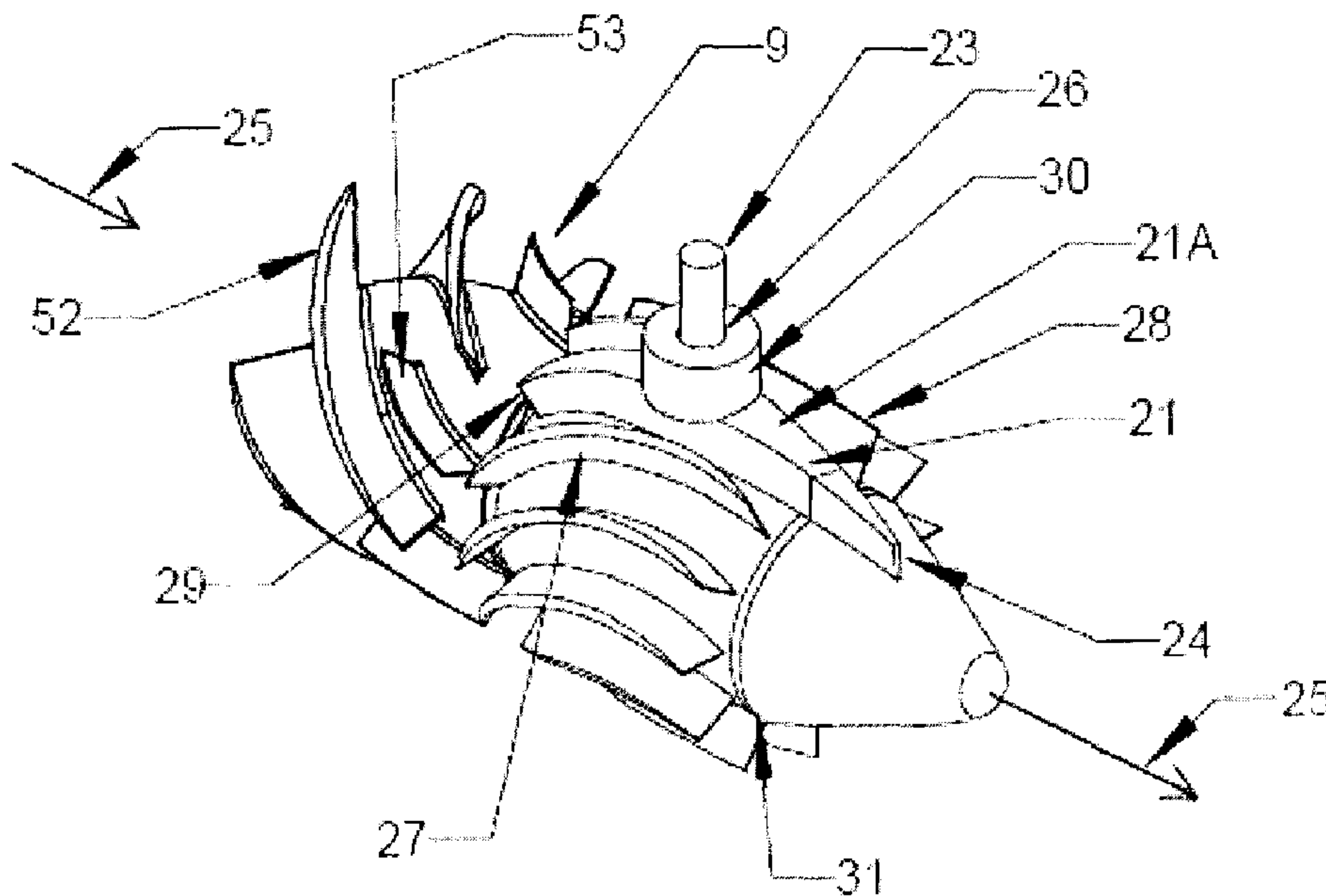




(22) Date de dépôt/Filing Date: 2010/04/06
 (41) Mise à la disp. pub./Open to Public Insp.: 2010/10/07
 (45) Date de délivrance/Issue Date: 2015/09/15
 (30) Priorité/Priority: 2009/04/07 (NZ576072)

(51) Cl.Int./Int.Cl. *B63H 11/103* (2006.01),
B63H 11/08 (2006.01), *F03B 3/18* (2006.01),
F04D 29/54 (2006.01)
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(54) Titre : POMPE A JET D'EAU SERVANT A PROPULSER UN VEHICULE AQUATIQUE
 (54) Title: WATER JET PUMP FOR PROPELLING WATER BORNE CRAFT



(57) **Abrégé/Abstract:**

A water jet pump for water borne craft that can have an 'outboard' or a 'stern- drive' configuration. The stator-gearbox housing of the jet pump may have an outboard power-head attached to its upper surface or alternatively a right angle drive can be attached thus permitting an inboard engine or 'stern-drive' layout. A further useful feature is the provision of a flexible neck to the jet pump intake that facilitates steering and trim. The stator-gearbox housing may be manufactured as a single component or comprise three separate components that are bolted together. An important feature of the stator-gearbox drive housing is that water is able to pass through the stator section of the stator-gearbox and a vertically arranged drive shaft without significant frictional losses due to turbulence. This is achieved by passing the shaft through a thickened stator blade that is hydrodynamically matched to the adjacent blades.

ABSTRACT

A water jet pump for water borne craft that can have an 'outboard' or a 'stern-drive' configuration. The stator-gearbox housing of the jet pump may have an outboard power-head attached to its upper surface or alternatively a right angle drive can be attached thus permitting an inboard engine or 'stern-drive' layout. A further useful feature is the provision of a flexible neck to the jet pump intake that facilitates steering and trim. The stator-gearbox housing may be manufactured as a single component or comprise three separate components that are bolted together. An important feature of the stator-gearbox drive housing is that water is able to pass through the stator section of the stator-gearbox and a vertically arranged drive shaft without significant frictional losses due to turbulence. This is achieved by passing the shaft through a thickened stator blade that is hydrodynamically matched to the adjacent blades.

Water Jet Pump for Propelling Water Borne Craft

TECHNICAL FIELD

- 5 This invention relates to water jet propulsion systems used for propelling boats and other water borne craft. In particular it relates to a water jet pump arrangement for propelling, steering and trimming a jet boat.

BACKGROUND ART

- 10 Marine propulsion is currently dominated by two main propulsion systems. The first being based on exposed propeller drives and the second, water jet pump designs of a centrifugal, mixed or axial flow configuration. The propeller drives fall into three broad classes called stern-drive, inboard/shaft, and outboard with further subclasses relating to more recent innovations. Propeller systems by far and away out sell those based on the water jet pump in spite of the obvious benefit that most jet pumps offer, their installation requiring no below-hull
15 projections.

- The reasons for this lie, in part, with the basic functionality of propeller systems, in that they are relatively quick to install, have compact and easily managed control systems for steering, trim and throttle control and are well integrated with the driving engine. Further a propeller is still in most circumstances more efficient than the jet pump although improved hydrodynamic
20 design is closing this gap, particularly for high speed applications. In respect of the jet pump based propulsion systems, an outboard design, US Patent 3,082,732 (Stallman), is currently manufactured with the pump being of a centrifugal design, whereby a vertical shaft drives a horizontally arranged impeller, fixed directly to the end of the vertical shaft. This design has some inherent deficiencies that make it somewhat hydrodynamically inefficient being by some
25 estimates 20 to 30 % less efficient than axial or mixed flow jet pump designs (Reference - The Jet Boat pp.80). Its major benefit is its simplicity of design and in particular, an ability to attach the pump section of the device to existing outboard power-head stems, thereby reducing the overall cost of manufacture.

- This jet pump is currently supplied to the world market by most of the major recreational
30 marine manufacturers. Other types of "axial flow outboard jets" are produced in much smaller numbers but these devices operate such that the pump section is submerged below the bottom hull line of the boat, when the boat is in planing mode.

Significantly the jet plume is therefore exhausted under the water rather than being expelled into the air behind the boat, with a consequent loss in efficiency. Examples of this type of jet pump are shown in US patents 3,249,083 and 3,389,558.

5 For boating applications these devices cannot therefore be used in very shallow water, such as might be found in the shallow braided rivers of North America and shallow coastal marine waters. Their usefulness seems primarily aimed at increased user safety, because the impeller is enclosed by the pump casing as compared to an exposed outboard propeller.

10 In US 4,281,996 is shown a simple outboard jet pump design having a geared assembly inside the flow path, where the vertical drive shaft penetrates through to the driving gears downstream of the stator section. This patent fails to address the hydrodynamic losses that arise from the multiple directional changes in the flow path, between the intake and nozzle.

Further, the jet nozzle is significantly elevated above water level when the boat is in planing mode, resulting in excessive head loss.

15 Also not addressed, are the means by which frictional losses are to be avoided as a result of the placement of a vertical drive shaft in the flow path.

This patent also fails to deal with the dimensional requirements needed for such a device, in respect of low loss flow through the pump, and its overall dimensions, particularly its length. If constructed as shown, this device would protrude a considerable distance out from the transom making it commercially unacceptable in the marine propulsion market.

20 In US 6,776,674 the patent attempts to improve on the efficiency of the outboard jet pump concept but is essentially a conventional axial flow jet pump attached by a swivel to the boat transom. This concept lacks the compactness of a conventional outboard propeller system, which incorporates both a trimming and steering function together using a "centralized" pivot system. In this example there is again, a lack of compactness. In particular its longitudinal overall length being excessive because the entire pump, including the intake, is mounted to the transom of the boat. As previously mentioned this leads to considerable market resistance because by default, it significantly increases the overall length of the craft in which it is installed.

30 Other examples of outboard jet pumps that propose to operate in planing mode are shown in US 5,769,674 and US 6,283,805. US 5,769,674 attempts to show how the lower superstructure of a conventional propeller outboard can be inserted into a pump housing with an attached intake and thus achieve an axial configuration. The excessive approach angles in the intake and the internal structures of the pump housing mean that it has poor efficiency, relative to the conventional axial or mixed flow pump designs.

35 US 6,283,805 attempts to integrate a conventional axial flow pump with an outboard power head, where the entire device is mounted on the boat transom. In respect of its hydrodynamic

efficiency, this jet pump is certainly more efficient than that shown in US 3,082,732 but again, its excessive length makes it less suitable for commercial or recreational use. The reader will also note that this jet pump retains a 'through the intake' drive shaft. The drawing FIG.2 of US 6,283,805 also fails to show the actual dimensional requirements that such a device will have. That is, the pump portion of this outboard design will be much longer than is represented - if the intake, for example, is to have an efficient geometry. It should be noted that in the drawings FIGS. 1 – 16 of US 6,283,805, that they are scaled correctly whereby the impellers shown are 210 mm in diameter thus giving the reader an idea of the relative proportional dimensions of the various components. The drawings therefore represent a dimensional outcome arising from the hydrodynamic constraints necessary to minimise losses as the water passes through the intake/pump. In FIG. 7 of US 6,283,805, for example, where the pump has 210 mm diameter impeller (for scaling purposes) the distance from the transom to the end of the steering nozzle is typically about 500 mm. The entire length of the pump shown as FIG. 7 of US 6,283,805 is about 1320mm. Given a smaller impeller of 160 mm diameter, driving the same sized craft, the pump length would still be in excess of say, 900 mm. So for designs allowing for the entire pump (including the intake housing) to be attached to the stern of, for example, a 5 metre long boat, the pump would extend beyond the transom by at best 900 mm and at worst 1320 mm. These dimensions thus give the reader an indication as to the limitations this imposes on commercial viability and ultimately pump design as it relates to an efficient outcome.

Inherent in all of the above mentioned devices is a failure to isolate and deal with the hydrodynamic losses arising in the intake but more particularly, the hydrodynamics involved in the stator-gearbox housing design and how this is applied to, in the end, producing a compact and commercially acceptable jet pump. The following describes how the short-comings of present jet pumps may be overcome, whereby an axial or mixed flow jet pump may be at least as hydrodynamically efficient, in either a stern-drive or outboard configurations, as conventional jet pumps having a through-intake drive shaft design.

It is an object of the present invention to address the foregoing problems or at least to provide the public with a useful choice.

No admission is made that any reference referred to in this specification constitutes prior art. The discussion of the references states what their authors assert, and the applicants reserve the right to challenge the accuracy and pertinency of the cited documents. It will be clearly understood that, although a number of prior art publications are referred to herein, this reference does not constitute an admission that any of these documents form part of the common general knowledge in the art, in New Zealand or in any other country.

Throughout this specification, the word "comprise", or variations thereof such as "comprises" or "comprising", will be understood to imply the inclusion of a stated element, integer or step, or

group of elements integers or steps, but not the exclusion of any other element, integer or step, or group of elements, integers or steps.

Further aspects and advantages of the present invention will become apparent from the ensuing description which is given by way of example only.

