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(54) **Bi-directional axial-flow blower.**

(57) A bi-directional axial-flow blower which requires no complex mechanism such as a rotor-reversing mechanism and employs a proper shape of rotor to enables air-blowing operation with high efficiency and low noise both in the forward and reverse directions. The bi-directional axial-flow blower (1) for selectively sending a wind either in forward direction (A) or in a reverse direction (B), comprises a cylindrical casing (3), a forwardly-rotating impeller (8) and a reversely-rotating impeller (9) having airfoil blade rotors (8a, 9a) with camber, and a forward drive motor (6) for driving the forwardly-rotating impeller (8) and a reverse drive motor (7) for driving the reversely-rotating impeller (9), in which the forwardly-rotating impeller (8) is operated whereas the reversely-rotating impeller (9) is made free to rotate when the blower (1) is in the forward wind mode, and the reversely-rotating impeller (9) is operated and the forwardly-rotating impeller (8) is made free to rotate in the reverse wind mode.

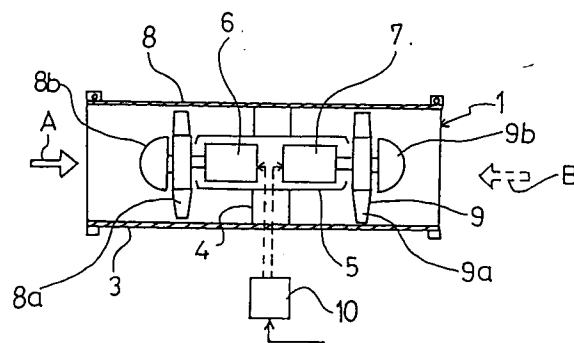


Fig. 1

### (Field of the Invention)

The present invention relates to a bi-directional axial-flow blower which is mounted, for example, near the ceiling of the tunnel of an automobile road for ventilating the tunnel.

### (Background of the Invention)

It is required of the blower used for ventilating a tunnel that the wind direction is reversed depending on environmental conditions such as the direction of natural wind flowing through the tunnel and the occurrence of fire in the tunnel. Thus, a bi-directional axial-flow blower generally referred to as a jet-fan is commonly used. Such type of well-known bi-directional blower is grouped in the following categories.

#### (1) Simple contrarotating type:

An impeller having a rotor cascade is connected to a reversible drive motor and is housed in a casing. With the direction of the rotors fixed, the drive motor operates in either directions to produce air flow in either axial directions.

#### (2) Adjustable rotor-direction contrarotating type:

A reversible drive motor is connected to an impeller having in the boss thereof an airfoil rotor with camber such as circular-arc plate and an automatic rotor reversing mechanism that reverses the orientation of the rotor by 180 degrees. Then, the entire assembly is housed in a casing. The air-flow can be set in either direction by operating the drive motor in either direction while at the same time changing the direction of rotor.

### (Problems to be Solved by the Invention)

The aforementioned well-known bi-directional axial-flow blowers have the following drawbacks in terms of performance and reliability.

(1) In the simple contrarotating type, the impeller provided with a rotor having camber exhibits different performance for the forward rotation mode of impeller and the reverse rotation mode, showing poor efficiency and noise characteristic particularly in the reverse rotation mode. Thus, this type of blower is not suitable for use as a bi-directional axial-flow blower. If the rotor is of a flat plate type not having camber so that the same blower performance is achieved in either directions, then high performance is not expected in either directions.

(2) In the adjustable rotor-direction contrarotating type, high blower efficiency can be achieved in either of the forward and reverse directions. However, a complex rotor-reversing mechanism is required which makes it difficult to obtain high

reliability.

The present invention has been made in view of the above mentioned drawbacks. An object of the invention is to provide a bi-directional axial-flow blower which requires no complex mechanism such as a rotor-reversing mechanism and employs a proper shape of rotor to enables air-blowing operation with high efficiency and low noise both in the forward and reverse directions.

