

DECLARATION

In the matter of PCT Application No. PCT/CH97/00152 in the name of Lindenport SA.

I, Christoph Brogle, residing at Seestrasse 3, 8002 Zurich, Switzerland, do hereby declare that I am conversant with the English and German languages and am a competent translator thereof. I declare further that the following is a true and correct translation made by me into English of the German document attached hereto and related to PCT Application No. PCT/CH97/00152 in the name of Lindenport SA.

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METHOD AND DEVICE FOR LIQUEFACTION OF SEDIMENTS OF THICKENED CRUDE OIL

The invention concerns a method according to the generic part of the first independent method claim as well as a device for carrying out the method. Method and device serve for recovering crude oil bound in thickened crude oil or its sludgy to compact sediments in vessels in which crude oil is stored
5 and/or transported.

Crude oil hauled from the ground in crude oil production is first stored without further treatment in storage vessels, i.e. in crude oil tanks of large
10 volume and is held ready for distribution. The storage times of the oil in this kind of vessels is mostly sufficiently long for considerable sedimentation to occur, especially under extreme climatic conditions. Hereby, the sedimentation speed and the composition of the sediments usually differ according to the origin of the oil. If such vessels are emptied and refilled several times without
15 removing the sediments, a layer of sediments of a thickness of 1.5 m or more can be formed. The quantity of crude oil contained in this kind of sediment layer is considerable because this layer consists to a large extent of thickened oil and higher molecular substances such as e.g. asphalt, paraffins or waxes. The sediments can, however also be formed from lighter components of crude
20 oil by means of thickening under the influence of heat. The sediments often



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have a jelly-like consistency and are nothing else than a heavy fraction of crude oil, the components of which are very mixable with crude oil or lighter components of crude oil or are soluble in these. The sediments, however, also contain foreign matter in form of e.g. stones or pieces of metal, mostly rust.

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For a long time, the sediments in crude oil containers as described above have been unwanted material which still today is removed in periodic cleaning processes from the vessels with corresponding cleaning media, mostly aqueous solutions of detergents, is deposited of in more or less sensible manner or is destroyed. In the patent publication EP-160805, a method has been described with which this kind of sediment in crude oil containers or similar storage or transport vessels can be brought into a recyclable form. For this purpose, crude oil is injected into the sediment by means of rotating heads with nozzles which heads are introduced into the sediment. Thus, over a large area the sediment is swirled round and distributed in the liquid, is made to move is dissolved at least partly. Hereby, it proves to be advantageous to match the activities of the individual nozzle heads to each other, such that due to opposite rotation, the vortices created by each nozzle head create currents.

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From the named publication (EP-160805) it can be seen that the described method is rather complicated. The reason for this is the necessary use of rotating lances with which a region as large as possible is treated with injected oil and with which the vortices are to be achieved. Regarding the use of energy and in particular regarding the device and the method for assembling it, the whole thing is relatively costly. Means, i.e. drives, for rotating the lances are required. The diluting media, the fresh crude oil must be introduced through these same lances. For the desired forming of eddies, controlling means are required to control the direction of rotation of the lances. Furthermore, this type of rotating lance is complicated mechanically and thus

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subject to disturbances. If the combined rotation fails the forming of eddies also fails, which, however, is relatively insignificant due to the two-dimensional effect of the rotating nozzles. However, the required simultaneous triple function, i.e. rotating the heads with e.g. pneumatic means, pumping and
5 injecting the crude oil and controlling the nozzle heads is costly and rather disadvantageous concerning the process. In addition, the construction of rotating lances requires a relatively high precision because roller bearings and other elements requiring narrow tolerances e.g. for fit are included in the device. This makes designing and manufacturing such devices relatively
10 expensive.

It can be shown that such relatively high costs can be prevented. For this reason, the invention has the object to eliminate these disadvantages. The
15 object is achieved by the method and the device which are defined in the claims.

The inventive method substantially consists in bringing a plurality of liquid
20 jets having a fixed spatial direction into and directly above the sediment by means of hydrodynamic energy such that the introduced liquid forms a substantially horizontal current. The object is to create with the totality of all the liquid jets a concerted current or concerted currents respectively. The plurality of specifically arranged and directed lances having defined nozzle
25 orientation effect in a vessel with a circular plan e.g. a current which is closed in itself and which is behaving as if driven by a gigantic stirrer. Hereby, the upper border of the flowing liquid is to remain as little disturbed as possible and its lower border, i.e. the border between flowing liquid and sediment, is to be formed such that an amplified erosive effect is achieved by the current.
30 In order to keep the energy required for the process as low as possible it is also an object of the method only to create directed mass currents where they

are necessary for dissolution of the sediment. An attempt is made to substantially only form a current within a predetermined layer, i.e. in the region just above the sediment layer. It is not necessary to move the liquid above this region. However, due to the inner friction in the liquid this cannot
5 be prevented totally but the additionally required energy is kept low.

Thus, the inventive method consumes less process-energy than known methods and is more simple to be carried out. The device to be created for carrying
10 out the inventive method is much more simple and is easier to operate than the corresponding device for the known method and it is in particular more easily adapted to and mounted in the vessels to be treated. The required means are very simple, are cheaply fabricated, easily mounted, robust, little susceptible and practically maintenance-free lances.

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The liquid introduced directly above the sediment differs from the crude oil above the sediment at least in that its concentration of substances from the sedimentation is lower. This liquid, in the case of a crude oil tank, is e.g.
20 crude oil from the upper region of the vessel or a less concentrated portion of the same crude oil, i.e. a portion of crude oil from which the heavy components have been removed. In any case, the main components of the liquid are the same as the main components of the liquid to be stored and/or transported in the vessel to be treated. Therefore, the liquid, after taking up
25 the sediments can be mixed into the stored liquid without scruples and/or can be fed into the same further processing.

The inventive method makes use of the finding that by corresponding supply
30 of current energy (hydrodynamic energy) it is possible to produce a current in a region or a layer of a resting liquid, whereby a kind of shear planes are

formed between the flowing layer and the resting layer above or below the flowing layer or between the flowing layer and layers above and below which flow at different speeds. In order to form this kind of flowing layer the liquid to be introduced is injected into the resting liquid in a direction substantially tangential to the flow axis and at a predetermined speed. For this purpose, the pressurized liquid is pressed through stationary injection nozzles which are correspondingly orientated in a fixed direction.

10 It is advantageous if at least in the region of the upper shear plane mixing is impeded as far as possible; this for the following reason: in vessels in which crude oil or liquids of similar character are stored in a stationary condition for a sufficiently long time not only sediments form but probably also a composition gradient across the whole height of the liquid column such that
15 the concentration of the substances most concentrated in the sediment increases from top to bottom. The lowermost layers of liquid thus contain a considerable concentration of the substances contained in the sediment and therefore, are hardly suited for an efficient re-liquefaction of the described sediments. With the inventive method it becomes possible to introduce a new
20 liquid above the sediment and to mix it with the lowest layers of the stored oil only to a limited degree which means that the inventive method is of a higher efficiency than known methods.

25 If a liquid from the layer above the circular-current-layer and more suitable for the liquefaction is injected into the circular-current-layer a certain mass current is formed on the shear plane from the circular-current-layer into the superposed region above the shear plane or a corresponding quantity of liquid is continuously drawn from the circular-current-layer, i.e. the quantity of the
30 injected liquid. Thus, the continuity condition for the circular-current-layer is maintained.

The sediments generally have a landscape-like, uneven surface which alone causes an increased dissolving effect on the lower border of the flowing layer. Additionally some or all of the injection nozzles can point downward in a flat
5 angle such that the introduced liquid is injected directed slightly towards the sediment surface, i.e. not quite horizontally, by which a local vertical flow component is favored.

10 An exemplified embodiment of a device for carrying out the inventive method substantially consists of a plurality of hollow lances for guiding the crude oil to be injected. These lances are introduceable into the vessel to be treated in a substantially vertical direction, through the sediment also and advantageously down to the floor of the vessel. Hereby the end region of each
15 lance orientated towards the floor of the vessel has at least one nozzle arranged laterally on the lance, advantageously several such nozzles arranged above each other at a distance. The other end of each lance protrudes from the top of the vessel and is connectable to a supply line for pressurized liquid. The nozzles arranged on one lance are all directed in the same direction. A
20 further embodiment shows two rows of nozzles extending axially and having a radial angle between them. The lances are positioned such that one part of the nozzles is positioned above the sediment surface and the other part below the sediment surface. This is e.g. realized with lances which comprise rows of superimposed nozzles, whereby the length of the rows of nozzles is
25 advantageously so large that they can rise above thick sediment layers.

The lances distributed over the base area of the vessel are positioned substantially vertically in the vessel such that the end regions of the lances
30 which are equipped with the nozzles reach as far down towards the floor of the vessel as possible, i.e. they are introduced into the sediment layer. All

lances are orientated such that the ejecting directions of their nozzles, have a component e.g. directed in the same direction tangentially relative to a predetermined current center (or to a different central region). For cylindrical vessels, the flow center is located advantageously on the vessel axis.

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When the lances are positioned, the nozzles are correspondingly orientated and the lances are connected to the supply system and the liquid is pressed into the vessel through the nozzles. Hereby, the liquid will be pressed particularly through nozzles located above the sediment surface because pressing through other nozzles meets a considerably higher resistance. Due to the orientation of the nozzles as described above a substantially horizontal current develops above the sediment after some time e.g. in form of a flowing liquid layer which mainly consists of freshly supplied liquid. This liquid interacts with the sediment surface and erodes it, whereby the sediment surface is lowered and further nozzles contribute to the general flow of liquid directly on the surface of the sediment.

20 Through the current such generated and developing into e.g. a circular current, the liquid is transported into the region of other nozzles located in flowing direction (downstream), whereby it is enriched with the sediment substances to be liquefied and is then displaced upwards by the freshly supplied liquid.

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In this manner, the sediment can be removed right down to the floor of the vessel. Heavy, not soluble sediment components such as stones, pieces of metal, rust or the like will hardly leave the region of the floor due to the small but inevitable turbulence and they can be removed from the floor in a separate process.

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For static reasons, storage tanks for crude oil usually have a circular base which is extremely suitable for carrying out the inventive method because there are no corners where the liquid is not agitated. All the same it is possible to apply the inventive method in vessels with other shapes also,
5 whereby the current to be created, which is as closed in itself as possible, advantageously flows in parallel with the vessel wall.

The inventive method and the inventive device are explained in detail in
10 connection with the following Figures, whereby

Figure 1 shows the principle of a moving circular-current-layer with adjacent shear planes in a cylindrical container containing a liquid;
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Figure 2 shows the principle of creating a circular-current-layer;

Figure 3 shows the principle of creating a circular-current-layer in the lower part of a cylindrical tank with the help of the inventive
20 lances;

Figure 4 shows the principle orientation of the nozzles for creating currents;

25 Figures 5, 7 and 8 show three exemplified arrangements of lances in vessels with different base areas;

Figure 6 shows the principle of the transfer of currents between pairs of successive nozzles;
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Figure 9 shows the creation of a circular current above a sediment layer;

- Figure 10** shows the injection of liquid into the sediment layer;
- Figure 11** shows an advantageous embodiment of the lances by means of a longitudinal section through a crude oil tank and through a lance-system.
- Figure 12** shows an embodiment of a nozzle movable in two axes;
- Figure 13** shows a section through a lance with two rows of nozzles with different directions;
- Figure 14** shows an embodiment of a nozzle-system rotatable around an axis;
- Figure 15** shows a cheap, robust and simple embodiment of the end portion of a lance with a row of nozzles movable in one axis;
- Figure 16** shows an embodiment of a lance partly consisting of a flexible tube;
- Figure 17** shows embodiments of nozzles which if desired can be blocked or closed;
- Figure 18** shows an embodiment of lances with a primary and a secondary row of nozzles which allow the creation of more distinct shear planes;
- Figure 19** shows a possible principle which supports the desired form of disturbance with the help of sucking means;

Figure 20 shows, by means of a three-dimensional diagram, in simplified, i.e. idealized manner how the inventive method operates.

5 Figure 1 shows, in a schematic representation, the idealized principle of a liquid layer driven in a circle. The Figure shows a cylindrical vessel 1 with a central axis 34 representing the center of the current. The vessel 1 contains a liquid 2 which is divided into layers. The layers 6.1 and 6.2 are layers of liquid 2 at rest relative to vessel 1. Between these two resting layers there is a layer
10 5 in which the liquid is in motion. The direction of motion of the layer is indicated by arrow 35. The layer moves in substantially circular form, i.e. there is a circular current in layer 5 around the central axis 34 of the vessel 1. The circular current is a current without eddies or turbulence. The current field within the layer is homogenous and consists of horizontal motion
15 components only.

Because the layer 5 moves relative to the layers 6.1 and 6.2, shear planes 30.1 and 30.2 form between the resting layers 6 and the circular-current-layer 5. As
20 mentioned above, Figure 1 describes an ideal system in which the friction on the shear planes is neglected. In reality, most shear planes are characterized by shearing strains due to the horizontal relative movement of the adjacent liquid layers and the friction within the liquid. The friction forces being oriented substantially tangentially to the outer wall of vessel 1, may cause the
25 layer 6 ideally being at rest relative to vessel 1 or at least the one part of it which is directly adjacent to the moving layer 5 to move slightly. For better understanding these secondary effects are neglected in what follows.

30 In Figure 1 the means which introduce the necessary energy into the layer to be moved are not shown because the actual embodiment is not important

here and it is the intention to show the principle of the circular-current-layer only.

