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| (54) | Title | **Pump System and Method for Pumping Goods or Objects in a Liquid** |
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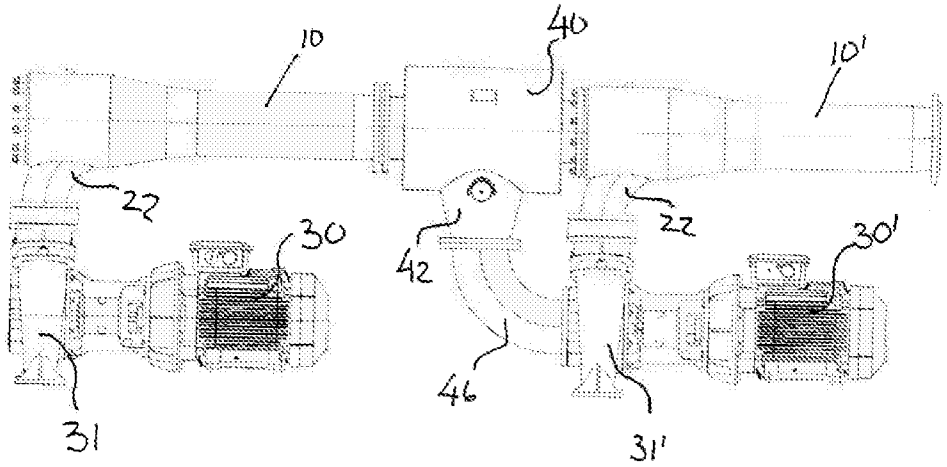
| (57) | Abstract | |

This publication relates to a system for transporting a goods in a main liquid, device (10) causes the main liquid to flow at a velocity in a desired direction through the system, wherein the flow is produced by means of an ejector (10,10') injecting a liquid into the main flow. The system comprises a first injector (10) and a second injector (10') connected in series and with a liquid take out chamber (40) arranged between an outlet of the first injector (10) and the inlet of the second injector (10'), the liquid to be injected in the second injector (10') being drawn from the exit liquid from the first ejector (10).
This publication relates also to a method for transporting goods from one station to another using a liquid as a transport agent, using an ejector as a driving means for creating a suction upstream of the ejector inlet, wherein an injected liquid flow is injected into a main flow carrying a goods, by forcing liquid through nozzle outlets or apertures. The system uses more than one ejectors (10.10') arranged in series is used and where liquid to be delivered as injection liquid to a consecutive ejector (19') is drawn from liquid flow leaving an upstream ejector (10).



*The Technical Field of Invention*

The present invention relates to an ejector used in a pipe system for creating a pumping effect by injecting water at a pressure into a primary or main fluid flow, transporting particles, comprising a main tube or cylinder with a main inlet, through which the primary fluid flow is flowing, an ejector chamber provided with one or more peripherally arranged apertures or nozzles, and a main outlet, the ejector chamber and apertures or nozzles being associated with a pump, supplying injection liquid to the injector chamber and through the nozzles into the primary flow, and a downstream chamber where the main fluid flow is mixed with the fluid from the injector.

The invention relates also to a method for avoiding damage on live organisms or goods pumped through a pipe system, comprising an ejector creating suction upstream the system by injecting a liquid at a pressure and with a velocity into a main flow transporting the live organisms or the good, where the injected liquid is introduced through a nozzle system into the main flow,

*Background of the Invention*

It is known to pump live biomass, such as salmon from a aquaculture cage to a well vessel for transport to an abattoir, using a piping system and a pump creating a suction at the piping inlet, submerged into the cage, thus causing a flow of sea water containing the live biomass from the cage through the piping system and out through the outlet into the well in the well vessel.

Various types of pumps for transporting object through a pipe are known. From CA 1 151 006 it is known a method and apparatus for pumping large solid articles, using a rotary pump having a plain disc impeller disposed in a substantially cylindrical chamber of a housing with an inlet coaxial of the impeller into the housing and an outlet from the periphery of the chamber. A rotor is arranged to provide substantially unobstructed passage between the inlet, past the discs of the rotor to the outlet of the pump.

NO 301440 describes a double acting ejector pump for transport of living and solid organisms. The ejector pump comprises peripherally arranged nozzles injecting water into a main water flow transporting the fish or solid bodies. The system also introduces bobbles into the main stream upstream the nozzle. Reference is also made to EP 332466, showing an ejector pump for transport of solid objects in water.

NO 325581 relates to a method and a device for pumping a mixture of relatively large particles and a liquid through an inlet funnel to and into a pipe in a gentle manner for the particles to be pumped. The pump is based on the ejector

principle where a driving liquid is pumped into the pipe substantially in the general direction of flow. The liquid is fed into an inlet nozzle at a relative high pressure producing a sub-pressure or suction in a retardation chamber.

CH 101872 relates to a method and apparatus for suctioning and compressing a gaseous fluid The subject is a process for the suction and compression of a gaseous fluid intended to suck a gaseous fluid contained at low pressure p in a space determined for discharging it into a second space at a pressure P greater than p, the suction taking place under the action of a driving fluid, a suitably pulverized liquid being discharged into the mixture of aspirated fluid and motor fluid, for the purpose of performing the work of compressing the fluid sucked under the isothermal regime. US 2005/061378 relates to multi-stage ejector apparatus and includes a first stage ejector with an inlet, an outlet, and a venturi throat between the inlet and outlet into which a driving fluid is injected to flow from the outlet and create a suction at the inlet for drawing material into the inlet and through the first stage ejector with the driving fluid, and at least a second stage ejector of the same or similar configuration, with the inlet of the second stage ejector connected directly to the outlet from the first stage ejector, thereby increasing the suction at the inlet to the first stage ejector and maintaining the suction at the inlet to the first stage ejector through a wide range of driving fluid flow rates.

US 2,444,615 relates to an ejector or jet pump commonly used onboard a naval vessel when compartments are flooded and must be un-watered and at the same time must be cleared of debris of various type.

US 2,396,290 relates to an apparatus for quickly and economically removing viscous tar or semi-fluid tar or the like from storage tanks.

US 4,551,042 relates to pumping fish and other articles by extracting water and adding air at a location in the pumping system higher than the initial air injection point, thereby excluding a certain percentage of water.

US 2,000,762 relates to a fluid jet pump or injector for conveying or compressing a fluid by means of a fast moving stream and converting velocity energy of the mixture into pressure energy in a diffuser.

US 2,399,249 relates to a pump for pumping viscous material such as tank sludge through a transmission line.

It is known that the fish during this operation is stressed and that the fish may be injured or harmed when passing through the system. Such inflicted stress may reduce the quality of the fish meat.

Moreover, it has been experienced that ejector pumps tend to produce increased vacuum when pumping fish from for example a cage and into a well in a

well vessel, exposing the fish to a too high velocity and/or a low pressure or vacuum effect, which may have a negative effect on the fish health. If the fish is exposed to a jet with too high velocity, the jet could cause detrimental skin damage to the fish. Moreover, if fish is subjected to a too large suction or vacuum, such pressure could cause damage to the fish, for example to the eyes of the fish.

There is therefore a need for a pumping system which reduces such detrimental effects when transporting live fish or other type of goods through the system, i.e. a system where the effects of large vacuum or suction and high water velocity for moving the fish up from a cage and over the gunwale of the bulwark and into the well tank are eliminated or at least reduced.

*Summary of the Invention*

A main principle relied upon is to provide an ejector where the energy supplied to the main flow through the ejector by means of the injected liquid, is prevented from coming into contact with the goods transported until a major portion of the energy from the injected liquid at least is leveled out. Yet another major principle applied is to configure the ejector in such manner that the goods to be transported will be positioned as centrally as possibly within the cross section of the ejector. Another main principle relied upon is to remove liquid from a main flow through the system downstream one ejector and inject the removed liquid as injection liquid in the following ejector in the tandem ejector system, in order to secure increased suction without causing excessive vacuum and harm to the objects to be transported and maintaining constant liquid velocity through the system and constant or unaffected pipe diameter. Moreover, due to such configuration the downstream ejector and the liquid inertia will function as a non-return valve in the system.

