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(54) Title: MOTOR MOUNTING ASSEMBLY FOR AN AXIAL FAN

(57) Abstract: A support arm for a mounting arrangement for mounting a motor of an axial fan within an outer casing, the support arm comprising an elongate vane arranged and configured to extend between said motor and the inner wall of said casing, and a connecting portion for connecting said vane to said motor, said connecting portion comprising means for varying the angle of the surface of said vane relative to the direction of airflow through said axial fan.



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MOTOR MOUNTING ASSEMBLY FOR AN AXIAL FAN

This invention relates generally to an axial fan and, more particularly, to an improved mounting arrangement for mounting the motor of an axial fan within an outer case.

Axial fans are generally used to move high volumes of air at low static pressure. Referring to Figure 1 of the drawings, an axial fan typically comprises an outer cylindrical case 10 within which a motor 12 is mounted, with pressed or fabricated steel brackets 14 being used to connect and hold the motor within the case 10. An impeller 16 is also provided within the case 10, which comprises a plurality of blades 18 extending from a central hub, and which is connected to the shaft of the motor for propulsion thereby.

It is known to a person skilled in the art that, in order to maximise aerodynamic performance and efficiency, whilst minimising noise generation, it is desirable to maximise the distance between the rotating impeller 16, 18 and the bracket arrangement 14. In fact, if the bracket arrangement could be omitted completely then turbulence would be eliminated along with any losses caused thereby. In practice, however, there are significant limitations in this regard, for example, there may be tight constraints on the overall size of the product or design limitations on the length of the shaft of the motor on which the impeller is mounted.

It is therefore an object of the present invention to provide an improved mounting arrangement for mounting the motor of an axial fan within its outer case, which enables the aerodynamic performance of the axial fan to be significantly increased without a corresponding increase in input power or speed.

In accordance with a first aspect of the present invention, there is provided a support arm for a mounting arrangement for mounting a motor of an axial fan within an outer casing, the support arm comprising an elongate vane arranged and configured to extend between said motor and the inner wall of said casing, and a connecting portion for connecting said vane to said motor, said connecting portion comprising means for varying the angle of the surface of said vane relative to the direction of airflow through said axial fan.

The support arm vane is designed to be fixed to the motor and not varied in angular position during service. The angle is pre-selected as a specific service angle and fixed in place. The invention enables specific angled arm vane to be used in variable angular orientations dependent upon the "in service" requirements and the specific fan structure and size.

Accordingly, it is preferred that the vane is secured with respect to the motor at a specific "in service" angular orientation and not subsequently varied. Beneficially the vane is secured to the motor by means of a tightening mechanical fixing such that the orientation of the vane cannot be varied (once fixed) without releasing the mechanical fixing by untightening.

Preferably, said connecting portion comprises an arcuate slot defining a plurality of selectable angular orientations at which said elongate vane can be mounted. In one exemplary embodiment, the arcuate slot is provided on a connecting plate which is substantially perpendicular to, and formed integrally with, said elongate vane. The arcuate slot is beneficially arranged and configured to receive a connector such that it extends through said slot into a mounting hole provided on said motor. In a preferred embodiment, the angle of the surface of the vane, measured between a first axis perpendicular to the longitudinal axis of said elongate vane and a second axis parallel to the longitudinal axis of said axial fan, is between 80° and 50°, and more preferably between 70° and 55°. In one preferred embodiment, the angle is between 65° and 60°.

Beneficially, the angle of the profile of the elongate vane varies along its length. In one embodiment, the elongate vane might be twisted through, say, 15° along its length. Alternatively, the vane could be bent by, say, 15° at, say, 3/3 of its full length.

In fact, in accordance with a second aspect of the present invention, there is provided a support arm for a mounting arrangement for mounting a motor of an axial fan within an outer casing, the support arm comprising an elongate vane arranged and configured to extend between said motor and the inner wall of said casing, and a connecting portion for connecting said vane to said motor, wherein the angle of the profile of the elongate vane varies along its length.

Once again, in one embodiment, the elongate vane might be twisted through, say, 15° along its length. Alternatively, the vane could be bent by, say, 15° at, say, 3/3 of its full length.

The present invention extends to an axial fan comprising a motor and an impeller housed within an outer casing, the fan further comprising a mounting assembly for mounting said motor within said casing, the mounting assembly comprising one or more support arms as defined above connected between said motor and the inner wall of said outer casing.

Preferably, the support arms are connected between the motor and the inner walls of said outer casing by means of a connector assembly comprising means for connecting said vane to said motor at a selected one of a plurality of longitudinal distances from said impeller. Preferably, the motor may be provided with a plurality of discrete, beneficially substantially equi-distant, mounting holes defining the respective distances.

In accordance with a third aspect of the present invention, there is provided an axial fan comprising a motor and an impeller housed within an outer casing, the fan further comprising a mounting assembly for mounting said motor within said casing, said mounting assembly comprising at least one elongate vane extending between the inner wall of said casing and said motor and being connected to said motor by means of a connector assembly comprising means for connecting said vane to said motor at a selected one of a plurality of distances from said impeller.

It has been determined that by providing mounting brackets that are manufactured in an aerofoil section and are twisted along their length, a significant improvement in aerodynamic performance (i.e. movement of larger volumes of air at higher pressure) can be achieved. Further improvement can be achieved by making the brackets adjustable, such that the distance thereof from the impeller can be varied and the angle thereof can be matched to the direction of airflow, depending on the type of impeller being used.

These and other aspects of the present invention will be apparent from, and elucidated with reference to, the embodiments described herein.

Embodiments of the present invention will now be described by way of examples only and with reference to the accompanying drawings, in which:

Figure 1 is a perspective view of an axial fan according to the prior art;

Figure 2 is a perspective view of an axial fan including a mounting arrangement according to an exemplary embodiment of the present invention;

Figure 3 is a perspective view of a mounting arm of a mounting arrangement according to a first exemplary embodiment of the present invention;

Figure 4 is a perspective view of a mounting arm of a mounting arrangement according to a second exemplary embodiment of the present invention;

Figure 5 is a close-up view of a motor-connecting portion of one of the mounting arms of the mounting arrangement of Figure 2;

Figure 6 is a schematic illustration showing the support arm at various angles relative to the airflow direction;

Figures 7 and 8 are illustrative of the relationship of velocities of an axial fan blade at two respective points;

Figures 9, 10, 11 and 12 are illustrative of airflow as a result of angling the support arms at 90°, the ideal position, under-rotation of the support arms, and over-rotation of the support arms, respectively;

Figure 13 illustrates the force applied to an impeller blade during use; and

Figure 14 illustrates the variation in airflow direction along the length of an impeller blade.

