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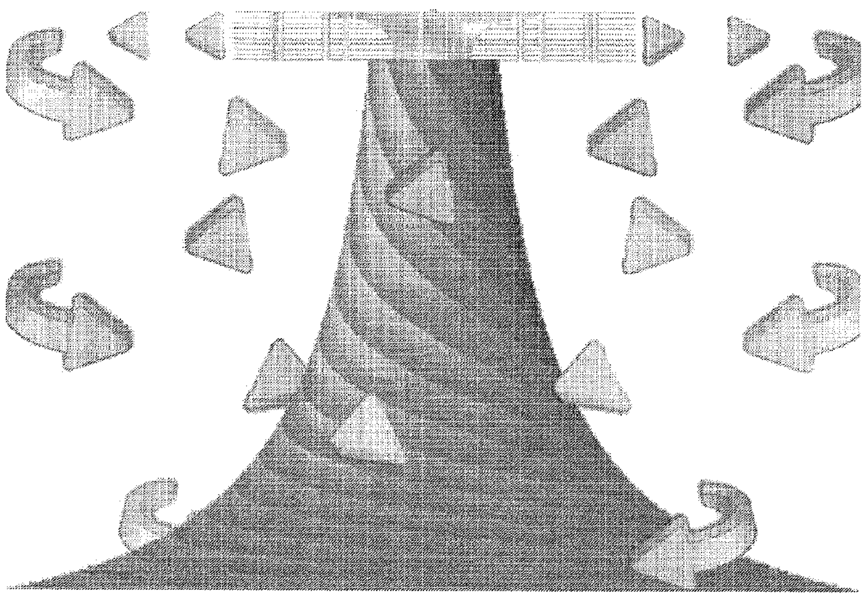

(57) Abrégé/Abstract:
The prior art has used pitched blades attached to a stationary motor, normally electric, to move air within the confines of a structure or room. The preferred invention incorporates a series of solid discs. The discs are affixed to a stationary electric motor and thus rotate around a central axis. The discs are equally spaced and centrally perforated in a manner that will allow air to flow in high volumes through the perforations and pass along the discs thus exiting symmetrically between each disc perpendicularly to the flow of air that is at its entrance. Due to the less restrictive or low pressure air entrance as well as the correct vertical disc spacing a corresponding increase in the laminar flow is realized. This feature of the preferred invention allows for operation at a rotational speed that practical for use as a ceiling fan.

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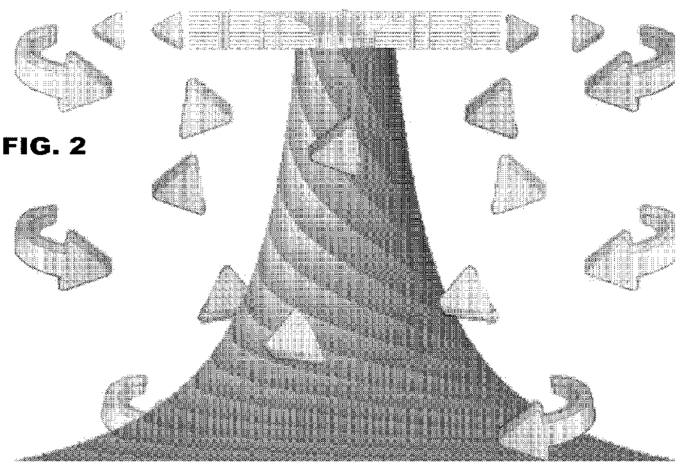

FIG. 2

(57) Abstract: The prior art has used pitched blades attached to a stationary motor, normally electric, to move air within the confines of a structure or room. The preferred invention incorporates a series of solid discs. The discs are affixed to a stationary electric motor and thus rotate around a central axis. The discs are equally spaced and centrally perforated in a manner that will allow air to flow in high volumes through the perforations and pass along the discs thus exiting symmetrically between each disc perpendicularly to the flow of air that is at its entrance. Due to the less restrictive or low pressure air entrance as well as the correct vertical disc spacing a corresponding increase in the laminar flow is realized. This feature of the preferred invention allows for operation at a rotational speed that practical for use as a ceiling fan.

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LAMINAR FLOW RADIAL CEILING FAN

BACKGROUND OF THE INVENTION

[0001] The invention disclosed herein maintains a level of human comfort within a dwelling by employing the forced movement of air. When temperatures are warm, this artificial breeze aids in a feeling cooler as the breeze passes over one's body.

[0002] A preferred embodiment of the invention is a ceiling fan. The job on any fan is to convert the motion of the fan, typically the motion of flat pitched blades, into movement of air. The prior art employs blades rotated by motor which causes the movement of air to create an artificial breeze.

[0003] Since the middle of the 20th Century systems such as central air-conditioning were incorporated in dwellings, to control the internal temperature of homes during summer months. Those systems added heating elements to have a singular central system for the home owner. However, limitations in the distribution of the heat or cold produced by these systems have demonstrated that an uneven distribution within a room or enclosed area of a structure lends itself to the addition of a ceiling fan to supplement the circulation of air within those confines for the comfort of the user.

[0004] As stated the deficiencies that are part of the heating and or cooling system have been partially addressed by the use of a ceiling fan that obviously increases the movement of air within the confines of a room, the normal operating state of the ceiling fan is for its operation to be continuous. This continuous operation occurs while the heating/cooling system is cycled from operating to its off state.

[0005] Another benefit of the prior art bladed ceiling fan is a overall reduction in energy consumption caused by the ability to alter the set temperature of the heating/cooling system to reduce its time of operation yet provide the user the level of comfort with a lower duty cycle of the centralized heating/cooling system.

[0006] The known physical property of air lends itself to the supplemental aid of a ceiling fan. To be specific, the fact that cooler air that has a greater density will seek a level lower with warmer air rising. The fan of the prior art will drive down the warmer air at the ceiling level in an attempt to create a higher state of movement within the confines of a room thus an attempt to equalize the distribution of the cool air when the cooling air source system is in use. Most ceiling fans of the prior art incorporate an ability to reverse the flow of air by reversing the direction of rotation of the fan blades. The purpose of the reverse flow is to enhance the distribution of warm air when the central heating feature of the heating/cooling system is being used, during the winter months. During the reverse flow of operation the warmer air at the ceiling is circulated across the ceiling and the desired results is for this movement to create a circulation that distributes the room air with greater equality.

[0007] Important to note is that all of the ceiling fans of the prior art attempt to gain the improvements in comfort to the user by moving air parallel to the vertical surfaces of the room and thus perpendicular to the horizontal surfaces of the room. Thus the motion of the air circulation of the prior art is limited to a single column of forced air commonly found at the center of the room, or for lager rooms multiple fans are affixed to the ceiling. For the sake of clarity, we describe a preferred embodiment, a single unit mounted in the center of an average room in a typical single family dwelling.

[0008] As previously stated the pitched blade ceiling fan of the prior art forces a singular vertical column of air from the ceiling downward to the floor.

[0009] The prior art uses the movement of the single vertical column of air to strike one of the horizontal surfaces of the room thus requiring an abrupt 90 degree turn of that column of air. This, in turn creates inefficient turbulent air flow. Accordingly, the prior art is deficient in attempting to efficiently circulate the air and equalize or homogenize the natural hot and cold layers.