### (Means to Solve the Problems)

To solve the aforementioned problems, a bi-directional axial-flow blower of the present invention is constructed as follows:

(1) A bi-directional axial-flow blower according to the first aspect of the invention, comprises a hollow cylindrical casing for forming a wind path, a forwardly-rotating impeller and a reversely-rotating impeller serially aligned in the casing, each of which includes an airfoil rotor having camber, and a reverse drive motor for driving the reversely-rotating impeller and a forward drive motor for driving the forwardly-rotating impeller, whereby the forward drive motor is operated while the reverse drive motor is stopped with the reversely-rotating impeller left free to rotate when the blower is in the forward wind mode, and contrary, the reverse drive motor is operated while the forwardly-rotating impeller left free to rotate when the blower is in the forward wind mode.

(2) A bi-directional axial-flow blower according to the second aspect of the invention, comprises a hollow cylindrical casing for forming a wind path, a reversely-rotating impeller and a forwardly-rotating impeller serially aligned in the casing, each of which includes an airfoil rotor having camber, and a double-loaded drive motor which is coupled at one end of its shaft through a clutch to a forwardly-rotating impeller and at the other end through another clutch to a reversely-rotating impeller, whereby the clutch between the drive motor and the reversely-rotating impeller is disengaged when the blower produces a wind in the forward direction, the clutch between the drive motor and the forwardly-rotating impeller is disengaged when the blower produces a wind in the reverse direction.

(3) A bi-directional axial-flow blower according to the third aspect of the invention, comprises a cylindrical casing for forming a wind path, a rotating impeller having an airfoil rotor with camber provided in the casing, a drive motor for driving the rotating impeller, and wind-direction selecting means for rotating the casing so that an inlet and an outlet of the wind path is reversed in accordance with a desired wind direc-

tion.

(4) In the bi-directional axial-flow blower of the third aspect of the invention, the impeller is disposed upstream of the wind path and the drive motor is disposed downstream of the wind path in the casing, and the drive motor is secured to the casing by means of stay vanes having a cross section such that an angle with respect to the center axis of the casing gradually decreases from the front edge toward the rear edge.

(5) In the bi-directional axial-flow blower of the third aspect of the invention, a stationary casing is disposed adjacent to the casing in which the impeller and drive motor are incorporated and the stationary casing defines a wind path communicating with the latter casing and has at the central axis thereof a conical wind guide.

### (Operation)

According to the first aspect of the invention, the wind is controlled to flow either in the forwardly direction or in the reverse direction by selectively operating one of the forward or reverse drive motor in accordance with the command for changing wind directions. The airfoil type rotors having camber suitable for the respective wind directions provide high blower efficiency in either directions. Additionally, the impeller of the inoperative motor side is left free, so that the inoperative impeller receives air flow produced by the operative impeller to rotate free without adversely affecting the ventilation performance.

According to the second aspect of the invention, the drive motor is, for example, of the reversible type in which the drive motor is operated either in the forward direction or in the reverse direction in accordance with the desired wind direction and the clutches inserted between the drive motor and impellers are engaged or disengaged in accordance with the desired wind direction, thereby changing the wind directions. The use of rotor having a camber, similar to those of the first aspect of the invention, offers high blower efficiency. The inoperative impeller disengaged from the drive motor by the clutch is freely rotated due to air flow produced by the operative impeller. Therefore, it will not adversely affect the ventilation performance.

According to the third aspect of the invention, the impellers are driven into rotation in the same direction regardless of the desired direction of wind. With the blower operating, when the casing is turned around in response to the command of changing wind direction so as to change the orientation of wind path, the impellers and drive motor are also turned around together with the casing so

that the wind flow is reversed. The use of airfoil rotor having a camber offers high blower efficiency.

According to the fourth aspect of the invention, the stay vane converts a high rotating dynamic pressure produced at the outlet of the impeller into a static pressure for pressure recovery as well as controls the separation on the surface of stay vane. Thus, the wind pressure of blower is increased achieving highly efficient and low noise operation of the blower.