Referring to Figure 2 of the drawings, an axial fan according to an exemplary embodiment of the present invention comprises a cylindrical outer case 30 having a circumferential flange 32 at each end thereof, each flange extending upwardly relative to the outer wall of the case 30 and substantially perpendicular thereto. The fan further comprises an impeller 34 consisting of a plurality of blades 36 extending from a central hub. The impeller 34 is housed within the case 30 and connected to the shaft of a motor 38 for propulsion thereby. The motor 38 is mounted within the case 30 by four substantially equi-distant arms 40 which are connected between the outer circumference of the motor 38 and the inner wall of the cylindrical case 30.

Referring to Figure 5 of the drawings, each arm 40 comprises an elongate portion 40a and a mounting portion 40b. The elongate portion 40a is of substantially aerofoil section and of a length sufficient to extend between the outer circumference of the motor casing and the inner wall of the cylindrical case. The mounting portion 40b extends substantially perpendicular to the elongate portion 40a and is provided with an arcuate slot 42. In use, the arm 40 is connected to the motor by means of a screw or pin which extends through the arcuate slot 42 and into a mounting hole in the motor housing. As shown, a plurality of mounting holes 46 may be provided along a portion of the length of the motor housing, such that the arm 40 may be mounted at a selected one of a number of distances from the impeller.

The arcuate slot 42 enables the angle of the elongate portion 40a of the arm 40 to be varied, as can be seen more clearly in Figure 6 of the drawings. The angle referred to in this case is the angle between a first axis (X) which is perpendicular to the length of the elongate portion 40a of the arm and a second axis (Y) which is perpendicular to the flange 32 of the cylindrical case 30. Thus, in Figure 6a, the mounting portion of the arm 40 is connected to the motor housing at the end of the arcuate slot 42 closest to the elongate portion 40a of the arm 40 and the arm 40 is at 90°. In Figure 6b, the connection point between the mounting portion 40b of the arm and the motor housing has moved along the arcuate slot 42 in a direction away from the elongate portion 40a of the arm 40 and the arm 40 is at 75°. In Figure 6c, the connection point has moved even further along the arcuate slot 42 in a direction away from the elongate portion 40a of the arm 40 and the arm 40 is at 60°.

This ability to vary the angle of the arm 40 relative to the airflow caused by the impeller results in significant advantages in terms of increased aerodynamic performance, because the angle of the arm can be set to match the direction of the airflow, depending on the type of impeller used, as will now be described in more detail.

Consider first the basic theory in relation to an axial fan. Figure 7 shows the relationship of velocities for an axial fan blade at a working point, and the three velocities to be considered are:

- Absolute air flow velocity (local air flow velocity/fix coordinates (x,y)):

$$\vec{V} = \frac{\vec{Q}_v}{S}$$

$\vec{Q}_v$: Volume air flow (m³/s)

S : Section of the air flow considerate (m²)

At the inlet fan, this velocity is axial to the impeller.

- Blade velocity:

$$U = R \cdot \vec{\omega}$$

R : Radius of the blade (m)

$\vec{\omega}$: Angular velocity of the blade (rad/s)

- Relative air flow velocity (air flow velocity/rotation coordinates at the point considerate) :

$$\vec{V} - \vec{U} = \vec{W}$$

At the fan outlet, the airflow exhibits helicoidal movement and the velocities triangle at the point to be considered hereinafter is represented in Figure 8. An evaluation of the motor support arms and the effect on airflow of different angular orientations thereof relative to the airflow is illustrated in Figures 9, 10, 11 and 12.

Referring to Figure 9, when the arm is fixed at 90° (Figure 3a), the angle formed by the direction of fluid and the surface of the arm is significant. As a consequence of the illustrated

arrangement, at a high velocity airflow, turbulence (depicted at 50) occurs because of a flow separation of the air, which results in a consequential decrease in performance.

In contrast, if the arm is oriented to match the direction of air flow, better performance can be achieved. In an ideal case (a “laminar flow” situation), whereby the support arm is oriented precisely relative to the direction of air flow, the profile of the velocity can be considered to be as shown in Figure 10. If, on the other hand, the support arm is angled relative to the airflow, but by an insufficient amount, turbulence will once again occur (as illustrated in Figure 11), but still to a lesser extent than if the arms are fixed at 90°. So even if the ideal case is attained, turbulence is relatively low compared with prior art arrangements.

Finally, and for completeness, if the support arms are rotated too much relative to the direction of airflow, a similar case to the previous one occurs and the consequential turbulence is created because of the flow separation (air wake), as illustrated in Figure 12, but again to a lesser extent than in the case where the arms are fixed at 90°.

Depending on the impeller blade angle (which is a significant contributory factor of airflow direction), it is possible to estimate the ideal angular rotation of the support arms to optimise aerodynamic performance. Figure 13 shows the force applied on the impeller blade.

Consider that pressure of air is perpendicular to the surface of the impeller blade and creates a dynamic force oriented by the angle “ α ”. In order to achieve the optimum performance, the support arms should be oriented at the same angle as α . However, fluctuation of the air is constant, whereas the direction is variable, so the angle α can only be estimated by using the relationship:

$$A = 90 - \beta;$$

where β is the impeller blade angle.

Experimental results have shown the total efficiency of the fan can be increased by setting the angle of the support arms to match the direction of airflow, depending on the type of impeller and the angle of the impeller blades. It has been further observed that the total efficiency of the fan can be increased by changing the angle of the arms from 90° (prior art) to 60° as

discussed above in relation to Figures 9 and 10 respectively. It has also been observed that, at least in some applications, the efficiency can start to drop again from an arm angle of around 55° . From these results, it is considered that, at least for some applications, the optimum arm angle may be 65° to 60° .

Another significant consideration is that there is a variation of the air flow direction along the length of the impeller blade. This variation may be located within an interval of, say, 15° . For example, by the tip of the blade, the airflow direction might be about 45° and the direction might change to about 60° further along the blade towards the motor, as illustrated in Figure 14. Thus, in a preferred embodiment, it is desirable to have a variation, preferably progressive, of the support arm angle within the case, as well as having the arm orientated according to the air flow direction.