5 Because the circular-current-layer 5 comprises few eddies, i.e. has components running substantially tangentially to the outer wall of the vessel, the energy needed for creating and maintaining this current is small. The current has a small energy loss because the liquid mass in layer 5 moves homogeneously and without forming eddies. It is even possible for the user of the method to
10 select the thickness (or height) of the circular-current-layer or -column by using the inventive device and thus, the user has the possibility to bring only such a part of the liquid mass into motion or keep it in motion respectively as is necessary for the method. This reduces the energy consumption (e.g. pump power) of the system further and to a considerable degree.

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Figure 2 schematically shows the (again idealized) principle of the energy supply into the circular-current-layer 5. The thickness of the circular-current-layer 5 is substantially determined by the arrangement of the means for
20 supplying the motion energy to the liquid (in the following called motion-energy-sources 7). In the Figure these motion-energy-sources 7 are shown as points from which a directed liquid jet or a directed liquid acceleration issues. The arrows 36 show the direction into which the liquid is accelerated or moved respectively by the motion-energy-sources 7. Here, nozzles or elements
25 supplying motion-energy to the system in the sense of Figure 2, are used to inject liquid.

The present invention is concerned with the energy supply into the liquid by
30 means of injecting liquid stemming from the resting layers 6.1 or 6.2 or advantageously from the circular-current-layer itself, which liquid is pressed

through the nozzles by means of a pump. This method is described in detail in connection with Figure 3.

5 The orientation of circular-current-layer 5 is substantially influenced by the orientation of the motion-energy-sources 7. This orientation is visualized in the Figure by means of arrows 36. In Figure 2 the arrows are orientated such that, viewing the vessel from the top, an anti-clockwise circular current is created. The arrows point substantially in flowing direction, i.e. tangentially to
10 the wall of the vessel.

The extension of the circular-current-layer 5 in longitudinal direction of the vessel 1 is substantially dependent on the extension of the motion-energy-sources 7 in the direction of the longitudinal axis 34 of the vessel, which axis
15 is at the same time the center of the current. In order to create a distinct circular-current-layer 5 it is advantageous if the motion-energy-sources 7 are distributed as regularly as possible over the height, the radius and the circumference of the circular-current-layer 5 to be created. In Figure 2 the
20 motion-energy-sources 7 are arranged in five rows of superimposed sources at regular distances. The Figure shows the principle arrangement only. Optimum arrangements are discussed exhaustively in connection with some of the following Figures.

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Figure 3 shows, by means of a schematic representation, the inventive principle of the injection of liquid into a circular-current-layer 5 of a cylindrical crude oil tank 1 with a central axis 34 forming the current center around which the liquid of the moving layer 5 flows in circular manner.
30 Lances 10 are immersed into tank 1 through the surface of the liquid. These lances reach down to the region of the floor of tank 1. The lances 10 comprise

rows of nozzles which rows reach from the ends of the lances 10 facing the floor of the tank to the shear plane 30. The nozzles serve as motion-energy-sources (7 in Figure 2).

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In Figure 3 several lances 10 are arranged regularly on a circle concentric to the base area of the tank. The lances 10 are orientated such that the axis of the nozzles 11 is orientated substantially tangentially to the base area of the tank. The openings of the nozzles 11 are aimed into the direction of motion
10 of the circular current.

The ends of the lances protruding out of the tank are connectable to a supply system, which in Figure 3 is schematically shown as supply lines 20, a
15 distributor 29, a pump 26 and a suction means in the region of the moving circular-current-layer. Thus, it is possible to suck liquid from the circular-current-layer and to pump this liquid into the individual lances 10 from where it can be re-injected into the moving layer 5 through the nozzles 11.

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The liquid 2 which is pumped through a nozzle creates a liquid jet which is shown by means of arrow 36. If the lances 10 are introduced into the liquid 2 in the arrangement and orientation as described above, motion energy is introduced into the layer 5 in such a manner that, at constant pump power,
25 after a certain time, a substantially stationary circular current, as described in connection with Figure 1, is created with the difference that a lower resting layer (6.2 in Figure 1) cannot form due to the arrangement of the lances according to Figure 3. Using the arrangement described in Figure 3, a stationary layer 5 with a circular motion is created at the bottom of the tank.

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The arrangement and the quantity of lances 10 shown in Figure 3 merely show the principle of the inventive device for creating a circular-current layer. Crude oil tanks have a diameter between 30 and 100 m. It is evident that with such dimensions many more lances must be positioned for creating a circular-current-layer. It is evident also how essential energy saving pumping is as soon as such large amounts of liquid are to be pumped.

Figure 4 schematically shows the orientation principle for the nozzles. The Figure shows one lance 10 with one nozzle 11, a predetermined current center 34 and a horizontal circle 32 around the current center, whereby the nozzle opening is located on this circle. The circle 32 is an example for a current line of a horizontal current closed in itself, i.e. a circular current around the current center 34. The jet direction is shown in a somewhat exaggerated angle and is denominated with vector R divided into a vertical component R_v , a horizontal, tangential component R_t (parallel to the current line) and a horizontal, radial component R_r (perpendicular to the current line).

The conditions for orientating the nozzle and for carrying out the inventive method are the following:

- Vector R has an optional vertical component R_v or a component directed orthogonally downward.
- Vector R has a horizontal, tangential component R_t , whereby the components of all nozzles of the system have the same sense of rotation relative to the current center.
- Vector R can have a horizontal, radial component R_r . This component is shorter than the horizontal, tangential component R_t , i.e. the angle

between the tangent on circle 7 and the horizontal projection of R is at the most 45° .

- 5 Figure 5 shows a top view of a vessel with circular base area or floor respectively and with a current center 34 extending perpendicular to the center of this base or floor. However, it must be taken into account that with radii of up to 50 m the curved current lines look like straight lines in smaller segments and that the arrows look exaggeratedly large in this Figure of a
10 vessel with a radius of a few centimeters. However, they correspond to about the double of the ejection capacity of the nozzles such that the successive formation of the current can be well imagined.
- 15 Over the base of the vessel, a plurality of vertically positioned lances 10 is arranged on concentric circles in a substantially regular pattern. The ejection directions through the nozzles are also shown or the horizontal components R_h of these directions respectively all of them being arranged tangentially and anti-clockwise (no component R_r). The shown nozzles can be individual
20 nozzles on each lance which are then advantageously arranged at different heights or they can be arranged in rows and be orientated all in the same direction, as shown in Figure 3. The nozzles can be directed, apart from horizontally (parallel to the floor), downward in identical or different angles α . It may be sufficient to arrange nozzles only on the outer third of the vessel
25 radius such that a closed current is first created in the region of the vessel wall which then gradually expands inward. In order to influence the inner region the nozzles can be radially orientated instead of tangentially such that the currents forming between the nozzles meet in the center in a radial manner.

Figure 6 shows the possibility for creating a distinct liquid current with the help of the inventive method with 'steady' lances 10. It must be taken into account that with the immense dimensions of crude oil tanks the curved current lines look like straight lines if, as mentioned above, only a section of a few meters of the same current is looked at. For this reason, the main flow direction achieved by means of the corresponding arrangement of the lances is shown curved or not curved respectively in Figure 6.

10 The lowermost part of a lance arrangement of four lances 10.1, 10.2, 10.3 and 10.4 is shown schematically. The nozzles 11 arranged above each other form rows of nozzles extending vertically at the one end of the lances 10 which faces the floor of the tank. The nozzles are shown as rings. The liquid pressed out of the nozzles and the direction of the liquid jet are shown by means of
15 arrows 36. Obviously, it is a pointed cone 31 with a larger or smaller opening angle according to the nozzle form which is formed when the liquid is pressed out (indicated on one of the nozzles in Figure 6). The arrows 36 indicating the liquid jets relate to the cone axes, the actual jets though have the form of slender funnels.

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The arrows 36 of two adjacent lances (10.1 and 10.2 or 10.3 and 10.4 respectively) not only have a component in direction of the main current 37 but also a component directed towards the main flowing direction. The
25 ejected liquid of lance 10.1 thus meets the liquid jets of lance 10.2 in the region of the main current and accelerates the liquid in this region. The supplied energy decreases with the distance that the liquid moves away from the lance. At a distance from the lances 10.1 and 10.2 where the driving energy has decreased to a high degree, a further pair of lances 10.3 and 10.4
30 is positioned in the liquid in the same manner as lances 10.1 and 10.2, such that the desired main current 37 is maintained or, depending on the distance

between the pairs of lances, is even accelerated. The course of the main current 37 is influenced by the geometric arrangement of the pairs of lances (10.1 and 10.2 or 10.3 and 10.4 respectively) and by the pressure of the injected liquid. Thus currents can be created in a tank with a circular base or
5 a base of different shape.

It shows that in a crude oil tank of a diameter in the range of 30 and 100 m a jet range of more than 5 m can be achieved within the crude oil using a
10 ejection pressure of 5 to 30 bar. Therefore, it is advantageous to maintain the distances between the lances, in particular the tangential distances between the lances within this range.

15 **Figure 7** shows a further top view into a vessel in which lances 10 with nozzles are arranged substantially on four current lines (current lines shown by means of broken lines) of a current to be created. The nozzles of the lances of two adjacent current lines are each orientated slightly towards each other (with radial components directed towards each other, as shown in Figure 6) such
20 that between the current lines of a pair of lances a main current develops.

Figure 8 shows, by means of a top view, a vessel which does not have a circular base but an oval one. Within the vessel, vertical lances 10 with
25 nozzles are arranged. The liquid current to be created by injecting liquid is again closed in itself and for covering as much of the base area as possible it is not arranged around a current center but around a 'rotation area' 34. The lances are substantially arranged on inner current lines S_i and outer current lines S_a of this liquid current and the nozzles are orientated such that the
30 corresponding jet directions have a horizontal, tangential component R_t and a horizontal radial component R_r , whereby the radial component R_r of the

nozzles is directed outward on the inner current line S_i and the radial component R_r of the nozzles is directed inward on the outer current line S_a .

- 5 With the arrangement shown in Figure 8, a main current is created between the inner and the outer current lines, whereby unwanted forming of eddies in the region of current area A along the wall of the vessel is prevented which means that the pumps use less energy.

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Figure 9 shows a schematic representation of a crude oil tank 1 with a sediment layer 3 at the bottom of the tank 1. The Figure shows an exemplified embodiment of the inventive method and the inventive device for liquefaction of crude oil sediments.

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On their one end, the lances 10 (in Figure 9 only one lance is shown as an example) have one nozzle 11 only, a small number of nozzles 11 or a short line of nozzles arranged close together and they are not introduced into the sediment layer but only reach down to its surface. The circular-current-layer 5 extends above the sediment surface and the current erodes and gradually dissolves the sediment. During the dissolution of the sediment layer 3, the lances 10 are lowered step by step till they reach the tank floor. In a crude oil tank with a floating roof this can e.g. be realized by means of corresponding lowering of the liquid level (pumping out of crude oil). The injected liquid can be crude oil from the upper part of the circular-current-layer 5, fresh liquid or crude oil from the upper resting level 6.

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- 25
- 30 If fresh liquid or crude oil from the layer 6 is injected without liquid being removed from the circular-current-layer 5 there will be a mass transfer in the

region of the shear plane as the continuity equation for level 5 would otherwise not be fulfilled. Instead of a distinct shear plane 30 a more or less diffuse and less distinct transition region may form in such a case.

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Figure 10 shows by means of a schematic section through a part of a crude oil tank 1 a further exemplified embodiment of the inventive device for liquefaction of crude oil sediments. The device shows two lances 10, each with a row of nozzles comprising at least one nozzle 11 and being arranged on the end of the lances facing the floor of the crude oil tank 1. Supply lines 20, a pump 26 and means 21 for removing oil by suction are also shown schematically. The lances 10 are e.g. positioned into the openings in the floating roof 4 provided for the supports and are lowered down towards the floor of the tank 1 and locked in this position. Needless to say, that for the actual, immensely large crude oil tanks a large amount of lances is to be used.

The injected liquid (here crude oil from the upper layers in the tank 1) is pressed through the nozzles 11 into the sediment layer consisting of thickened crude oil which gradually dissolves due to the contact with crude oil from the upper region of tank 1. During the gradual liquefaction of the sediment layer 3 individual nozzles 11 and a part of the nozzle rows gradually becoming larger emerge from the remaining sediment layer 3 and create a circular-current-layer directly above the sediment layer which current layer additionally accelerates the decomposition of the sediments 3. Only foreign matter in the form of e.g. stones, metal pieces and most of all rust remain on the floor and can be removed from the tank by means of a separate process. The circular-current-layer which can now form without disturbance prevents a renewed formation of a sediment layer.

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Figure 11 shows schematically a preferred embodiment of the inventive device for carrying out the inventive method. The crude oil tank shown in section has a floating roof 4 and contains crude oil 2 stored above a sediment layer 3. The tank 1 is equipped with a number of lances 10 arranged as demanded by the inventive method for creating a circular-current-layer above the sediment layer 3. Only one lance is shown in Figure 11 as an example. These lances extend through the liquid layer 2 into the sediment layer 3 and down to the floor region of the tank. The lances 10 comprise rows of superimposed nozzles, which rows of nozzles extend from the end of the lances facing the floor of the tank to the liquid layer above the sediment layer. The lances are designed and positioned such that they create a circular-current-layer 5, as described in connection with Figure 3, above the sediment layer 5.