The invention is based on the “ejector” principle, where a liquid is supplied through peripherally arranged nozzles into a main stream of liquid, the latter being the carrier of goods or bodies to be transported through the system. The ejector is in particular, but not exclusively, suited for transporting live fish stock from for example a cage to a well vessel or for transporting fish through several stations for example removal of lice.

The present invention is suitable for use as an ejector intended to form part of a system or a plant where it is required to transport objects from one position or level to another. The ejector is for example suitable for transporting fish from for example an aquaculture plant or cage to a vessel or from one cage to another.

It is an object of the present invention to provide a device for transporting fish or other living organisms by pumping, where the fish or other living organisms are transported in a main flow of water through a piping system without exposing the fish or other in a manner where the fish or the other types of living organisms are not exposed to too large suction or water jets with too high velocity, or to any substantial degree is exposed to obstacle or moving parts in the transporting system.

Another object of the present invention is to provide a transporting system wherein the fish or other living organisms are not exposed to detrimental or hazardous treatment affecting the fish health.

A further object of the invention is to prevent smaller bodies or fish from coming into the injected water or into the powered pumps.

Yet another object of the present invention is to provide a transporting system that may also be used for transporting other objects than fish or living organisms, without exposing the object of any rough or harsh impacts during transportation through the system.

A further object of the invention is to provide a nozzle where the goods to be transported are more or less completely protected from the effect of the fluid jets from the nozzles.

A further object of the present invention is to provide an ejector where the effect of the fluid entering through the nozzles of the ejector causes a minimum of effect on the goods to be transported in liquid through the system.

Another object of the invention is to provide an ejector where the nozzle openings are configured in such way that liquid ejected through the nozzle openings produces a suction upstream the ejector and where the goods to be transported are drawn into the piping arrangement and transported with an appropriate velocity.

Yet another object of the present invention is to provide an ejector where the objects to be transported are guided towards the centre of the ejector when passing through the ejector.

The objects are obtained by a system and a method as defined by the independent claims, while variants, alternatives and embodiments are defined by the dependent claim.

According to the invention, it is provide a system for transporting a goods in a main liquid, such as fish or other types of solid articles or materials, where a suction is made upstream by a suction producing device, and where the suction producing device causes the main liquid to flow at a velocity in a desired direction through the system, wherein the flow is produced by means of an ejector injecting a liquid into the main flow. The system comprises a first injector and a second injector

connected in series and with a liquid take out chamber arranged between an outlet of the first injector and the inlet of the second injector, the liquid to be injected in the second injector being drawn from the exit liquid leaving the first ejector.

According to one embodiment, liquid may be drawn from the outlet of the first ejector by a powered pump, the withdrawn water being delivered as injection liquid to the second ejector by the same pump.

The ejector may comprise a main tube or cylinder extending in longitudinal direction through the injector, with an inlet, through which the primary fluid flow is flowing, ejector chamber provided with one or more peripherally apertures or nozzles, and an outlet, the ejector chamber and apertures or nozzles being associated with a pump, supplying injection liquid to the injector chamber and through the nozzles into the primary flow, and a downstream chamber where the main fluid flow is mixed with the fluid from the injector, and wherein that the downstream chamber is configured in such way that injected fluid from the one or more nozzle aperture or opening to a large degree may be in the form of a directional determined flow, flowing out of the openings or aperture along the circumference of the downstream chamber at least until the difference in energy of the injected flow is more or less levelled out with that of the main flow.

According to an embodiment, a number of fins or ribs may be arranged on the inner circumferential surface of the downstream chamber, extending downstream in generally longitudinal direction of the downstream chamber.

Moreover, the ribs may extend upstream beyond the openings or apertures of the nozzle. The ends of the ribs may preferably extend upstream the openings or apertures of the nozzle have a decreasing height in upstream direction. Moreover, the upstream ends of the ribs extend into interior of the ejector chamber.

According to the present invention, the maximum height of the ribs may be in the range between 0.08 to 0.2 times the diameter of the diameter of the cylindrical part of the nozzle.

The part of the ribs arranged inside the ejector chamber and an outer and inner circumferential wall may form guides towards the nozzle openings or apertures for the supplied water to be injected.

According to an embodiment, the upper surface of the downstream end of the ribs may be skewed downwards towards the ejector end, forming an angle α in the range of 2 to 10 degrees.

According to the invention, the liquid take out unit comprises a duct or channel communicating seamless with the outlet of the first ejector and the inlet of the second ejector. The duct in the liquid take out unit may preferably, but not

necessarily comprise a number of parallel fins or plates arranged in spaced relation around at least a part of the circumference of the main duct or channel and extending in the direction of the general direction of flow, the ducts being in fluid communication with a surrounding annulus, the annulus being in fluid communication with the inlet to the pump, delivering liquid to the second ejector. Alternatively the duct may configured in such way that parts of the liquid in the main flow may be extracted, said goods, objects or particles are prevented from entering the annulus, such particles or objects following the main flow through the liquid take out unit and into the downstream, second ejector.

The fines may as an variant be configured to extend around the entire periphery of the a duct, and the distance between two adjacent fins are chosen such that water is allowed to flow between the fins, while the particles transported by the main flow is prevented from entering the surrounding annulus or chamber.

According to the invention a method for transporting goods from one station to another using a liquid as a transport agent is provided, using an ejector as a driving means for creating a suction upstream of the ejector inlet, wherein an injected liquid flow is injected into a main flow carrying a goods, by forcing liquid through nozzle outlets or apertures. The system uses more than one ejector arranged in series and where liquid to be delivered as injection liquid to a second ejector is drawn from liquid flow leaving an upstream ejector. According to one embodiment a liquid may be withdrawn by means of a liquid take out unit connected to a pump delivering pressurized liquid to nozzles in the second ejector. Moreover, the pump used for delivering injection liquid to the second ejector may preferably be the same as used for drawing liquid from the main flow in a suction unit.

A part of the liquid is drawn out of the main flow, while the goods still follow the general direction of flow and the suction in the suction unit established may be created by a pump and that the same pump re-delivers the liquid to the downstream second ejector as injection liquid.

By re-using the liquid from the main flow through the first ejector as the injection liquid in the second ejector arranged downstream of the first ejector, the water velocity through the second ejector is reduced, making it possible to reduce of dimensions of the piping arrangement and also reducing the energy loss caused by friction and less volumes of liquid to filter.

It should also be noted that because of the suction unit and the removal of part of the liquid from the main flow downstream the ejector outlet, the lifting height of the system is enhanced.

By using such tandem ejector arrangement with an intermediate liquid take out unit according to the present invention, the following advantages may be obtained:

- The second ejector and the liquid inertia will function as a non-return valve, securing a flow in the intended direction and avoiding the liquid to flow in the reversed direction.
- Reduction of the total flow of liquid downstream the first ejector makes it possible to maintain constant velocity and uniform pipe diameter in the system.
- Reduction of the total flow of liquid reduces the pipe friction of the process.
- Reduction of the total volume of liquid reduces the total volume that need to be filtrated in case filtration is required or deemed necessary.
- Use of two or more ejectors in series improves the produced suction without causing harm to the transported goods. In fact the enhanced suction is more than the additive effect of twice the size and effect of suction from on ejector.

By using the disclosed fin configuration the flow of injected liquid will remain between the fins inside the ejector until the energy is levelled out with that in the main flow, preventing the objects to be transported to be affected by such higher fluid velocity. In addition the suction is maintained at a level which will not cause detrimental harm to the objects to be transported.

The configuration of the fins and the intermediate slots in the liquid take out unit are such that particles or goods associated with the main flow are prevented from being sucked into the withdrawn liquid flow.

The system is designed and configured in such way that the possibilities for detrimental interference between the pumped fish and interior surfaces of the main flow duct or channel through the system eliminate the risk of causing damage to or harming the fish and its fins or tail.