Referring to Figure 3, in one exemplary embodiment, the arm 40 might be twisted through, say, 15° along its length. Alternatively, as shown in Figure , the arm 40 could be bent by, say, 15° at, say, 3/3 of its full length. Whilst it is thought that the first embodiment (Figure 3) might provide a solution closest to the ideal, the second embodiment (Figure 4) may be more practical in terms of fabrication.

It should be noted that the above-mentioned embodiments illustrate rather than limit the invention, and that those skilled in the art will be capable of designing many alternative embodiments without departing from the scope of the invention as defined by the appended claims. In the claims, any reference signs placed in parentheses shall not be construed as limiting the claims. The word "comprising" and "comprises", and the like, does not exclude the presence of elements or steps other than those listed in any claim or the specification as a whole. The singular reference of an element does not exclude the plural reference of such elements and vice-versa. The invention may be implemented by means of hardware comprising several distinct elements. In a device claim enumerating several means, several of these means may be embodied by one and the same item of hardware. The mere fact that certain measures are recited in mutually different dependent claims does not indicate that a combination of these measures cannot be used to advantage.

CLAIMS:

1. A support arm for a mounting arrangement for mounting a motor of an axial fan within an outer casing, the support arm comprising an elongate vane arranged and configured to extend between said motor and the inner wall of said casing, and a connecting portion for connecting said vane to said motor, said connecting portion comprising means for varying the angle of the surface of said vane relative to the direction of airflow through said axial fan.
2. A support arm according to claim 1, wherein the vane is secured with respect to the motor by means of a mechanical fixing such that the orientation of the vane cannot be varied once fixed, without releasing the mechanical fixing.
3. A support arm according to claim 1 or claim 2, wherein said connecting portion comprises an arcuate slot defining a plurality of selectable angular orientations at which said elongate vane can be mounted.
4. A support arm according to claim 3, wherein the arcuate slot is provided on a connecting plate which is substantially perpendicular to, and formed integrally with, said elongate vane.
5. A support arm according to claim 3 or claim 4, wherein the arcuate slot is arranged and configured to receive a connector such that said connector extends through said slot into a mounting hole provided on the housing of said motor.
6. A support arm according to any one of the preceding claims, wherein the angle of the surface of the vane, measured between a first axis perpendicular to the longitudinal axis of said elongate blade and a second axis parallel to the longitudinal axis of said axial fan, is between 80° and 50°.
7. A support arm according to claim 6, wherein said angle is between 70° and 55°.

8. A support arm according to claim 7, wherein said angle is between 65° and 60°.
9. A support arm according to any one of the preceding claims, where the angle of the profile of the elongate vane varies along its length.
10. A support arm according to claim 9, wherein the elongate vane is twisted through along its length.
11. A support arm according to claim 9, wherein the vane is bent by an angle at a point along its full length.
12. A support arm for a mounting arrangement for mounting a motor of an axial fan within an outer casing, the support arm comprising an elongate vane arranged and configured to extend between said motor and the inner wall of said casing, and a connecting portion for connecting said vane to motor, wherein the angle of the profile of the elongate vane varies along its length.
13. A support arm according to claim 12, wherein the elongate vane is twisted through an angle along its length.
14. A support arm according to claim 1, wherein the vane is bent by an angle at a point along its full length.
15. An axial fan comprising a motor and an impeller housed within an outer casing, the fan further comprising a mounting assembly for mounting said motor within said casing, the mounting assembly comprising one or more support arms according to any one of the preceding claims connected between said motor and the inner wall of said outer casing.
16. An axial fan according to claim 15, wherein the support arms are connected between the motor and the inner walls of said outer casing by means of a connector assembly

comprising means for connecting said vane to said motor at a selected one of a plurality of longitudinal distances from said impeller.

17. An axial fan according to claim 16, wherein the motor housing is provided with a plurality of discrete substantially mounting holes defining the respective distances.
18. An axial fan comprising a motor and an impeller housed within an outer casing, the fan further comprising a mounting assembly for mounting said motor within said casing, said mounting assembly comprising at least one elongate vane extending between the inner wall of said casing and said motor and being connected to said motor by means of a connector assembly comprising means for connecting said vane to said motor at a selected one of a plurality of distances from said impeller.
19. A method of assembling an axial fan in which a support arm according to any of claims 1 to 13 is capable of being secured to the motor at varying angles and is secured at a predetermined angle such that the angle remains fixed during operation of the axial fan.

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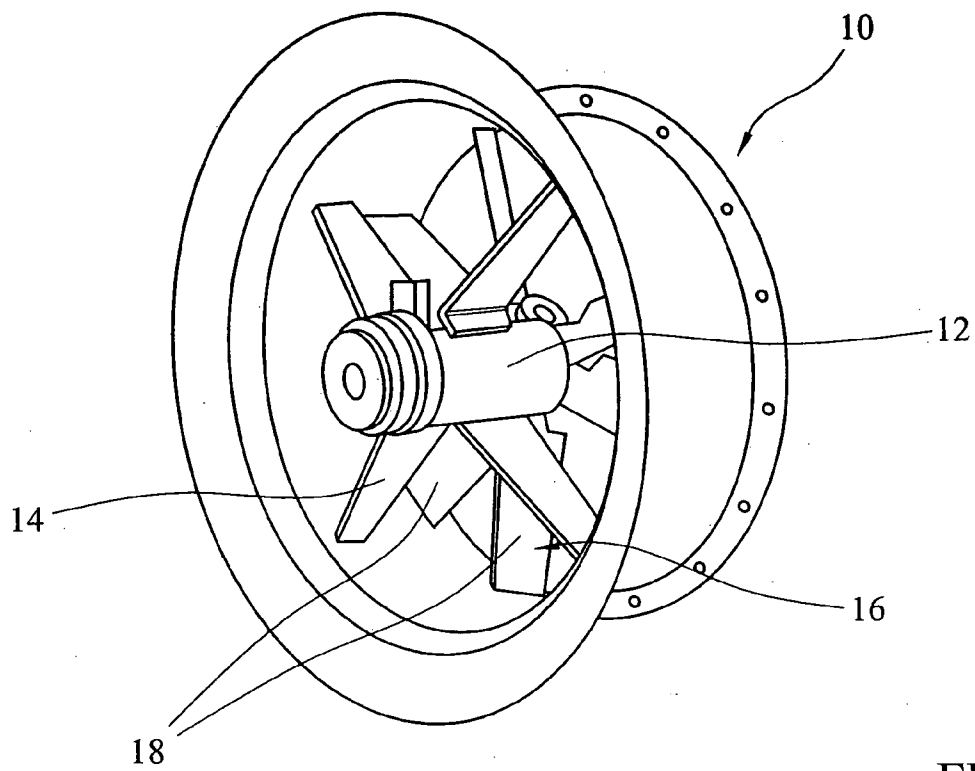


