Office de la Propriété
Intellectuelle
du Canada

Un organisme
d'Industrie Canada

Canadian
Intellectual Property
Office

An agency of
Industry Canada

CA 2631297 A1 2009/11/14

(21) **2 631 297**

(12) DEMANDE DE BREVET CANADIEN
CANADIAN PATENT APPLICATION

(13) **A1**

(22) Date de dépôt/Filing Date: 2008/05/14

(41) Mise à la disp. pub./Open to Public Insp.: 2009/11/14

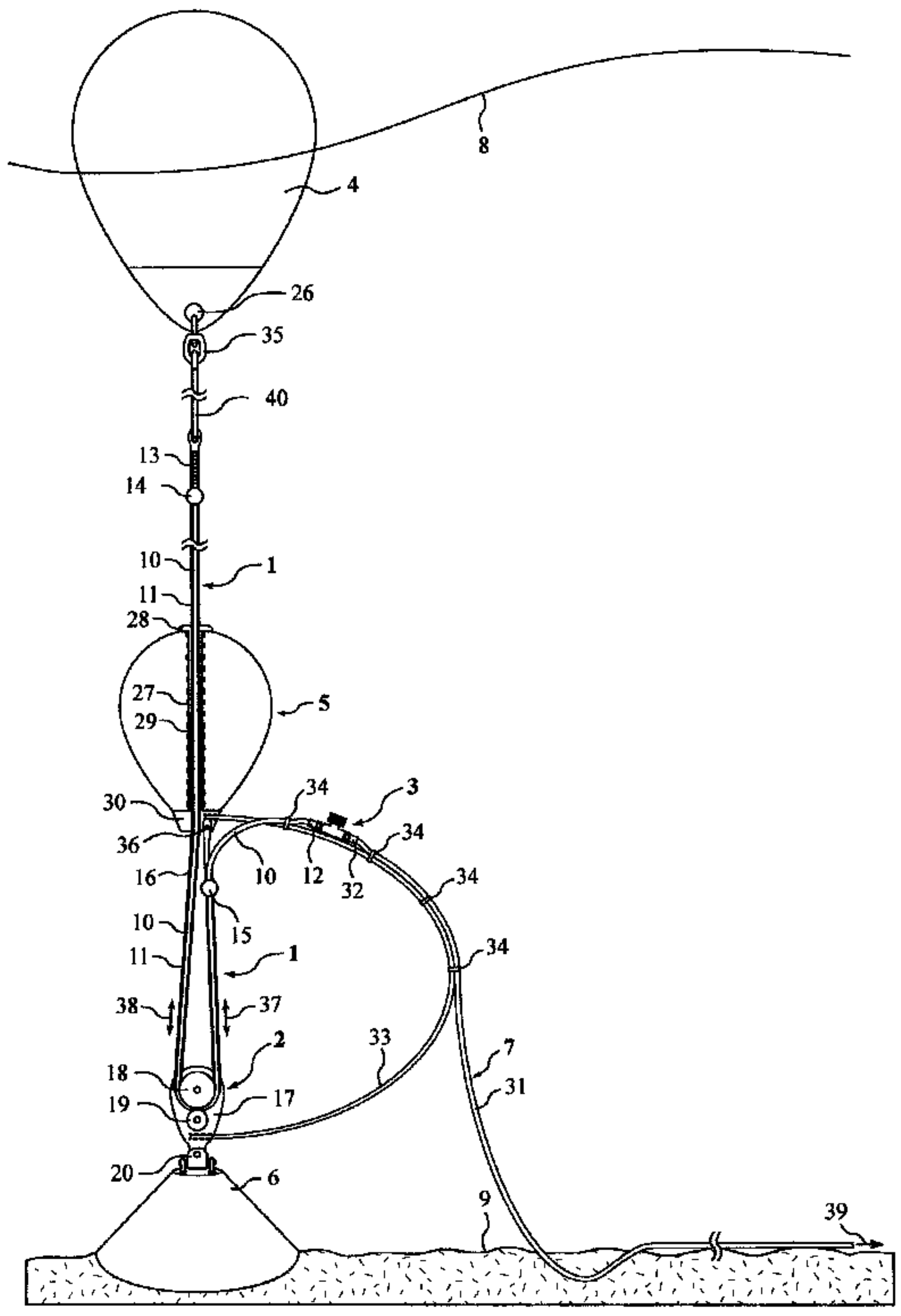
(51) Cl.Int./Int.Cl. *F03B 13/14* (2006.01), *F04B 43/12* (2006.01)

(71) Demandeur/Applicant:
VOWLES, GERALD J., CA

(72) Inventeur/Inventor:
VOWLES, GERALD J., CA

(54) Titre : POMPE PERISTALTIQUE A BOYAU A MOUVEMENT ALTERNATIF ALIMENTEE PAR L'ENERGIE DES VAGUES

(54) Title: WAVE-POWERED, RECIPROCATING HOSE PERISTALTIC PUMP



This document represents a preliminary submission of a patent application for the purpose of establishing a priority date.

Inventor

Gerald J. Vowles
57 Joyce Crescent,
Belleville, ON
Canada
K8N 1Y6

Tel: 613-967-2600

Title

Wave-Powered, Reciprocating Hose Peristaltic Pump

Technical Field

This invention relates generally to devices designed to extract energy from the undulating motion of swells and waves on a body of fluid and converting this energy to a useable form. More particularly, it relates to a wave driven, ~~two-way~~ reciprocating peristaltic pump capable of powering a variety of devices or processes such as, but not limited to brackish and sea water desalination, water purification, electricity generation, hydraulic power generation and hydrogen fuel production by electrolysis.

Background Information and Prior Art

Driven by a number of factors including increasing demand, dwindling, low-cost reserves and increasing global conflict, energy costs have risen dramatically in recent years. Predictions are that these costs will continue to escalate over time rather than diminish. At the same time, broad-based concern is escalating into growing alarm in both the scientific community and the general population about the effects of global warming and its relationship to the burning of fossil fuels, our primary source of energy.

As a result, there is now international consensus that the development and widespread deployment of clean, renewable and sustainable energy technologies must be supported by industry and governments at all levels and that the transition to these technologies must occur with all expediency.

This shift is now well underway and is expected to gain momentum. This is evidenced by the continuing rapid growth of wind and photovoltaic installations in a growing number of countries worldwide. More recently, the focus has been expanded to involve new opportunities, with investment in research and development in ocean energy conversion being particularly high. Beyond the obvious environmental benefits, ocean wave and swell energy is of great interest because of its much higher density and consistency than wind and solar energies and it is widely distributed.

The impact of this transition has been accompanied by a high profile debate that has become increasingly geopolitical in nature as particularly evidenced by ongoing and evolving reaction to the Kyoto Accord. Currently, the greatest single issue expressed by the so-called holdout nations relates to a requirement for much greater use of cleaner and more efficient energy technologies by the underdeveloped and developing nations, many with huge and growing populations.

At the same time, there is growing recognition of the need for and use of what has been termed "appropriate technology" if these efforts are to be successful. Usually, the term has been described as synonymous with, simple, low-cost, easily taught and serviced and more often than not, small by developed nation standards; in effect, often requiring a paradigm shift in terms of thinking and design.

The demand for these new technologies is not limited to these markets however. There is also demand from a growing segment of the population in highly developed nations for cost effective alternative energy technologies that can be used to provide for small community, organizational and even individual needs in addition to the more common, centralized installations requiring a distribution grid infrastructure.

In terms of prior art however, now as in the past, most research and development continues to focus on very large utility scale apparatus, the smallest of which can cost in the millions of dollars. Unfortunately, most of these designs do not scale down well nor are they suitable for use in many regions where need is high but both wave climates ~~are~~ and budgets are modest.

Related costs also add tremendously to real versus acquisition cost for these apparatus: In particular, delivery and handling, installation and start-up and, where the devices are located offshore or are fully sub-surface, routine maintenance costs.

In addition, because these apparatus typically incorporate a significant number of custom and highly specialized components rather than readily available, competitively priced parts and service items, the cost benefits often associated with economies of scale and volume are limited.

To a lesser degree, smaller, more flexible prior art apparatus have also been proposed. Although these devices have made some progress towards overcoming the deficiencies outlined above, they too exhibit certain limitations. *Several examples of these are summarized below.*

Common prior art limitations include:

PCT Pat No. WO 00/70218 Wave Powered Pump, WIENAND, Henry Lemont. Priority Date May 12, 1999.

An arcuate apparatus in that the floats are attached to a rotating arm such that the apparatus stroke, and therefore, output diminishes as the arm's rotation evolves from primarily vertical to primarily horizontal. There is also a limit to how long the arm, and, therefore, the stroke can be before its flexibility reduces the apparatus efficiency.

These limitations become particularly significant when the device is exposed to tidal variations in addition to the undulating waves. In addition, a pump housing and a mounting platform are incorporated into the apparatus, the latter adding non-working superstructure to the cost. These features expose a larger face area to loading from water movement such as turbulence, thereby increasing anchoring requirements and susceptibility to damage.

US Pat No. 6,392,314 B1 Wave Energy Converter, DICK, William. PCT Filed Dec. 3, 1998.

While there are limited similarities between this prior art and the present invention it is useful in terms of comparing efficiency. In this case, a submerged variable buoyancy float operates a pump as its buoyancy changes in relation to wave height. The displacement of the variable buoyancy float is reduced as the water pressure increases around it as a wave crest passes over it causing the float to drop lower. This phenomenon is explained by Boyle's Law. The disadvantage associated with this type of apparatus is that when all other factors are equal, using the variation in buoyancy of a float to produce work is significantly less efficient than using the buoyancy of that same float when used as a wave follower operating in unison to the surface.

US Pat No. 4,754,157 Float Type Wave Energy Extraction Apparatus and Method, WINDLE, Tom T. Filed Oct. 10, 1986:

Two surface floats (~~remember I want to include this too to prevent a competitive work-around~~). Pump has a rod vs. rodless so has only 1/3 the travel range in a given anchoring config. length because the rod ends cannot turn about the pulleys so pulley gap needs to be min. 3 X cylinder length. Cylinder and rod alignment with the pulleys is critical to reduce side loads on the rod bearings (a common cause of premature failure). This would require fixed pulleys which is itself a problem as the floats swing in all directions to some degree. Refers to "conventional valving" and also to "conventional stuffing glands". Refers to pump being "on the bottom" in the brief desc. of Fig. 5.

US Pat No. 3,918,260 Wave Powered Driving Apparatus, MAHNEKE, Klaus M. Filed Dec. 30, 1974:

A good concept in that by converting the reciprocating cyl limits to rotary the stroke is not limited, however, this does add complexity and cost. High likelihood of fouling in the gears and linkage or at least more sub-surface maintenance is likely. It describes the need for a heavy anchoring/mounting platform making installation a challenge. this is an expired (1975) buoy/counter-buoy concept so can be used by anyone but also prevents the newer active ones from claiming the concept.

As will become apparent in the following description, the present invention overcomes these limitations.

List of Figures

FIG. 1 shows a side view of a first embodiment the invention, that being a vertically oriented, single acting, wave powered peristaltic pump that can be deployed from the surface of a body of liquid, in this case being seawater.

FIG. 2 To facilitate ease of understanding, an enlarged, more detailed view of the apparatus' flow control assembly is shown adjacent to FIG. 1.

FIG. 3 shows a side view of a similar, second embodiment the invention which makes use of a reinforced peristaltic hose without the use of a flexible link.

FIG. 4 To facilitate ease of understanding, an enlarged, more detailed view of the apparatus' backside strainer is shown alongside FIG. 3.

FIG. 5 To further facilitate ease of understanding, an enlarged, more detailed view of the apparatus' integrated flow control assembly and sub-surface float base plate is shown alongside FIG. 3.

FIG's 6a through 6e show a partial range of block assemblies that may be used with the apparatus of the present invention.

FIG's 7a through 7f show a partial range of anchor means that may be used with the apparatus of the present invention.

FIG. 8 shows a side view of a further embodiment the present invention (hose) which differs from the embodiments shown in FIG's 1 & 3 in that a second peristaltic ~~link~~ assembly and second compression roller block assembly are introduced to provide for two-way pumping in a horizontally oriented apparatus.

FIG. 9 To facilitate ease of understanding, an enlarged, more detailed view of the apparatus' flow control assembly is shown alongside FIG. 8.

FIG. 10 shows a side view of a still further embodiment the invention similar to that shown in FIG.8 but wherein two separate peristaltic hose assemblies are routed through a common compression roller assembly in order that the two compression pulley blocks shown in Fig. 6 6a can be replaced by simple pulley blocks. In this embodiment, back and forth movement of the peristaltic hoses along the seabed can be eliminated.

FIG. 11 To facilitate ease of understanding, an enlarged, more detailed view of the apparatus' compression assembly is shown alongside FIG. 10.

FIG. 12 shows a partial view of how a plurality of apparatus may be linked in an array.

Summary of the Invention

The apparatus described hereafter is intended for use in any body of fluid upon which surface waves may be propagated, usually by the movement of a secondary fluid across the surface of the first or primary fluid. However, for this class of apparatus, the primary fluid is typically a body of water such as an ocean, sea or lake upon which waves are propagated when a secondary fluid which is typically wind blows across it . Therefore, for the sake of clarity, this description will use the term "water" to represent any primary fluid and the term "wind" to represent any secondary fluid in this context. More specifically, the preferred embodiment of the invention taught in the following description is an ocean wave powered pump capable of delivering a flow of pressurized seawater to power one or more driven devices such as but not limited to desalinators, electricity generators, hydraulic motors and hydrogen fuel generators.

The overall goal of this invention is to provide a practical, cost-effective and generally affordable apparatus with which global environmental, ecological and societal crises and issues can be mitigated. More specifically:

A first objective of this invention is to provide a wave energy conversion apparatus that requires neither externally generated power nor fuel of any kind in order to operate efficiently and effectively.

As such, a second objective of this invention, which is the ability to install and use the apparatus without penalty of higher cost or significant inconvenience, in locations where advanced infrastructure such as good roads and conventional power and fuel sources are not available or practical, can be achieved.

A third objective of this invention is to provide a wave energy conversion apparatus that can be transported and deployed rapidly, easily and without the need for heavy or specialized equipment during times of crisis and in response to natural disasters when the immediate need for safe freshwater is especially critical.

A fourth objective of this invention is to provide a wave energy conversion apparatus that can be built, transported and installed in a body of water, at a low enough cost to be considered expendable yet, at the same time, be capable of withstanding aggressive storm action.

Ocean-based, on-site maintenance and repair is typically expensive, difficult and often dangerous. Therefore, it is yet a further objective of this invention is to provide an apparatus that can be built from generally available, recyclable materials and components of sufficiently low cost that it can be cost-effectively extracted and replaced as needed, ideally through a manufacturer's repair-rebuild-recycle exchange program.

It is an established fact that extreme storms such as hurricanes and typhoons are capable of damaging or destroying virtually any ocean based apparatus in their track. With this in mind, it is yet another objective of this invention to provide the option of installing all or most of the more sensitive, higher cost and routine service components on shore in order to minimize damage and costs in the event of such an event.

As a means of maximizing budget, site and output suitability, as well as simplified scale-up capability, a further objective of this invention to provide a modularized apparatus wherein any number of wave interface modules mounted in a body of water can be linked to any number of shore or platform based processing modules; the latter containing all or most routine service components and control means as well as any linked driven devices.

A still further objective of this invention is to provide a wave energy conversion apparatus that provides for maximum installation site flexibility in terms of wave and tidal range, anchoring, site accessibility, environmental impact including visual and weather conditions.

Yet another objective of this invention is to provide an apparatus that is easily tuned and adjusted for prevailing or anticipated or seasonal wave, wind and current conditions.

Accordingly, the wave energy conversion apparatus described herein teaches a preferred embodiment of the present invention best described as a wave powered, linear peristaltic pump utilizing pressurized seawater as its hydraulic fluid and, in the case of desalination, a feed water as well and potentially for other applications and processes.

Detailed Description of the Invention

Referring now to the drawings, **Fig. 1** represents a preferred embodiment of the present invention. It is comprised primarily of a peristaltic link assembly **1**, a block assembly **2**, a flow control assembly **3**, a surface float **4**, a sub-surface float assembly **5**, an anchor **6** and a delivery hose assembly **7**. With the exception of the surface float **4**, the apparatus is fully submerged between the surface **8** of a body of fluid, in this case seawater, upon which waves occur and the bottom **9**, in this case being the seabed. The surface float **4** generally protrudes in variable amounts above the surface **8**. A peristaltic hose **10** is located within the peristaltic link assembly **1**. The apparatus draws the water that it pumps from the body of water in which it is installed.