The other ends of the lances 10 protrude from the vessel and are connected to a supply system which is shown schematically by means of a supply line 20, a distributor 29, a pump 26 and means for oil removal by suction 21. Between the means for oil removal 21 and the pump 26, a three-way cock 27 can be provided. Depending on the position of the cock, fresh oil from a fresh oil supply 38 or oil removed from the tank by suction is pumped and injected through the lances. In such tanks, oil is not removed by suction at a location in the tank wall but e.g. an immersion pipe. The means for removing oil by suction as shown, only serve for illustrating how, for maintaining the mass equilibrium, crude oil is removed from the driven layer (the circular-current-layer).

Crude oil tanks often have floating roofs which float on the liquid surface and have a distance from the tank floor which varies with the liquid level. In order to prevent the floating roof 4 to sink right down onto the floor of the tank the roof is equipped with stilt-like supports on which the roof is supported when

the liquid level sinks below a minimum. The distance between roof and floor then substantially corresponds to the height of the supports. It is advantageous to introduce and position the lances 10 through the openings provided for the supports. A big advantage of the inventive device is the fact that by means of
5 pipe adapters 22 it can easily be adapted to different openings for such supports as being standard in different countries. The use of this kind of very simple, cheap and maintenance-free pipe adapters allows, when applied in connection with a lance adapter 23, the same lances to be used in different countries and it reduces adaptation work to a minimum. The slotted pipe
10 adapters 22 may be reinforced and may replace the supports.

The nozzles or the ejection direction of the liquid jets from the lances respectively can be oriented according to the inventive method in the most
15 various ways. E.g. the nozzles are orientated by orientating a fixed mark M on the pipe adapter 22 on an angle scale 25 being stationary relative to the floating roof. The orientation for the assembly of lances can be optimized in a computer simulation. According to a calculated plan, the lances are then individually orientated and locked. It is also possible to carry out multi-stage
20 operations in which, after a certain working time, part of the lances or all of them are brought into different relative positions in order to achieve currents of different character, e.g. for vessels of complicated form.

25 The adapter pipe has a slot S with a length adapted to the length of the nozzle row in order for the liquid to be ejected out of the nozzles unhindered even if the nozzle row is positioned within the adapter pipe. A possible guidance between adapter pipe 22 and lance 10 is shown in Figure 11 by means of a guide element 13. The lance adapter 23 forms a link between the
30 pipe adapters 22, which are different in size depending on the support standard, and the lances 10, which can be designed to be one only size and

not being dependent on any support standard. This is a further reason why the inventive device is comparatively cheap in production.

- 5 If desired, the lances can be moveable relative to the adapter pipe 22. With such moveable lances, variations in the height of the liquid level do not lead to displacing the lances 10 or the rows of nozzles on the lances 10 respectively in relation to the tank 1 and to the sediment layer 3 lying on the tank floor. Thus the lance system is adaptable to variations of the liquid level in the tank
- 10 1 in a most simple manner. No complicated readjusting needs to be carried out. This, in a very simple manner, makes the method extremely maintenance-friendly.
- 15 The lances 10 are pushed axially through the elements 23 and the nozzles 11 arranged in the lower region of the lances 10 are kept in the region of the tank floor with the help of weight elements 12 which are e.g. attached in the upper region of the lances. The mass of the weight elements 12 is adapted to the mass of the lances 10 such that the lance 10 is pushed into the sediment
- 20 layer 3 without further effort or such that the lower ends of lances 10 remain in the region of the tank floor when the liquid level in the tank 1 is lowered or raised.
- 25 Figure 12 shows a section through an exemplified embodiment of a lance 10 with a nozzle 11 attached to it and through the pipe adapter 22. The embodiment of the nozzle comprises a ball-and-socket joint for adjusting the direction of the ejected jet 36 to a limited degree. A pipe with an external thread and with a ball socket 25 is fitted to the lance pipe 10. The actual ball-
- 30 nozzle 50 is located in the ball socket and is held in position by means of a union nut 51. It is advantageous if the dimensions of the lance-nozzle-system

is smaller than the inner dimensions of the pipe adapter. Thus, it is possible to remove the lances from the pipe adapter by means of pulling them upward.

- 5 It is important that the position of the nozzle does not change e.g. under the influence of vibration. For this purpose a simple nut locking device or other means to prevent loosening of the union nut can be used. It can be advantageous to increase friction between the ball nozzle 50 and counterparts 51 and 52 by rough surfaces or even teeth. It can also be advantageous if
10 these elements have a surface such as is found on untreated cast steel parts.

- The elements shown in Figure 12 can be produced with a minimum accuracy. The shown embodiment demands no special tolerances, apart from what
15 concerns the thread. Therefore, it is possible to use very cheap manufacturing methods and cheap materials (e.g. St-37, GGT). It is evident that the cross section of the lances need not necessarily be circular. It can be imagined that the cross section of the lance 10, as described in connection with Figure 15, can be quadrangular or can have any other form, as will be shown further
20 below.

- Figure 13 shows a further embodiment of a lance-nozzle-system. It concerns a lance 10 with two rows of nozzles 11.1 and 11.2 pointing in different
25 directions. The individual nozzles or at least one of the two in each row can of course be adjustable, as shown in Figure 12 or can be designed to be rigid, as shown here. The shown embodiment can be constructed simply and most cheaply with tolerances in the millimeter range using standard profiles.

Figure 14 shows an embodiment of a further lance-nozzle-system which allows adjustment of the nozzles 11 around an adjusting axis 63. The body which contains the actual nozzle 11 is a shaft piece with a corresponding bore serving as nozzle 11 and with two lateral bores equipped with internal threads and defining the adjusting axis 63 together with corresponding bores in a rectangular pipe piece 61 fitted to the lance. Here, it is again possible to exclusively use cheap standard parts and standard profiles and to work with production tolerances which are a lot less tight than is usual in general mechanical engineering. This embodiment allows adjusting the nozzle direction horizontally by turning the lance around its longitudinal axis (indication by mark M on scale 25) and vertically by turning the nozzle around the adjusting axis 63.

Figures 15 A, B, C show the exploded (Figure 15A) and assembled parts (Figure 15B) of a further embodiment of a lance-nozzle-system according to the same principle as described in connection with Figure 14. This embodiment has been simplified such that the process for manufacturing the lances is as simple as possible. All used elements such as rod material 60, hollow support 61, bolts 62, plates 70 and U-profile 71 are standard elements or can be manufactured simply from standard profiles (e.g. profile made of weldable steel, such as St-37). The plates 71 are fitted to the U-profile and the sections 61 of the hollow support are fitted to it by means of weld points 72, the bored nozzles 60 are bolted in. The foot piece of the lance is closed with a plate 71, the upper part of the lances closed with a corresponding long plate 71 as a side wall, the elements for the liquid supply are mounted and the lance is completed. Here it is again possible to work with very broad manufacturing tolerances (Figure 15C). E.g. a gap 73 of several millimeters between the disc-nozzle 60 and the rectangular piece 61 of pipe is permissible because this does not substantially influence the total function of the lance. When welding the individual parts together it is sufficient to do this with

relatively short weld points 72; complicated closed weldings in the region of the rows of nozzles are not required.

5 **Figure 16** shows an example of an embodiment of a lance 10 which is designed as a relatively stiff construction containing nozzles 11 and a relatively flexible tube 81 being connected to the rigid part of the lance 10 via a hose coupling 80. The rigid part with the rows of nozzles is guided in the pipe adapter 22 with the help of lance adapters 23 and guide element 13. The
10 adapter pipe 22, which is matched to the standard support openings of the concerned country, is slotted over its whole length for introducing or removing the lance 10 from the top. The advantage of this kind of design or a similar one is its reduced weight and the fact that the stiff part of the lance is considerably shorter than a whole lance consisting of stiff material. Therefore,
15 it is a lot more simple to handle (transport, storage, assembly). Again, standard components can be used for the stiff part of the lance with the at least one row of nozzles and standard flexible tubes 81 with standard couplings 80 available on the market.

20

It is important that the length of the stiff part of the lance is larger than the difference between the maximal liquid level H1 and the minimal liquid level H0 in order to make sure that the lance 10 is guided through the adapter pipe 22 at any liquid level.

25

Figures 17 A and B show two embodiments of nozzles which can be closed or blocked respectively such that no distinct liquid jet can escape from the nozzle 11. In Figure 17A an embodiment is shown with the principle described in
30 connection with Figures 14 and 15. The disc nozzle 60 is blocked in a position in which no distinct liquid stream can be formed. The disc nozzle 60 in the

shown position cannot, however, block the nozzle completely. A certain amount of liquid can escape all the same. As the inventive method is not susceptible to such small disturbances this kind of incomplete blocking can be tolerated. It is evident that nozzles can also be closed with other simple means. E.g. covers can be attached to the nozzle openings or a pipe nozzle 55 can, as shown in Figure 17B, e.g. be sealed with the help of a union nut 56 serving as cover.

10 Figure 18 schematically shows an embodiment of lances 10 with two rows of nozzles, which nozzles 11.1 or 11.2 are orientated in substantially opposite directions. The primary rows of nozzles 11.1 on the lances 10 are arranged such that they create a circular current around the main axis 34 of the vessel in a lower layer 5. The secondary rows of nozzles 11.2 are located directly
15 above the shear plane and contain at least one nozzle 11.2. They are oriented on a direction substantially opposite to the direction of the nozzles of the primary rows, i.e. the liquid ejected by these nozzles 11.2 moves the liquid mass directly above the shear plane 30 and for the support of this shear plane in the opposite direction to the circular-current-layer 5. These secondary
20 nozzle rows are advantageously substantially smaller, i.e. contain less nozzles than the primary nozzle rows.

As mentioned earlier, due to the inner friction of the liquid it is in practice
25 difficult to create an ideal shear plane. The orientation of secondary nozzles 11.2 shown in Figure 18 can, however, considerably facilitate the formation of this kind of distinct shearing plane. If a very thick layer 6 is positioned above the circular-current-layer 5 it can, regarded from the energy point of view, be of advantage if movement of the layer 6 is prevented by crating a distinct
30 shear plane as described above.

Figure 19 schematically shows the principle of an embodiment of lances with suction means 21. It is advantageous if the suction means for the described system are designed as immersion pipes penetrating through the tank roof. For not disturbing the circular current, it may be advantageous to design
5 several suction means such that they even contribute to a certain degree to the formation and maintenance of the current. The suction pipes can e.g. comprise, as shown in the Figure, in the same way as the lances comprise nozzles, superimposed suction openings positioned in the circular-current-layer such that the rows of suction openings are oriented substantially downstream.
10 By sucking liquid into the suction openings, the liquid is accelerated and moved accordingly. Thus, by using this kind of immersion pipes directed motion energy can, similarly as with the lances, be introduced into the liquid and thus the efficiency of the whole system can be increased.

15

Figure 20 shows in a qualitative diagram the inventive method for removing a sediment layer in a crude oil tank. The representation is designed for better understanding of the method and is purely qualitative. The following simplifying assumptions are made:

20

- No fresh liquid is introduced at any time into the method.
- The circular-current-layer is an ideal, friction-free current, which is limited by an ideal shear plane.

25

- The circulation of the liquid only takes place in the circular-current-layer, i.e. the liquid which is injected into the sediment layer originates from the circular-current-layer.

30

- The diagram bases on the embodiment of the method according to Figure 11.

The axes in the diagram are denominated as follows: t denominates the time axis, h the height above the tank floor and k stands for the sediment concentration. The diagram contains three important regions. Firstly region 98
5 which describes the actual sediment layer, secondly region 97 which describes the conditions in the ideal circular-current-layer and thirdly region 96 which describes the resting layer above the circular-current-layer.

10 As this resting layer is protected from the circular-current-layer by the ideal shear plane, i.e. substantially no mass currents leave this layer or enter it nothing will change concerning the sediment concentration. Area 90 is a horizontal plane representing the sediment concentration k on the liquid surface. Area 91 describes the sediment concentration k from the liquid
15 surface down to the shear plane remaining constant. The courses of area 90 and 91 do not change with time.

The horizontal area 92 represents the sediment concentration in the shearing
20 plane. Its height h the same as the altitude of the shearing plane above the tank floor. It is evident that the sediment concentration k in this layer changes with time. This is due to concentration k in the circular current layer constantly rising with time due to the dissolution of the sediment layer, which fact is also described by area 93 which visualizes the concentration k in the
25 circular-current-layer above the sediment layer.

The horizontal layer 94 represents the concentration k in the sediment layer. The height of the sediment layer decreases with time and corresponds to the
30 medium height of the sediment layer at each point in time t . It is the object of

the method to dissolve the thickened sediment layer. This is achieved after a certain time t_3 and at this point in time areas 94 and 95 disappear.

5 If the injected liquid, as described in connection with Figure 20, originates from the circular-current-layer itself, then a mass equilibrium develops in the moving layer, i.e. a circulation process takes place. If the liquid is injected from the resting layer above the circular-current-layer through the lances and the nozzles attached to these, then, if no corresponding amount of liquid is
10 withdrawn continuously from the circular-current-layer, a mass flow into the region above the circular-current-layer must take place, which mass flow makes the formation of a distinctive shear plane on the upper border of the circular-current-layer more difficult.

15

Concerning energy, it may be advantageous if the injected liquid is taken from the circular-current-layer because thus the continuity equation in the circular-current-layer is fulfilled. The thinner the circular-current-layer to be created the less mass must be brought into motion and the less energy is required.
20 Thus it is advantageous to make the circular-current-layer as thin as possible by raising and lowering the immersion pipe for removal of liquid to be injected.

