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(54) **Title:** AN APPARATUS FOR CREATING FORCED VORTEX

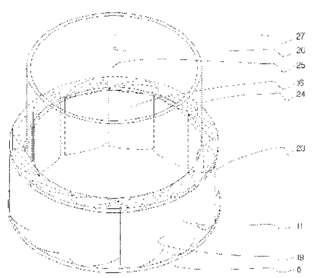
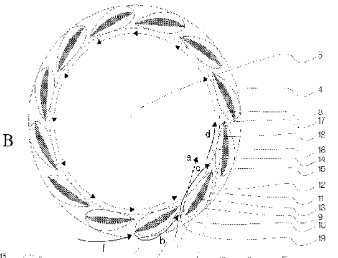


Figure 1A

Figure 1B



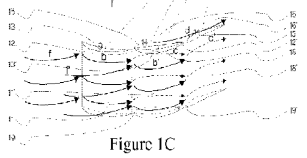


Figure 1C

(57) **Abstract:** An apparatus for creating forced vortex utilize convexly curved vanes to deflect flow according to the principle of the Coanda effect that a fluid flow along a convex curved surface will flow closely along the convex curved surface even though the convex curved surface is deviated away from its original direction or its emerging axis, and that a flow along a convex curved surface has a higher flow speed than that of a flow along other surface configurations. Using convexly curved surfaces of outer vanes which are convexly curved inward to induce or pull fluid to flow closely along the convexly curved surfaces of outer vane ridges and pass through gaps between the vanes into convexly curved surfaces of inner vane ridges which are convexly curved into an inner wall of a vortex chamber, the inner vanes mounted diagonally after the outer vane tailing edges, a gap between outer vane tailing edge and inner vane leading edge is provided, provide that the inner vane ridges tangential to the emerging axis of the said gap between vanes, and the vane tailing edges of inner vanes curved back beyond the circumference of the inner wall of the vortex chamber, due to Coanda Effect the fluid is pulled to flow closely along the convexly curved surfaces of the inner vanes. By arranging the vanes as said manner symmetrically in an annular shape, the fluid from each vane will flow in relay to pull the fluid to flow closely along the convexly curved surface of the vanes which are the inner wall of the vortex chamber so that a forced vortex is created in the vortex chamber. Since the flow is generated on convexly curved surfaces, a laminar swirling flow is created at a high rotational speed and loss of flow energy in the form of flow pressure is low as the convexly curved surfaces have a low pressure, a low flow pressure, and low pressure drag, to use convexly curved vanes to draw or pull fluid into a system to flow on the convexly curved vane surfaces, there's no need for a very high pressure difference to build up a desirably high rotational speed. Due to the flow energy is highest when flowing through the gaps between vanes then gradually decreases when swirling toward the vortex center.

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Therefore, the rotational speed is highest when flowing closely along the inner wall of vortex chamber, rotational speed gradually decreases when swirling toward the vortex center according to the decreasing flow energy. The apparatus for creating forced vortex is mounted inside an external structure.

Title of the invention

An apparatus for creating forced vortex

Field of the invention

This invention relates to an apparatus for creating forced vortex.

Background of the invention

Most conventional apparatuses for creating vortex create free vortex i.e., a vortex in which the rotational speed of its outer swirl is lower and become higher when swirling toward the vortex center. However, some applications rely on a forced vortex to perform an effective operation but not many apparatuses for creating forced vortex are available. In a forced vortex, the rotational speed is highest at its outermost region and becomes lower when swirling toward the vortex center due to its decreased energy. Applications relying on a forced vortex in their operations include e.g., fluid separation using vortex centrifugal force, heat or cold transfer from a tube wall using fluid swirling flow in the tube.

Two main types of apparatus for creating forced vortex include a first type in which a centrifugal impeller is used to generate fluid flow along an inner wall of a concavely curved circular vortex chamber, e.g., a round tube, or a cylindrical chamber, or a conical chamber, to create a vortex in a tube, a cylindrical chamber, a conical chamber, e.g., the invention according to patent No. JP1995155698; another type in which guide vanes which are stator blades twisted at guide vane tailing edges are used to generate fluid flow along a concavely curved circular inner wall such as a tube, or a cylindrical or conical chamber, etc. to create a vortex in said container. In said forced vortex creating method, fluid is usually introduced via an axial inlet e.g., the invention according to patent No. US20190168147A1 in which in addition to the guide vanes, pairs of vortex tab are also mounted to create a counter rotating vortex to carry small particles to a tube wall or a chamber wall so that they are settled. Both of the above-mentioned vortex creating methods have a common principle i.e., the curved configuration of an inner wall of a container is used to force fluid to flow along said concavely curved circular inner wall so that a vortex is created in said container. The concave curvature of the inner wall of the container obstructs fluid from flowing in a straight line so that flow pressure is generated, and pressure drag is generated such that a propelling force therein is reduced and flow speed decreases. If the vortex's rotational speed is increased to a certain extent, a turbulent flow will be generated which is a disadvantage when using said vortex in generating centrifugal force for separation. Since a centrifugal force varies directly with a vortex's rotational speed, the higher the rotational speed, the more centrifugal force is attained and the more effective the separation becomes. However, creating a vortex using a concavely curved circular inner wall of a container has a limitation of rotational speed acceleration as mentioned above. Therefore, there is an objective to devise a method and create an apparatus for creating forced vortex having a high rotational speed, having formed therein a laminar swirling flow, and having a low pressure loss rate.

Summary of the invention

An apparatus for creating forced vortex according to the present invention aims to find a method and create an apparatus for creating forced vortex having a high rotational speed, having formed therein a laminar swirling flow, and having a low pressure loss rate in which the vortex is created using convexly curved surfaces to deflect flow direction so that fluid flows along the surfaces in a high velocity according to the principle of Coanda Effect in which fluid tends to keep flowing along a convexly curved surface even if the convexly curved surface deviates away from the original flow direction.

The apparatus for creating forced vortex according to the present invention utilizes convexly curved vanes to deflect flow according to the principle of the Coanda effect in which fluid keeps flowing along a convexly curved surface even if the convexly curved surface deviates away from the original flow direction and in which the rotational speed of the flow along the convexly curved surface is high. Convexly curved outer vanes are used to achieve the Coanda effect such that the flow is deflected and pulled to flow along outer vane ridges, passes through gaps between vanes, flow closely along convexly curved inner vane ridges whose curves toward inner wall of the vortex chamber, and flow along convexly curved surfaces of inner vane ridges which are the inner wall such that the flow is generated on the surface of the inner wall so that a forced vortex is created in the vortex chamber. The apparatus for creating forced vortex according to the present invention consists of vanes each having a convexly curved ridge surface extending from vane leading edge to vane tailing edge thereof. Vane lower side opposite to the convexly curved ridges being concavely curved or flat or slightly convexly curved such that its curvature is less than that of the vane ridge. The vanes are designed and arranged symmetrically in an annular shape on a circular base wherein vanes are arranged in two layers, the leading edges and the convexly curved vane ridges of the outer vanes are diagonally and outwardly oriented toward the fluid distribution chamber, the vane tailing edges are diagonally and inwardly oriented. The inner vanes are disposed next to preceding vane tailing edges with vane lower side thereof facing outward wherein the convexly curved leading edges face the convexly curved outer vane tailing edges with gaps there-between. Both the outer vanes and the inner vanes are designed and arranged with a gap between the outer vane tailing edges and the inner vane leading edges having a certain width. The outer vane tailing edges are tangential to or close to an emerging axis of the gap between the outer vane tailing edges and the inner vane leading edges that is tangential to the ridges of the inner vanes. The inner vane tailing edges are curved inward slightly from a circumferential edge of the inner wall. Said successively arranged set of double-layer vanes are symmetrically arranged into an annular shape on a circular base plate. The inner vane of a preceding set of vanes abuts against the outer vane of a set of vanes of interest. The outer vane of the subsequent set of vanes abuts against the inner vane of the set of vanes of interest. The annularly arranged upper vane tips are covered by an annular cover plate to only allow fluid to flow through the gaps between vanes into the internal cavity . The sets of vanes arranged into an annular shape according to said configuration are mounted inside an external structure having a fluid inlet for allowing fluid to enter the fluid distribution chamber enclosing a transmission base having the vanes which are said apparatus for creating forced vortex mounted. Said fluid inlet is disposed in a position such that fluid is directed to and attacks the convexly curved side of the vane leading edges. Due to the Coanda effect, fluid is deflected and flows closely along the convexly curved ridges of the vanes which are suction side and fluid in said area which is a part of the fluid distribution chamber is induced or drawn to flow toward the vane tailing edges and through the gaps between the vanes arranged according to said configuration and attack the inner vane leading edges. With the Coanda effect, fluid is deflected and flows closely along the convexly curved surfaces of the inner vane ridges. With the inner vane tailing edges curved inward slightly beyond the inner wall's circumference and the pulling force of the fluid flowing through the gaps between vanes of the subsequent set of vane, fluid is pulled to flow closely along the convexly curved surfaces of the inner vane ridges of the subsequent set of vanes. With the vanes arrangement according to said configuration, the flows along each set of vanes flow in relay with each other such that the flow along the inner wall of the vortex chamber which is the convexly curved ridges of the inner vanes is generated so that the vortex is created inside the vortex chamber. With the Coanda effect as explained, fluid is pulled to flow closely along the convexly curved surfaces of the inner vanes so that the flow along the inner wall of the vortex chamber is generated in the form of a laminar flow. Due to highest force at exits of the gaps between the vanes. Therefore, the rotational speed is highest at the outermost area of the vortex and gradually decreases when swirling toward the center due to its reduced force as referred to as a forced vortex. Due to a low pressure on the convexly curved surfaces, a low pressure generated from the flow, and a low flow drag, the flow speed is higher than a flow on a concavely curved surface, a flat surface, or a space filled with fluid. Therefore, the apparatus for creating vortex according to the present invention can achieve a vortex with a high rotational speed, low energy loss and pressure loss. The vortex chamber can be extended axially toward the open end of the internal cavity of the transmission base by a certain extent to increase vortex space and residential time, wherein the end of the vortex chamber defines an exit for the swirling fluid to be used in other processes.

The convexly curved vane-type apparatus for creating vortex according to the present invention can be mounted inside an external structure having a volute configuration wherein the fluid inlet introduces fluid into the fluid distribution chamber enclosing the transmission base of the apparatus for creating vortex, which is widest at its entrance and gradually tapers toward a partitioning wall separating the entrance from the end of the fluid distribution chamber, in order to evenly distribute fluid into all gaps between the vanes across the transmission base so that the fluid is directed to the internal cavity that is the vortex chamber which can be extended upward axially from the vane tips by a certain extent and wherein the end of the vortex chamber defines the exit for the swirling fluid to be used in desired processes.

When the fluid is forced into the fluid distribution chamber, it will be distributed into the gaps between the vanes. Due to the convex curvature of the vane leading edges and the convex curvature of the vane ridges, when the fluid attacks the vane leading edges, as a result of the Coanda effect, the fluid will be deflected to flow closely along the convexly curved surfaces of the vane ridges. Since the convexly curved vane surfaces block pressure from the side of the convexly curved vane surfaces, the convexly curved surfaces have the lowest pressure when compared with that of other parts in said area. In fluid dynamics, the vane ridge side is referred to as the suction side. Due to the convex curvature of the surfaces, pressure is not generated from the swirling flow and therefore, the flow on the convexly curved surfaces is multiple times faster than one on a flat surface or a concavely curved surface. Since the fluid distribution chamber has a volute configuration, the concavely curved wall of the fluid distribution chamber opposite to the vanes arranged in an annular shape defines a pressure side. Accordingly, a suction is generated from the suction side and pressure is generated from the pressure side causing the fluid flows along the convexly curved surfaces of the vane ridges at a high speed and through the gaps between the vanes to attack the vane leading edges. The following operation is as previously explained in the section of the vanes having a convexly curved side for creating vortex.

The convexly curved vane-type apparatus for creating vortex according to the present invention can also be mounted next to fluid outlet of an impeller compressor in which fluid flowing from its diffuser wherein base of the diffuser is inclined by a certain extent, diffuser vanes are mounted on a diffuser base plate, the diffuser vanes each has a tapering, elongated shape and a concentric curved ridge having a convexly curved surface which is convexly curved from a vane leading edge to a vane tailing edge, the diffuser vane leading edges are positioned close to an edge of the impeller, the diffuser vanes are disposed with a wide angle inclination from a radius line that is perpendicular to tangent of the circumference of diffuser base plate and curved toward a rotation direction of impeller blades, the diffuser vane tailing edges are slightly curved inward from the circumference of the diffuser base plate, the diffuser vanes are mounted perpendicularly to the diffuser vane plate that is inclined by a certain extent such that the diffuser vane tailing edges located at circumferential edge of the diffuser base extend beyond the circumferential edge line of the base due to the degree on inclination thereof. In fluid dynamics, the convexly curved diffuser vane ridge side is referred to as the suction side and the concave side having a certain thickness which reduces the concave curvature is referred to as the pressure side. A plurality of diffuser vanes are symmetrically arranged about the diffuser base such that a preceding diffuser vane (in the flow direction) creates a flow stream to flow along the convexly curved surface of a subsequent diffuser vane such that the flow from one diffuser vane to another to flow in relay with each other. Due to the fact that diffuser vane tailing edges are slightly curved inward from the circumferential edge of the diffuser vane plate and with the Coanda effect, the flow is deflected to flow closely along the convexly curved surfaces of the ridges of the diffuser vanes and a vortex is created around the diffuser base's circumferential edge. Due to the inclination of the diffuser base and the inclination of ridge side of the diffuser vane tailing edge extending beyond the circumferential edge line of the diffuser base , a mixed flow consisting of a radial flow and an axial flow is created such that a swirling flow tangential to the convexly curved surfaces surround a circular core enclosed by a fluid distribution chamber is created . The flow tangential to the circular central rim has a higher speed than that of the flow on a concavely curved surface or a flow in a space filled with fluid having a higher pressure and a higher pressure drag. A downward rim extension of a certain extent is downwardly and axially formed from the diffuser base edge, next to the rim on which the convexly curved vane-type apparatuses for creating forced vortex are mounted. When the fluid flowing closely along the central rim reaches the apparatus for creating vortex according to the present invention, attacks the vane leading edges of the swirling flow generating vanes, due to the convex curvature of the vane leading edges and the vane ridges acting as the suction side and the concavely curved wall of the fluid distribution chamber opposite to the vane acting as the pressure side in combination with the fluid flowing from the impeller compressor along the central rim at a high speed, the suction from the suction side that is the convexly curved vane ridges and the pressure from the pressure side that is the wall of the fluid distribution chamber are generated such that the fluid flows through the vanes and the gaps between the vanes at a high speed. With the designs and arrangements of the vanes according to the above-mentioned configuration, a forced vortex having formed therein a laminar swirling flow and having a high rotational speed and a low- pressure loss would be created as described in detail above in the section of the operation of the convexly curved vanes of the apparatus for creating vortex.