For greater clarity, attention is drawn here to the separate nature and functions of the peristaltic link assembly **1** and the peristaltic hose **10** found within it. In this embodiment, the primary function of the peristaltic link assembly **1** is to provide a flexible, fixed link between the surface float **4** and the sub-surface float assembly **5**. In this embodiment, the primary function of the peristaltic hose **10** is as a necessary component of a peristaltic pump. However, for efficiency of design as well as other benefits that shall become apparent, the present invention provides a novel means by which these components can function in a complimentary and synergistic manner. Therefore, for ease of understanding, all references to the peristaltic link assembly **1** shall be taken to mean that the peristaltic hose **10** is found within. Specifically, the peristaltic link assembly **1** is comprised of a woven, tubular, flexible link **11**, a hose fitting **12**, a backside strainer **13**, and first and second travel stops **14** and **15** as well as the separate functioning peristaltic hose **10** contained within it. It is noted, however, that in other embodiments of the present invention, the peristaltic hose **10** can indeed serve in the dual role of peristaltic hose and flexible link member.

A more detailed breakdown of the remaining assemblies and components, as well as other minor parts, is now provided in advance of describing their function and interaction within the apparatus as a whole.

The peristaltic hose **10** is circumferentially bonded to the flexible link **11** at location **16**, in this case being in the vicinity of the mid-point of the peristaltic link assembly **1**. It is noted that instead of being located within the flexible link **11**, the backside strainer **13** may also be installed such that it or the peristaltic hose **10** to which it is attached, protrude through the strands of the wall of the flexible link **11**, particularly if a replaceable type strainer or filter is employed. It is further noted that the flexible link **11** itself may also provide adequate filtering capability such that the apparatus can function without the need for the backside strainer **13**.

The block assembly **2** is comprised of a body **17**, a freely rotating pulley **18**, a freely rotating compression roller **19** and a two-way joint **20** upon which the block assembly **2** can pivot on both horizontal axes. The pulley **18** and compression roller **19** have mating faces, whether flat or some other combination such as convex to concave.

The flow control assembly **3**, as shown in **Fig. 2** adjacent, is comprised of a body **21**, an intake check valve **22**, an outlet check valve **23** and an intake filter **24**. The check valves **22** and **23** are located within the tee shaped cavity **25** of the body **21**, as shown. The intake filter **24** is mounted at the opening of the tee cavity branch, as shown.

The surface float **4** is, in this case, represented by a commercially available, inflatable mooring or net buoy incorporating a moulded-in eye **26**. It may, however, take many forms, even including a boat for example, as long as it provides adequate buoyancy and wave following capability.

The sub-surface float assembly **5** is also represented here by a commercially available, inflatable mooring or net buoy but, in this case, one which incorporates a different connecting means. Rather than an eye, a centre tube **27** with openings on both its top and bottom is moulded in. A top plate **28**, a hollow- bodied through tube **29** and a base plate **30** are fixedly attached, whether by cement or threads, such that the through tube **29** passes through the centre tube **27**.

The delivery hose assembly **7** in this case a common rubber hose **31** of appropriate pressure rating, is fitted at each end with standard hose fittings. The first hose fitting **32** is shown here connected to the control assembly **3**. The second one is not visible but is understood to be attached to the other end of the hose **31** and connected to some driven apparatus. It is noted that the delivery hose **31** may also be allowed to float freely in the body of water as long as the amount of slack does not allow for entanglement with the apparatus. However, if it does need to be held down, the apparatus can still be installed from the surface **8** by clipping small weights intermittently along the delivery hose **31**. It is further noted that by using small hook type anchors for this purpose, it will help prevent undesirable rotation of the apparatus on its vertical Z axis during turbulent conditions.

A gravity type anchor **6** of adequate mass to counteract the buoyant and other forces acting on the apparatus is employed in this case to provide the means by which the apparatus remains fixed to the bottom **9** in order to provide the reaction point needed for the apparatus to function. It is noted, however, that any other anchoring means that provides a reaction point capable of remaining fully or immovable in relation to the apparatus as a whole could be utilized.

Lastly, a flexible hoop **33** is fixedly attached at its one end to the block assembly **2** and at its other end to the base plate **30** such that it forms an arc as shown. The peristaltic hose **10**, the flow control assembly **3** and the delivery hose assembly **7** are then intermittently and fixedly attached to the hoop **33** by means of a plurality of cable ties **34** as shown or by other suitable means.

Let us now look at how these various assemblies and components fit together. In general terms, the peristaltic link assembly **1** is attached at one end to the surface float **4**, routed freely through the centre tube **27** of the sub-surface float assembly **5**, between the pulley **18** and the compression roller **19** of the pulley block assembly **2** and attached at its other end to the bottom of the sub-surface float assembly **5**.

More specifically, one end of the flexible link **11** is robustly attached to a swivel type snap shackle **35** which is connected through the eye **26** of the surface buoy **4.** The swivel prevents unwanted twisting of the peristaltic link assembly **1** due to the surface float **4** rotating on its vertical axis in response to water or wind movement. The use of a snap shackle **35** also allows for quick connection and disconnection. The other end of the flexible link **11** is robustly attached with a retainer pin **36** or similar means to the base plate **30** of the sub-surface float assembly **5**.

The peristaltic hose **10** exits through an opening between the strands in the side wall of the flexible link **11** between the travel stop **15** and the retainer pin **36**. In this way, the flexible link **11** rather than the peristaltic hose **10** bears most of the tensile load experienced by the peristaltic link assembly **1** during operation of the apparatus, an important and novel feature of this embodiment of the present invention that shall become apparent. After exiting the flexible link **11**, the peristaltic hose is connected by a fitting **12** to the flow control assembly **3** which is, in turn, connected to the delivery hose assembly **7**, all of which will be further discussed.

As previously indicated, a flexible hoop **33** is fixedly attached at its one end to the block assembly **2** and at its other end to the base plate **30** of the sub-surface float assembly **5** such that it forms an arc as shown. The peristaltic hose **10**, the flow control assembly **3** and the delivery hose assembly **7** are intermittently and fixedly attached to the hoop **33** by means of a plurality of cable ties **34** as shown or by other suitable means. In this way, the hoop **33** provides a means by which these components can be held away, and thus prevented from becoming entangled in adjacent parts of the peristaltic link assembly **1** during operation of the apparatus, especially during during periods of turbulence. In this embodiment, the hoop **33** is a highly flexible fibreglass or carbon composite rod cemented into holes drilled into the base plate **30** and block housing **17**. The length and flexibility of the hoop **33** are sufficient that the apparatus can reciprocate fully within its design parameters without being either limited in travel or suffering significant loss of efficiency. It is noted that other means can also be used for this purpose. For example, a whip style flexible arm could be fixedly attached at only one point, such as to the base plate **30**, from whence it would extend horizontally outward.

Also, as previously indicated, the flow control assembly **3** is installed between the peristaltic hose **10** and the delivery hose assembly **7**. The connection in this case, is accomplished by threading the peristaltic hose fitting **12** into the in-line inlet port and the delivery hose fitting **32** into the in-line outlet port of the flow control assembly **3**. However, quick-coupler fittings or other appropriate means may also be used. It is at this point that the reciprocating or two-way flow of water within the peristaltic hose **10** is converted to one-way outflow and transmitted via the delivery hose assembly **7** to power a nearby or remote linked driven device or apparatus. For greater clarity, the flow control assembly **3** is shown in greater detail in **Fig. 2** adjacent, and will be explained in due course in the system function discussion.

To protect against binding or jamming of the peristaltic link assembly **1** in either the block assembly **2** or the sub-surface float assembly **5**, travel stops **14** and **15** are fitted over and securely bonded to the peristaltic link assembly **1** as shown. These may be commonly available rope stops used on sailboats, single-piece, moulded fishing net floats or some other suitable means such as a two piece assembly if removal and replacement is preferred. In any case, the outside diameter of these travel stops must be large enough to prevent their entry into the pulley block assembly **2** and/or the centre tube **27** opening of the sub-surface float assembly **5**, through which the peristaltic link assembly **1** reciprocates.

In this embodiment of the present invention, the gravity anchor **6** is of adequate mass to counteract the buoyant and other forces acting on the apparatus. It provides the means by which the apparatus, via the pulley block assembly **2**, is flexibly fixed to the bottom **9**. In this case the bottom **9** is a seabed but any other reaction point deemed to be immovable in relation to the rest of the apparatus and the undulating surface **8**, or out of phase with the undulating surface **8** may also be appropriate; for example a portion of a fixed or floating drilling platform. In fact, the choice of anchoring means is usually dependent on a number of factors such as local conditions, convenience, availability and whether or not the installation is of a permanent or temporary nature. Several examples of alternative anchoring means will be presented later in this description. As previously indicated, the block assembly **2** incorporates a two-way joint **20** upon which it can pivot on both its horizontal X and Y axes but cannot rotate on its vertical Z axis when attached to the anchor **6**. In this configuration, it is advisable to align the apparatus such that an imaginary line drawn through the frontside **37** and the backside **38** of the peristaltic link assembly **1** is perpendicular to the prevailing wave fronts . This attachment means is employed to reduce the likelihood of the delivery hose **31** becoming wrapped around or entangled with the peristaltic link assembly **1** during periods of turbulence when the apparatus would be more likely to rotate on its vertical Z axis if allowed to swivel freely.

It is noted that a key feature of this embodiment of the present invention lies in the combined use of a gravity type anchor **6** and the flexible hoop **33**, which allows the apparatus to be rapidly and simply deployed by lowering it from a boat or raft on the surface; an especially important advantage in the case of emergencies, disaster response and/or lack of specialized installation equipment or scuba diving capability.

Finally, an optional link extension **40** is shown here in **Fig. 1**. It's purpose is to provide a simple means by which final adjustments may be made for installation depth such that the peristaltic link assemblies can be pre-built in standard lengths. Any number of design variations are seen to be possible ranging from a simple piece of rope or cable fixedly attached to the peristaltic link assembly **1** at its one end and to the snap shackle **35** at its other end as shown to, for example, a similarly attached site-adjustable reel assembly.

Assembled together, the components and assemblies discussed above form an apparatus which may be generally described as follows: A wave-powered, positive displacement pump wherein a peristaltic link assembly is reciprocally drawn through one or more anchored compression pulley blocks by opposing buoyant members reacting to undulating wave action, this for the purpose of producing a one-way outflow of pressurized water.

In general terms, the peristaltic link assembly **1** is drawn back and forth through the block assembly **2** due to the opposed, reciprocating action of a primary buoyancy member called the surface float **4** and a secondary buoyancy member called the sub-surface float assembly **5**. The peristaltic hose **10** enclosed within the peristaltic link assembly **1** becomes fully occluded at the point where it passes through the block assembly **2**, before returning to its normal, internally open shape, thereby alternately increasing and decreasing the internal volume of the peristaltic hose **10** on each side of the block assembly **2**. When the internal volume of either side increases, water is drawn in and alternately, when the internal volume of either side decreases, water is displaced or pumped out. In this case, the water is drawn from the body of seawater in which the apparatus is installed. In practice, the peristaltic link assembly **1** functions both as a pump component as well as a flexible connecting member of fixed length.

In more specific terms, the buoyant surface float **4** functions as what is commonly referred to in this field of art as a wave follower in that it follows or tracks the surface **8** of the body of water as it rises and falls with the waves. The less buoyant sub-surface float **5** remains submerged and, therefore, continuously strives to rise to the surface **8**. The surface float **4** and the sub-surface float **5** operate in opposition to each other because the peristaltic link assembly **1** to which they are attached, turns a nominal 180 degrees about the freely rotating pulley **18** such that the floats **4** and **5** both pull in the same direction, that being toward the surface **8**. The peristaltic link assembly **1** remains taut as it reciprocates through the pulley block assembly **2** because, being anchored to the bottom **9**, it functions as a fixed reaction point and also because the peristaltic link assembly **1** remains at a generally fixed length once under tension for reasons that will be made apparent. Because the surface float **4** is significantly more buoyant, the sub-surface float **5** always acts in response to the movement of the surface float **4**. Therefore, the sub-surface float assembly **5** is drawn down toward the bottom **9** each time the surface float **4** moves upward with the rising waves and conversely, the sub-surface float assembly **5** rises up toward the surface **9** when the surface float **4** subsequently moves downward and thus the cycle continues.

This results in a cyclic shortening and lengthening of that section of the peristaltic link assembly **1** located between the pulley block **2** and the flow control assembly **3**, hereafter called its frontside **37** and, in reversed sequence, a cyclic lengthening and shortening of that section of the peristaltic link assembly **1** located between the pulley block **2** and and the snap shackle **35**, hereafter called its backside **38**. Because the peristaltic hose **10** becomes fully occluded at the point where it is temporarily compressed between the freely rotating pulley **18** and the freely rotating, mating compression roller **19** of the pulley block assembly **2**, water is drawn in and then pumped out on both its frontside **37** and backside **38** as their internal volumes alternately increase and decrease.

Each time that the frontside **37** of the peristaltic link assembly **1** lengthens with the falling wave, water is drawn into it through the flow control assembly **3** and conversely, each time the frontside **41** of the peristaltic link assembly **1** shortens, water is forced out of it and through the flow control assembly **3**, from whence it is carried away via the delivery hose assembly **7** as shown at location **39** for the purpose of powering and/or feeding any number or combination of downstream driven devices or processes.

For greater clarity in this regard, we refer to **Fig. 2**, which shows the flow controller **3** to be comprised of a main body **21**, an inner hydraulic circuit **25**, which carries the water pumped from the peristaltic link assembly **1** through the flow controller **3**, an internal, one-way intake check valve **22** terminated by an external intake filter **24** and an internal, one-way output check valve **23**. Each time the frontside **37** of the peristaltic link assembly **1** shortens as the surface float **4** follows a rising wave, water is forced under pressure out of the peristaltic link assembly **1** and into the inner hydraulic circuit **25** of the flow control assembly **3** and pushes up against the two check valves **22** and **23** located therein. The pressurized water cannot flow through the inward opening, one-way intake check valve **22**, however it can push open the outward opening, one-way outlet check valve **23** and, in so doing, continues to flow downstream through the delivery hose assembly **7** as long as the frontside **37** of the peristaltic link assembly **1** continues to displace water as it shortens. Although not part of the flow control assembly **3**, the peristaltic link assembly **1** and the delivery hose assembly **7** are also shown to clarify how the three assemblies are interconnected. It is noted, however, that while mating, threaded fittings are used in this case, such connections may vary. For example, they might be cemented together, incorporate what are generally referred to as quick-connect couplings for convenience and expediency of assembly and servicing, or be connected by still other appropriate means.

Conversely, each time the frontside **37** of the peristaltic link assembly **1** lengthens as the surface float **4** follows a falling wave, water is drawn into the peristaltic link assembly **1**. This occurs due to the combination of two factors. Firstly, as indicated, the frontside **37** of the peristaltic link assembly **1** lengthens, thereby increasing the internal volume of the peristaltic hose **10** within. Secondly, while the peristaltic hose remains fully occluded at the point of compression between the pulley **18** and compression roller **19**, it springs back to its natural shape beyond that point with enough elastic force to draw water back in to replace that which had been displaced. More specifically, this replacement water is drawn into the flow control assembly **3** with minimal resistance through the intake filter **24** and the inward opening, one-way intake check valve **22**. Once in the inner hydraulic circuit **25**, it is drawn freely into the frontside **37** of the peristaltic hose **10**. At the same time, water is prevented from being drawn back in from the delivery hose assembly **7** because the still pressurized water held therein holds the check valve **23** closed with greater force than the combined force required to open the check valve **22** and draw water through the intake filter **24**.

Returning now to **Fig. 1**, it is noted that while the flow controller **3** is shown here as being in close proximity to the rest of the apparatus and before the involvement of the delivery hose assembly **7**, it is understood that in other variations of the apparatus, the flow controller assembly **3** may be located at some distance away. For example, it could be incorporated downstream from the rest of the apparatus including being located on shore or at any other suitable location such as, but not limited to on a breakwater or an ocean based platform, as long as adequate pressure and flow can be delivered and the peristaltic hose **10** is still capable of exerting enough force in returning to its natural shape to draw in replacement water.

