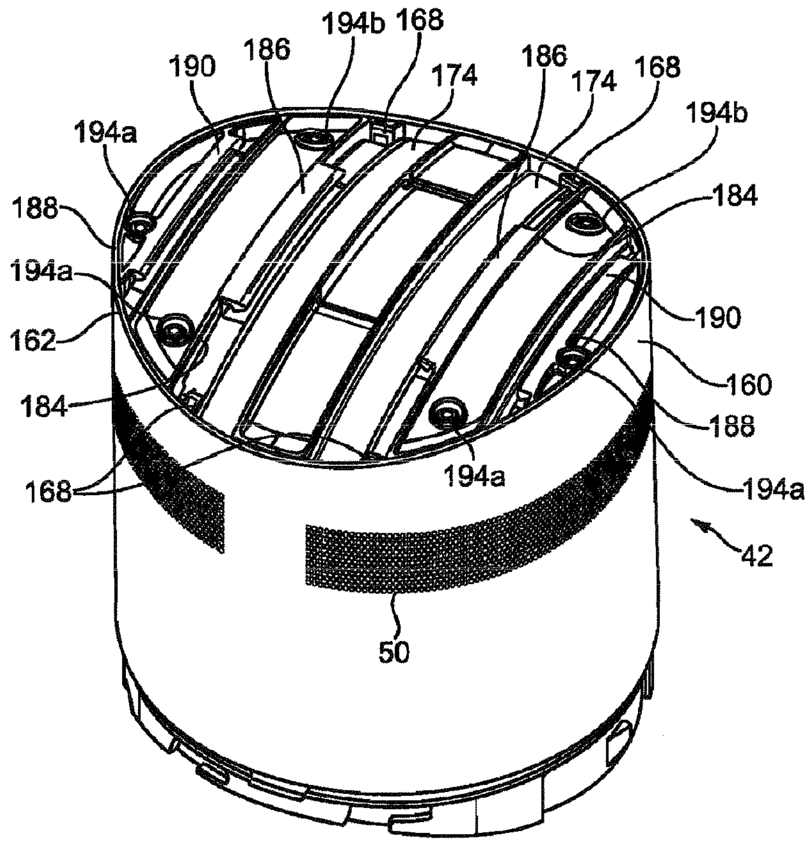
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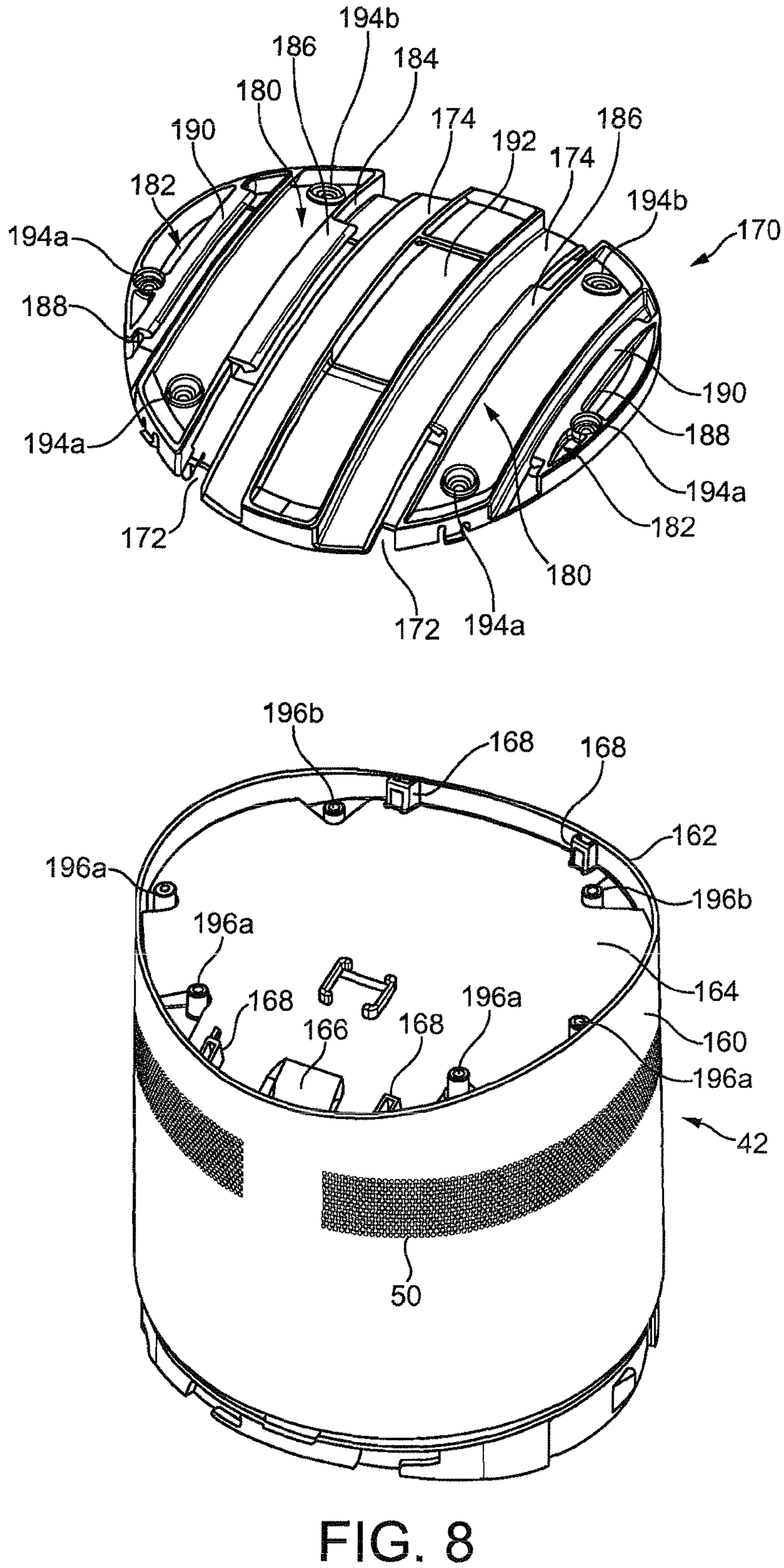
FIG. 7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162
196a
196b
196a
164
168
196a
166
168
160
196a
42
50

FIG. 8

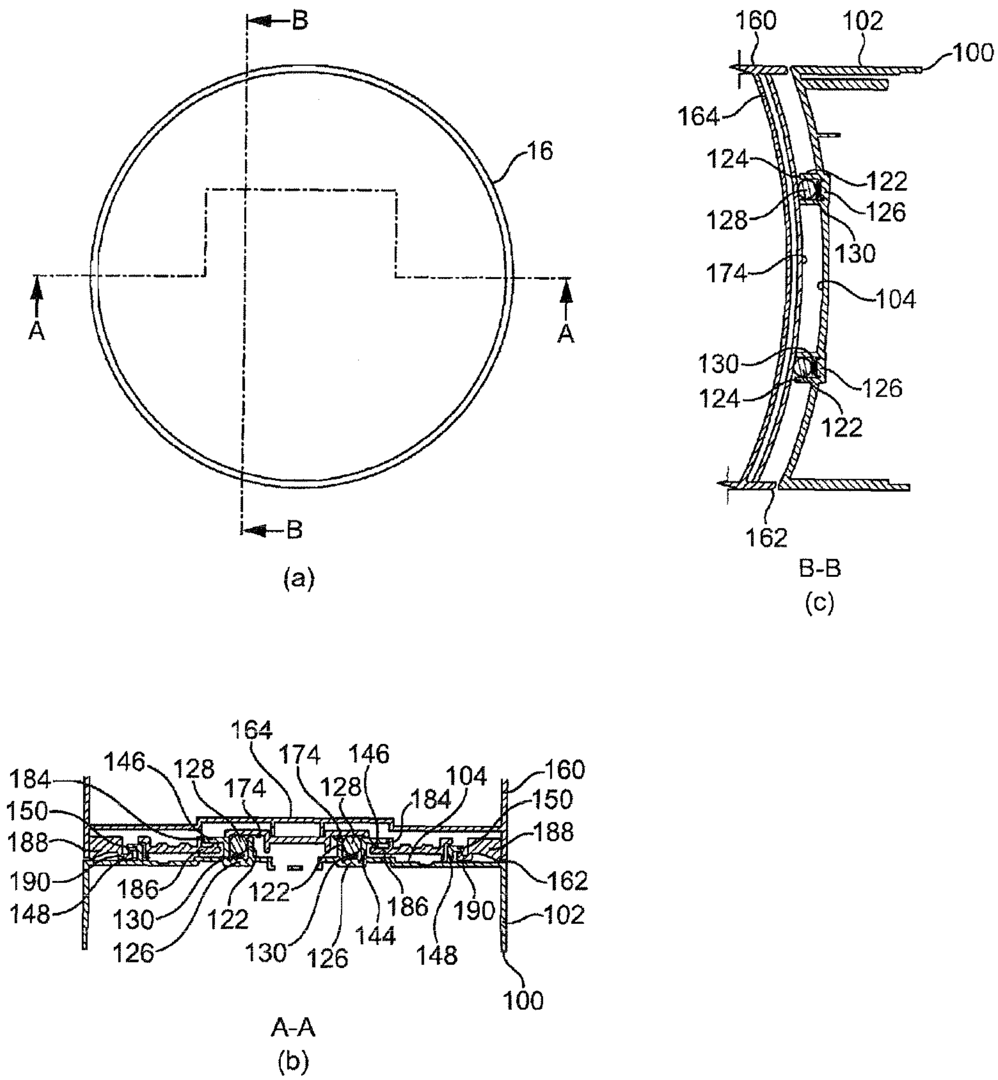
B
B
16
A
A
(a)
160
102
100
164
124
122
128
126
130
174
104
130
126
124
122
162
B-B
(c)
164
174
146
146
184
128
128
104
174
160
150
184
150
188
188
190
186
122
162
148
130
122
186
190
102
126
130
126
144
148
100
A-A
(b)

FIG. 9

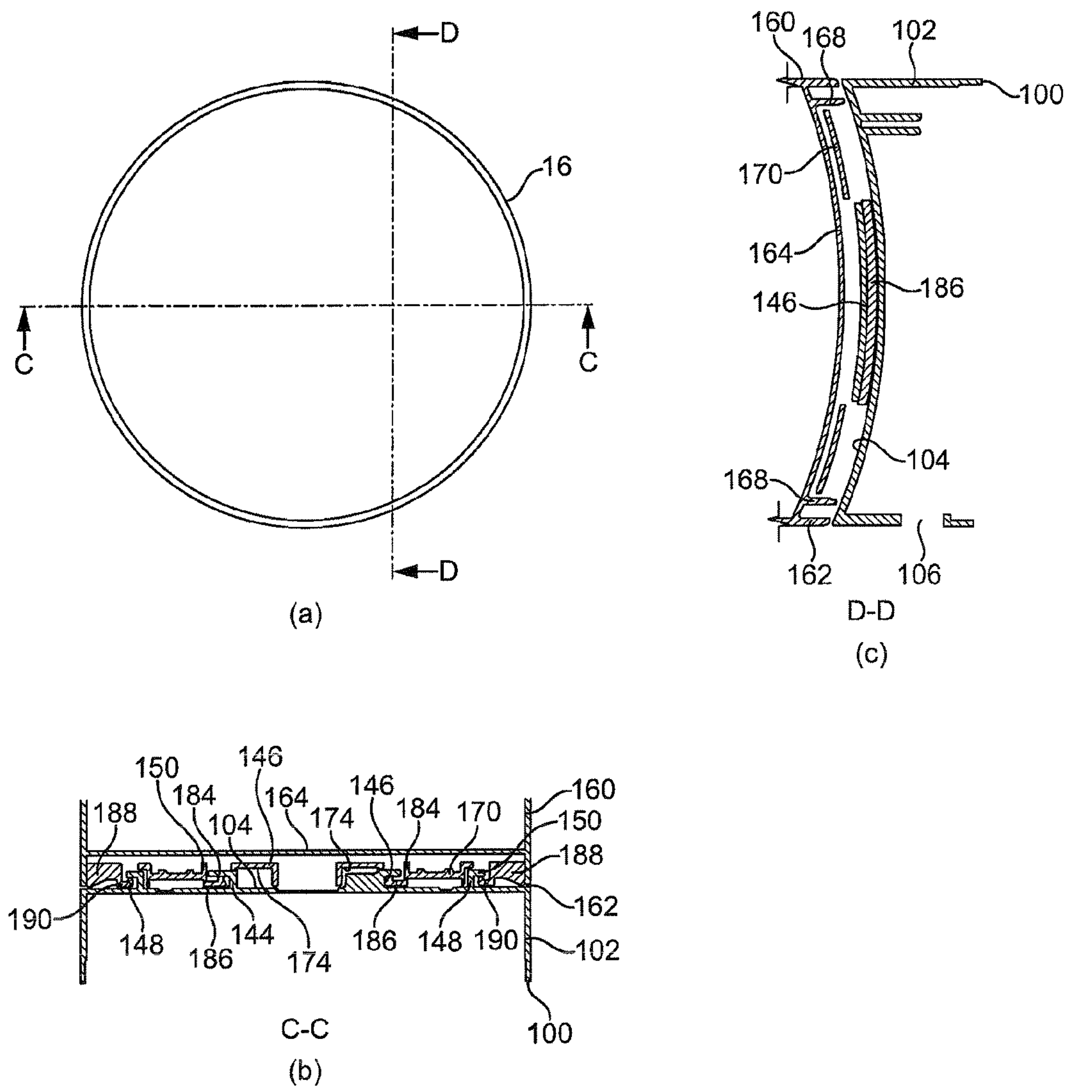
D
D
16
C
C
(a)
160
168
102
100
170
164
146
186
104
168
162
106
D-D
(c)
150
184
146
164
146
184
170
160
188
104
174
150
188
162
190
148
186
144
174
186
148
190
102
C-C
100
(b)

FIG. 10

FAN ASSEMBLY

REFERENCE TO RELATED APPLICATIONS

This application claims the priority of United Kingdom Application No. 0903674.0, filed 4 Mar. 2009, the entire contents of which are incorporated herein by reference.

FIELD OF THE INVENTION

The present invention relates to a fan assembly. Particularly, but not exclusively, the present invention relates to a domestic fan, such as a desk fan, for creating air circulation and air current in a room, in an office or other domestic environment.

BACKGROUND OF THE INVENTION

A conventional domestic fan typically includes a set of blades or vanes mounted for rotation about an axis, and drive apparatus for rotating the set of blades to generate an air flow. The movement and circulation of the air flow creates a 'wind chill' or breeze and, as a result, the user experiences a cooling effect as heat is dissipated through convection and evaporation.