The apparatus for creating forced vortex according to the present invention may further comprise an extension to the vortex chamber and the present invention may also provide an extension chamber of the vortex chamber which creates a vortex having a higher rotational speed and a lower flow turbulence than those created by a conventional vortex chamber having a shape of a circular, cylindrical, or conical tube by mounting flow accelerators. The swirling flow in the circular, cylindrical, or conical tube, due to the circular inner wall of the tube is concavely curved, the swirling flow in the circular tube generates a flow pressure which generates a flow drag. The present inventor solves this problem by forming convexly curved surfaces on inner walls of the extension chamber of vortex chamber which is either a cylindrical or conical chamber. However, due to the circular configuration of the inner wall of the cylindrical or conical tube vortex chamber, the convexly curved surfaces cannot be formed without concavely curved surfaces that generates high flow pressure and pressure drag. The present invention solves the problem of flow pressure and pressure drag caused by the concavely curved surfaces by mounting double-convexly curved-sided vanes over the concavely curved surfaces of the inner wall of the vortex chamber having formed alternately and symmetrically thereon convexly curved corrugations and concavely curved corrugations. The vanes are disposed at a certain distance from the surfaces of the concavely curved corrugations to form flow channels under the vanes through which fluid flows from the convexly curved surface of a preceding convexly curved corrugation to the convexly curved surface of a subsequent convexly curved corrugation. vane leading edges are disposed to receive fluid flowing from the convexly curved surface of the preceding convexly curved corrugation. Vane tailing edges are disposed such that the curvature thereof is tangential to or close to the emerging axis of the flow channels under the vanes which is tangential to the convexly curved surfaces of the subsequent convexly curved corrugations. Due to the Coanda effect, when fluid flows along the convexly curved surfaces and attacks the vane leading edges, a portion of the fluid will flow along the convexly curved surfaces under the vanes acting as the suction side. Since the wall opposite to the convexly curved surfaces is the concavely curved surfaces of the concavely curved corrugations acting as the pressure side, most of the fluid flowing through the flow channels under the blades is pulled and push to flow closely along the convexly curved surfaces of the convexly curved ridges under the vanes. Due to the disposition of the vane tailing edges to be tangential to or close to the emerging axis of the flow channels under the vanes and to be tangential to the convexly curved surfaces of the subsequent convexly curved corrugations, and with the Coanda effect, fluid flowing through the flow channels under the blades is deflected to flow tangentially along the convexly curved surfaces under the vanes and then flow tangentially along the convexly curved surfaces of the subsequent convexly curved corrugations. The other portion of fluid attacking the leading vane edges flow along the convexly curved surfaces above the blades. Due to the pulling force applied to the fluid flowing along the convexly curved surfaces under the vanes to flow closely along the subsequent convexly curved surfaces of the subsequent convexly curved corrugations, induce the fluid flowing along the convexly curved surfaces above the vane to flow tangentially to the convexly curved surfaces of the subsequent convexly curved corrugations. Therefore, the vortex in the tube is the flow from the convexly curved surfaces of the convexly curved corrugations to the convexly curved surfaces of the vanes both under the vanes and above the vanes and consequently the flow tangential to the convexly curved surfaces of the subsequent convexly curved corrugations in an alternating fashion in said manner throughout the occurrence of the swirling in the vortex chamber, most of which is a swirling flow on the convexly curved surfaces. The convexly curved surfaces have a much lower pressure, flow pressure, and pressure drag than those of the concavely curved surfaces and said flow on the convexly curved surfaces has a low-pressure loss. Therefore, the swirling flow speed is higher than that in the cylindrical or conical vortex chamber having a circular inner wall that is a concavely curved surface. In addition, the flow on the convexly curved surfaces acting as the suction side generates a laminar flow, then a laminar swirling flow in the cylindrical or conical chamber.

The convexly curved vane-type apparatus for creating forced vortex according to the present invention can create a forced vortex having a laminar swirling flow without the occurrence of a turbulent flow. Since the flow on the convexly curved surfaces has a low pressure and a low-pressure drag, said flow has a low flow pressure loss. Due to the Coanda Effect generates high velocity flow on the convexly curved vane surface, therefore no need for a very high pressure difference potential energy for generating a desired high speed swirling flow . Also due to the Coanda effect occurring while fluid flow on the convexly curved surfaces, induces or pulls the fluid to flow along the convexly curved surfaces. The created swirling flow is laminar swirling flow which is suitable for fluid separation. The convexly curved vane-type apparatus for creating vortex according to the present invention can solve the technical problems of the prior art apparatus for creating vortex, involves an inventive step, and is favorably industrially applicable.

Brief description of the drawings

Figure 1A is a perspective view of the apparatus for creating forced vortex in which bilayer vanes are arranged in a cylindrical shape and the cylindrical extension chamber of the vortex chamber is provided.

Figure 1B is a plan view of the arrangement of the bilayer vanes in an annular shape.

Figure 1C is a perspective view of the non-squared rectangular-shaped bilayer vanes and the flow profile of the bilayer vanes.

Figure 2A is a perspective view of the apparatus for creating forced vortex in which bilayer vanes are arranged in a conical shape and the conical extension chamber of the vortex chamber is provided.

Figure 2B is a plan view of the arrangement of the bilayer vanes in an annular shape.

Figure 2C is a perspective view of a trapezoid-shaped bilayer vanes.

Figure 3A is a perspective view of an oval-shaped cross-section view vane-type apparatus for creating forced vortex in which the vanes are arranged perpendicularly to the base in a cylindrical shape and the cylindrical extension chamber of the vortex chamber is provided.

Figure 3B is a plan view of an arrangement of the oval-shaped cross-section view vanes in an annular shape.

Figure 3C is a perspective view of the rectangular, oval-shaped cross-section view vanes and a flow profile of the oval-shaped cross-section view vanes.

Figure 4A is a plan view showing details of a volute-casing apparatus for creating forced vortex.

Figure 4B is a perspective view of the volute-casing apparatus for creating forced vortex.

Figure 4C shows the internal structure of the volute-casing apparatus for creating forced vortex and shows an arrangement of bilayer vanes for creating vortex.

Figure 5A is a perspective view of the impeller compressor-type apparatus for creating forced vortex.

Figure 5B is an exploded view showing components of the impeller compressor-type apparatus for creating forced vortex.

Figure 5C is a plan view of an impeller and diffusor system of the impeller compressor-type apparatus for creating forced vortex.

Figure 5D is a cross-section view of the impeller compressor-type apparatus for creating forced vortex.

Figure 5E shows details of the swirling flow in the impeller compressor-type apparatus for creating forced vortex.

Figure 6A is a plan view of the extension chamber of the vortex chamber to which a flow accelerator, in which the convexly curved corrugations followed by concavely curved corrugations are formed and in which the double-convexly curved-sided vanes are mounted over the concavely curved corrugations, is mounted.

Figure 6B is a plan view showing a flow profile of the flow accelerator in which the convexly curved corrugations followed by concavely curved corrugations are formed and in which the double-convexly curved-sided vanes are mounted over the concavely curved corrugations.

Figures 6C and 6D are perspective views of the conical vortex chamber to which the flow accelerator, in which the convexly curved corrugations followed by concavely curved corrugations are formed and in which the double-convexly curved-sided vanes are mounted over the concavely curved corrugations, is mounted.

Detailed description of the invention

Figures 1A, 1B, 1C show the apparatus for creating forced vortex according to the present invention which is the apparatus to be mounted inside an external structure consisting of the fluid inlet, the fluid distribution chamber enclosing the transmission base of the vortex creating apparatus (4), the bilayer vanes being mounted on the base plate (6), wherein the outer vanes (9) are each configured into a non-squared rectangular shape, the vane ridges (11) are convexly curved from the vane leading edges (10) to the vane tailing edges (12), the vane lower side (13) is concavely curved or flat, the inner vanes (14) are also each configured into a non-squared rectangular shape, the ridges (16) of the inner vanes are convexly curved from the vane leading edges (15) to the vane tailing edges (17), the inner vane lower side (18) is concavely curved or flat, preferably flat, said vanes are curved and have a certain thickness such that the concave curvature of the vane lower side is reduced, the outer and inner vanes are configured and arranged such that the convexly curved vane ridges (11) of the outer vanes (9) are diagonally and outwardly oriented toward the fluid distribution chamber, the vane tailing edges (12) are diagonally and inwardly oriented, the inner vanes (14) are diagonally disposed next to the outer vane tailing edges with a gap (19) between the outer vane tailing edges (12) and the inner vane leading edges (15), the inner vanes (14) are disposed such that the ridges (16) of the inner vanes are oriented toward the internal cavity (5), the convexly curved inner vane leading edges (15) are oriented toward the convexly curved side of the outer vane tailing edges (12) such that the vane leading edges are oriented to receive fluid flowing along the outer vane tailing edges (12), the inner vane tailing edges (17) are oriented to be curved back slightly from the inner wall circumference (8) of the internal cavity (5) of the transmission base, the outer vanes (9) are oriented such that the vane tailing edges are tangential to or close to an emerging axis (a) of the gap between the outer vane tailing edges (12) and the inner vane leading edges (15)—that is tangential to the convexly curved surfaces of the ridges (16) of the inner vanes, the vanes are symmetrically arranged in said configuration in a circular and cylindrical shape on the base plate (6) such that the inner vane (14) of a preceding set of vanes abuts against the outer vane (9') of a set of vanes of interest and the outer vanes of the subsequent set of vanes abut against the inner vane (14') of the set of vanes of interest, the cylindrical internal cavity serves as the vortex chamber (5), the annularly arranged vane tips are covered by an annular cover plate (23) so that fluid only flows along the vanes and then through the gap between the vanes, an extension chamber wall (24) of the vortex chamber axially extends from the vane tips cover plate to a certain distance, the open end downstream of the vortex chamber defines a fluid outlet (27) for the generated forced vortex to be used in a further process.

The apparatus for creating forced vortex according to the present invention is mounted in an external structure. When fluid is forced in through the fluid inlet into the fluid distribution chamber enclosing the transmission base of the apparatus for creating forced vortex (4) by the convexly curved vanes acting as the suction side and the fluid flow along a flow line f to attack the outer vane leading edges (10), due to the Coanda effect, the fluid is deflected to flow along the convexly curved surfaces of the outer vane ridges (11) along the flow line b which is directing the fluid into the transmission base of the apparatus for creating vortex as the laminar flow. When the fluid flow to the vane tailing edges (12) and through the gap (19) between the outer vane tailing edges (12) and the inner vane leading edges (15) to attack the inner vane leading edges (15), due to the Coanda effect, the fluid is deflect to flow along the ridges (16) of the inner vanes along the flow line c. Since inner vane tailing edges (17) are curved back from the circumference (8) of an inner wall of the vortex chamber and due to the suction of the fluid flowing through the gap (19') between the outer vane tailing edge (12') and the inner vane leading edge (15') of the subsequent set of vanes, the fluid is pulled to flow along the convexly curved surfaces of the ridges (16') of the inner vanes (14') of the subsequent set of vanes which are a part of the inner wall of the vortex chamber along the flow line c'. Due to the symmetrical arrangement of the vanes across the transmission base of the apparatus for creating vortex, the fluid flow in relay with each set of vanes and the flow along the inner wall of the vortex chamber is generated as shown as the flow line d such that the swirling flow is created in the vortex chamber. Since the pressure is lowest on the convexly curved surfaces compared with the pressure on the other portions in the area as the convexly curved vane surfaces block the pressure from the fluid flowing from the side of the convexly curved vane surfaces but the pressure is higher in the other portions as they are filled with fluid and since the flow on the convexly curved surfaces has less pressure drag than that in the flow on other surface configurations e.g., the flow on the concavely curved surfaces, a high flow speed can be achieved without requiring a high potential energy of pressure difference. Since the pressure drag is low, the flow pressure loss is also low. The flow speed is highest on the convexly curved surfaces of the vane ridges and is gradually reduced as the swirling flow approaches the center of the vortex as the energy decreases. The apparatus for creating vortex according to the present invention created a forced vortex in which a laminar swirling flow is generated and having a high rotational speed.

Figures 2A, 2B, and 2C show another embodiment of the apparatus for creating forced vortex according to the present invention in which the vanes for generating a swirling flow each has a trapezoid shape and in which the vortex chamber is formed in a conical shape. The operation principle is the same as mentioned in section of the apparatus for creating forced vortex provided with the non-squared rectangular vanes and a cylindrical vortex chamber. The only difference is that both the outer vanes (109) and the inner vanes (114) each has a trapezoid shape as shown in figure 2C that tapers from its vane root connected to the base to its vane tip. When the vanes are arranged on the round base plate (106) as annular shape of transmission base according to the above-mentioned configuration in the section of the apparatus for creating vortex provided with the non-squared rectangular vanes, a conical shape is formed both externally and internally. As shown in Figure 2A, an internal cavity (105) defining the vortex chamber can also has an extension chamber (125) of the vortex chamber mounted thereto. An extension chamber wall (124) of the vortex chamber extends from an annular vane tip cover plate (123). An extension chamber inner wall (126) is inclined in the same degree as that of the inclination of the vanes forming the inner wall of the vortex chamber (105) and is connected as a continuous plane to the inner wall of the vortex chamber. An open end downstream of the vortex chamber defines a fluid outlet (127) for the forced vortex swirling flow to be used in a further process.