It is further noted, that while both the frontside **37** and backside **38** portions of the peristaltic link assembly **1** are capable of producing pressurized water flow, the embodiment taught here in **Fig. 1** is such that only the frontside flow is harvested in order to maximize the simplicity of the apparatus. While the water on the frontside **37** becomes pressurized due to downstream resistance, pressure is not developed on the backside **38** because the water therein flows freely in and out through the backside strainer **13** without significant resistance.

The backside strainer **13** is fixedly attached to the open end of backside **38** of the peristaltic hose **10** for the purpose of reducing fouling over time. This is necessary to prevent both pressure and suction from developing on the backside **38** in opposition to the pressurization and suction cycles on the frontside **37**, a condition that would greatly reduce the efficiency of the apparatus. Being that it is a porous, woven member separating the open end of the peristaltic hose **10** and the body of water in which the apparatus is both installed a draws from, this straining function may be provided by the flexible link **11** itself in some instances.

For greater clarity in terms their function, structure and interaction, certain assemblies and components will now be discussed beginning with the flexible link **11**.

Under high tensile load conditions, conventional, fully bonded hose reinforcements, whether woven, spiral or otherwise and whether internally or externally located, can tear or shear away from those layers of the hose to which they are bonded, leading to de-lamination and, therefore, loss of resistance to further elongation as well as potential rupture and/or separation into parts. Being that most heavy duty peristaltic hoses utilize this means of reinforcing, they are also susceptible to this type of failure under high tensile load conditions.

The primary role of the flexible link **11** described herein is to provide an improved means by which longitudinal elongation of the peristaltic hose **10** can be limited or even eliminated, particularly in those cases where a conventional peristaltic hose's structural capabilities are not adequate to allow the apparatus of the present invention to function dependably without it. In other words, the primary role of the flexible link **11** is not to add reinforcement to the peristaltic hose **10** but rather to eliminate the need for it by transferring the load bearing requirements of the apparatus to the flexible link **11**.
For greater clarity, a defining difference is that there can exist a difference in the amount of elongation occurring between the flexible link **11** and the peristaltic hose **10** such that this unique capability is used to advantage, as shall become evident in the description that follows.

In this particular embodiment of the present invention then, the peristaltic hose **10** is enclosed within the flexible link **11**, the latter being a flexible, braided tube similar in structure to the outer, hollow braid found on the double braided ropes commonly used to rig sailboats.

Depending on the openness of the weave as well as differences between the outside diameter of the peristaltic hose **10** and the inside diameter of the flexible link **11** under tension, the flexible link **11** functions - in varying degrees from negligible to great - in much the same way as what is commonly known as a "chinese finger trap". The degree of variation in the gripping or squeezing force is a design optimization decision based on many variables so not discussed here. For clarity, a "chinese finger trap" is a loosely woven tube that compensates for any increase in its length by reducing its diameter. Because a finger inserted into the trap has limited compressibility, those forces attempting to reduce the diameter are increasingly applied as a gripping or squeezing force, thereby preventing the sliding withdrawal of the inserted finger. The greater the effort to pull the finger out by pulling, the greater the gripping force becomes.

In this particular embodiment of the present invention, the flexible link **11** exhibits a relatively tight weave while its inside diameter under tension is only modestly less than the outside diameter of the peristaltic hose **10** within. In this fashion, the initial stretching of the flexible link **11** due to the pull of the floats **4** and **5** is quickly arrested and converted to a modest compressive or gripping force acting on the peristaltic hose **10** as soon as the flexible link **11** becomes snug.

Because the flexible link **11** is, in this case, manufactured from a synthetic fibre exhibiting very low stretch characteristics, once locked down on the peristaltic hose **10**, the peristaltic hose assembly **1**, including the peristaltic hose **10** within, does not undergo any significant additional stretching. Also, because a relatively tight weave has been chosen in this case, a continued increase in the force attempting to squeeze the peristaltic hose **10** are arrested preventing the potential for crushing or significant occlusion of the peristaltic hose **10**.

The result is that the flexible link **11** provides for greatly increased tensile loading capacity of the peristaltic link assembly **1** while also providing for minimal elongation and, therefore, damage to or failure of the peristaltic hose **10** itself as the flexible link **11** rather than the peristaltic hose **10** bears most of the tensile loads experienced during operation of the apparatus. It is noted that in this way, the flexible link **11** clearly differs in function from that of the woven reinforcements commonly incorporated into, or otherwise applied to various hose types, generally in order to increase their pressure handling capability and clearly differs as well from the sheaths used and tough outer skins applied to hoses from time to time in order to improve their abrasion resistance.

As a means of preventing uneven, directional creeping of the peristaltic hose **10** within the flexible link **11**, at times when there may be no gripping force being applied, it is recommended that the flexible link **11** be bonded at some point or points to the peristaltic hose **10** within. In this embodiment of the present invention, a flexible, marine grade silicon adhesive bond **16** is circumferentially applied between the peristaltic hose **10** and the flexible link **11** at a location somewhere near the centre of the peristaltic link assembly **1**. However, neither the bonding means nor the location, number or extent of these bonds are critical for the function of the apparatus and so, for example, it may also be with other embodiments, assuming the flexible link **11** to be pre-stretched over the peristaltic hose **10** to the degree that any significant further stretch is arrested, a plurality of bonds may be applied at other locations such as between the peristaltic hose **10** and the flexible link **11** beneath the travel stops **14** and **15**. In the case of this embodiment, however, the single, centrally located bond is such that the peristaltic hose **10** elongation is not caused to, nor is it needed to match the flexible link **11** elongation, especially as the flexible link **11** goes through its greatest degree of elongation before clamping down on the peristaltic hose **10**.

It is noted that while the use of a flexible link **11** as described in **Fig. 1** is a novel feature in their own right, its absence, whether in part or in full, does not prevent the basic function and operation of or detract from the novelty of other embodiments of the present invention. For example, rather than using one continuous flexible link **11** as described, separate, shorter lengths can be installed at either end of the peristaltic hose **10** in situations where the peristaltic hose **10** is capable of handling the tensile loads required of it without detrimental effects. In such cases, the separate flexible links, while functionally and structurally equivalent to that described, function as simple and convenient link means.

Nonetheless, the use of a single, continuous flexible link **11** as described in this embodiment does provide for a number of important and novel advantages such as: It allows for the use of otherwise unsuitable and often more generally available and less costly hoses, even including some not normally rated for peristaltic applications; in allowing for the use of significantly thinner walled hoses compared to typically very heavy walled conventional peristaltic hoses, larger inside diameters can be taken of advantage of in order to increase volumetric output when maximum outside diameters are limited by such factors as the inside diameter of the centre tube **27** of the subsurface float assembly **5** and; it prevents a loss of seal and, therefore, pumping capability that could be caused by incomplete occlusion of the inside diameter of the peristaltic hose **10** at the compression point between the pulley **18** and compression roller **19**, this due to excessive reduction of the wall thickness of the peristaltic hose **10**, caused by stretching, especially when exposed to unusually high tensile loads due to storm activity and, It is noted that other anti-creep means such as a clamping device may be employed instead of an adhesive.

Besides wall thickness, the composition, design and pressure rating of the peristaltic hose **10** can also vary in response to operating conditions and requirements. However, by definition, it must be able to return promptly to its natural, internally open state following each occlusion or compression cycle in order to draw in the water displaced during the previous pumping cycle. By comparison, a flat hose such as a fire hose would not work for this application. For those embodiments of the present invention designed without a flexible link **11**, the peristaltic hose **10** must be of adequate tensile strength and pressure rating in its own right, as well as being able to resist linear elongation under load to the extent that full occlusion between the pulley **18** and compression roller **19** occurs and may be so designed when appropriate. It is only when the construction of the peristaltic hose **10** allows too much elongation under tensile load, such that it's wall thickness is reduced enough that the seal formed in the peristaltic hose's **10** inside diameter at the compression point between the pulley **18** and roller **19** is no longer complete or effective, that the flexible link **11** becomes a necessity in order for the apparatus to function as intended. While it is understood and envisioned that such an undesirable condition could also be rectified by the use of additional mechanisms to allow for some means of automatically adjusting the gap between the pulley **18** compression roller **19**, to compensate for varying degrees of stretch in the peristaltic hose **10**, an objective of the present invention is to keep it simple and inexpensive to produce.

In this embodiment of the present invention, the travel stops **14** and **15**, are resilient, spherical rubber mouldings similar in form to a sponge rubber ball with a centre bore of similar inside diameter to the outside diameter of the peristaltic link assembly **1**. Travel stop **14** is threaded over and fixedly attached to peristaltic link assembly **1** between block **2** and the location where the peristaltic hose **10** exits through the wall of the flexible link **11**, immediately below the latter. Travel stop **15** is likewise mounted to the peristaltic link assembly **1** between where it exits through the top of the sub-surface float assembly **5** and the snap shackle **35**, immediately below the point where the backside strainer **13** is located. **1**. In this way, travel stops **14** and **15** function as peristaltic link assembly **1** travel limiters, positioned to prevent those parts of the apparatus outside of the travel stops **14** and **15** from entering the block assembly **2** and/or the sub-surface float assembly **5**, an undesirable condition that could cause jamming of and potentially damage to the apparatus.

As previously discussed, the design of the pulley block assembly **2** is such that the peristaltic hose **10** becomes fully occluded at the point where it is temporarily compressed between a freely rotating pulley **18** and a freely rotating, mating compression roller **19**. In this case, the mating surfaces of both the pulley **18** and the compression roller **19** are flat, however, other profiles may be used as long as the result is full occlusion of the peristaltic hose **10** and the peristaltic link assembly **1** and peristaltic hose **10** within are not damaged from uneven or excessive compression. It is noted that a plurality of compression rollers **19** may be incorporated into the block assembly **2** in order to increase the pressure handling capabilities of the apparatus.

In this embodiment, the surface float **4** and the sub-surface float assembly **5** are both single-piece, moulded, inflatable pneumatic buoys. The surface float **4** incorporates a moulded in tethering eye whereas the sub-surface float assembly **5** incorporates a moulded in centre tube **27** with openings on both its top and bottom. Because this embodiment of the present invention provides for one-way only pressurized pumping with the rising waves, it requires only enough buoyant energy to keep the peristaltic link assembly **1** taut as the surface float **4** then drops with the falling wave. Therefore, the displacement of the sub-surface float assembly **5** need not be any greater than what is needed to ensure the return of the surface float to its initial position in order to begin the next pumping cycle, bearing in mind additional influences factors such as prevailing or anticipated wave, wind and current conditions as well as seasonal changes. That said, any excessive buoyancy of the sub-surface float assembly **5** has the negative effect of reducing the potential pumping capability of the apparatus by the same amount. In this embodiment, this fine tuning can be accomplished by the partial deflation or further inflation of either, or both of, the surface float **4** and the sub-surface float **5**. However, other appropriately buoyant means including those whose buoyancy is not adjustable could be used for the purpose taught herein, albeit with less flexibility.

It is noted that in other embodiments of the present invention that provide for two-way pressurized pumping, the displacement of the sub-surface float **5** is ideally about one half the displacement of surface float **4**. However, once again, this ratio may be modified depending on prevailing or anticipated wave, wind and current conditions as well as seasonal changes.

Referring now to **Fig. 3**, the drawing represents a second embodiment of the present invention quite similar to that taught in **Fig. 1**. In this case, peristaltic link assembly **1** of **Fig. 1**. is replaced with a peristaltic hose assembly **41** comprised of a reinforced peristaltic hose **42** fitted on each of its ends with common, crimped-on or similarly attached hose fittings **43** and **44** and travel stops **14** and **15**. This assembly is capable of handling the tensile load or stretching forces generated during normal operation of the apparatus plus a safety factor. In effect, the peristaltic hose assembly **41** fulfills the functions of both the peristaltic hose **10** and the flexible link **11** of **Fig. 1**.

The role of the hoop **33** of **Fig. 1** is provided instead by a bungee cord **45** or some other similar means, the function of which is to hold the delivery hose **31** taut for reasons taught in **Fig. 1**. The bungee cord **45** is fixedly attached to the delivery hose **31** by hose clamps **46** and **47** or some other appropriate means, such that a slack loop **48** is created between these two attachment points.

By design, the stretch capability of the bungee cord **45** and the amount of slack in the loop **48** are adequate to allow the apparatus to reciprocate at its full capability while the resistance force of the bungee cord **45** combined with the lead angle of the delivery hose **31** are optimized to cause the least possible loss of efficiency while still contributing to the prevention of rotation of the apparatus on its vertical Z axis. The clamp **47** is also employed to fixedly attach the delivery hose **31** to an anchor **49**.

Being that the bottom **9** is shown here to be a seabed of fissured rock, the delivery hose anchor **49**, as well as the main apparatus anchor **50** are readily available climbing pitons, which are made in different sizes and are manually hammered into the fissures.

It is noted that a variation to this embodiment incorporates a pre-tensioned, flexible link **11** as taught in **Fig. 1**, mounted over the peristaltic hose **10** of **Fig. 1** or the peristaltic hose **42** taught here and crimped or similarly combined into a heavier duty peristaltic hose assembly.

Referring now to **Fig. 4**, the backside strainer **13** of **Fig. 1** is replaced by an internally bored, backside strainer assembly **51** that is threaded at its bottom end to mate with the hose fitting **44** of the peristaltic hose assembly **41** and incorporates at its upper end, a commonly available “quick link” **52** or other similar attachment means linked to the snap shackle **35**. In this way, backside strainer assembly **51** functions as both a backside strainer and a link between the peristaltic hose assembly **41** and the snap shackle **35**.

Referring now to **Fig. 5**, this drawing details how the flow control assembly **3** and base plate **30** of **Fig. 2** have been integrated to form a flow control/base assembly **53**, which otherwise fulfills the same functions with the same components and is attached in the same ways as was taught in **Fig. 1**, which becomes apparent when comparing **Fig’s 2** and **5**. For greater clarity, the intake check valve **22** that would otherwise be hidden behind the intake filter **24** in this view, is shown here in exploded view with its actual location indicated by an arrow **54**.

Referring now to **Fig’s 6a, 6b, 6c, 6d and 6e**, each representing a variation of the block assembly **2** as taught in **Fig. 1**: For greater clarity, the drawings are shown both with and without the flexible link **11** component of the peristaltic link assembly **1** taught in **Fig. 1** in order to reinforce the understanding that the apparatus of the present invention can function in either configuration.

Fig. 6a is a representation of the single compression, roller type, block assembly **2** taught in **Fig. 1** and redrawn here for easier reference and comparison to the subsequent **Fig. 6 Series** drawings shown adjacent. It is comprised of a body **17**, a freely rotating pulley **18**, a freely rotating compression roller **19** and a two-way joint **20** upon which the block assembly **2** can pivot on both horizontal axes. The peristaltic hose **10** and flexible link **11** components of the peristaltic link assembly **1** are also shown.

Fig. 6b shows a block assembly **55** incorporating two compression rollers **56** and **57** and a non-swiveling snap shackle **58** in place of a two-way joint **20** but otherwise, is similar to that shown in **Fig. 6a**. The purpose for using two or more compression rollers is to increase the pressure handling capability of the peristaltic hose **10**, as well as to reduce the potential for pressure loss due to leakage should occlusion not be complete between the pulley **18** and either one of the compression rollers **56** or **57**.

Fig. 6c represents a block assembly **58** wherein a compression roller is not required to occlude the peristaltic hose **10** due to the use of a much smaller diameter pulley **59** than that used in the block assembly shown in **Fig. 6a**. In effect, the load from two equivalent floats, is distributed over a much smaller area in the case of the block assembly **58** resulting in a much higher pressure being applied to the peristaltic hose assembly **1** where it is in contact with the smaller pulley **59** and thus, by design, causing full occlusion of the peristaltic hose **10** in the area at the bottom of the pulley **59**.