5 DISCLOSURE OF THE INVENTION

According to one aspect of the present invention there is provided a water jet pump having a stern-drive configuration wherein the water jet pump includes:

10 a drive shaft assembly, wherein the drive shaft assembly includes a first right angle drive located inside a stator-gearbox housing and wherein at least part of the drive shaft assembly connected to the first right angle drive is oriented at a right angle to a longitudinal axis of the stator-gearbox housing;

an impeller connected to the first right angle drive, the impeller located upstream of the stator-gearbox housing within an impeller housing attached to the stator-gearbox housing;

15 and a first stator blade attached to the stator-gearbox housing,

wherein the part of the drive shaft assembly connected to the first right angle drive passes through the first stator blade, and

20 wherein the first stator blade includes an upstream portion having a straight section that feathers into a curved section, wherein a leading edge of the upstream portion has a helix angle greater than 20°, and a downstream portion which is substantially parallel to a centreline of the stator-gearbox housing.

In a preferred embodiment the water jet pump includes a nozzle attached to, or formed with, the downstream end of the stator-gearbox housing.

25 In a preferred embodiment the water jet pump includes an intake configured to attach to, or formed with, the upstream end of the impeller housing.

In a preferred embodiment the water jet pump includes an engine configured to attach to the drive shaft assembly.

30 In a preferred embodiment the engine is an inboard engine configured to attach to the drive shaft assembly. The entire engine and jet pump assembly may be referred to as having a stern drive configuration.

In some embodiments the engine is an outboard power-head having a drive stem wherein a vertical shaft within the drive stem is configured to pass through the first stator blade and to engage with the first right angle drive.

In a preferred embodiment the first right angle drive includes two spiral bevel gears in constant mesh and oriented at right angles to one another.

In a preferred embodiment the drive shaft assembly includes a second right angle drive fixed to the stator-gearbox housing wherein one side of the second right angle drive is connected to an inboard stern-drive engine and the other side is connected to the part of the drive shaft assembly connected to the first right angle drive.

In a preferred embodiment the second right angle drive includes two spiral bevel gears in constant mesh and oriented at right angles to one another.

In a preferred embodiment the first stator blade is foil shaped having a length to width ratio in the range from 5.5:1 to 6.5:1.

In a preferred embodiment the water jet pump includes at least one second stator blade attached to the stator-gearbox housing adjacent the first stator blade wherein a wall of the second foil shaped stator blade is configured to be substantially parallel to a wall of the first stator blade.

In a preferred embodiment the leading edges of the first stator blade and the at least one second stator blade include a straight portion having a helix angle in the range from 35 degrees to 45 degrees and wherein the downstream portions of the stator blades, which form from 50 to 70 percent of the blade length, are parallel to each other and the centreline of the stator-gearbox housing.

One important advantage of the present invention is that it may overcome the substantial losses that can occur when the vertical drive shaft passes directly into the water flow being driven at high velocity through the stator-gearbox housing. This is provided for by the use of a first stator blade in the form of a thickened, foil shaped stator blade, through which the drive shaft passes, that allows a more or less parallel (to the adjacent stator blades), unobstructed, low loss flow path, for the impinging flow.

The foil shaped blades may be formed in two parts such that the second part, being the downstream portion of the blade, is tapered and forms part of the stator cone casting inside the nozzle, where it smoothly butts into the downstream end of the upstream portion of the blade. Alternatively, it can be cast as a single structure as part of the stator-gearbox housing. The stator blades, apart from the thickened foil shaped stator blade (the first stator blade), may extend to the rear of the stator-gearbox housing but the number of blades may either be increased and/or they may be lengthened so that they pass into the nozzle when more control of plume divergence is desired.

In a preferred embodiment the impeller has two sets of overlapping blades where one set of blades is upstream of the other set of blades.

To further improve the flow path in preferred embodiments, the inner surface of the internal section of the stator-gearbox housing, being also the outer surface of the stator-gearbox housing, is tapered from the upstream end, through to the upstream end of the nozzle in order to keep directional changes of the flow inside the stator-gearbox housing and nozzle as smooth as possible.

One important aspect of this invention is the need to provide a hydrodynamically efficient flow through-put, such that the impeller and stator blades interact to provide maximum efficiency whereby frictional losses are minimised and thrust output is maximised. Some geometrical considerations for this are described in the preferred embodiments, but do not preclude the use of existing impeller and/or stator configurations, that allow the invention to operate within the operating efficiency of existing axial or mixed flow jet pumps.

Another important advantage offered by this aspect of the invention is that it shows how to obtain hydrodynamic lift in the stator blade section which may increase the thrust output and thus the efficiency of the jet pump. This is achieved by setting the leading edge portion of the stator blades at a helix angle of about between 35 degrees and 45 degrees (preferably as close to 45 degrees to obtain the theoretical maximum lift) and configuring the geometry of the impeller blades such that the flow entering the stator blades is substantially parallel to the surface of the stator blades. Since the stator blades are foil shaped this may produce hydrodynamic lift and thus an increase in thrust output. The geometry of the stator blades may be described as having an upstream portion comprising a straight section that feathers into a curved section, such that both sections comprise between about one third and one half of the overall length of the stator blades. The straight sections of the upstream portions of the stator blades preferably have a helix angle of about 35 degrees to 45 degrees. The remaining downstream one half to two thirds of the stator blades are substantially parallel to each other (i.e. have the same shape as one another).

In a preferred embodiment the water jet pump includes pivoting means to support the water jet pump, the pivoting means including two concentric, conjointly pivoted rings, wherein an inner ring is attached to the impeller housing, the inner ring configured to pivot about an axis at right angles to a longitudinal axis of the impeller housing, and an outer ring configured to pivot about the longitudinal axis of the impeller housing, wherein the outer ring is attached to a swivel bearing block configured to attach to a transom.

In a preferred embodiment the intake includes a flexible neck.

In a preferred embodiment the flexible neck includes a concertina section formed from plastic or rubber reinforced with a helically wound steel coil.

In other embodiments the flexible neck includes two flexible "u-shaped" sections that are bonded together with a central rigid ring sandwiched between them.

Preferably, in use, the intake does not protrude below a hull.

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In other embodiments the water jet pump includes a ram adjusted mounting frame incorporating, or attached to, two concentric, conjoined pivoted rings that provide a means of steering and trim and a means of transmission of thrust to a transom.

This aspect of the invention relates to the use of a flexible intake and pivoting means that permits articulation of the jet pump about two orthogonal axes, typically in use this would correspond to vertical and horizontal axes. This feature allows for both steering and trim functions to be performed, without the need for a steering system to be coupled to the jet pump nozzle. Further advantages of this may be that it provides for improved hydrodynamics over that of conventional steering systems and also a reduction in the cost of construction of the intake, as, in use, the intake no longer receives the thrust loading from the jet pump, the thrust being transmitted initially to rotatable mounts, then to the boat's transom.

5 Another aspect of the invention allows for an outboard power-head to be attached to both the 'flexible' intake design and also a 'rigid' intake design. This is made possible because the stator-gearbox housing is a component common to both an outboard and an inboard stern-drive configuration, whereby an additional right angle drive or an outboard power-head/drive stem assembly respectively may be attached to it.

10 In some embodiments the intake, the impeller housing, the stator-gearbox housing and the nozzle are fixed rigidly together. In such embodiments the intake is formed as a single rigid component (i.e. without the flexible neck).

In a preferred embodiment the stator-gearbox housing, including the first right angle drive and the nozzle is detachable from the impeller housing as a single unit.

This embodiment of the invention may be used in a simplified device for use with an inboard engine or an outboard power head. The intake is a rigid structure, whereby the thrust from the jet pump is transmitted to the solid mounted intake. In a further configuration an advantage is that the stator-gearbox housing, impeller and nozzle may all be removed as one integrated unit, for maintenance purposes, by simply removing bolts that attach the stator-gearbox housing to the impeller housing. The impeller housing may be a separately attached housing or it may be formed as part of the intake whereby the impeller housing and the intake are combined into a single component. In these embodiments the steering and trim functions are provided via the nozzle as in conventional arrangements.

15 In some embodiments the stator-gearbox housing includes an inner gearbox housing and at least two outer housings configured to fit around the inner gearbox housing.

Another useful feature is that, while the stator-gearbox housing and gearbox housing would, for commercial purposes, usually be cast as a single unit from a corrosion resistant aluminium alloy, it may also be made in three parts. This includes a separate inner gearbox housing, with attached stator blades, and an outer component comprising two machined and doweled outer

housings. The inner gearbox housing can thus be located and locked inside the two outer housings, using bolts for example, that hold the outer housings together.

Rotation of the inner gearbox housing (including the stator blades) may be prevented by a locating boss, formed as an extension of the thickened foil shaped stator blade where the vertical shaft penetrates through into the outer housings, thus creating a locking structure. This improvement may allow the end user to change both the impeller and the stator geometry, for example for experimental purposes, which may provide the ability to adjust the pump's performance for a variety of uses or circumstances.

In a preferred embodiment the inboard stern-drive engine is configured to be mounted in a three point fashion to a transom shelf and to the inside of a transom.

In another embodiment the inboard stern-drive engine is configured to be mounted in a three point fashion by two mounting points in the vicinity of the intake and at least one other mounting
5 point to the inside of a transom.

In this case the invention is directed to the manner in which an inboard located engine may be coupled and securely fixed. The engine may be attached by flexible mounts to a 'shelf' attached to the inside of a transom whereby the engine is fixed to the shelf and the transom, in a three point arrangement. Alternatively, two of the lower mounts may be provided as part of the intake, while the third is still attached to the inside of the transom.

BRIEF DESCRIPTION OF THE DRAWINGS

Further aspects of the present invention will become apparent from the ensuing description which is given by way of example only and with reference to the accompanying drawings in which:

- 10 Figure 1 shows an isometric view of a stern-drive jet pump according to a preferred embodiment of the present invention;
- Figure 2 shows a cut-away view of part of the jet pump of Figure 1;
- Figure 3 shows an isometric view of a jet pump according to another embodiment of the present invention;
- 15 Figure 4 shows another isometric view and part cut-away of a jet pump according to another embodiment of the present invention;
- Figure 5 shows an isometric, part cut-away of a stern-drive jet pump according to another embodiment of the present invention;
- Figure 6 shows a side view of a jet pump according to another embodiment of the present
20 invention;

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- Figure 7 shows a side view of a jet pump according to another embodiment of the present invention;
- Figure 8 shows an isometric view of a part of a jet pump according to another embodiment of the present invention;
- 5 Figure 9 shows an isometric view of a part of a jet pump according to another embodiment of the present invention;
- Figure 10 shows a sternward looking isometric view of a part of a jet pump according to another embodiment of the present invention;
- Figure 11 shows an isometric view of a part of a jet pump according to another
10 embodiment of the present invention;
- Figure 12 shows an upward looking isometric view of the bottom of a boat including a part of a jet pump according to another embodiment of the present invention;
- Figure 13 shows an isometric view of a part of a jet pump according to another embodiment of the present invention;
- 15 Figure 14 shows a part of a jet pump according to another embodiment of the present invention;
- Figure 15 shows an isometric view of a part of a jet pump according to another embodiment of the present invention; and
- Figure 16 shows a geometric view of a stator blade according to one embodiment of the
20 present invention.

BEST MODES FOR CARRYING OUT THE INVENTION

FIG. 1 shows a stern-drive configuration of a water jet pump according to one preferred embodiment of the invention. An inboard engine (1) is attached to a drive shaft assembly including drive shaft (3) and vertical shaft (23) (shown in Fig. 5). Vertical shaft (23) engages
25 with a first right angle drive, in the form of two spiral bevel gears (12, 13) in Fig. 5 while the engine (1) engages with the second right angle drive (2), also in the form of two spiral bevel gears (10,11), via the drive shaft (3). The drive shaft (3) comprises a central shaft (4) and two constant velocity joints (5) and (6). These may also be seen in the part cutaway view in FIG. 2.

A flexible cover (not shown) clips to the second right angle drive (2) at one end and an oval or
30 elliptical shaped spigot (8), FIG. 10, fixed to a transom (50), at the other end. This ensures that a watertight seal exists between the jet pump and the transom (50), and that the drive shaft (3), FIG. 2, is also sealed off from water intrusion.

FIGs. 2 and 5 shows a drive train consisting of the inboard engine (1), attached to the drive shaft assembly, including the drive shaft (3), second right angle drive (2) (spiral bevel gears 10 and 11), vertical shaft (23) and the first right angle drive (spiral bevel gears 12 and 13) is connected to the impeller (9). Spiral bevel gears (10) and (11) are in constant mesh as are the lower spiral bevel gears (12) and (13). The spiral bevel gears (10) and (11), FIG. 2 are supported by bearings (14) and (15) mounted inside the second right angle drive (2), FIG. 2 and bearings (not shown) mounted inside the nose cap (17), that is fixed by bolts (18) to the stator-gearbox housing (22) at the face (16), as seen in FIG. 5. Alternatively, but not shown in FIG. 5, the spiral bevel gear (13) may be further supported by locating an additional bearing (not shown) at the down-stream end of the stator-gearbox housing (22).