FIG. 1

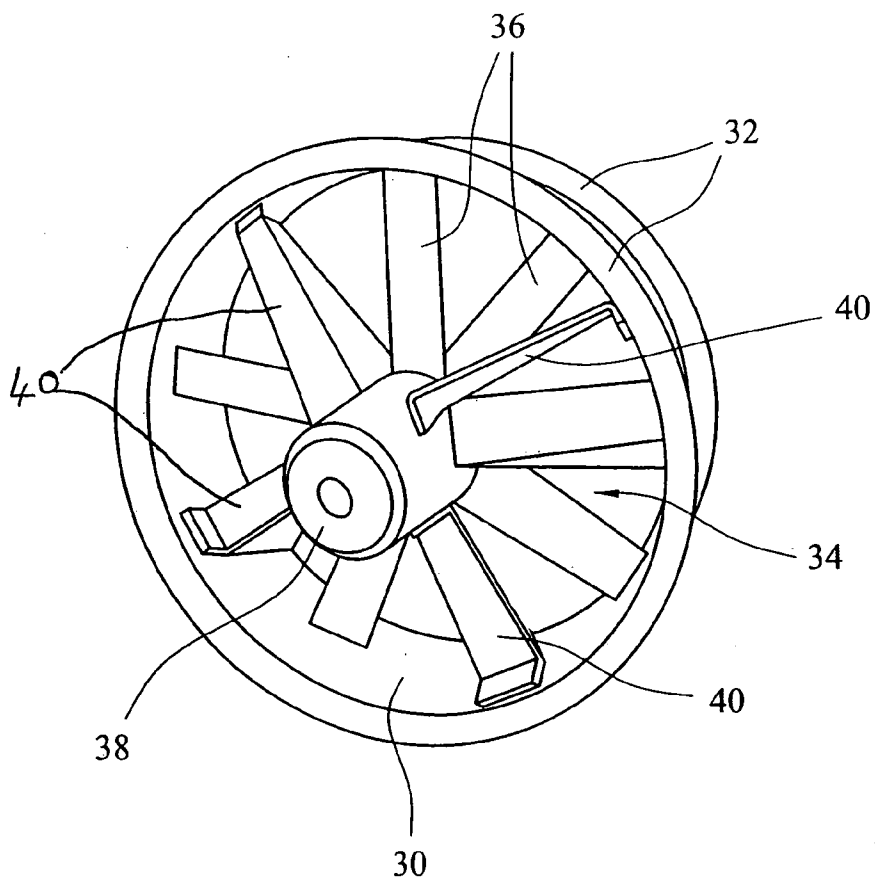


FIG. 2

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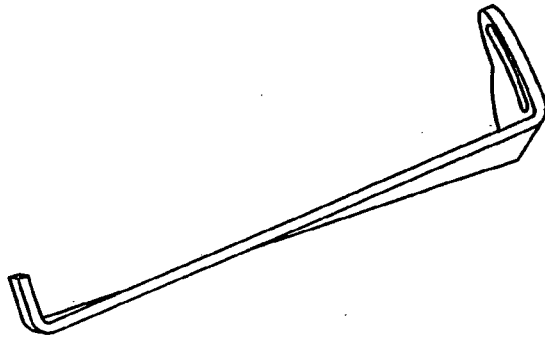