Fig. 6d represents the upper portion of a block assembly **60** wherein a compression roller is not required to occlude the peristaltic hose **10**. While a larger diameter pulley **61** is used in this case, it's circumference is star shaped rather than round as can be seen here wherein a variable plurality of contact points is typified by point **62**. This has the same effect as that taught in **Fig. 6c** in that the load is distributed over a smaller total area, being limited to those points where contact is made with the peristaltic hose **10**. In this case, the load is progressively applied over these occlusion points with the greatest pressure being those closest to the bottom of the pulley **61**, which in this case, are points **62** and **63**. By design, the number and contact area of these evenly spaced contact points on the pulley **61** are such that full occlusion can occur simultaneously at more than one point, again as seen with points **62** and **63**, thereby allowing for those same benefits as described for **Fig. 6b**. Also shown here represented by the dashed line **64** is the use of a convex rather than flat face on the circumference of the pulley **61**. It is foreseen that among other potential benefits, this allows the occlusion process to occur more easily.

In **Fig. 6e**, the block assembly **65** is generally the same as that taught in **Fig. 6d** except that the pulley **66** has less compression points and, in this case where three are used, simultaneous, full occlusion is not necessarily constant although possible depending on the peristaltic hose **10** characteristics. However, it is shown here in order to reinforce the understanding that other pulley shapes are foreseen for use within various block assembly configurations.

Fig's 7a, 7b, 7c, 7d, 7e and 7f represent an incomplete sampling of various anchoring means that are foreseen. The main requirement of any anchor is that it provides the means by which the apparatus is flexibly fixed to the bottom **9** or any other reaction point deemed to be immovable in relation to the rest of the apparatus and the undulating surface **8**. That said providing an anchoring means that is moveable but out of phase with the undulating surface **8** may also be appropriate. For example, a sub-surface portion of an off-shore drilling platform. Depending on whether it is a fixed or floating platform, it could be either immovable or or out of phase. Important considerations in this case would be that there not be interference between the apparatus of the present invention and the apparatus to which it is anchored and that any apparatus such as the drilling platform to which apparatus of the present invention is anchored is capable of safely handling the modified load placed upon it. In fact, the choice of anchoring means is also dependent on a number of other factors as well such as local conditions, convenience, availability and whether or not the installation is of a permanent or temporary nature.

Fig. 7a shows a gravity anchor **6** as seen in **Fig. 1**, which is only one of many possible shapes and types possible. The primary requirements in this case are that it is of adequate mass to counteract the buoyant and other forces acting on the apparatus and that it resist movement along the bottom **9**. Any appropriate means can be used to attach the anchor **6** to the apparatus of the present invention, which in this case, is the threaded holes **67** and **68** to which the block assembly **2** of **Fig. 1** is attached. The apparatus of the present invention is then flexibly attached such that the apparatus can pivot on its horizontal X and Y axes but not rotate on its vertical Z axis. The primary benefit of this type of anchor is that it may be set from the surface.

Fig. 7b shows a common helical anchor **69**, sometimes also called an earth anchor. These small but highly effective anchors are typically used where the bottom **9** is comprised mainly of a softer, loose material such as gravel. They are turned into the bottom much as a screw is turned into wood. The apparatus of the present invention is then flexibly attached through the eye **70** such that the apparatus can pivot on its horizontal X and Y axes but not rotate on its vertical Z axis.

Fig. 7c shows a common rock anchor **69**, also called a piton and widely used by mountain and rock climbers. These anchors can be used where the bottom **9** is comprised of solid, fissured rock and are highly effective when driven in by hand held hammer or other similarly acting impact device. It is best to set the rock anchor **69** as close as possible to perpendicular to the direction of pull by the apparatus of the present invention, which is flexibly attached through the eye **72** such that the apparatus can pivot on its horizontal X and Y axes but not rotate on its vertical Z axis.

Fig. 7d shows a common spike or pile anchor **73**, the latter term being used for larger applications. These anchors can be used in a variety of bottom **9** conditions such as where the seabed is comprised of broken rock, gravel, sand or even compressed mud in some cases. There is much engineering information and data available with regard to the selection and setting pile anchors.

Fig. 7e shows what is commonly referred to as a snap shackle **75**, of which there are a number of types. The term snap denotes that it is removable. The one used with the apparatus of the present invention is of the non-swiveling type in order to prevent rotation of the apparatus on its vertical Z axis for reasons previously discussed. As shown here, the snap shackle **75** actually serves as an anchor linkage means in that it is clipped onto any appropriate anchoring means represented by the dashed line **76**. For greater clarity, it is also shown here attached at location **77** to the block assembly **2** of the apparatus taught in **Fig. 1**.

Fig. 7f provides one example of any number of means by which the apparatus of the present invention can be raised up from the bottom **9**. This may be necessary in order to raise the block assembly **2** above shifting sand levels, adjust for a peristaltic link assembly **1** that is found to be too short or for other unspecified reasons. A primary requirement in this case is to prevent or at least limit the degree to which the apparatus of the present invention can rotate on its vertical Z axis for reasons previously discussed. This is accomplished through the use of a raised anchor assembly **78** comprised of a stabilizer bar **79**, a number of non-stretch cables or ropes as represented here by the ropes **80**, **81**, **82** and **83** being fixedly attached on their upper ends to the stabilizer bar **79** and on their lower ends to their corresponding rock anchors **84**, **85**, **86** and **87**. The raised anchor assembly **78** is held above the bottom **9** by the upward pull of the buoyant apparatus of the present invention and is prevented from rotating to any significant degree by the combination of its length and the locations at which the anchor ropes **80** and **83** are attached to it. Movement is further restricted by ensuring that the anchor ropes **81** and **82** are effectively separate by knotting them or using rope stops **88** and **89** as shown here on either side of the stabilizer bar **79** if they are comprised of a single length of rope. For greater clarity, any significant degree of rotation would require a similar, corresponding drop in height of the stabilizer bar **79** in the configuration as shown here, a situation that is largely prevented by the constant, upward pull of the apparatus of the present invention. The stabilizer bar **79** is designed to be of a length needed to optimize this approach. A block assembly **2** of the type shown in the apparatus taught in **Fig. 1** is also shown here attached by means of an axle pin **90** to the stabilizer **79**.

Fig. 8 represents a two-way acting, horizontally oriented embodiment of the present invention which, nonetheless, utilizes the same or similar components and functions according to the same operating principles as the vertically oriented embodiment taught in **Fig. 1** and **Fig. 3**. Specific variations include; the open centre-tube type sub-surface float **5** of **Fig. 1** is replaced with an equivalent sized, bottom eye type sub-surface float **91** being of the same type as the surface float **4**; a second peristaltic hose **92** identical to the existing peristaltic hose **10** is incorporated into a peristaltic link assembly **93**, which is the functional equivalent of the peristaltic link assembly **1** taught in **Fig. 1**; the sub-surface buoy **91** is linked to the peristaltic link assembly **93** with a second, swivel type snap-shackle **94** identical to the existing snap-shackle **35**; two block assemblies **95** and **96** are functional equivalents to the block assembly **2** taught in **Fig. 1** with the exception that they do not incorporate a means of preventing rotation on any axis, a feature not needed in this embodiment of the present invention so instead the block assemblies **95** and **96** are flexibly attached to their respective anchor means **97** and **98** by rope loops **99** and **100** or some other appropriate, flexible attachment means and;

the flow control assembly **3** taught in **Fig. 1** is replaced by the flow control assembly **101** shown in greater detail in **Fig. 9** adjacent, which will be further described in due course.

The peristaltic hoses **10** and **92** as shown here lying generally in a loop **102** in order to provide the slack needed to allow unimpeded reciprocation of the peristaltic link assembly **93**. Assuming that the peristaltic hoses **10** and **92** do not naturally float upward, no means is indicated to prevent their entanglement with either the reciprocating peristaltic link assembly **93** or the block assemblies **95** and **96**. However, such an intervention can be applied if necessary by using the same bungee cord **45** based means taught in **Fig. 3** or by some other appropriate means. Also, for greater clarity in this regard but not shown here due to the two dimensional nature of the drawing, the peristaltic hoses **10** and **92** seen looped at location **102** are best laid out perpendicular to rather than parallel to the reciprocating peristaltic link assembly **93**.

As was indicated, this embodiment of the present invention functions in similar fashion and according to the same operating principles as the vertically oriented embodiment taught in **Fig. 1**. However, for greater clarity, the following details are provided.

In this embodiment of the present invention, the peristaltic link assembly **93** is comprised of a woven, tubular, flexible link **11**, first and second backside strainers **13** and **103**, four travel stops **14**, **15**, **104** and **105**, and first and second quick couplers **106** and **107**, as well as the separate functioning peristaltic hoses **10** and **92** contained within it. It is again noted that in other embodiments of the present invention, the peristaltic hose **10**, as well as peristaltic hose **92** introduced here, can serve in the dual role of peristaltic hose and flexible link. As was the case where the peristaltic hose **10** exited through the side wall of the flexible link **11**, both peristaltic hoses **10** and **92** exit through the side wall of the flexible link **11** at locations **108** and **109** from whence they proceed in similar fashion to connect with the flow control assembly **101** as seen in **Fig. 9** adjacent.

Fig. 9 further details the construction of the flow control assembly **101** shown in **Fig. 8**. Although their function and operating principles are similar, a significant difference exists between the flow control assemblies taught in **Fig. 2** and **Fig. 5** and the one taught herein. Specifically, the **Fig. 2** and **Fig. 5** assemblies are designed to handle the alternating intake and output of a single acting apparatus of the type taught in **Fig. 1**, whereas the flow control assembly **101** taught here is designed to handle the alternating intake and output of a dual acting apparatus of the type described in **Fig. 8**.

In this case, the flow control assembly **101** is comprised of an enclosure **110** openable for servicing, a hydraulic circuit **111** incorporating a primary loop **112** and four branches **113**, **114**, **115** and **116** with flow directions shown by arrows three of which are terminated as shown by appropriate hose connectors **117**, **118**, and **119** such as quick-couplers, fixedly mounted through the enclosure **110**, four check valves **120**, **121**, **122** and **123** fixedly mounted within the primary loop **112** of the hydraulic circuit **111**, and an intake filter **124** that terminates the fourth branch of the hydraulic circuit **111** and is also fixedly mounted through the enclosure **110**.

For greater clarity the peristaltic hoses **10** and **92** and their corresponding quick-couplers **106** and **107**, as well as the delivery hose assembly **127** and its corresponding quick-connector **128** are shown here connected to the flow control assembly **101** but seen in greater detail in **Fig. 9** adjacent.

Referring once again to **Fig. 8**, it can be seen that the apparatus described shares the same operating principles and means and is comprised mainly of either like or similar assemblies and components with the apparatus' of **Fig. 1**, **Fig. 3** and **Fig. 8**. In terms of operating principles for example, each apparatus has one or more pressurized frontsides and one or more non-pressurized backside separated by a fully occluding block assemblies. In this regard, it is noted that the alternating cycle of displacing or pumping and then drawing in of replacement water by the first peristaltic hose **10** occurs simultaneously but in reverse order with the second peristaltic hose **92**.

As has become apparent, the only significant differences are those required to convert the apparatus from a single-acting peristaltic pump to a double-acting peristaltic pump and convert to arrangement from a vertically arranged to a horizontally arranged apparatus. In all cases, however, pressurized pumping is accomplished by reciprocating one or more peristaltic hoses through one or more block assemblies that incorporate both pulley and occlusion means.

It is noted variations of the embodiment of the present invention taught here in **Fig. 9** are foreseen including those in which the role of the flexible link **11** and peristaltic hoses **10** and **92** are carried out by a suitable, heavy duty peristaltic hose of the type taught in **Fig. 3**. In such cases it would be practical to employ separate, short lengths of flexible link, not only to connect to the surface and sub-surface floats but also to link the two separate peristaltic hoses, such as the peristaltic hoses **10** and **92** taught here where this linkage would be attached between the travel stops **15** and **105**.

Referring now to **Fig. 10**, a further embodiment of the present invention quite similar to that taught in **Fig. 8** in that it is also a double acting, horizontally oriented embodiment of the present invention. It's two-way pumping capability is derived from the reciprocating action of two peristaltic link assemblies **136** and **137** acting simultaneously but in reverse order in response to the opposed action of a surface float **4** that is flexibly linked to a sub-surface float **91**.

However, while the apparatus herein described again functions according to the same operating principles as previously described apparatus', there are notable variations in the design and interaction of two key components. More specifically, previously taught variations of the the block assembly incorporated both a pulley and a compression roller, thereby fulfilling a dual role; for example, the block assembly **2** as taught in **Fig.1** and the block assemblies **95** and **96** taught in **Fig. 8**. In this case, the roles of the pulley and of the peristaltic hose compression means handled by separate components. More specifically, the block assembly **132** shown here does not incorporate any compression rollers and so does not provide for the necessary occlusion of the hose within the peristaltic link assembly **136**, which operates about its freely rotating pulley **134**. In like manner, the block assembly **133** does not incorporate any compression rollers and so does not provide for the necessary occlusion of the hose within the peristaltic link assembly **137**, which operates about its freely rotating pulley **135**. Furthermore, it is noted that the pulleys **134** and **135** are grooved in this case. These concave grooves are cut to match the normally round shape and outer diameter of the peristaltic link assemblies **136** and **137** or, in the case of other embodiments of this design not using discrete flexible link assemblies, the outer diameter of the peristaltic hoses themselves.

New to this embodiment of the present invention is a separate but shared compression assembly **131** that provides the necessary full occlusion points for the reciprocating peristaltic link assemblies **136** and **137**.

For greater clarity, construction of the compression assembly **131** is further detailed in **Fig. 11** adjacent. As shown, it is comprised of a main body **142** which houses a first freely rotating pulley **143**, a second freely rotating pulley **144** and a common, freely rotating compression roller **144**. Combined, these components interact with the two peristaltic link assemblies **136** and **137** in the same way to cause occlusion as did the pulley and compression roller combinations taught in previous embodiments.

Directional arrows are used to show that the the lower portion of the peristaltic link assembly **136** located between the anchor **138** and the compression assembly **131** and the lower portion of the peristaltic link assembly **137** located between the anchor **140** and the compression assembly **131** do not move to and fro as a result the ongoing reciprocation of the remaining, upper portion of the peristaltic link assembly **136** located between the snap shackle **94** and the compression assembly **131** and the remaining, upper portion of the peristaltic link assembly **137** located between the snap shackle **35** and the compression assembly **131**. Arrows are also applied to pulleys **143** and **144** and the compression roller **144** to clarify their direction of rotation with respect to the reciprocating travel of the compression assembly **131**. It is noted that the arrows in the **Fig. 11** drawing show the movement of the various components during the rising wave phase as which time the surface float **4** moves upward and the sub-surface float **91** moves downward in response. During the return phase, that being with the falling wave, these directional movements are reversed.

A unique and novel feature of this particular embodiment of the present invention is its ability to use two different peristaltic hose diameters so that the apparatus can be tuned or optimized to react to uneven energy levels being harvestable from the rising wave fronts and falling wave backs. That said, this feature could be implemented in other embodiments including some or all of those previously taught but with less ease. A further feature of this particular embodiment of the present invention is that those portions of the peristaltic link assemblies **136** and **137** that are in contact with the bottom **11** as well the flow control assembly **101** and the delivery hose assembly **127**, that are also in contact with the bottom **11** in this case, do not move to and fro with the reciprocating action of those portions of the peristaltic link assemblies **136** and **137** operating between the floats **4** and **91** and the anchors **138** and **140** to which the peristaltic link assemblies **136** and **137** are fixedly attached by any appropriate means, shown here as woven flexible links **139** and **141**, that do not arrest, restrict or hinder the flow of water through the peristaltic link assemblies **136** and **137**.

Finally, it is noted that because of a change in mechanical advantage of the apparatus described herein, the displacement of the peristaltic link assemblies **136** and **137** would need to be increased by the same ratio if the intent is to produce the same output.

Fig. 12 shows one of various means by which different embodiments of the present invention can be linked in arrays. In this case, a series of surface floats such as but not limited to rigid type surface floats **146** and **147** are flexibly linked by any appropriate means at location **148** as shown or in some other similarly acting fashion. In this case, a peristaltic link assembly **149** is attached with a snap shackle **150** to a fixedly attached strap assembly **151** wrapped around the circumference of the surface float **146**. While not shown here it is assumed that the corresponding sub-surface floats may or may not be similar in design and similarly attached in a series. It is noted, however, that the operating principles are again reflective of those previously taught in this description.