Such fans are available in a variety of sizes and shapes. For example, a ceiling fan can be at least 1 m in diameter, and is usually mounted in a suspended manner from the ceiling to provide a downward flow of air to cool a room. On the other hand, desk fans are often around 30 cm in diameter, and are usually free standing and portable. Other types of fan can be attached to the floor or mounted on a wall. Fans such as that disclosed in U.S. Pat. No. D 103,476 and U.S. Pat. No. 1,767,060 are suitable for standing on a desk or a table.

A disadvantage of this type of fan is that the air flow produced by the rotating blades is generally not uniform. This is due to variations across the blade surface or across the outward facing surface of the fan. The extent of these variations can vary from product to product and even from one individual fan machine to another. These variations result in the generation of an uneven or 'choppy' air flow which can be felt as a series of pulses of air and which can be uncomfortable for a user. A further disadvantage is that the cooling effect created by the fan diminishes with distance from the user. This means that the fan must be placed in close proximity to the user in order for the user to experience the cooling effect of the fan.

An oscillating mechanism may be employed to rotate the outlet from the fan so that the air flow is swept over a wide area of a room. The oscillating mechanism can lead to some improvement in the quality and uniformity of the air flow felt by a user although the characteristic 'choppy' air flow remains.

Locating fans such as those described above close to a user is not always possible as the bulky shape and structure of the fan mean that the fan occupies a significant amount of the user's work space area.

Some fans, such as that described in U.S. Pat. No. 5,609,473, provide a user with an option to adjust the direction in which air is emitted from the fan. In U.S. Pat. No. 5,609,473, the fan comprises a base and a pair of yokes each upstanding from a respective end of the base. The outer body of the fan houses a motor and a set of rotating blades. The outer body is secured to the yokes so as to be pivotable relative to the base. The fan body may be swung relative to the base from a generally vertical, untilted position to an inclined, tilted position. In this way the direction of the air flow emitted from the fan can be altered.

In such fans, a securing mechanism may be employed to fix the position of the body of the fan relative to the base. The securing mechanism may comprise a clamp or manual locking screws which may be difficult to use, particularly for the elderly or for users with impaired dexterity.

In a domestic environment it is desirable for appliances to be as small and compact as possible due to space restrictions. In contrast, fan adjustment mechanisms are often bulky, and are mounted to, and often extend from, the outer surface of the fan assembly.

When such a fan is placed on a desk, the footprint of the adjustment mechanism can undesirably reduce the area available for paperwork, a computer or other office equipment. In addition, it is undesirable for parts of the appliance to project outwardly, both for safety reasons and because such parts can be difficult to clean.

SUMMARY OF THE INVENTION

In a first aspect the present invention provides a fan assembly for creating an air current, the fan assembly comprising a stand and an air outlet mounted on the stand for emitting an air flow, the stand comprising a base and a body tiltable relative to the base from an untilted position to a tilted position, the body comprising a device for creating said air flow, the fan assembly having a centre of gravity located so that when the base is located on a substantially horizontal support surface, the projection of the centre of gravity on the support surface is within the footprint of the base when the body is in a fully tilted position.

The weight of the components of the device for creating said air flow can act to stabilise the body on the base when the body is in a tilted position. The centre of gravity of the fan assembly is preferably located within the body. Preferably the device for creating said air flow comprises an impeller, a motor for rotating the impeller, and preferably also a diffuser located downstream from the impeller. The impeller is preferably a mixed flow impeller. The motor is preferably a DC brushless motor to avoid frictional losses and carbon debris from the brushes used in a traditional brushed motor. Reducing carbon debris and emissions is advantageous in a clean or pollutant sensitive environment such as a hospital or around those with allergies. While induction motors, which are generally used in pedestal fans, also have no brushes, a DC brushless motor can provide a much wider range of operating speeds than an induction motor.

The body preferably comprises at least one air inlet through which air is drawn into the fan assembly by the means for creating said air flow. This can provide a short, compact air flow path that minimises noise and frictional losses.

The projection of the centre of gravity on the support surface may be behind the centre of the base with respect to a forward direction of the fan assembly when the body is in an untilted position.

Each of the base and the body preferably has an outer surface shaped so that adjoining portions of the outer surfaces are substantially flush when the body is in the untilted position. This can provide the stand with a tidy and uniform appearance when in an untilted position. This type of uncluttered appearance is desirable and often appeals to a user or customer. The flush portions also have the benefit of allowing the outer surfaces of the base and the body to be quickly and easily wiped clean. The outer surfaces of the base and the body are preferably substantially cylindrical. In the preferred embodiment the stand is substantially cylindrical.

Preferably the base has a substantially circular footprint having a radius r, and a longitudinal axis passing centrally therethrough. Preferably the centre of gravity of the fan assembly is spaced by a radial distance of no more than 0.8 r, more preferably no more than 0.6 r and preferably no more than 0.4 r, from the longitudinal axis when the body is in a fully tilted position. This can provide the fan assembly with increased stability.

Preferably, the base comprising a plurality of rolling elements for supporting the body, the body comprising a plurality of curved races for receiving the rolling elements and within which the rolling elements move as the body is moved from an untilted position to a tilted position. The curved races of the body are preferably convex in shape. Preferably the base comprises a plurality of support members each comprising a respective one of the rolling elements. The support surfaces preferably protrude from a curved, preferably concave, surface of the base of the stand.

The stand preferably comprises interlocking means or members for retaining the body on the base. The interlocking means are preferably enclosed by the outer surfaces of the base and the body when the body is in the untilted position so that the stand retains its tidy and uniform appearance.

The stand preferably comprises biasing means for urging the interlocking means together to resist movement of the body from the tilted position. The base preferably comprises a plurality of support members for supporting the body, and which are preferably also enclosed by the outer surfaces of the base and the body when the body is in the untilted position. Each support member preferably comprises a rolling element for supporting the body, the body comprising a plurality of curved races for receiving the rolling elements and within which the rolling elements move as the body is moved from an untilted position to a tilted position.

The interlocking means preferably comprises a first plurality of locking members located on the base, and a second plurality of locking members located on the body and which are retained by the first plurality of locking members. Each of the locking members is preferably substantially L-shaped. The interlocking members preferably comprise interlocking flanges, which are preferably curved. The curvature of the flanges of the interlocking members of the base is preferably substantially the same as the curvature of the flanges of the interlocking members of the body. This can maximise the frictional forces generated between the interlocking flanges which act against the movement of the body from the tilted position.

The stand preferably comprises means for inhibiting the movement of the body relative to the base beyond a fully tilted position. The movement inhibiting means preferably comprises a stop member depending from the body for engaging part of the base when the body is in a fully tilted position. In the preferred embodiment the stop member is arranged to engage part of the interlocking means, preferably a flange of an interlocking member of the base, to inhibit movement of the body relative to the base beyond the fully tilted position

The base preferably comprises a controller for controlling the fan assembly. For safety reasons and ease of use, it can be advantageous to locate control elements away from the tiltable body so that the control functions, such as, for example, oscillation, lighting or activation of a speed setting, are not activated during a tilt operation.

The fan assembly is preferably in the form of a bladeless fan assembly. Through use of a bladeless fan assembly an air current can be generated without the use of a bladed fan. Without the use of a bladed fan to project the air current from the fan assembly, a relatively uniform air current can be generated and guided into a room or towards a user. The air current can travel efficiently out from the outlet, losing little energy and velocity to turbulence.

The term 'bladeless' is used to describe a fan assembly in which air flow is emitted or projected forward from the fan assembly without the use of moving blades. Consequently, a bladeless fan assembly can be considered to have an output area, or emission zone, absent moving blades from which the air flow is directed towards a user or into a room. The output area of the bladeless fan assembly may be supplied with a primary air flow generated by one of a variety of different sources, such as pumps, generators, motors or other fluid transfer devices, and which may include a rotating device such as a motor rotor and/or a bladed impeller for generating the air flow. The generated primary air flow can pass from the room space or other environment outside the fan assembly into the fan assembly, and then back out to the room space through the outlet.

Hence, the description of a fan assembly as bladeless is not intended to extend to the description of the power source and components such as motors that are required for secondary fan functions. Examples of secondary fan functions can include lighting, adjustment and oscillation of the fan assembly.

The air outlet preferably comprises a nozzle mounted on the stand, the nozzle comprising a mouth for emitting the air flow, the nozzle extending about an opening through which air from outside the nozzle is drawn by the air flow emitted from the mouth. Preferably, the nozzle surrounds the opening. The nozzle may be an annular nozzle which preferably has a height in the range from 200 to 600 mm, more preferably in the range from 250 to 500 mm.

Preferably, the mouth of the nozzle extends about the opening, and is preferably annular. The nozzle preferably comprises an inner casing section and an outer casing section which define the mouth of the nozzle. Each section is preferably formed from a respective annular member, but each section may be provided by a plurality of members connected together or otherwise assembled to form that section. The outer casing section is preferably shaped so as to partially overlap the inner casing section. This can enable an outlet of the mouth to be defined between overlapping portions of the external surface of the inner casing section and the internal surface of the outer casing section of the nozzle. The outlet is preferably in the form of a slot, preferably having a width in the range from 0.5 to 5 mm, more preferably in the range from 0.5 to 1.5 mm. The nozzle may comprise a plurality of spacers for urging apart the overlapping portions of the inner casing section and the outer casing section of the nozzle. This can assist in maintaining a substantially uniform outlet width about the opening. The spacers are preferably evenly spaced along the outlet.

The nozzle preferably comprises an interior passage for receiving the air flow from the stand. The interior passage is preferably annular, and is preferably shaped to divide the air flow into two air streams which flow in opposite directions around the opening. The interior passage is preferably also defined by the inner casing section and the outer casing section of the nozzle.

The fan assembly preferably comprises means for oscillating the nozzle so that the air current is swept over an arc, preferably in the range from 60 to 120°. For example, the base of the stand may comprise means for oscillating an upper base member, to which the body is connected, relative to a lower base member.

The maximum air flow of the air current generated by the fan assembly is preferably in the range from 300 to 800 liters per second, more preferably in the range from 500 to 800 liters per second.

The nozzle may comprise a surface, preferably a Coanda surface, located adjacent the mouth and over which the mouth is arranged to direct the air flow emitted therefrom. Preferably, the external surface of the inner casing section of the nozzle is shaped to define the Coanda surface. The Coanda surface preferably extends about the opening. A Coanda surface is a known type of surface over which fluid flow exiting an output orifice close to the surface exhibits the Coanda effect. The fluid tends to flow over the surface closely, almost 'clinging to' or 'hugging' the surface. The Coanda effect is already a proven, well documented method of entrainment in which a primary air flow is directed over a Coanda surface. A description of the features of a Coanda surface, and the effect of fluid flow over a Coanda surface, can be found in articles such as Reba, Scientific American, Volume 214, June 1966 pages 84 to 92. Through use of a Coanda surface, an increased amount of air from outside the fan assembly is drawn through the opening by the air emitted from the mouth.

Preferably, an air flow enters the nozzle of the fan assembly from the stand. In the following description this air flow will be referred to as primary air flow. The primary air flow is emitted from the mouth of the nozzle and preferably passes over a Coanda surface. The primary air flow entrains air surrounding the mouth of the nozzle, which acts as an air amplifier to supply both the primary air flow and the entrained air to the user. The entrained air will be referred to here as a secondary air flow. The secondary air flow is drawn from the room space, region or external environment surrounding the mouth of the nozzle and, by displacement, from other regions around the fan assembly, and passes predominantly through the opening defined by the nozzle. The primary air flow directed over the Coanda surface combined with the entrained secondary air flow equates to a total air flow emitted or projected forward from the opening defined by the nozzle. Preferably, the entrainment of air surrounding the mouth of the nozzle is such that the primary air flow is amplified by at least five times, more preferably by at least ten times, while a smooth overall output is maintained.

Preferably, the nozzle comprises a diffuser surface located downstream of the Coanda surface. The external surface of the inner casing section of the nozzle is preferably shaped to define the diffuser surface.

In a second aspect the present invention provides a fan assembly for creating an air current, the fan assembly comprising an air outlet mounted on a stand comprising a base and a body tiltable relative to the base from an untilted position to a tilted position, the air outlet comprising a nozzle mounted on the stand, the nozzle comprising a mouth for emitting the air flow, the nozzle extending about an opening through which air from outside the nozzle is drawn by the air flow emitted from the mouth, the fan assembly having a centre of gravity located so that when the base is located on a substantially horizontal support surface, the projection of the centre of gravity on the support surface is within the footprint of the base when the body is in a fully tilted position.

Features described above in relation to the first aspect of the invention are equally applicable to the second aspect of the invention, and vice versa.

BRIEF DESCRIPTION OF THE DRAWINGS

An embodiment of the invention will now be described with reference to the accompanying drawings, in which:

FIG. **1** is a front view of a fan assembly;

FIG. **2** is a perspective view of the nozzle of the fan assembly of FIG. **1**;

FIG. **3** is a sectional view through the fan assembly of FIG. **1**;

FIG. **4** is an enlarged view of part of FIG. **3**;

FIG. **5**(*a*) is a side view of the fan assembly of FIG. **1** showing the fan assembly in an untilted position;

FIG. **5**(*b*) is a side view of the fan assembly of FIG. **1** showing the fan assembly in a first tilted position;

FIG. **5**(*c*) is a side view of the fan assembly of FIG. **1** showing the fan assembly in a second tilted position;

FIG. **6** is a top perspective view of the upper base member of the fan assembly of FIG. **1**;

FIG. **7** is a rear perspective view of the main body of the fan assembly of FIG. **1**;

FIG. **8** is an exploded view of the main body of FIG. **7**;

FIG. **9**(*a*) illustrates the paths of two sectional views through the stand when the fan assembly is in an untilted position;

FIG. **9**(*b*) is a sectional view along line A-A of FIG. **9**(*a*);

FIG. **9**(*c*) is a sectional view along line B-B of FIG. **9**(*a*);

FIG. **10**(*a*) illustrates the paths of two further sectional views through the stand when the fan assembly is in an untilted position;

FIG. **10**(*b*) is a sectional view along line C-C of FIG. **10**(*a*); and

FIG. **10**(*c*) is a sectional view along line D-D of FIG. **10**(*a*);

DETAILED DESCRIPTION OF THE INVENTION

FIG. **1** is a front view of a fan assembly **10**. The fan assembly **10** is preferably in the form of a bladeless fan assembly comprising a stand **12** and a nozzle **14** mounted on and supported by the stand **12**. The stand **12** comprises a substantially cylindrical outer casing **16** having a plurality of air inlets **18** in the form of apertures located in the outer casing **16** and through which a primary air flow is drawn into the stand **12** from the external environment. The stand **12** further comprises a plurality of user-operable buttons **20** and a user-operable dial **22** for controlling the operation of the fan assembly **10**. The stand **12** preferably has a height in the range from 200 to 300 mm, and the outer casing **16** preferably has an external diameter in the range from 100 to 200 mm. In this example, the stand **12** has a height h of around 190 mm, and an external diameter 2 r of around 145 mm.