FIG. 3

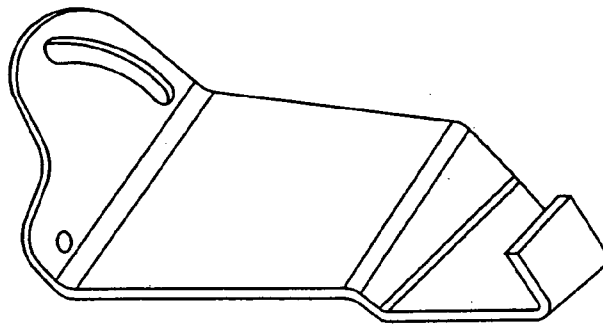


FIG. 4

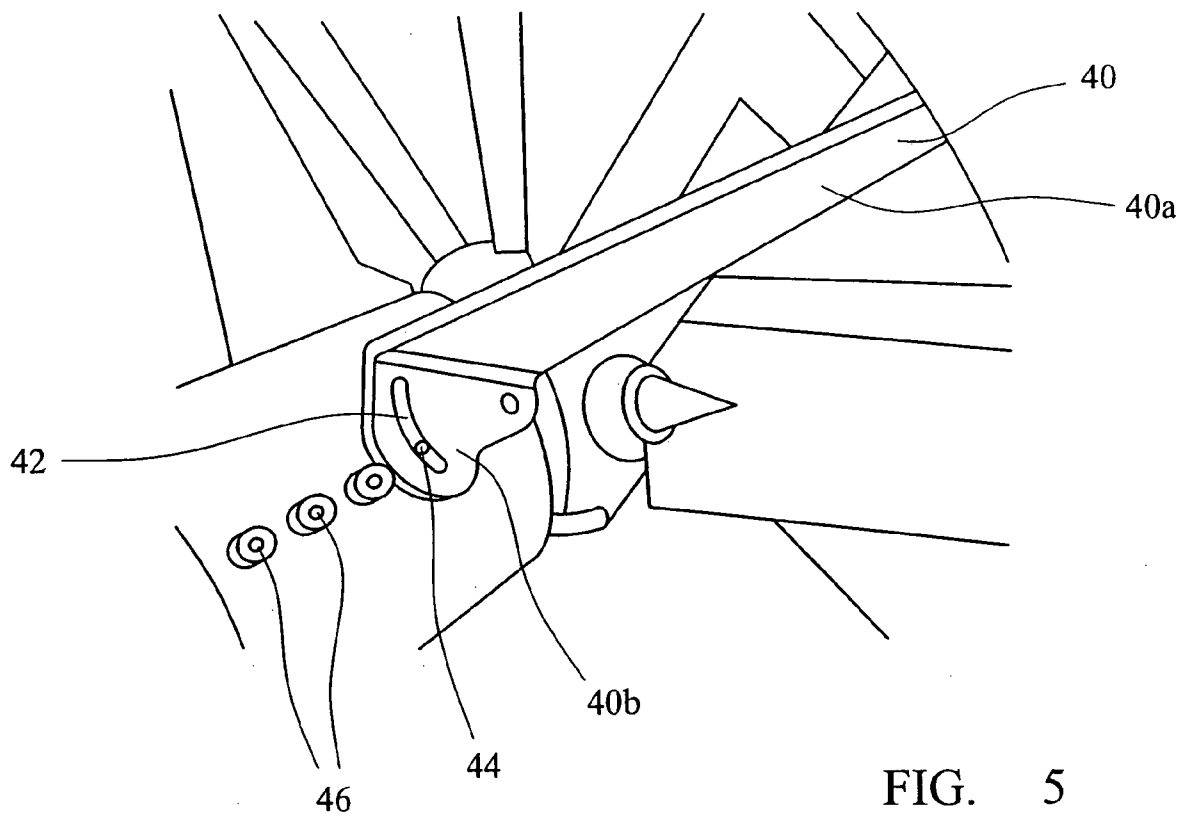


FIG. 5

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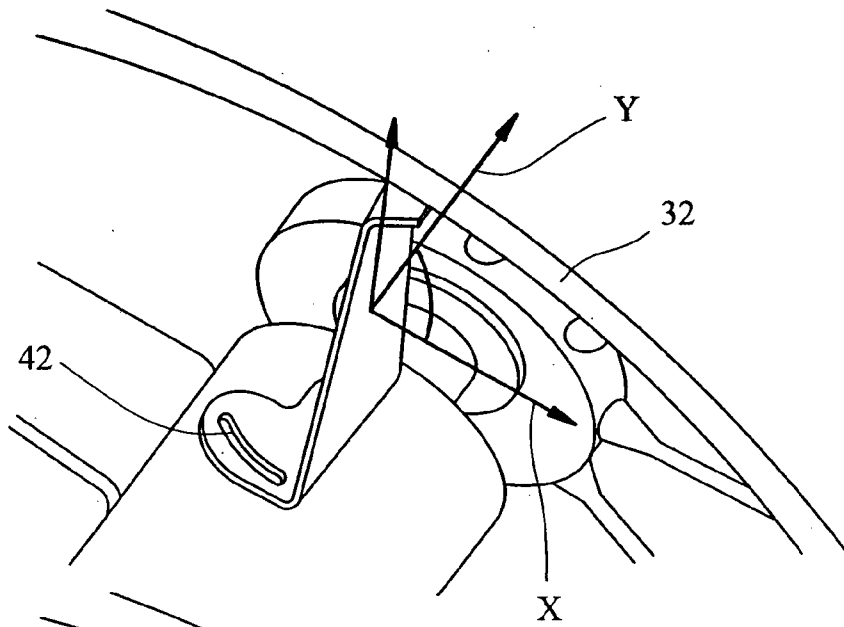