*Brief Description of the Drawings*

The accompanying drawings, which are incorporated in and constitute a part of the specification, illustrate one or more embodiments and, together with the description, explain these embodiments. In the drawings:

Figure 1 shows schematically a view seen in perspective of an ejector according to the present invention;

Figures 2a to 2c show three different views of the ejector disclosed in Figure 1, where Figure 2a shows one side view of the ejector disclosed in Figure 1, Figure 2 b shows another side vie of the ejector, while Figure 2 c shows an end view of the ejector showing the upstream end of the ejector;

Figure 3 shows schematically a vertical section through the ejector shown in Figure 1, seen along the line A-A, showing the position of the nozzles;

Figure 4 shows a cross section of the ejector, seen along the line B-B in Figure 2a;

Figure 5 shows schematically in an enlarge scale details within the circle C in Figure 3, showing an outlet from a nozzle, marked with C in Figure 3;

Figure 6 shows schematically in an enlarge scale details within the circle D in Figure 3, showing the bolt connection for fixing the ejector to the supply line for the main flow line;

Figure 7 shows schematically and in perspective a view of a rib according to one embodiment of the invention;

Figure 8 shows schematically a view of the rib shown in Figure 7, seen from above;

Figure 9 shows a side view of the rib shown in Figure 7, seen from a side; and

Figure 10 shows schematically a section through the rib shown in Figure 7, seen along the line C –C;

Figure 11 shows schematically a view of a system with two ejectors arranged in tandem with a an intermediate suction unit; drawn water from the outlet of the first ejector and supplying the water drawn to a downstream second ejector; and

Figures 12a to 12d showing details related to the intermediate suction unit.

*Detailed Description of Embodiments disclosed in the Figures'*

The following description of the exemplary embodiments refers to the accompanying drawings. The same reference numbers in different drawings identify the same or similar elements. The following detailed description does not limit the invention. Instead, the scope of the invention is defined by the appended claims. The following embodiments are discussed, for simplicity, with regard to an ejector for pumping fish carried by a main water flow, where a suction is created upstream of the inlet if the ejector and where pressurized water is ejected through a plurality of nozzles into the main flow. The embodiments to be discussed next are, however, not limited to pumping fish, but may used for transporting any goods or material using a liquid as a transporting means, whether such goods are fragile or requiring careful handling or not. It should also be noted that the transporting medium may be any liquid suitable for such transport.

Reference throughout the specification to “one embodiment” or “an embodiment” means that a particular feature, structure, or characteristic described in connection with an embodiment is included in at least one embodiment of the subject

matter disclosed. Thus, the appearance of the phrases “in one embodiment” or “in an embodiment” in various places throughout the specification is not necessarily referring to the same embodiment. Further, the particular features, structures, or characteristics may be combined in any suitable manner in one or more embodiments.

In the description below, the invention is described in connection with transport of fish through a conveying system. It should be appreciated, however, that the invention is not limited to transportation of live fish. The ejector is also suitable for conveying other types of goods, such as food, agricultural products, solid particles or particulate material, etc.

Figure 1 and Figures 2a to 2c show different views of the ejector disclosed in Figure 1, where Figure 1 shows the ejector 10 in perspective, Figure 2a shows one side view of the ejector disclosed in Figure 1, Figure 2 b shows another side view of the ejector, while Figure 2 c shows an end view of the ejector, showing the upstream end of the ejector.

The ejector 10 comprises a first cylindrical tube 11, a first conical part 12, a second conical part 13, and a second, elongate, cylindrical tube 14. The end of the second cylindrical tube 14 is terminated with a third conical part 15. The first tube 11, the two conical parts 12,13, and the second cylindrical tube 14 are hollow and concentrically arranged, forming an internal hollow flow chamber. The diameter of the first cylindrical tube 11 is larger than the diameter of the second cylindrical tube 14. At the free end of the first cylindrical part 14, the ejector 10 is provided with an end plate 15 and bolts 17 for attachment to a main tube (not shown). At the opposite end, the ejector 20 is provided with a slip-on flange for collar 18, a plate 19 and an O-ring 20. The slip-on ring 18 is provided with a number of holes around the circumference of the ring in order to enable connection with a downstream tube (not shown).

At the inlet end of the ejector, i.e. at the first cylindrical tube 11, the ejector 10 is provided with a 90 degrees long radius hollow elbow 21, the free end of which being provided with a slip-on flange 22, provided with holes around the circumference for attachment to a pump or the like (not shown).

Figure 3 shows schematically a vertical section through the ejector 10 shown in Figure 1, seen along the line A-A in Figure 2b. As indicated the ejector 10 is provided with a cylindrically shaped opening extending through the entire length of the ejector 10. An inner cylindrically shaped tube or sleeve 24 is provided in the region of the first cylindrical part 11 having larger diameter and extending through the first conical part 12 and partly into the second conical part 13. The inner tube 24

has a diameter which generally is the same as the diameter of the second cylindrical part 14 and preferably being aligned with the second elongate cylindrical part 14, forming an inlet annulus at the inlet end of the ejector 10. Said inlet annulus 25 is in fluid communication with the long radius elbow 22. One end of the tube 24 is fixed to an end plate 16, while at the other end of the tube 24 is terminated in the middle region of the second conical part, forming opening into the second cylindrical part 14, allowing the annulus to be in fluid communication with the second cylindrical tube 14 Moreover, as indicated in Figure 3, a number of elongate ribs 23 is arranged inside the ejector, the ribs 23 being arranged axially and longitudinally and in parallel and spaced relation, evenly distributed around the entire internal periphery of the cylindrical opening, projecting radially into the longitudinal opening of the ejector 10. One end of the ribs extends into the annulus 25, past the nozzle openings 26, while the other ends of the ribs are terminated in the region of the third conical part 15. In this way, the ribs 23, the end region of the tube 24 and the inner surface of the first and second conical parts 12,13 will form the nozzles 26, the outlet of which thus being a number of separate openings arranged between each of the ribs 23, evenly distributed around the circumference of the inner surface of the ejector 10. One embodiment of the ribs 23 is described below, referring to Figures 7 to 10.

It should be noted that the cross section area of the annulus 25 decreases in direction towards the nozzle outlet 25 due to the conically shaped inner surface of the first and second conical part 12,13, the referenced annulus part with decreasing area being formed into separate ducts because of the ribs extending through the tube 24 and into the annulus 24 below. In this manner, a separate duct or channel for each nozzle opening is provided, the cross section area of which decreases in direction towards the nozzle outlet 26. The nozzles 26 or fluid outlets 26 from the annulus into the elongate cylindrical are arranged evenly distributed around the circumference of the inner surface of the ejector 10.

Figure 4 shows a cross sectional view of the ejector 10, seen along the line B–B in Figure 2a, while Figure 5 shows schematically in an enlarge scale details within the circle C in Figure 3, showing an outlet from a nozzle, marked with C in Figure 3. The cross sectional shape of the ducts 27 leading towards the nozzle outlet 26 is indicated in Figure 4. As shown the ribs are radially oriented and the cross sectional are of the ducts 27 being sector shaped, having two curved concentrically surfaces, spaced apart and two radially plane surfaces spaced apart. The duct area shown is seen along the line B–B in Figure 2a. Towards the nozzle outlets 26, this area decreases in that the height of the duct decreases towards the nozzle outlet 26. Moreover, as indicated in Figure 4, the ribs extend radially inwards from the inner

surface of the first and second conical parts 23,13, through the cylindrically shaped tube 24 and partly into the cylindrically shaped flow path through the ejector 10. As shown in further detail in Figure 3, the height of the ribs projecting inwards into the flow path of the ejector 10, increases from its inner end, i.e. the end inside the first cylindrical part 11 towards the region for the nozzle outlet 26, whereupon the height is constant until the outlet end of the ejector where the height decreases gradually and is terminated in the region of the third conical part 15.

Figure 6 shows schematically in an enlarge scale details within the circle D in Figure 3, showing the bolt connection 17 for fixing the ejector 10 to the supply line (not shown) for the main flow through the ejector 10.