With reference also to FIG. **2**, the nozzle **14** has an annular shape and defines a central opening **24**. The nozzle **14** has a height in the range from 200 to 400 mm. The nozzle **14** comprises a mouth **26** located towards the rear of the fan assembly **10** for emitting air from the fan assembly **10** and through the opening **24**. The mouth **26** extends at least partially about the opening **24**. The inner periphery of the nozzle **14** comprises a Coanda surface **28** located adjacent the mouth **26** and over which the mouth **26** directs the air emitted from the fan assembly **10**, a diffuser surface **30** located downstream of the Coanda surface **28** and a guide surface **32** located downstream of the diffuser surface **30**. The diffuser surface **30** is arranged to taper away from the central axis X of the opening **24** in such a way so as to assist the flow of air emitted from the fan assembly **10**. The angle subtended between the diffuser surface **30** and the central axis X of the opening **24** is in the range from 5 to 25°, and in this example is around 15°. The guide surface **32** is arranged at an angle to the diffuser surface **30** to further assist the efficient delivery of a cooling air flow from the fan assembly **10**. The guide surface **32** is preferably arranged substantially parallel to the central axis X of the opening **24** to present a substantially flat and substantially smooth face to the air flow emitted from the mouth **26**. A visually appealing tapered surface **34** is located downstream from the guide surface **32**, terminating at a tip surface **36** lying substantially perpendicular to the central axis X of the opening **24**. The angle subtended between the tapered surface **34** and the central axis X of the opening **24** is preferably around 45°. The overall depth of the nozzle **24** in a direction extending along the central axis X of the opening **24** is in the range from 100 to 150 mm, and in this example is around 110 mm.

FIG. **3** illustrates a sectional view through the fan assembly **10**. The stand **12** comprises a base formed from a lower base member **38** and an upper base member **40** mounted on the lower base member **38**, and a main body **42** mounted on the base. The lower base member **38** has a substantially flat, substantially circular bottom surface **43** for engaging a support surface upon which the fan assembly **10** is located. Due to the cylindrical nature of the base, the footprint of the base is the same size as the bottom surface **43** of the lower base member **38**, and so the footprint of the base has a radius r. The upper base member **40** houses a controller **44** for controlling the operation of the fan assembly **10** in response to depression of the user operable buttons **20** shown in FIGS. **1** and **2**, and/or manipulation of the user operable dial **22**. The upper base member **40** may also house an oscillating mechanism **46** for oscillating the upper base member **40** and the main body **42** relative to the lower base member **38**. The range of each oscillation cycle of the main body **42** is preferably between 60° and 120°, and in this example is around 90°. In this example, the oscillating mechanism **46** is arranged to perform around 3 to 5 oscillation cycles per minute. A mains power cable **48** extends through an aperture formed in the lower base member **38** for supplying electrical power to the fan assembly **10**.

The main body **42** of the stand **12** has an open upper end to which the nozzle **14** is connected, for example by a snap-fit connection. The main body **42** comprises a cylindrical grille **50** in which an array of apertures is formed to provide the air inlets **18** of the stand **12**. The main body **42** houses an impeller **52** for drawing the primary air flow through the apertures of the grille **50** and into the stand **12**. Preferably, the impeller **52** is in the form of a mixed flow impeller. The impeller **52** is connected to a rotary shaft **54** extending outwardly from a motor **56**. In this example, the motor **56** is a DC brushless motor having a speed which is variable by the controller **44** in response to user manipulation of the dial **22**. The maximum speed of the motor **56** is preferably in the range from 5,000 to 10,000 rpm. The motor **56** is housed within a motor bucket comprising an upper portion **58** connected to a lower portion **60**. One of the upper portion **58** and the lower portion **60** of the motor bucket comprises a diffuser **62** in the form of a stationary disc having spiral blades, and which is located downstream from the impeller **52**.

The motor bucket is located within, and mounted on, an impeller housing **64**. The impeller housing **64** is, in turn, mounted on a plurality of angularly spaced supports **66**, in this example three supports, located within the main body **42** of the stand **12**. A generally frustro-conical shroud **68** is located within the impeller housing **64**. The shroud **68** is shaped so that the outer edges of the impeller **52** are in close proximity to, but do not contact, the inner surface of the shroud **68**. A substantially annular inlet member **70** is connected to the bottom of the impeller housing **64** for guiding the primary air flow into the impeller housing **64**. Preferably, the stand **12** further comprises silencing foam for reducing noise emissions from the stand **12**. In this example, the main body **42** of the stand **12** comprises a disc-shaped foam member **72** located towards the base of the main body **42**, and a substantially annular foam member **74** located within the motor bucket.

FIG. **4** illustrates a sectional view through the nozzle **14**. The nozzle **14** comprises an annular outer casing section **80** connected to and extending about an annular inner casing section **82**. Each of these sections may be formed from a plurality of connected parts, but in this embodiment each of the outer casing section **80** and the inner casing section **82** is formed from a respective, single moulded part. The inner casing section **82** defines the central opening **24** of the nozzle **14**, and has an external peripheral surface **84** which is shaped to define the Coanda surface **28**, diffuser surface **30**, guide surface **32** and tapered surface **34**.

The outer casing section **80** and the inner casing section **82** together define an annular interior passage **86** of the nozzle **14**. Thus, the interior passage **86** extends about the opening **24**. The interior passage **86** is bounded by the internal peripheral surface **88** of the outer casing section **80** and the internal peripheral surface **90** of the inner casing section **82**. The outer casing section **80** comprises a base **92** which is connected to, and over, the open upper end of the main body **42** of the stand **12**, for example by a snap-fit connection. The base **92** of the outer casing section **80** comprises an aperture through which the primary air flow enters the interior passage **86** of the nozzle **14** from the open upper end of the main body **42** of the stand **12**.

The mouth **26** of the nozzle **14** is located towards the rear of the fan assembly **10**. The mouth **26** is defined by overlapping, or facing, portions **94**, **96** of the internal peripheral surface **88** of the outer casing section **80** and the external peripheral surface **84** of the inner casing section **82**, respectively. In this example, the mouth **26** is substantially annular and, as illustrated in FIG. **4**, has a substantially U-shaped cross-section when sectioned along a line passing diametrically through the nozzle **14**. In this example, the overlapping portions **94**, **96** of the internal peripheral surface **88** of the outer casing section **80** and the external peripheral surface **84** of the inner casing section **82** are shaped so that the mouth **26** tapers towards an outlet **98** arranged to direct the primary flow over the Coanda surface **28**. The outlet **98** is in the form of an annular slot, preferably having a relatively constant width in the range from 0.5 to 5 mm. In this example the outlet **98** has a width of around 1.1 mm. Spacers may be spaced about the mouth **26** for urging apart the overlapping portions **94**, **96** of the internal peripheral surface **88** of the outer casing section **80** and the external peripheral surface **84** of the inner casing section **82** to maintain the width of the outlet **98** at the desired level. These spacers may be integral with either the internal peripheral surface **88** of the outer casing section **80** or the external peripheral surface **84** of the inner casing section **82**.

Turning now to FIGS. **5**(*a*), **5**(*b*) and **5**(*c*), the main body **42** is moveable relative to the base of the stand **12** between a first fully tilted position, as illustrated in FIG. **5**(*b*), and a second fully tilted position, as illustrated in FIG. **5**(*c*). This axis X is preferably inclined by an angle of around 10° as the main body **42** is moved from an untilted position, as illustrated in FIG. **5**(*a*) to one of the two fully tilted positions. The outer surfaces of the main body **42** and the upper base member **40** are shaped so that adjoining portions of these outer surfaces of the main body **42** and the base are substantially flush when the main body **42** is in the untilted position.

The centre of gravity of the fan assembly is identified at CG in FIGS. **5**(*a*), **5**(*b*) and **5**(*c*). The centre of gravity CG is located within the main body **42** of the stand **12**. When the lower base member **38** of the stand **12** is located on a horizontal support surface, the projection of the centre of gravity CG on the support surface is within the footprint of the base, irrespective of the position of the main body **42** between the first and second fully tilted positions, so that the fan assembly **10** is in a stable configuration irrespective of the position of the main body **42**.

With reference to FIG. **5**(*a*), when the main body **42** is in the untitled position the projection of the centre of gravity CG on the support surface lies behind the centre of the base with respect to a forward direction of the fan assembly, which is from right to left as viewed in FIGS. **5**(*a*), **5**(*b*) and **5**(*c*). In this example, the radial distance x_1 between the longitudinal axis L of the base and the centre of gravity CG is around 0.15 r, where r is the radius of the bottom surface **43** of the lower base member **38**, and the distance y_1 along the longitudinal axis L between the bottom surface **43** and the centre of gravity is around 0.7 h, where h is the height of the stand **12**. When the main body **42** is in the first fully titled position illustrated in FIG. **5**(*b*) the projection of the centre of gravity CG on the support surface lies slightly in front of the centre of the base. In this example, the radial distance x_2 between the longitudinal axis L of the base and the centre of gravity CG is around 0.05 r, while the distance y_2 along the longitudinal axis L between the bottom surface **43** and the centre of gravity remains around 0.7 h. When the main body **42** is in the second fully titled position illustrated in FIG. **5**(*c*), the projection of the centre of gravity CG on the support surface lies behind the centre of the base. In this example, the radial distance x_3 between the longitudinal axis L of the base and the centre of gravity CG is around 0.35 r, while the distance y_3 along the longitudinal axis L between the bottom surface **43** and the centre of gravity remains around 0.7 h. The difference between y_2 and y_3 is preferably no more than 5 mm, more preferably no more than 2 mm.

With reference to FIG. **6**, the upper base member **40** comprises an annular lower surface **100** which is mounted on the lower base member **38**, a substantially cylindrical side wall **102** and a curved upper surface **104**. The side wall **102** comprises a plurality of apertures **106**. The user-operable dial **22** protrudes through one of the apertures **106** whereas the user-operable buttons **20** are accessible through the other apertures **106**. The curved upper surface **104** of the upper base member **40** is concave in shape, and may be described as generally saddle-shaped. An aperture **108** is formed in the upper surface **104** of the upper base member **40** for receiving an electrical cable **110** (shown in FIG. **3**) extending from the motor **56**.

The upper base member **40** further comprises four support members **120** for supporting the main body **42** on the upper base member **40**. The support members **120** project upwardly from the upper surface **104** of the upper base member **40**, and are arranged such that they are substantially equidistant from each other, and substantially equidistant from the centre of the upper surface **104**. A first pair of the support members **120** is located along the line B-B indicated in FIG. **9**(*a*), and a second pair of the support members **120** is parallel with the first pair of support members **120**. With reference also to FIGS. **9**(*b*) and **9**(*c*), each support member **120** comprises a cylindrical outer wall **122**, an open upper end **124** and a closed lower end **126**. The outer wall **122** of the support member **120** surrounds a rolling element **128** in the form of a ball bearing. The rolling element **128** preferably has a radius which is slightly smaller than the radius of the cylindrical outer wall **122** so that the rolling element **128** is retained by and moveable within the support member **120**. The rolling element **128** is urged away from the upper surface **104** of the upper base member **40** by a resilient element **130** located between the closed lower end **126** of the support member **120** and the rolling element **128** so that part of the rolling element **128** protrudes beyond the open upper end **124** of the support member **120**. In this embodiment, the resilient member **130** is in the form of a coiled spring.

Returning to FIG. **6**, the upper base member **40** also comprises a plurality of rails for retaining the main body **42** on the upper base member **40**. The rails also serve to guide the movement of the main body **42** relative to the upper base member **40** so that there is substantially no twisting or rotation of the main body **42** relative to the upper base member **40** as it is moved from or to a tilted position. Each of the rails extends in a direction substantially parallel to the axis X. For example, one of the rails lies along line D-D indicated in FIG. **10**(*a*). In this embodiment, the plurality of rails comprises a pair of relatively long, inner rails **140** located between a pair of relatively short, outer rails **142**. With reference also to FIGS. **9**(*b*) and **10**(*b*), each of the inner rails **140** has a cross-section in the form of an inverted L-shape, and comprises a wall **144** which extends between a respective pair of the support members **120**, and which is connected to, and upstanding from, the upper surface **104** of the upper base member **40**. Each of the inner rails **140** further comprises a curved flange **146** which extends along the length of the wall **144**, and which protrudes orthogonally from the top of the wall **144** towards the adjacent outer guide rail **142**. Each of the outer rails **142** also has a cross-section in the form of an inverted L-shape, and comprises a wall **148** which is connected to, and upstanding from, the upper surface **52** of the upper base member **40** and a curved flange **150** which extends along the length of the wall **148**, and which protrudes orthogonally from the top of the wall **148** away from the adjacent inner guide rail **140**.

With reference now to FIGS. **7** and **8**, the main body **42** comprises a substantially cylindrical side wall **160**, an annular lower end **162** and a curved base **164** which is spaced from lower end **162** of the main body **42** to define a recess. The grille **50** is preferably integral with the side wall **160**. The side wall **160** of the main body **42** has substantially the same external diameter as the side wall **102** of the upper base member **40**. The base **164** is convex in shape, and may be described generally as having an inverted saddle-shape. An aperture **166** is formed in the base **164** for allowing the cable **110** to extend from the base **164** of the main body **42**. Two pairs of stop members **168** extend upwardly (as illustrated in FIG. **8**) from the periphery of base **164**. Each pair of stop members **168** is located along a line extending in a direction substantially parallel to the axis X. For example, one of the pairs of stop members **168** is located along line D-D illustrated in FIG. **10**(*a*).

A convex tilt plate **170** is connected to the base **164** of the main body **42**. The tilt plate **170** is located within the recess of the main body **42**, and has a curvature which is substantially the same as that of the base **164** of the main body **42**. Each of the stop members **168** protrudes through a respective one of a plurality of apertures **172** located about the periphery of the tilt plate **170**. The tilt plate **170** is shaped to define a pair of convex races **174** for engaging the rolling elements **128** of the upper base member **40**. Each race **174** extends in a direction substantially parallel to the axis X, and is arranged to receive the rolling elements **128** of a respective pair of the support members **120**, as illustrated in FIG. **9**(*c*).

The tilt plate **170** also comprises a plurality of runners, each of which is arranged to be located at least partially beneath a respective rail of the upper base member **40** and thus co-operate with that rail to retain the main body **42** on the upper base member **40** and to guide the movement of the main body **42** relative to the upper base member **40**. Thus, each of the runners extends in a direction substantially parallel to the axis X. For example, one of the runners lies along line D-D indicated in FIG. **10**(*a*). In this embodiment, the plurality of runners comprises a pair of relatively long, inner runners **180** located between a pair of relatively short, outer runners **182**. With reference also to FIGS. **9**(*b*) and **10**(*b*), each of the inner runners **180** has a cross-section in the form of an inverted L-shape, and comprises a substantially vertical wall **184** and a curved flange **186** which protrudes orthogonally and inwardly from part of the top of the wall **184**. The curvature of the curved flange **186** of each inner runner **180** is substantially the same as the curvature of the curved flange **146** of each inner rail **140**. Each of the outer runners **182** also has a cross-section in the form of an inverted L-shape, and comprises a substantially vertical wall **188** and a curved flange **190** which extends along the length of the wall **188**, and which protrudes orthogonally and inwardly from the top of the wall **188**. Again, the curvature of the curved flange **190** of each outer runner **182** is substantially the same as the curvature of the curved flange **150** of each outer rail **142**. The tilt plate **170** further comprises an aperture **192** for receiving the cable **110**.