The jet pump outlet nozzle (19) bolts directly to the down stream end of the stator-gearbox housing (22). The downstream end of the stator-gearbox housing (22), FIG. 2 has a cone (20) attached to it to provide better flow characteristics in the nozzle (19).

To prevent the substantial losses that would occur should the vertical shaft (23), FIG. 5 and FIG. 15, pass directly through the impinging water flow (25), FIG. 14 and FIG. 15, the shaft (23) is aligned such that it passes through a hole (26) in the first stator blade, hereafter sometimes referred to as the thickened stator blade (21). Current pump designs do not allow this as their stator blades are constructed as thinly as is practicably possible to keep losses to a minimum. To overcome this the first stator blade (21) has a thickened foil like geometry, as seen in FIG. 15. The first blade (21) thus provides a more or less parallel, to the adjacent stator blades (27) and (28), low loss path, for the impinging flow (25). The first blade (21) typically has a length to width ratio of about 6.0:1 and the widest portion through which the vertical drive shaft (23) passes is found about 0.45 of the foil length downstream of its upstream edge (29). The first blade (21) may be in two parts such that the second part (24) is formed as part of the cone (20) where it smoothly butts into the downstream end of the upstream portion of the blade (21).

Where the stator-gearbox housing (22) is not constructed as a single casting as shown in FIG. 11 and FIG. 15, the foil shaped first stator blade (21) has a locating boss (30) formed into its upper surface (21A) that serves to locate the gearbox housing (31), FIG. 15, as a separate component inside the outer housing(s), (32) and (33) as seen in FIG. 11. O ring seals, not shown, inserted in grooves (not shown) in the boss (30) prevent water intrusion.

The outer housings (32) and (33) of the stator-gearbox housing, as shown in FIG. 11, are dowelled and bolted together (dowels and bolts not shown) such that they clamp the gearbox housing (31) into place.

The impeller housing (34) seen in FIG. 1 and FIG 2 bolts (bolts not shown) to the stator-gearbox housing (22) via flanges (35) and (36), FIG. 1. On the upstream end of the impeller housing (34) is fixed, by means of a clamp (not shown), a flexible neck or coupling (37) which in turn attaches to the intake (38), FIG. 1 and FIG 2. The flexible neck (37) can be seen more

clearly as FIG. 9. The flexible neck (37) consists of a concertina section of high strength plastic or rubber, reinforced with a helically wound steel coil (not shown) cast into it during manufacture. The embedded coil (not shown) prevents the flexible neck (37) from collapsing when the inside of the intake (38), FIG. 2 is operating under vacuum or suction. An alternative construction method is shown for the flexible neck (37) in FIG. 8, where two flexible 'u' sections (39) and (40), seen in cutaway view, are bonded together with a central rigid ring (41) sandwiched between, that also allows a smooth inner surface.

In respect of the rotatable jet pump the upstream end of the impeller housing (34) has a ring (42) cast or fixed to it via lugs (43) and (44), as shown in FIG. 1 and FIG. 2. Each north and south pole of the ring (42) has a locating swivel pin (45) and (46), seen in FIG. 2, that pass into bearings (not shown) in the outer ring (47). The ring (42) is not shown in FIG. 2. The outer ring (47) is also, in turn, located by the swivel bearing blocks (48) and (49) seen in FIG. 10, and pins, not shown. The bearing blocks (48) and (49) seen in FIG. 10, are in turn fixed to the transom (50), FIG. 10. The thrust is transferred to the hull (51), FIG. 12 at this point. The two rings (42) and (47), FIG. 1, pivot approximately about the centre point of the flexible neck (37) in order to allow the flexible neck (37) to rotate in a relatively unstressed state. This arrangement permits movement of the entire downstream section of the jet pump comprising the impeller housing (34), stator-gearbox housing (22) and the nozzle (19) in both the vertical and horizontal plane. This action facilitates steering and trimming of the boat in which the jet pump is installed.

FIG. 15 shows the thickened foil shaped first stator blade (21) and the impeller (9) with blades (52) and (53). FIG. 14 shows a 'rolled-out' two dimensional diagram of the impeller blades (52) and (53) and stator blades (27), (21) and (28), relative to each other, with arrows (55) indicating the direction of hydrodynamic lift relative to the surface (54) of the stationary stator blades (27), (21) and (28). The leading portion (56) of the stator blade (27) ideally has a helix angle (59), FIG. 16 of about 45 degrees. The downstream portion (57) of the stator blade (27) comprising about 0.55 of the overall length of the blade (27) feathers out from the curved portion (58) of the blade (27), FIG. 14 and FIG. 16, so that the downstream portion (57) of the blade (27) is more or less parallel to the adjacent downstream portions (57A) of the adjacent stator blades (21) and (28) as seen in FIG. 14.

In FIG. 16 is described the basic geometrical shape of the stator blade (27) in relation to the centreline (60) of the stator-gearbox housing (22). The leading portion (56) of the stator blade (27) is in one configuration inclined as shown in FIG. 14 and FIG. 16, where for about 0.45 of its length it is helically rotated about the centreline (60) such that the helix angle (59) is about 45 degrees. The variation in the angular change of the root portion (61) of the stator blade (27) may be ignored since the radial width (62) of the stator blade (27) is small in relation to the distance from the centreline (60) to the outer edge (63) of the stator blade (27). The leading

portion of the stator blade (56) curves into the downstream portion (57) of the stator blade (27) such that the downstream portion (57) is parallel with the centreline (60).

The curved portion (58) of the stator blade (27) formed between the leading portion of the stator blade (56) and the downstream portion (57) has the geometry described in FIG. 16 where
 5 the distance "r" (64) is the radius from the centreline (60) of the stator-gearbox housing (22) to the outer edge (63) of the stator blade (27). Rotation of the line (60) through the angle (65), being about 28 degrees, generates the curved portion (58) of the blade (27). The pivot point (66) is located at a point on the centreline (60) about 0.5 of the length of the stator blade (27) towards the impeller (9) end of the stator gearbox housing (22).

10 FIG. 16 is shown in a two dimensional view looking down onto the outer edge (63) of the stator blade (27) but with the centreline (60) rotated at 90 degrees. The impeller (9), FIG. 15 has two sets of blades (52) and (53). The downstream blades (53) are overlapped into the upstream blades (52).

FIG. 12 and FIG. 13 show a method of installation. FIG. 13 shows the engine mounts (67),
 15 (67A) and intake (38). FIG. 12 shows an inside hull (51), bottom view of the transom shelf (68), engine (1) and transom (50). The intake (38) is installed from the outside of the hull (51) so that it can be withdrawn in the manner shown, through the bottom of the hull (51). Because the intake (38) accepts no thrust from the jet pump it can be made of lighter cheaper materials such as, for example, rotary moulded plastics. The sternward looking end of the intake (38)
 20 inserts into the transom shelf (68) via the neck hole (69) and has an internal spigot (not shown). An O ring or flexible skirt (both not shown) seals the close fitting surfaces to prevent water intrusion.

FIG. 13 shows a hatchway (70) into the transom shelf recess (71) enabling access to the flexible neck (37), seen in FIG. 2. In order to remove debris from the intake (38) a clip (not
 25 shown) retaining the flexible neck (37), to the intake (38), can be undone and the flexible neck (37) then be pushed back to allow entry to the internal area of the intake (38). A view of the intake (38) with the flexible neck (37) removed altogether, can be seen in FIG. 10.

The top of the transom shelf (68) is designed so that it is above the water line at all times and is closed off by a lid (not shown) since the internal space is open to the rear of the boat, as seen
 30 in FIG. 10. Up and down movement of the impeller housing (34), stator-gearbox housing (22) and nozzle (19), that allows the boat to be trimmed under power, is achieved by remote movement of a rotatable trim lever arm (72), FIG. 1, (part view only shown), attached to the outer ring (47). Pulling the arm (72) towards the bow angles the nozzle (19) of the jet pump upwards, whilst in the opposite direction, it moves downwards. Steering is achieved by pulling
 35 and pushing on the control cable/rod (73) via a cable (not shown) attached to the steering wheel (not shown) at the helm of the boat. The cable/rod (73) is attached to the impeller housing (34) at location point (74) with a swivel joint (75).

FIG. 3, FIG. 4, and FIG. 6 describe an outboard configuration whereby an outboard power-head/drive stem (76) is attached directly to the stator-gearbox housing (22) wherein a vertical shaft (23) is attached to the first right angle drive (spiral bevel gears 12 and 13), thus removing the need for the second right angle drive (2). Further, the impeller housing (34), power-head/drive stem (76) and nozzle (19) assembly may be rigidly in connection with the intake (38), FIG. 4, or as shown in FIG. 3, attached to the intake (38) by a flexible neck (37).

In respect of mounting, trimming and steering, the outboard jet pump is largely similar to the stern-drive version, however FIG. 3 shows a mounting frame (77) where the outer ring (47) is incorporated into the frame (77). In this design the power-head/drive stem (76), is attached to the vertical pivot shaft (78) via two brackets (79) and (80). Trimming is achieved by means of the rams (81) and (82) and steering by remote activation of the steering arm (83).

FIG. 3 and FIG. 4 show an outboard power-head/drive stem (76) and extension/adaptor plate (84) fixed to the stator-gearbox housing (22).

FIG. 6 shows a simple means for cleaning debris from inside the intake (38) where an access port (85) is built into the intake (38).

The access port (85) is sized so that when the boat is stationary the port (85) extends well above the waterline. A removable access lid (86) is fixed in place and sealed with an 'O' ring (not shown) to prevent leakage. To provide continuity of shape of the inner wall of the intake (38), a water-tight plug (87) is fixed inside the access port (85). Access is gained by removing the lid (86) and plug (87) allowing safe and easy removal of debris up to the impeller (9). This modification is particularly suited to the outboard jet pump shown as FIG. 4 and FIG. 6.

Aspects of the present invention have been described by way of example only and it should be appreciated that modifications and additions may be made thereto without departing from the scope thereof as defined in the appended claims.

WHAT I CLAIM IS:

1. A water jet pump having a stern-drive configuration wherein the water jet pump includes:

a drive shaft assembly, wherein the drive shaft assembly includes a first right angle drive located inside a stator-gearbox housing and wherein at least part of the drive shaft assembly connected to the first right angle drive is oriented at a right angle to a longitudinal axis of the stator-gearbox housing;

an impeller connected to the first right angle drive, the impeller located upstream of the stator-gearbox housing within an impeller housing attached to the stator-gearbox housing;

and a first stator blade attached to the stator-gearbox housing,

wherein the part of the drive shaft assembly connected to the first right angle drive passes through the first stator blade, and

wherein the first stator blade includes an upstream portion having a straight section that feathers into a curved section, wherein a leading edge of the upstream portion has a helix angle greater than 20° , and a downstream portion which is substantially parallel to a centreline of the stator-gearbox housing.
2. A water jet pump as claimed in claim 1 wherein the helix angle is greater than 35° .
3. A water jet pump as claimed in claim 1 wherein the helix angle is in the range from 35° to 45° .
4. A water jet pump as claimed in claim 1 wherein the first right angle drive includes two spiral bevel gears in constant mesh and oriented at right angles to one another.
5. A water jet pump as claimed in either one of claims 1 or 2 wherein the first stator blade is foil shaped having a length to width ratio in the range from 5.5:1 to 6.5:1.
6. A water jet pump as claimed in any one of claims 1 to 3 including at least one second stator blade attached to the stator-gearbox housing adjacent the first stator blade wherein a wall of the second foil shaped stator blade is configured to be substantially parallel to a wall of the first stator blade.
7. A water jet pump as claimed in claim 6 wherein the leading edges of the first stator blade and the at least one second stator blade include a straight portion having a helix angle in the range from 35 degrees to 45 degrees and wherein the downstream portions

- of the stator blades, which form from 50 percent to 70 percent of the blade length, are parallel to each other and the centreline of the stator gearbox housing.
8. A water jet pump as claimed in any one of claims 1 to 7 wherein the impeller has two sets of overlapping blades where one set of blades is upstream of the other set of blades.
 9. A water jet pump as claimed in any one of claims 1 to 8 wherein the stator-gearbox housing includes an inner gearbox housing and at least two outer housings configured to fit around the inner gearbox housing.
 10. A water jet pump as claimed in any one of claims 1 to 9 including a nozzle attached to, or formed with, the downstream end of the stator-gearbox housing wherein the stator-gearbox housing, including the first right angle drive, and the nozzle is detachable from the impeller housing as a single unit.
 11. A water jet pump as claimed in any one of claims 1 to 10 including an intake attached to, or formed with, the upstream end of the impeller housing, and a nozzle attached to, or formed with, the downstream end of the stator-gearbox housing, wherein the intake, the impeller housing, the stator-gearbox housing and the nozzle are connected rigidly together.
 12. A water jet pump as claimed in any one of claims 1 to 11 including pivoting means to support the water jet pump, the pivoting means including two concentric, conjointly pivoted rings, wherein an inner ring is attached to the impeller housing, the inner ring, configured to pivot about an axis at right angles to a longitudinal axis of the impeller housing, and an outer ring configured to pivot about the longitudinal axis of the impeller housing, wherein the outer ring is attached to a swivel bearing block configured to attach to a transom.
 13. A water jet pump as claimed in claim 12 including an intake wherein the intake includes a flexible neck.
 14. A water jet pump as claimed in claim 13 wherein the flexible neck includes a concertina section formed from plastic or rubber reinforced with a helically wound steel coil.
 15. A water jet pump as claimed in claim 13 wherein the flexible neck includes two flexible "u-shaped" sections that are bonded together with a central rigid ring sandwiched between them.
 16. A water jet pump as claimed in any one of claims 13 to 15, wherein, in use, the intake does not protrude below a hull.