Figure 7 shows schematically and in perspective a view of a rib 23 according to one embodiment of the invention, while Figure 8 shows schematically a view of the rib shown in Figure 7, seen from above. As indicated in the Figure and also in Figure 9, showing a side view of the rib shown in Figure 7, the rib 23 is provided with a slot 28 intended to be threaded onto and fixed to the annulus forming cylinder 24. As further indicated the upper surface of the rib 23 is given a rounded shape, while at each end the height decreases in direction towards each end, forming a sloped surface. In this way, maintenance of a linear flow is enhanced.

On the part of the rib 23, configured to be positioned below the cylinder or tube 24 forming the inner surface of the annulus, the rib is provided with a wing shaped body 29, the front part being rounded and the height decreasing towards the middle region of the second conical part 13. The lower edge of this portion the wing 29 is given a shape in longitudinal direction that corresponds with the inner surface of the first and second conical part 12,13, decreasing in vertical height towards the linear part of the second cylindrical part 14. At the opposite end of the rib 23, i.e. the end intended to be downstream, the upper surface of the rib 23 is inclined downwards towards it tip, the angle α between the skewed surface and the straight portion of the rib being in the order of 4 to 10 degrees.

Figure 10 shows schematically a section through the rib shown in Figure 7, seen along the line C –C.

Figure 11 shows schematically a view of a system with two ejectors 10,10' arranged in tandem with a an intermediate suction unit 40; drawing liquid from the outlet of the first ejector 10 and supplying the same liquid as injection liquid to the second ejector 10'. It should be noted that both ejectors 10,10' are of a type as described in connection with the Figures 1 to 10. As indicated in Figure 11, both ejectors 10,10' are associated with a motor 30,30' driving a pump 31 delivering liquid through the long-radius elbow to the annulus 25 and further out through the

apertures of the nozzles 26. The pumps 31,31' may be of any suitable type, delivering the required volumes of liquid at the required pressure. Liquid to the upstream pump 31 and ejector 10 is supplied from a liquid source (not shown).

A suction unit 40 is arranged downstream of the first ejector 10 and upstream of the second ejector. 10'. The suction unit 40 draws liquid from the exit stream from the first ejector 10 and delivers the same liquid to the second ejector 10' at its upstream end. Liquid is drawn from the downstream flow by means of the pump 31' associated with and driven by the associated motor 30' and delivers the same liquid by the same pump 31' to said upstream end of the second ejector.

Details of the suction unit shall be described below, referring to Figures 12a to 12d. Figure 12a shows schematically a side view of the liquid take out unit 40, showing the inlet A and the outlet B, while Figure 12b shows schematically an end view from the inlet side A. Figure 12c shows schematically a vertical section in longitudinal direction through the liquid take out unit 40, while Figure 12 d shows a vertical end section through the liquid take out unit 40. Figure 12e shows schematically in perspective the liquid take out unit 40 with the housing removed.

The liquid take out unit 40 comprises a cylindrical housing 41, provided with an exit pipe 42, connected to the inlet side of the pump 31 delivering pressurized liquid to of a downstream ejector 10'. The liquid take out unit 40 is at each end provided with devices including flanges for sealing attachment to the outlet of the upstream ejector 10 and the inlet of the downstream ejector 10'. A number of laterally extending curved plates 43 is used for interconnecting the two endplates of the housing. Said curved plates function also as flow stoppers, preventing the main flow to change flow direction. These are concentrically arranged inside the housing 41, forming an annulus 44, within which a frame supporting a number of ribs or fins 45 are arranged, the inner volume formed by the fins or ribs 45 being in fluid communication with the exit opening of the first ejector and with the inlet of the second ejector 10', the passage through the first ejector, the passage formed by the ribs in the suction unit and the passage for the main flow through the second ejector 10' forming a flow path for liquid and objects through the tandem system. Said passages are aligned without any obstacles projecting into the flow path that may prevent free flow through the tandem system. The ribs or fins 45 are arranged parallel and in spaced relation allowing liquid to flow radially out and into the annulus 44 and further to the inlet for the pump 31 through the outlet 42. A long radius elbow 46 connects the outlet from the suction unit 40 with the inlet to the pump 31'. The distances between two neighbouring fins 45 are chosen so as to prevent smaller particles or objects following the main flow from entering into the surrounding

annulus 44. Such particles, goods, or bodies may for example be fish removing lice from salmon, such as for example wrasses.

In the following, the functioning of the ejector will be described. The ejector 10, when in operation, is configured to work as a pump causing a sub-pressure at one end, drawing water and fish from for example a cage for delivery for example to a well vessel or the like. One end of the ejector – the upstream end, i.e. the end being encompassing the first cylindrical hollow tube, is connected to a pipe or a hose (not shown) communicating with for example a cage, for pumping water and fish. At the opposite end – the downstream end, the ejector may be connected to a pipe or hose (not shown) for transporting the water and fish to a delivery station, such as for example a well. In order to provide the suction and the required energy for transporting the water and the fish through the system, the free end of the long-radius bend is connected to a pump for delivering water at a required pressure and rate into the annulus provided the first cylindrical tube, surrounding the internal sleeve or tube. The water in the annulus is forced out through the opening or apertures forming the nozzles, guided by the ribs, flowing along the cross sectional volume between adjacent ribs. The height, length and shape of the ribs are configured so as to prevent the injected water to hit the ribs and change direction due to an undesired collision with a rib. In such manner secure a controlled mixing with the water in the main flow is achieved and the difference between water velocity of the injected water and that of the main flow through the system being eliminated, or at least substantially reduced.

When leaving the nozzle aperture or opening the injected water is guided along the downstream pipe along the outer part of the cross section. The energy from the injected water is mixed in a controlled manner into the main flow to avoid any local high velocities in the main flow. The impulse is distributed over a long section of the downstream pipe. The injected water with high velocity is causing areas with vacuum (low absolute pressure). (Pressure is sometimes referred to as the sum of velocity and static height and absolute pressure). The rib geometry is efficiently protecting the transported object sensitive to vacuum by guiding the object away from the low pressure areas towards the centre of the ejector. The local velocities and vacuum areas are decreasing in the direction of the ejector outlet.

When the liquid leaves the first ejector 10, the liquid enters the suction unit 40 where at least a part of the liquid is sucked out of the housing through the ribs or fins 45 into the pump 31' and is then delivered back into the second ejector 10' as injection water. The goods transported leaving the main flow path of the first ejector

10 and is moved through the flow path in the suction unit 40 and further into the flow path of the second ejector 10'.

The openings or apertures of the nozzle are arranged along the periphery of the cross section and may be in the form of circular, oval or semi-circular shape or may be in the form of one or more slot.

Claims

1. System for transporting goods in a main liquid, such as fish or other types of solid articles or materials, where a suction is made upstream by a suction producing device (10), and where the suction producing device (10) causes the main liquid to flow at a velocity in a desired direction through the system, wherein the flow is produced by means of an ejector (10,10') injecting a liquid into the main flow, *characterized in that* the system comprises a first ejector (10) and a second ejector (10') connected in series and with a liquid take out chamber (40) arranged between an outlet of the first ejector (10) and the inlet of the second ejector (10'), the liquid to be injected in the second ejector (10') being drawn from the exit liquid from the first ejector (10).

2. System according to claim 1, wherein liquid is drawn from the outlet of the first ejector (10) by a powered pump (31'), the withdrawn liquid being delivered as injection liquid to the second ejector (10') by the same pump (31').

3. System according to claim 1 or 2, wherein each of the first and second ejector (10,10') comprises a main tube or cylinder with an inlet, through which the main liquid flow is flowing,

- ejector chamber provided with one or more peripherally apertures or nozzles (26), and an outlet,
- the ejector chamber and apertures or nozzles being associated with a pump (31,31'),
- supplying injection liquid to the ejector chamber and through the apertures or nozzles (26) into the main flow, and
- a downstream chamber where the main liquid flow is mixed with the liquid from the ejector, and wherein the downstream chamber is configured in such way that injected liquid from the one or more apertures or nozzles (26) to a large degree may be in the form of a directional determined flow,
- flowing out of the one or more apertures or nozzles (26) along the circumference of the downstream chamber at least until the difference in energy of the injected flow is more or less levelled out with that of the main flow.