25 In a preferred embodiment of the method, only as much mass as necessary is brought into motion to form the circular-current-layer, i.e. a volume of crude oil of the size which is required to dissolve the volume of sediment 3 on hand. This minimal volume is determined by the maximal capacity of the injected liquid to take up sediment material. With the help of this saturation value, the
30 minimal volume of the circular-current-layer in the case of the mentioned circular-current-layer-circulation can be determined. Because in this

circulation, liquid e.g. from the upper region 6 of the circular-current-layer 5, is injected through nozzles 11 onto and/or into the sediment layer 3 the material removed from the sediment layer substantially stays in the circular-current-layer 5. The sediment layer 3 is gradually dissolved and the concentration of sediment material solved in the crude oil rises up to the complete disappearance of the sediment layer 3. If the saturation value of the crude oil is reached before this the remaining sediment layer 3 is not dissolved any further.

10

The length of the nozzle rows on the lances 10 substantially corresponds to the thickness of the circular-current-layer 5 and can be matched to the above mentioned calculated minimum thickness by using lances 10 with correspondingly long rows of nozzles 11. In order to avoid special manufacture of such lances 10 the individual nozzles can be designed to be blockable, i.e. by providing means as described above for preventing liquid from being pressed through specified ones of the nozzles 11. Thus, it is possible that only a lower part of the nozzle rows, adapted to the circular-current-layer to be created, is active and the nozzles 11 of the upper part are closed or blocked. The suction means 21 can be designed as an immersion pipe with an adjustable height mounted in the roof 4 of tank 1 and also adapted to the thickness of the circular-current-layer 5.

25 Further variants of the described embodiments of the inventive method and the inventive device are e.g. the following:

- The lances comprise nozzles with different orientation, whereby the orientation of each nozzle fulfills the given conditions for current formation.

30

- The lances are branched.
- The nozzles are arranged on flexible pressure tubes for support being positioned in guide pipes having slotted windows for the nozzles. This embodiment allows diameter adaptation to the support openings with one only standard part carrying the nozzles. Furthermore, the lances become cheaper.
- The method is not applied for removing sediments but for preventing sedimentation by keeping the lances constantly mounted in the supports and by periodically ejecting liquid and temporarily creating a current.

The diagram in Figure 20 describes a system with ideal circular-current-layer, i.e. with a distinct shear plane. It is evident that in reality transverse strain develops in the shearing plane and this is transmitted by inner friction in the liquid to the 'resting layers' 6. In reality, a speed profile will also develop in the layers 6. i.e. the liquid masses described as resting layers also move slightly. The model of the ideal circular-current-layer however, is used as a basis in the discussion of the invention for better understanding and as simplification.

The main advantages of the inventive method compared to the state of the art are the facts that the device required for carrying out the method operates without moving parts positioned under the surface of the liquid. The pump only contains parts moving in operation. Furthermore, no means for rotating the lances are required. The lances are of very simple design and thus can be manufactured cheaply and without precision (tolerances in the millimeter range). The device may consist of cheap material, e.g. steel-37. Due to the simplicity of the design the inventive lances are a lot lighter than rotation-

lances and thus more simple to be handled and less susceptible to mechanical damage, e.g. when being mounted. They are very simple to operate and they do not require special maintenance.

5

By largely avoiding unnecessary formation of eddies, which, however, is looked at as an advantage of rotation-lances, a considerable amount of pumping energy can be saved which makes it possible to use lighter, mobile and cheaper pump units; additionally, the lances are lighter, which increases mobility. Furthermore it is evident that these arrangements, the device (lance) as well as the method (nozzle orientation) require no precision. The whole technique is robust and comprises, as mentioned above, cheap lances and a very simple operation of the method for achieving the desired effect.

15

It is also advantageous that the tank to be treated must not be emptied. As soon as a sediment layer has formed the lances can be installed at a given liquid level and the current can be generated. Meanwhile the tank can remain in full operation; crude oil can be added or removed. Due to the relatively lightweight equipment and the possibility of the use of standard lances (i.e. high numbers of identical lances) in different applications the system is extremely adaptable; e.g. lances from different appliances can be combined or exchanged. Furthermore, the fact that the method can operate perfectly without complicated and expensive control is very advantageous.

25

The inventive method for recovering crude oil from thickened crude oil or from its sludgy to compact sediments in vessels in which crude oil is stored and/or transported by treating the sediment with crude oil or refinery products as a solvent and at least partly liquefying and dissolving it whereby the solvent is pressed out of nozzles in order to form a current which erodes

30

the sediment and dissolves it as far as this is possible, is substantially characterized by creating a plurality of directed liquid solvent jets being ejected from fixed nozzles, which are orientated such that the liquid jets drive the surrounding medium sectionwise in a mutual direction, bring it into
5 motion and unite with this medium to form a mutual current.

The device for carrying out the method substantially consists of a hollow body connected to supply means for a liquid and comprising nozzles through which
10 the liquid is ejected under pressure. The nozzles are arranged over a part of the length of the device whereby a plurality of nozzles is arranged radially fixed and at a distance from each other, the nozzles being orientable or being orientated such that liquid jets can be created of which jets at least a part is substantially parallel.

15

An arrangement of inventive devices for carrying out the method in a vessel is such that a plurality of nozzles is positioned in nozzle pairs on each one of a pair of current lines (S_i/S_a) of a current to be created and such that the
20 nozzles are orientated with a horizontal, radial component (R_r) of the injecting directions of the nozzles of one pair being directed in an acute angle towards each other and between the nozzles of a further pair following downstream. Thereby, the liquid jets drive the surrounding medium in a mutual direction and unite with it to form a mutual current. One or several
25 pumps are connected to the lances for supplying these with liquid. For supplying the pump or pumps with liquid, one or several immersion pipes are provided, the suction side of the immersion pipes protruding into the layer to be made to flow or connections for sucking liquid from outside the named layer are provided.

30



CLAIMS

1. Method for recovering crude oil from thickened crude oil or from sludgy to compact sediments of crude oil in vessels in which crude oil is stored and/or transported by treating the sediment with crude oil or refinery products as solvent and at least partly liquefying and dissolving it, whereby the solvent is pressed out of nozzles in order to form a current which erodes the sediment and dissolves it as far as it can be dissolved, characterized in that from stationary and fixedly orientated nozzles, a plurality of directed liquid jets of solvent is created, which nozzles are orientated such that the liquid jets drive the surrounding medium sectionwise in a common direction and move it and unite with it in a joint current. 5

2. Method according to claim 1, characterized in that a liquid current flowing substantially horizontally is created in the liquid above the sediment layer (3) by injecting the liquid to be injected into the crude oil (2) resting above the sediment (3) from a plurality of nozzles (11) directed in the same sense, whereby the injection direction (R) of all nozzles is substantially horizontal or slightly inclined towards the floor of the vessel and comprises a horizontal component (R_h) tangential to the radius of the vessel which component is tangential to a current line of the liquid current and pointing in the current sense. 15 20

25

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REPLACED SHEETS		SG
☐	Description : paged	to paged
☒	Claim(s) : paged <u>34</u>	to paged <u>38</u>
☐	Drawing(s) : paged	to paged
☐	Abstract : paged	to paged



3. Method according to claim 1 or 2, characterized in that above the sediment layer (3) a substantially horizontal liquid current more or less closed in itself is created by injecting the liquid from a plurality of nozzles (11) arranged above the surface of the sediment into the liquid resting above the sediment (3), whereby the injection direction (R) of all the nozzles is directed downward at an angle of 0 to 10 degrees in relation to the vertical and comprises a horizontal, tangential component (R_t) which is orientated tangentially to a current line of the liquid current and in the current sense. 5
4. Method according to claim 2 or 3, characterized in that the direction of injection of at least part of the nozzles has a horizontal, radial component (R_r) which is smaller than the horizontal, tangential component (R_t). 10
5. Method according to one of claims 1 to 4, characterized in that a substantially horizontal liquid current in form of a circular current around a current center (34) is created by a plurality of correspondingly positioned ejection points. 15
6. Method according to claim 5, characterized in that a predetermined layer in the liquid column of the vessel is stimulated to a circular current which forms a shear plane to other sections or layers such that these other sections are substantially undisturbed by the current and start flowing themselves. 20





7. Method according to one of claims 1 to 6, **characterized** in that the liquid driving the current is taken from the layer with the circular current.
- 5
8. Method according to one of claims 1 to 6, **characterized** in that the liquid is crude oil or a refinery product and has a same or a smaller concentration of components of higher molecular weight than the crude oil positioned above the sediment (3).
- 10
9. Device for carrying out the method according to one of claims 1 to 8, which device comprises at least one hollow body with a connection for supplying it with a liquid and with nozzles (11) for ejecting the liquid under pressure, **characterized** in that over a part of the length 15 of the hollow body a plurality of nozzles (11) are provided the nozzles being arranged fixedly and distanced from each other and being directable or directed such that substantially parallel liquid jets can be created with the aid of at least part of the nozzles being joint.
- 20
10. Device according to claim 9, **characterized** in that the nozzles (11) comprise means for changing the direction of ejection and are arranged on substantially vertical, hollow, pipe shaped lances (10) to 25 be introduced into the vessel.
11. Device according to claim 9 or 10, **characterized** in that the vertically arranged device resting on the part facing the floor of the vessel has 30 an ejection direction (R) of each nozzle (11) orientated horizontally



or downward at an angle (α) and having a horizontal, tangential component (R_t) parallel to a liquid surface which horizontal tangential component is tangential to a current line of the liquid current to be driven, is orientated in flowing direction and is larger than a horizontal, radial component (R_r).

5

12. Device according to one of claims 9 to 11, characterized in that the lances (10) comprise on their ends facing the floor of the vessel at least one row of nozzles (11) extending over the lance length, the nozzles being arranged at a distance from each other, which nozzle row has a length of between 2 and 5 meters such that part of the nozzles (11) are positioned above the sediment surface when the lance rests on the floor of the vessel.

15

13. Device according to one of claims 9 to 12, characterized in that a guide (22) is allocated to each of the lances the guide being slotted at least in the outlet region of the nozzles and the lances (10) being arranged in the guide and being adjustable for nozzle orientation with the guide by being pivotable around their longitudinal axis.

20

14. Arrangement of devices according to claims 9 to 13 in a vessel wherein a plurality of nozzles (11) is positioned in pairs on each current line of a pair of current lines (S_1/S_2) of a created liquid current or of a current to be created and wherein the nozzles are orientated such that a horizontal, radial component (R_r) of the injecting direction of one nozzle of a pair of nozzles positioned one on each of the two current lines is directed in an acute angle towards the injection direction of the other nozzle of the pair and between

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- 38 -

the nozzles of a further pair following downstream, the liquid jets driving the surrounding medium in a common direction and uniting with it to form a joint current and wherein for supplying the lances with liquid one or several pumps are connected to the lances and for supplying the pump or pumps with liquid, one or several immersion 5 pipes are arranged with their suction side immersed in the layer to be made to flow or connections for sucking liquid from outside of said layer are provided.

ABSTRACT

The inventive method and the inventive device serve for liquefaction of sludgy to compact sediments (3) in vessels (1) in which crude oil (2) is stored and/or transported, whereby a liquid is injected above the sediment surface via
5 nozzles (11) under the effect of which liquid the sediment (3) is at least partly liquefied or dissolved in the liquid such that it can be removed from the vessel (1) together with the liquid. For this purpose a substantially horizontally flowing liquid current which is possibly closed in itself is created above the sediment surface by directing the injection through all nozzles (11)
10 such that the injection direction has a horizontal component which is orientated tangentially to a current line of the liquid current to be created and is orientated in flowing direction. The injected liquid is crude oil or a refinery product and differs from the lowest levels above the sediment in that it comprises a smaller share of heavy components.