According to the fifth aspect of the invention, the conical wind guide provided within the stationary casings form a wind path whose cross section continuously grows smaller(upstream) toward and larger(downstream) from the boss of impeller and the drive motor which are incorporated within the casing adjacent to the fixed casing. This permits the smooth acceleration and deceleration of the air flowing through the bore of casing, retarding the occurrence of separation. Further, the conical wind guide in the stationary casing arranging is separated from the casing in which the impeller and drive motor are incorporated, thus achieving a short and small casing that rotates in accordance with the desired wind direction. This is particularly advantageous in that adjacent casings will not interfere each other during rotation even if a plurality of blowers for ventilation are suspended from the tunnel ceiling side by side in a narrow space.

### (Brief Description of the Drawings)

Fig. 1 is a cross-sectional view of a first embodiment of the invention;

Figs. 2 is a front elevational view showing the manner in which the blower of the first embodiment is installed in a tunnel;

Fig. 3(a)-3(b) show the orientation of the forwardly-and reversely-rotating rotors of Fig. 1;

Figs. 4(a)-4(b) show the orientation of rotors of a modified embodiment;

Fig. 5 is a cross-sectional view of a second embodiment;

Fig. 6 and 7 are cross-sectional views of a third embodiment showing different operating conditions of a blower;

Fig. 8 shows the positional relation of the rotor and stay vane shown in Fig. 7;

Fig. 9 is a cross-sectional view of a fourth embodiment; and

Fig. 10 is a top view of Fig. 9.

### (Embodiment)

Embodiments of the present invention will now be described with reference to the drawings.

#### First embodiment

Figs. 1 - 3 show an embodiment according to first aspect of the invention. In the figures, reference numeral 1 denotes a blower supported from the ceiling of tunnel 2. The blower 1 comprises a hollow cylindrical casing 3 opening at two ends thereof, an inner hollow cylinder 5 mounted in the middle of the casing 3 by means of a stay 4, a forward drive motor 6 and a reverse drive motor 7 housed in the inner hollow cylinder 5 on the same axis thereof, and a forwardly-rotating impeller 8 and a reversely-rotating impeller 9 coupled to the output shafts of the respective motors 6 and 7, respectively. Reference numeral 10 denotes a controller for controlling the wind direction, 8a and 9a denote rotors of the impellers, and 8b and 9b denote cones enclosing the ends of the impellers.

The rotors 8a and 9a of aforementioned impellers 8 and 9 have a camber shown in Figs. 3(a) and 3(b) (curved rotor whose thickness grows thinner toward the rear edge of the rotor plate or circular-arc plate whose thickness is constant along the camber line of rotor), and are disposed with respective orientation in accordance with the rotational directions of the forward and reverse motors 6 and 7 as shown by arrows a and b. With this construction, when the wind is delivered from left to right in the direction of the arrow A, upon the command from a controller 10, the forward drive motor 6 is operated to drive the forwardly-rotating impeller 8 into rotation in the direction of the arrow a of Fig. 3(a) while the reverse drive motor 7 is deenergized. Thus, within the casing 3 is produced an air flow in the direction of the arrow A. The impeller 9 directly coupled to the inoperative motor 7 is free, so that it receives the wind flow A to rotate free without disturbing the wind flow.

On the other hand, when the wind is delivered from right to left in the direction of the arrow B, the command is supplied to the controller 10 so as to change the wind direction. The forward drive motor 6 is stopped and the reverse drive motor 7 is started so as to drive the reversely-rotating impeller 9 into rotation in the direction of the arrow b of Fig. 3(b). Thus, within the casing 3 is produced an air flow in the direction of the arrow B. The impeller 9 directly coupled to the inoperative motor 8 is free, so that it receives the air flow B to rotate free.

In Fig. 1, the inner hollow cylinder 5 may be omitted and the forward drive motor 6 and the reverse drive motor 7 may be mounted within the casing 3 by the means of the stay 4. The dual-rotor type motor in which two rotors are assembled into a common stator may be used in place of two independent motors such as the motor 6 for driving the forwardly-rotating impeller and the motor 7 for driving contrarotating impeller. Where the dual-rotor type motor is used, the inner hollow cylinder 5 may be omitted and the drive motor may be directed

mounted in the casing 3 by means of the stay 4.