4. System according to claim 3, wherein a number of fins or ribs (23) are arranged on the inner circumferential surface of the downstream chamber, extending downstream in generally longitudinal direction of the downstream chamber.

5. System according to claim 4, wherein the ribs (23) extend upstream beyond the openings or apertures of the nozzle (26).

6. System according to claim 5 wherein the ends of the ribs (23) extending upstream the one or more apertures or nozzles (26) have a decreasing height in upstream direction.

7. System according to anyone of the claims 3 to 6, wherein the upstream ends of the ribs (23) extend into interior of the ejector chamber.

8. System according to 7, wherein the part of the ribs (23) arranged inside the ejector chamber and an outer and inner circumferential wall form guides towards the one or more apertures or nozzles (26) for the supplied liquid to be injected.

9. System according to anyone of the claims 4 to 8, wherein the upper surface of the downstream end of the ribs (23) are skewed downwards towards the ejector end, forming an angle α in the range of 2 to 10 degrees.

10. System according to anyone of the claims 1 to 9, wherein the liquid take out chamber (40) comprises a duct or channel communicating seamless with the outlet of the first ejector (10) and the inlet of the second ejector (10').

11. System according to claim 10, wherein the duct in the liquid take out chamber (40) comprises a number of parallel fins or plates (45) arranged in spaced relation and extending in the direction of the general direction of flow, the ducts being in liquid communication with a surrounding annulus (44), the annulus (44) being in liquid communication with the inlet to the pump (31'), delivering liquid to the second ejector (10').

12. System according to claim 11, wherein the fins (45) are configured to extend around the entire periphery of the duct, and the distance between two adjacent fins (45) being chosen such that liquid is allowed to flow between the fins, while the

particles transported in the main flow is prevented from entering the surrounding chamber.

13. Method for transporting goods from one station to another using a liquid as a transporting agent, using an ejector as a driving means for creating a suction upstream of the ejector inlet, wherein an injected liquid flow is injected into a main flow carrying goods, by forcing liquid through one or more apertures or nozzles (26), c h a r a c t e r i z e d in that the system uses more than one ejectors (10,10') arranged in series and where liquid to be delivered as injection liquid to a consecutive ejector (10') is drawn from the liquid flow leaving the upstream ejector (10).

14. Method according to claim 13, wherein a liquid is withdrawn by means of a liquid take out chamber (40) by means of a pump delivering pressurized liquid to one or more apertures or nozzles (26) in the consecutive ejector.

15. Method according to claim 13 or 14, wherein the pump used for delivering injection liquid to the second ejector is the same as used for drawing liquid from the main flow in a suction unit.

16. Method according to anyone of the claims 13-15, wherein part of the liquid is drawn out of the main flow, while the goods still follow the general direction of flow.

17. Method according to claim 13, where the suction in the suction unit is created by a pump and that the same pump re-delivers the liquid to the downstream ejector as injection liquid.

# PATENTKRAV

1. System for transportering av gods i en hovedvæske, slik som fisk eller andre typer faste artikler eller materialer, hvor et sug er dannet oppstrøms av en sug-produserende anordning (10), og hvor den sug-produserende anordningen (10) forårsaker at hovedvæsken strømmer med en hastighet i en ønsket retning gjennom systemet, hvor strømmen er produsert ved hjelp av en ejektor (10,10') som injiserer en væske inn i hovedstrømmen, **karakterisert ved at** systemet omfatter en første ejektor (10) og en andre ejektor (10') forbundet i serie og med et væskeuttakskammer (40) anordnet mellom et utløp fra den første ejektoren (10) og innløpet til den andre ejektoren (10'), der væsken som skal injiseres i den andre ejektoren (10´) trekkes ut fra utgangsvæsken fra den første ejektoren (10).

2. System i samsvar med krav 1, hvor væsken er trukket fra utløpet til den første ejektoren (10) av en strømsatt pumpe (31'), der den uttrukne væsken blir levert som injeksjonsvæske til den andre ejektoren (10´) av den samme pumpen (31').

3. System i samsvar med krav 1 eller 2, hvor hver av den første og andre ejektoren (10,10') omfatter et hovedrør eller sylinder med et innløp, gjennom hvilket hovedvæskestrømmen strømmer,

- ejektorkammer utstyrt med en eller flere periferiske spalter eller dyser (26), og et utløp,
- ejektorkammeret og spaltene eller dysene forbindes med en pumpe (31,31'),
- tilføring av injeksjonsvæske til ejektorkammeret og gjennom spaltene eller dysene (26) inn i hovedtrømmen, og
- et nedstrømskammer hvor hovedvæskestrømmen blandes med væsken fra ejektoren, og hvor
- nedstrømskammeret er konfigurert på en slik måte at injisert væske fra den ene eller flere spalter eller dyser (26) i stor grad kan være i form av en retningsbestemt strøm, som strømmer ut av den ene eller flere spaltene eller dysene (26) langs omkretsen av nedstrømskammeret i det minste til forskjellen i energi til den injiserte strømmen er mer eller mindre utjevnet med den i hovedstrømmen.

4. System i samsvar med krav 3, hvor et antall finner eller ribber (23) er anordnet på den indre periferiske overflaten av nedstrømskammeret, som strekker seg nedstrøms i generelt langsgående retning av nedstrømskammeret.

5. System i samsvar med krav 4, hvor ribbene (23) strekker seg oppstrøms utover åpningene eller spaltene til dysen (26).

6. System i samsvar med krav 5, hvor endene til ribbene (23) strekker seg oppstrøms den ene eller flere spaltene eller dysene (26) som har en avtakende høyde i oppstrømsretningen.

7. System i samsvar med ethvert av kravene 3 til 6, hvor oppstrømsendene til ribbene (23) strekker seg inn i det indre av ejektorkammeret.

8. System i samsvar med krav 7, hvor delen av ribbene (23) anordnet innvendig av ejektorkammeret og en ytre og indre periferisk vegg som danner føringer mot den ene eller flere spaltene eller dysene (26) for injisering av den tilførte væsken.

9. System i samsvar med ett av kravene 4 til 8, hvor den øvre overflaten av nedstrømsenden til ribbene (23) skråner nedstrøms mot ejektorenden, som former en vinkel α i området 2 til 10 grader.

10. System i samsvar med ett av kravene 1 til 9, hvor væskeuttakskammeret (40) omfatter et rør eller en kanal som kommuniserer sømløst med utløpet til den første ejektoren (10) og innløpet til den andre ejektoren (10').

11. System i samsvar med krav 10, hvor røret i væskeuttakskammeret (40) omfatter et antall parallelle finner eller plater (45) anordnet i et avstandsforhold og strekker seg i retningen av den generelle strømningsretningen, idet rørene er i væskekommunikasjon med en omliggende annulus (44), hvor annulusen (44) er i væskekommunikasjon med innløpet til pumpen (31'), som leverer væske til den andre ejektoren (10').

12. System i samsvar med krav 11, hvor finnene (45) er konfigurert til å strekke seg rundt hele periferien av røret, og avstanden mellom to tilstøtende finner (45) blir valgt slik at væske får adgang til å strømme mellom finnene, mens partiklene som transporteres i hovedstrømmen er forhindret fra å entre det omliggende kammeret.

13. Metode for å transportere gods fra en stasjon til en annen ved å bruke en væske som en transportagent, bruke en ejektor som et drivmiddel for å skape et sug oppstrøms av ejektorinnløpet, hvor en injisert væskestrøm er injisert inn i en hovedstrøm som bærer gods, ved å tvinge væske gjennom en eller flere spalter eller dyser (26),
**karakterisert ved at** systemet bruker mer enn en ejektor (10,10') anordnet i serie og hvor væske som skal leveres som injeksjonsvæske til en etterfølgende ejektor (10') er trukket ut fra væskestrøm som forlater en oppstrøms ejektor (10).

14. Metode ifølge krav 13, hvor en væske er trukket ut med hjelp av en væskeuttaksenhet med hjelp av en pumpe som leverer trykksatt væske til en eller flere spalter eller dyser (26) i den etterfølgende ejektoren.