FIG. 6a

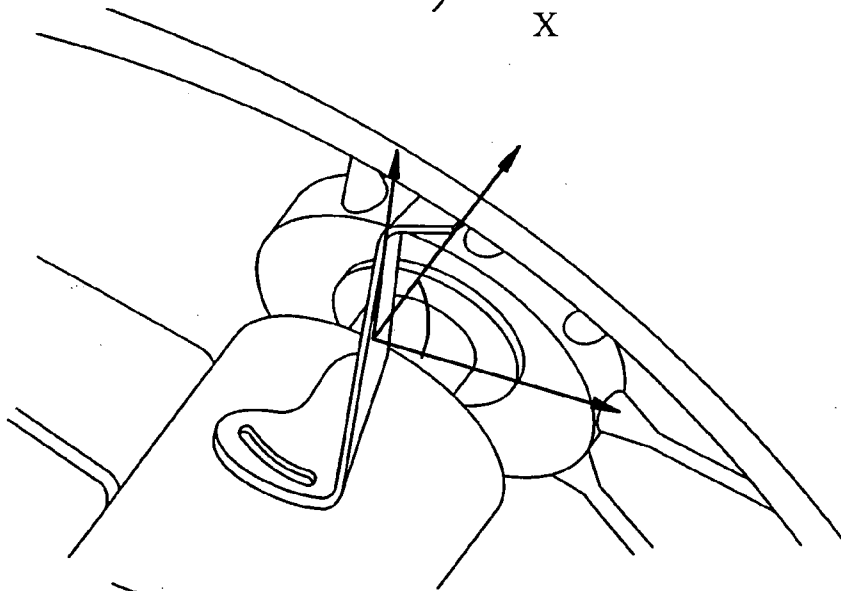


FIG. 6b

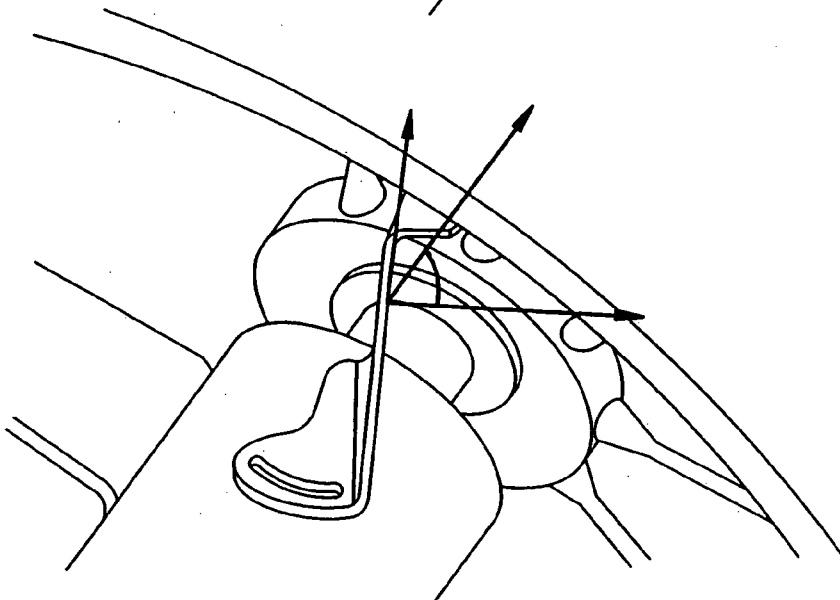


FIG. 6c

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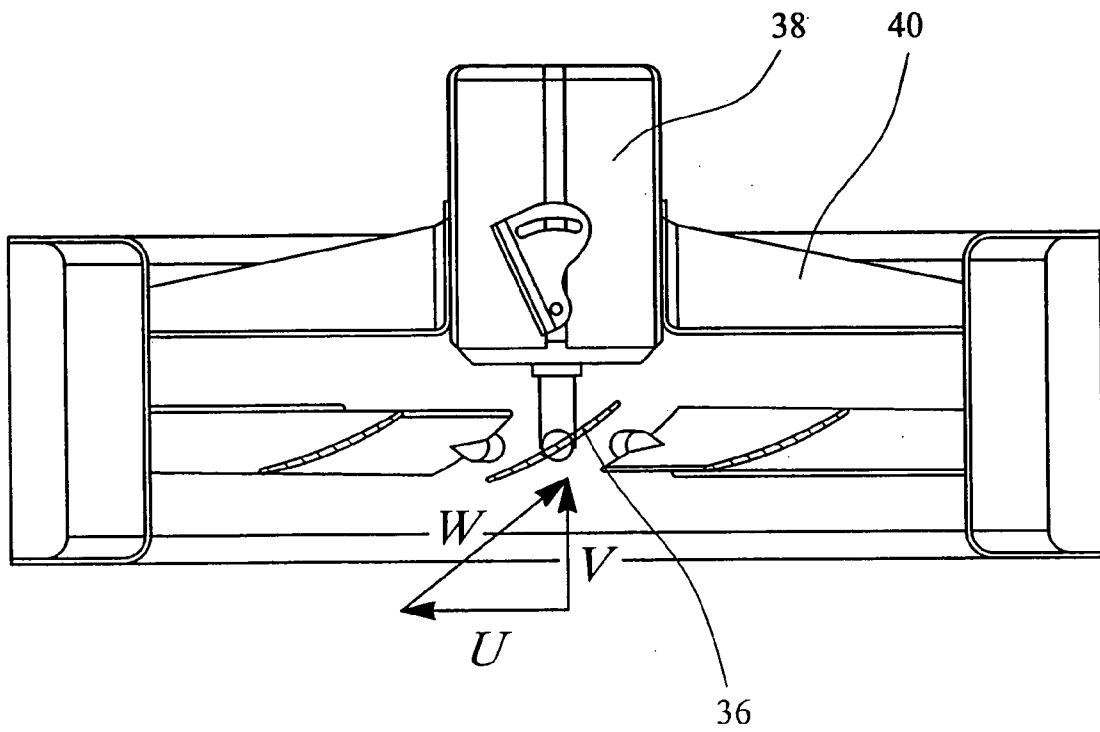


FIG. 7

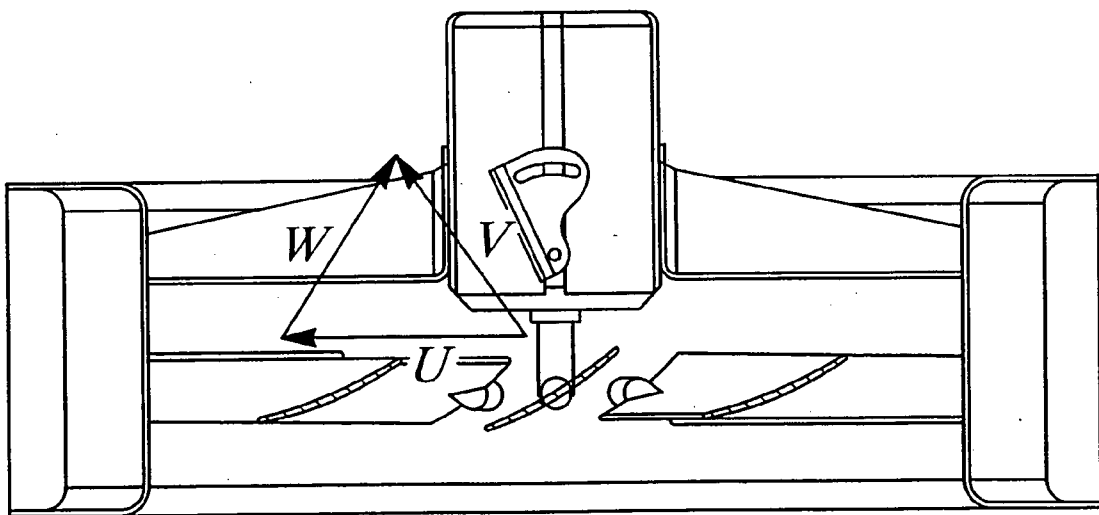


FIG. 8

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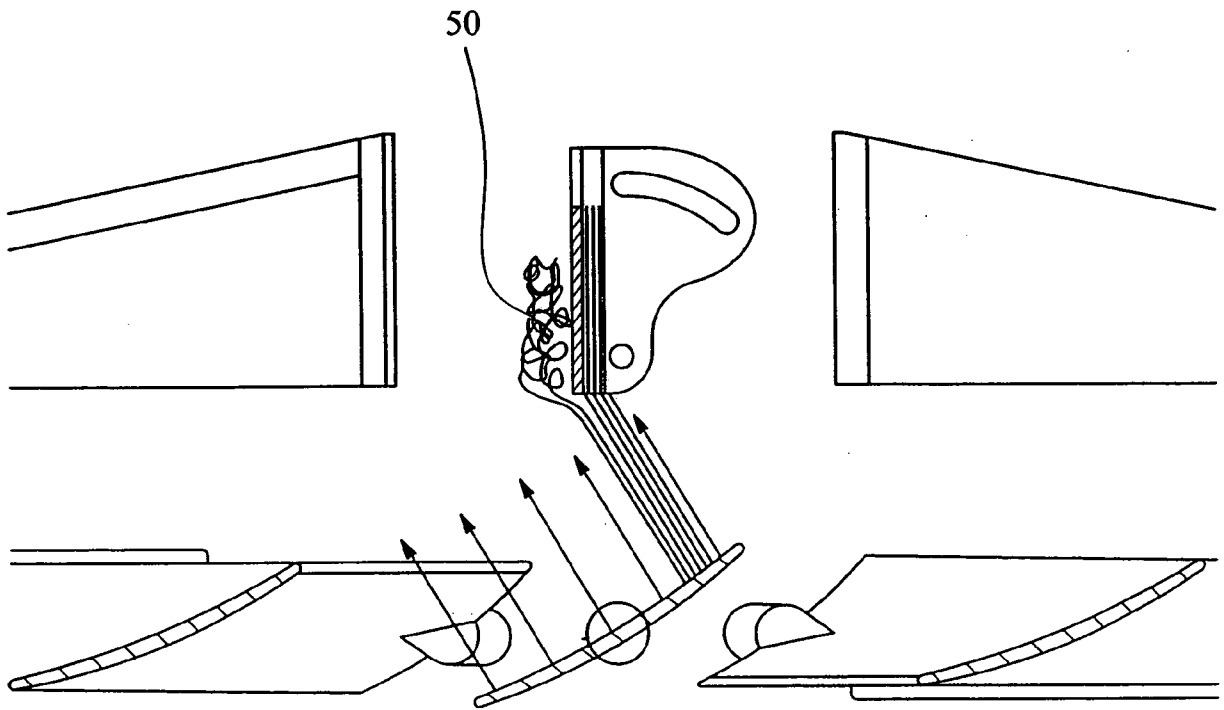