17. A water jet pump as claimed in any one of claims 1 to 16 including a ram adjusted mounting frame incorporating, or attached to, two concentric, conjoined pivoted rings that, in use, provide a means of steerage and trim and a means of transmission of thrust to a transom.
18. A water jet pump as claimed in any one of claims 1 to 17 wherein the drive shaft assembly includes a second right angle drive fixed to the stator-gearbox housing wherein one side of the second right angle drive is configured to connect to an inboard engine and the other side is connected to the part of the drive shaft assembly connected to the first right angle drive.
19. A water jet pump as claimed in claim 18 wherein the second right angle drive includes two spiral bevel gears in constant mesh and oriented at right angles to one another.
20. A water jet pump as claimed in any one of claims 1 to 19 including an inboard engine configured to attach to the drive shaft assembly.
21. A water jet pump as claimed in claim 20 wherein the inboard engine is configured to mount in a three point fashion to a transom shelf and to the inside of a transom.
22. A water jet pump as claimed in claim 20 wherein the inboard engine is configured to mount in a three point fashion by two mounting points in the vicinity of the intake and at least one other mounting point to the inside of a transom.
23. A water pump jet as claimed in any one of claims 1 to 17 including an outboard power-head having a drive stem, wherein a vertical shaft inside the drive stem is configured to pass through the first stator blade and to engage with the first right angle drive.