15. Metode ifølge krav 13 eller 14, hvor pumpen som er brukt for å levere injeksjonsvæske til den andre ejektoren er den samme som er brukt for å trekke ut væske fra hovedstrømmen i en sug-enhet.

16. Metode ifølge ethvert av kravene 13-15, hvor deler av væsken er trukket ut fra hovedstrømmen, mens godset fortsatt følger den generelle strømretningen.

17. Metode ifølge krav 13, hvor suget i sug-enheten er laget av en pumpe og at den samme pumpen tilbakeleverer væsken til nedstrøms ejektoren som injeksjonsvæske.

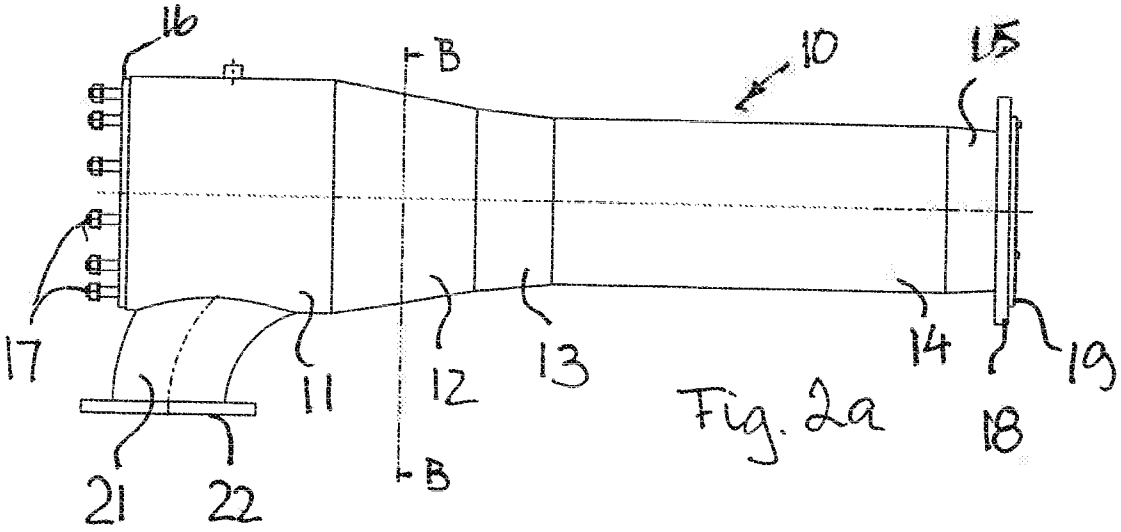



Fig. 2a

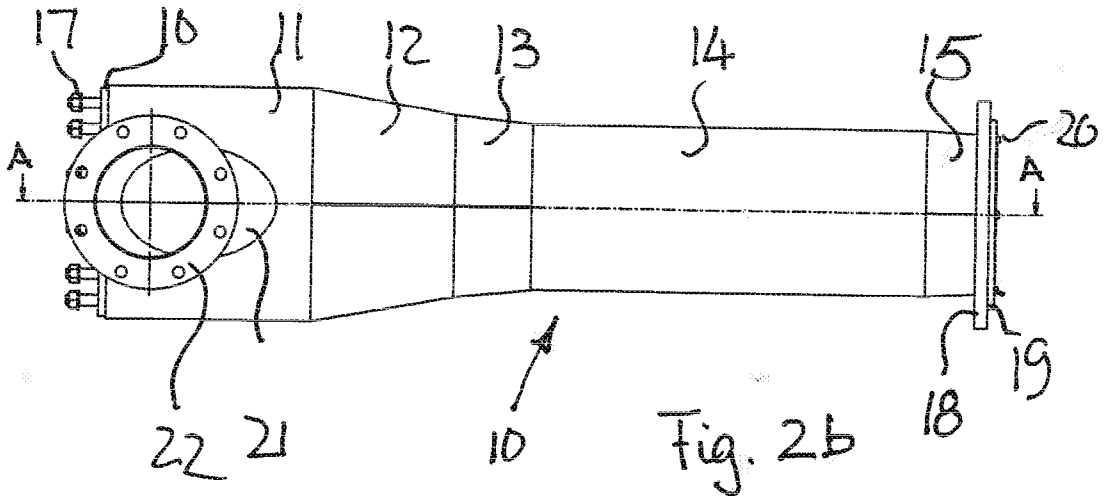



Fig. 2b

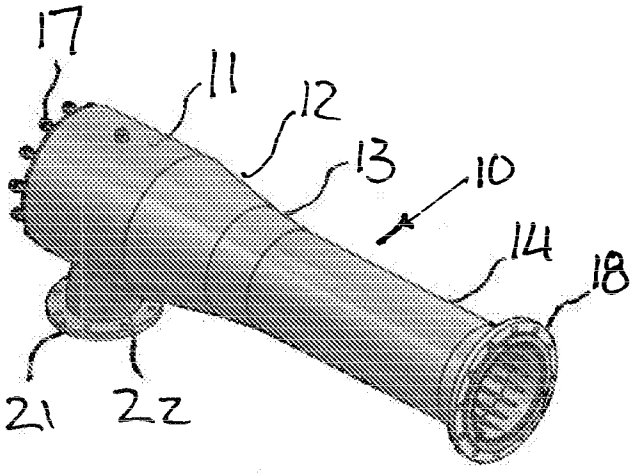



Fig. 1

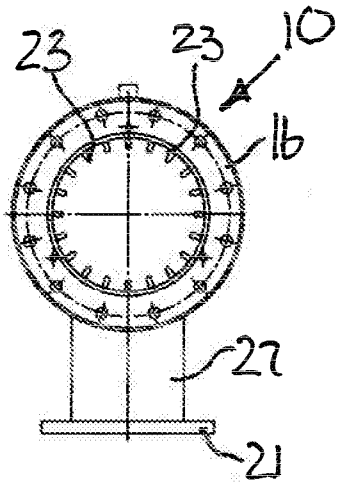



Fig. 2c

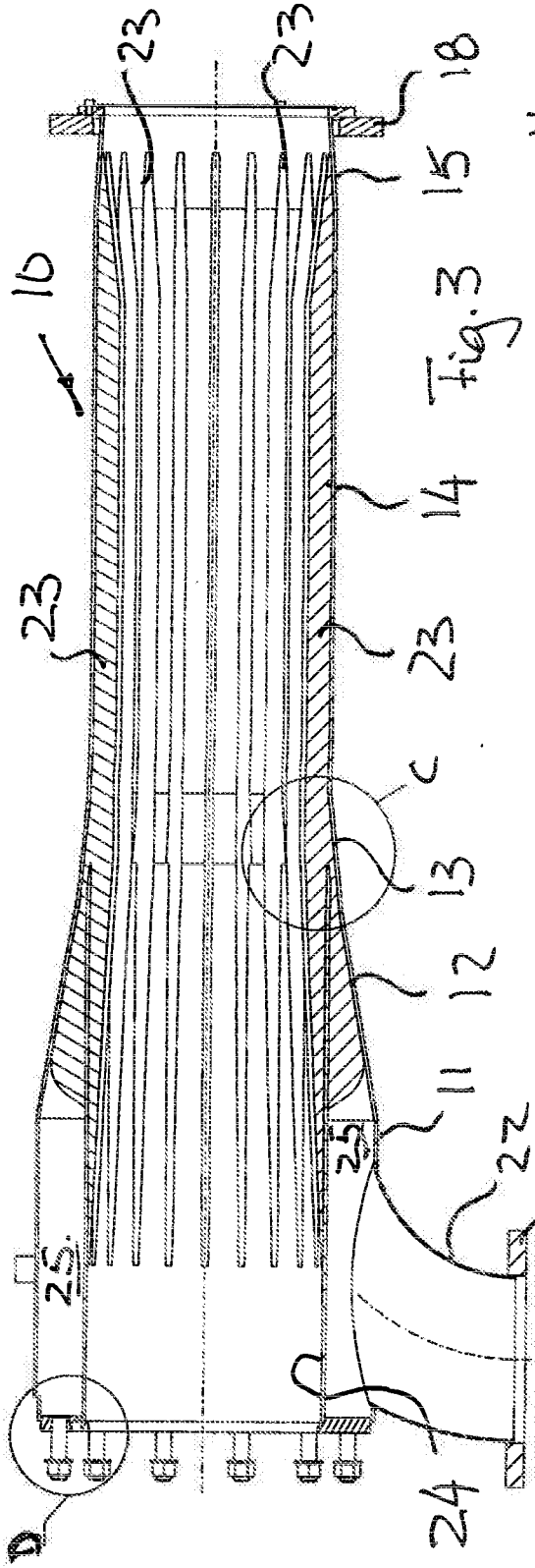



Fig. 3

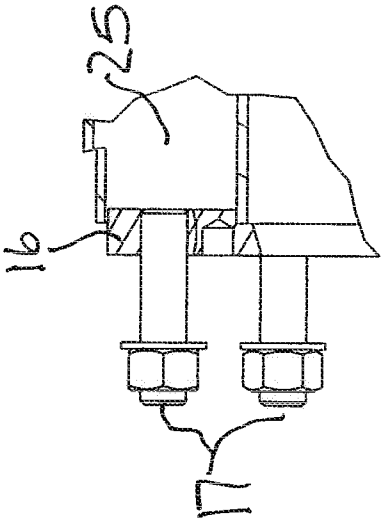



Fig. 6

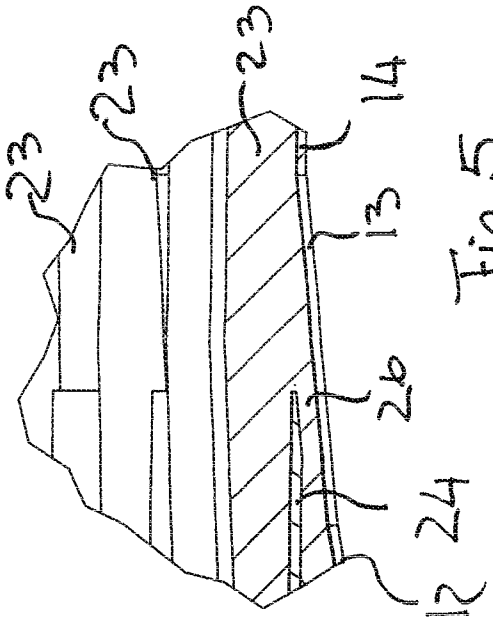



Fig. 5

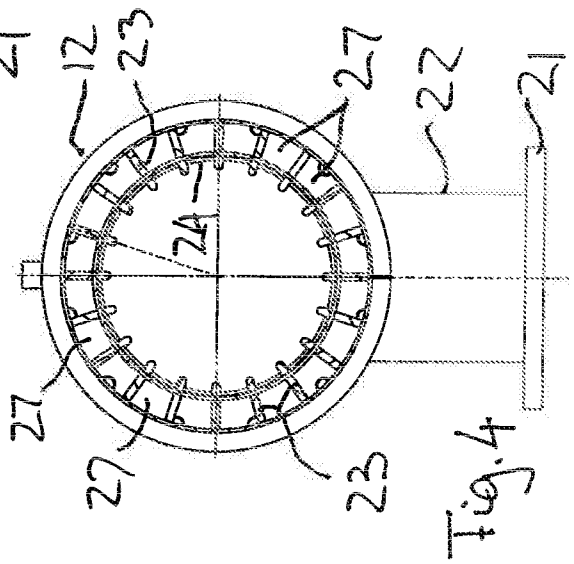