In the figure, the cones 8b and 9b are mounted to the impellers 8 and 9, the cones may be separated from the impellers and fixed in the casing 3. In Fig. 3, the rotor 8a of the forwardly-rotating impeller 8 and the rotor 9a of the reversely-rotating impeller 9 are oriented 180 degrees opposite to each other and the drive motor 6 runs in the direction of a and the drive motor 7 in the direction of b. A modification can be made such that the rotors 8a and 9a are oriented differently as shown in Fig. 4 and the drive motors 6 and 7 may be rotated in the same direction, a and b.

## Second embodiment

Fig. 5 shows an embodiment according to second aspect of the invention. A reversible drive motor 11 (double loaded) is used in the place of the forward and reverse drive motors 6 and 7 of the first embodiment. To the two ends of shaft extending outwardly of the motor 11 are coupled the forwardly-and reversely-rotating impellers 8 and 9 via clutches 12 and 13 electromagnetically operated. The shape and orientation of the rotors of the impellers 8 and 9 are the same as those in Figs. 3(a) and 3(b).

With such a construction, when the wind is blown from left to right in the direction of the arrow A, upon the command from the controller 10, the drive motor 11 is operated in the forward direction and the clutch 13 between the drive motor 11 and the reversely-rotating impeller 9 is disengaged so as to drive the forwardly-rotating impeller 8 into rotation in the direction of the arrow a of Fig. 3(a). Thus, within the casing 3 is produced an air flow in the direction of the arrow A. In this case, the impeller 9 is not constrained and receives the air flow A to rotate free.

On the other hand, when the wind is blown from right to left in the direction of the arrow B, the command is supplied to the controller 10 so as to change the wind direction, the drive motor 11 is reversed its direction while at the same time the clutch 12 between the drive motor 11 and the forwardly-rotating impellers 8 is disengaged. Then, the clutch 13 between the reversely-rotting impeller 9 is engaged so that the impeller 9 is driven into rotation in the direction b shown in Fig. 3(b). Thus, within the casing 3 is produced an air flow in the direction of the arrow B. The impeller 8 is not constrained, so that it receives the air flow B to rotate free.

While the drive motor 11 is of a reversible type and runs to rotate the impellers 8 and 9 either in the direction a or in the direction b in accordance with the desired wind direction A or B, the rotors 8a and 9a of the impellers 8 and 9 may be cascaded

as shown in Fig. 4 so that the impellers 8 and 9 can rotate in the same direction without regard to the desired wind directions A or B. The use of this construction allows that a ordinary double-loaded drive motor that rotates in a fixed direction may be used in place of the reversible type drive motor 11.

### Third embodiment

Figs. 6-8 show an embodiment according to third and fourth aspect of the invention. Within a hollow cylindrical casing 3 are housed a drive motor 15 supported by means of a stay vane 14 and an impeller 16 coupled to the output shaft of the drive motor 15. The casing has a wind inlet 3a, a wind outlet 3b, an impeller 16 disposed upstream of the drive motor 15. A cone 17 for guiding the wind is mounted at the front end of the impeller 16 and a cone 18 at the rear end of the drive motor 15.

The casing 3 is mounted to a motor shaft 19a of a wind-direction selecting motor 19 for selecting the wind direction such that the casing is suspended from the motor 19 mounted on the ceiling. The casing 3 is rotated about the shaft 19a in the direction of the arrow C.

As shown in Fig. 8, the impeller 16 has an airfoil type rotor 16a having a camber. The orientation of rotor blades relative to the rotational direction  $\alpha$  is that shown in Fig. 8. As shown, the stay vane 14 aligned downstream of the rotor 16a is formed with a curved surface, so that the cross section of the stay vane is such that the angle  $\theta$  with respect to the central axis O of the casing 3 decreases from front edge to rear edge.

The wind-direction selecting operation of the blower 1 of the aforementioned construction will now be described. When the wind is delivered from left to right in the tunnel 2, having the inlet 3a of the casing 3 directed to the left as shown in Fig. 6, the motor 15 drives the impeller 16 into rotation in the direction of the arrow  $\alpha$ . Thus, within the casing 3 is produced an air flow in the direction of the arrow A.