[0010] There is an alternative fan design. In its most basic set up, it consists of two flat parallel discs. The discs rotate which will rotate the air mass trapped between the discs. Centrifugal force acts on the air mass and expels it outward beyond the edges of the discs and into the surrounding air space. If the discs have some sort of pathway to allow new air to take the place of the expelled air then the rotating discs will circulate the air. Thus, rotating discs can circulate the air without the need of traditional fan blades.

[0011] The prior art has recognized this structure as a "Tesla turbine," a "Prandtl layer turbine" or a "disc-type" turbine. This design has been considered useful only in the context of water turbines or high pressure air applications such as in vacuum cleaner motors or jet engine turbines.

[0012] The Tesla turbine was considered impractical in the context of a room fan because at the standard air pressure of one atmosphere, it was thought, a Tesla turbine simply could not move a sufficient volume of air without being impractically bulky. The device would have required far too many discs, each disc being far too large and the discs would have to rotate at too high an RPM to be practical.

[0013] Surprisingly, the current inventors have found a practical design for a disc type fan operable at standard atmospheric pressures. Indeed, as will be seen by one skilled in the art the disclosed invention the disc type fan is not only practical, but it improves on prior art fan systems.

OBJECTS OF THE INVENTION

[0014] The following disclosure of invention "objects" is meant to describe examples, or preferred embodiments, to be used in comparing and contrasting the invention with the prior art. This disclosure is not, however, intended to limit the claimed invention in any way.

[0015] It is therefore a general object of the invention to provide a ceiling fan apparatus that will meet the objectives and minimize limitations of the type previously described.

[0016] It is a specific object of the invention to provide a ceiling fan that is forcing its output laterally to its plane of rotation at an increased laminar flow.

[0017] It is another specific object of the invention to provide complete circulation and mixing of air of different temperatures when used within the confines of a room.

[0018] It is another specific object of the invention to disperse its high volume of laminar flow air displacement in all directions (360°) parallel to its plane of rotation.

[0019] It is another object of the invention to have the air entering the ceiling fan to be unobstructed.

[0020] It is another object of the invention to have the output laminar flow air expelled without buffeting caused by the unobstructed input air.

BRIEF SUMMARY OF A PREFERED EMBODYMENT OF THE INVENTION

[0021] In order to provide a solution to the deficiencies of the prior art, a preferred embodiment of the present invention provides a laminar flow radial ceiling fan, comprised of multiple disc(s) stacked about equally and having radial symmetry around a central axis. The fan operates by rotating the discs about the central axis. The rotating disc(s) are manufactured in a fashion that allows unobstructed air to enter from a central opening in the disc(s) and then exit in all directions via equal spaces between the array of disc(s) at a high volume of laminar flow, this unique air flow within the room eliminates any dead air when the preferred invention is in use. Prior art attempts to obtain increased laminar flow at useful rotational speeds customary to ceiling fans failed due to the relativity small input aperture.

[0022] Additionally the preferred invention improves upon the motion of air movement as a result of the relative low pressure wide input aperture. As air returns to the fan it does so as an inverse expanding cone of rotation. This conical shaped return air has its origin at the lowest point within the room (the floor) with its base expanding to the vertical boundaries of the room (the walls). The apex of this conical return air is the base of the fan at the input opening itself.

THE DRAWINGS

[0023] Objects and advantages of the present invention will become apparent from the following detailed description of embodiments taken in conjunction with the accompanying drawings, wherein:

[0024] Figure 1 illustrates a preferred airflow pattern for the air leaving the fan.

[0025] Figure 2 shows a preferred airflow pattern highlighting the air return, a conical return pattern.

[0026] Figure 3 shows the completed view of a preferred embodiment including the unique air flow paths exiting the fan and entering the fan.

[0027] Figure 4 shows an exploded view of the preferred invention.

[0028] Figure 5 is a top view of a single slave disc of the preferred invention.

[0029] Figure 6 is the cross section view of two vertical spacers illustrating the mating cavity.

[0030] Figures 7A-D show various views of an aerodynamic vane, a design variation which further promotes laminar air flow.

[0031] Figure 8 is the top, or master, drive disc of a preferred embodiment which includes a motor attachment and a smooth conical shape to promote laminar air flow.

[0032] Figure 9 is a top view of the attachment retention ring of a preferred embodiment.

[0033] Figure 10 is a cross-section of the bolt receiving cylinder which is mounted on the attachment retention ring of Figure 9.

DETAILED DESCRIPTION

[0034] One improvement over the prior art is more efficient air circulation. Due to the plurality of discs, their specific size, shape and relative positioning, the fan generates, in a preferred embodiment, a laminar air circulation pattern that efficiently circulates air throughout a standard room. For example, when the fan is located in the center of the ceiling, the air exits the rotating discs horizontally across the ceiling, spreading out uniformly in all directions toward the walls of the room as shown in Figure 1. At the walls, the air travels downward, parallel with the walls where the air flow turns inward along the floor and travels back toward the room center, see again Figure 1. Next, the air rotates upward in an inverse cyclonic pattern toward an air return aperture located in the bottom of the fan as show in Figure 2. Finally, the air enters the fan, through the air return aperture, and thus completing the circulation pattern.

[0035] This air circulation is the result of empirical experimentation in various functional fan designs, each of which combine various features of the fan, in particular, the disc dimensions, the disc number and the disc relative positioning.

[0036] These air patterns result from the fan illustrated in Figure 3 which is a built up laminar flow ceiling fan also shown in exploded view in Figure 4 below. The horizontal arrows **407** show the air exiting the fan beyond the edges of the slave discs **401**. The returning air **406** is shown entering the fan through a central air return aperture, see also Figure 5 **103**. As the air enters the fan it is smoothly directed outward by the conically shaped portion **408** of the master drive disc described in more detail in Figure 8 below. This novel feature, directing an air current into and out of a fan without significantly disrupting the laminar flow of that air current is an unique property utterly absent from the prior art.

[0037] The Figure 3 embodiment comprises one master, or drive, disc **405** mounted above an array of eight (8) slave discs **401** below. The through bolts **402** attaching the master disc to the slave discs are threaded through vertical spaces **403** that keep the slave discs **401** parallel and spaced apart a predetermined distance. The master disc also features a smooth invented cone shape that directs air entering through the air entry path **406** to the laminar flow output **407** shown at the side of the array.

[0038] Figure 4 is an exploded view of the complete fan. The electric motor is **501**. Through bolts **502** travel through the entire array, binding the entire slave disc array to the master drive disc **503**, and terminate at the attachment and retention ring **504**. The base air guide **505** covers the motor mounting screw assembly **506** during fan operation but can be removed during fan assembly and servicing. This assembly connects the motor **501** to the master drive disc **503**.

[0039] The completed slave disc array **507** and master drive disc **503** are shown assembled and affixed to the stationary drive motor **501** by affixing five (5) machine screws through the master drive disc motor mounting screw holes **506** completing the construction of the preferred invention. The motor **501** rotates the entire master drive disc and slave disc array **503** and **507** respectively.

[0040] Figure 5 is a top view of a single slave disc **101** of a preferred embodiment. Each slave disc is preferably injection molded from raw plastic and manufactured identically with a circular opening. An air entry cavity **103** is present in the center of each disc. Each disc in the fan will have this cavity. When the discs are stacked together as shown in Figure 3, the air entry cavities will create an air return aperture into which air will flow **406** as will be explained more fully below.