To connect the main body **42** to the upper base member **40**, the tilt plate **170** is inverted from the orientation illustrated in FIGS. **7** and **8**, and the races **174** of the tilt plate located directly behind and in line with the support members **120** of the upper base member **40**. The cable **110** extending through the aperture **166** of the main body **42** may be threaded through the apertures **108**, **192** in the tilt plate **170** and the upper base member **40** respectively for subsequent connection to the controller **44**, as illustrated in FIG. **3**. The tilt plate **170** is then slid over the upper base member **40** so that the rolling elements **128** engage the races **174**, as illustrated in FIGS. **9**(*b*) and **9**(*c*), the curved flange **190** of each outer runner **182** is located beneath the curved flange **150** of a respective outer rail **142**, as illustrated in FIGS. **9**(*b*) and **10**(*b*), and the curved flange **186** of each inner runner **180** is located beneath the curved flange **146** of a respective inner rail **140**, as illustrated in FIGS. **9**(*b*), **10**(*b*) and **10**(*c*).

With the tilt plate **170** positioned centrally on the upper base member **40**, the main body **42** is lowered on to the tilt plate **170** so that the stop members **168** are located within the apertures **172** of the tilt plate **170**, and the tilt plate **170** is housed within the recess of the main body **42**. The upper base member **40** and the main body **42** are then inverted, and the base member **40** displaced along the direction of the axis X to reveal a first plurality of apertures **194*a*** located on the tilt plate **170**. Each of these apertures **194*a*** is aligned with a tubular protrusion **196*a*** on the base **164** of the main body **42**. A self-tapping screw is screwed into each of the apertures **194*a*** to enter the underlying protrusion **196*a***, thereby partially connecting the tilt plate **170** to the main body **42**. The upper base member **40** is then displaced in the reverse direction to reveal a second plurality of apertures **194*b*** located on the tilt plate **170**. Each of these apertures **194*b*** is also aligned with a tubular protrusion **196*b*** on the base **164** of the main body **42**. A self-tapping screw is screwed into each of the apertures **194*b*** to enter the underlying protrusion **196*b*** to complete the connection of the tilt plate **170** to the main body **42**.

When the main body **42** is attached to the base and the bottom surface **43** of the lower base member **38** positioned on a support surface, the main body **42** is supported by the rolling elements **128** of the support members **120**. The resilient elements **130** of the support members **120** urge the rolling elements **128** away from the closed lower ends **126** of the support members **120** by a distance which is sufficient to inhibit scraping of the upper surfaces of the upper base member **40** when the main body **42** is tilted. For example, as illustrated in each of FIGS. **9**(*b*), **9**(*c*), **10**(*b*) and **10**(*c*) the lower end **162** of the main body **42** is urged away from the upper surface **104** of the upper base member **40** to prevent contact therebetween when the main body **42** is tilted. Furthermore, the action of the resilient elements **130** urges the concave upper surfaces of the curved flanges **186**, **190** of the runners against the convex lower surfaces of the curved flanges **146**, **150** of the rails.

To tilt the main body **42** relative to the base, the user slides the main body **42** in a direction parallel to the axis X to move the main body **42** towards one of the fully tilted positions illustrated in FIGS. **5**(*b*) and **5**(*c*), causing the rolling elements **128** to move along the races **174**. Once the main body **42** is in the desired position, the user releases the main body **42**, which is retained in the desired position by frictional forces generated through the contact between the concave upper surfaces of the curved flanges **186**, **190** of the runners and the convex lower surfaces of the curved flanges **146**, **150** of the rails acting to resist the movement under gravity of the main body **42** towards the untilted position illustrated in FIG. **5**(*a*). The fully titled positions of the main body **42** are defined by the abutment of one of each pair of stop members **168** with a respective inner rail **140**.

To operate the fan assembly **10** the user depresses an appropriate one of the buttons **20** on the stand **12**, in response to which the controller **44** activates the motor **56** to rotate the impeller **52**. The rotation of the impeller **52** causes a primary air flow to be drawn into the stand **12** through the air inlets **18**. Depending on the speed of the motor **56**, the primary air flow may be between 20 and 30 liters per second. The primary air flow passes sequentially through the impeller housing **64** and the open upper end of the main body **42** to enter the interior passage **86** of the nozzle **14**. Within the nozzle **14**, the primary air flow is divided into two air streams which pass in opposite directions around the central opening **24** of the nozzle **14**. As the air streams pass through the interior passage **86**, air enters the mouth **26** of the nozzle **14**. The air flow into the mouth **26** is preferably substantially even about the opening **24** of the nozzle **14**. Within each section of the mouth **26**, the flow direction of the portion of the air stream is substantially reversed. The portion of the air stream is constricted by the tapering section of the mouth **26** and emitted through the outlet **98**.

The primary air flow emitted from the mouth **26** is directed over the Coanda surface **28** of the nozzle **14**, causing a secondary air flow to be generated by the entrainment of air from the external environment, specifically from the region around the outlet **98** of the mouth **26** and from around the rear of the nozzle **14**. This secondary air flow passes through the central opening **24** of the nozzle **14**, where it combines with the primary air flow to produce a total air flow, or air current, projected forward from the nozzle **14**. Depending on the speed of the motor **56**, the mass flow rate of the air current projected forward from the fan assembly **10** may be up to 400 liters per second, preferably up to 600 liters per second, and the maximum speed of the air current may be in the range from 2.5 to 4 m/s.

The even distribution of the primary air flow along the mouth **26** of the nozzle **14** ensures that the air flow passes evenly over the diffuser surface **30**. The diffuser surface **30** causes the mean speed of the air flow to be reduced by moving the air flow through a region of controlled expansion. The relatively shallow angle of the diffuser surface **30** to the central axis X of the opening **24** allows the expansion of the air flow to occur gradually. A harsh or rapid divergence would otherwise cause the air flow to become disrupted, generating vortices in the expansion region. Such vortices can lead to an increase in turbulence and associated noise in the air flow which can be undesirable, particularly in a domestic product such as a fan. The air flow projected forwards beyond the diffuser surface **30** can tend to continue to diverge. The presence of the guide surface **32** extending substantially parallel to the central axis X of the opening **30** further converges the air flow. As a result, the air flow can travel efficiently out from the nozzle **14**, enabling the air flow can be experienced rapidly at a distance of several metres from the fan assembly **10**.

The invention is not limited to the detailed description given above. Variations will be apparent to the person skilled in the art. For example, the stand **12** may be used in a variety of appliances other than a fan assembly. The movement of the main body **42** relative to the base may be motorised, and actuated by the user through depression of one of the buttons **20**.

The invention claimed is:

1. A fan assembly for creating an air current, the fan assembly comprising an air outlet mounted on a stand comprising a base and a body tiltable relative to the base from an untilted position to a tilted position, the fan assembly having a center of gravity located so that when the base is located on a substantially horizontal support surface, a projection of the center of gravity on the support surface is within the footprint of the base when the body is in a fully tilted position, wherein the body comprises a device for creating an air flow through the fan assembly and the air outlet comprises a nozzle mounted on the body of the stand, the nozzle comprising a mouth for emitting the air flow, the nozzle extending about an opening through which air from outside the nozzle is drawn by the air flow emitted from the mouth, and wherein the nozzle comprises a Coanda surface located adjacent the mouth and over which the mouth is arranged to direct the air flow emitted therefrom.

2. The fan assembly of claim **1**, wherein the center of gravity of the fan assembly is located within the body.

3. The fan assembly of claim **1**, wherein the device for creating the air flow comprises an impeller and a motor for driving the impeller.

4. The fan assembly of claim **1**, wherein the projection of the center of gravity on the support surface is behind the center of the base with respect to a forward direction of the fan assembly when the body is in an untilted position.

5. The fan assembly of claim **1**, comprising interlocking members for retaining the body on the base.

6. The fan assembly of claim **5**, comprising a biasing member for urging the interlocking members together to resist movement of the body from the tilted position.

7. The fan assembly of claim **1**, wherein the stand comprises at least one stop member for inhibiting the movement of the body relative to the base beyond a fully tilted position.

8. The fan assembly of claim **7**, wherein the stop member extends from the body for engaging part of the base when the body is in a fully tilted position.

9. The fan assembly of claim **1**, wherein the base of the stand comprises a controller for controlling the fan assembly.

10. The fan assembly of claim **1**, wherein the device for creating the air flow further comprises a diffuser located downstream from the impeller.

11. The fan assembly of claim **1**, wherein the body comprises at least one air inlet through which the air is drawn into the fan assembly by the device for creating the air flow.

12. A fan assembly for creating an air current, the fan assembly comprising an air outlet mounted on a stand comprising a base and a body tiltable relative to the base from an untilted position to a tilted position, the fan assembly having a center of gravity located so that when the base is located on a substantially horizontal support surface, a projection of the center of gravity on the support surface is within the footprint of the base when the body is in a fully tilted position, wherein the body comprises a device for creating an air flow through the fan assembly and the air outlet comprises a nozzle mounted on the body of the stand, the nozzle comprising a mouth for emitting the air flow, the nozzle extending about an opening through which air from outside the nozzle is drawn by the air flow emitted from the mouth, and wherein the base comprises a plurality of rolling elements for supporting the body, and the body comprises a plurality of curved races for receiving the rolling elements and within which the rolling elements move as the body is moved from an untilted position to a tilted position.

13. The fan assembly of claim **12**, wherein the curved races of the body are convex in shape.

14. The fan assembly of claim **12**, wherein the base further comprises a plurality of support members each comprising a respective one of the rolling elements.

15. The fan assembly as claimed in claim **14**, wherein the support members protrude from a curved surface of the base.

16. The fan assembly of claim **15**, wherein the curved surface of the base is concave in shape.

* * * * *

EXHIBIT D

US008092166B2

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Nicolas et al.

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(54) **FAN**

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F04D 29/44 (2006.01)
F04D 29/54 (2006.01)

(52) **U.S. Cl.** **415/209.2**; 415/209.4; 415/211.2; 415/220; 415/223; 415/225; 415/226; 415/914; 239/419.5; 239/590; 239/590.5; 239/597; 239/598; 239/DIG. 7

(58) **Field of Classification Search** .... 415/185, 415/191, 208.1, 208.2, 210.1, 211.2, 220, 415/222, 223, 225, 226, 209.2, 209.3, 914, 415/189, 190, 209.4; 239/419.5, 590, 590.5, 239/597, 598, DIG. 7
See application file for complete search history.

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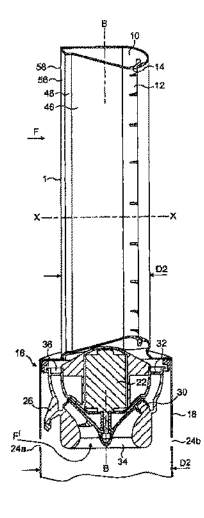
(57) **ABSTRACT**

A fan assembly for creating an air current is described. The fan assembly includes a nozzle mounted on a base housing a device for creating an air flow through the nozzle. The nozzle includes an interior passage for receiving the air flow from the base, a mouth through which the air flow is emitted, the mouth being defined by facing surfaces of the nozzle, and spacers for spacing apart the facing surfaces of the nozzle. The nozzle extends substantially orthogonally about an axis to define an opening through which air from outside the fan assembly is drawn by the air flow emitted from the mouth. The fan provides an arrangement producing an air current and a flow of cooling air created without requiring a bladed fan. The spacers can provide for a reliable, reproducible nozzle of the fan assembly and performance of the fan assembly.

26 Claims, 6 Drawing Sheets



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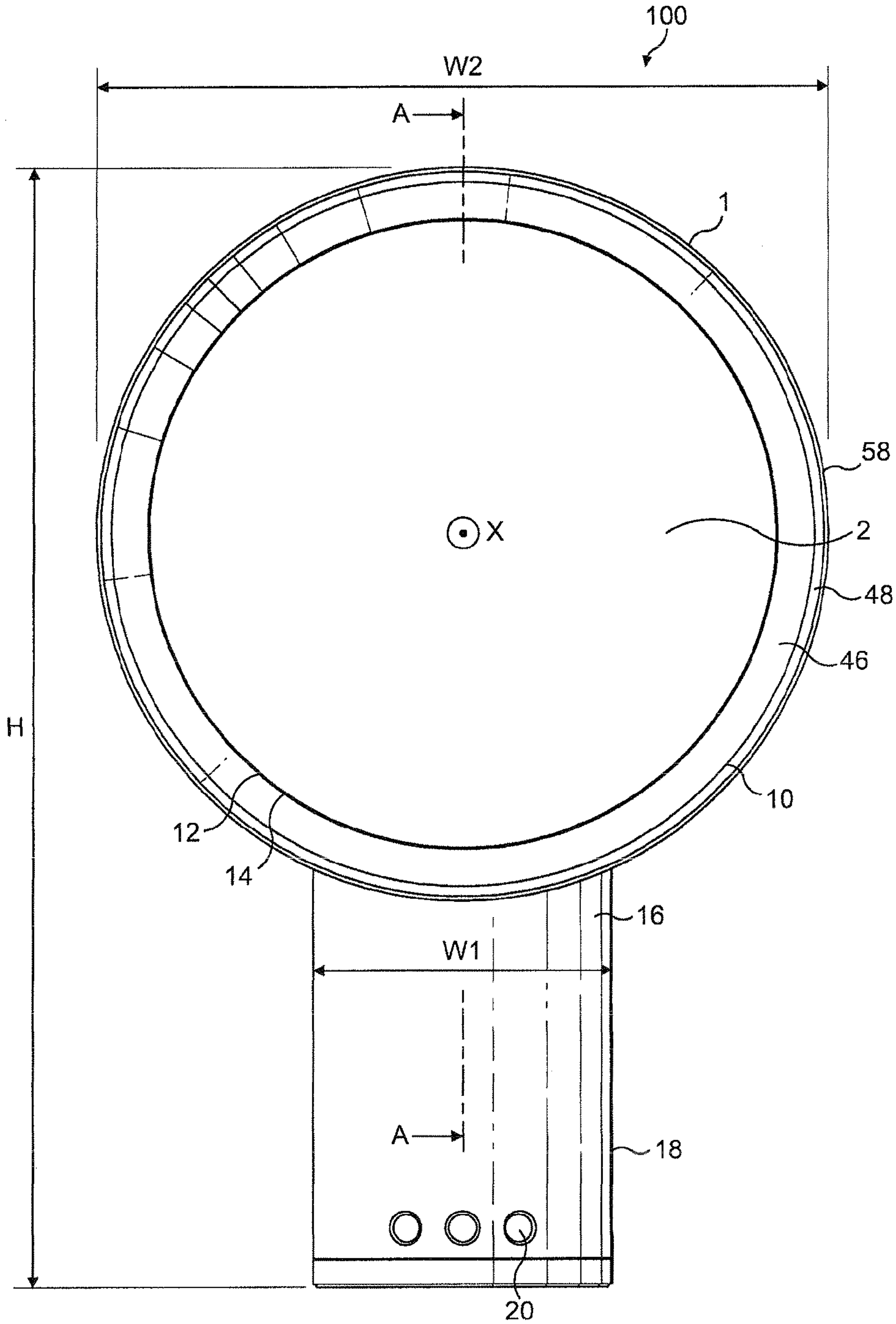