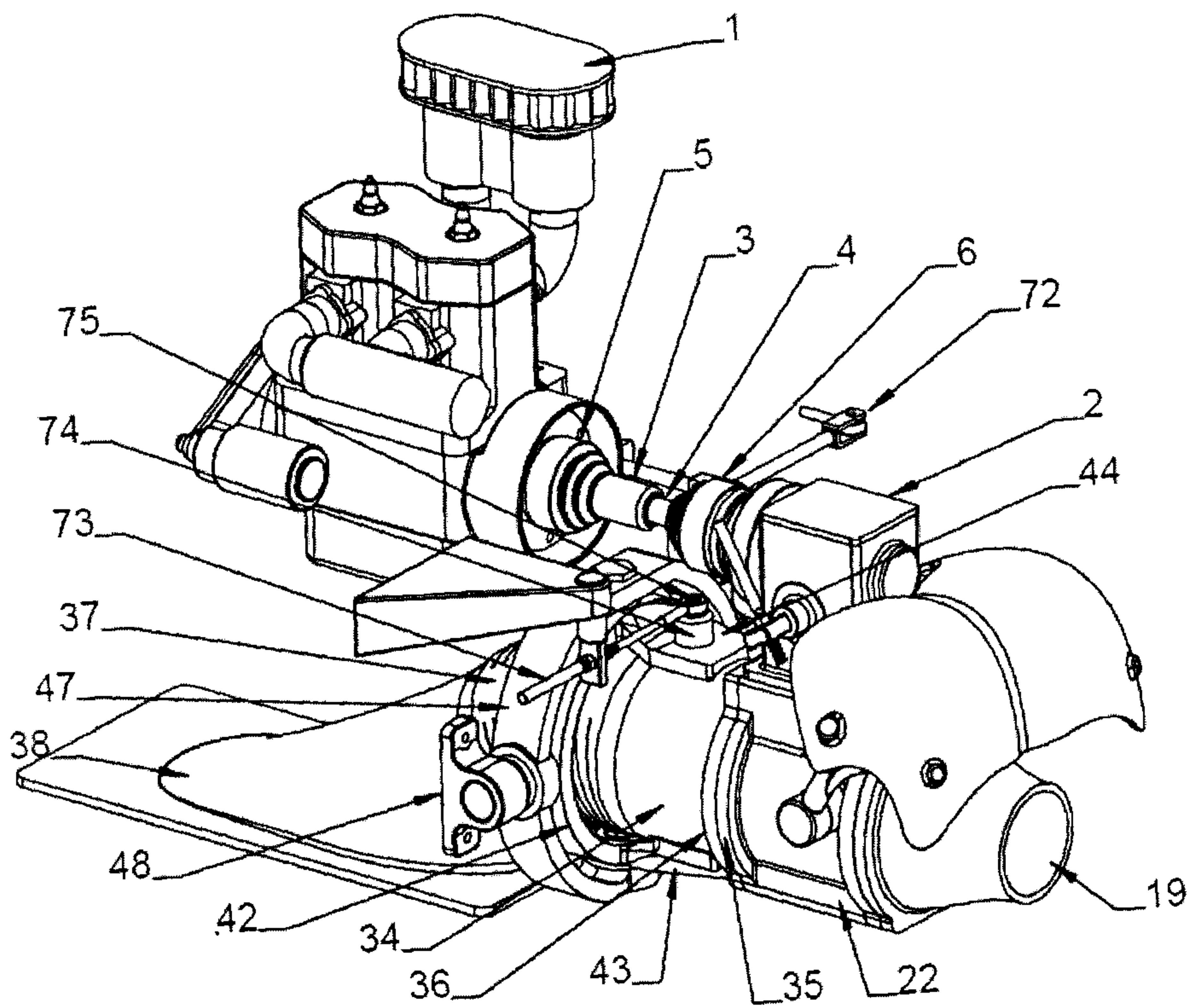


FIG. 1

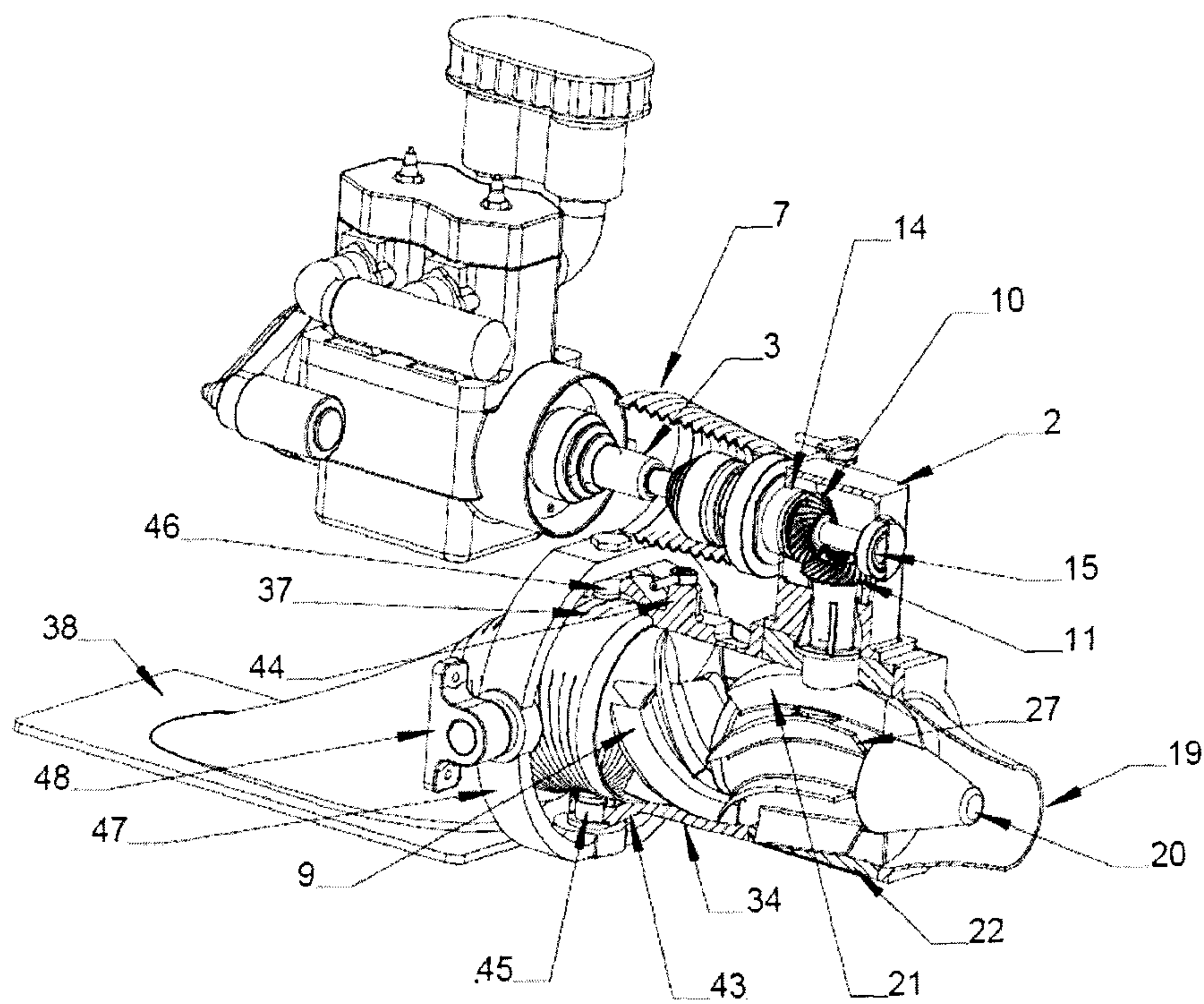


FIG. 2

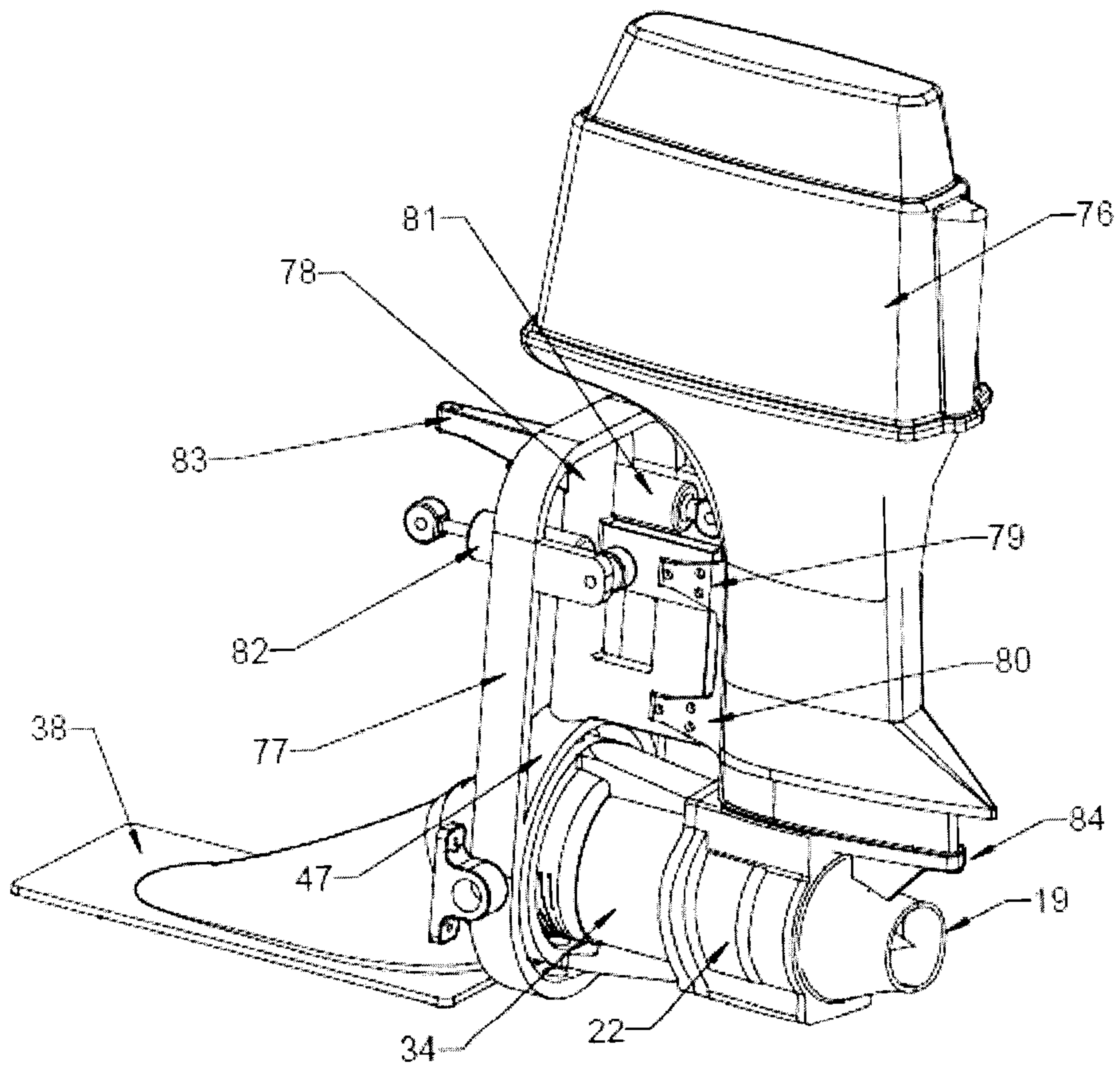


FIG. 3

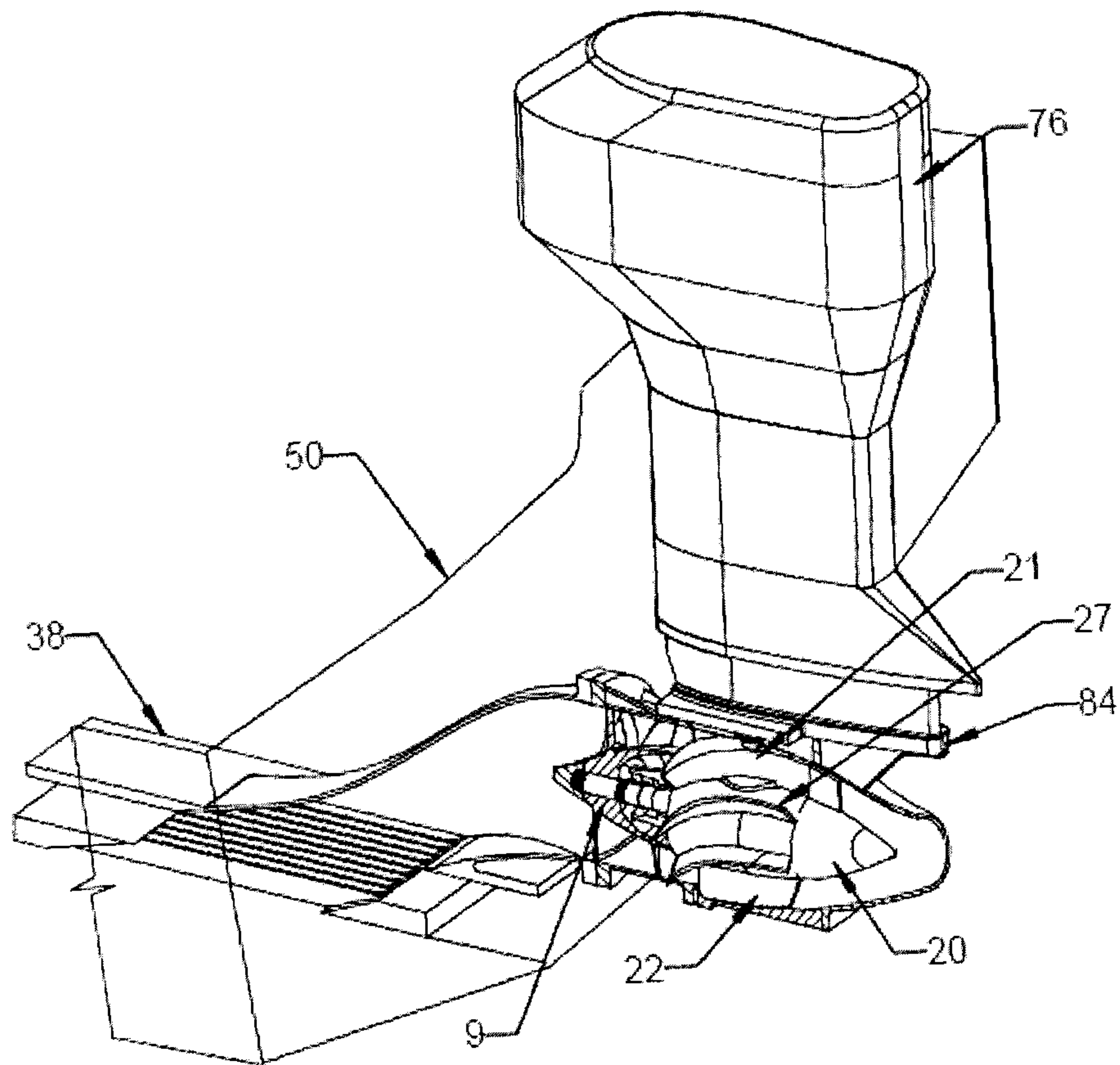


FIG 4