The operation principle of the apparatus for creating forced vortex in which each of the vanes has a trapezoid shape and in which the vortex chamber has a conical configuration is the same as that of the apparatus for creating vortex provided with the non-squared rectangular vanes and the cylindrical vortex chamber (5). The differences are the trapezoid vanes and the conical vortex chamber. The outer trapezoid vanes (109) and the inner trapezoid vanes (114) each tapers from its vane root connected to the base to its vane tip. Therefore, the distance of the flow path from the vane leading edges outwardly facing the fluid distribution chamber flow through ridges (111) and flow through vane tailing edges (112) of the outer vanes (109) flow through gaps (119) between vanes flow through ridges (116) of inner vanes (114) to vane tailing edges (117). On the transmission base, the flow path from vane leading edge to vane tailing edge is gradually shorter from the vane roots to the vane tips . When said vanes are assembled according to the configuration mentioned in the section of the trapezoid vanes, a conical shape is formed as shown in Figure 2A. At a conical vortex chamber (105) a conical extension chamber (125) of the conical vortex chamber can be mounted thereto. Due to the circumference of the conical chamber which is continuously shorter from the upstream side to the downstream side as well as the distance of flow path which is gradually shorter from the vane roots to the vane tips, the rotational speed is continuously increased from the upstream side to the downstream side such that a forced vortex having a high rotational speed and in which a laminar swirling flow is formed can be obtained.

Figures 3A, 3B, and 3C show an apparatus for creating forced vortex swirling flow provided with double-convexly curved-sided vanes having an oval-shaped cross-section (209) that is a vane improved from the above-mentioned apparatus for creating vortex provided with two sets of vanes abutting each other i.e., an inner vane of a preceding set of vanes abuts an outer vane of a set of vanes of interest or an outer vane of the subsequent set of vanes abuts an inner vane of the set of vanes of interest. When the abutting vanes are combined into one vane such that the contour of curved ridges of two vanes are converged into one and their configuration is maintained, vane having an oval-shaped cross-section in which its vane leading edge is more rounded than its vane tailing edge (including the surface of its outer blade tailing edge (212) and the surface of its inner vane tailing edge (215)) wherein its shape is designed and arranged according to a predetermined configuration into an annular shape on a base plate (206). The apparatus for creating forced vortex provided with the oval-shaped vane (209) mounted inside an external structure consists of a fluid inlet for introducing fluid into a fluid distribution chamber enclosing a transmission base of the apparatus for creating forced vortex (204). The oval-shaped vane (209) is mounted on the base plate (206) and arranged into an annular shape on the base plate. An internal cavity (205) of the enclosing vanes has a cylindrical configuration defines a vortex chamber (205). Both outer side (211) and inner side (214) of the oval-shaped vane (209) are convexly curved wherein the vane leading edges including outer side (210) and the inner side (213) of the vane leading edge have more rounded configurations than those of the vane tailing edges including outer side vane tailing edge (212) and the inner side vane tailing edge (215). The oval-shaped vane (209) has a non-squared rectangular shape and a constant configuration and thickness from vane roots to vane tips. The configuration and size of the vanes are designed and the oval-shaped vanes are arranged on an annular area on the base plate (206) such that the vanes are disposed diagonally on the annular base plate such that the surfaces of the outer side vane leading edge (210) is diagonally oriented toward the fluid distribution chamber, the outer side vane ridge (211) is diagonally oriented toward the fluid distribution chamber, the outer side vane tailing edges (212) are diagonally oriented inward, the inner side vane tailing edge (215) is curved back slightly beyond an inner wall circumference (208) of the vortex chamber. The subsequent oval-shaped vanes are disposed similarly. The vanes are designed and arranged so that a certain distance gap (216) between vanes is provided and that the outer side vane tailing edge (212) is tangential to or close to an emerging axis (a) of the gap between vanes which is tangential to inner side ridge-side convexly curved vane surface (214') of a subsequent set of vanes (209'). The oval-shaped vanes are symmetrically arranged into an annular shape on the base plate (206). An extension chamber wall (224) of the vortex chamber can be extended upwardly from an annular cover plate (223) to a certain height to define an extension chamber (225) of the vortex chamber. At an open end downstream of the vortex chamber, a fluid outlet (227) for the generated forced vortex to be used in a further process.

When the fluid in the fluid distribution chamber flow to attack the outer side vane leading edge (210) as shown flowing along a flow line f, due to the Coanda effect, fluid is deflected to flow closely along the ridge-side convexly curved vane surface (211) of the outer side vane surface as shown by a flow line b. Upon reaching the outer side vane tailing edge (212), the outer side vane tailing edge disposed such that it is tangential to or close to the emerging axis (a) of the gap (216) between vanes which is tangential to the inner side ridge-side convexly curved vane surface (214') of the subsequent set of vanes (209') will cause the fluid to flow and attack an inner side vane leading edge (213') of the subsequent set of vanes. Due to the Coanda effect, the fluid is deflected to flow closely along the convexly curved surface of the inner side vane ridge (214') of the subsequent set of vanes (209') along a flow line c. Due to the inner side vane tailing edge (215') curved back from the circumference (208) of the inner wall of the vortex chamber and the suction force of the fluid flowing through the subsequent gap between vanes, the fluid is pulled to flow along the inner side ridge-side convexly curved vane surface (214') of the subsequent set of vanes (209'). The fluid in the distribution chamber flowing along a flow line f' attack a subsequent vane leading edge (210'). Due to the Coanda effect, the fluid is deflected to flow closely along an outer side ridge-side convexly curved surface (211') along a flow line b'. Due to the disposition of an outer side vane tailing edge (212') of the subsequent set of vanes (209') such that it is tangential to or close to an emerging axis of a subsequent gap (216') between vanes which is tangential to a convexly curved surface of an inner ridge-side (214") of a further subsequent set of vanes (209"), the fluid flows through the outer side vane tailing edge (212') and through the gap between vanes to attack an inner side vane leading edge (213"). Due to the Coanda effect, the fluid is deflected to flow closely along the ridge-side convexly curved surface (214") of an inner side vane surface of the further subsequent set of vanes (209") along a flow line c' that acts as a suction side. Therefore, fluid flowing toward the inner side vane tailing edge (215') of the subsequent set of vanes (209') whose vane tailing edge is curved back from the circumference of the inner wall of the vortex chamber, that is close to the gap (216') between vane is pulled to flow together with the fluid flowing along the ridge-side convexly curved surface (214") of the inner side vane surface of the further subsequent set of vanes (209") (the disposition of the inner side vane tailing edge to be curved back from the circumference of the inner wall of the vortex chamber has a great significance for inducing fluid to flow closely along the ridge-side surface of the inner side vane surface, on the contrary, if the vane tailing edge is not curved back, the fluid would gradually swirl toward the center of the vortex). Therefore, the fluid is pulled to flow closely along the convexly curved surface of the vane inner ridge-side which is a part of the wall of the vortex chamber along a flow line d. Due to the above-mentioned symmetrical arrangement of the oval-shaped vanes, flows on the inner convexly curved surface of each of the vanes flow in relay along the wall of the vortex chamber formed by the convexly curved surface of the inner ridge-side of each of the vanes such that a swirling flow is generated in the vortex chamber. Due to the above-mentioned vane arrangement, the fluid is pulled to flow along the inner wall of the vortex chamber such that a forced vortex is created. Due to the Coanda effect, the generated swirling flow is a laminar swirling flow. Since the swirling flow on the convexly curved surfaces has a low pressure and a low pressure drag, its rotational speed is high. The fluid flows swirlingly out of the apparatus for creating vortex according to the present invention through the fluid outlet (227) located at the open end downstream of the vortex chamber.

The oval-shaped vanes type apparatus for creating forced vortex provided with the oval-shaped vane (209) for generating a swirling flow can be designed to have a trapezoid configuration in which the vanes gradually taper on all sides from vane roots connected to the base to vane tips on the other end. When the said configuration oval-shaped vanes were arranged according to above mentioned non-squared rectangular vanes which are symmetrically arranged on the base plate, a conical chamber defining the vortex chamber is formed and a conical extension chamber of the vortex chamber can be mounted in which its inclination angle is the same as that of the vanes section vortex chamber and in which the inner wall of the extension chamber of the vortex chamber is connected with the same plane to the vortex chamber. The apparatus for creating forced vortex provided with the trapezoid, oval-shaped vanes for generating a swirling flow has the same operation principle as that of the trapezoid-shaped bilayer vane-type apparatus for creating vortex with the conical vortex chamber (104) as mentioned in detail in said section.

Figures 4A, 4B, and 4C show a volute compressor-type forced vortex generator (1) consisting of a fan and a motor for forcing fluid in through a tangential fluid inlet (2) into a volute fluid distribution chamber (3) enclosing the apparatus for creating vortex (4). The fluid distribution chamber is widest at the portion adjacent to the inlet and gradually becomes narrower toward the narrowest portion where it converges to the inlet such that the fluid is evenly distributed into all the gaps (16) between vanes. A partitioning wall (20) is mounted at the area where the inlet converges to the end of the fluid distribution chamber. A fluid distribution chamber wall (7) is continuously concavely curved and converges to the partitioning wall. An inlet side partitioning wall (21) has a convexly curved surface. The non-squared rectangular, bilayer vane-type apparatus for creating vortex and the cylindrical vortex chamber (5); the trapezoid shape, bilayer vane-type apparatus and the conical vortex chamber (104); the non-squared rectangular, oval-shaped vane-type apparatus and the cylindrical vortex chamber (204); or the trapezoid, oval-shaped vane-type apparatus and the conical vortex chamber are mounted on the base plate (6). The fluid outlet is formed at the open end downstream of the vortex chamber.

When fluid is forced in through the fluid inlet (2) into the fluid distribution chamber (3), due to the wall of the fluid distribution chamber having a concavely curved configuration acting, in fluid dynamics, as a pressure side, the partitioning wall at the inlet, and the vane ridges (11) each facing outward and having a convexly curved surface acting as a suction side, the fluid is pressured and drawn to flow toward and attack the vane leading edges (10). Due to the Coanda effect, the fluid is deflected to flow closely along the ridge-side convexly curved surfaces (11) of the outer vane toward the vane tailing edges (12). Since the outer vane is disposed such that the emerging axis of the gaps between the outer vane tailing edges and the inner vane leading edges (15) are tangential to the ridges (16) of the inner vane , the fluid flows toward and attacks the inner vane leading edges (15). Due to the Coanda effect, the fluid is deflected to flow closely along the convexly curved surfaces of the inner vane ridges (16). Due to the disposition of the inner vane tailing edges (17) to be curved back slightly beyond the circumference (8) of the inner wall of the vortex chamber together with the suction of fluid flowing through the gaps between vanes of the subsequent vane set, the fluid is pulled to flow closely along the convexly curved surfaces of the ridge side of the subsequent vane set. Due to the symmetrical arrangement of the vanes across the transmission base of the apparatus for creating vortex, flows upon the convexly curved surfaces of the ridges of each vane sets flow in relay to each other . The vortex in the vortex chamber is created and continuously transferred to an extension chamber (25) of the vortex chamber and then exit the vortex chamber through the fluid outlet

(27). The other embodiments of the apparatus for creating vortex including the trapezoid, bilayer vane-type apparatus and the conical vortex chamber, and the non-squared rectangular, oval-shaped vane-type apparatus are mentioned above. The operation of the trapezoid, oval-shaped vane-type apparatus and the conical vortex chamber is similar to that of the trapezoid, bilayer vane-type and the conical vortex chamber.

Figures 5A, 5B, 5C, and 5D show an impeller compressor-type forced vortex generator (300) consisting of: an axial fluid inlet (301), an impeller with rotor (303), a diffuser (307), a fluid distribution chamber (315), an apparatus for creating forced vortex consisting of: the vortex creating vanes (109,114) in case of trapezoid bilayer vane type according to Figures 2A 2B 2C , or trapezoid double-convexly curved-sided having oval-shape cross section type vanes , the vortex chamber (105), the extension chamber of the vortex chamber (125), and a fluid outlet (127).