FIG. 9

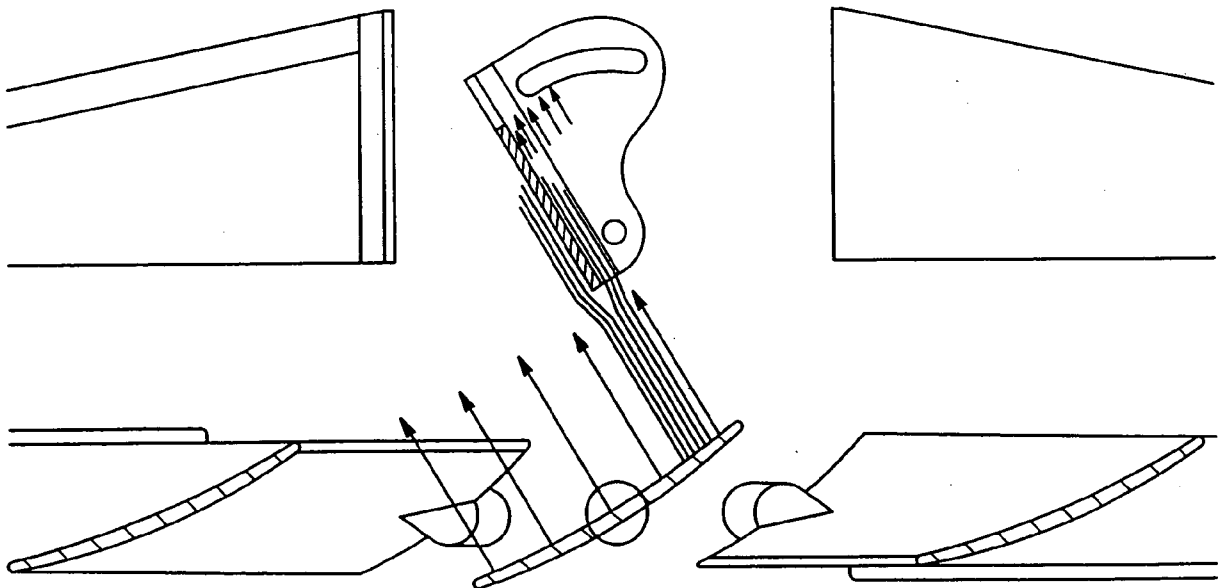


FIG. 10

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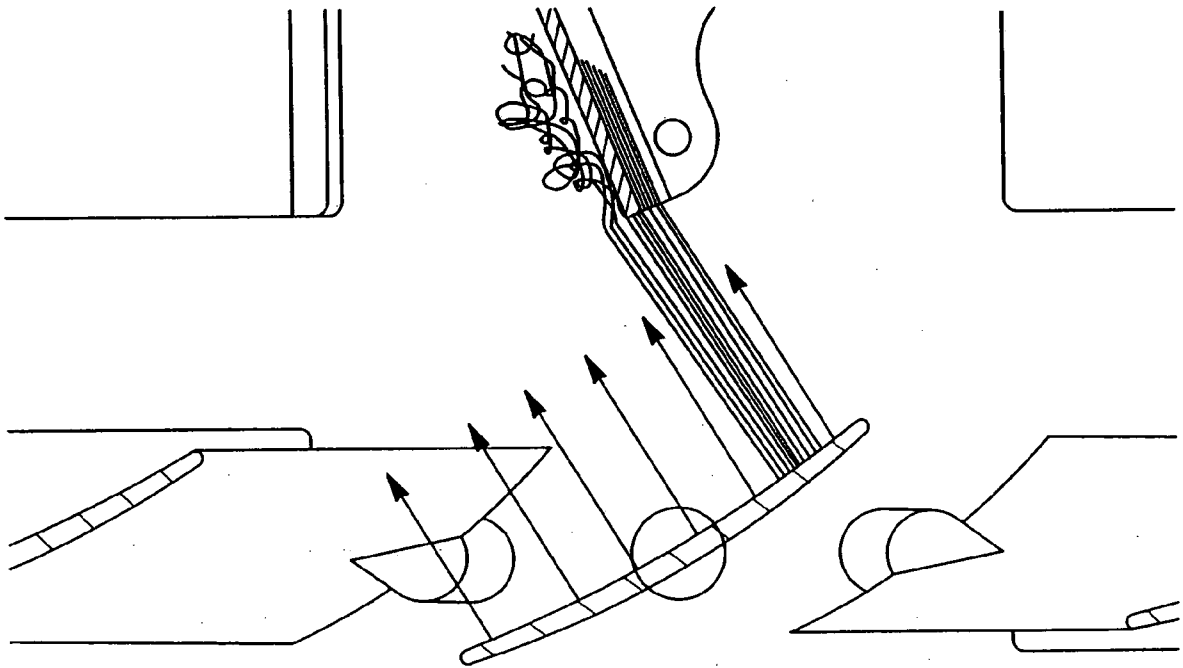