[0041] The slave disc **101** is preferably manufactured via plastic injection molding so as to create smooth surfaces on both sides. A smooth surface is a preferred surface for promoting laminar flow on a rotating disc(s) **101**. Of course any surface designed to promote laminar flow will function in the invention. This is particularly true in high end designs were advanced aeronautical engineering can be employed.

[0042] The diameter of the air entry cavity **103** is derived with the following equations. The disc inner diameter (ID) is a function of the surface area (A) of a single disc as follows:

$$ID = \sqrt{A}$$

The outer diameter (OD) of the slave disc **105** is determined as follows:

$$OD \cong 1.5 \times ID$$

or, more precisely:

$$OD = \sqrt{\frac{4+\pi}{\pi}} \times ID$$

Of course, some variation in the exact ID:OD ratio of is allowable. Indeed, under specific conditions (room size, atmospheric pressure) some testing can be carried out and variations of 2, 5, 10 and up to 15 percent could be necessary to achieve optimal performance.

[0043] In a preferred embodiment, the surface area (A) is about 500 sq. inches, the outer diameter (OD) is about 34 inches and the inner diameter (ID) is about 23 inches.

[0044] An optimal number discs in the array **301**been determined. The fan works more efficiently as one increases the number of slave discs from one (1) to eight (8). (Note, if one includes the master disc then this range is two (2) to nine (9).) In the preferred embodiment, there is a marginal, but significant increase in efficiency as one increases the discs in the array from seven (7) to eight (8). Surprisingly, eight appears to be an upper limit as no increase in efficiency is observed when one increases the number beyond eight.

[0045] Item **102** depicts an integral spacer with a vertical cylindrical or aerodynamic shape. The space between discs, the vertical dimension (V), is a function of the disc outer diameter (OD) and inner diameter (ID) as follows:

$$V = (OD - ID) \times 0.0625$$

In a preferred embodiment, the vertical dimension (V) is 0.75 inches.

[0046] While the preceding formula provides a useful solution for designing an embodiment of the claimed invention, there is of course, an allowable variance in the vertical dimension, but it is surprisingly small. We estimate that laminar flow will persist as one increases the vertical distance by about 10 percent but will have ceased after the vertical distance is increased by 100 percent. Of course, for high end uses one can determine the maximum vertical dimension limit for a particular embodiment by brute force experimentation. One simply builds various fans with different vertical dimensions until one finds the optimal distance for which laminar flow predominates over turbulent flow and maximizing the air volume moved.

[0047] Figure 6 is a vertical cross section of the spacers. A set of spacers are distributed around the slave disc in a uniform circular pattern at a distance that is, in a preferred embodiment, one third (1/3) of the distance from the ID of the disc to the OD of the disc. In a preferred embodiment, a total of 10 integral vertical spacers are molded along the arc signified by the dashed line **104** in Figure 5 and dispersed equally as described above.

[0048] Figure 6 illustrates a preferred design allowing for vertical stacking of the spacers. As described above, the spacer(s) **102** provide for uniform vertical separation by and between each disc in the slave disc array **401**and feature a center hole **102a** that allows the through bolt **402**, **502** to pass through the disc array. In addition the integral spacer has a mating attachment and alignment cavity **101b** that conforms to and accepts the vertical spacer counterpart **102b** that will result in the next successive disc to rest on the shoulder **103b** of the vertical spacer.

[0049] Figures 7A-D illustrate laminar airfoil vane which can, optionally, be connected in the vertical spacers of Figure 6. Figure 7A is an axonometric view. Figure 7B is a top view. Figure 7C is a front view and Figure 7D is a right side view. The height **703** of each vane **701** is less than that of the vertical spacer to which the vane is mounted and the diameter of the mounting hole **702** is slightly larger than the outer diameter of the vertical spacer. Taken together, these features allow the vane to rotate freely. The entire vane can change its angle of attack to align with the incoming laminar air movement which can vary from time to time due to changes in air speed, charges in motor RPM etc. These vanes **701** augment the output air speed due to the centrifugal force of a vertical vane rotating and placed in the path of the incoming laminar flow air. The effect is similar to that that of taking a flat piece of cardboard and waving it in front of one's face to create a cooling breeze.

[0050] The vane as illustrated is a preferred embodiment and may take on differed shapes depending on the type of laminar airfoil desired. The vanes can also be made stationary if so desired.

[0051] Figure 8 is a depiction of the top master drive disc **301** which provides the attachment base for the slave disc(s) array **401** and the drive motor through motor mounting holes **303**. The master disc **301** is preferably molded as a single piece. The master drive disc **301,** in axonometric view, shows the bolt through holes **302** that allow the bolt to pass through and connect to attachment retention ring **201**. Note that the alignment cavity **304** pattern identical to that of Figures 5 and 9 so that the through bolts and the vertical spacers **102** can pass from the upper most disc through the array to the retention ring on the bottom of the fan. Note again that the master drive disc has a conical conformal air guide **305** that aids the entry of air as well as increasing the laminar flow by providing an unobstructed air passage into and out of the rotating disc array.

[0052] Figures 9 and 10 illustrate the retention ring and retention ring bolts, respectively. The attachment retention ring 201 is shown in top view. The purpose of the retention ring is to receive the bolts that pass through the master drive disc **301**, see Fig. 8, and each slave disc **101** in the disc array. Figure 10 shows an alignment and retention ring bolt receiving cylinder **201a, 202a** designed to recess into the bottom slave disc **101** and is formed to accept the threaded bolt through a central hole **102a**, of the bolt receiving cylinder. These retention bolts are distributed in a pattern that will match the that of the integral vertical spacers **201**. This pattern is depicted by the dashed line **203**. The bolt receiving cylinder **201a** is conformal to the alignment cavity **101b** at the bottom of the bolt. The attachment retention ring **201** is affixed to the bottom disc of the array **401** so that its top surface is flush to the bottom most disc.

[0053] The preferred invention as a unit will have the number of discs as described by the aforementioned equation. The operational rotational speed of the preferred invention is within the normal range for a conventional ceiling fan. The motor **501** is designed to accommodate various speeds depending on the user's desired rate of laminar flow air. The formula below can be used to describe the force of the airflow. This is defined as the difference in pressure generated by the air exiting the fan over the surrounding air pressure, (P2 – P1).

$$P2 - P1 = \frac{(fluid\ density \times angular\ velocity^2)}{2(R2^2 - R1^2)}$$

where the “fluid density” is the standard air density and R2 and R1 are the distances to the disc outer edge and inner edge, respectively, as measured from the disc center of rotation.

[0054] As described above, the air flow patterns of prior art fans are inefficient. They are generally limited to creating a single column of column of air that displaces the surrounding air. The size of this air column is limited by the diameter of the blades rotating about the hub of the fan. Also, the air column exits a fan located in the center of the room, in a typical installation, where the air column has a limited effect at any point lateral to that air column until contact is made with a horizontal surface of the room. During the summer the air column, somewhat cooler and denser then the surrounding air, will deflect downward which will allow hot air to collect near the ceiling, a very inefficient way to cool a room.

[0055] In describing the invention, reference are made to preferred embodiments and illustrative advantages of the invention. Those skilled in the art and familiar with the instant disclosure of the subject invention may recognize additions, deletions, modifications, substitutions, and other changes which fall within the purview of the subject invention and claims.