The impeller compressor of the impeller compressor-type forced vortex generator consists of the axial fluid inlet (301), a motor transmitting rotation power via a shaft (302) to an impeller (304) in which its radius is shorter on its upstream side and longer on its downstream side such that the fluid propelling rate at impeller blade tips (305) is higher than that the fluid can be drawn by the impeller on the upstream side at a sufficient replacement to compensate for outflow fluid such that a vacuum is formed on the upstream side. Therefore, the impeller compressor has a highly efficient suction. Since the impeller compressor operates effectively at a very high rotational speed as a simultaneous rotation of the rotor and the impeller continuously propel the fluid, a high kinetic energy is generated and converted to pressure by the diffuser that decreases the speed and convert the kinetic energy to pressure potential energy. Since the vortex generator according to the present invention requires suction force, pressure, rotational speed, and tangential flow about the central rim wherein the suction force is used to draw fluid into the system wherein the suction force is high when exit flow rate is high, the kinetic energy of the high velocity flow and the pressure potential energy accelerates the flow speed, the tangential flow about the central rim causes the fluid to flow along the vanes to generate a high rotational speed to generate a high centrifugation force, therefore to achieve said objectives, an impeller base plate (306), the impeller (304), impeller blade tips (305), a diffuser base plate (308), and diffuser vanes (309) are designed to be inclined by a certain extent so that the exit flow from the impeller/diffuser system is a mixed flow of a radial flow and an axial flow. To generate a radial flow, the diffuser vanes are designed to be inclined relatively steep on a plane and to form a relatively wide angle to the radius line which is perpendicular to the tangent of circumference of the diffuser base plate and to be inclined toward the same direction as that of the rotation of the impeller such that most of the fluid forced away from the impeller blade flows along ridge-side convexly curved surface (312) of the diffuser vanes which are also caused by multiple factors e.g., the inclination of the impeller blade, the rotational speed of the impeller, etc. Diffuser vane tailing edges (311) are slightly curved back beyond the circumferential edge of the diffuser base plate (308). A concave side of each diffuser vane (313) has a certain thickness such that the fluid flowing from the concave side of the diffuser vanes flows toward the ridge-side edge portions (312) of the subsequent diffuser vanes such that a high tangential component is generated . To avoid the fluid exiting the impeller/diffuser system having a high pressure but a low flow speed, the number of the diffuser vanes is preferably low i.e., the solidity value of the diffuser vanes is preferably relatively low. The diffuser vanes are disposed perpendicularly on the inclined diffuser base plate. Due to the perpendicular disposition on the diffuser base plate (308), the upper part of the diffuser vane (320) on which diffuser vane is adjacent to a circumference of the diffuser base plate extends beyond the diffuser base plate (308) to a certain extent. A conical rim (316) extends from the diffuser base plate having an inclination of the same or similar degree to that of the diffuser blades extending from the circumference of the diffuser base plate. The conical rim (316) has a certain length which acts as a short surface for the fluid to swirl about before the fluid flows into the vane gaps of the apparatus for creating vortex. The conical rim (316) is long in case the motor of the impeller is coupled to the blades mounted under the diffuser base plate (308). The conical rim (316) is short in case the motor is mounted separately from the blades so that the motor is not in the flow path wherein the motor transmits rotational power via the shaft (302). Further to the conical rim, the apparatus for creating forced vortex is axially mounted such that the base (106) adjoins the conical rim (316).

The fluid is drawn in through the fluid inlet (301) and, by centrifugation force, is thrown outward through impeller blade tips . Due to the inclination of the diffuser vanes (309) and the inclination of the diffuser base plate (308) corresponding to the inclination of the impeller blade tips (305), most of the fluid is thrown by centrifugation force to flow along the ridge-side convexly curved surfaces (312) of the diffuser vanes. Due to the diffuser vane tailing edges (311) that are slightly curved back from the circumference of diffuser base plate (308) with the suction force of the subsequent diffuser vanes, the fluid is pulled to flow tangentially to the diffuser vane tailing edges (311) as shown by a flow line (400) in Figure 5E. Due to the inclination of the impeller base plate (306), the inclination of the impeller blades (304), the inclination of the diffuser base plate (308), and the inclination of the diffuser vanes having the same or similar degrees, the mixed flow of the radial flow and the axial flow is created and a tangential, swirling, and diagonal flow along the conical rim (316) that is a convexly curved surface is generated as shown by a flow line (401) in Figure 5E as a laminar flow having a very high flow speed as the convexly curved surface has a lower pressure and lower pressure drag than those of other parts in that area, particularly when compared with the flow on the concavely curved surface of a fluid distribution chamber wall (319). When the fluid swirlingly flows downward to the vanes for creating vortex as shown in Figure 2A, 2B, and 2C and attacks the vane leading edges, due to the convexly curved outer vane leading edges (110) and the Coanda effect, the flow is deflected to flow closely along the convexly curved vane ridges (111) toward the vane tailing edges (112) and then attack the convexly curved surfaces of the inner vane leading edges (115). Due to the Coanda effect, the flow is deflected to flow closely along the ridge-side convexly curved surfaces (116) of the inner vanes toward the inner vane tailing edges (117) that are slightly curved back from the circumference (108) of the inner wall. Additionally, with the suction of fluid flowing through the subsequent gaps between vanes, the fluid is pulled to flow closely along the convexly curved surfaces of the subsequent inner vane ridges. Due to the convexly curved surface of the outer vane leading edges diagonally oriented outward toward the fluid distribution chamber acting, in fluid dynamics, as a suction side and the opposite side that is the fluid distribution chamber wall (319) that is concavely curved according to the configuration of the annular conical vortex chamber (315) as shown in Figure 5C, and 5D acting, in fluid dynamics, as a pressure side, the suction from the suction side of the vane leading edges (110) and the vane ridges (111) and the pushing force from the distribution chamber wall are generated so that the fluid flow enters the gaps between vanes along the flow line (402) as shown in Figure 5E.,to flow closely along the convexly curved surface of the inner vane ridges (116) to the inner vane tailing edges (117), due to the inner vane tailing edges (117) to be curved back slightly beyond the circumference (108) of the inner wall of the vortex chamber (105) as shown in Figures 2B to pull the fluid to flow closely along the convexly curved surface of the inner vane ridges (116). Due to the symmetrical disposition of both the outer and inner vanes across the ring, fluid flows in relay with flow of each vanes to generate swirling flow in the vortex chamber (105). Due to the Coanda effect, the fluid is induced or pulled to flow closely along the convexly curved surfaces of all vane ridges defining the inner wall of the vortex chamber (105) such that a forced vortex is created in which the rotational speed is highest at the outermost area of the vortex and a laminar swirling flow is created at a high rotational speed as the pressure and the pressure drag on the convexly curved surfaces are much lower than those in other surfaces in said area. Due to the trapezoid configuration of the vanes in which the size of the vanes is gradually smaller from the vane roots toward the van tips, when the vanes are arranged on the annular area, an inclination is formed on both the inner side and the outer side. The outer inclination tapers in and the inner inclination forms a conical internal cavity as shown in Figure 2A. Due to size of the vanes which is gradually smaller from the vane roots to the vane tips , distances of the flow path which fluid flow from the fluid distribution chamber to the vortex chamber through vane leading edges to vane tailing edges are gradually shorter from the vane roots to the vane tips and the circumference of the conical vortex chamber gradually shortens from vane roots to vane tips, therefore rotational speed is continuously increased according to the shorten flow path. Since the extension chamber (125) of the vortex chamber is inclined by the same degree, the rotational speed is gradually increased until the fluid flows out through the fluid outlet (127) located at the open end downstream of the vortex chamber. The created vortex (403) is a forced vortex in which a laminar swirling flow is created due to Coanda Effect, fluid deflected to flow closely along convexly curved ridges surface of inner vanes, in which the rotational speed is high as shown by the flow line (403) in Figure 5E.

The impeller compressor-type forced vortex generator can be mounted with other configurations of the apparatus for creating vortex as mentioned above including the apparatus for creating vortex comprising overlapping bilayer vanes having a non-squared rectangular configuration and a cylindrical vortex chamber, the apparatus for creating vortex comprising double-convexly curved-sided vanes each having an oval-shaped cross-section and having a non-squared rectangular configuration and a cylindrical vortex chamber, and the apparatus for creating vortex comprising double-convexly curved-sided vanes each having an oval-shaped cross-section and having a trapezoid configuration and a conical vortex chamber whose operation details were same as explained above.

With regard to the extension chamber of the cylindrical or conical vortex chamber, each has a circular inner wall according to their configuration , swirling in the cylindrical or conical vortex chamber is flowing toward concavely curved surface, to flow along a concavely curved surface in which the flow pressure and pressure drag is high, the rotational speed on the concavely curved surface is lower, and the pressure loss is high. In order to solve the problem, the invention as shown in Figures 6A, 6B, 6C, and 6D is provided by forming an inner wall surface of the extension chamber of the vortex chamber as alternated convex corrugations (501) and concave corrugations (502) and mounting double-convexly curved-sided vanes (503) over the concave corrugations. The double-convexly curved-sided vanes each comprises a vane upper convexly curved ridge side (506) and a vane lower convexly curved ridge side (505), in which the oval-shaped cross-section view on the side of the vane leading edges (504) is more rounded than that on the side of vane tailing edges (507). The shape of each of them can be relatively tapered or relatively circular depending on the height or the depth of the corrugations or the width of the corrugations. The vanes mounted to the concave corrugations (502) may be fixed to the floor of each concave corrugation by circular dowel pins, fin, thin double-convexly curved-sided vanes, or other means with minimum obstruction or variance to the flow path of the fluid. The space under each vane defines a flow passage (508) from a convexly curved surface of a previous convexly curved corrugation (A1) to a convexly curved surface of the subsequent convexly curved corrugation (A2). The vane leading edges (504) are designed and disposed to face the inward flow path of the fluid from the convexly curved surface of the previous convexly curved corrugation (A1) and the vane tailing edges (507) to be tangential to or close to emerging axis (a) of the under-vane flow gaps (508), tangential to the convexly curved surfaces of the following convexly curved corrugations (A2). The curved corrugations are perpendicular to a flow direction or substantially perpendicular to the flow direction as shown in Figure 6B. The curved corrugations Y are perpendicular to the flow direction X. The convexly curved corrugation (A1) is followed by the concavely curved corrugation (B1) mounted with the double-convexly curved-sided vane. The convexly curved corrugations and the concavely curved corrugations are alternately arranged in the following order: A1, B1, A2, B2, A3, B3, An....Bn across the inner wall of the extension chamber of the vortex chamber.

The inner wall surface of the extension chamber of the vortex chamber provided with the alternate convexly curved corrugations and concavely curved corrugations mounted with the double-convexly curved-side vane on the concavely curved corrugation to reduce an increase in the flow pressure and reduce the pressure drag wherein the corrugations and double-convexly curved-side vanes are perpendicular to the flow direction. When the fluid flows swirlingly to the extension chamber of the vortex chamber mounted with the apparatus for accelerating flow speed which is the convexly curved surfaces for reducing an increase in the flow pressure and reducing the pressure drag, due to the Coanda effect, the swirling fluid flow closely along the inner wall convexly curved surfaces (501) of the extension chamber of the vortex chamber flows along the flow line f and attacks the vane leading edges (504) of the double-convexly curved-sided vane (503). Due to the curvature of each vane leading edge defining a convexly curved surface and the disposition of the vane leading edges with a suitable angle of attack, the Coanda effect is created, the fluid is deflected to flow closely along the convexly curved surfaces of the vane leading edges in two paths. The path b1 flows along the vane lower convexly curved surfaces and along the ridge-side convexly curved surfaces (505) of the vane lower side toward the vane tailing edges (507). These vane lower convexly curved surfaces each act as a suction side and the surfaces opposite to these vane lower convexly curved surfaces are concavely curved surfaces of concavely curved corrugations each acting as a pressure side. The fluid is pushed and pulled to flow mostly toward the vane lower convexly curved surfaces with a much higher flow speed than that in the concave sides. Due to the disposition of the vane tailing edges to be tangential to or close to the emerging axis (a) of the under-vane flow gaps (508), tangential to the convexly curved surfaces of the subsequent convexly curved corrugations (A2), the fluid flow closely along the convexly curved surfaces of the subsequent convexly curved corrugations (A2) along the flow line c. The path b2 flows closely along the convexly curved surfaces of the vane leading edges and along the ridge-side, convexly curved surfaces (506) of the vane upper surface toward the vane tailing edges (507). Due to the suction force of the fluid flowing through the gaps (508) between the vane tailing edges and the convexly curved surfaces of the subsequent convexly curved corrugations (A2), the fluid flowing closely along the ridge-side, convexly curved vane upper surfaces (506) and passing the vane tailing edge (507) flows closely along the convexly curved surfaces of the subsequent convexly curved corrugations (A2) along the flow line c. Due to the alternate convexly curved corrugation surfaces and concavely curved corrugations symmetrically mounted with the double-convexly curved-sided vanes as said manner around the inner wall of the extension chamber of the vortex chamber, most of the flows are from one convexly curved surface to another i.e., the flows from the convexly curved surfaces of the convexly curved corrugations to the vane lower convexly curved surfaces and the vane upper convexly curved surfaces. These flows always repeat in said manner for the duration of the swirling flow in the extension chamber of the vortex chamber in which the pressure on the convexly curved surfaces, the flow pressure increment and the pressure drag are less than those on the flow on the concavely curved surfaces or a flat surface, therefore the achieved rotational speed is higher, the pressure loss is lower, and the laminar swirling flow is more favorably sustained.

The apparatus for creating forced vortex and the forced vortex generator according to the present invention implement the convexly curved vanes for deflecting the flow with the Coanda effect in which the fluid flows along the convexly curved surfaces even if these convexly curved surfaces deviate from the original flow directions. The flow along the convexly curved surfaces has less pressure, generates less flow pressure, and has less pressure drag therefore has a higher flow speed than that of the flow on the concavely curved surfaces or a flat surface. The flow on the convexly curved vane surfaces is considered a flow on a suction side which creates a laminar flow. Since the swirling flow in the vortex chamber according to the present invention is deflected by the convexly curved vanes using kinetic energy as the main energy for creating vortex without using a high amount of pressure potential energy to create vortex, combining with the generation of the flow on the convexly curved surfaces having a low pressure, a low increase in the flow pressure, a low pressure drag, and a low loss of energy particularly the pressure loss, they are apparatus/generator for creating forced vortex with a high rotational speed and laminar swirling flow .