FIG. 1

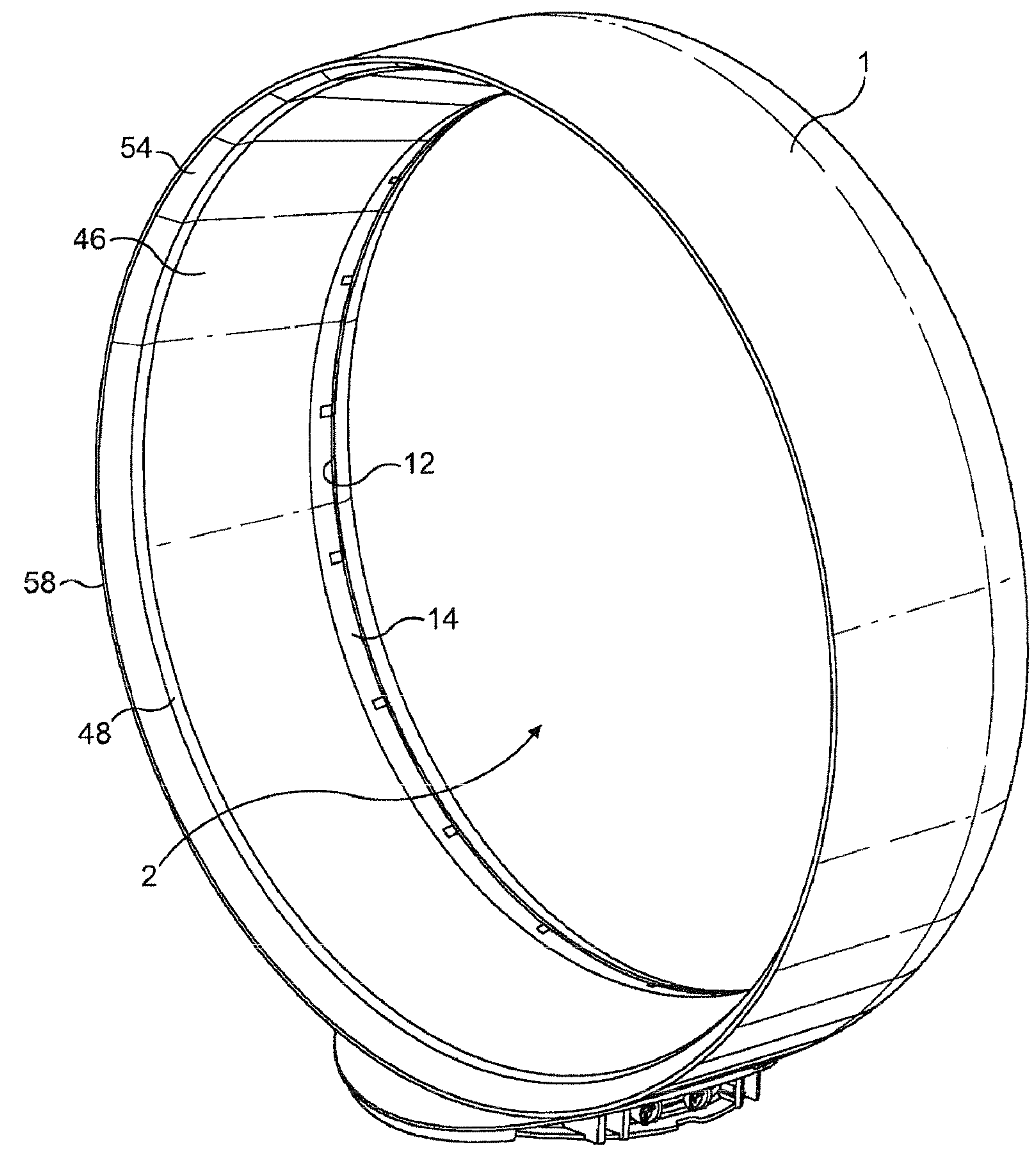


FIG. 2

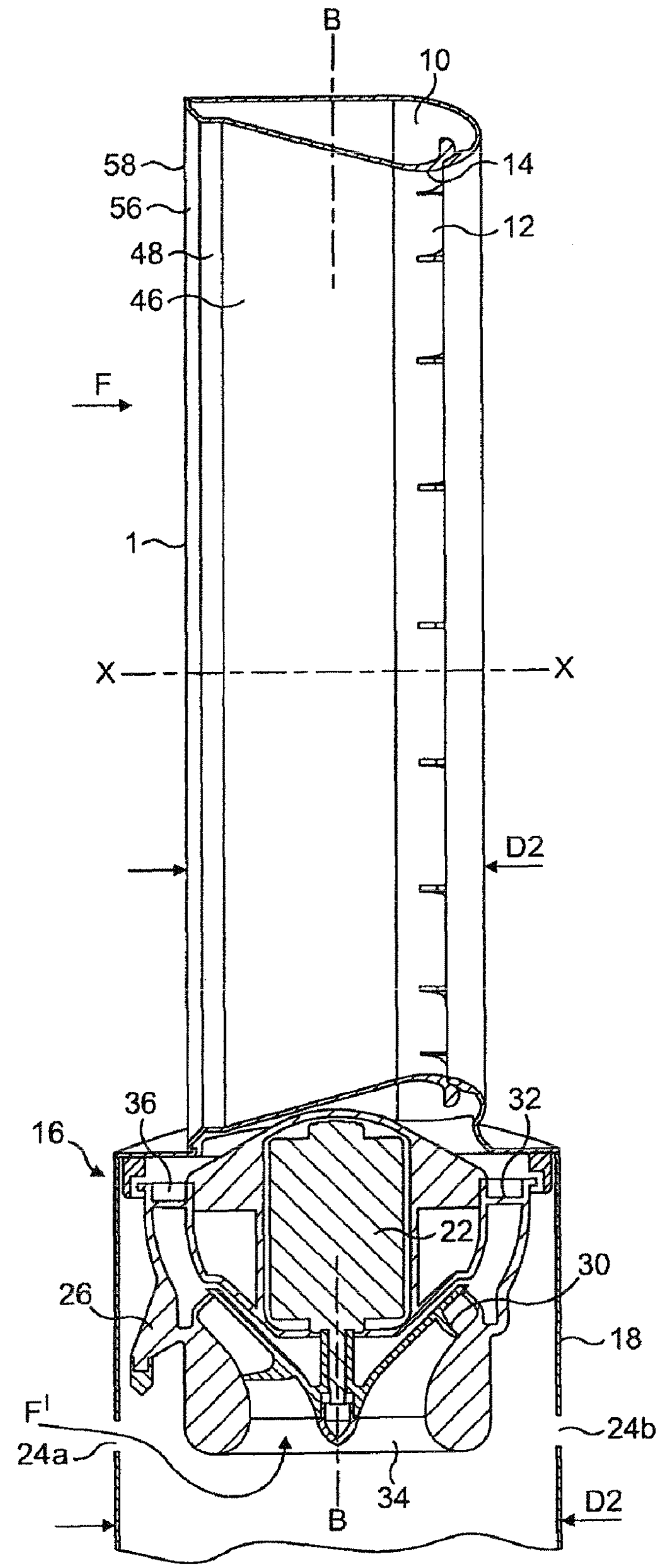


FIG. 3

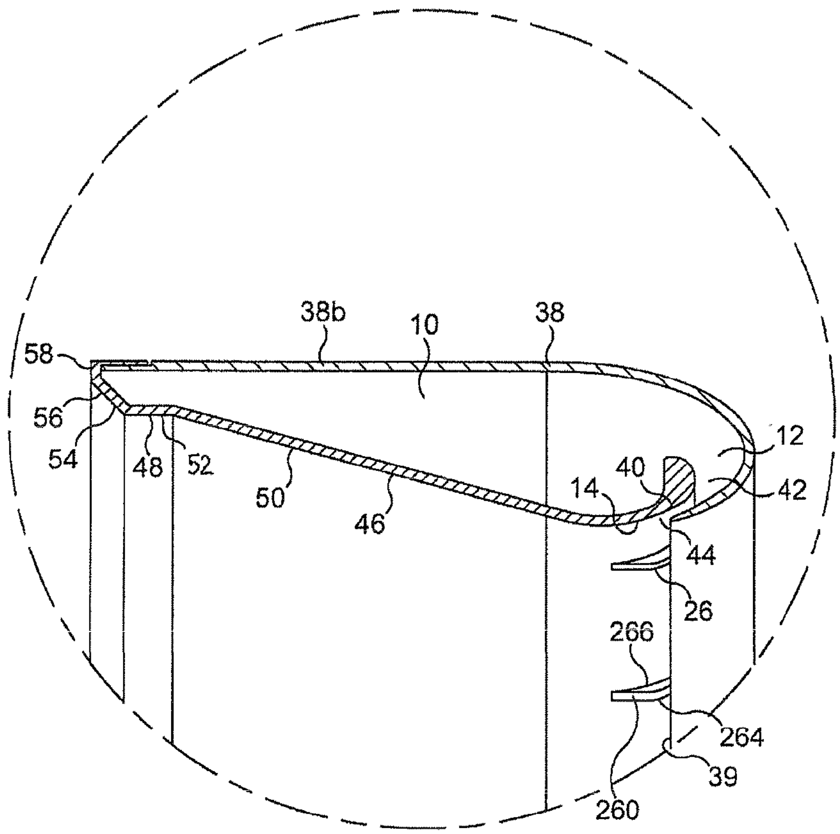


FIG. 4

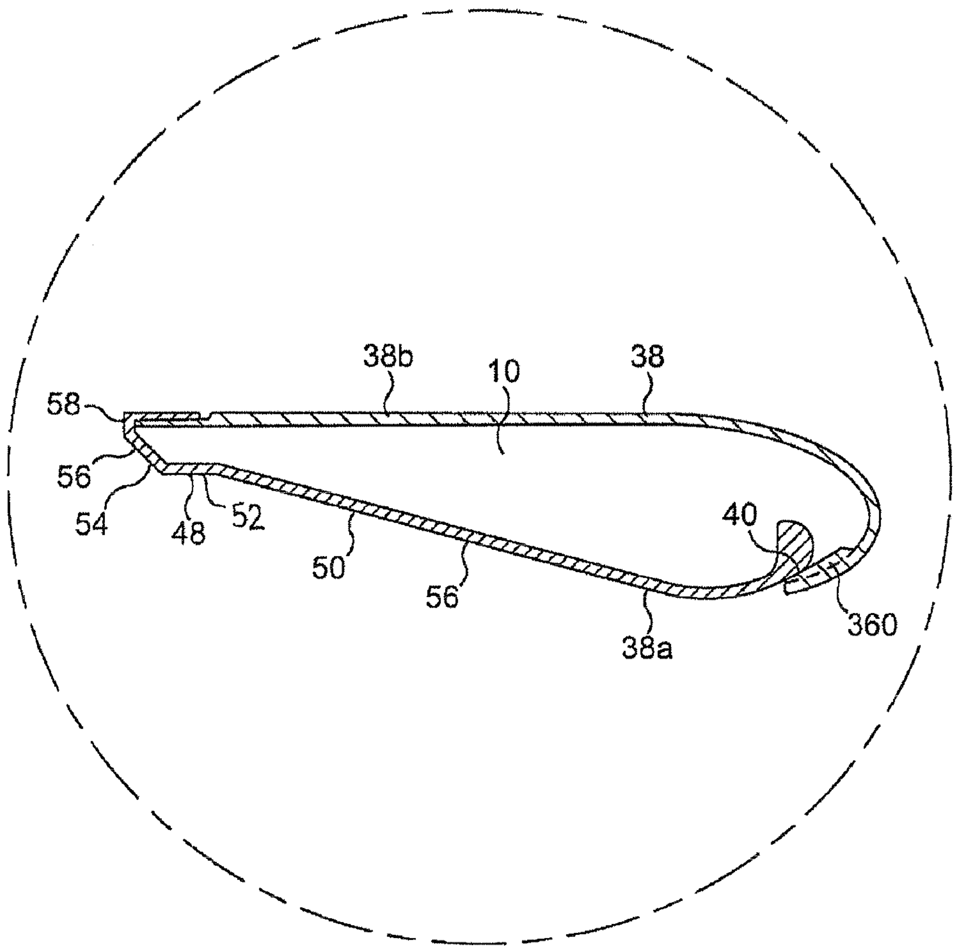


FIG. 5

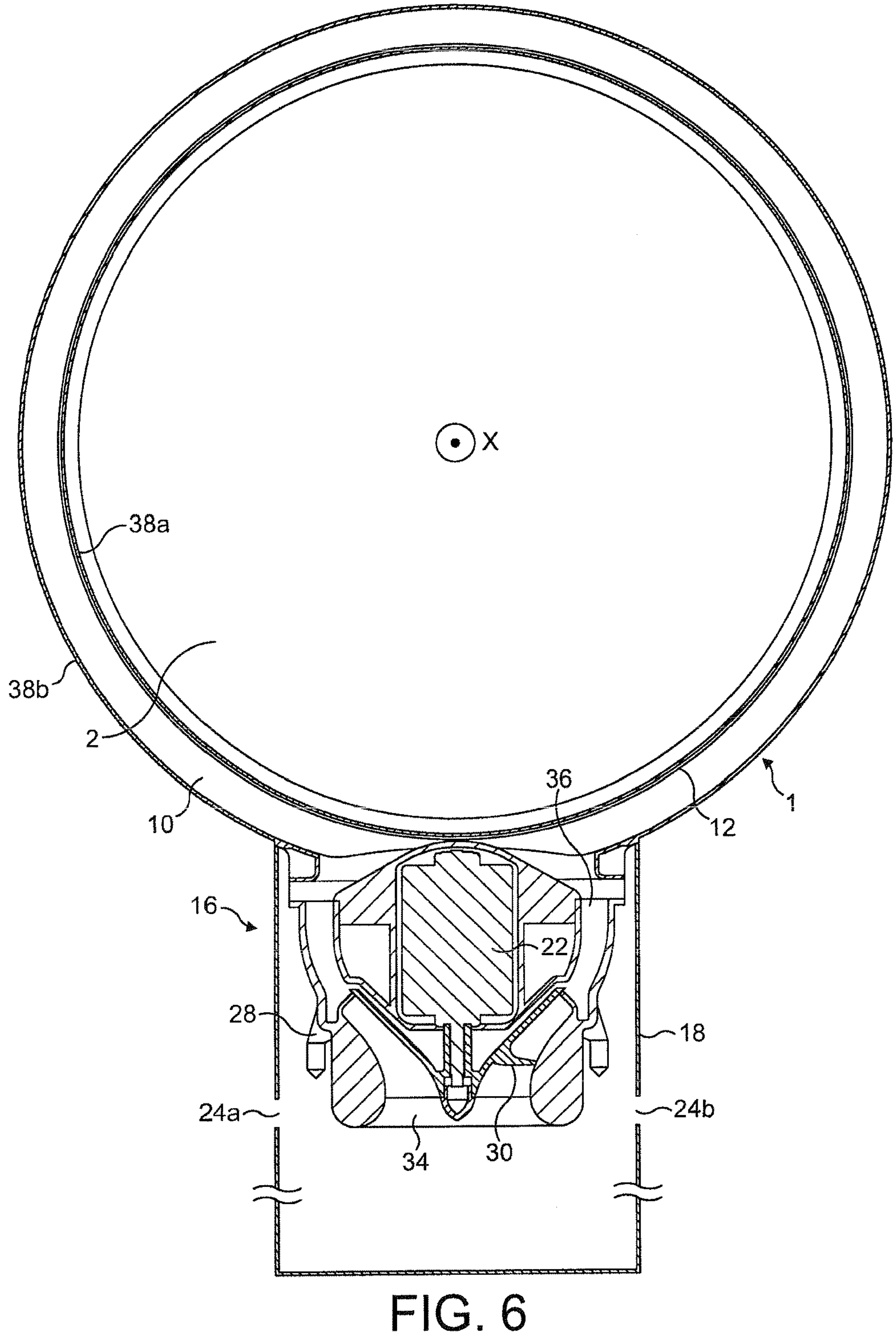


FIG. 6

FAN

REFERENCE TO RELATED APPLICATIONS

This application claims the priority of United Kingdom Application No. 0822612.8, filed Dec. 11, 2008, the entire contents of which are incorporated herein by reference.