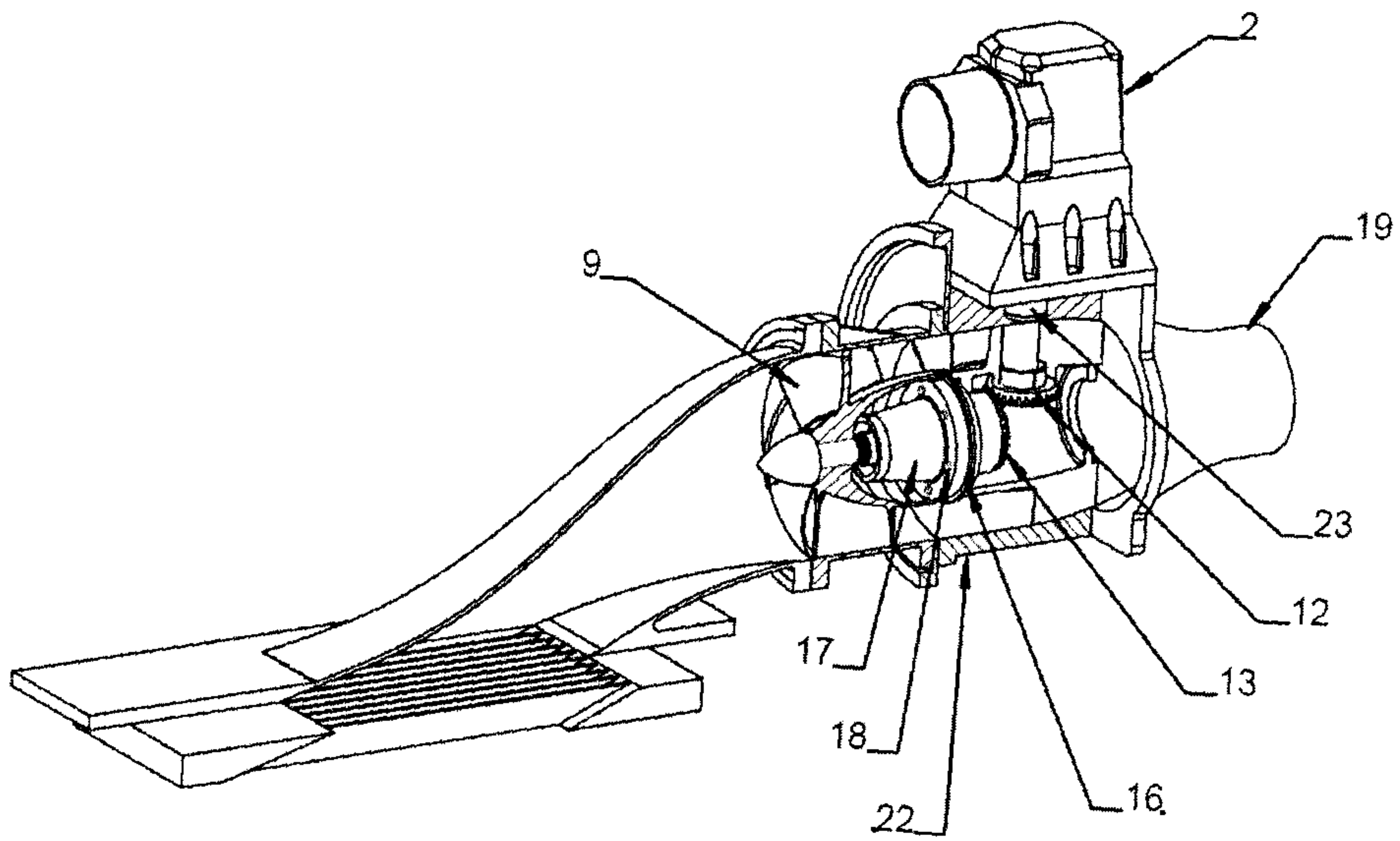


FIG. 5

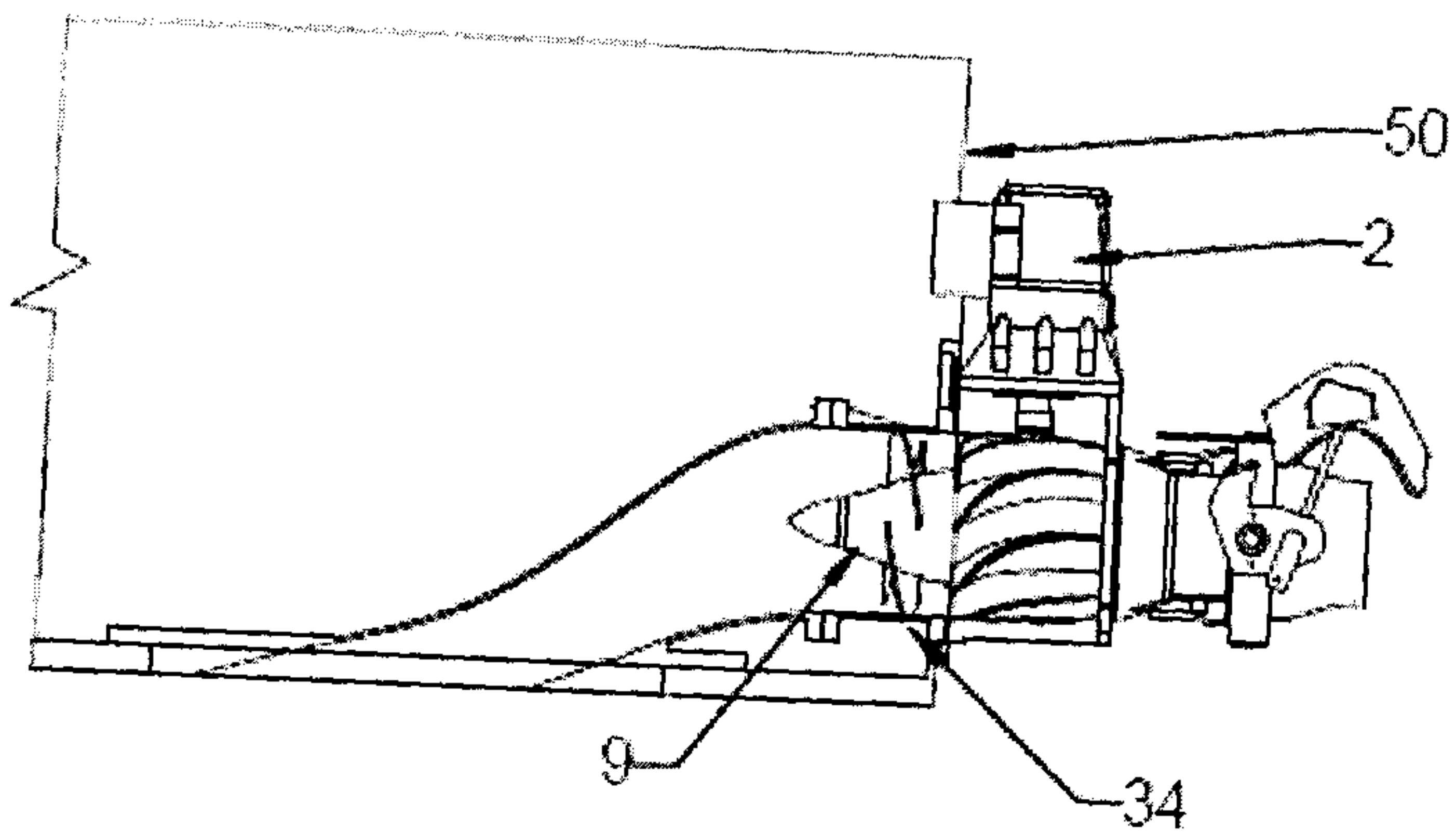


FIG. 7

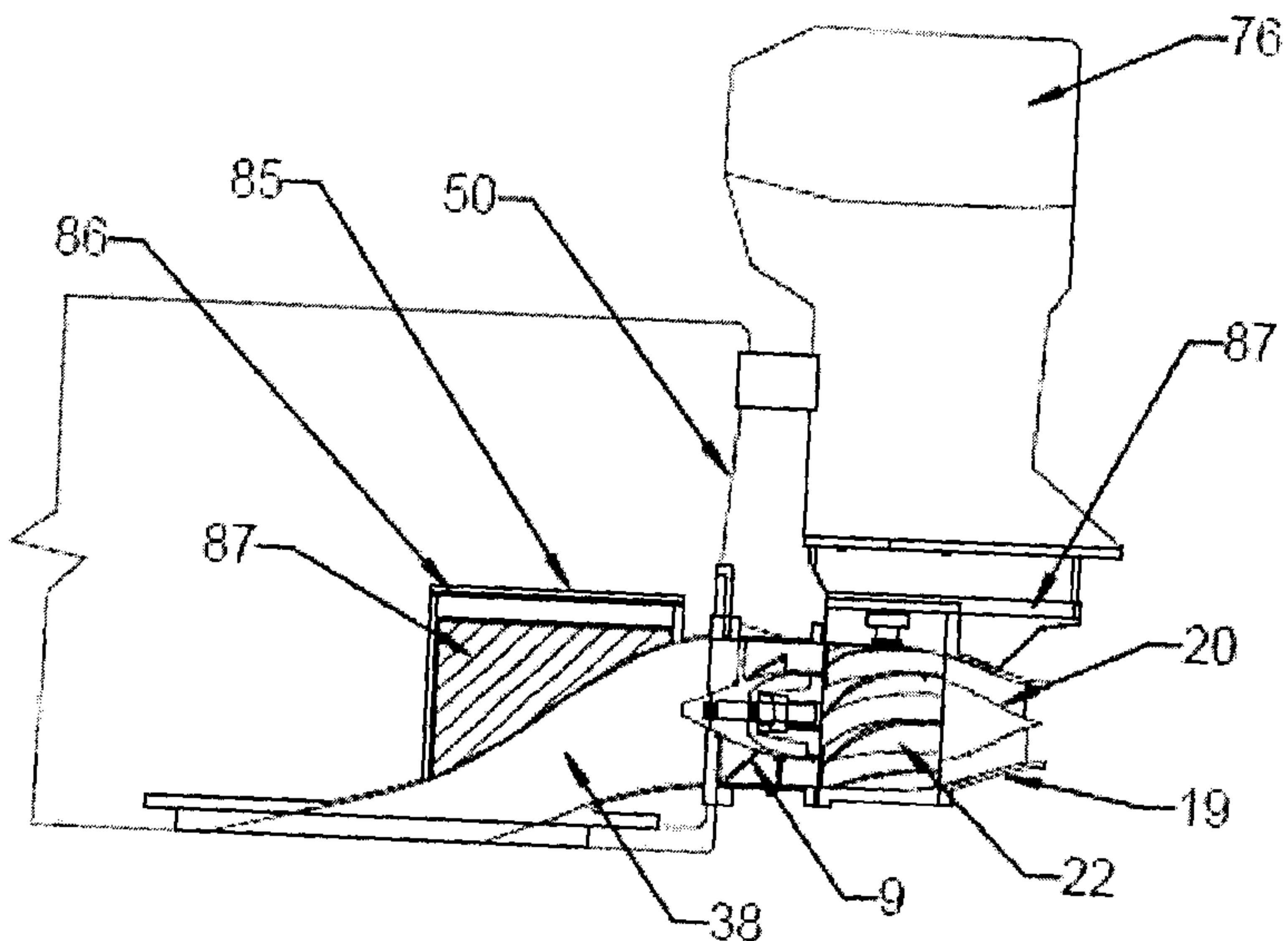


FIG. 6

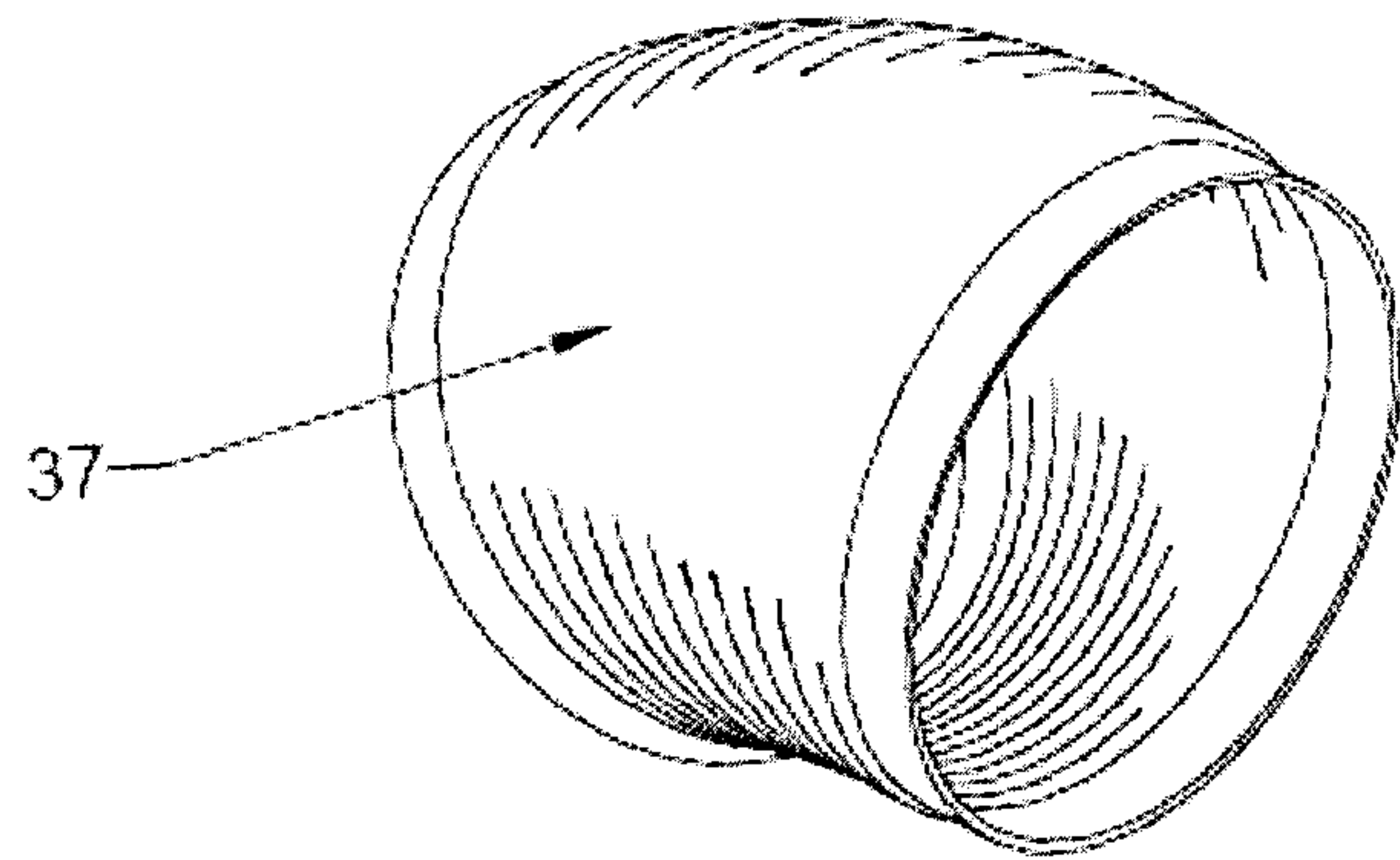


FIG. 9