FIG. 11

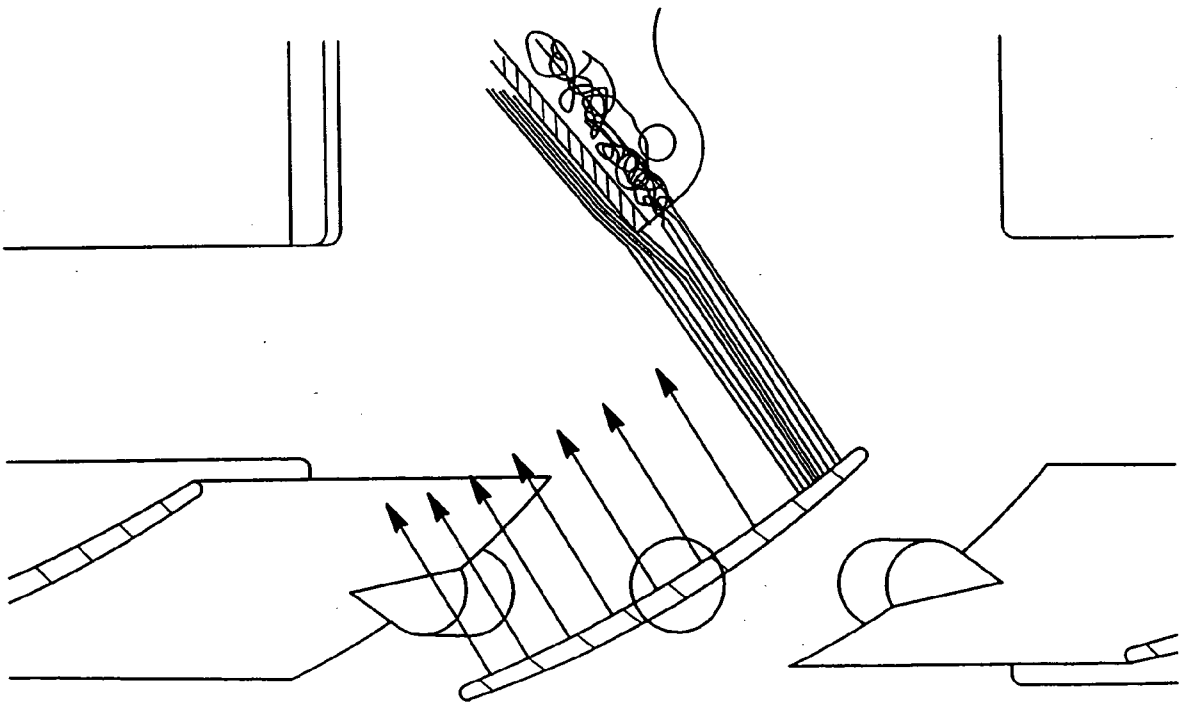


FIG. 12

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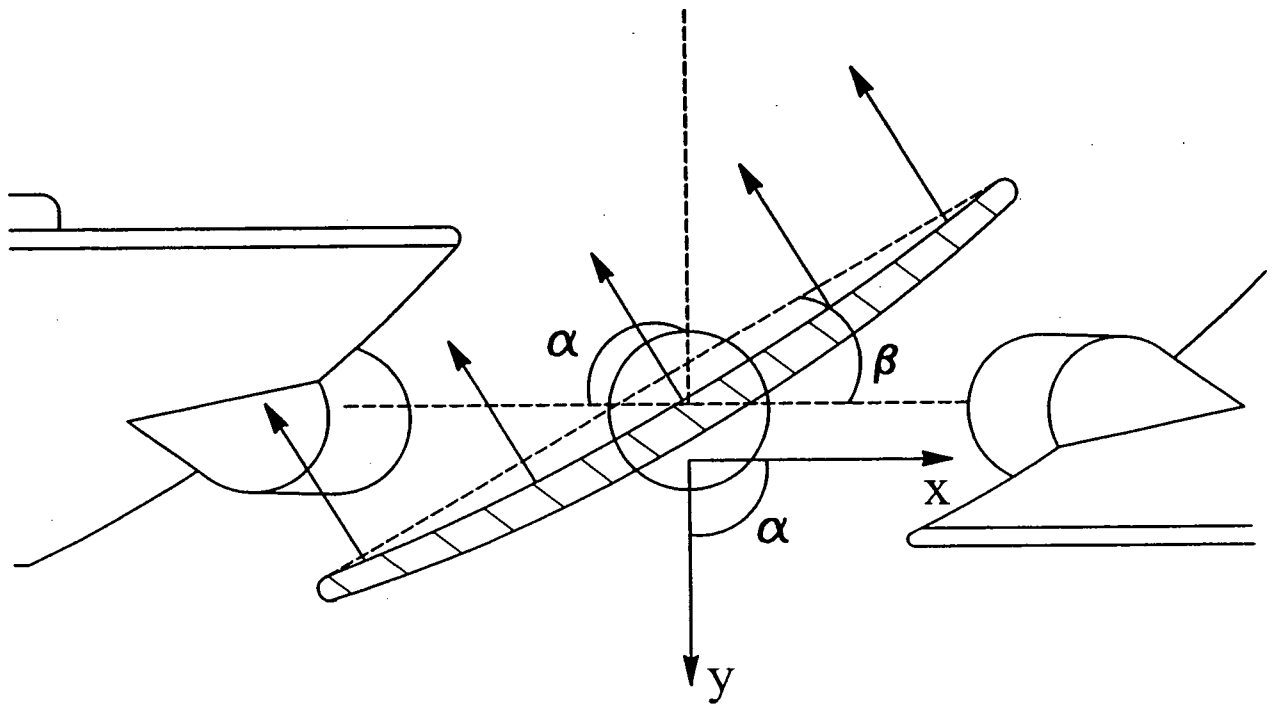


FIG. 13

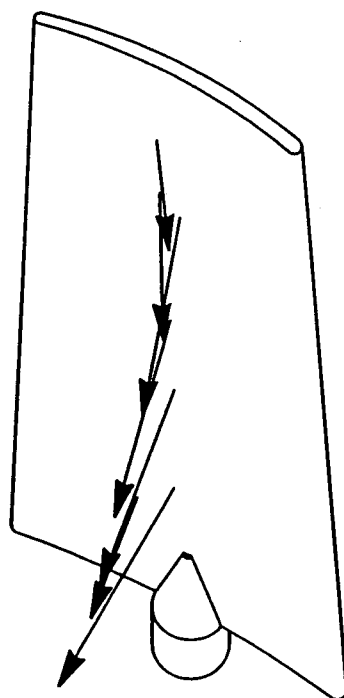


FIG. 14