FIELD OF THE INVENTION

The present invention relates to a fan appliance. Particularly, but not exclusively, the present invention relates to a domestic fan, such as a desk fan, for creating air circulation and air current in a room, in an office or other domestic environment.

BACKGROUND OF THE INVENTION

A number of types of domestic fan are known. It is common for a conventional fan to include a single set of blades or vanes mounted for rotation about an axis, and driving apparatus mounted about the axis for rotating the set of blades. Domestic fans are available in a variety of sizes and diameters, for example, a ceiling fan can be at least 1 m in diameter and is usually mounted in a suspended manner from the ceiling and positioned to provide a downward flow of air and cooling throughout a room.

Desk fans, on the other hand, are often around 30 cm in diameter and are usually free standing and portable. In standard desk fan arrangements the single set of blades is positioned close to the user and the rotation of the fan blades provides a forward flow of air current in a room or into a part of a room, and towards the user. Other types of fan can be attached to the floor or mounted on a wall. The movement and circulation of the air creates a so called 'wind chill' or breeze and, as a result, the user experiences a cooling effect as heat is dissipated through convection and evaporation. Fans such as that disclosed in U.S. D Pat. No. 103,476 and U.S. Pat. No. 1,767,060 are suitable for standing on a desk or a table. U.S. Pat. No. 1,767,060 describes a desk fan with an oscillating function that aims to provide an air circulation equivalent to two or more prior art fans.

A disadvantage of this type of arrangement is that the forward flow of air current produced by the rotating blades of the fan is not felt uniformly by the user. This is due to variations across the blade surface or across the outward facing surface of the fan. Uneven or 'choppy' air flow can be felt as a series of pulses or blasts of air and can be noisy. Variations across the blade surface, or across other fan surfaces, can vary from product to product and may even vary from one individual fan machine to another.

In a domestic environment it is desirable for appliances to be as small and compact as possible due to space restrictions. It is undesirable for parts to project from the appliance, or for the user to be able to touch any moving parts of the fan, such as the blades. Some arrangements have safety features such as a cage or shroud around the blades to protect a user from injuring himself on the moving parts of the fan. U.S. D Pat. No. 103,476 shows a type of cage around the blades however, caged blade parts can be difficult to clean.

Other types of fan or circulator are described in U.S. Pat. No. 2,488,467, U.S. Pat. No. 2,433,795 and JP 56-167897. The fan of U.S. Pat. No. 2,433,795 has spiral slots in a rotating shroud instead of fan blades. The circulator fan disclosed in U.S. Pat. No. 2,488,467 emits air flow from a series of nozzles and has a large base including a motor and a blower or fan for creating the air flow.

Locating fans such as those described above close to a user is not always possible as the bulky shape and structure mean that the fan occupies a significant amount of the user's work space area. In the particular case of a fan placed on, or close to, a desk the fan body or base reduces the area available for paperwork, a computer or other office equipment. Often multiple appliances must be located in the same area, close to a power supply point, and in close proximity to other appliances for ease of connection and in order to reduce the operating costs.

The shape and structure of a fan at a desk not only reduces the working area available to a user but can block natural light (or light from artificial sources) from reaching the desk area. A well lit desk area is desirable for close work and for reading. In addition, a well lit area can reduce eye strain and the related health problems that may result from prolonged periods working in reduced light levels.

SUMMARY OF THE INVENTION

A first aspect of the present invention provides a bladeless fan assembly for creating an air current, the fan assembly comprising a nozzle, a device for creating an air flow through the nozzle, the nozzle comprising an interior passage for receiving the air flow, a mouth through which the air flow is emitted, the mouth being defined by facing surfaces of the nozzle, and spacers for spacing apart the facing surfaces of the nozzle, the nozzle defining an opening through which air from outside the fan assembly is drawn by the air flow emitted from the mouth.

Advantageously, by this arrangement an air current is generated and a cooling effect is created without requiring a bladed fan. The air current created by the fan assembly has the benefit of being an air flow with low turbulence and with a more linear air flow profile than that provided by other prior art devices. This can improve the comfort of a user receiving the air flow.

Advantageously, the use of spacers spacing apart the facing surfaces of the nozzle enables a smooth, even output of air flow to be delivered to a user's location without the user feeling a 'choppy' flow. The spacers of the fan assembly provide for reliable, reproducible manufacture of the nozzle of the fan assembly. This means that a user should not experience a variation in the intensity of the air flow over time due to product aging or a variation from one fan assembly to another fan assembly due to variations in manufacture. The invention provides a fan assembly delivering a suitable cooling effect that is directed and focussed as compared to the air flow produced by prior art fans.

In the following description of fans and, in particular a fan of the preferred embodiment, the term 'bladeless' is used to describe apparatus in which air flow is emitted or projected forwards from the fan assembly without the use of blades. By this definition a bladeless fan assembly can be considered to have an output area or emission zone absent blades or vanes from which the air flow is released or emitted in a direction appropriate for the user. A bladeless fan assembly may be supplied with a primary source of air from a variety of sources or devices such as pumps, generators, motors or other fluid transfer devices, which include rotating devices such as a motor rotor and a bladed impeller for generating air flow. The supply of air generated by the motor causes a flow of air to pass from the room space or environment outside the fan assembly through the interior passage to the nozzle and then out through the mouth.

Hence, the description of a fan assembly as bladeless is not intended to extend to the description of the power source and components such as motors that are required for secondary fan functions. Examples of secondary fan functions can include lighting, adjustment and oscillation of the fan.

In a preferred embodiment, the nozzle extends about an axis to define the opening, and the spacers comprise a plurality of spacers angularly spaced about said axis, preferably equally angularly spaced about the axis.

In a preferred embodiment the nozzle extends substantially cylindrically about the axis. This creates a region for guiding and directing the airflow output from all around the opening defined by the nozzle of the fan assembly. In addition the cylindrical arrangement creates an assembly with a nozzle that appears tidy and uniform. An uncluttered design is desirable and appeals to a user or customer. The preferred features and dimensions of the fan assembly result in a compact arrangement while generating a suitable amount of air flow from the fan assembly for cooling a user.

Preferably the nozzle extends by a distance of at least 5 cm in the direction of the axis. Preferably the nozzle extends about the axis by a distance in the range from 30 cm to 180 cm. This provides options for emission of air over a range of different output areas and opening sizes, such as may be suitable for cooling the upper body and face of a user when working at a desk, for example.

The nozzle preferably comprises an inner casing section and an outer casing section which define the interior passage, the mouth and the opening. Each casing section may comprise a plurality of components, but in the preferred embodiment each of these sections is formed from a single annular component.

In the preferred embodiment the spacers are mounted on, preferably integral with, one of the facing surfaces of the nozzle. Advantageously, the integral arrangement of the spacers with this surface can reduce the number of individual parts manufactured, thereby simplifying the process of part manufacture and part assembly, and thereby reducing the cost and complexity of the fan assembly. The spacers are preferably arranged to contact the other one of the facing surfaces.

The spacers are preferably arranged to maintain a set distance between the facing surfaces of the nozzle. This distance is preferably in the range from 0.5 to 5 mm. Preferably, one of the facing surfaces of the nozzle is biased towards the other of the facing surfaces, and so the spacers serve to hold apart the facing surfaces of the nozzle to maintain the set distance therebetween. This can ensure that the spacers engage said other one of the facing surfaces and thus can ensure that the desired spacing between the facing surfaces is achieved. The spacers can be located and orientated in any suitable position that enables the facing surfaces of the nozzle to be spaced apart as desired, without requiring further support or positioning members to set the desired spacing of the facing surfaces. Preferably the spacers comprise a plurality of spacers which are spaced about the opening. With this arrangement each one of the plurality of spacers can engage said other one of the facing surfaces such that a point of contact is provided between each spacer and the said other facing surface. The preferred number of spacers is in the range from 5 to 50.

In the fan assembly of the present invention as previously described, the nozzle may comprise a Coanda surface located adjacent the mouth and over which the mouth is arranged to direct the air flow. A Coanda surface is a known type of surface over which fluid flow exiting an output orifice close to the surface exhibits the Coanda effect. The fluid tends to flow over the surface closely, almost 'clinging to' or 'hugging' the surface. The Coanda effect is already a proven, well documented method of entrainment whereby a primary air flow is directed over the Coanda surface. A description of the features of a Coanda surface, and the effect of fluid flow over a Coanda surface, can be found in articles such as Reba, Scientific American, Volume 214, June 1963 pages 84 to 92. Through use of a Coanda surface, air from outside the fan assembly is drawn through the opening by the air flow directed over the Coanda surface.

In the preferred embodiments an air flow is created through the nozzle of the fan assembly. In the following description this air flow will be referred to as primary air flow. The primary air flow exits the nozzle via the mouth and preferably passes over the Coanda surface. The primary air flow entrains the air surrounding the mouth of the nozzle, which acts as an air amplifier to supply both the primary air flow and the entrained air to the user. The entrained air will be referred to here as a secondary air flow. The secondary air flow is drawn from the room space, region or external environment surrounding the mouth of the nozzle and, by displacement, from other regions around the fan assembly. The primary air flow directed over the Coanda surface combined with the secondary air flow entrained by the air amplifier gives a total air flow emitted or projected forward to a user from the opening defined by the nozzle. The total air flow is sufficient for the fan assembly to create an air current suitable for cooling.

Preferably the nozzle comprises a loop. The shape of the nozzle is not constrained by the requirement to include space for a bladed fan. In a preferred embodiment the nozzle is annular or substantially annular. By providing an annular nozzle the fan can potentially reach a broad area. In a further preferred embodiment the nozzle is at least partially circular. This arrangement can provide a variety of design options for the fan, increasing the choice available to a user or customer. Furthermore, the nozzle can be manufactured as a single piece, reducing the complexity of the fan assembly and thereby reducing manufacturing costs.

In a preferred arrangement the nozzle comprises at least one wall defining the interior passage and the mouth, and the at least one wall comprises the facing surfaces defining the mouth. Preferably, the mouth has an outlet, and the spacing between the facing surfaces at the outlet of the mouth is in the range from 0.5 mm to 10 mm. By this arrangement a nozzle can be provided with the desired flow properties to guide the primary air flow over the surface and provide a relatively uniform, or close to uniform, total air flow reaching the user.

In the preferred fan assembly the device for creating an air flow through the nozzle comprises an impeller driven by a motor. This arrangement provides a fan with efficient air flow generation. More preferably the device for creating an air flow comprises a DC brushless motor and a mixed flow impeller. This can enable frictional losses from motor brushes to be reduced, and can avoid carbon debris from the brushes used in a traditional motor. Reducing carbon debris and emissions is advantageous in a clean or pollutant sensitive environment such as a hospital or around those with allergies. While induction motors, which are generally used in bladed fans, also have no brushes, a DC brushless motor can provide a much wider range of operating speeds than an induction motor.

The device for creating an air flow through the nozzle is preferably located in a base of the fan assembly. The nozzle is preferably mounted on the base.

In a second aspect the present invention provides a nozzle for a fan assembly, preferably a bladeless fan assembly, for creating an air current, the nozzle comprising an interior passage for receiving an air flow, a mouth through which the air flow is emitted, the mouth being defined by facing surfaces of the nozzle, and spacers for spacing apart the facing surfaces of the nozzle, the nozzle defining an opening through which air from outside the fan assembly is drawn by the air flow emitted from the mouth.

Preferably, the nozzle comprises a Coanda surface located adjacent the mouth and over which the mouth is arranged to direct the air flow. In a preferred embodiment the nozzle comprises a diffuser located downstream of the Coanda surface. The diffuser directs the air flow emitted towards a user's location whilst maintaining a smooth, even output, generating a suitable cooling effect without the user feeling a 'choppy' flow.

The invention also provides a fan assembly comprising a nozzle as aforementioned.

The nozzle may be rotatable or pivotable relative to a base portion, or other portion, of the fan assembly. This enables the nozzle to be directed towards or away from a user as required. The fan assembly may be desk, floor, wall or ceiling mountable. This can increase the portion of a room over which the user experiences cooling.

Features described above in connection with the first aspect of the invention are equally applicable to the second aspect of the invention, and vice versa.

BRIEF DESCRIPTION OF THE DRAWINGS

Embodiments of the invention will now be described with reference to the accompanying drawings, in which:

FIG. **1** is a front view of a fan assembly;

FIG. **2** is a perspective view of a portion of the fan assembly of FIG. **1**;

FIG. **3** is a side sectional view through a portion of the fan assembly of FIG. **1** taken at line A-A;

FIG. **4** is an enlarged side sectional detail of a portion of the fan assembly of FIG. **1**;

FIG. **5** is an alternative arrangement shown as an enlarged side sectional detail of a portion of the fan assembly of FIG. **1**; and

FIG. **6** is a sectional view of the fan assembly taken along line B-B of FIG. **3** and viewed from direction F of FIG. **3**.