Fig. 4

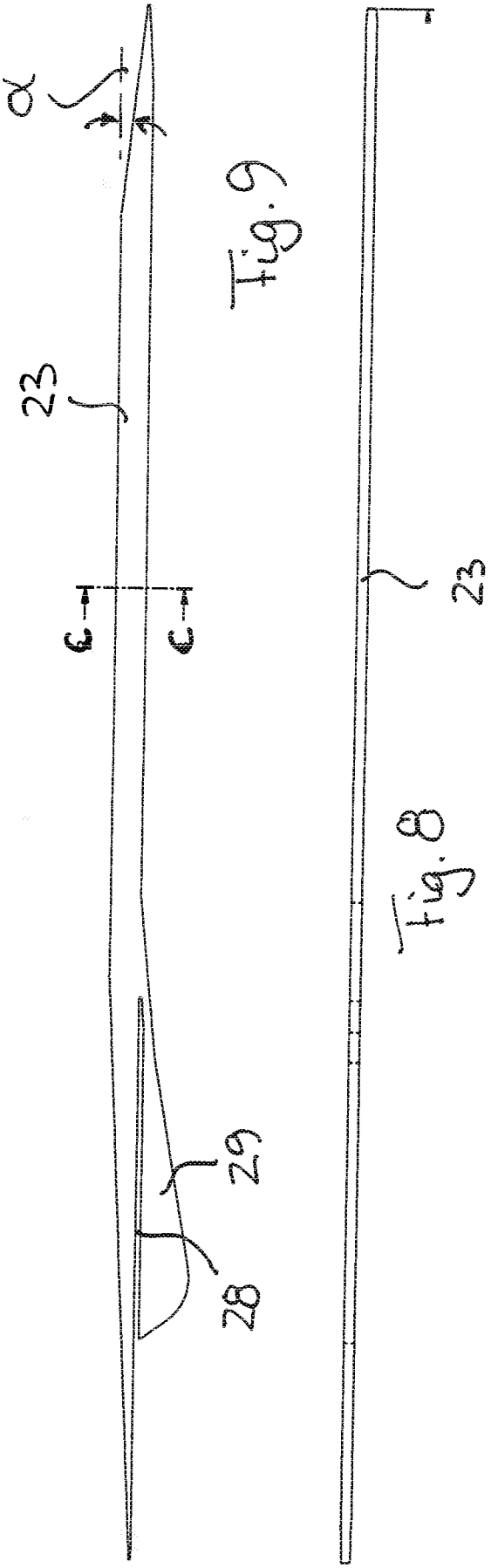



Fig. 9




Fig. 8


Fig. 10

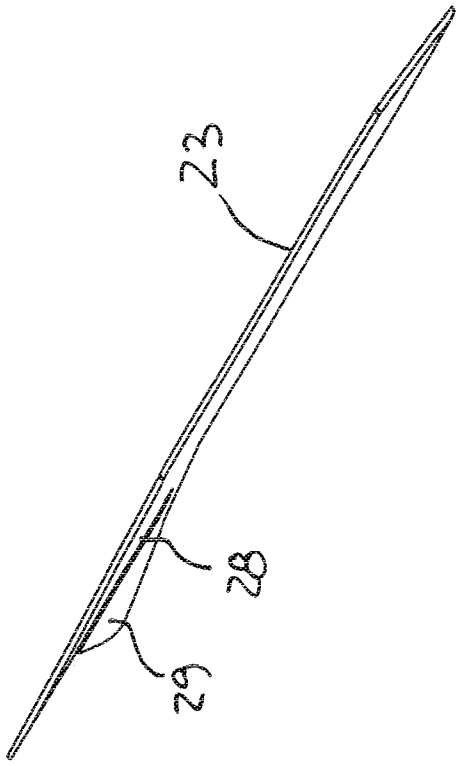



Fig. 7

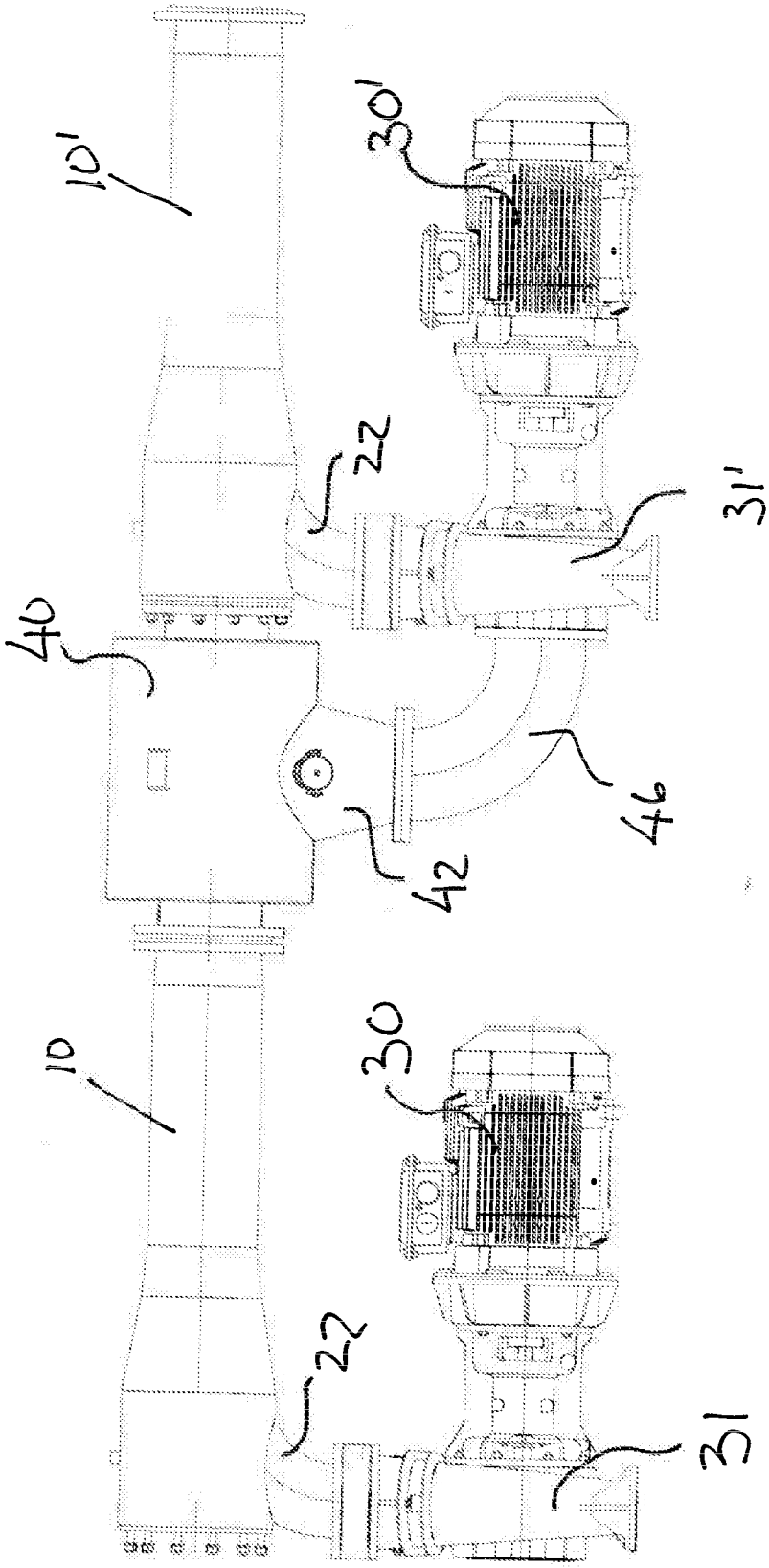



Fig. 11

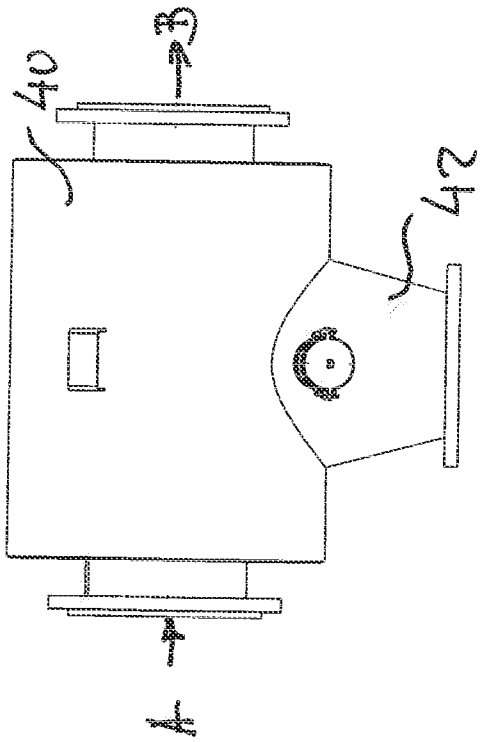



Fig. 12a

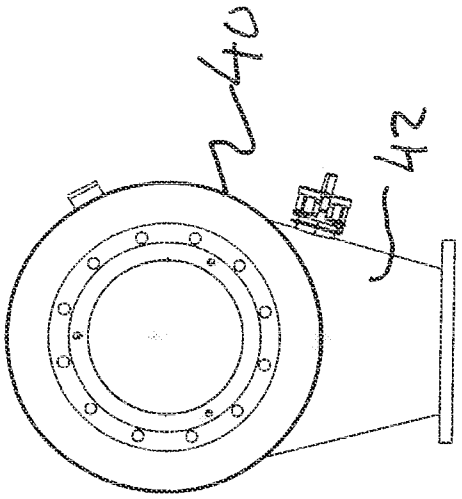



Fig. 12b

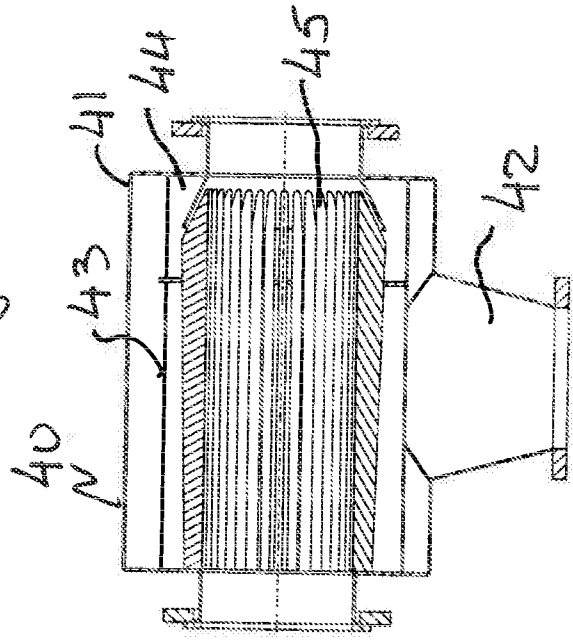



Fig. 12c

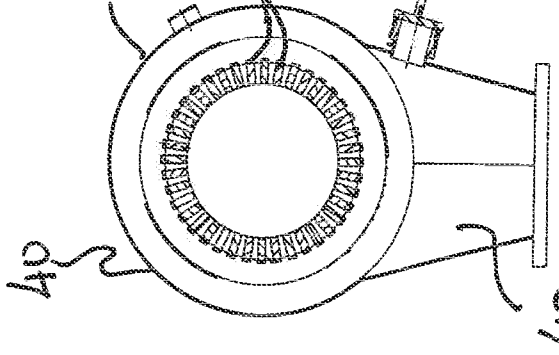



Fig. 12d

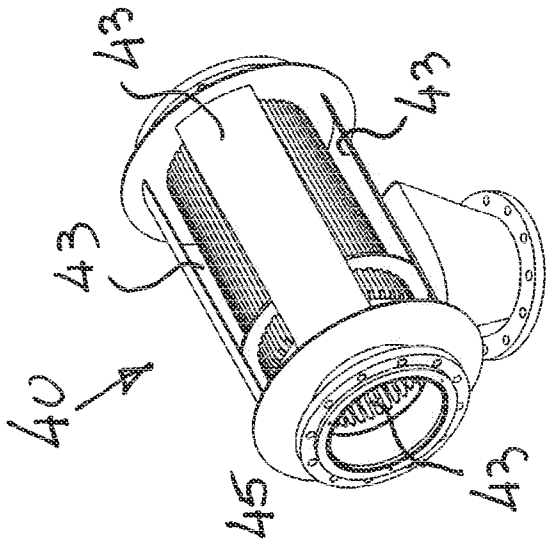



Fig. 12e