Claims

1. An apparatus for creating forced vortex according to the present invention which is an apparatus to be mounted inside an external structure consisting of a fluid distribution chamber enclosing a vortex creating apparatus (4), bilayer vanes being mounted on a base plate (6) and arranged into an annular shape, an internal cavity of the annulus being an internal cavity for use as a vortex chamber (5), wherein outer vanes (9) are each configured into a non-squared rectangular shape having a certain thickness, ridges (11) of the outer vanes are convexly curved from vane leading edges (10) to vane tailing edges (12), vane lower side (13) is concavely curved or flat, inner vanes (14) are configured into a non-squared rectangular shape having a certain thickness, ridges (16) of the inner vanes are convexly curved from vane leading edges (15) to vane tailing edges (17), inner vane lower side (18) is concavely curved or flat, the outer and inner vanes are configured and sized and arranged such that the leading edges (10) and the convexly curved vane ridges (11) of the outer vanes (9) are diagonally and outwardly oriented toward the fluid distribution chamber, the vane tailing edges (12) are diagonally and inwardly oriented, the inner vanes (14) are disposed next to the outer vane tailing edges (12) with a gap (19) between the outer vane tailing edges (12) and the inner vane leading edges (15), the inner vanes (14) are disposed such that the ridges (16) of the inner vanes are oriented toward the internal cavity which is the vortex chamber (5), the convexly curved inner vane leading edges (15) are oriented toward the convexly curved of the outer vane tailing edges (12), the inner vane tailing edges (17) are oriented to be curved back from circumference (8) of the inner wall , the outer vanes (9) are oriented such that the outer vane tailing edges (12) are tangential to or close to emerging axis (a) of the gap between the outer vane tailing edges (12) and the inner vane leading edges (15)—that is tangential to convexly curved surfaces of the ridges (16) of the inner vanes, both of the outer vanes (9) and the inner vanes (14) are symmetrically arranged in said configuration into the annular shape on the base plate (6), wherein the inner vane of a

preceding set of vanes abuts against the outer vane of a set of vanes of interest and the inner vane of the set of vanes of interest abuts against the outer vane of the subsequent set of vanes, annularly arranged vane tips are covered by an annular cover plate (23), an open end downstream of the vortex chamber defines a fluid outlet (27) for swirling fluid.

2. The apparatus for creating forced vortex according to the invention of claim 1 wherein both the outer blades (109) and the inner blades (114) for creating a vortex each has a trapezoid shape tapering from vane roots to vane tips, and when the vanes are arranged according to the configuration of the apparatus for creating forced vortex according to claim 1, a conical vortex chamber (105) is obtained.

3. The apparatus for creating forced vortex according to the invention of claim 1, wherein vanes for creating the vortex each is double-sided convexly curved vane with an oval-shaped cross-section with their leading edges being more rounded than their tailing edges, being configured as an apparatus to be mounted inside an external structure consisting of a fluid distribution chamber enclosing a vortex creating apparatus (204), double-convexly curved-sided vanes (209) being mounted on a base plate (206) and arranged into an annular shape (204), wherein the double convexly curved-sided vane (209) is configured into a non-squared rectangular shape having a certain thickness that is constant from the vane roots to vane tips thereof, the double-convexly curved-sided vane (209) is configured and sized and arranged such that an vane outer leading edge (210) and an vane outer ridge (211) is diagonally and outwardly oriented toward the fluid distribution chamber, an vane outer tailing edge (212) is diagonally and inwardly oriented, the curve of a convexly curved surface of an vane inner tailing edge (215) is positioned to curve back slightly beyond a circumference (208) of an inner wall, a subsequent double-convexly curved-sided vane (209') is disposed in the same manner with a certain distant vane gap (216) therebetween, a convexly curved surface of a vane inner leading edge (213') of the subsequent vane (209') is oriented toward a convexly curved surface of the vane outer tailing edge (212) of the preceding vane (209) so that a convexly curved ridge of inner surface (214') of the subsequent vane (209') is oriented toward an internal cavity for use as a vortex chamber (205) so that the curve of a convexly curved surface of a

vane inner tailing edge (215') of the subsequent vane (209') is curved back beyond the circumference (208) of the inner wall of the vortex chamber (205), both the preceding vane (209) and the subsequent vane (209') is arranged such that the vane outer tailing edge (212) of the preceding vane (209) is tangential to or close to emerging axis (a) of the gap (216) between vanes that is tangential to the convexly curved ridge of vane inner surface (214') of the subsequent vane (209'), each of the vanes in said configuration is arranged to form an annular shape (204), annularly arranged vane tips are covered by an annular plate (223), an open end downstream of the vortex chamber defines a fluid outlet (227) for swirling fluid to be used in a further process.

4. The apparatus for creating forced vortex according to the invention of claim 3 wherein vanes for creating the vortex each is double-sided convexly curved vane with an oval-shaped cross-section with their leading edges more rounded than the vane tailing edges thereof, the vanes have a trapezoid shape with a certain thickness, the vanes taper from the vane roots to the vane tips, and when the vanes each is double-sided convexly curved vane is arranged according to the configuration of the apparatus for creating forced vortex according to claim 3, a conical vortex chamber is formed.

5. The apparatus for creating forced vortex according to the invention of any one of claims 1, 2, 3, 4 further comprises an extension chamber of the vortex chamber.

6. The apparatus for creating forced vortex according to the invention of claim 5 wherein the extension chamber of the vortex chamber has a cylindrical shape.

7. The apparatus for creating forced vortex according to the invention of claim 5 wherein the extension chamber of the vortex chamber has a conical shape.

8. The apparatus for creating forced vortex according to the invention of claim 7 wherein the extension chamber of the vortex chamber has a conical shape, on the inner surface of the extension chamber of the vortex chamber, fluid accelerator consisting of a convexly curved corrugation (501) alternated transversely by a concavely curved corrugation (502), the corrugations are longitudinal corrugation from upstream to downstream of the extension vortex chamber , the corrugations are wider on an upstream side and become gradually narrower toward

a downstream side along the conical configuration of the extension chamber of the vortex chamber, a linear line Y of corrugation is perpendicular to a flow direction line X or substantially perpendicular to a flow direction X, the longitudinal convexly curved corrugation (501) which is alternated transversely by a longitudinal concavely curved corrugation (502) of the extension vortex chamber, corrugations are symmetrically mounted continuously along the entire inner wall of the extension chamber of the vortex chamber, a double-convexly curved-sided vane (503) is mounted on each of the concavely curved corrugations on the wall of the extension chamber of the vortex chamber, the vanes are positioned above the surface of the concavely curved corrugations (502) by a certain distance so that flow channels (508) are formed and connect a convexly curved surface of a preceding convexly curved corrugation (A1) to a convexly curved surface of a subsequent convexly curved corrugation (A2), the double-convexly curved-sided vanes (503) are disposed such that vane leading edges (504) are in a certain level and form an angle of attack to receive the fluid flowing from the preceding convexly curved corrugation (A1) and that vane tailing edges (507) are each tangential to or close to an emerging axis (a) of each of the flow channels (508) under each vane that is tangential to the convexly curved surface of the subsequent convexly curved corrugation (A2).

9. The apparatus for creating forced vortex according to the invention of claim 6 wherein the extension chamber of the vortex chamber has a cylindrical shape, on the inner surface of the extension chamber of the vortex chamber, a flow accelerator consisting of a convexly curved corrugations (501) alternated transversely by a concavely curved corrugations (502) mounted on the inner wall of the extension chamber of the vortex chamber, the curved corrugations are longitudinal corrugation from upstream to downstream of the extension chamber of the vortex chamber, each of the curved corrugations has the same width and depth over its entire length along the cylindrical configuration of the extension chamber of the vortex chamber, the curved corrugations are symmetrically arranged on a wall inside the extension chamber of the vortex chamber, the linear line Y of curved corrugation is perpendicular to the flow direction line X or substantially perpendicular to the flow direction line X, the double-convexly curved-sided vanes (503) are mounted over all concavely curved corrugations (502) on the inner wall of the

extension chamber of the vortex chamber wherein the vanes are positioned above the surface of the concavely curved corrugations (502) by a distance so that flow channels (508) are formed and connect the preceding convexly curved corrugation (A1) to the subsequent convexly curved corrugation (A2), the double-convexly curved-sided vanes (503) are disposed such that vane leading edges (504) are in a certain level and form the angle of attack to receive fluid flowing from the convexly curved surface of the preceding convexly curved corrugation (A1) and that vane tailing edges (507) are each tangential to or close to the emerging axis (a) of each of the flow channels (508)that is tangential to the convexly curved surface of the subsequent convexly curved corrugation (A2).

10. The apparatus for creating forced vortex according to the invention of any one of claims 1, 2, 3, 4, 5, 6, 7, 8, 9 wherein the apparatus for creating vortex is mounted in a volute compressor-type forced vortex generator consisting of a motor and an impeller for forcing fluid into a fluid inlet (2) to introduce the fluid into the fluid distribution chamber (3) enclosing the vortex creating apparatus (4), wherein the fluid distribution chamber (3) gradually tapers to its minimum width as it converges to a partitioning wall (20) disposed next to the fluid inlet (2), a side of the partitioning wall (20) adjacent to an opening of the fluid inlet formed as a convexly curved surface (21) to induce or pull fluid to attack the outer vane leading edges (10) of the outer vanes to evenly distribute the fluid into all gaps (19) between vanes of the vortex creating apparatus (4), the fluid outlet is disposed axially at the open end downstream of the vortex chamber of the apparatus for creating vortex.

11. The apparatus for creating forced vortex according to the invention of any one of claims 1, 2, 3, 4, 5, 6, 7, 8, 9 wherein the apparatus for creating vortex is mounted in an impeller compressor-type forced vortex generator (300) consisting of a fluid inlet (301), a motor, an impeller (304), an impeller base (306), a diffusor base plate (308) inclined by an extent, diffusor vanes (309) mounted on the diffusor base plate (308), wherein the diffusor vanes (309) are concentrically curved and diffusor vane tailing edges (311) are curved slightly inward from the circumferential edge of the diffusor base plate (308), the diffusor vanes are disposed such that they are relatively inclined from radius line that perpendicular to tangent of the

circumference of diffusor base and twisted in the rotation direction of the impeller (304), the diffusor vanes (309) have a certain thickness such that the concave curvature of diffuser vane lower side (313) is reduced so that fluid flowing along the concavely curved side (313) of the diffusor vanes passes the diffusor vane tips and attacks and flows closely along a ridge side convexly curved surface (312) of the subsequent diffusor vanes, the diffusor vanes (309) are mounted perpendicularly to the diffusor base plate (308) that is inclined by a certain extent such that upper part of the diffusor vane curved tailing edges (320) extend beyond the circumferential edge of the diffusor base plate (308) by a certain extent above a fluid distribution chamber (315) enable to form a mixed flow, i.e., a simultaneous radial flow and axial flow, to create a tangential flow along a convexly curved surface of an axially mounted conical rim (316) extending from the diffusor base plate (308) by a certain extent, the conical rim is inclined from the vertical direction by same degree or by a similar degree to that of the inclination of the diffusor vanes extending beyond the circumferential edge of the diffusor base plate (308), the apparatus for creating forced vortex according to the preceding claims is axially mounted inside the fluid distribution chamber (315), a fluid outlet is disposed axially at an open end downstream of a vortex chamber of the apparatus for creating forced vortex.

12. The apparatus for creating forced vortex according to the invention of claim 11 wherein the fluid distribution chamber gradually tapers to be narrower from an upstream side to a downstream side such that fluid is evenly distributed into all parts of the vane gaps.

13. The flow accelerator for accelerating fluid flow velocity on a flow path consisting of the convexly curved corrugation surfaces (501) alternated by the concavely curved corrugation surfaces (502), wherein the curved corrugations are formed such that the linear line Y of the curved corrugation is perpendicular to the flow direction line X or that the linear line of the curved corrugation substantially perpendicular to the flow direction line, the double-convexly curved-sided vanes (503) are mounted over all the concavely curved corrugations (502) wherein the vanes are positioned above the surface of the concavely curved corrugations by a distance so that the flow channels (508) are formed under the vanes and connect the preceding convexly curved corrugation (A1) to the subsequent convexly curved corrugation (A2), the double-

convexly curved-sided vanes (503) are disposed such that the vane leading edges (504) are in a certain level and form the angle of attack to receive the fluid flowing from the convexly curved surface of the preceding convexly curved corrugation (A1) attacks the vane leading edges (504) provided that the vane tailing edges (507) are each tangential to or close to the emerging axis (a) of each flow channel (508) that is tangential to the convexly curved surface of the subsequent convexly curved corrugation (A2), the convexly curved corrugations and the concavely curved corrugations are alternately arranged and the double-convexly curved-sided blades are mounted over the concavely curved corrugations according to said configuration over the flow path through which fluid flows.

14. A diffusor system of an impeller compressor for generating a mixed flow consisting of a radial flow and an axial flow, to create a tangential flow about a conical or cylindrical rim consisting of the impeller (304), and the impeller base plate (306), the diffusor vanes (309), the diffusor base plate (308), wherein the impeller, and the impeller base plate, and the diffusor vanes, and the diffusor base plate are inclined by a certain extent, preferably by the same degree, the diffusor vanes (309) have an aerodynamic shape, the ridge side (312) of the diffusor vanes (309) is convexly curved from vane leading edges (310) to vane tailing edges (311), the vanes have a certain thickness such that the concave curvature of vane lower side (313) is reduced, the diffusor vanes (309) are perpendicularly mounted on the diffusor base plate (308) such that the inclination of the upper side of the diffusor vane curved edges (320) tangential to the circumference of outer base edge of the diffusor base plate (308),the upper side of the the diffusor vane curved edges extends beyond the edge line of the diffusor base plate (308) by a certain extent, the diffusor vanes (309) are inclined and concentrically curved in the rotation direction of the impeller (304), the diffusor vanes (309) are radially diagonally disposed such that the diffusor vane tailing edges (311) are curved slightly inward from the edge of the diffusor base plate (308), and the vane lower side of the diffusor vanes are configured to have a certain thickness such that fluid flowing from the concavely curved side of the vane tailing edges is directed to the ridge-side convexly curved surface (312) of the subsequent diffusor vanes, the diffusor vanes are symmetrically arranged in said configuration on the diffusor base

plate (308), a conical or cylindrical rim (316) is continuously formed downward from the diffusor base plate (308), the conical or cylindrical rim is connected from the outer edge of the diffusor base plate (308), the conical rim (316) is vertically inclined in the same degree or similar degree as that of the inclination of the upper side of the diffusor vane edges (320) extending beyond the outer edge of the diffusor base plate (308).