- - - - -

The preceding represents a detailed description of an invention by Gerald J. Vowles of Belleville, ON Canada K8N 1Y6. The purpose of this document is to establish a priority date with regard to a yet to be completed patent application for the present invention. The balance of the documents and materials required to complete the application process will be provided in due course in accordance with the instructions provided by the Canadian Intellectual Property Office (CIPO).

Fig. 1

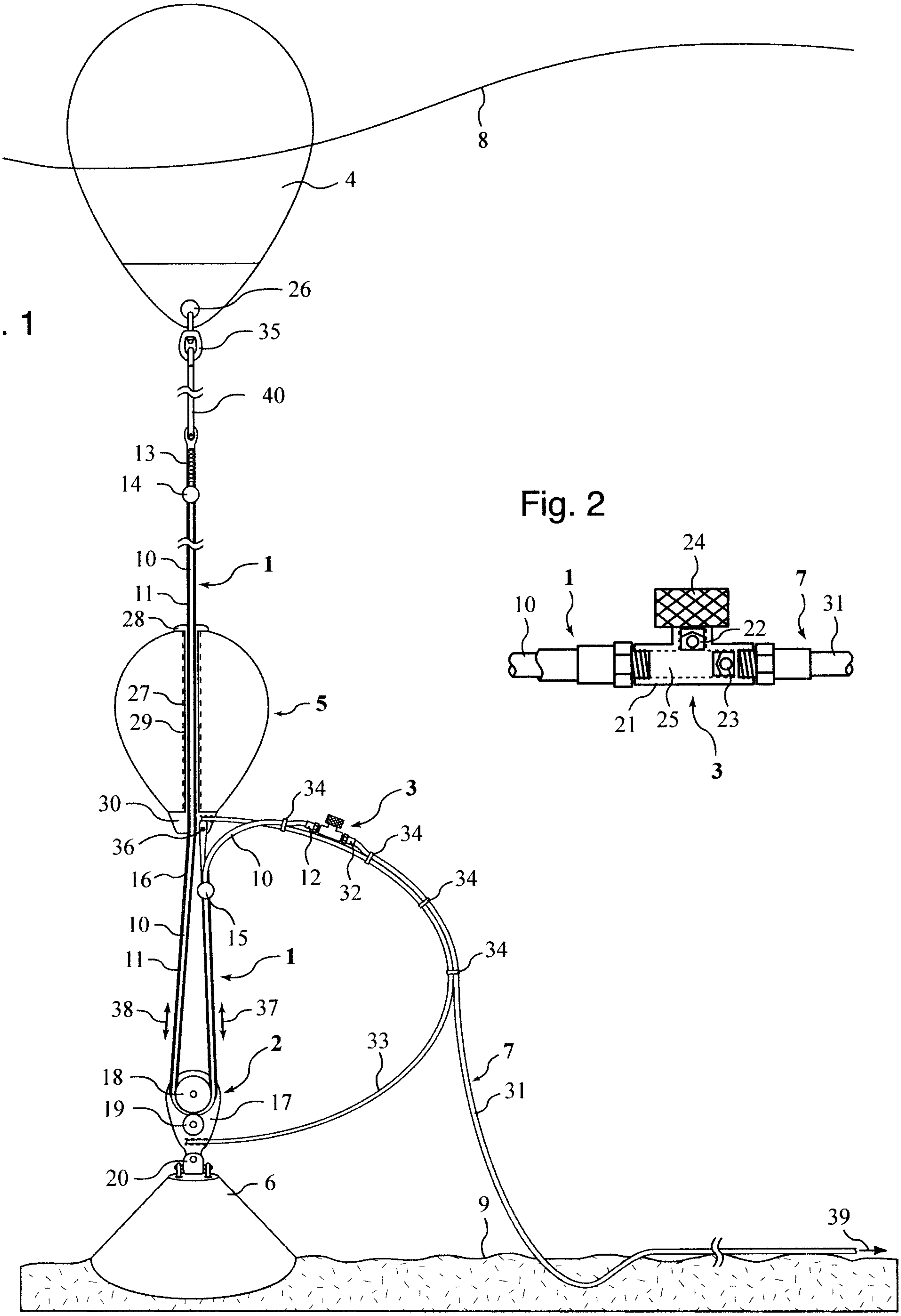

8
4
26
35
40
13
14
10
1
11
28
27
29
5
30
34
3
36
10
12
32
34
34
16
15
10
34
11
1
38
37
2
33
7
18
17
31
19
20
6
9
39