[0056] For example, one of the embodiments described above has eight (8) discs in the array as an optimally number. This array size, however, is dependent on the fan being designed for household use in an ordinary sized room. There is, however, no theoretical reason that a fan be this particular size. Indeed, given the appropriate budget, one could design a fan array suitable for large industrial spaces. In these applications, the air return aperture would be larger and the optimal number of discs in the array could be much greater. Most likely, these larger discs would be more expensive to manufacture. The discs would be subject to greater centrifugal forces and this, in turn, would require proportionally stronger, more expensive, materials. Nevertheless, there are no theoretical problems with constructing an array that could handle a large warehouse or an aircraft hangar.

[0057] In addition to the design features described about, the inventors specifically envision that any air dynamic feature that promotes laminar flow will be useful in certain embodiments of the claimed invention. This description has mentioned only a few, rather cost effective features. Depending on the budget available, additional features also become suitable.

SUMMARY OF MAJOR ADVANTAGES OF THE INVENTION

[0058] After reading and understanding the foregoing detailed description of an inventive laminar flow ceiling fan in accordance with preferred embodiments of the invention, it will be appreciated that several distinct advantages of the subject laminar flow ceiling fan are obtained.

[0059] At least some of the major advantages include providing a disc array 401 made of plastic and injection molded with integral vertical spacers. The disc array is easily constructed without a jig due to the integral vertical spacers 102 that allow the vertical stacking of the discs to be accomplished. The completed disc array 401, when rotated by drive motor 501 will intake unobstructed air via the open air entrance 406 and expel the laminar flow air at a high volume and lower RPM, relative to the prior art, in all directions 360 degrees parallel to the direction of rotation. When used and in relation to the prior art ceiling paddle fans the induced circulation of the preferred invention homogenizes the air within the room to cause even temperature distribution of the heated or conditioned air within without any change to its direction of rotation.

WHAT IS CLAIMED IS:

1. A method of producing a laminar flow air circulation via an apparatus, the apparatus comprising a plurality of spaced-apart discs, said discs being oriented parallel with each other and sharing a common central axis, each said disc having an outer circumference and an inner circumference, each said inner circumference defining a centrally located aperture, each of said discs being spaced apart at a distance of 0.7 to 0.8 inches, said discs ranging in number from five to eight, and the apparatus further including a post located at a central axis thereof, the post having an outer surface, said discs mounting about said post so as to form an air return space between the outer surface of the post and the inner circumference of a bottom most said disc, said discs being mounted such that the discs freely rotate around the common central axis thereof, and the outer surface of the post having a conical shape such that the outer surface of the post acts as an air guide that directs incoming air without turbulence, said laminar flow air circulation being produced through method steps comprising:

rotating said discs at a speed sufficient to cause the incoming air to flow up into the air return space, along the air guide which redirects the air flow from upward to outward without generating turbulence, then outward between the discs, out beyond the outer circumferences of the discs and a surrounding air space, wherein said method steps operating upon said apparatus produce generally said laminar flow air circulation in the surrounding air space.

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2. The method as claimed in claim 1 wherein the surrounding air space is a room in a building.

3. The method as claimed in claim 1 wherein the surrounding air space is a private residence in a building.

4. The method as claimed in claim 1 wherein the surrounding air space is a retail business space in a building.

5. The method as claimed in claim 1 wherein the surrounding air space is a front office business space in a building.

6. The method as claimed in claim 1 wherein the surrounding air space is a back office business space in a building.

7. The method as claimed in any one of claims 1 to 6 wherein the apparatus further includes a motor which drives at least one of said discs.

8. The method as claimed in any one of claims 1 to 6 wherein said discs comprise a single drive said disc which is driven by a motor and four to seven slave said discs which are driven by the single drive said disc.

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9. The method as claimed in any one of claims 1 to 7 wherein the post is a conically shaped portion of a drive said disc.

10. The method as claimed in any one of claims 1 to 7 wherein said discs comprise slave said discs which are essentially identical.

11. The method as claimed in claim 10, wherein the inner circumference of each of the slave said discs is 20 to 24 inches.

12. The method as claimed in any one of claims 1 to 11, wherein the outer circumference of each said disc is 30 to 38 inches.

13. The method as claimed in any one of claims 1 to 12, wherein vertical spacers, mounted between said discs, hold said discs spaced apart.

14. The method as claimed in claim 13, wherein said vertical spacers further include laminar airfoil vanes.

15. An apparatus comprising:

a plurality of spaced-apart discs, the discs being oriented parallel with each other and sharing a common central axis, each said disc having an outer circumference and an inner

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circumference, each said inner circumference defining a centrally located aperture, and said discs ranging in number from five to eight; and

a post located at a central axis of said apparatus, the post having an outer surfacewith a conical shape such that the outer surface of the post acts as an air guide that directs incoming air without turbulence, said discs being mounted about said post so as to form an air return space between the outer surface of the post and the inner circumference of a bottom most said disc, wherein each of said discs are spaced apart at a distance of 0.7 to 0.8 inches and said discs are mounted such that the discs freely rotate around the common central axis thereof, wherein the size of said air return space, the outer surface of said post, the distance between respective said discs, the number of said discs and a speed of rotation of said discs are all configured to produce a generally laminar flow air circulation in a space surrounding the apparatus.

16. The apparatus as claimed in claim 15 wherein the space surrounding the apparatus is a room.

17. The apparatus as claimed in claim 15 wherein the space surrounding the apparatus is a private residence in a building.

18. The apparatus as claimed in claim 15 wherein the space surrounding the apparatus is a retail business space in a building.

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19. The apparatus as claimed in claim 15 wherein the space surrounding the apparatus is a front office business space in a building.

20. The apparatus as claimed in claim 15 wherein the space surrounding the apparatus is a back office business space in a building.

21. The apparatus as claimed in any one of claims 15 to 20 wherein the apparatus further includes a motor which drives at least one of said discs.

22. The apparatus as claimed in any one of claims 15 to 20, wherein said discs comprise a single drive said disc which is driven by a motor and four to seven slave said discs which are driven by the single drive said disc.

23. The apparatus as claimed in any one of claims 15 to 21, wherein the post is a conically shaped portion of a drive said disc.

24. The apparatus as claimed in any one of claims 15 to 21 wherein said discs comprise slave said discs which are essentially identical.

25. The apparatus as claimed in claim 24, wherein the inner circumference of each of the slave said discs is 20 to 24 inches.

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26. The apparatus as claimed in any one of claims 15 to 25, wherein the outer circumference of each said disc is 30 to 38 inches.

27. The apparatus as claimed in any one of claims 15 to 26, wherein vertical spacers, mounted between said discs, hold said discs spaced apart.