When the wind is delivered from right to left with the drive motor 15 rotated in the direction  $\alpha$ , the casing 3 is rotated by the wind-direction selecting motor 19 so as to change the orientation of the casing 3 by 180 degrees from the position in Fig. 6 to that in Fig. 7. Thus, the inlet 3a of the casing 3 is oriented to the right and an air flow is produced in the direction B within the casing 3. The stay vane 14 holding the motor 15 is formed to have the aforementioned cross section so that the stay vane 14 retards the separation of wind flowing along the stay vane 14 and absorbs the dynamic pressure due to the rotating velocity produced by the impeller 16 to convert it into the static pressure. The

cones 17 and 18 provided at the front end of the impeller 16 and at the rear end of the drive motor 15, respectively, allow the smooth change of flow rate of air flow contributing to the retardation of separation.

### Fourth embodiment

Figs. 9 and 10 show a variation of the third embodiment as an embodiment of the fifth aspect of the invention. The drive motor 15 and impeller 16 are assembled just as in the third embodiment. A stationary casings 20 are suspended from the ceiling by means of wires 21 such that the stationary casings 20 are in line with the casing 3 and are disposed at the front of and at the rear of the casing 3. In the middle of each of the casings 20, a long conical wind guide 22 is mounted by means of the stays 23 so that the cross section of the wind path varies continuously toward the drive motor 15 and the front end of impeller 16. As shown in Fig. 10, the inlet and outlet of the casing 3 and the ends of the stationary casings 20 opposing the casing 3 are formed in an arcuate shape in concentric relation with the motor shaft 19a of the wind-direction selecting motor 19. The casings are opposing each other with slight clearances therebetween.

By this arrangement, the conical wind guide mounted to the stationary casing 20 smooths out the change in wind velocity just as in the third embodiment so as to control the occurrence of separation.

The casing 3 is allowed to rotate free in the direction of the arrow C without interfering with the stationary casings 20. Mounting the long conical wind guide 22 to the stationary casing 20 separately from the casing 3 permits a smaller size of the casing 3 which incorporates the drive motor 15 and impeller 16 therein. This minimizes the projection of the casing 3 to the sideways when the casing 3 is rotated. Thus, where a plurality of blowers 1 are provided side by side near the ceiling within the tunnel as shown in Fig. 2, the adjacent blowers may be spaced apart only by short distance between them without interference.

### **(Advantages of the Invention)**

A bi-directional type axial-flow blower according to the present invention is of the aforementioned constructed and has the following advantages.

With the construction according to first aspect of the invention, the rotor of impeller is constructed of the airfoil blade having a camber and the forward and reverse drive motor is selectively operated to achieve the forward and reverse flow of

wind for high efficiency wind production. The impeller requires no complex mechanism for changing the orientation of rotor blades ensuring high reliability.

With the construction according to second aspect of the invention, the rotor of impeller is constructed of the airfoil blade having a camber as the first aspect and the clutch is operated to select either forward wind direction or reverse wind direction thereby achieving highly efficient wind production.

With the construction according to third aspect of the invention, the orientation of the casing in which the impeller and drive motor are assembled, is reversed in accordance with the desired wind direction. Thus, a complex mechanism for changing the orientation of rotor blade is not required while the wind direction can be switched between the forward and reverse directions by rotating the casing with both the direction of rotor blade cascade and the motor direction unchanged.

With the construction according to fourth aspect of the invention, the impeller is disposed upstream of the wind in the casing and the drive motor downstream while at the same time the drive motor is mounted to the casing by means of a stay vane whose cross section is such that the angle with respect to the center axis of casing decreases from front edge to rear edge. This arrangement reduces the separation of wind and converts the dynamic pressure produced by the whirling velocity caused by the impeller into the static pressure to achieve high efficiency and low noise.

With the construction according to fifth aspect of the invention, the stationary casing having a wind path is disposed adjacent the casing, which has the impeller and drive motor assembled therein, in such a way that the wind path communicates with the casing. Then, the conical wind guide is provided within the stationary casing on the central axis. This allows the change in wind velocity to be smoothed out for high efficiency and low noise as well as achieves the smallest possible casing that is rotated to be oriented in accordance with the wind direction. The blower is advantageous in that if the blower is used for the ventilation in the tunnel where a plurality of blowers are to be aligned in a small space near the ceiling, the casings of adjacent blowers will not interfere each other when the casings are rotated.