Fig. 2

24
1
10
7
31
22
21
25
23
3

Fig. 3

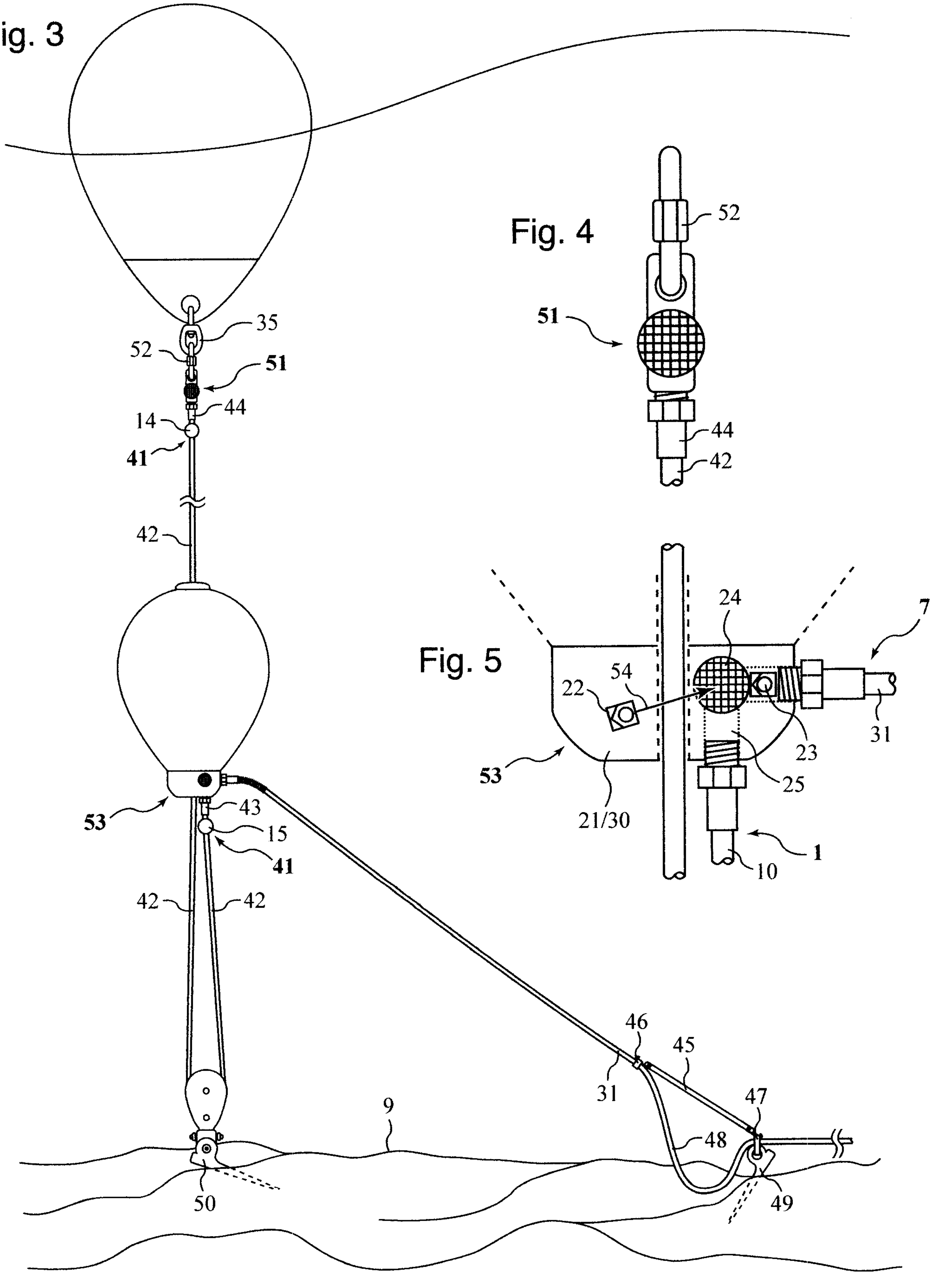


Fig. 4

Fig. 5

Fig. 6a

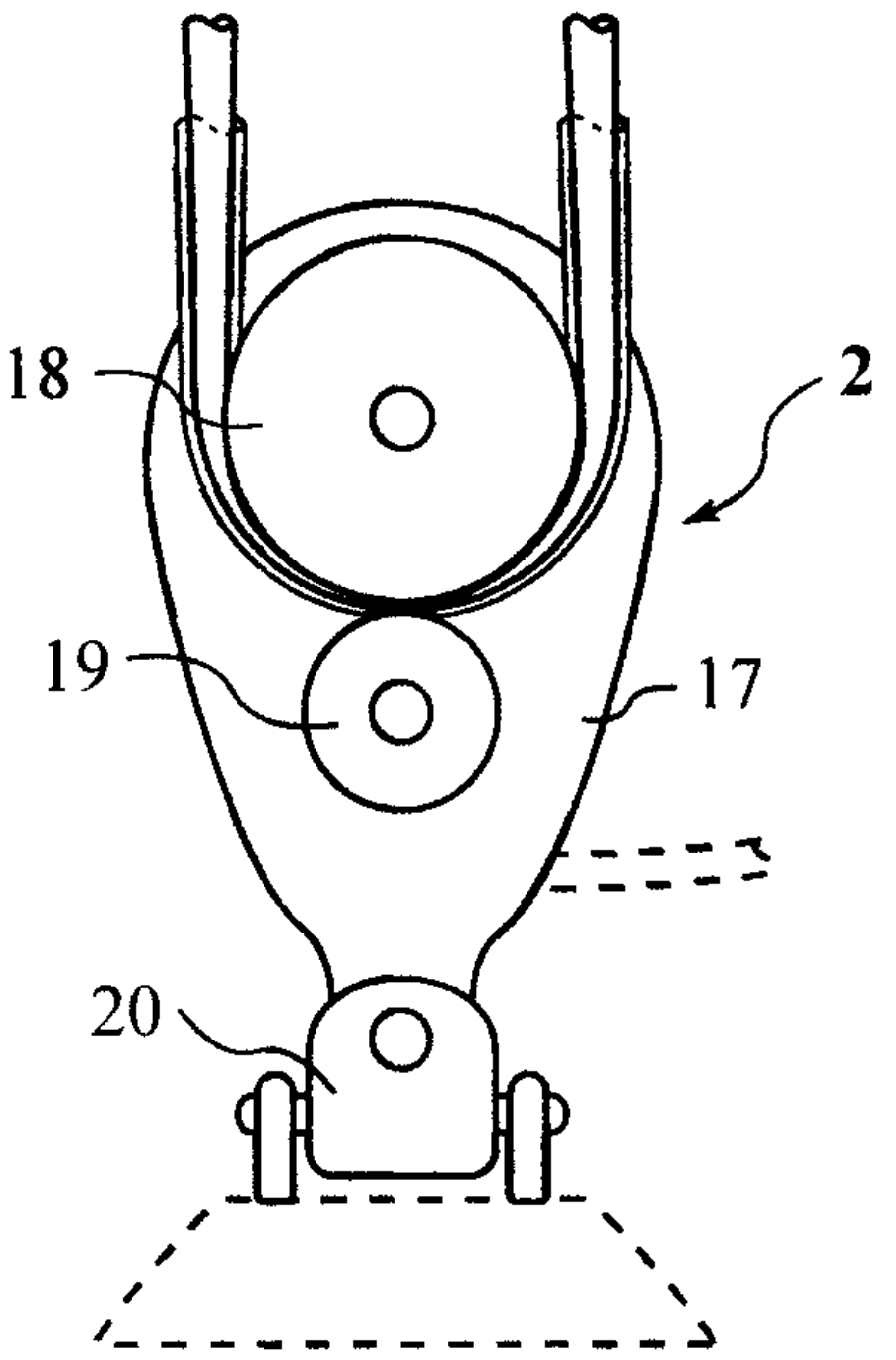


Fig. 6b

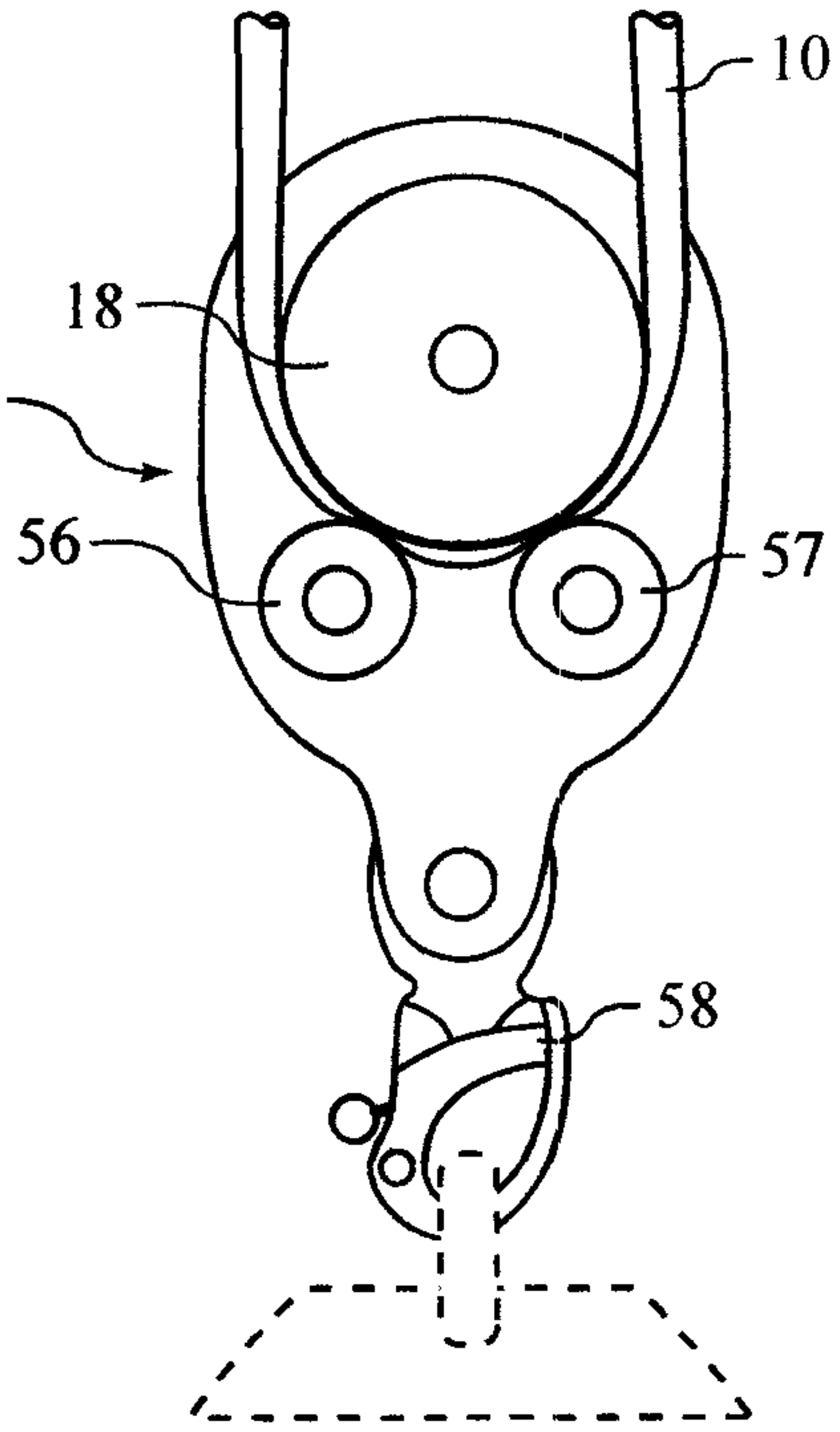


Fig. 6c

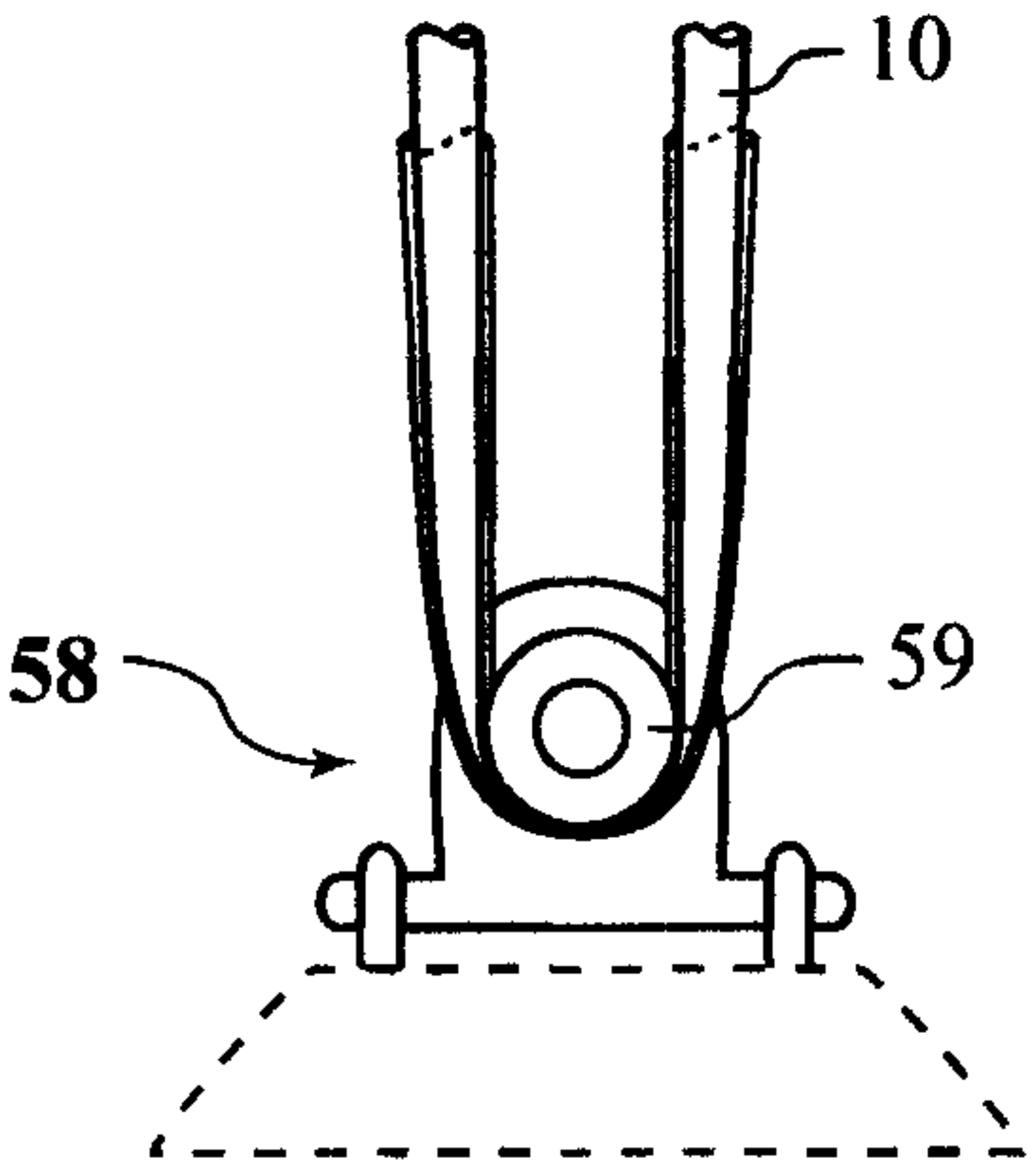


Fig. 6d

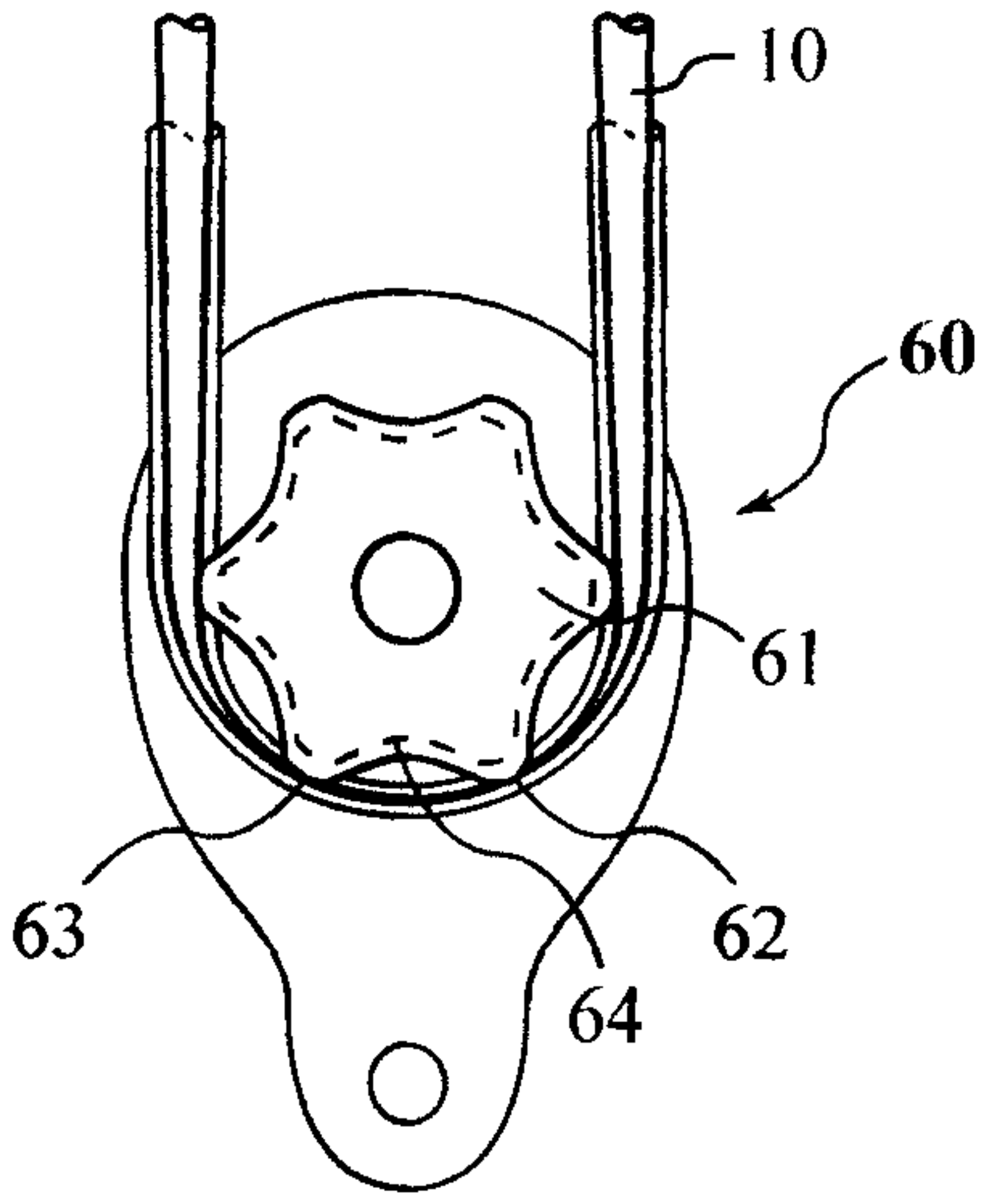


Fig. 6e

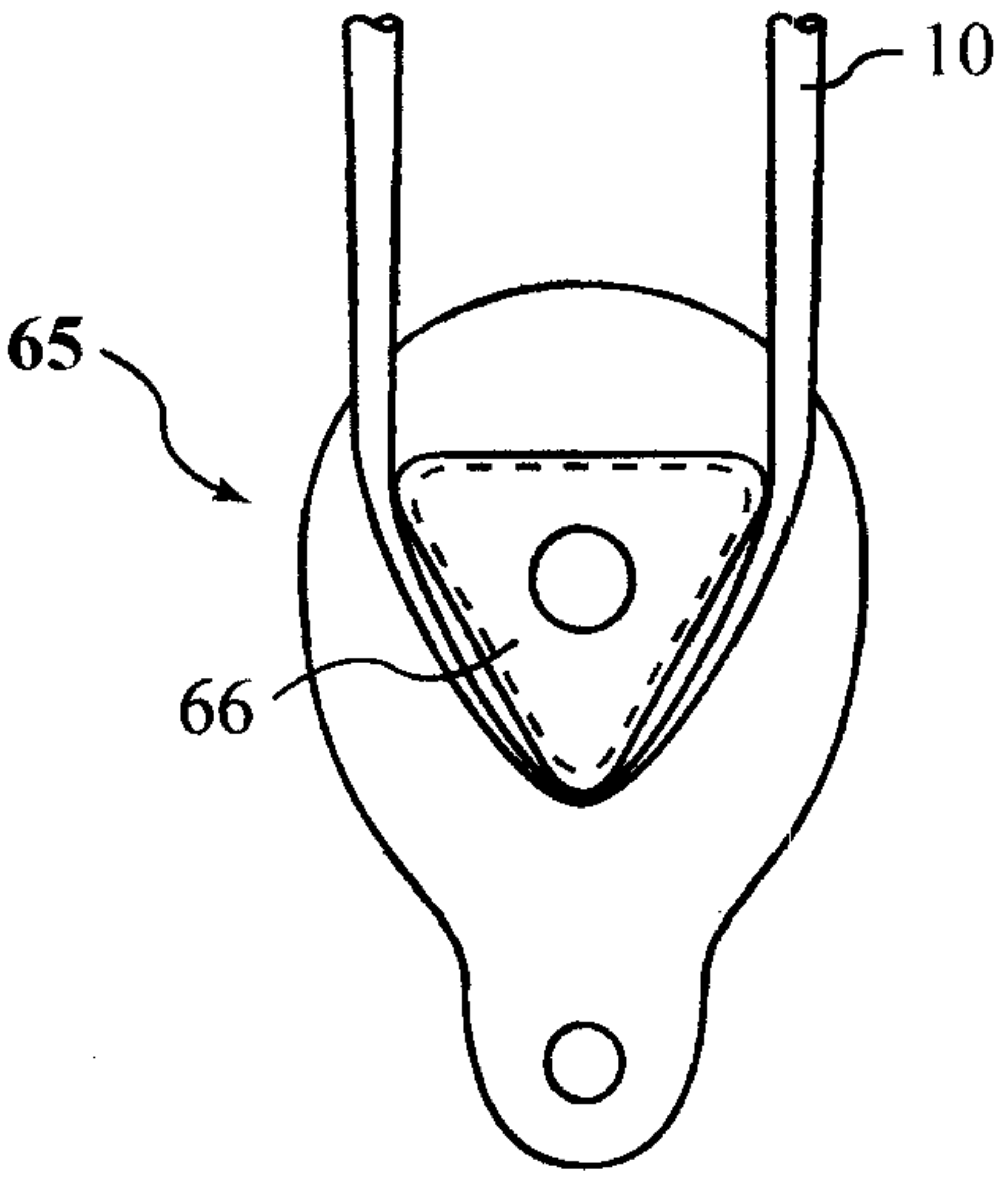


Fig. 7a

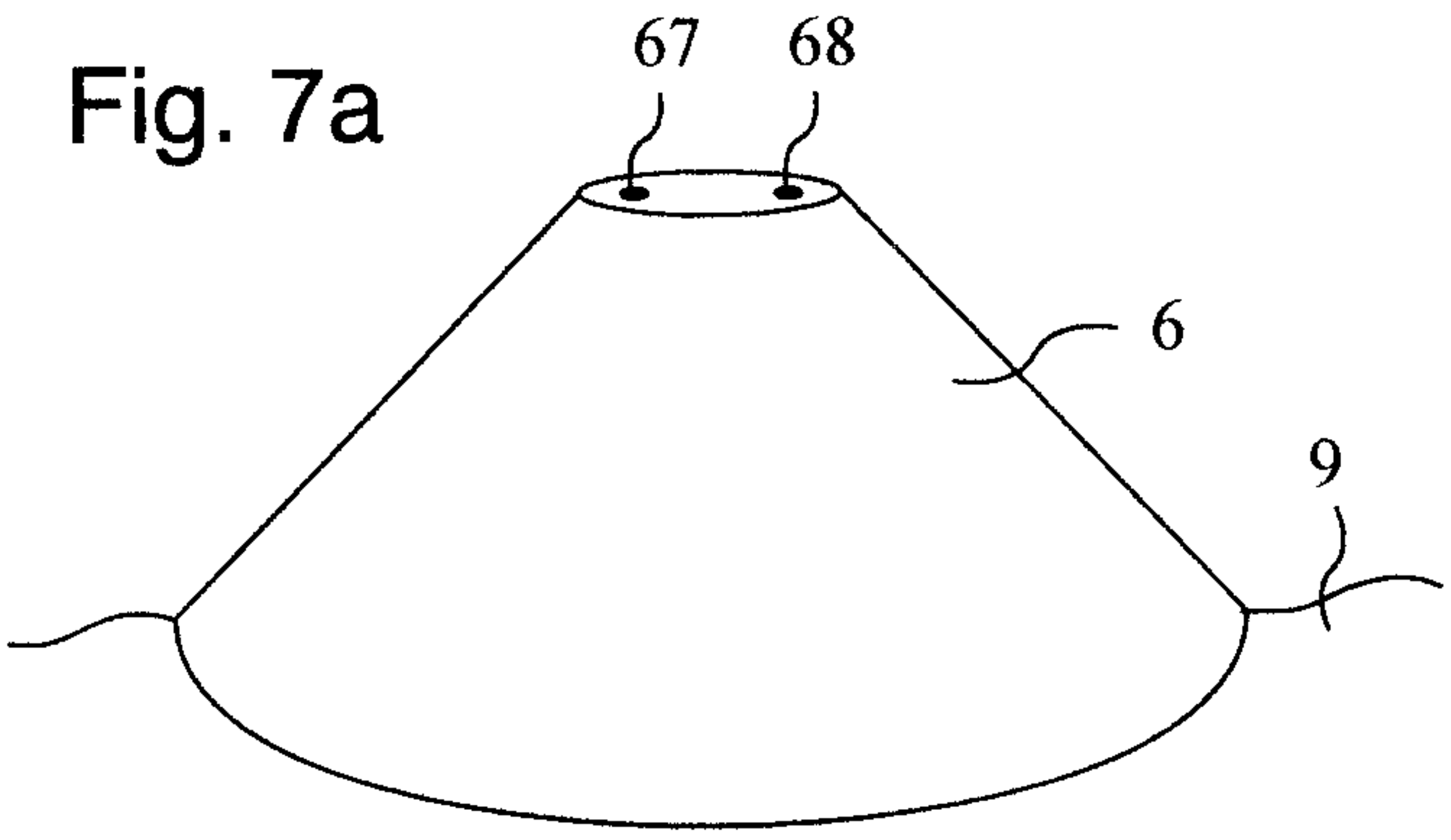


Fig. 7b