15

(Figures 9 and 11)

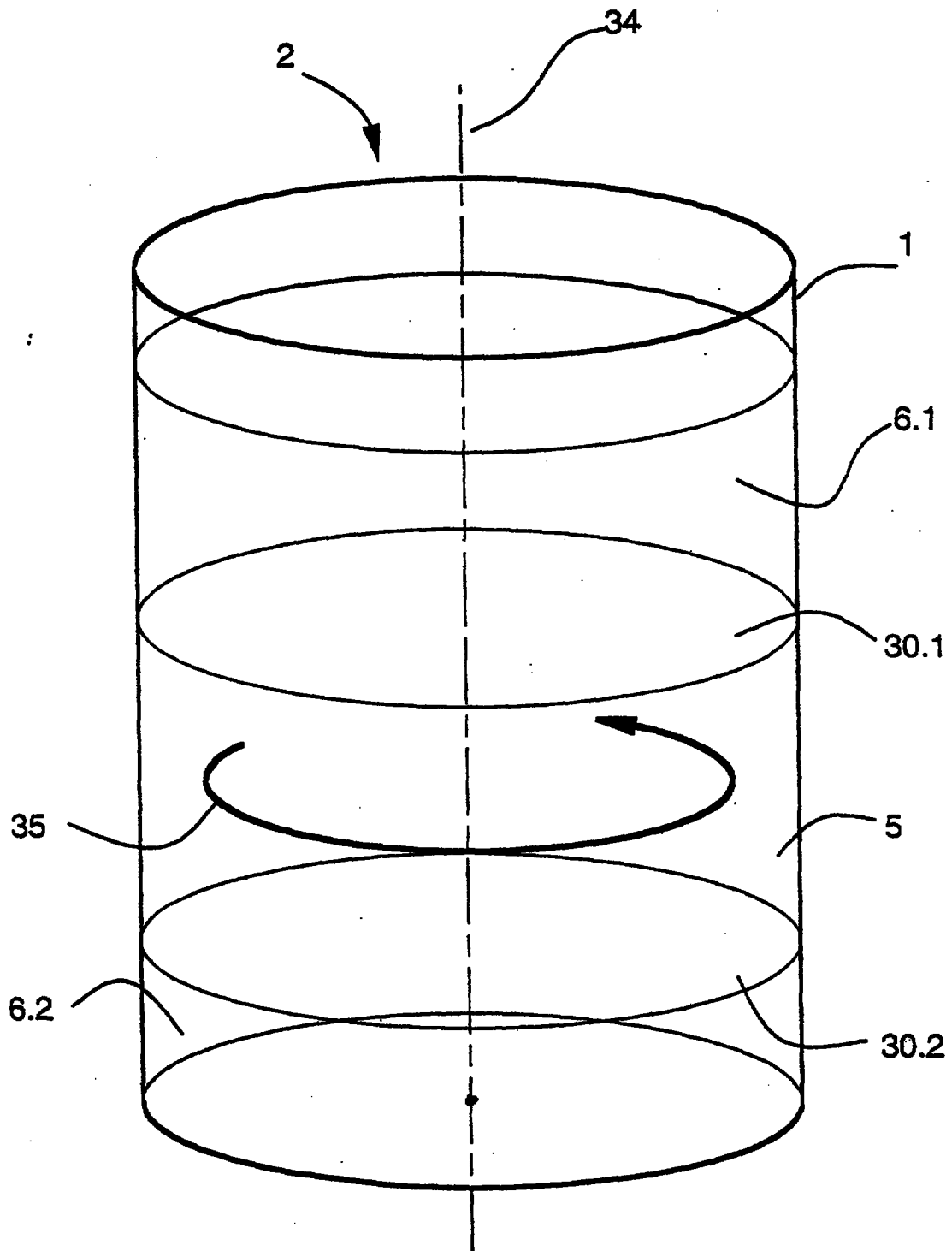


Fig.1

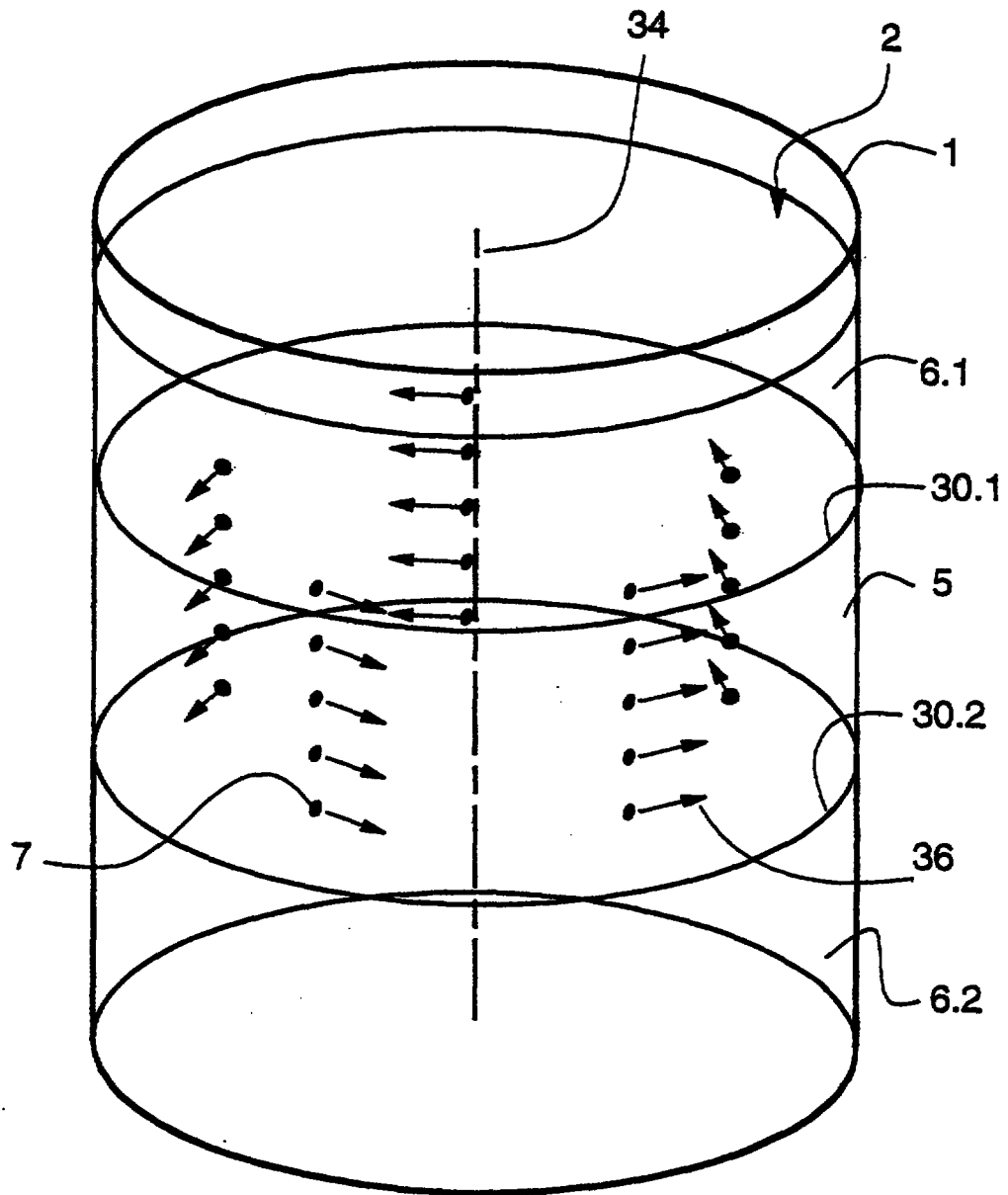


Fig. 2

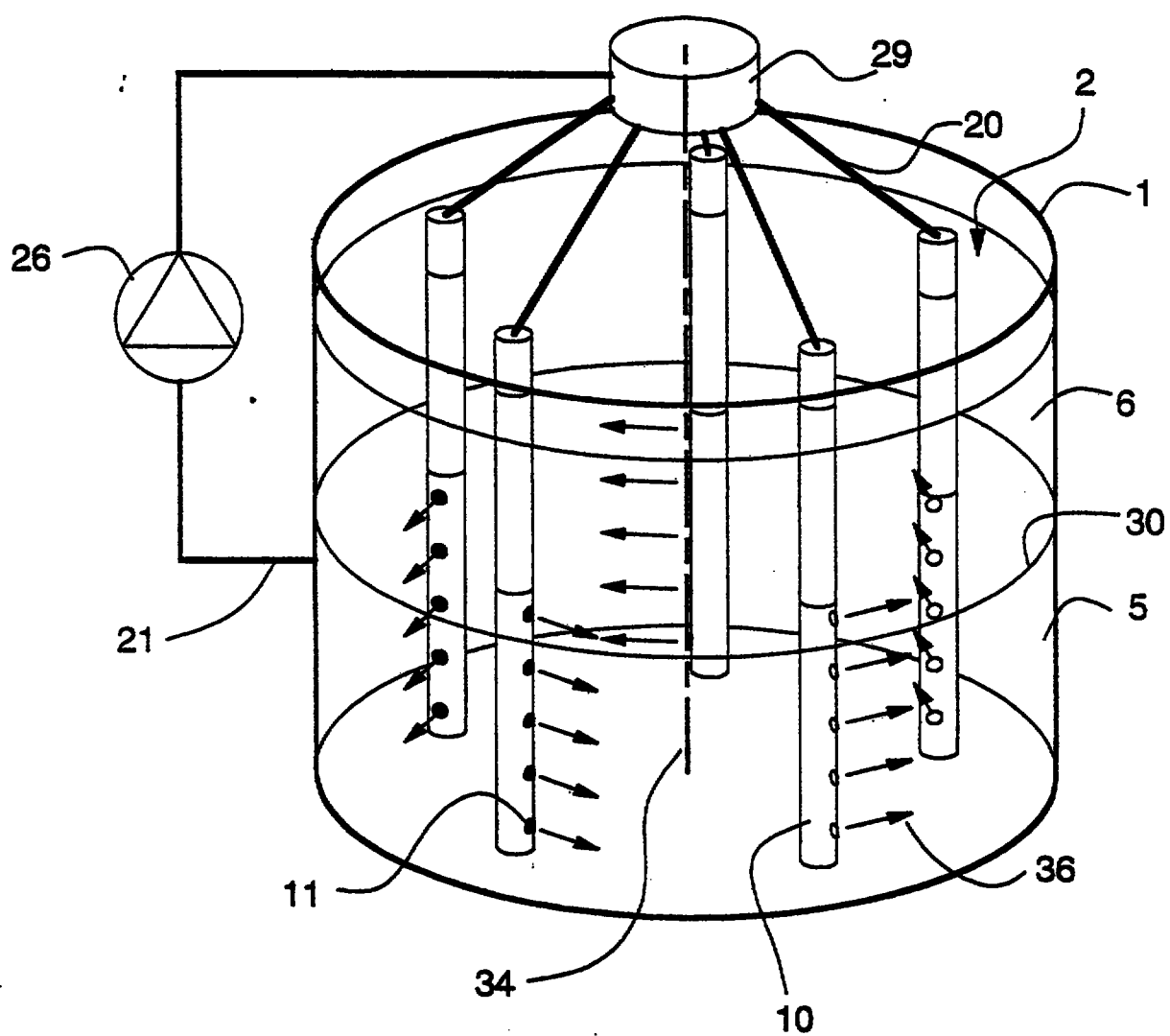


Fig. 3

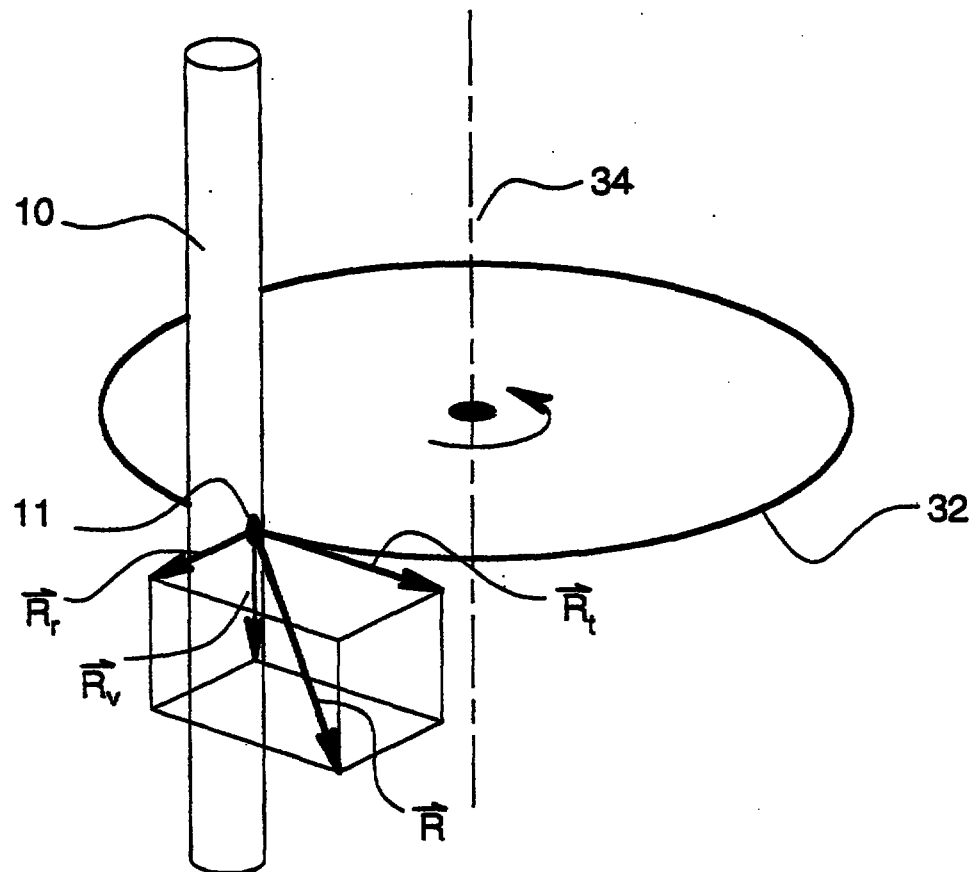


Fig. 4