## Claims

1. A bi-directional axial-flow blower for selectively sending a wind either in forward direction or in a reverse direction, CHARACTERIZED BY:
  - a cylindrical casing for defining a wind path;

a forwardly-rotating impeller and a reversely-rotating impeller serially aligned in said casing, said impellers having airfoil blade rotors with camber; and

a forward drive motor for driving the forwardly-rotating impeller and a reverse drive motor for driving the reversely-rotating impeller;

wherein the forward drive motor is operated whereas the reverse drive motor is stopped with the reversely-rotating impeller left free to rotate when the blower is in the forward wind mode, and the reverse drive motor is operated and the forward drive motor is stopped with the forwardly-rotating impeller left free to rotate in the reverse wind mode.

2. A bi-directional axial-flow blower for selectively sending a wind either in a forward direction or in a reverse direction, CHARACTERIZED BY:

a cylindrical casing for defining a wind path;

a forwardly-rotating impeller and a reversely-rotating impeller serially aligned in the casing, said impellers having airfoil blade rotors with camber; and

a double-loaded drive motor coupled at one end of its shaft through a first clutch to a forwardly-rotating impeller and at the other end thereof through a second clutch to a reversely-rotating impeller;

wherein said second clutch between the drive motor and the reversely-rotating impeller is disengaged when the blower sends the wind in the forward direction, and said first clutch between the drive motor and the forwardly-rotating impeller is disengaged when the blower sends the wind in the reverse direction.

3. A bi-directional axial-flow blower for selectively sending a wind either in a forward direction or in a reverse direction, CHARACTERIZED BY:

a cylindrical casing for defining a wind path;

an impeller having airfoil blade rotors with camber provided in the casing;

a drive motor for driving the impellers; and

a wind-direction selecting means for driving the casing to rotate so that an inlet and an outlet of the wind path is reversed in accordance with a desired with direction.

4. A bi-directional axial-flow blower according to Claim 3, CHARACTERIZED IN THAT said impeller is disposed upstream of the wind path and the drive motor is disposed downstream of the wind path in the casing, and the drive motor is secured to the casing by stay vane

means having a cross section such that an angle with respect to the center axis of the casing gradually decreases from the front edge toward the rear edge of the stay vane.

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5. A bi-directional axial-flow blower according to Claim 3, CHARACTERIZED IN THAT a stationary casing is disposed adjacent to the casing in which the impeller and drive motor are incorporated and said stationary casing defines a wind path communicating with the latter casing and has at the central axis thereof a conical wind guide.

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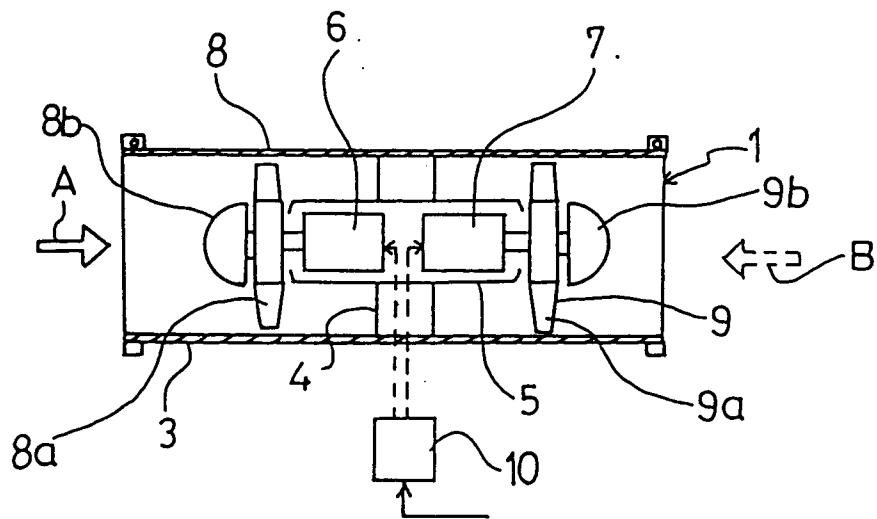