DETAILED DESCRIPTION OF THE INVENTION

FIG. **1** illustrates an example of a fan assembly **100** viewed from the front of the device. The fan assembly **100** comprises an annular nozzle **1** defining a central opening **2**. With reference also to FIGS. **2** and **3**, nozzle **1** comprises an interior passage **10**, a mouth **12** and a Coanda surface **14** adjacent the mouth **12**. The Coanda surface **14** is arranged so that a primary air flow exiting the mouth **12** and directed over the Coanda surface **14** is amplified by the Coanda effect. The nozzle **1** is connected to, and supported by, a base **16** having an outer casing **18**. The base **16** includes a plurality of selection buttons **20** accessible through the outer casing **18** and through which the fan assembly **100** can be operated. The fan assembly has a height, H, width, W, and depth, D, shown on FIGS. **1** and **3**. The nozzle **1** is arranged to extend substantially orthogonally about the axis X. The height of the fan assembly, H, is perpendicular to the axis X and extends from the end of the base **16** remote from the nozzle **1** to the end of the nozzle **1** remote from the base **16**. In this embodiment the fan assembly **100** has a height, H, of around 530 mm, but the fan assembly **100** may have any desired height. The base **16** and the nozzle **1** have a width, W, perpendicular to the height H and perpendicular to the axis X. The width of the base **16** is shown labelled W1 and the width of the nozzle **1** is shown labelled as W2 on FIG. **1**. The base **16** and the nozzle **1** have a depth in the direction of the axis X. The depth of the base **16** is shown labelled D1 and the depth of the nozzle **1** is shown labelled as D2 on FIG. **3**.

FIGS. **3**, **4**, **5** and **6** illustrate further specific details of the fan assembly **100**. A motor **22** for creating an air flow through the nozzle **1** is located inside the base **16**. The base **16** further comprises an air inlet **24***a*, **24***b* formed in the outer casing **18** and through which air is drawn into the base **16**. A motor housing **28** for the motor **22** is also located inside the base **16**. The motor **22** is supported by the motor housing **28** and held or fixed in a secure position within the base **16**.

In the illustrated embodiment, the motor **22** is a DC brushless motor. An impeller **30** is connected to a rotary shaft extending outwardly from the motor **22**, and a diffuser **32** is positioned downstream of the impeller **30**. The diffuser **32** comprises a fixed, stationary disc having spiral blades.

An inlet **34** to the impeller **30** communicates with the air inlet **24***a*, **24***b* formed in the outer casing **18** of the base **16**. The outlet **36** of the diffuser **32** and the exhaust from the impeller **30** communicate with hollow passageway portions or ducts located inside the base **16** in order to establish air flow from the impeller **30** to the interior passage **10** of the nozzle **1**. The motor **22** is connected to an electrical connection and power supply and is controlled by a controller (not shown). Communication between the controller and the plurality of selection buttons **20** enables a user to operate the fan assembly **100**.

The features of the nozzle **1** will now be described with reference to FIGS. **3**, **4** and **5**. The shape of the nozzle **1** is annular. In this embodiment the nozzle **1** has a diameter of around 350 mm, but the nozzle may have any desired diameter, for example around 300 mm The interior passage **10** is annular and is formed as a continuous loop or duct within the nozzle **1**. The nozzle **1** comprises a wall **38** defining the interior passage **10** and the mouth **12**. In the illustrated embodiments the wall **38** comprises two curved wall parts **38***a* and **38***b* connected together, and hereafter collectively referred to as the wall **38**. The wall **38** comprises an inner surface **39** and an outer surface **40**. In the illustrated embodiments the wall **38** is arranged in a looped or folded shape such that the inner surface **39** and outer surface **40** approach and partially face, or overlap, one another. The facing portions of the inner surface **39** and the outer surface **40** define the mouth **12**. The mouth **12** extends about the axis X and comprises a tapered region **42** narrowing to an outlet **44**.

The wall **38** is stressed and held under tension with a preload force such that one of the facing portions of the inner surface **39** and the outer surface **40** is biased towards the other; in the preferred embodiments the outer surface **40** is biased towards the inner surface **39**. These facing portions of the inner surface **39** and the outer surface **40** are held apart by spacers. In the illustrated embodiments the spacers comprise a plurality of spacers **26** which are preferably equally angularly spaced about the axis X. The spacers **26** are preferably integral with the wall **38** and are preferably located on the inner surface **39** of the wall **38** so as to contact the outer surface **40** and maintain a substantially constant spacing about the axis X between the facing portions of the inner surface **39** and the outer surface **40** at the outlet **44** of the mouth **12**.

FIGS. **4** and **5** illustrate two alternative arrangements for the spacers **26**. The spacers **26** illustrated in FIG. **4** comprise a plurality of fingers **260** each having an inner edge **264** and an outer edge **266**. Each finger **260** is located between the facing portions of the inner surface **39** and the outer surface **40** of the wall **38**. Each finger **260** is secured at its inner edge **264** to the inner surface **39** of the wall **38**. A portion of the arm **260** extends beyond the outlet **44**. The outer edge **266** of arm **260** engages the outer surface **40** of the wall **38** to space apart the facing portions of the inner surface **39** and the outer surface **40**.

The spacers illustrated in FIG. **5** are similar to those illustrated in FIG. **4**, except that the fingers **360** of FIG. **5** terminate substantially flush with the outlet **44** of the mouth **12**.

The size of the fingers **260**, **360** determines the spacing between the facing portions of the inner surface **39** and the outer surface **40**.

The spacing between the facing portions at the outlet **44** of the mouth **12** is chosen to be in the range from 0.5 mm to 10 mm. The choice of spacing will depend on the desired performance characteristics of the fan. In this embodiment the outlet **44** is around 1.3 mm wide, and the mouth **12** and the outlet **44** are concentric with the interior passage **10**.

The mouth **12** is adjacent a surface comprising a Coanda surface **14**. The surface of the nozzle **1** of the illustrated embodiment further comprises a diffuser portion **46** located downstream of the Coanda surface **14** and a guide portion **48** located downstream of the diffuser portion **46**. The diffuser portion **46** comprises a diffuser surface **50** arranged to taper away from the axis X in such a way so as to assist the flow of air current delivered or output from the fan assembly **100**. In the example illustrated in FIG. **3** the mouth **12** and the overall arrangement of the nozzle **1** is such that the angle subtended between the diffuser surface **50** and the axis X is around 15°. The angle is chosen for efficient air flow over the Coanda surface **14** and over the diffuser portion **46**. The guide portion **48** includes a guide surface **52** arranged at an angle to the diffuser surface **50** in order to further aid efficient delivery of cooling air flow to a user. In the illustrated embodiment the guide surface **52** is arranged substantially parallel to the axis X and presents a substantially flat and substantially smooth face to the air flow emitted from the mouth **12**.

The surface of the nozzle **1** of the illustrated embodiment terminates at an outwardly flared surface **54** located downstream of the guide portion **48** and remote from the mouth **12**. The flared surface **54** comprises a tapering portion **56** and a tip **58** defining the circular opening **2** from which air flow is emitted and projected from the fan assembly **1**. The tapering portion **56** is arranged to taper away from the axis X in a manner such that the angle subtended between the tapering portion **56** and the axis is around 45°. The tapering portion **56** is arranged at an angle to the axis which is steeper than the angle subtended between the diffuser surface **50** and the axis. A sleek, tapered visual effect is achieved by the tapering portion **56** of the flared surface **54**. The shape and blend of the flared surface **54** detracts from the relatively thick section of the nozzle **1** comprising the diffuser portion **46** and the guide portion **48**. The user's eye is guided and led, by the tapering portion **56**, in a direction outwards and away from axis X towards the tip **58**. By this arrangement the appearance is of a fine, light, uncluttered design often favoured by users or customers.

The nozzle **1** extends by a distance of around 5 cm in the direction of the axis. The diffuser portion **46** and the overall profile of the nozzle **1** are based, in part, on an aerofoil shape. In the example shown the diffuser portion **46** extends by a distance of around two thirds the overall depth of the nozzle **1** and the guide portion **48** extends by a distance of around one sixth the overall depth of the nozzle.

The fan assembly **100** described above operates in the following manner. When a user makes a suitable selection from the plurality of buttons **20** to operate or activate the fan assembly **100**, a signal or other communication is sent to drive the motor **22**. The motor **22** is thus activated and air is drawn into the fan assembly **100** via the air inlets **24***a*, **24***b*. In the preferred embodiment air is drawn in at a rate of approximately 20 to 30 litres per second, preferably around 27 l/s (litres per second). The air passes through the outer casing **18** and along the route illustrated by arrow F' of FIG. **3** to the inlet **34** of the impeller **30**. The air flow leaving the outlet **36** of the diffuser **32** and the exhaust of the impeller **30** is divided into two air flows that proceed in opposite directions through the interior passage **10**. The air flow is constricted as it enters the mouth **12**, is channelled around and past spacers **26** and is further constricted at the outlet **44** of the mouth **12**. The constriction creates pressure in the system. The motor **22** creates an air flow through the nozzle **16** having a pressure of at least 400 kPa. The air flow created overcomes the pressure created by the constriction and the air flow exits through the outlet **44** as a primary air flow.

The output and emission of the primary air flow creates a low pressure area at the air inlets **24***a*, **24***b* with the effect of drawing additional air into the fan assembly **100**. The operation of the fan assembly **100** induces high air flow through the nozzle **1** and out through the opening **2**. The primary air flow is directed over the Coanda surface **14**, the diffuser surface **50** and the guide surface **52**. The primary air flow is amplified by the Coanda effect and concentrated or focussed towards the user by the guide portion **48** and the angular arrangement of the guide surface **52** to the diffuser surface **50**. A secondary air flow is generated by entrainment of air from the external environment, specifically from the region around the outlet **44** and from around the outer edge of the nozzle **1**. A portion of the secondary air flow entrained by the primary air flow may also be guided over the diffuser surface **48**. This secondary air flow passes through the opening **2**, where it combines with the primary air flow to produce a total air flow projected forward from the nozzle **1**.

The combination of entrainment and amplification results in a total air flow from the opening **2** of the fan assembly **100** that is greater than the air flow output from a fan assembly without such a Coanda or amplification surface adjacent the emission area.

The distribution and movement of the air flow over the diffuser portion **46** will now be described in terms of the fluid dynamics at the surface.

In general a diffuser functions to slow down the mean speed of a fluid, such as air, this is achieved by moving the air over an area or through a volume of controlled expansion. The divergent passageway or structure forming the space through which the fluid moves must allow the expansion or divergence experienced by the fluid to occur gradually. A harsh or rapid divergence will cause the air flow to be disrupted, causing vortices to form in the region of expansion. In this instance the air flow may become separated from the expansion surface and uneven flow will be generated. Vortices lead to an increase in turbulence, and associated noise, in the air flow which can be undesirable, particularly in a domestic product such as a fan.

In order to achieve a gradual divergence and gradually convert high speed air into lower speed air the diffuser can be geometrically divergent. In the arrangement described above, the structure of the diffuser portion **46** results in an avoidance of turbulence and vortex generation in the fan assembly.

The air flow passing over the diffuser surface **50** and beyond the diffuser portion **46** can tend to continue to diverge as it did through the passageway created by the diffuser portion **46**. The influence of the guide portion **48** on the air flow is such that the air flow emitted or output from the fan opening is concentrated or focussed towards user or into a room. The net result is an improved cooling effect at the user.

The combination of air flow amplification with the smooth divergence and concentration provided by the diffuser portion **46** and guide portion **48** results in a smooth, less turbulent output than that output from a fan assembly without such a diffuser portion **46** and guide portion **48**.

The amplification and laminar type of air flow produced results in a sustained flow of air being directed towards a user from the nozzle **1**. In the preferred embodiment the mass flow rate of air projected from the fan assembly **100** is at least 450 l/s, preferably in the range from 600 l/s to 700 l/s. The flow rate at a distance of up to 3 nozzle diameters (i.e. around 1000 to 1200 mm) from a user is around 400 to 500 l/s. The total air flow has a velocity of around 3 to 4 m/s (metres per second). Higher velocities are achievable by reducing the angle subtended between the surface and the axis X. A smaller angle results in the total air flow being emitted in a more focussed and directed manner. This type of air flow tends to be emitted at a higher velocity but with a reduced mass flow rate. Conversely, greater mass flow can be achieved by increasing the angle between the surface and the axis. In this case the velocity of the emitted air flow is reduced but the mass flow generated increases. Thus the performance of the fan assembly can be altered by altering the angle subtended between the surface and the axis X.

The invention is not limited to the detailed description given above. Variations will be apparent to the person skilled in the art. For example, the fan could be of a different height or diameter. The base and the nozzle of the fan could be of a different depth, width and height. The fan need not be located on a desk, but could be free standing, wall mounted or ceiling mounted. The fan shape could be adapted to suit any kind of situation or location where a cooling flow of air is desired. A portable fan could have a smaller nozzle, say 5 cm in diameter. The device for creating an air flow through the nozzle can be a motor or other air emitting device, such as any air blower or vacuum source that can be used so that the fan assembly can create an air current in a room. Examples include a motor such as an AC induction motor or types of DC brushless motor, but may also comprise any suitable air movement or air transport device such as a pump or other device for providing directed fluid flow to generate and create an air flow. Features of a motor may include a diffuser or a secondary diffuser located downstream of the motor to recover some of the static pressure lost in the motor housing and through the motor.

The outlet of the mouth may be modified. The outlet of the mouth may be widened or narrowed to a variety of spacings to maximise air flow. The spacers or spacers may be of any size or shape as required for the size of the outlet of the mouth. The spacers may include shaped portions for sound and noise reduction or delivery. The outlet of the mouth may have a uniform spacing, alternatively the spacing may vary around the nozzle. There may be a plurality of spacers, each having a uniform size and shape, alternatively each spacer, or any number of spacers, may be of different shapes and dimensions. The spacers may be integral with a surface of the nozzle or may be manufactured as one or more individual parts and secured to the nozzle or surface of the nozzle by gluing or by fixings such as bolts or screws or snap fastenings, other suitable fixing means may be used. The spacers may be located at the mouth of the nozzle, as described above, or may be located upstream of the mouth of the nozzle. The spacers may be manufactured from any suitable material, such as a plastic, resin or a metal.

The air flow emitted by the mouth may pass over a surface, such as Coanda surface, alternatively the airflow may be emitted through the mouth and be projected forward from the fan assembly without passing over an adjacent surface. The Coanda effect may be made to occur over a number of different surfaces, or a number of internal or external designs may be used in combination to achieve the flow and entrainment required. The diffuser portion may be comprised of a variety of diffuser lengths and structures. The guide portion may be a variety of lengths and be arranged at a number of different positions and orientations to as required for different fan requirements and different types of fan performance. The effect of directing or concentrating the effect of the airflow can be achieved in a number of different ways; for example the guide portion may have a shaped surface or be angled away from or towards the centre of the nozzle and the axis X.