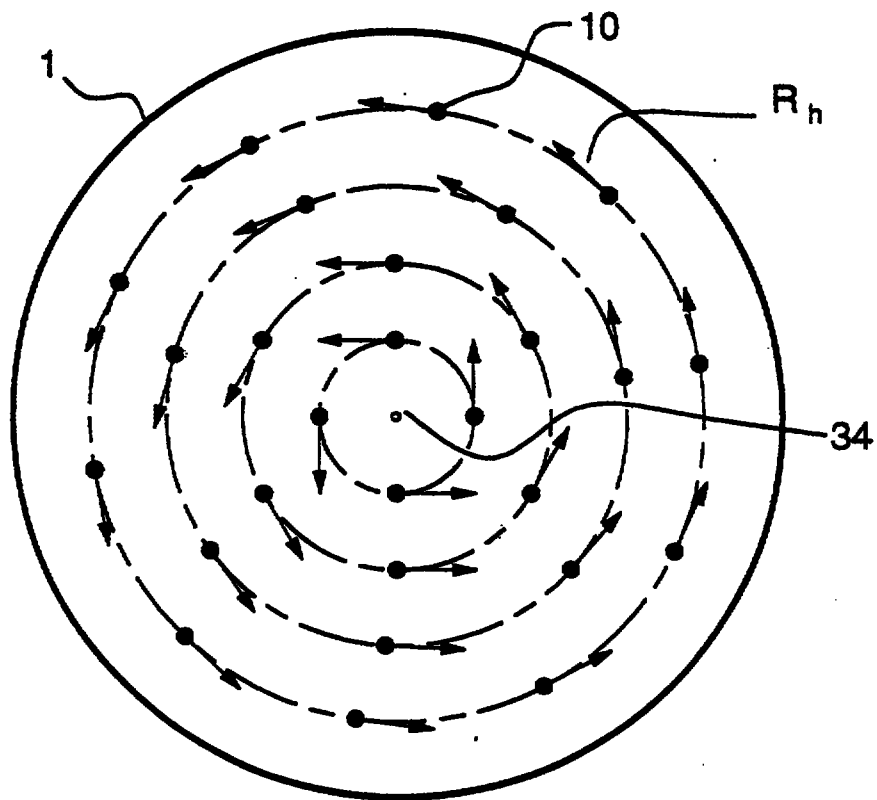


Fig.5

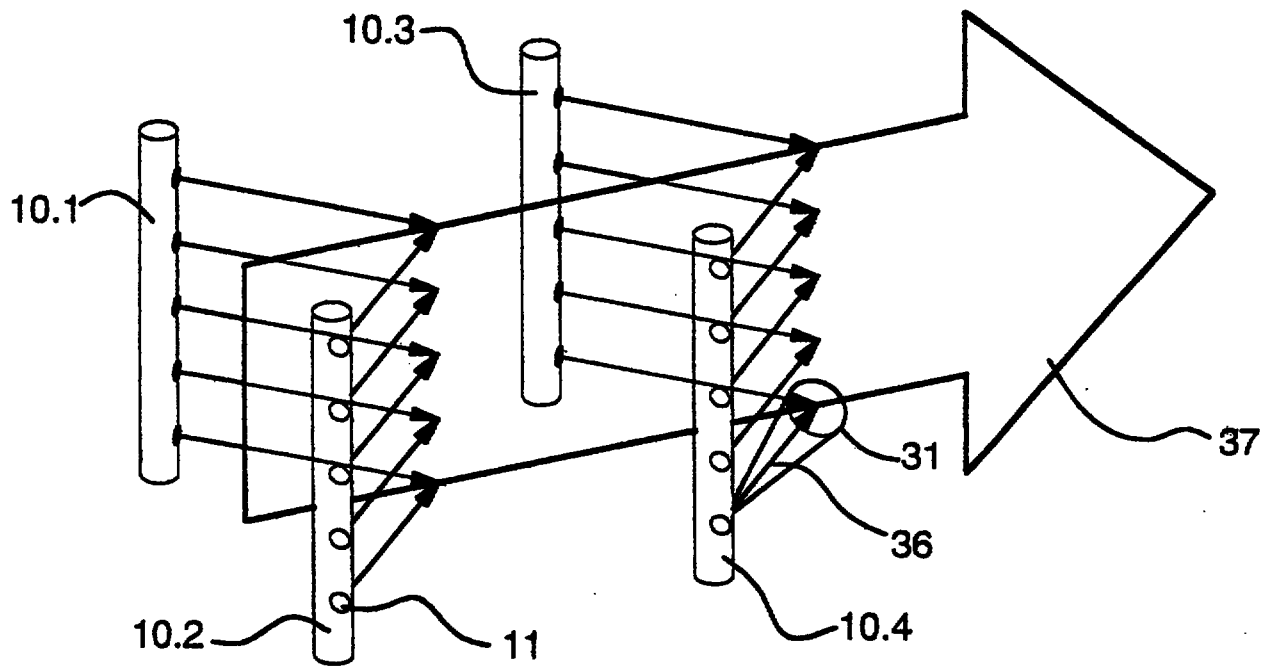


Fig. 6

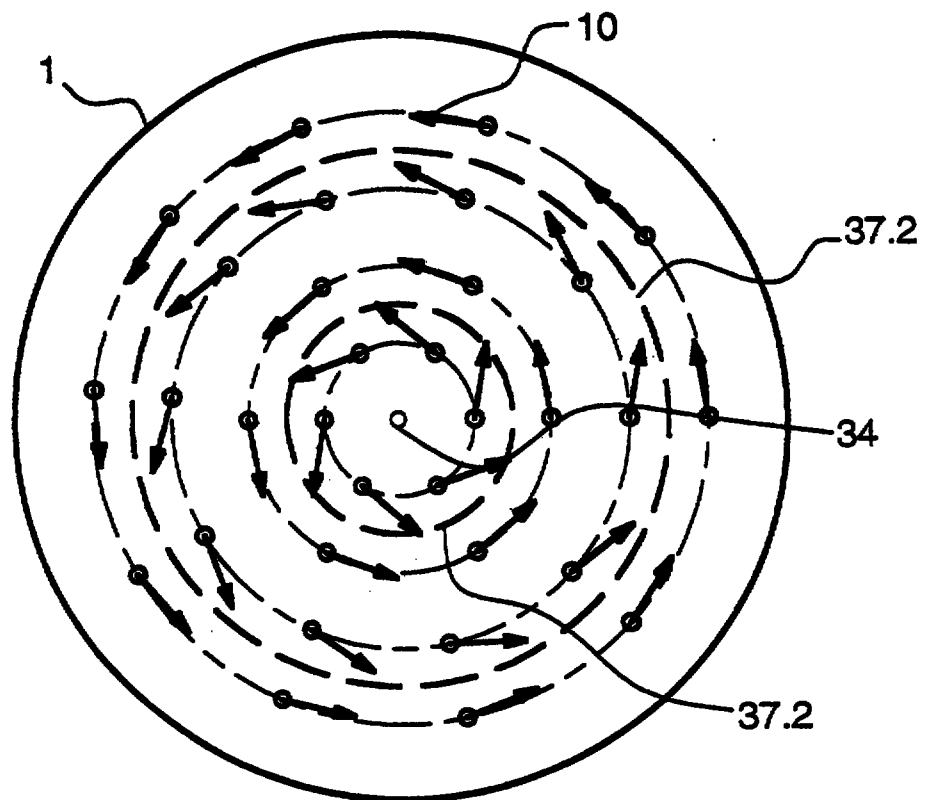


Fig.7

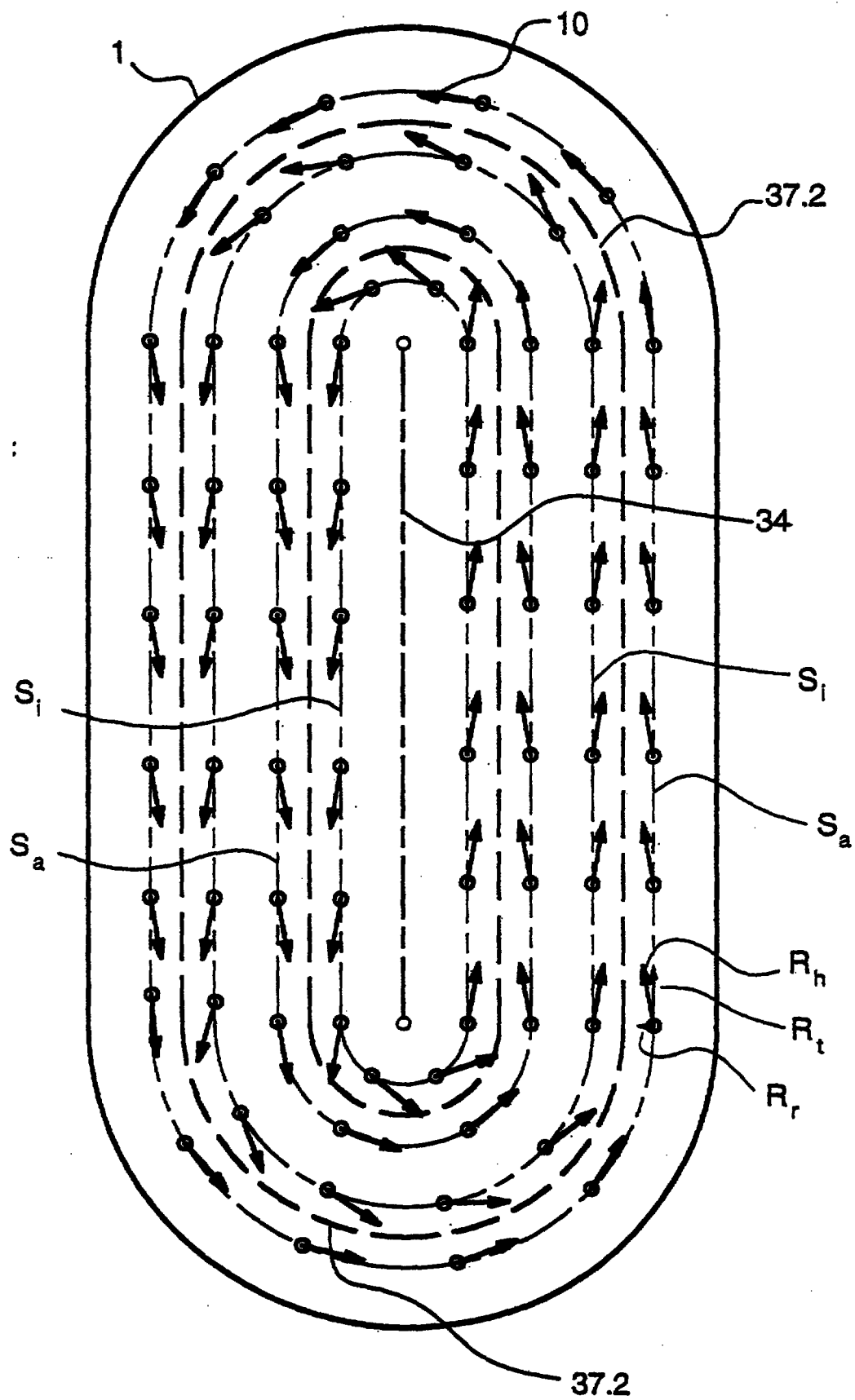


Fig.8