28. The apparatus as claimed in claim 27, wherein said vertical spacers further comprising laminar airfoil vanes.

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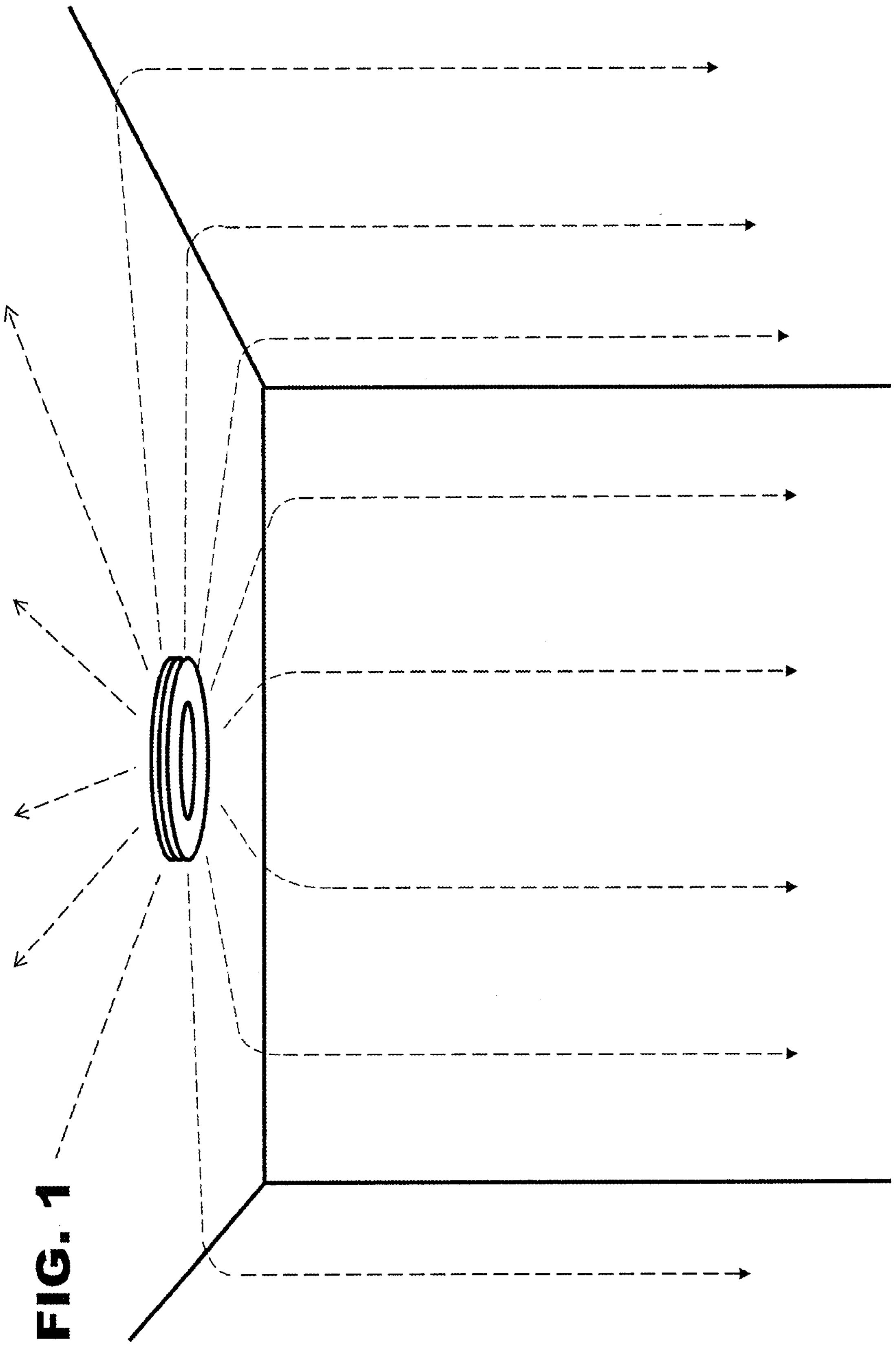