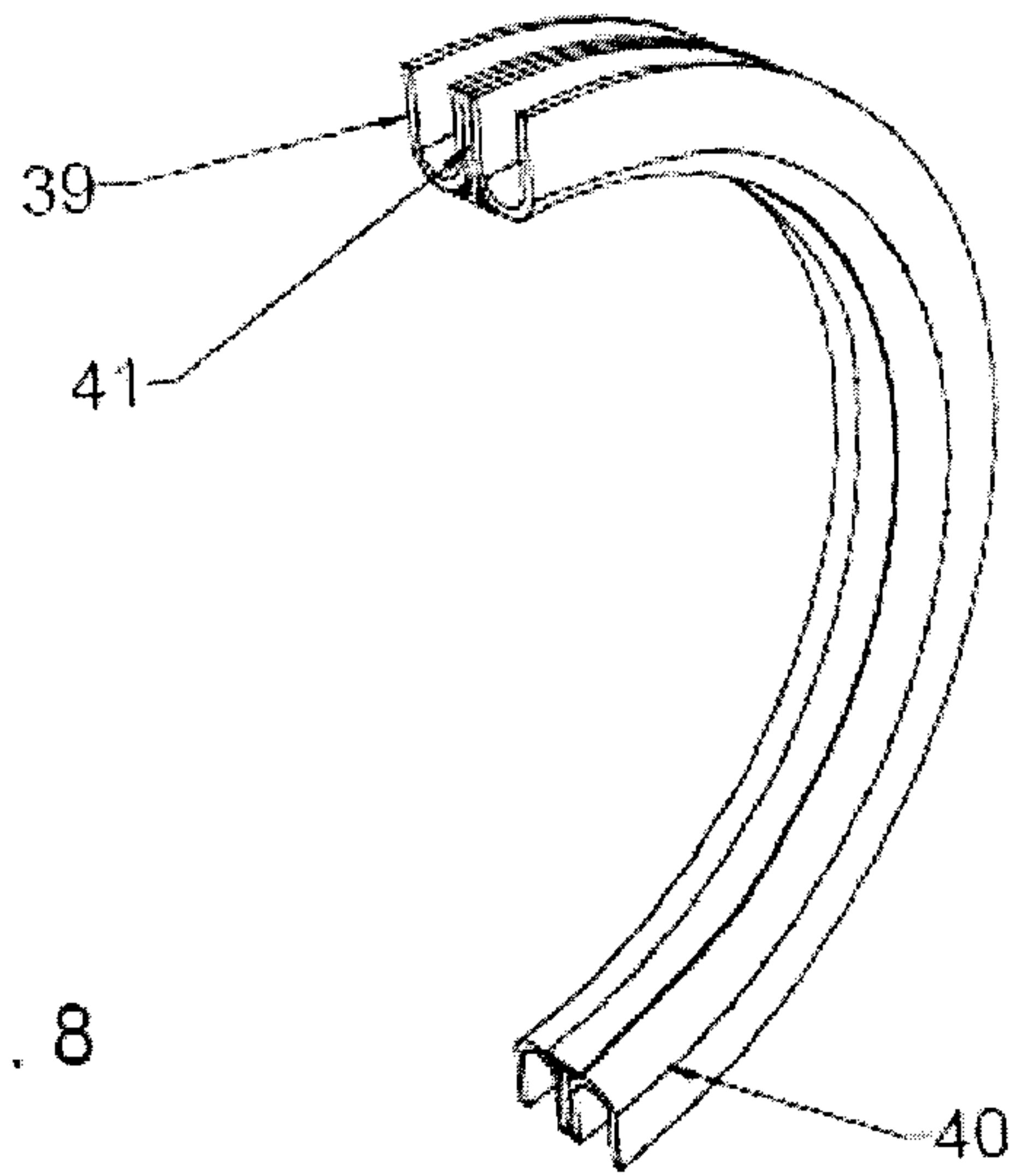


FIG. 8

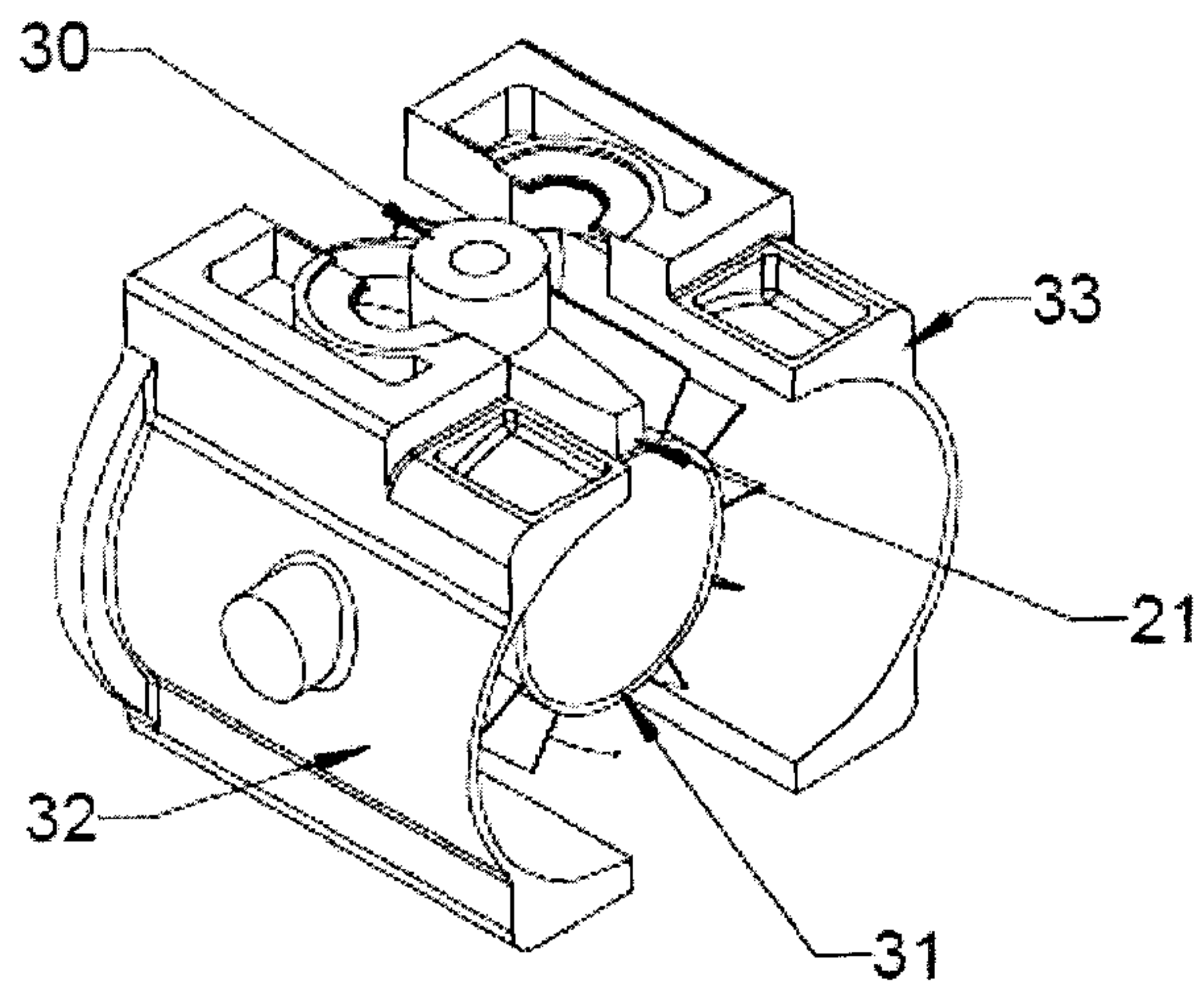


FIG. 11

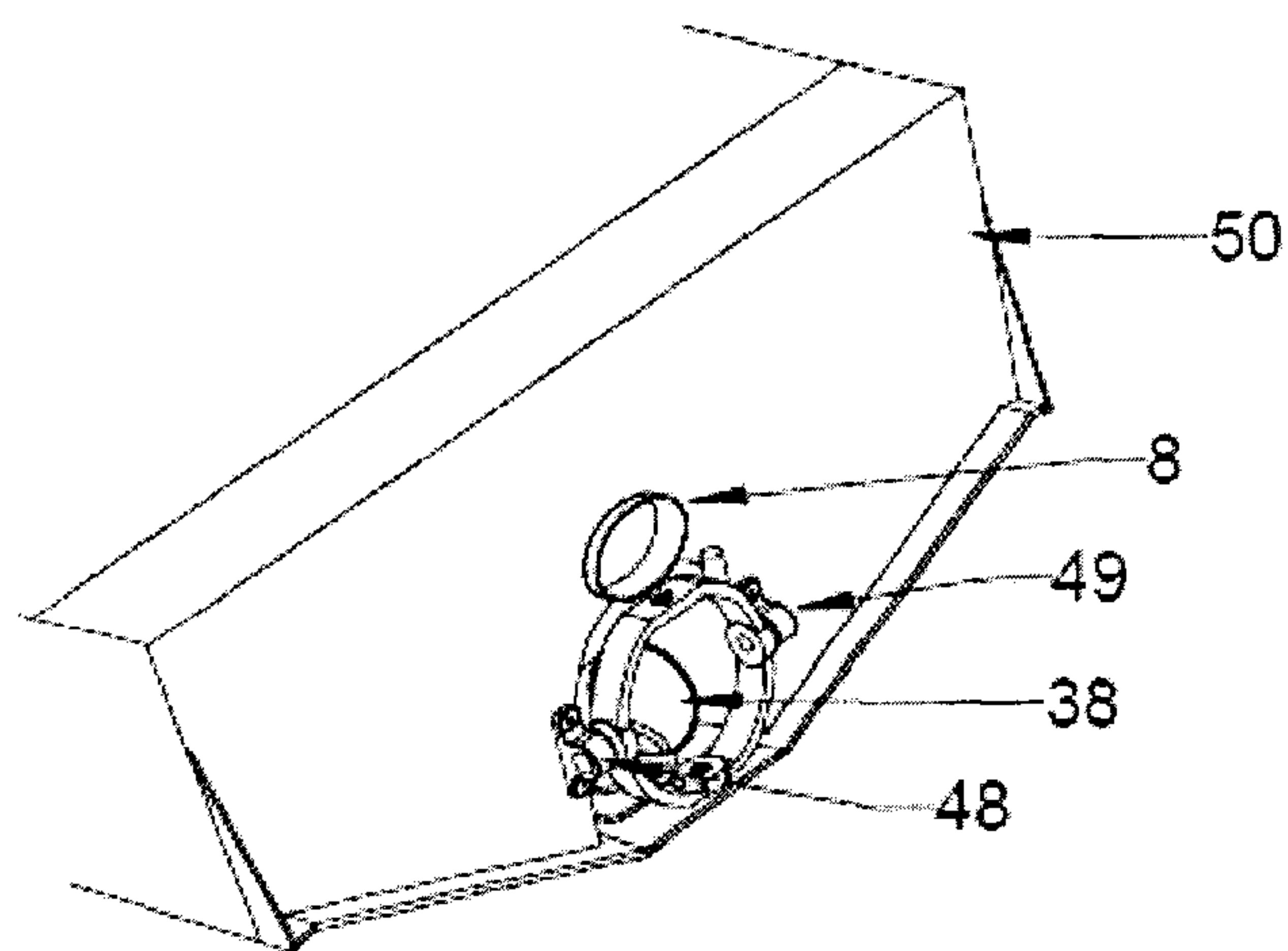


FIG. 10

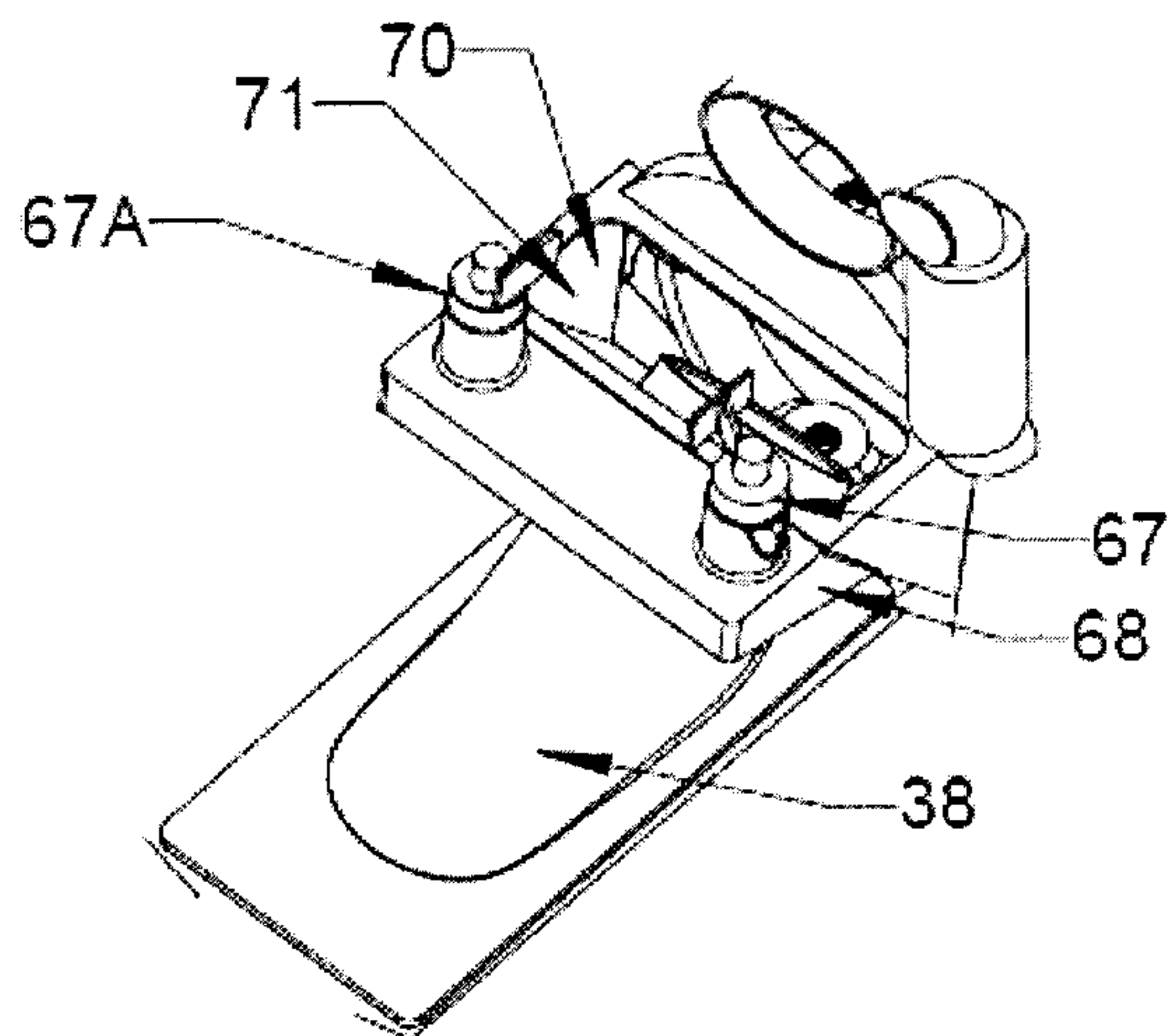


FIG. 13