Other shapes of nozzle are envisaged. For example, a nozzle comprising an oval, or 'racetrack' shape, a single strip or line, or block shape could be used. The fan assembly provides access to the central part of the fan as there are no blades. This means that additional features such as lighting or a clock or LCD display could be provided in the opening defined by the nozzle.

Other features could include a pivotable or tiltable base for ease of movement and adjustment of the position of the nozzle for the user.

The invention claimed is:

1. A bladeless fan assembly for creating an air current, the fan assembly comprising a nozzle mounted on a base for creating an air flow through the nozzle, the nozzle comprising an interior passage for receiving the air flow from the base, a mouth through which the air flow is emitted, the mouth being defined by first and second facing surfaces of the nozzle, and a plurality of spacers for spacing apart the facing surfaces of the nozzle, the nozzle defining an opening through which air from outside the fan assembly is drawn by the air flow emitted from the mouth, wherein the spacers are integral with the first facing surface, one of the facing surfaces of the nozzle is biased towards the other of the facing surfaces so that the spacers contact the second facing surface to space apart the facing surfaces, and the biasing occurs independently of the spacers.

2. The fan assembly of claim **1**, wherein the nozzle extends about an axis to define said opening, and wherein the spacers are angularly spaced about said axis, preferably equally angularly spaced about said axis.

3. The fan assembly of claim **2**, wherein the nozzle extends substantially cylindrically about the axis.

4. The fan assembly of claim **2**, wherein the nozzle extends by a distance of at least 5 cm in the direction of the axis.

5. The fan assembly of claim **2**, wherein the nozzle extends about the axis by a distance in the range from 30 cm to 180 cm.

6. The fan assembly of claim **1**, wherein the number of spacers is in the range of 5 to 50.

7. The fan assembly of claim **1**, wherein the nozzle comprises a loop.

8. The fan assembly of claim **1**, wherein the nozzle is substantially annular.

9. The fan assembly of claim **1**, wherein the nozzle is at least partially circular.

10. The fan assembly of claim **1**, wherein the nozzle comprises at least one wall defining the interior passage and the mouth, and wherein said at least one wall comprises the facing surfaces defining the mouth.

11. The fan assembly of claim **1**, wherein the mouth has an outlet, and the spacing between the facing surfaces at the outlet of the mouth is in the range from 0.5 mm to 10 mm.

12. The fan assembly of claim **1**, wherein the base comprises an impeller driven by a motor.

13. The fan assembly of claim 12, wherein the base comprises a DC brushless motor and a mixed flow impeller.

14. A nozzle for a bladeless fan assembly for creating an air current, the nozzle comprising an interior passage for receiving an air flow, a mouth through which the air flow is emitted, the mouth being defined by first and second facing surfaces of the nozzle, and a plurality of spacers for spacing apart the facing surfaces of the nozzle, the nozzle defining an opening through which air from outside the fan assembly is drawn by the air flow emitted from the mouth, wherein the spacers are integral with the first facing surface, one of the facing surfaces of the nozzle is biased towards the other of the facing surfaces so that the spacers contact the second facing surface to space apart the spacing surfaces, and the biasing occurs independently of the spacers.

15. The nozzle of claim 14, wherein the nozzle comprises a Coanda surface located adjacent the mouth and over which the mouth is arranged to direct the air flow.

16. The nozzle of claim 15, wherein the nozzle comprises a diffuser located downstream of the Coanda surface.

17. The nozzle of claim 14, wherein the nozzle extends about an axis to define said opening, and wherein the plurality of spacers are angularly spaced about said axis, preferably equally angularly spaced about said axis.

18. The nozzle of claim 17, wherein the nozzle extends substantially cylindrically about the axis.

19. The nozzle of claim 17, wherein the nozzle extends by a distance of at least 5 cm in the direction of the axis.

20. The nozzle of claim 17, wherein the nozzle extends about the axis by a distance in the range from 30 cm to 180 cm.

21. The nozzle of claim 14 or 15, wherein the plurality of spacers comprises between 5 to 50 spacers.

22. The nozzle of claim 14 or 15, wherein the nozzle comprises a loop.

23. The nozzle of claim 14 or 15, wherein the nozzle is substantially annular.

24. The nozzle of claim 14 or 15, wherein the nozzle is at least partially circular.

25. The nozzle of claim 14 or 15, wherein the nozzle comprises at least one wall defining the interior passage and the mouth, and wherein said at least one wall comprises the facing surfaces defining the mouth.

26. The nozzle of claim 14 or 15, wherein the mouth has an outlet, and the spacing between the facing surfaces at the outlet of the mouth is in the range from 0.5 mm to 10 mm.

* * * * *

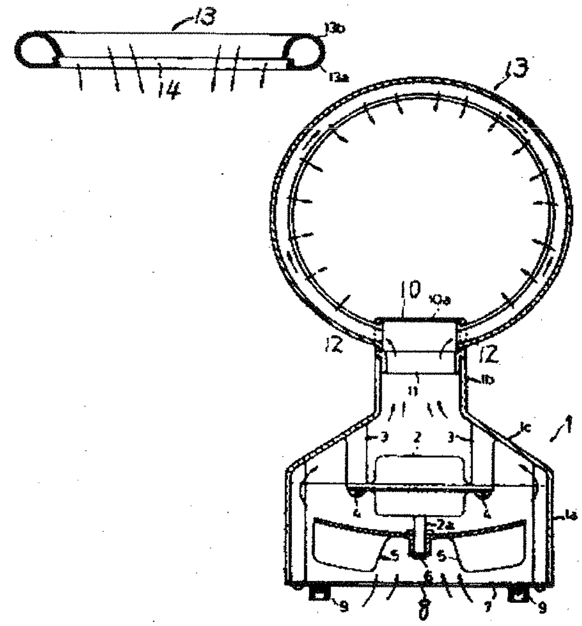
EXHIBIT E

EUROPEAN PATENT OFFICE

Patent Abstracts of Japan

PUBLICATION NUMBER : 56167897
PUBLICATION DATE : 23-12-81

APPLICATION DATE : 28-05-80
APPLICATION NUMBER : 55071978



APPLICANT : TOSHIBA CORP;

INVENTOR : HONJO SHIGERU;

INT.CL. : F04D 25/08

TITLE : FAN

ABSTRACT : PURPOSE: To improve the safety and stableness of the fan by providing an air discharging ring shaped in a hollow cylinder form to receive an air stream produced by vanes and having an annular slit to discharge the received air stream therethrough.

CONSTITUTION: The air around a base 1 is suctioned thereinto by the rotation of the vanes 5 of the fan, and then sent upwards within the base 1 to a neck piece 10, where it is divided into two air discharging ports 12 so that it can flow within the air discharging ring 13. The air flowing the air discharging ring 13 is then discharged through the annular slit 14. In this instance, the slit 14 is designed to be so narrow as to provide a strong air stream. Such a strong air stream can stir the air within the air discharging ring 13 and as a result of this, the air is sensed to flow out of the entire space surrounded by the air discharging ring 13.

⑲ 日本国特許庁（JP）　⑪ 特許出願公開
⑫ 公開特許公報（A）　昭56—167897

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⑤扇風機

㉑特　願　昭55—71978
㉒出　願　昭55（1980）5月28日
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明　細　書

1. 発明の名称　扇　風　機

2. 特許請求の範囲

1　送風羽根及びこれを駆動するモータを収めた基台と、この基台に支持され該基台から前記送風羽根が起こす風を受ける中空状を成して該部からその風を吐出せしめる環状スリットを有する吐風環とを具備して成る扇風機。

2　吐風環が基台に俯仰角調整可能に支持されていることを特徴とする特許請求の範囲第1項に記載の扇風機。

3　吐風環が基台に首振調整可能に支持されていることを特徴とする特許請求の範囲第1項に記載の扇風機。

3. 発明の詳細な説明

本発明は専ら安全性の向上を図つた扇風機に関する。

従来、扇風機は、基本的に、基台及び該基台によつてその上方に支持されたモータ部並びにそのモータ部により回転駆動される送風羽根により構成されており、そしてその送風羽根は、回転中に子供等が触れたりせぬようガードによつて覆われている。しかしながら、扇風機としての機能上、その送風羽根を送風に支障を生じるほど完全に覆い切ることもできず、従つて子供等が手を入れる危険性は依然として残り、安全性の点では未だ完全とは言えない問題点があつた。又、重量あるモータ部が基台の上方部にある為全体の安定性が悪く、而してその安定性を良くするためだけならば基台をたゞ大きくすれば良いが、それでは体裁が損われ、よつてそれらの折合から設計が困難になる欠点もあつた。

本発明は上述の如き事情に鑑みてなされたものであり、従つてその目的は、安全性の向上を基本として、更に安定性の向上，又、設計の容易化等を充分に図り得る扇風機を提供するにある。

以下本発明の一実施例につき図面を参照して説明する。先ず第1図に於いて、1は基台であり、この基台1は、下部に大円筒部1aを、上部に小

円筒部１ｂを夫々有し、それらの間をテーパ状円筒部１ｃにより繋いだ形状のもので、その下面の開口部から内部にモータ２を下向きにして収め、而してこのモータ２を、上記テーパ状円筒部１ｃの内面から下方に向けて突設したボス３‥の端部にねじ４‥によつて固着している。そして５は上記モータ２に続いて基台１内殊にその大円筒部１ａ内に収めた送風羽根であり、この送風羽根５を上記モータ２の回転軸２ａ端にボルト６等によつて固着している。尚７は基台１の上記下面の開口部に固着した底板で、８は該底板７の中央部に形成した吸気口、９は吸気口８周りの底板７周縁部に固着した脚である。一方、１０は前記基台１の小円筒部１ｂ上に回動可能に嵌着したキヤツプ状のネツクピースで、基台１内と連通すべく下面に開口部１１を有する他、該基台１上に突出した蓋部１０ａの両側部に夫々吐気口１２を有し、この吐気口１２の夫々に円形の環状を成す吐風環１３の両端部を各々ネツクピース１０の回動方向と直交する方向の上下方向に回動可能に嵌着している。

従つて、吐風環１３は上記ネツクピース１０を介して基台１に俯仰角調整可能に且つ首振調整可能に支持されたものであり、又、該吐風環１３は詳細には第２図に示す前半部品１３ａとこれより内径の小なる後半部品１３ｂとによつて前記ネツクピース１０の殊に吐気口１２を介して前記基台１内と連通する中空状に形成したものにて、その内周囲部分には上述の前半部品１３ａと後半部品１３ｂとの内径の差により前向きで該吐風環１３の全周にわたる環状の吐風用スリツト１４を形設している。

次に上記の様な構成とした本実施例の作用を述べる。先ずモータ２に通電すると、そのモータ２が起動することにより送風羽根５が回転する。この送風羽根５の回転によつて吸気口８から基台１外の空気が基台１内に吸入され、そしてその吸入された空気は基台１の内部を上方に向かつて流され、ネツクピース１０の両吐気口１２に分岐されて吐風環１３内に流される。而して吐風環１３内に流された空気は、その後該吐風環１３の全周に

わたる環状の吐風用スリツト１４から吐出される。尚、この様に吐風環１３の吐風用スリツト１４から吐出される空気即ち風は、該スリツト１４が細くかなり強い風速となる為、この風に連られて吐風環１３内方の空気も動かされ、この結果、吐風環１３が囲む空間の全体から風を吐出する感じを与え、実際に風量もスリツト１４から直接吐出される量よりかなり多くなる。

以上の様に本実施例によれば、送風羽根５を基台１内に収めた構造にて扇風機としての機能も充分に得ることができるもので、その基台１内に収めた送風羽根５にはもはや子供等が触れたりすることはなく、又、その送風羽根５に代わつて基台１外に突出した吐風環１３も、これが送風羽根５の様に回転するわけではないから、触れても安全で、総じて従来に比し使用上の安全性を飛躍的に向上させ得る。一方、本実施例に於いては、重量あるモータ２も上記送風羽根５と共に基台１内に収めており、従つて全体の安定性も同様に向上させ得、又、斯かる安定性の確保に無理がないから、

美観上からも従来よりかなり自由に形状を決めることができ、よつて設計を容易化することができる。

尚、特に本実施例にあつては上述の他に下記の効果を得ることができる。

その１．　吐風環１３を基台１に俯仰角調整可能に支持したから、風向きを上下所望の向きに定めることができる。

その２．　吐風環１３を基台１に首振調整可能に支持したから、風向きを左右所望の向きに定めることができる。

尚、本発明は上記し且つ図面に示した実施例にのみ限定されるものではなく、殊に吐風環１３は円形に限らず第３図に示す様に四角形の環状を成すものでも良いのであり、その他ネツクピース１０の有無等についても要旨を逸脱しない範囲内で適宜変更して実施し得る。

以上要するに本発明は、送風羽根及びこれを駆動するモータを収めた基台と、この基台に支持され該基台から前記送風羽根が起こす風を受ける中

空状を成して該部からその風を吐出せしめる環状スリットを有する吐風環とを具備して成ることを特徴とするものであり、以て安全性の向上を基本として、更に安定性の向上，又、設計の容易化等を充分に図り得るという優れた効果を奏する扇風機を提供することができる。

4. 図面の簡単な説明

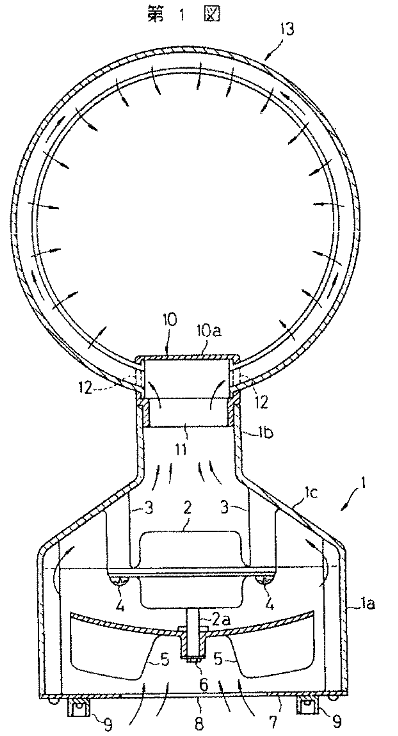
第1図は本発明の一実施例を示した全体の縦断面図、第2図は同実施例の吐風環の横断面図、第3図は本発明の異なる実施例を示した吐風環部分の正面図である。

図中1は基台、2はモータ、5は送風羽根、13は吐風環、14はスリットである。

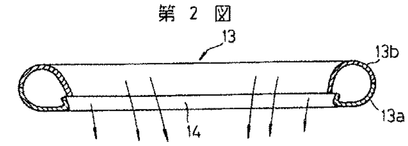
出願人　東京芝浦電気株式会社
代理人　弁理士　佐藤　強

(7)

第1図



第2図



第3図