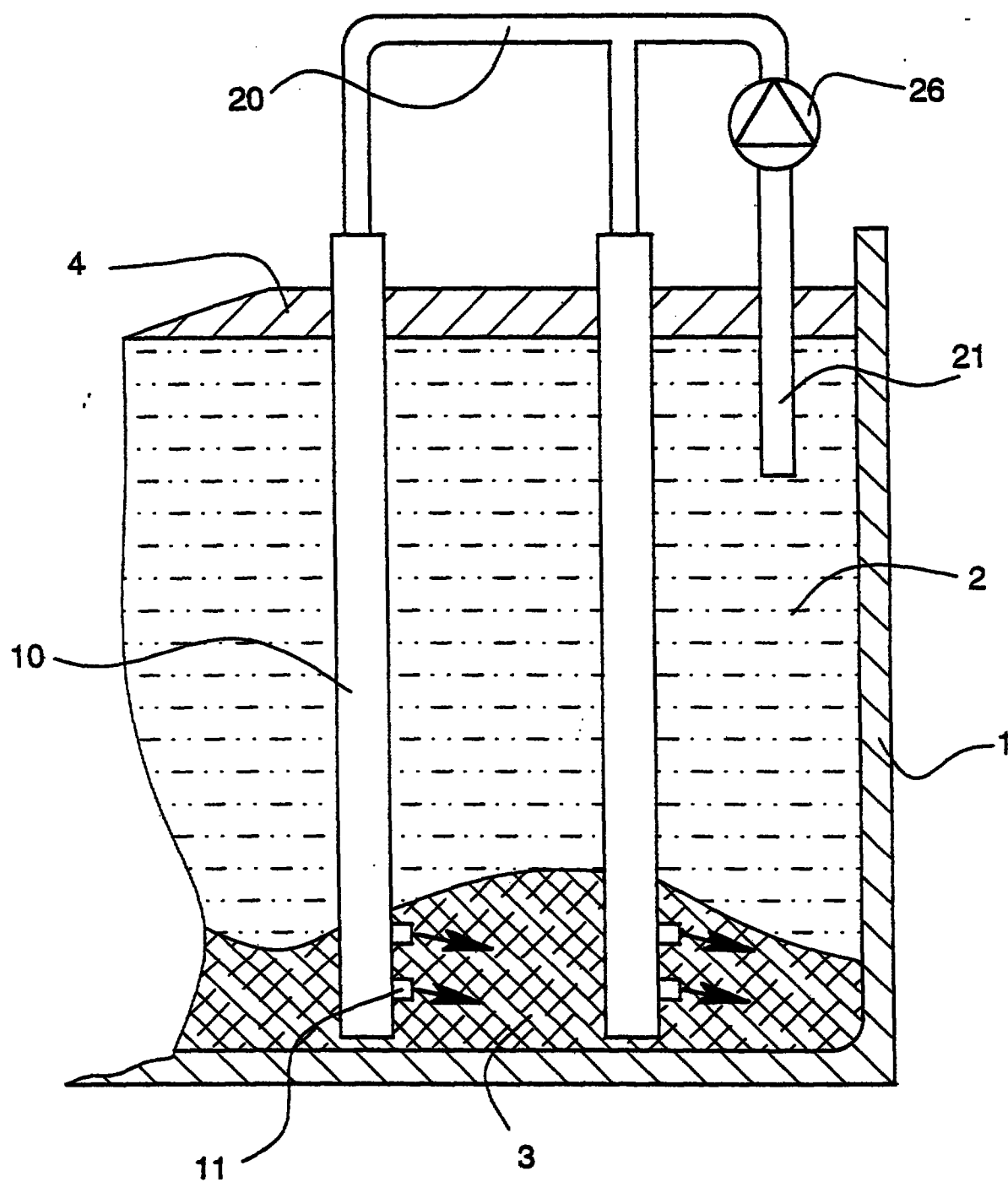


Fig.10

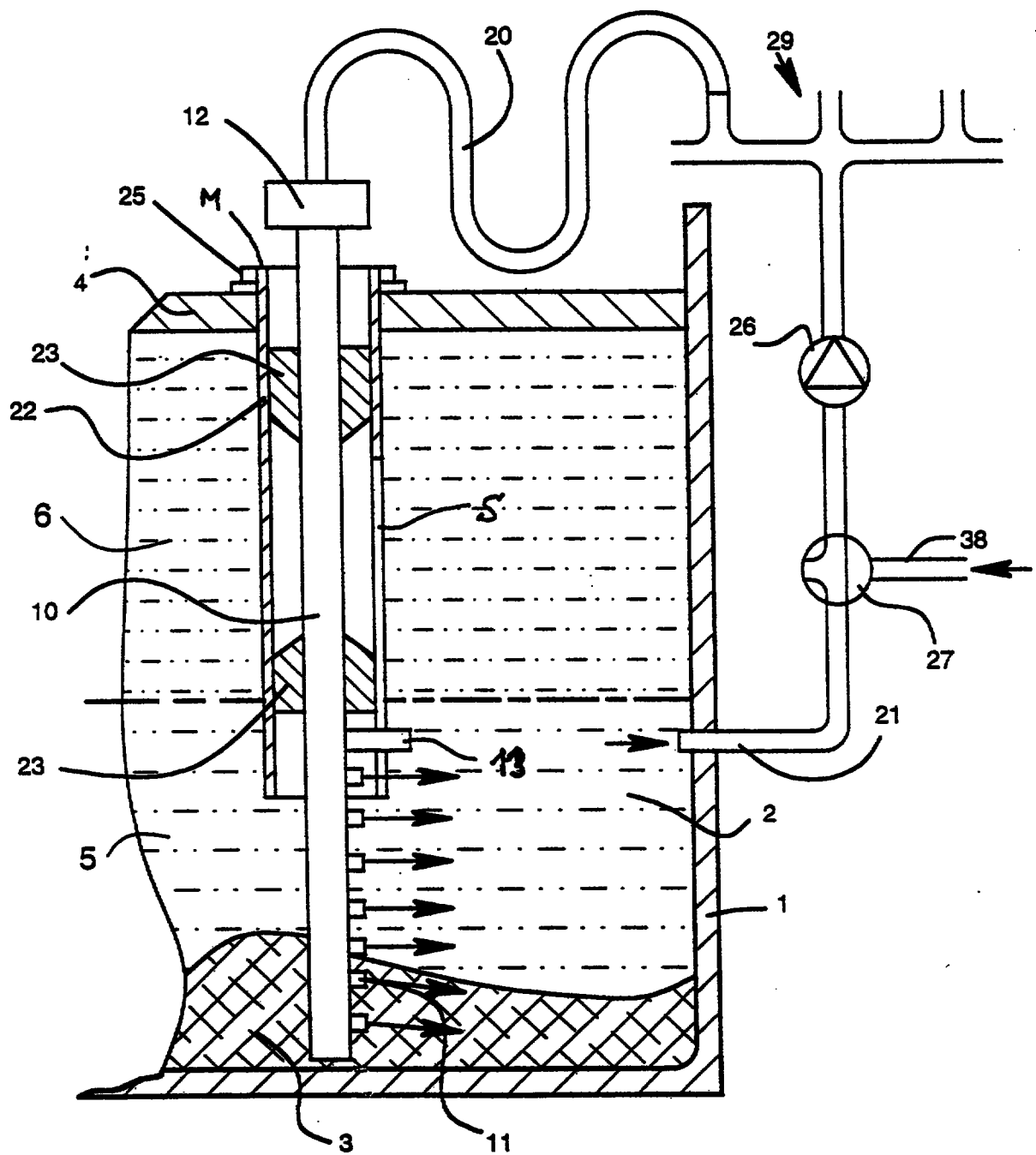


Fig.11

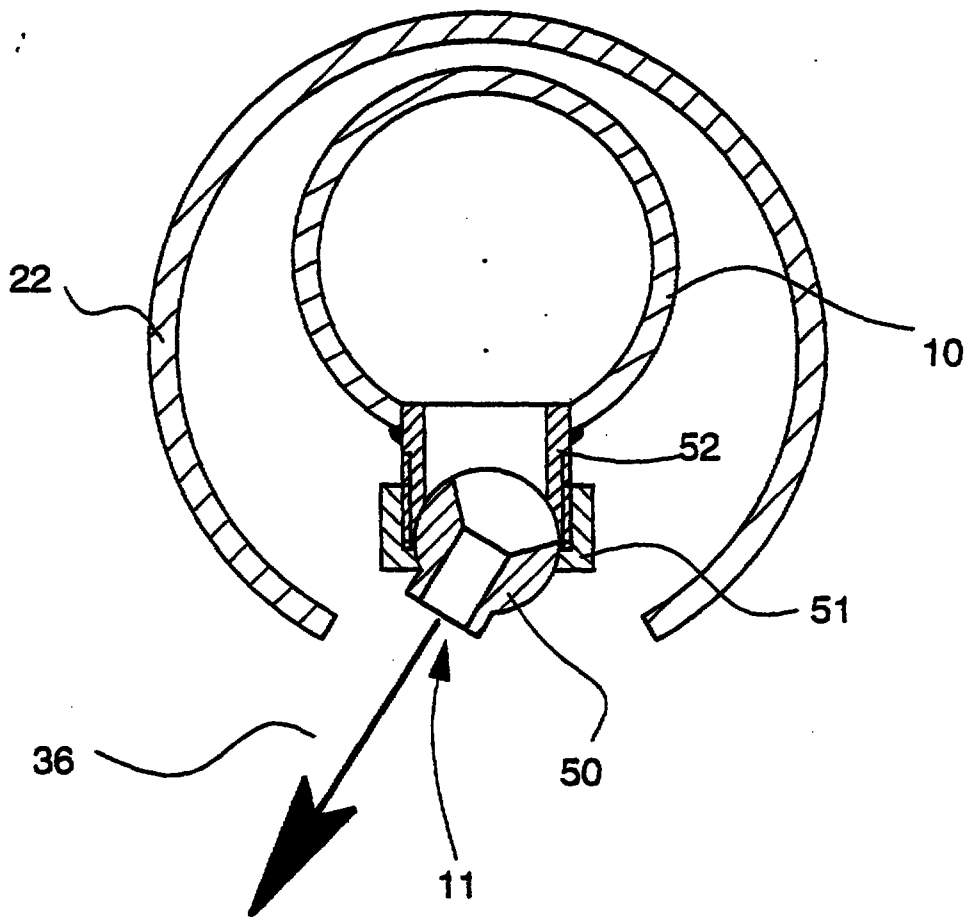


Fig. 12

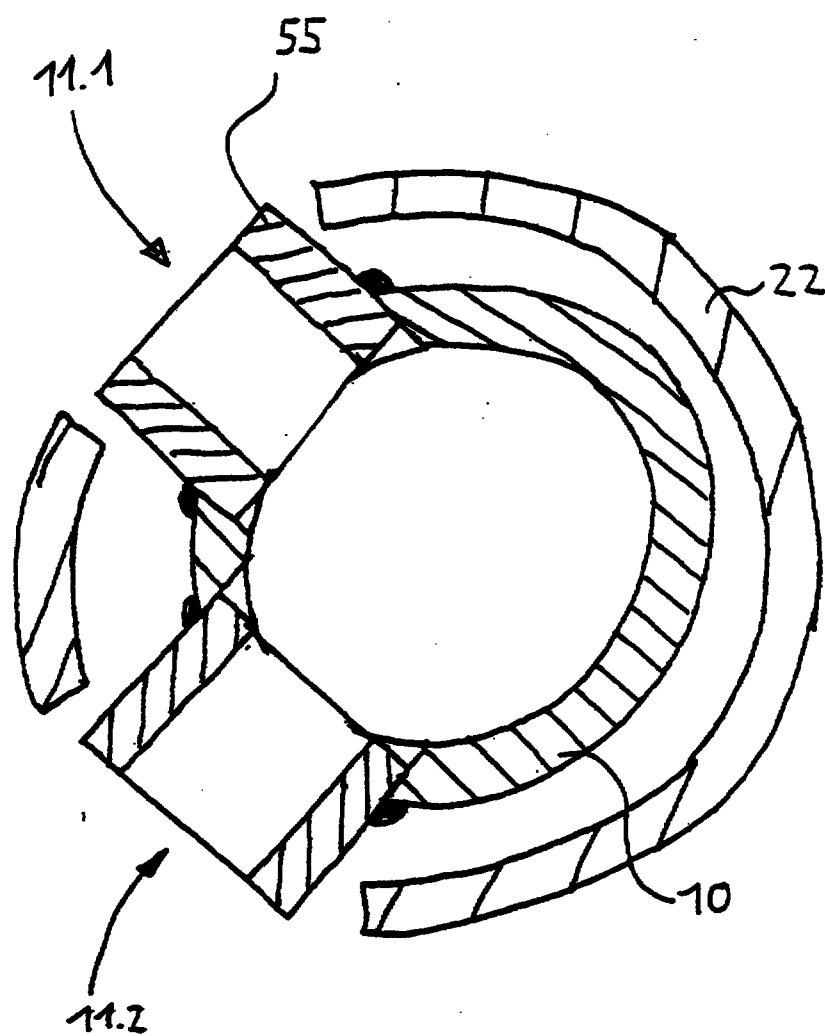


Fig. 13

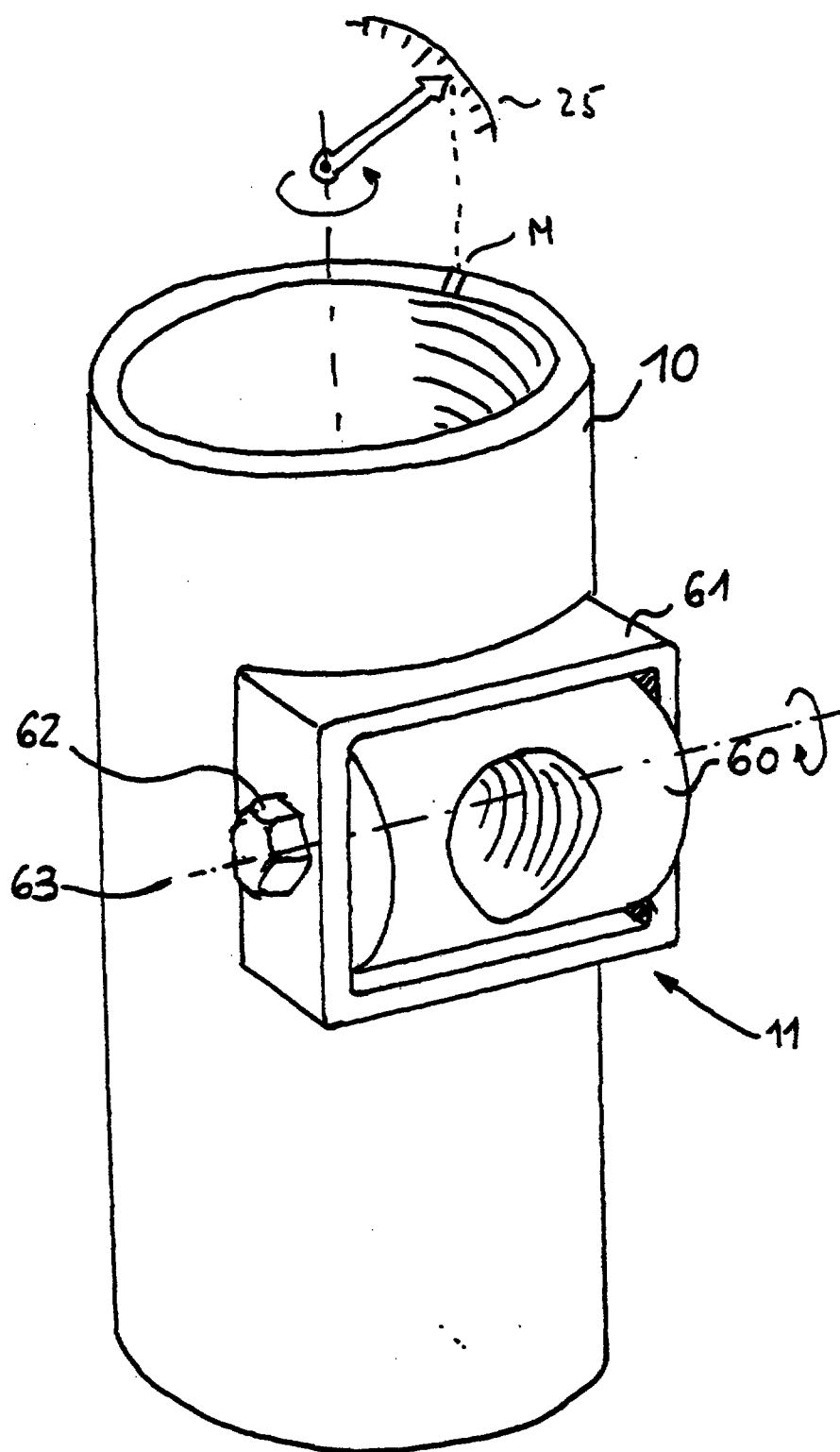