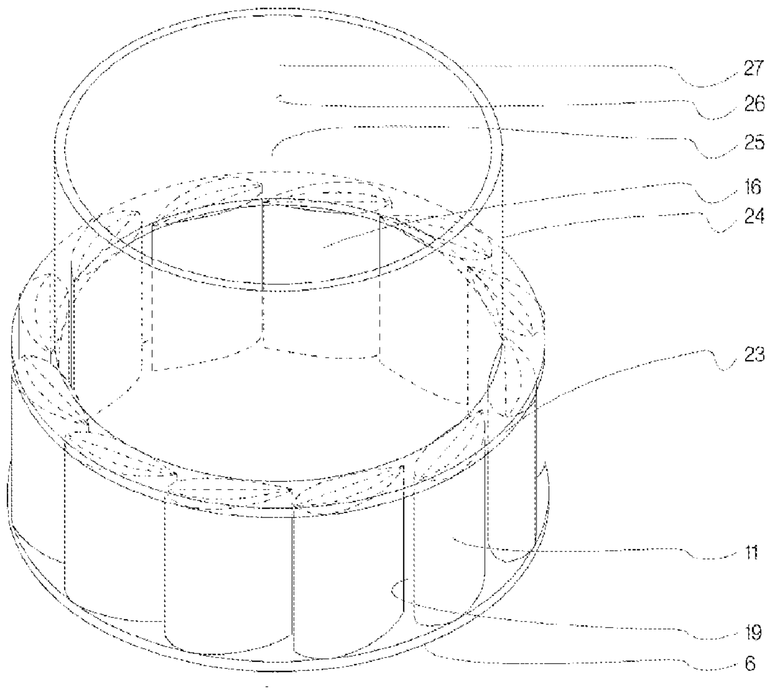
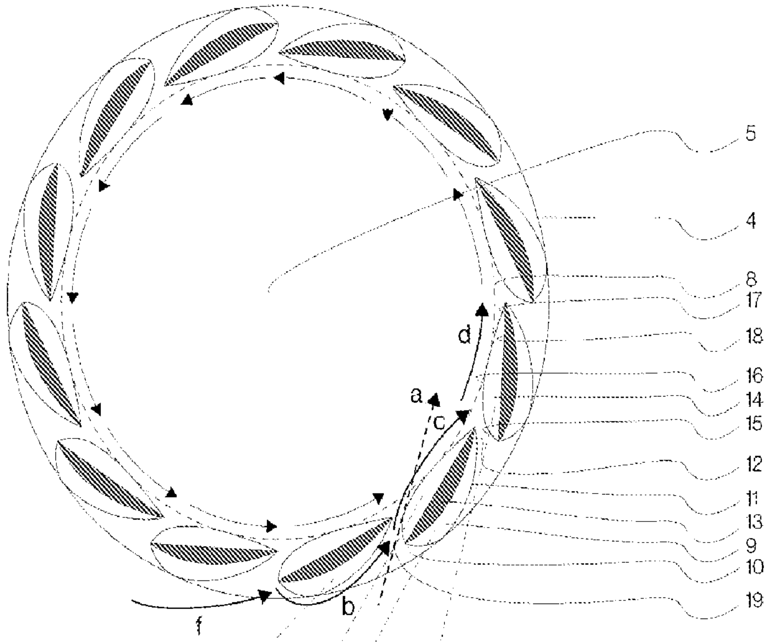


Figure 1A

Figure 1B



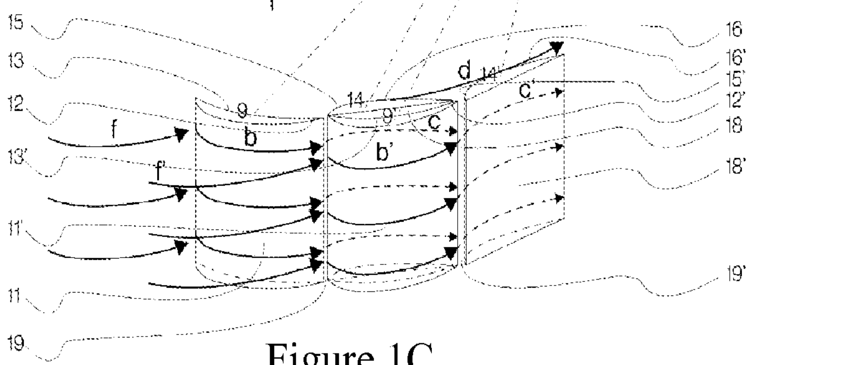


Figure 1C

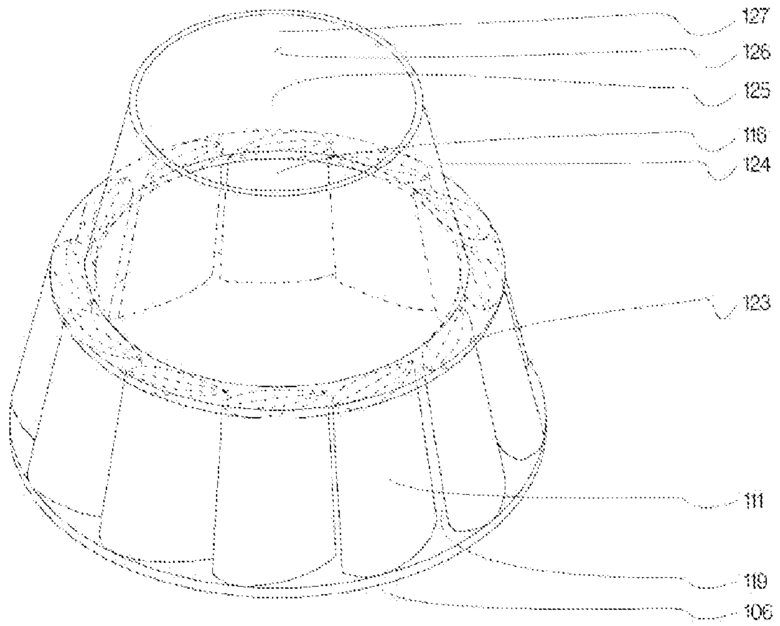


Figure 2A

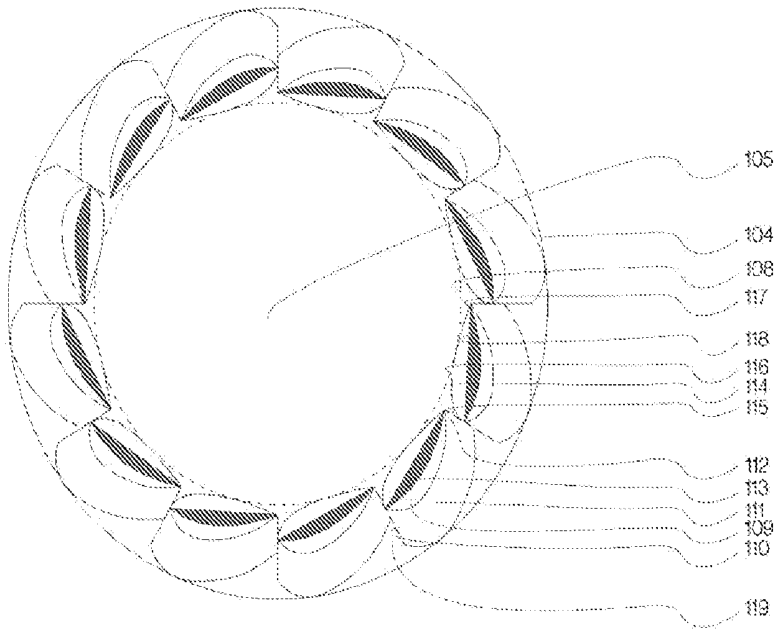


Figure 2B

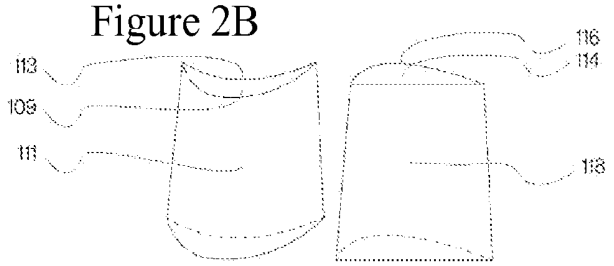


Figure 2C

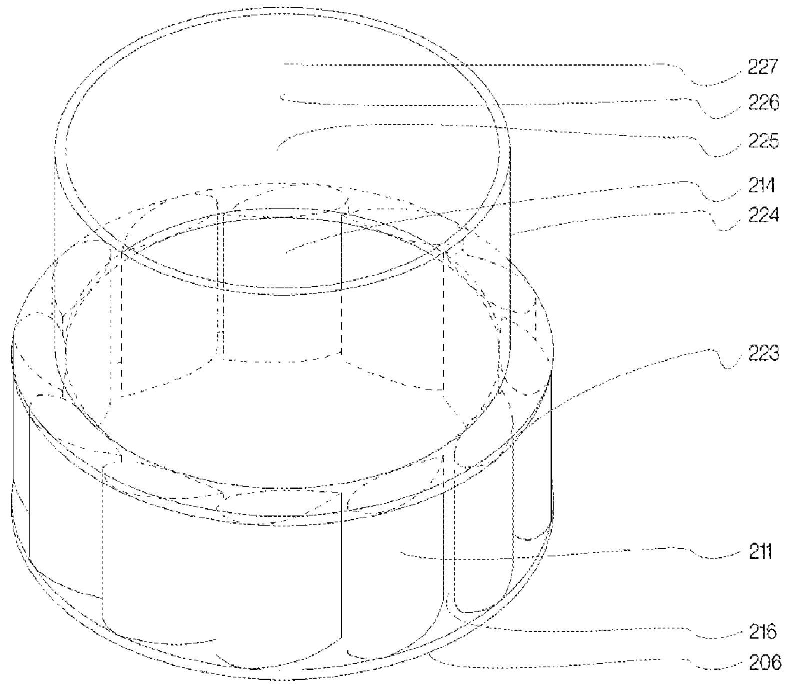
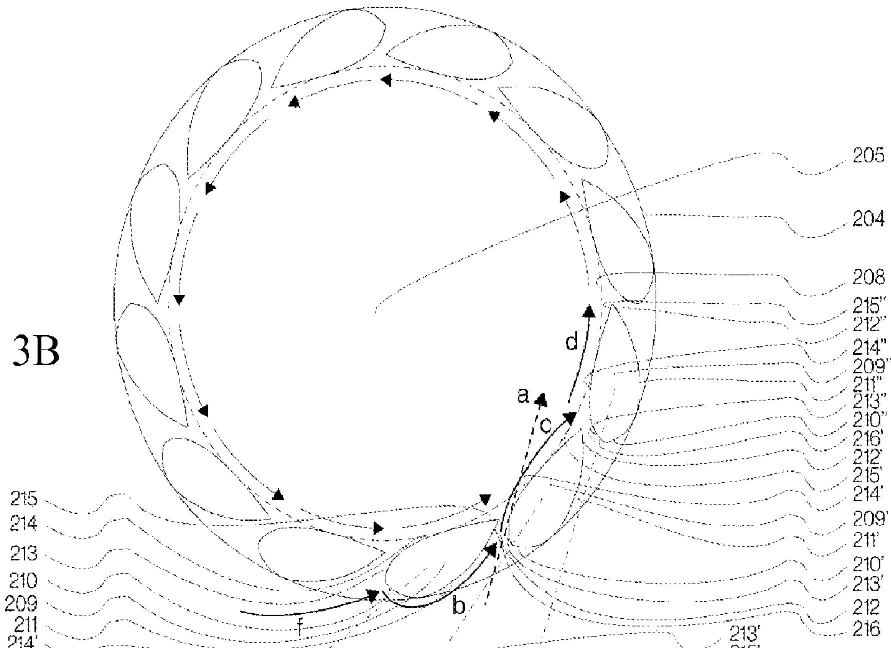