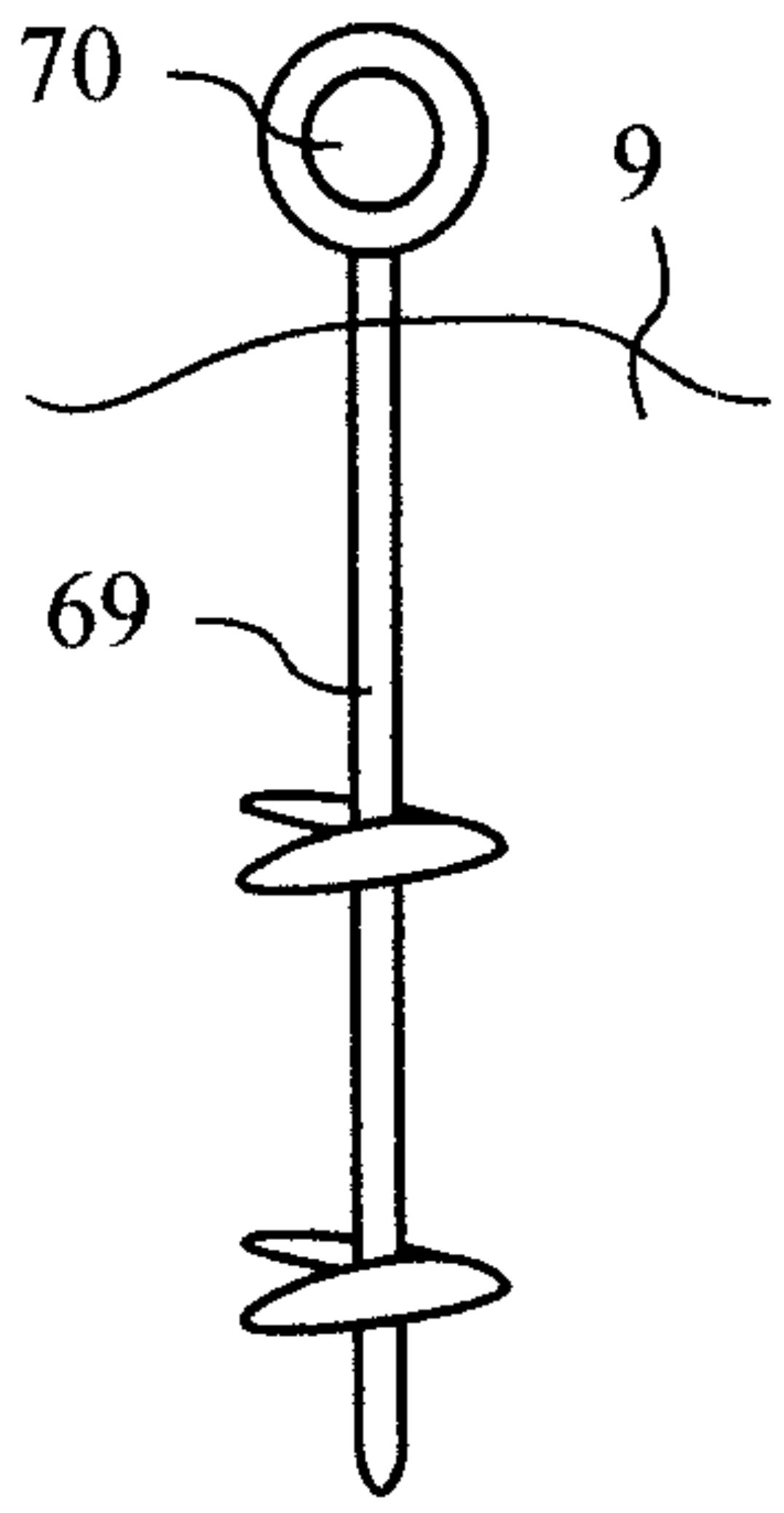


Fig. 7c

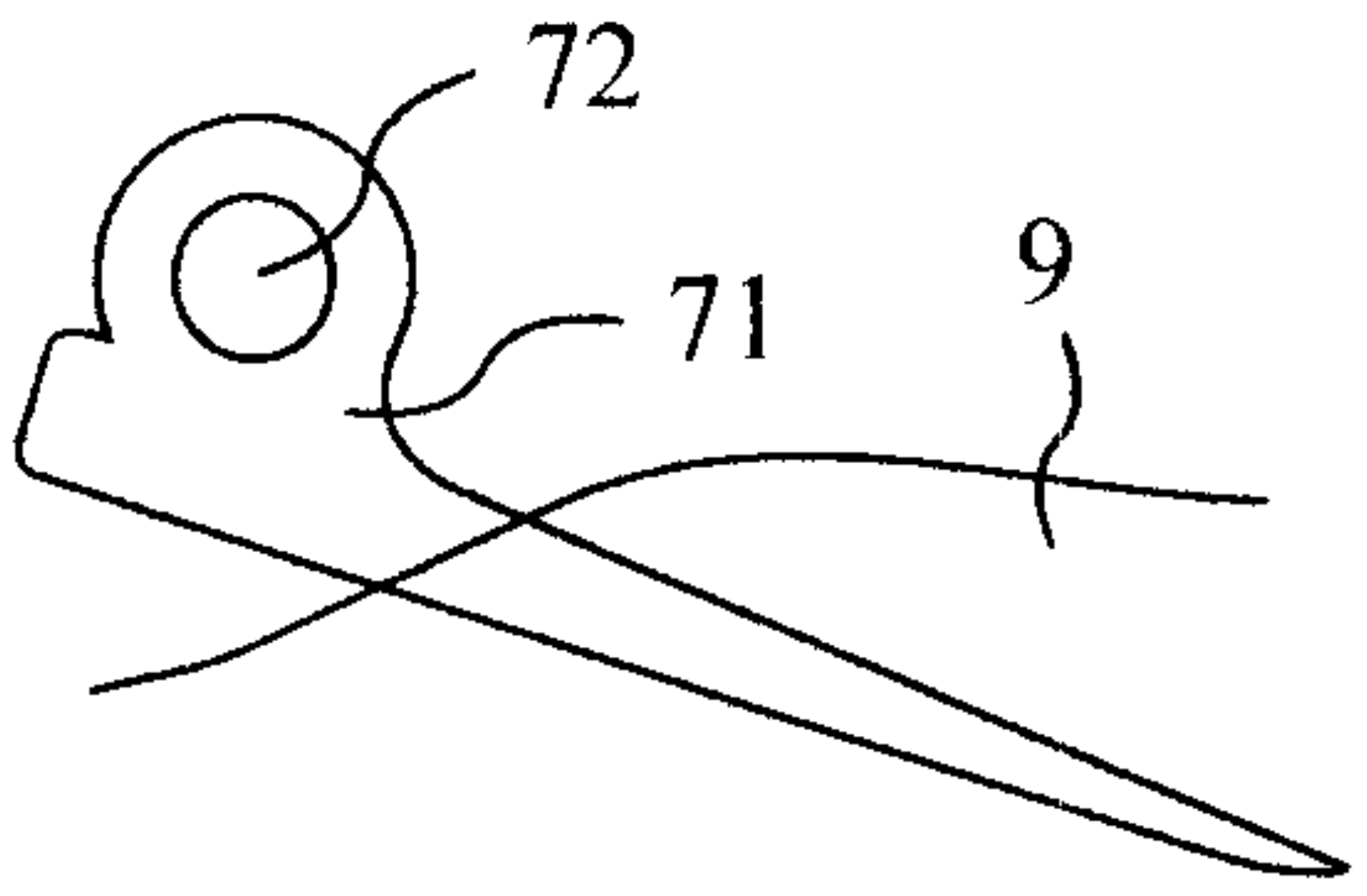


Fig. 7d

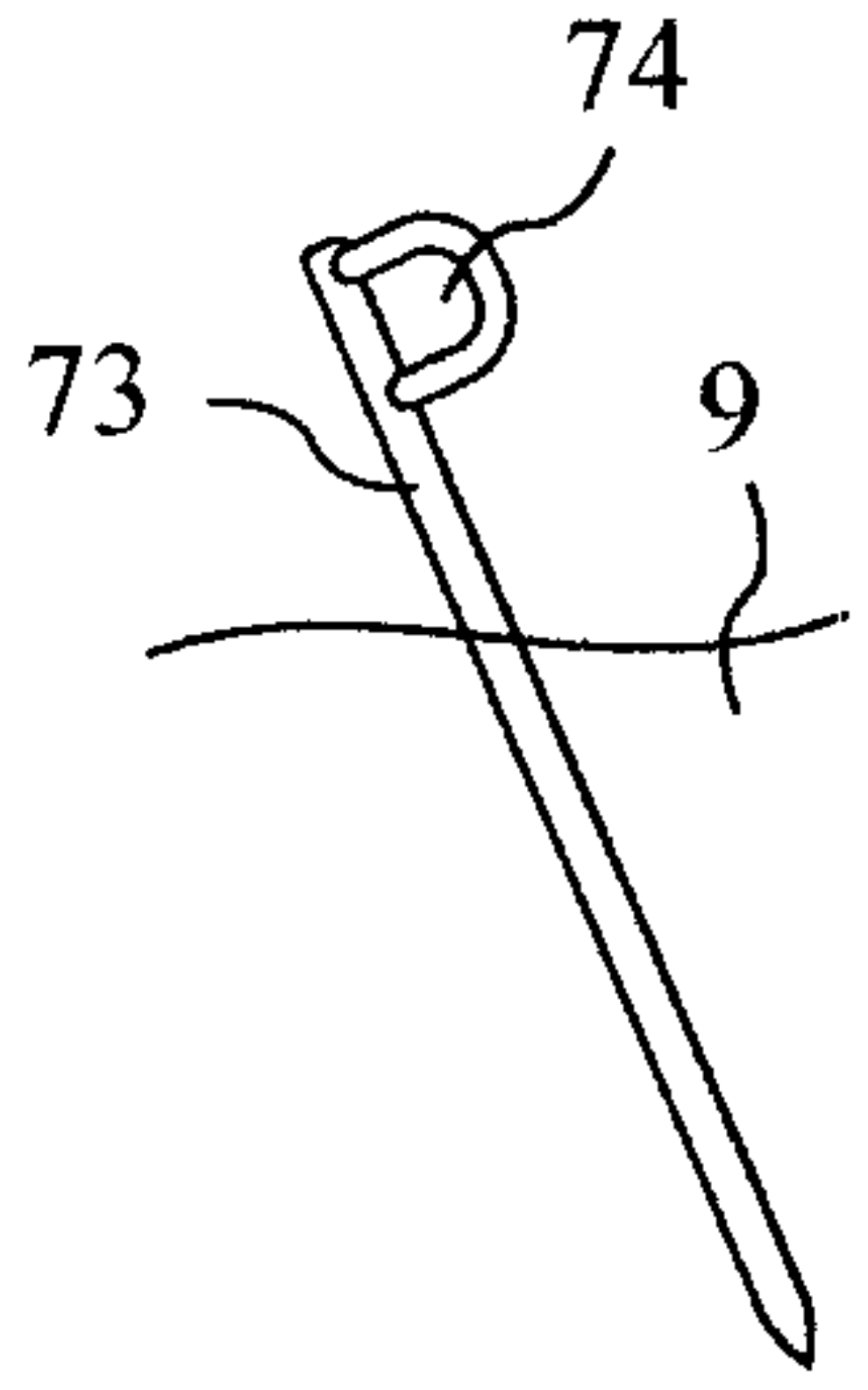


Fig. 7e

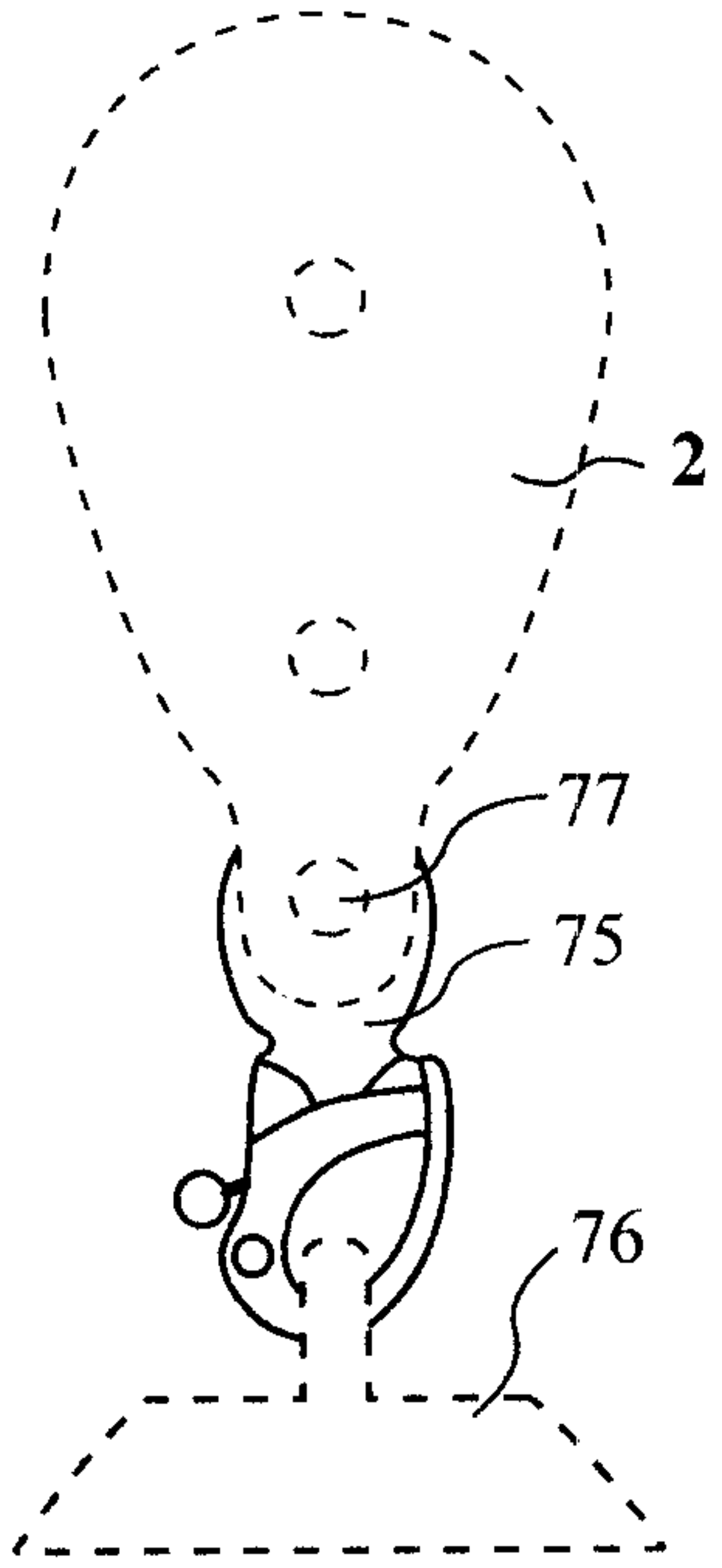


Fig. 7f

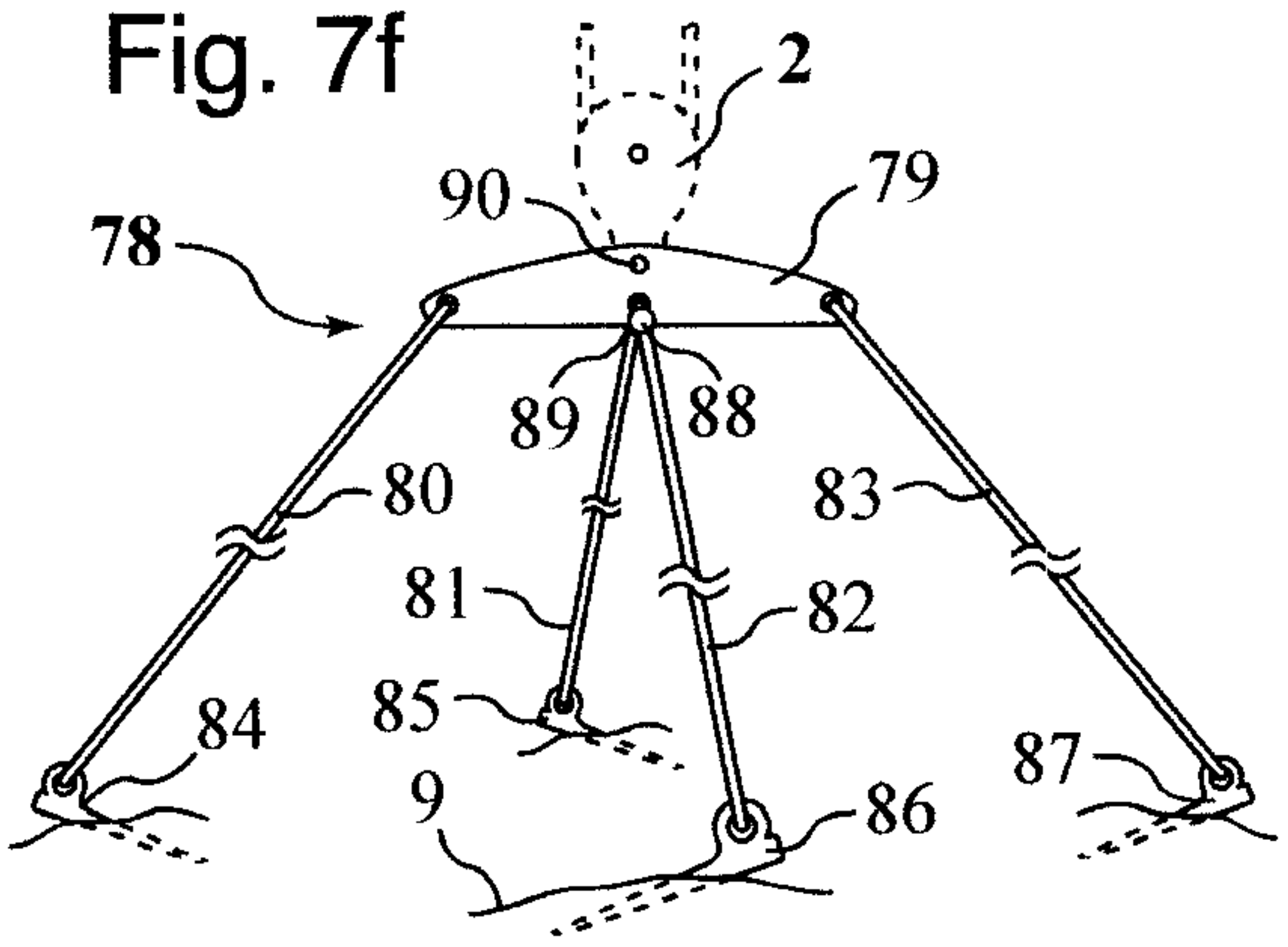
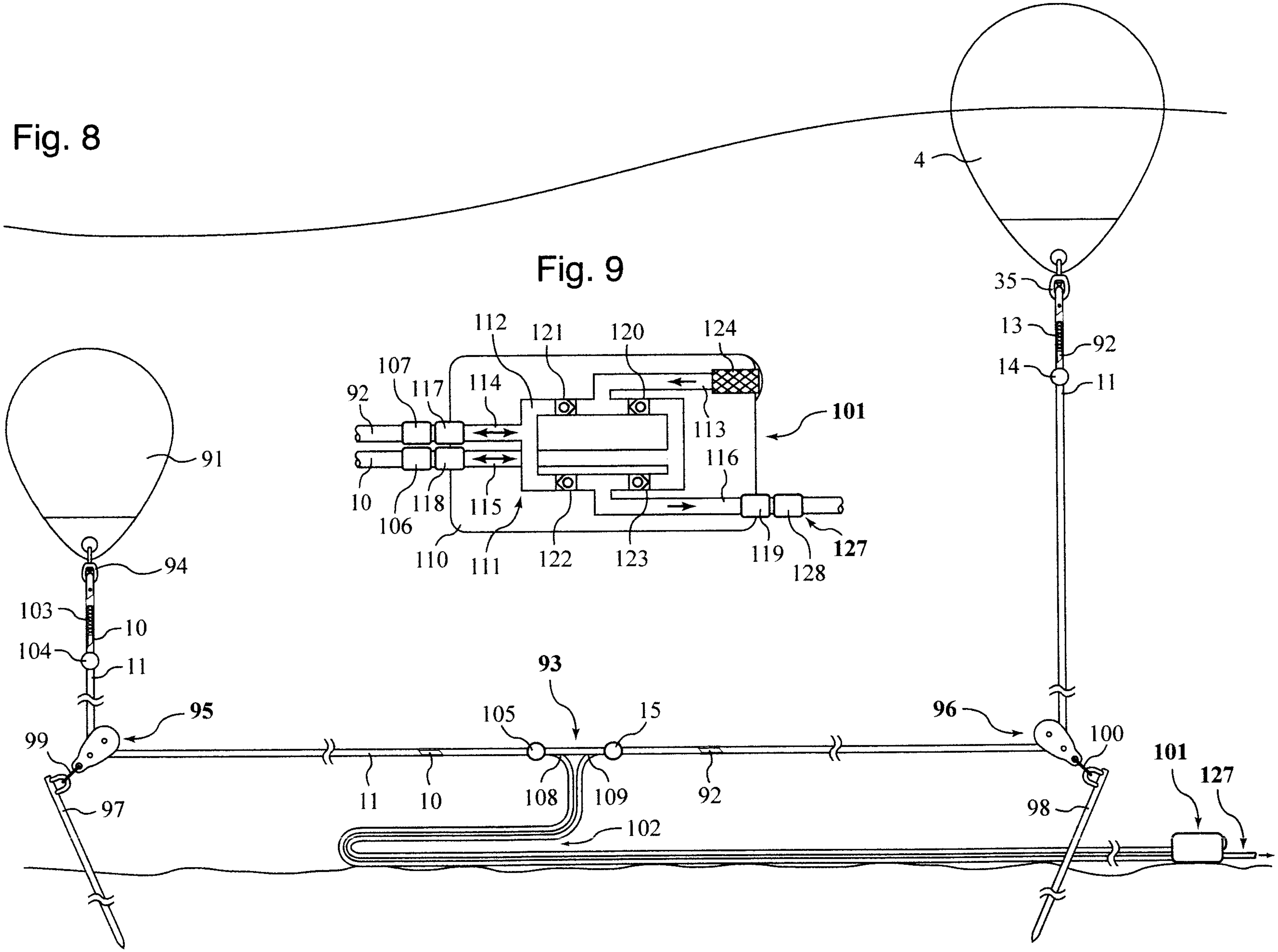


Fig. 8

Fig. 9


4
35
13
92
14
11
91
94
103
10
104
11
95
99
97
112
121
120
124
107
117
114
92
113
101
116
10
106
118
115
110
111
122
123
119
128
127
93
105
15
96
100
101