FIG. 1

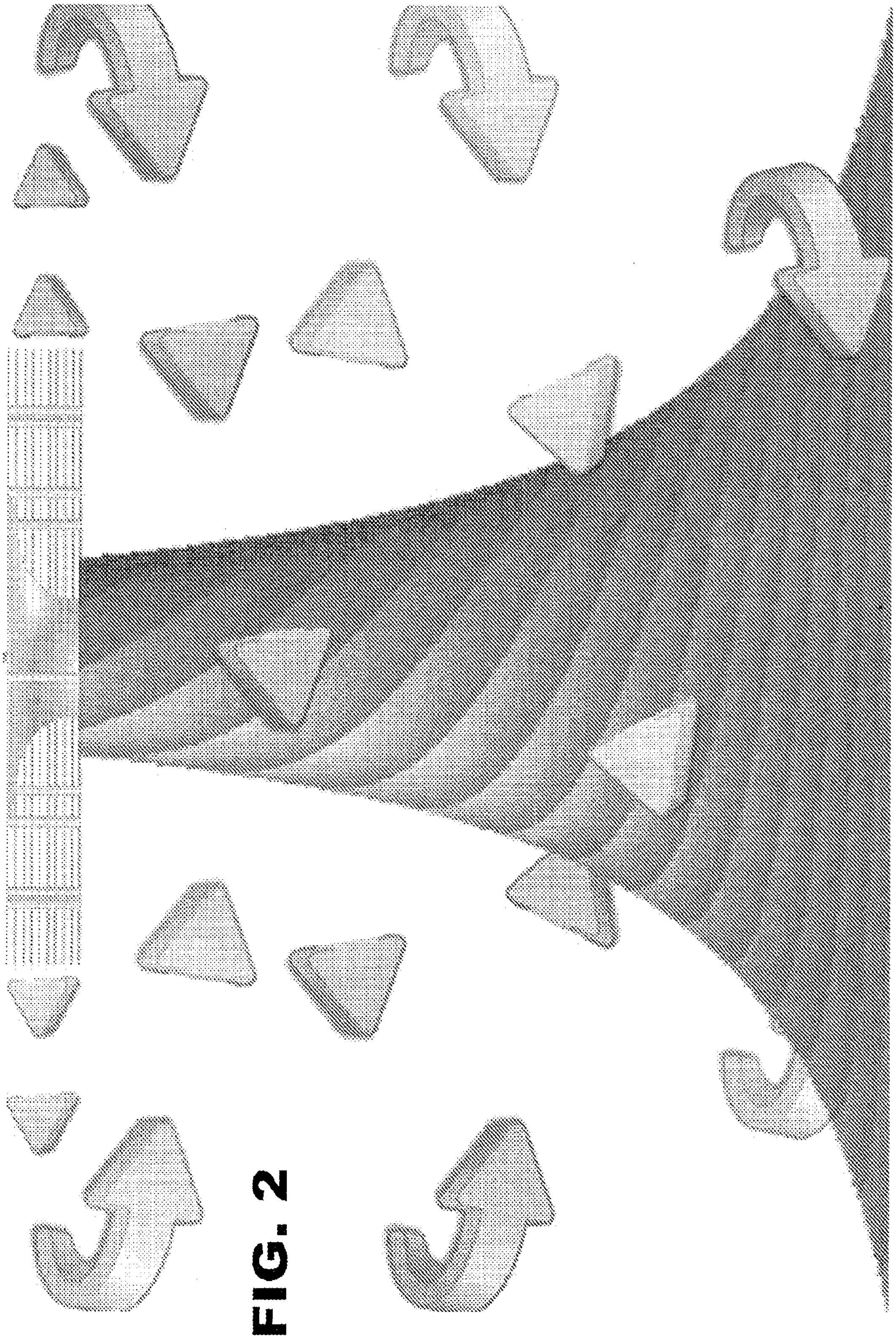


FIG. 2

FIG. 3

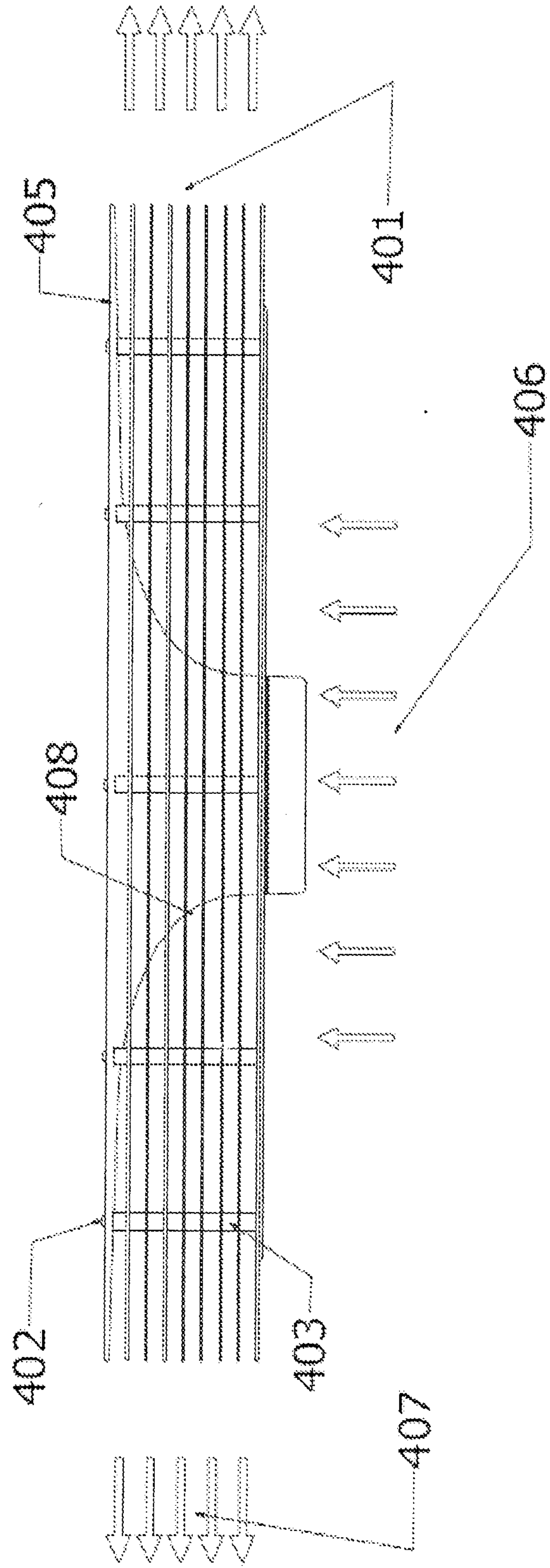


FIG. 4