Figure 3A

Figure 3B



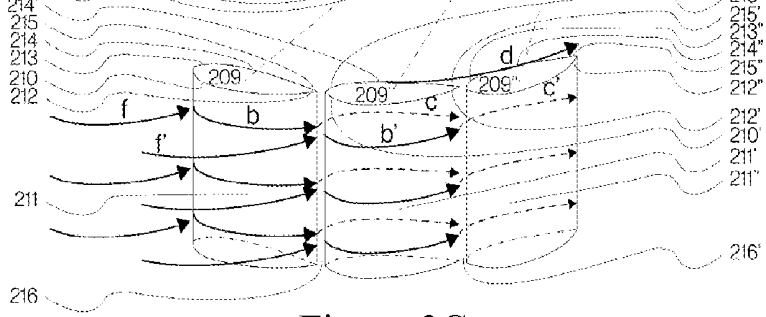


Figure 3C

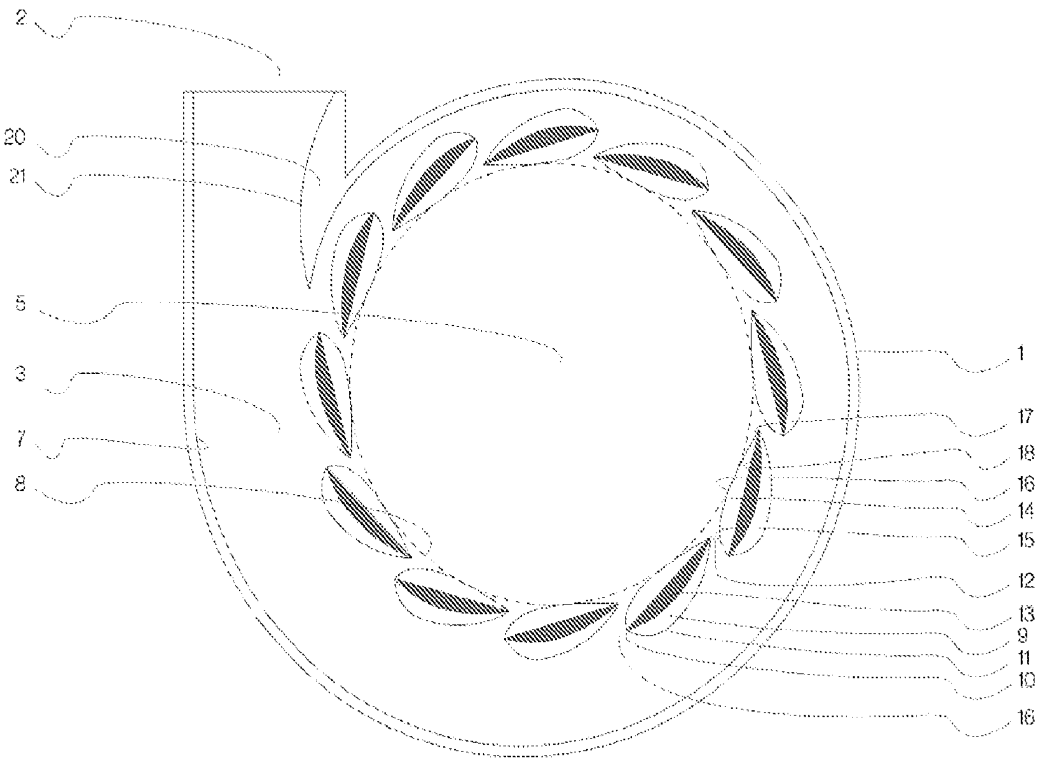


Figure 4A

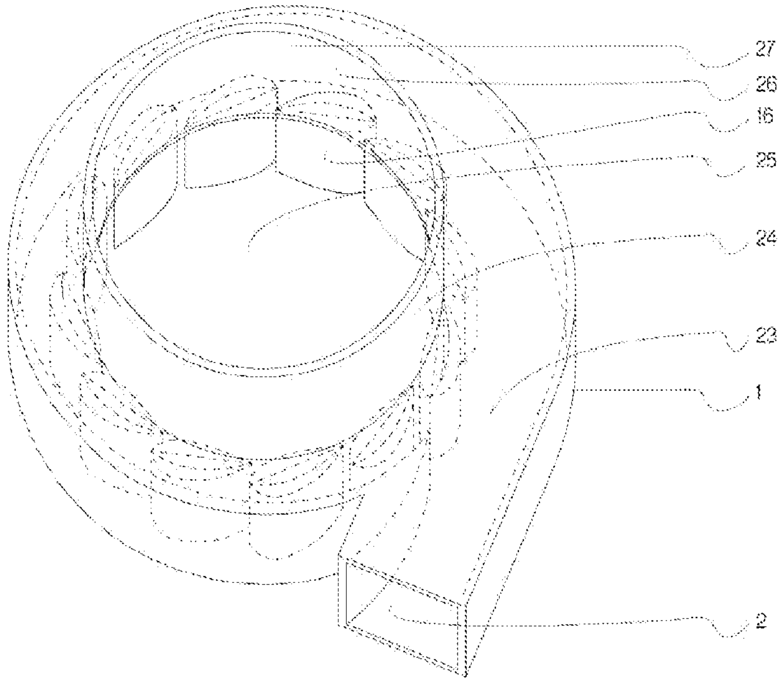


Figure 4B

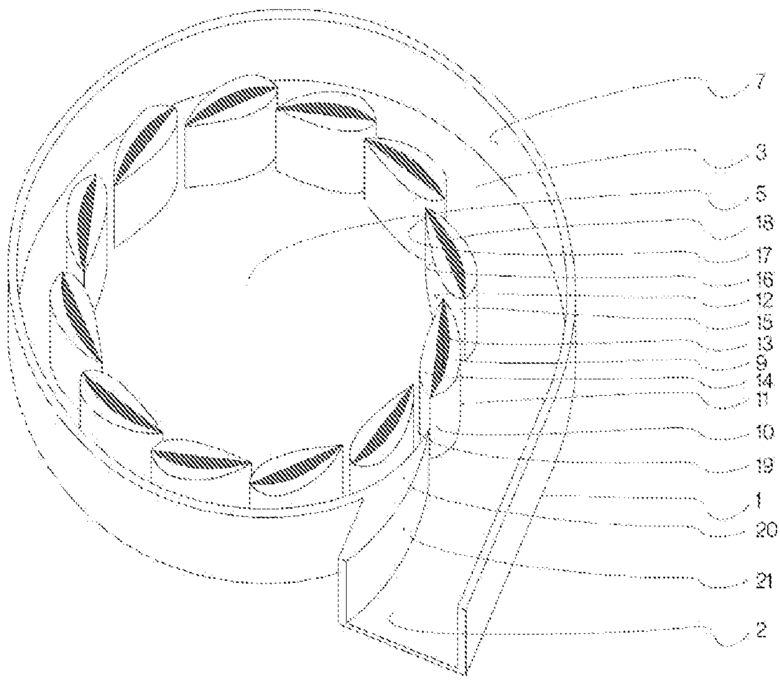


Figure 4C

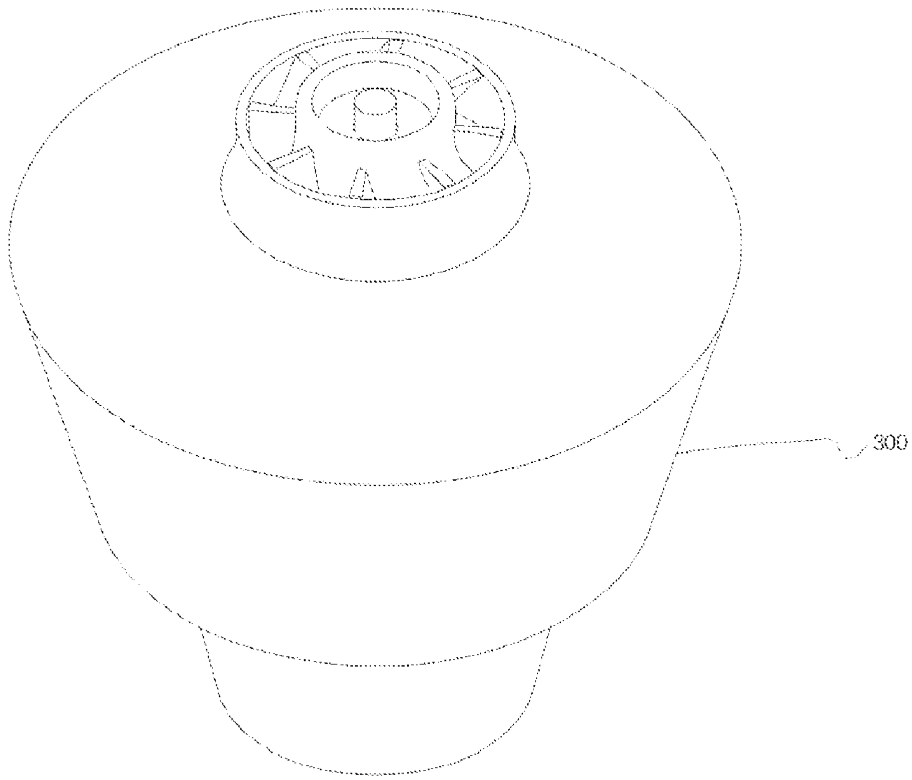


Figure 5A

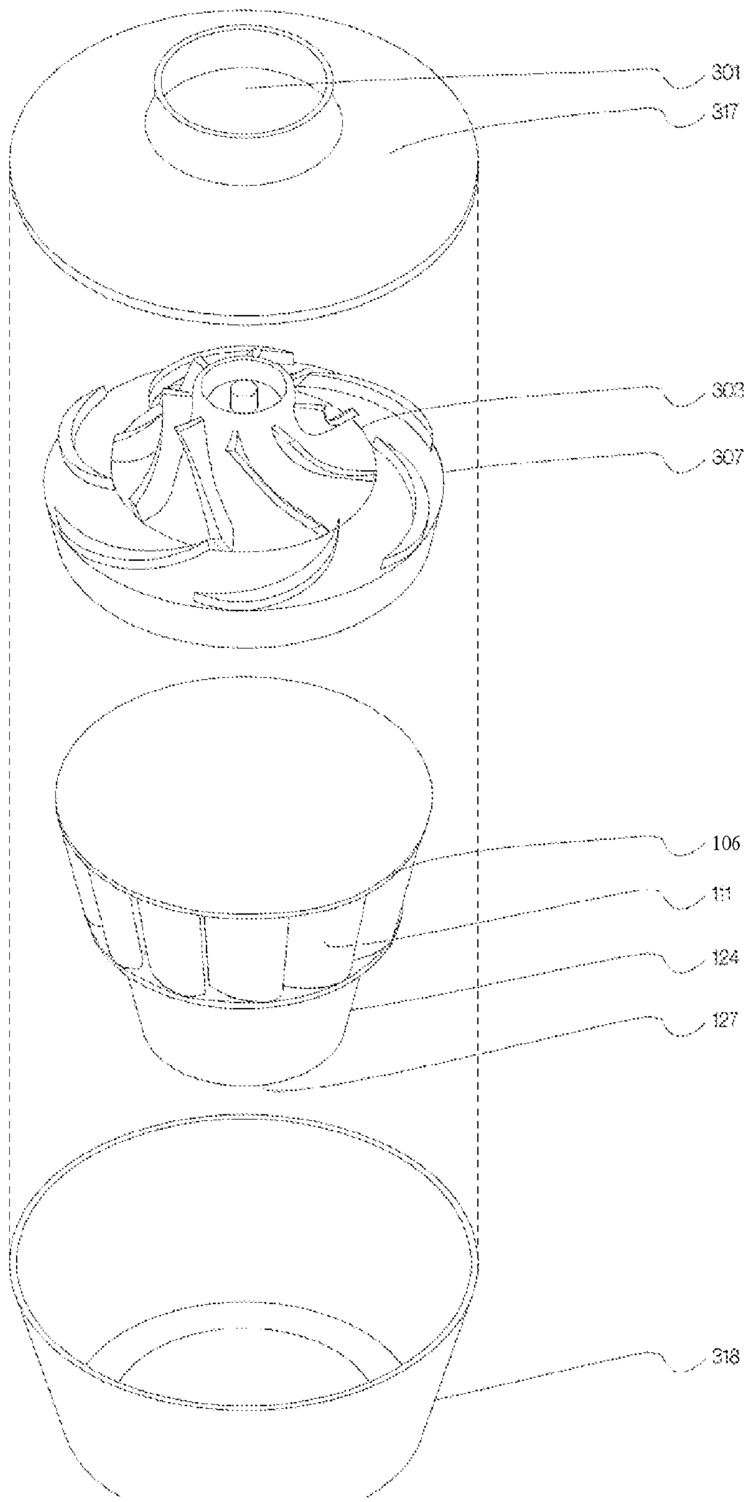


Figure 5B

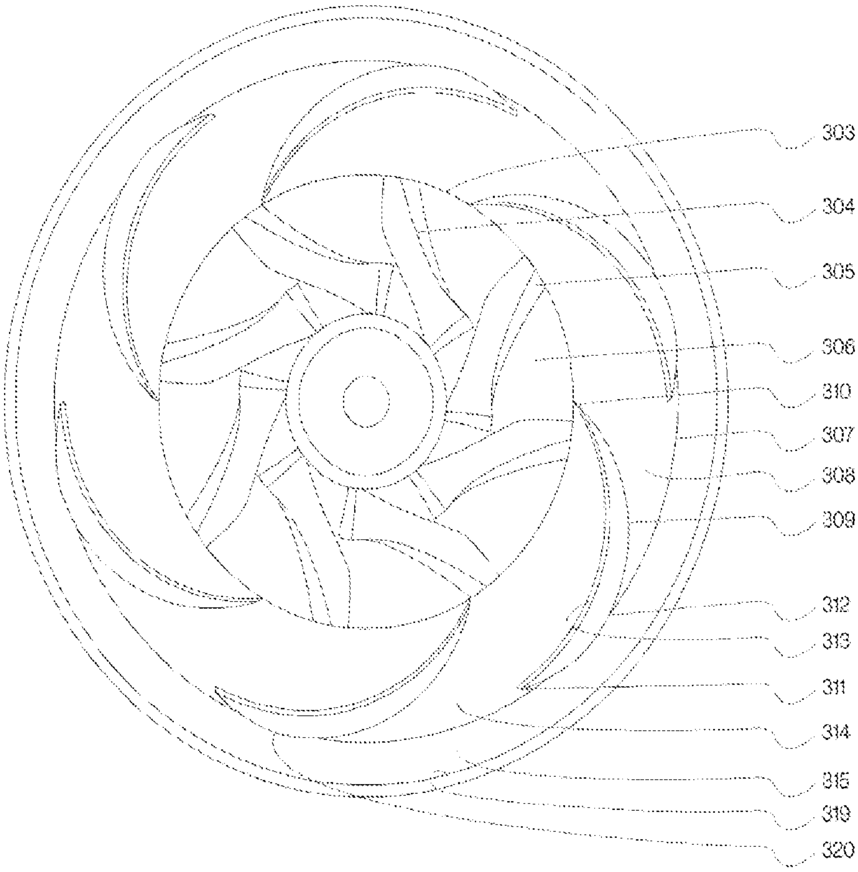


Figure 5C

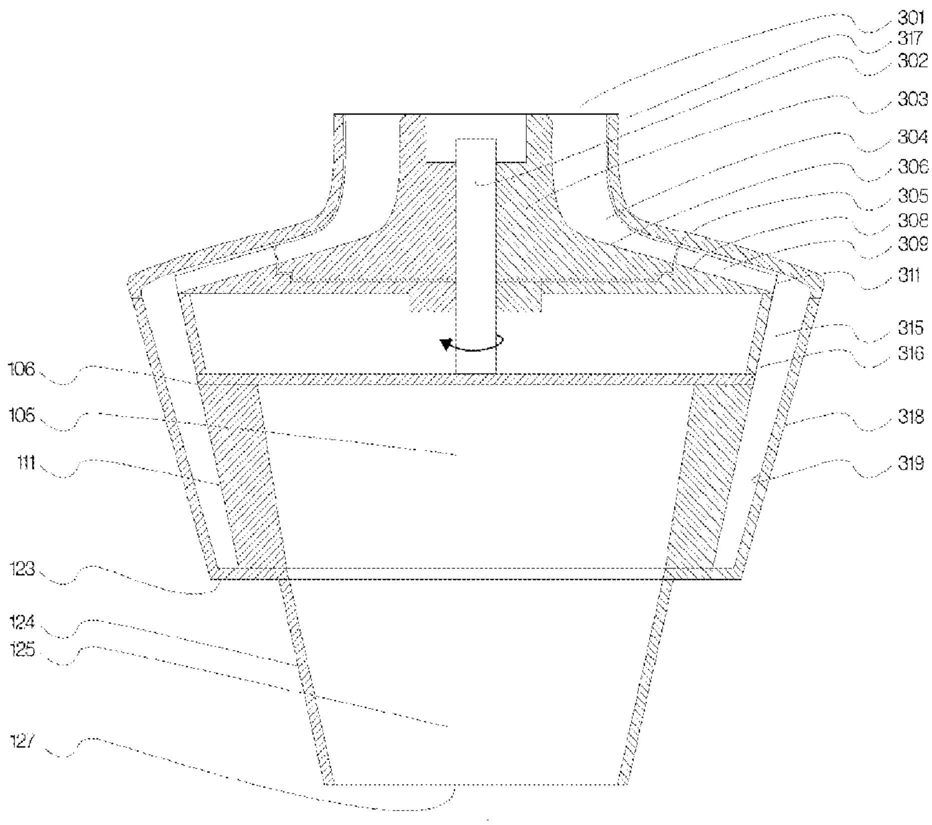

301
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Figure 5D

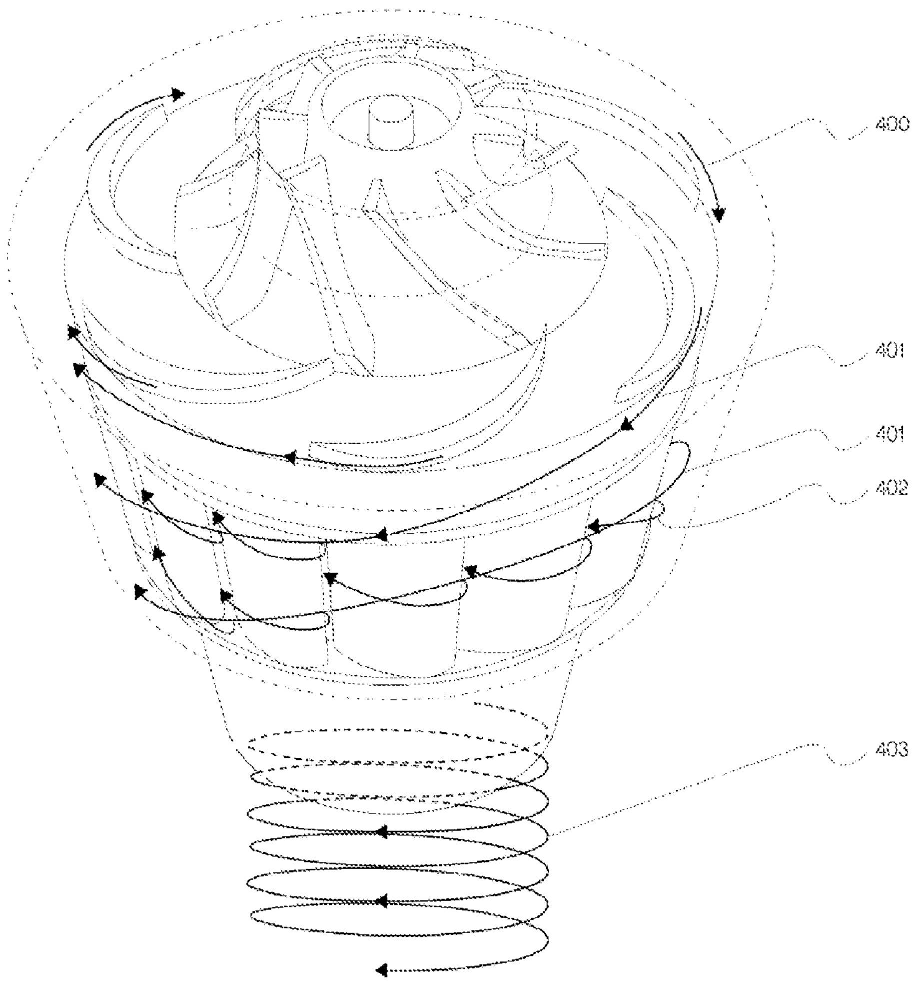

Figure 5E

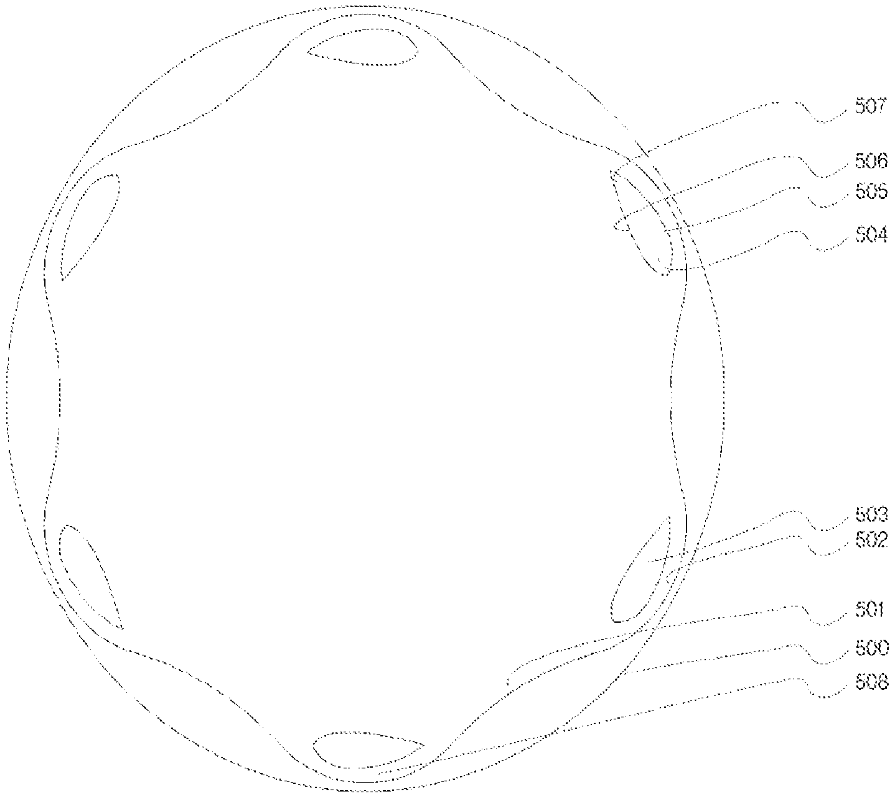

Figure 6A

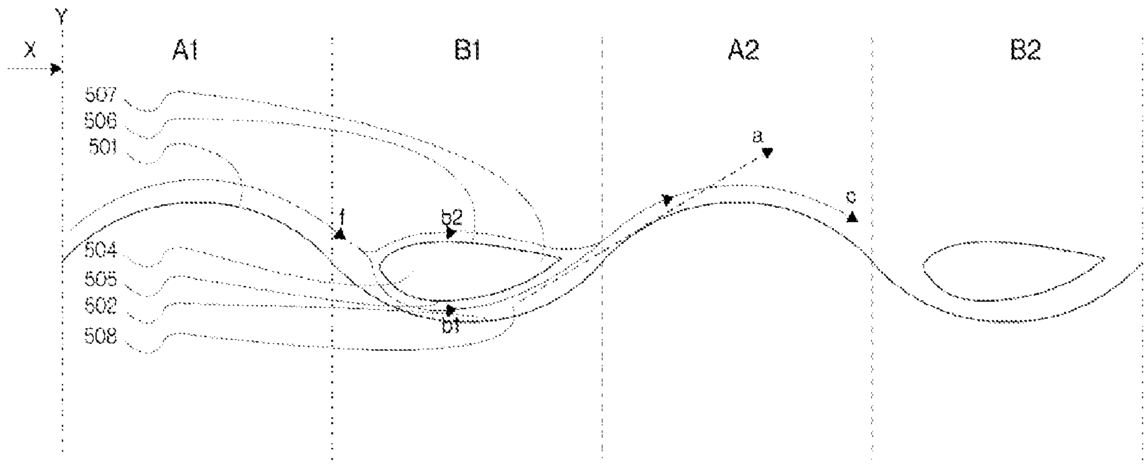

Figure 6B

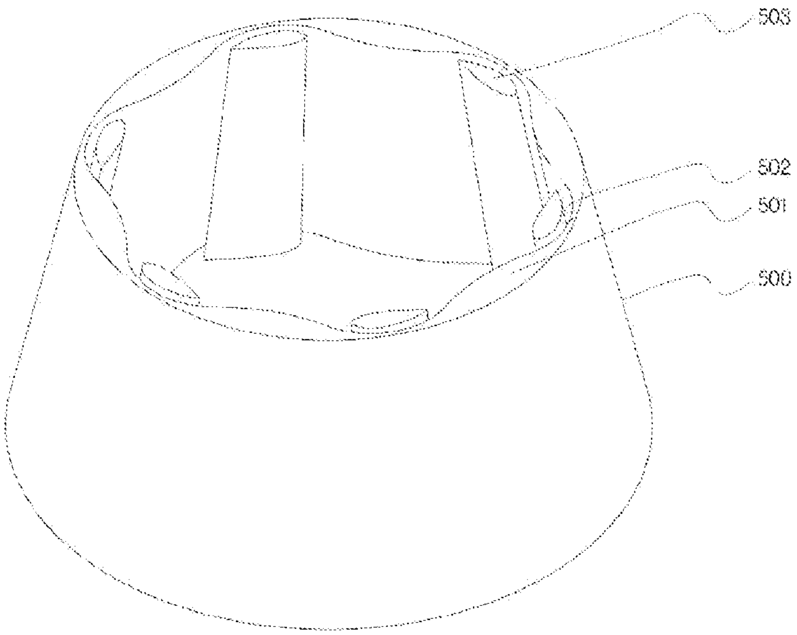

Figure 6C

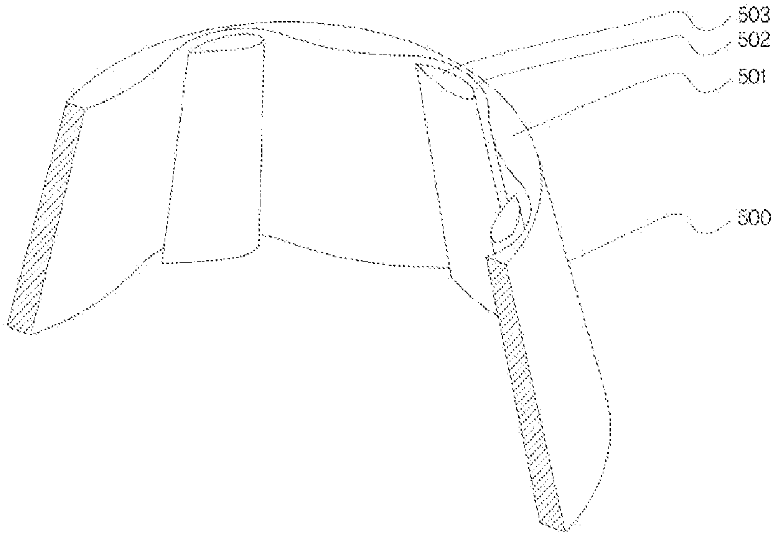

Figure 6D

INTERNATIONAL SEARCH REPORT

International application No.
PCT/IB2024/058626

A. CLASSIFICATION OF SUBJECT MATTER

F15D1/00(2006.01)i; F04D29/44(2006.01)i

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC:F15D,F04D

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

CNTXT,ENTXTC,VEN,CNKI:vortex, swirl, forced, generat+, creat+, convex+, curved, Coanda, accelerat+, diffuser, diffusor, inclin+, diagonal+, flow, tangent

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	CN 104487717 A (YAOVAPHANKUL, M.) 01 April 2015 (2015-04-01) description, paragraphs 10 to 19 and figures 1-4	1-12
A	KR 20140117012 A (LEE, Sang Myung et al.) 07 October 2014 (2014-10-07) description, paragraphs 42 to 43 and figures 7-8	13
A	CN 113530855 A (LG ELECTRONICS INC.) 22 October 2021 (2021-10-22) description, paragraphs 66 to 167 and figures 1-8	14
A	CN 107076184 A (YAOWAPANKUL, M.) 18 August 2017 (2017-08-18) the whole document	1-12
A	JP H07155698 A (CHICHIBU ONODA CEMENT CORP.) 20 June 1995 (1995-06-20) the whole document	1-12