Fig. 1

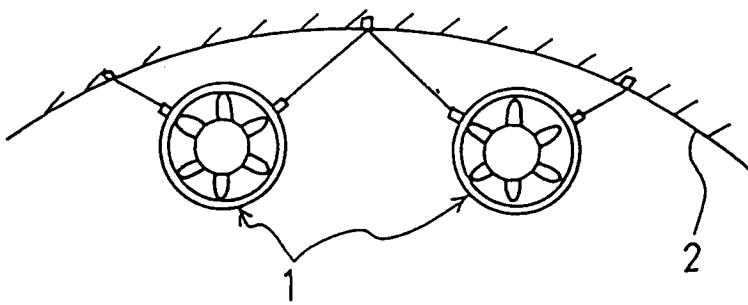


Fig. 2



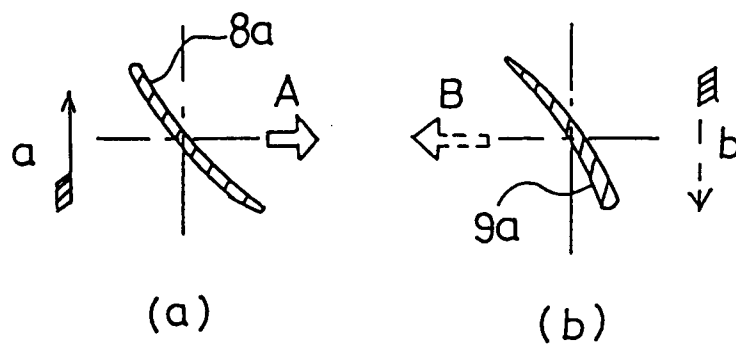


Fig. 3

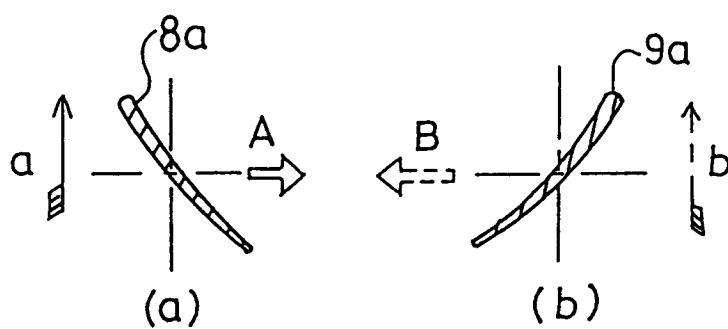


Fig. 4

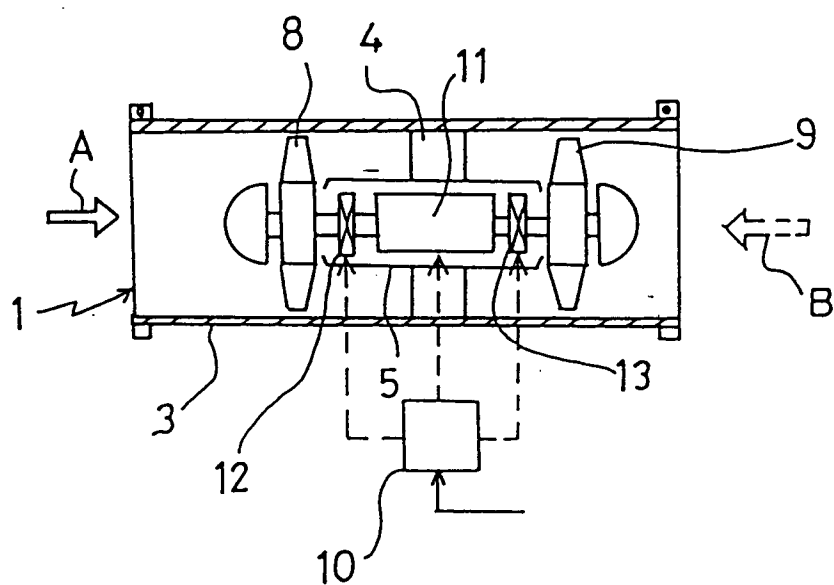


Fig. 5