127
11
10
108
109
92
98
102

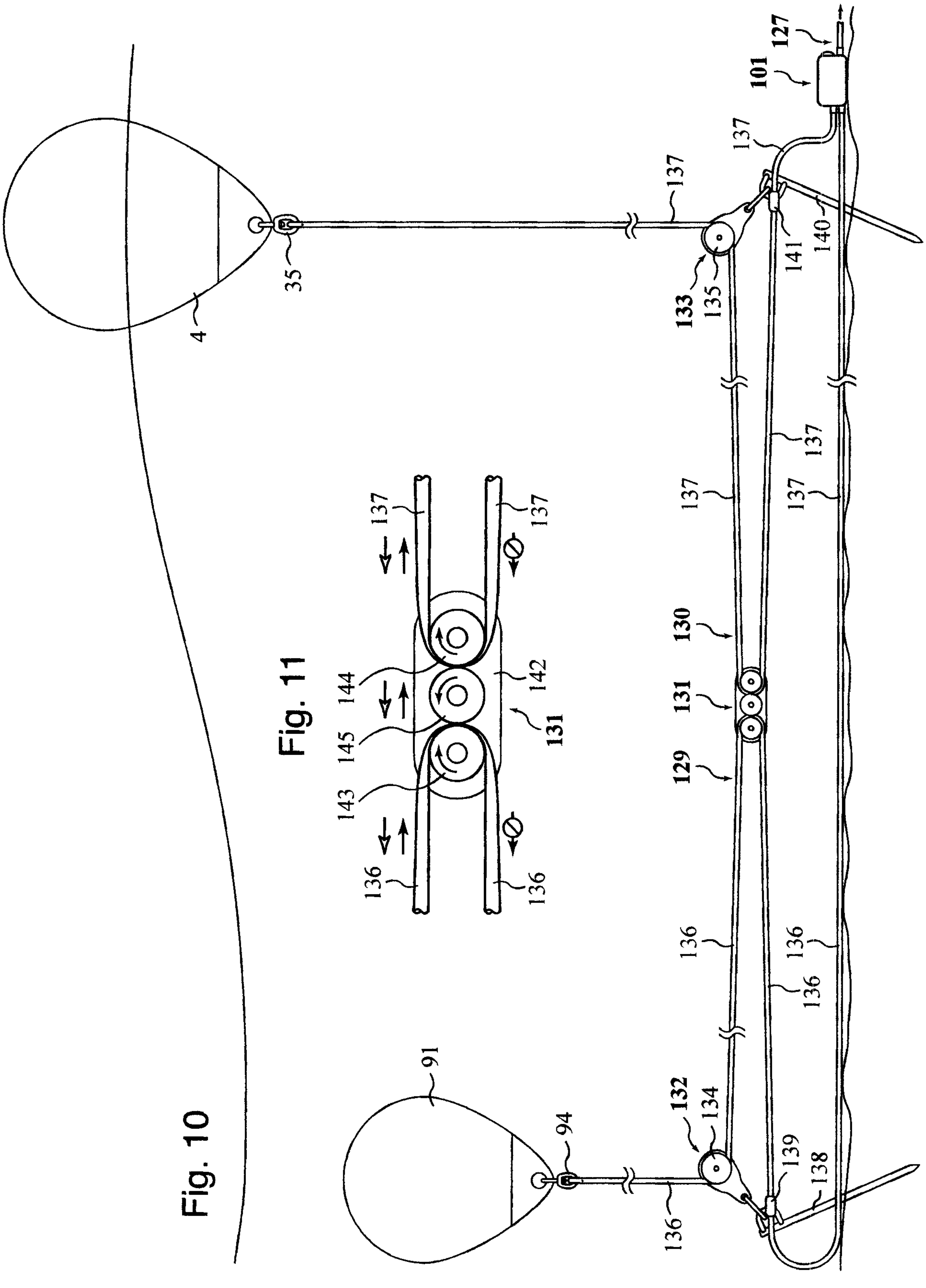
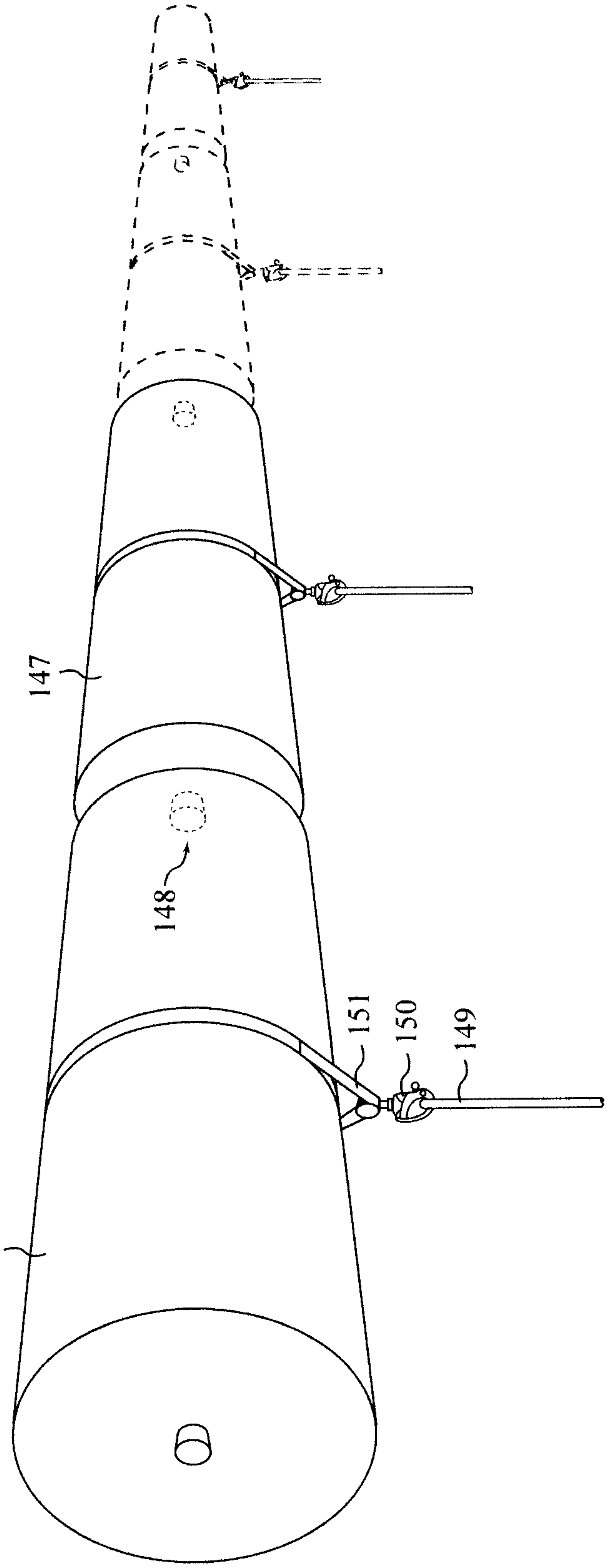
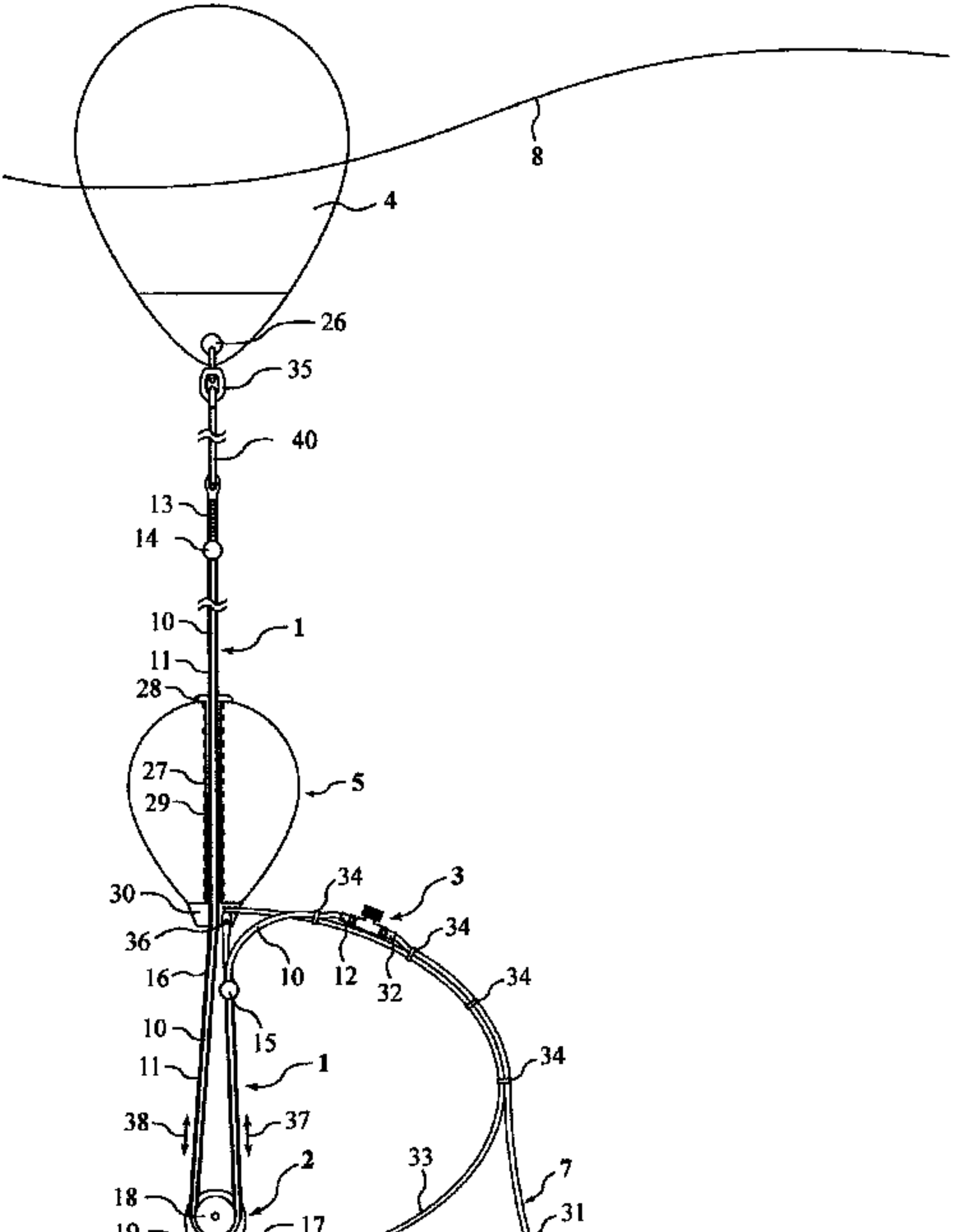

4
35
137
133
135
141
140
101
127
137
137
137
137
137
130
131
129
136
136
136
136
132
134
94
91
139
138
136
137
137
144
142
145
131
143
136
136

Fig. 10

Fig. 11

Fig. 12




8
4
26
35
40
13
14
10
1
11
28
27
5
29
34
3
30
34
36
10
12
32
34
16
15
10
34
11
1
38
37
2
33
7
18
31
17
19
20
6
9
39