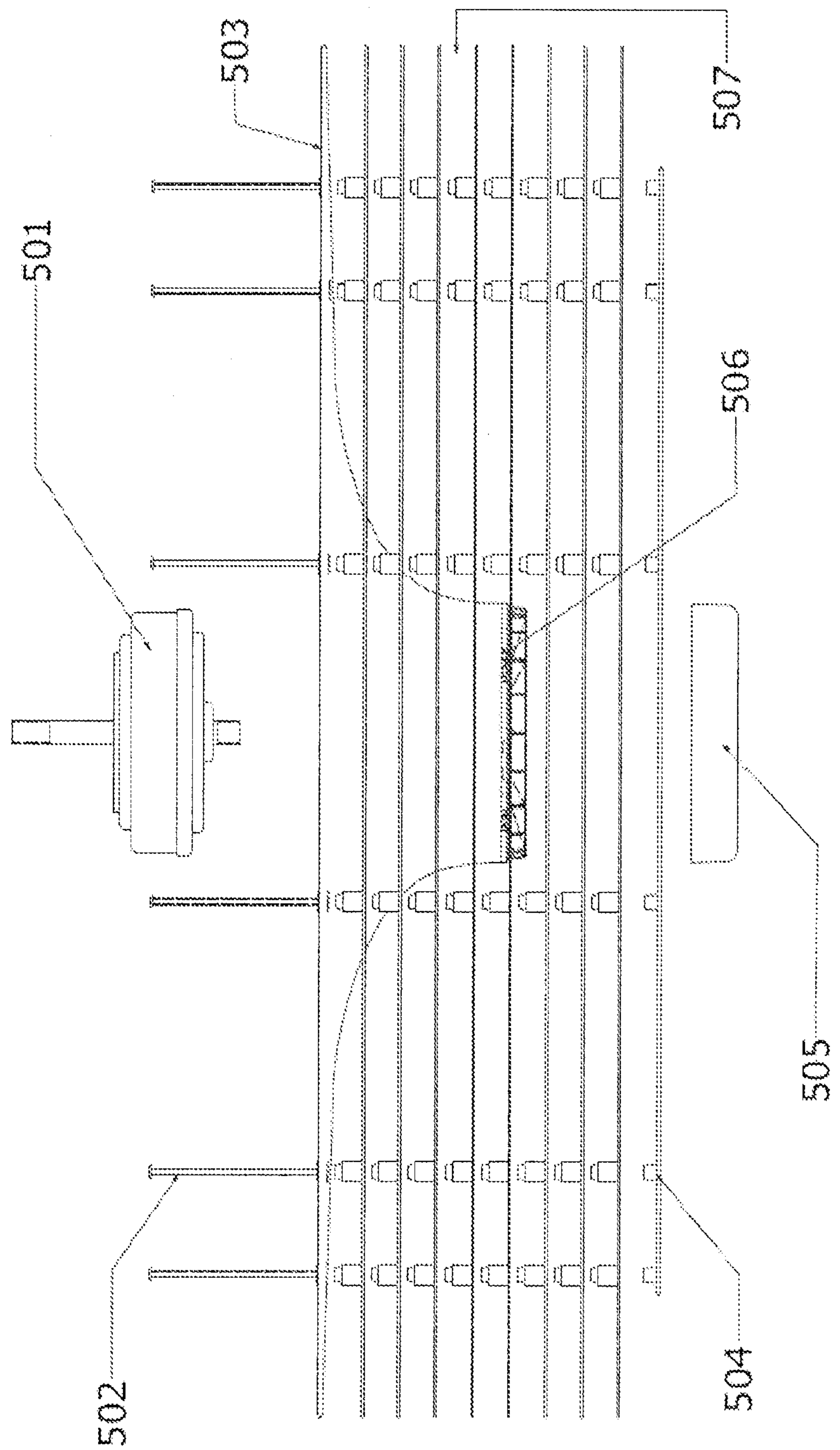


FIG. 5

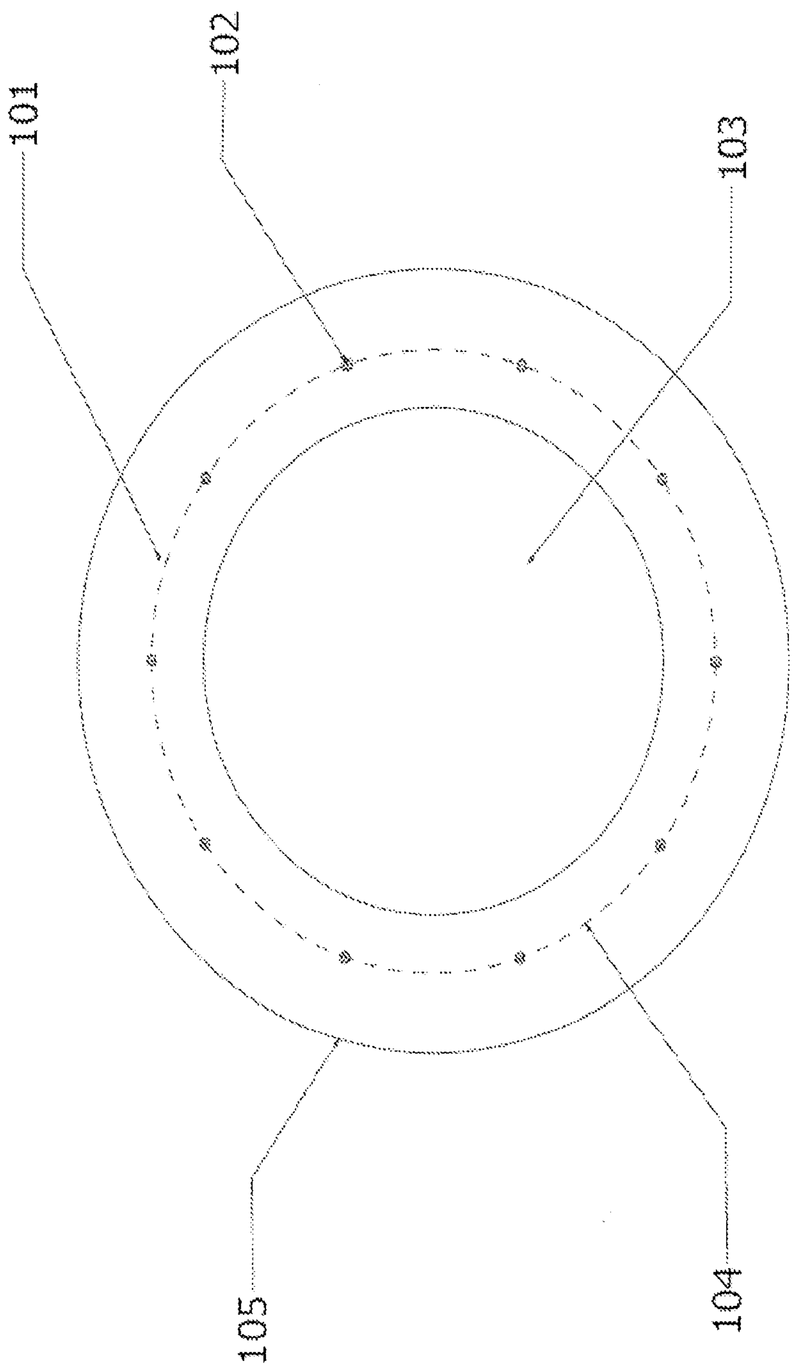
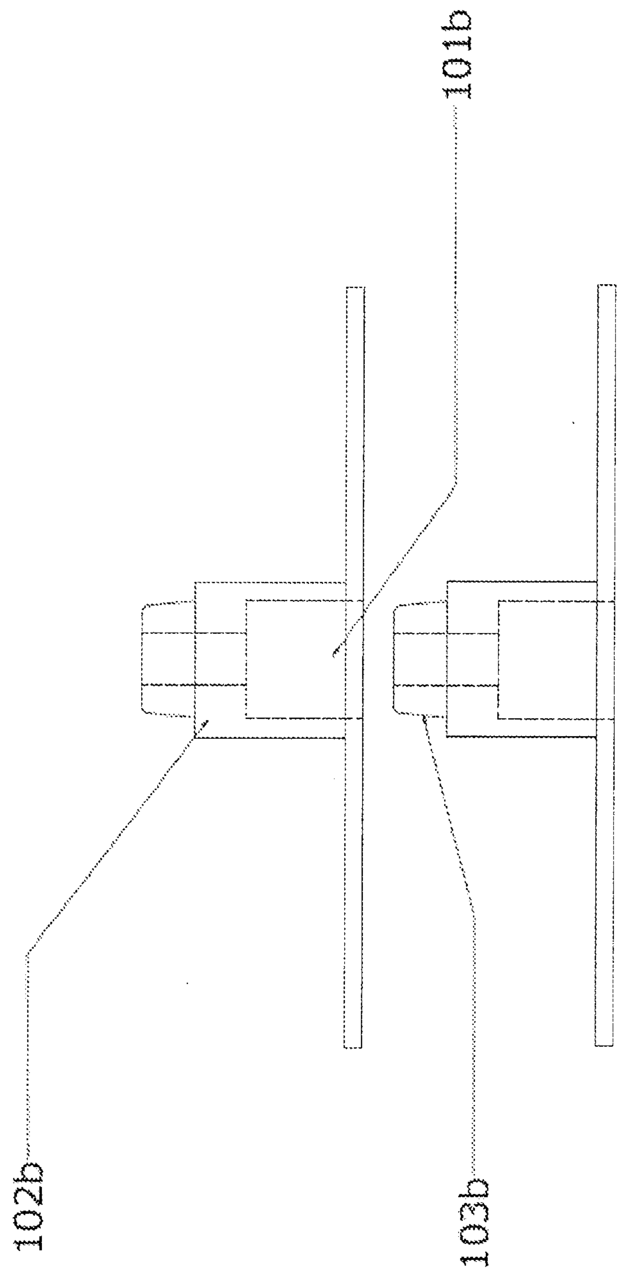