A	US 2019168147 A1 (BRATTON, Rodney Allan) 06 June 2019 (2019-06-06) the whole document	1-12
A	US 2015041487 A1 (TGG AUTOMATION LTD.) 12 February 2015 (2015-02-12) the whole document	1-12

☑ Further documents are listed in the continuation of Box C. ☑ See patent family annex.

* Special categories of cited documents:
- "A" document defining the general state of the art which is not considered to be of particular relevance
- "D" document cited by the applicant in the international application
- "E" earlier application or patent but published on or after the international filing date
- "L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
- "O" document referring to an oral disclosure, use, exhibition or other means
- "P" document published prior to the international filing date but later than the priority date claimed
- "T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
- "X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
- "Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
- "&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
14 December 2024	**27 December 2024**

Name and mailing address of the ISA/CN

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C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	CN 107850017 A (YOO, B. N. et al.) 27 March 2018 (2018-03-27) the whole document	13
A	CN 212389575 U (WELLING (WUHU) MOTOR MFG. CO., LTD. et al.) 22 January 2021 (2021-01-22) the whole document	14
A	KR 20230006788 A (LG ELECTRONICS INC.) 11 January 2023 (2023-01-11) the whole document	14

INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.
PCT/IB2024/058626

Patent document cited in search report			Publication date (day/month/year)	Patent family member(s)			Publication date (day/month/year)
CN	104487717	A	01 April 2015	US	2015136261	A1	21 May 2015
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