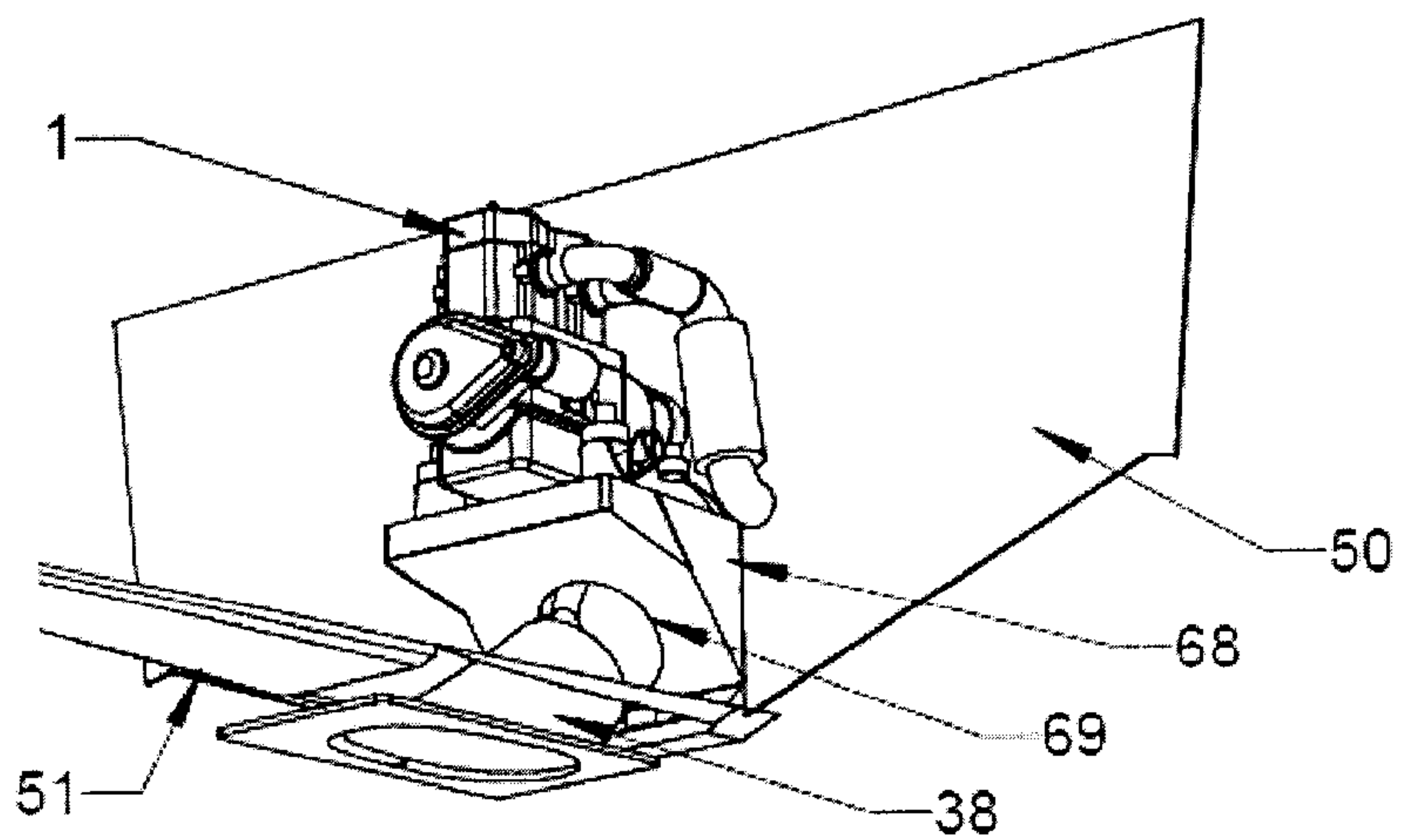


FIG. 12

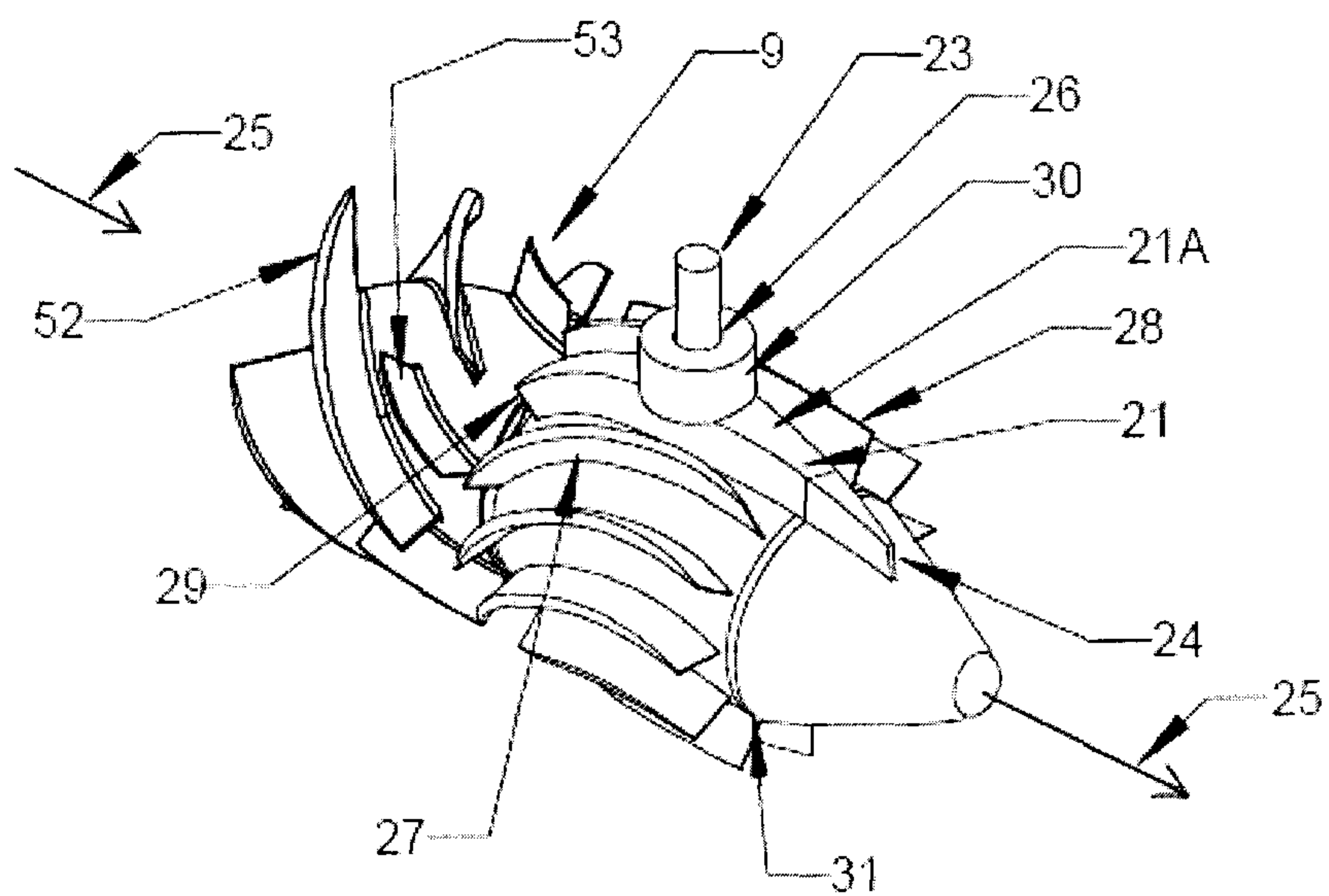


FIG. 15

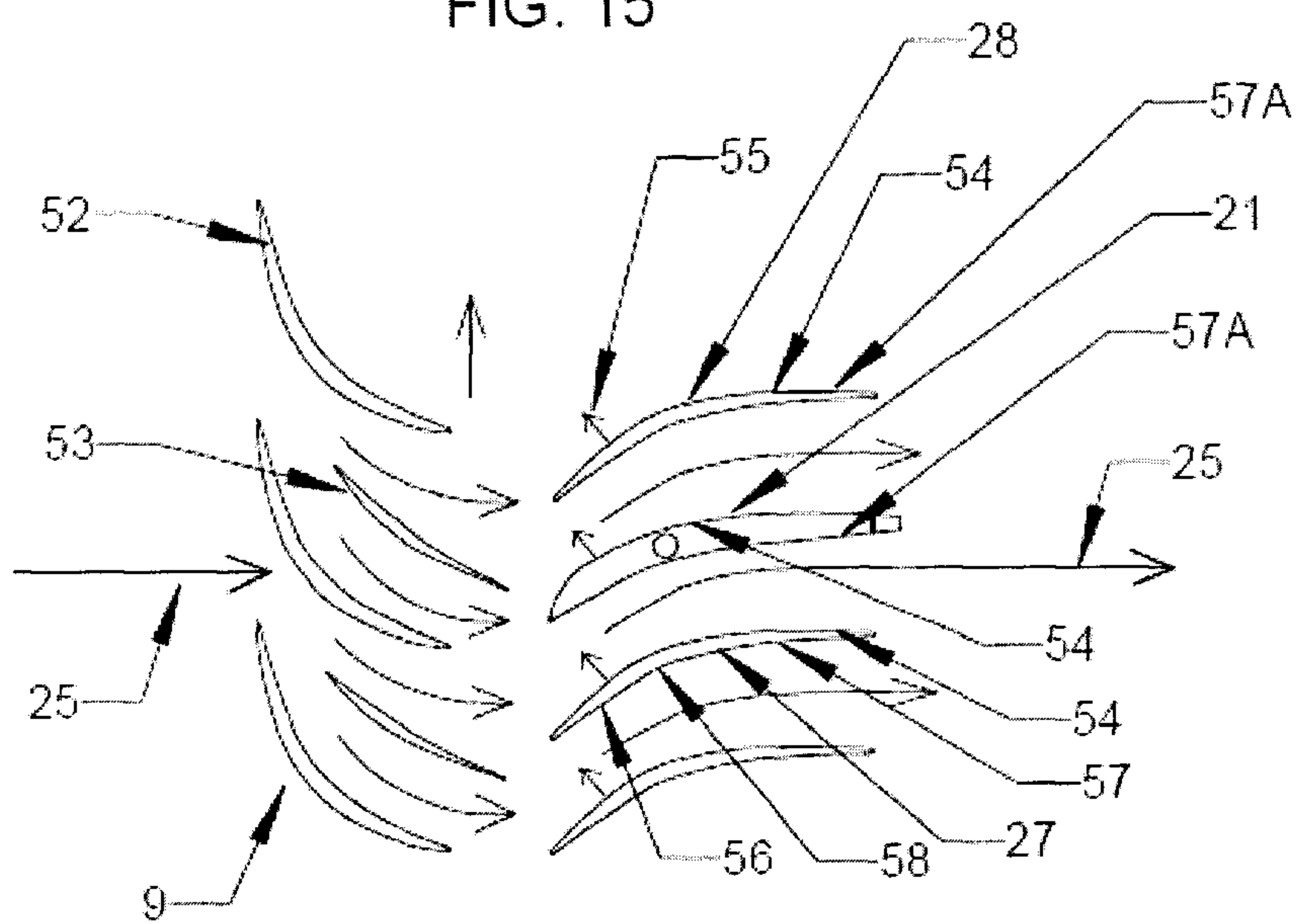


FIG. 14

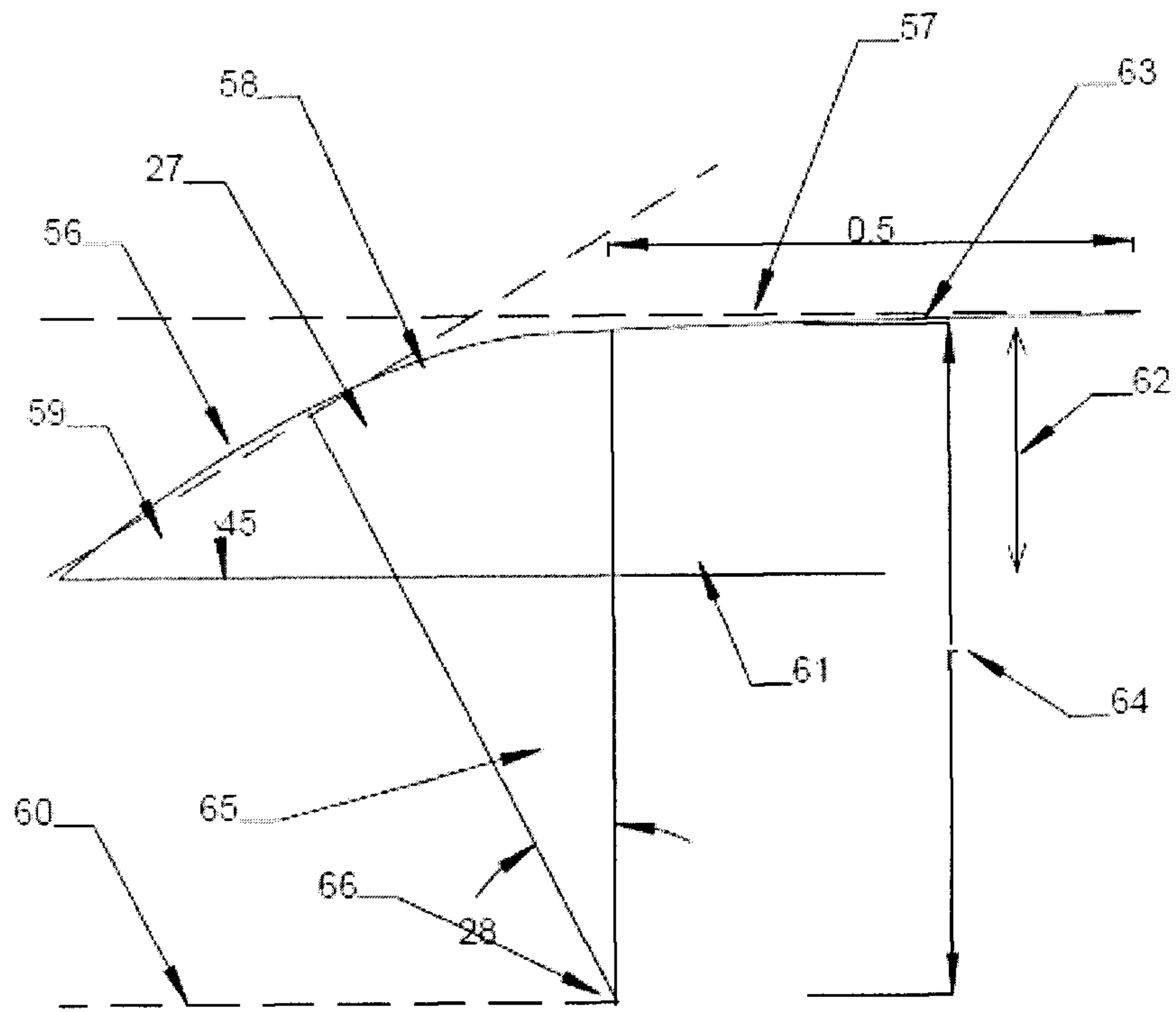


FIG. 16