FIG. 6



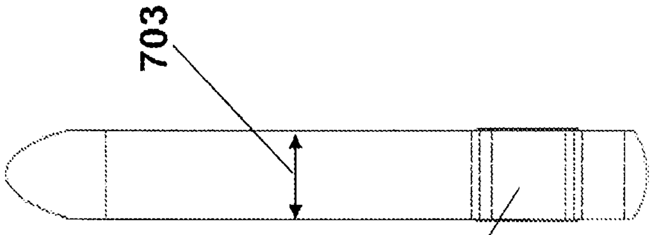


FIG. 7D

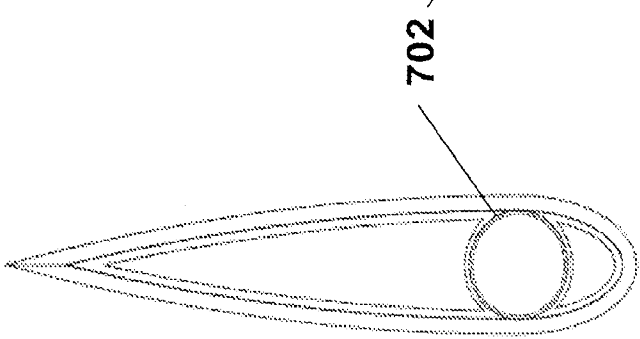


FIG. 7B

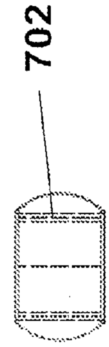


FIG. 7C

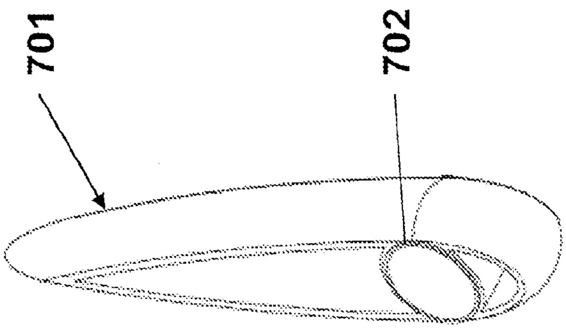
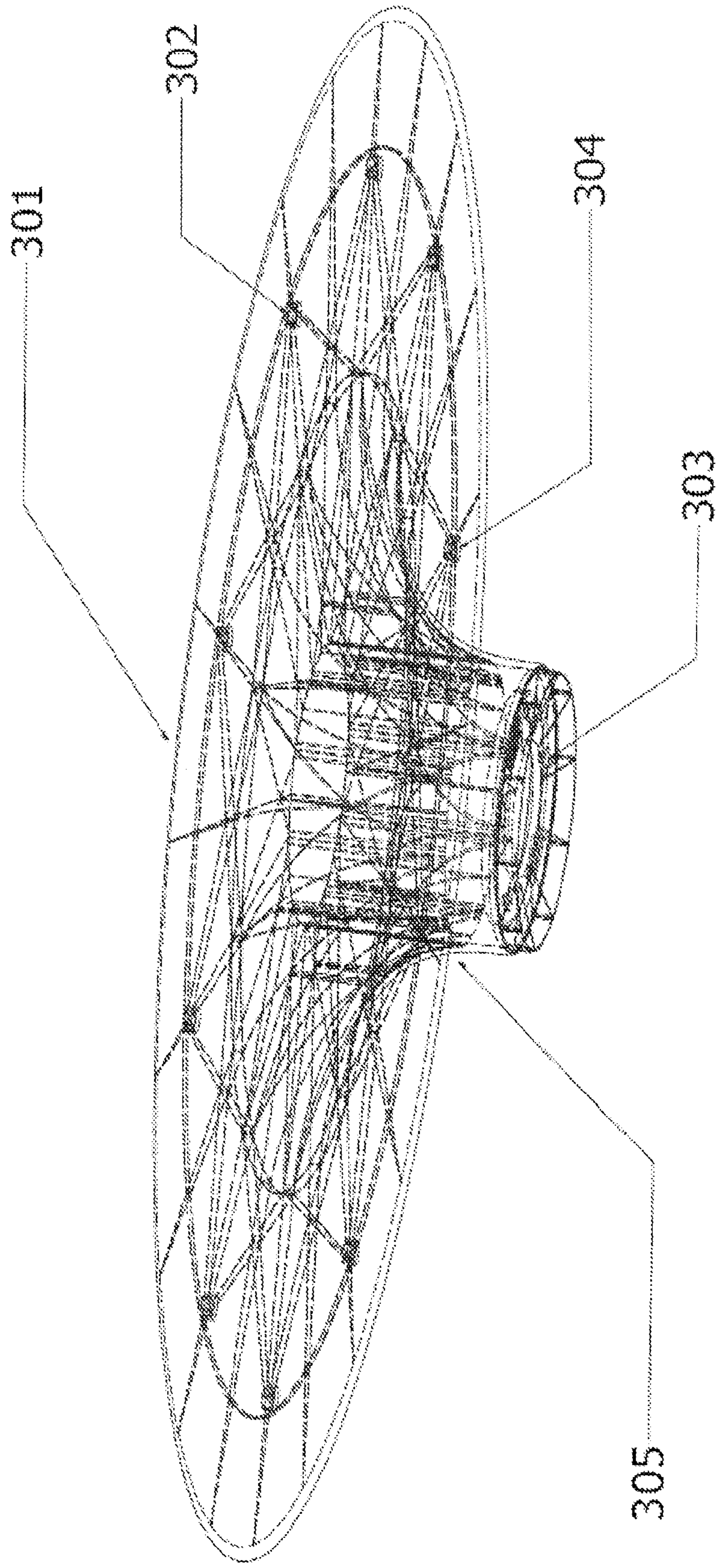


FIG. 7A

FIG. 8



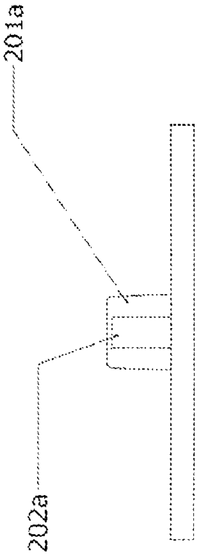


FIG. 10

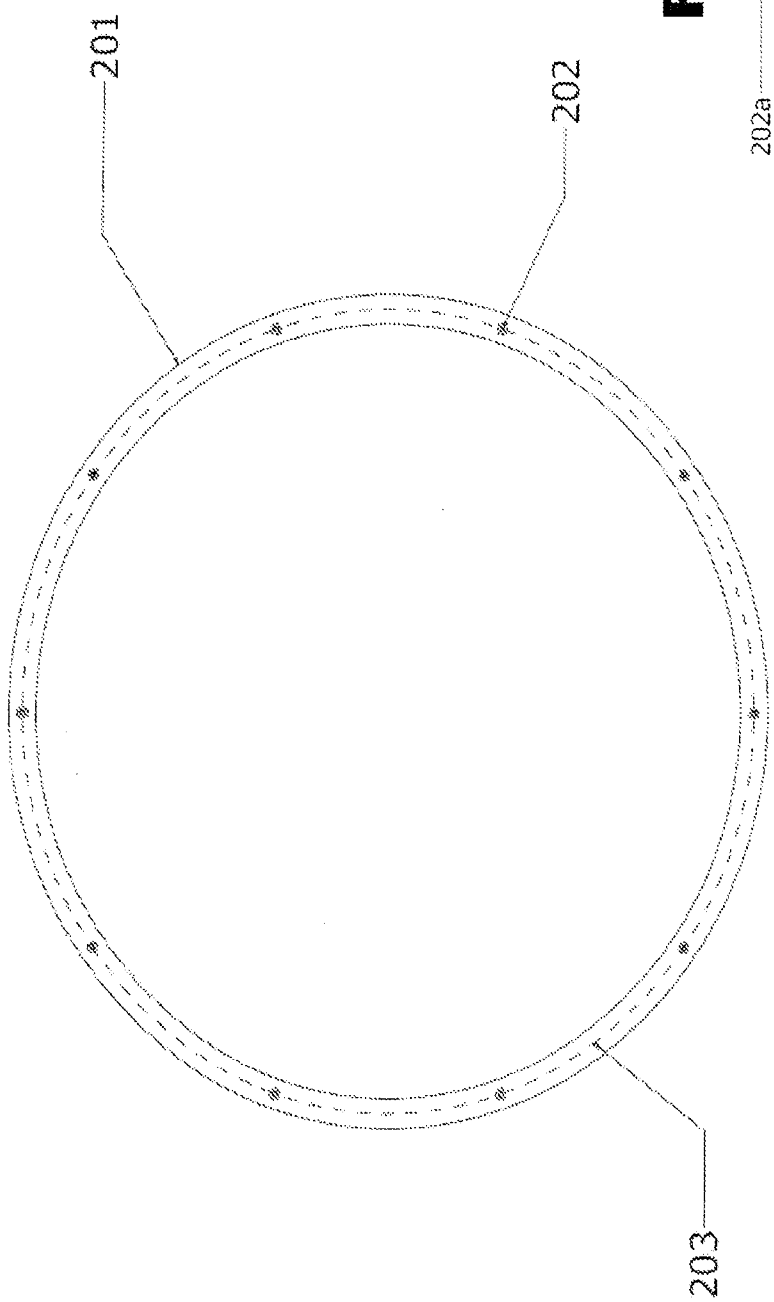


FIG. 9