Fig. 14

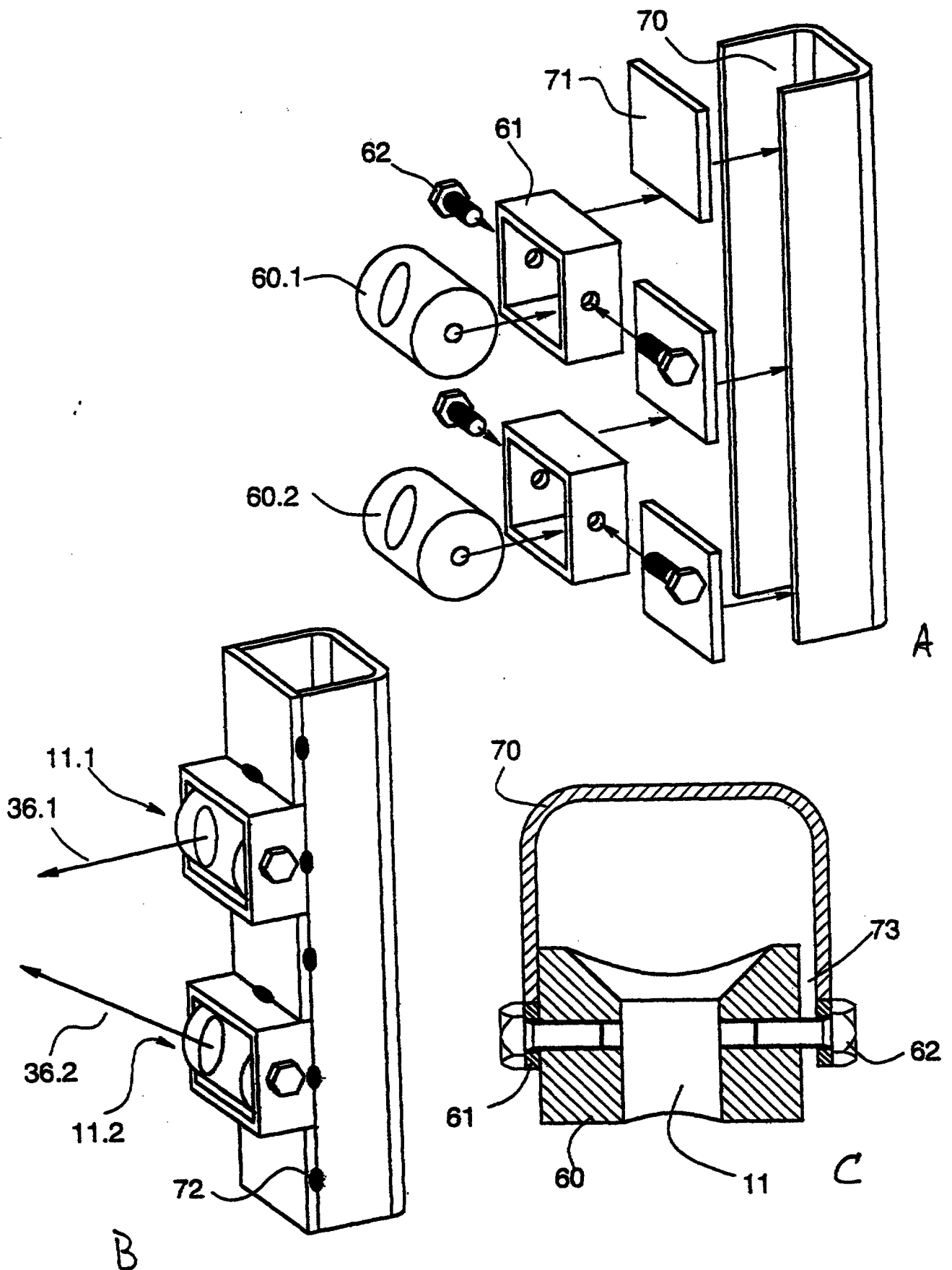


Fig. 15

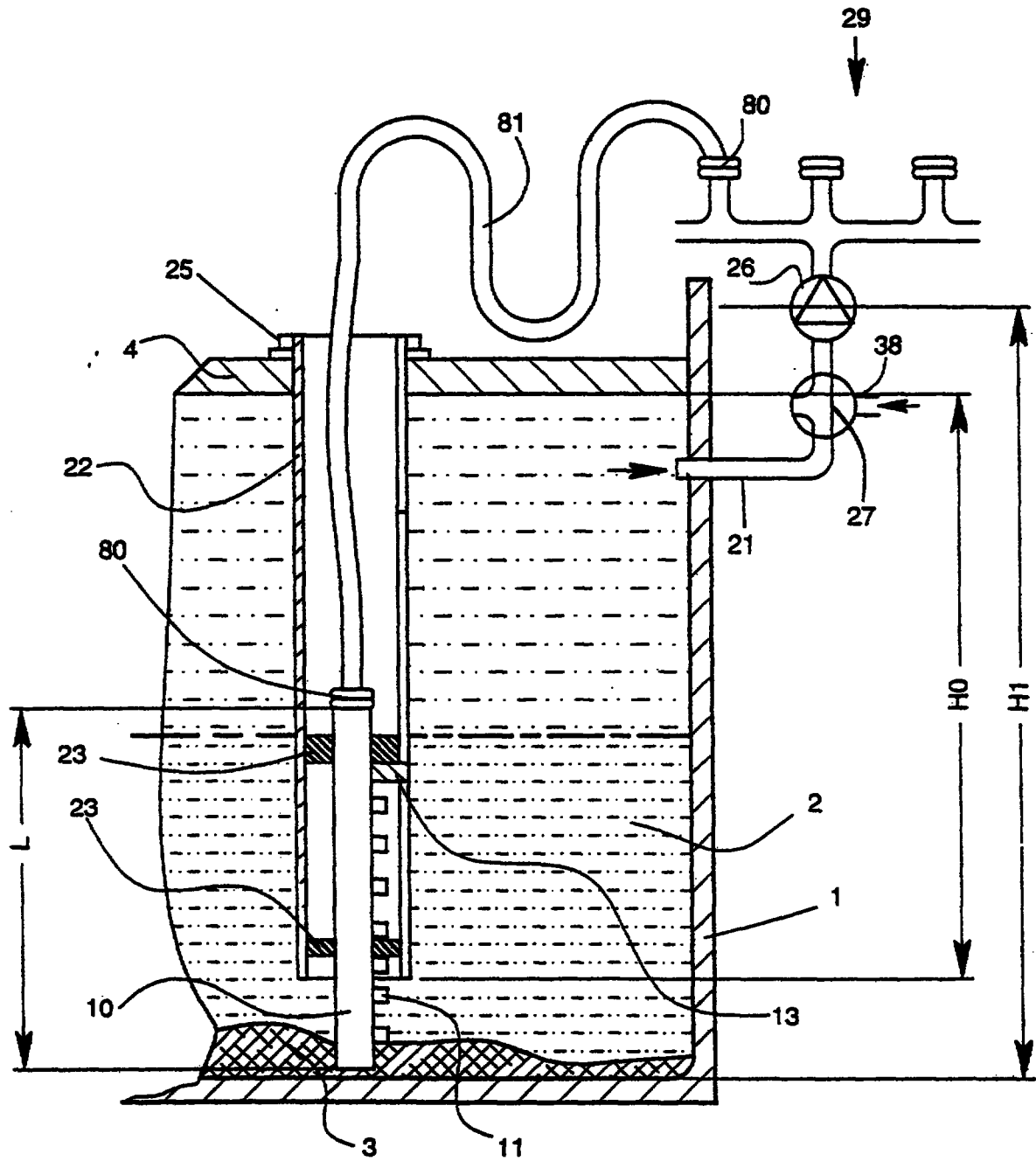


Fig.16

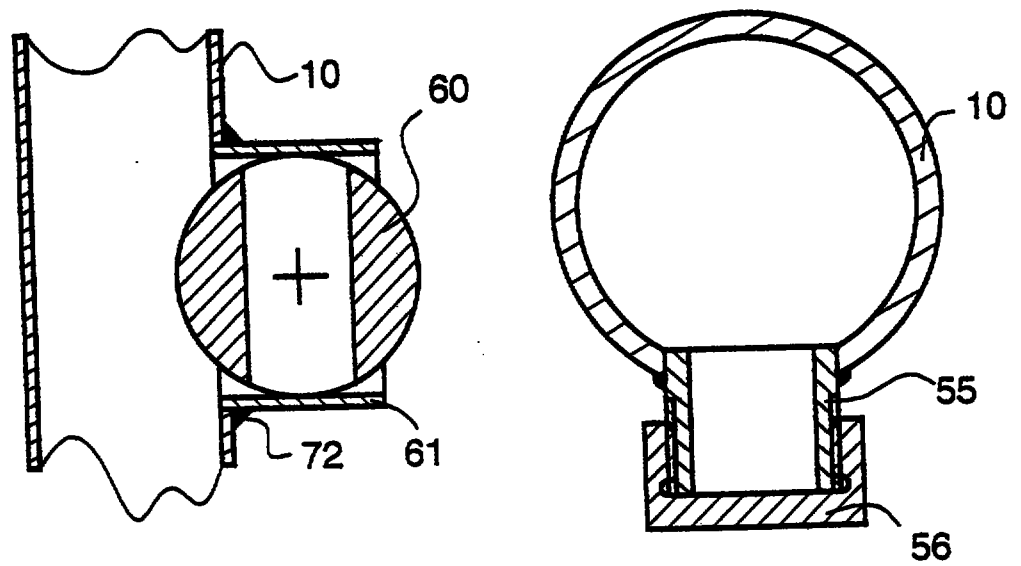


Fig. 17

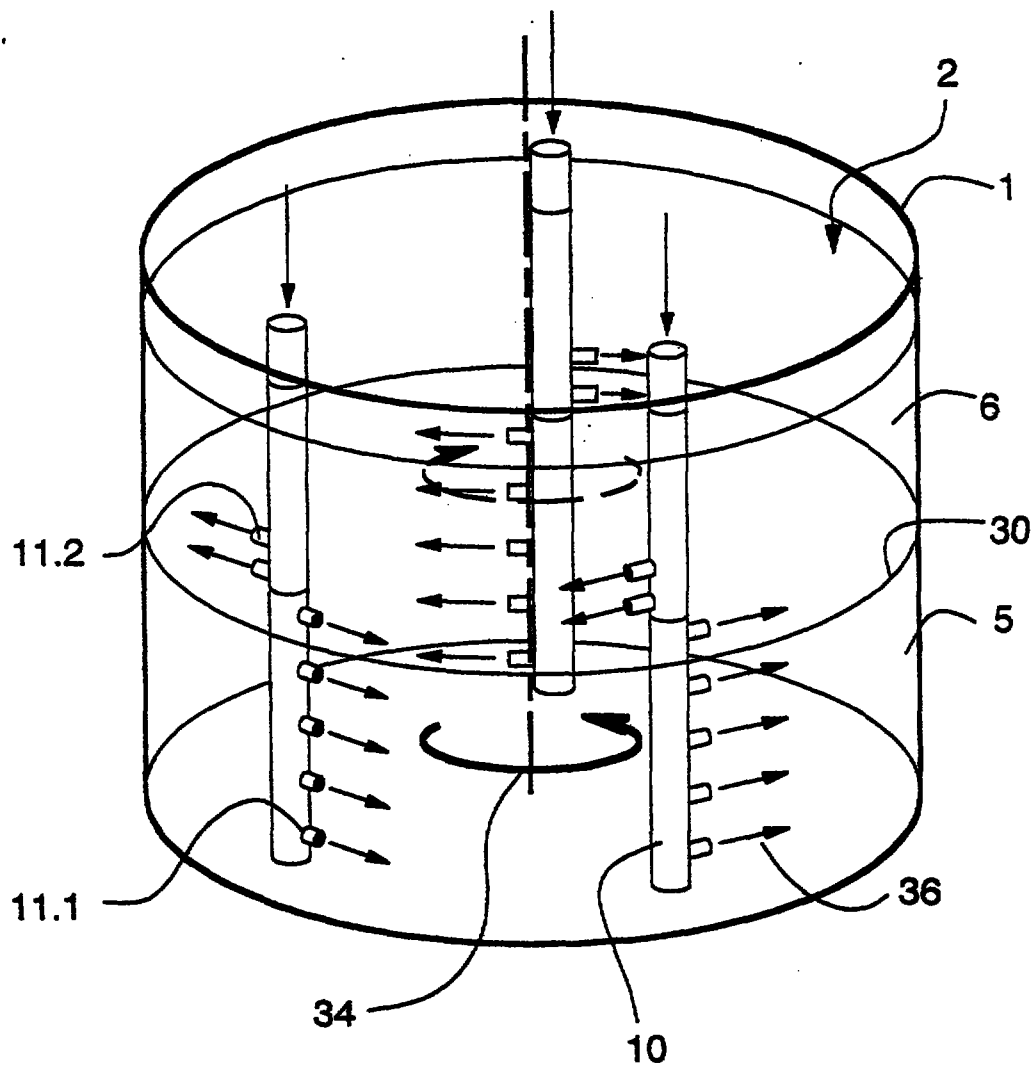


Fig. 18

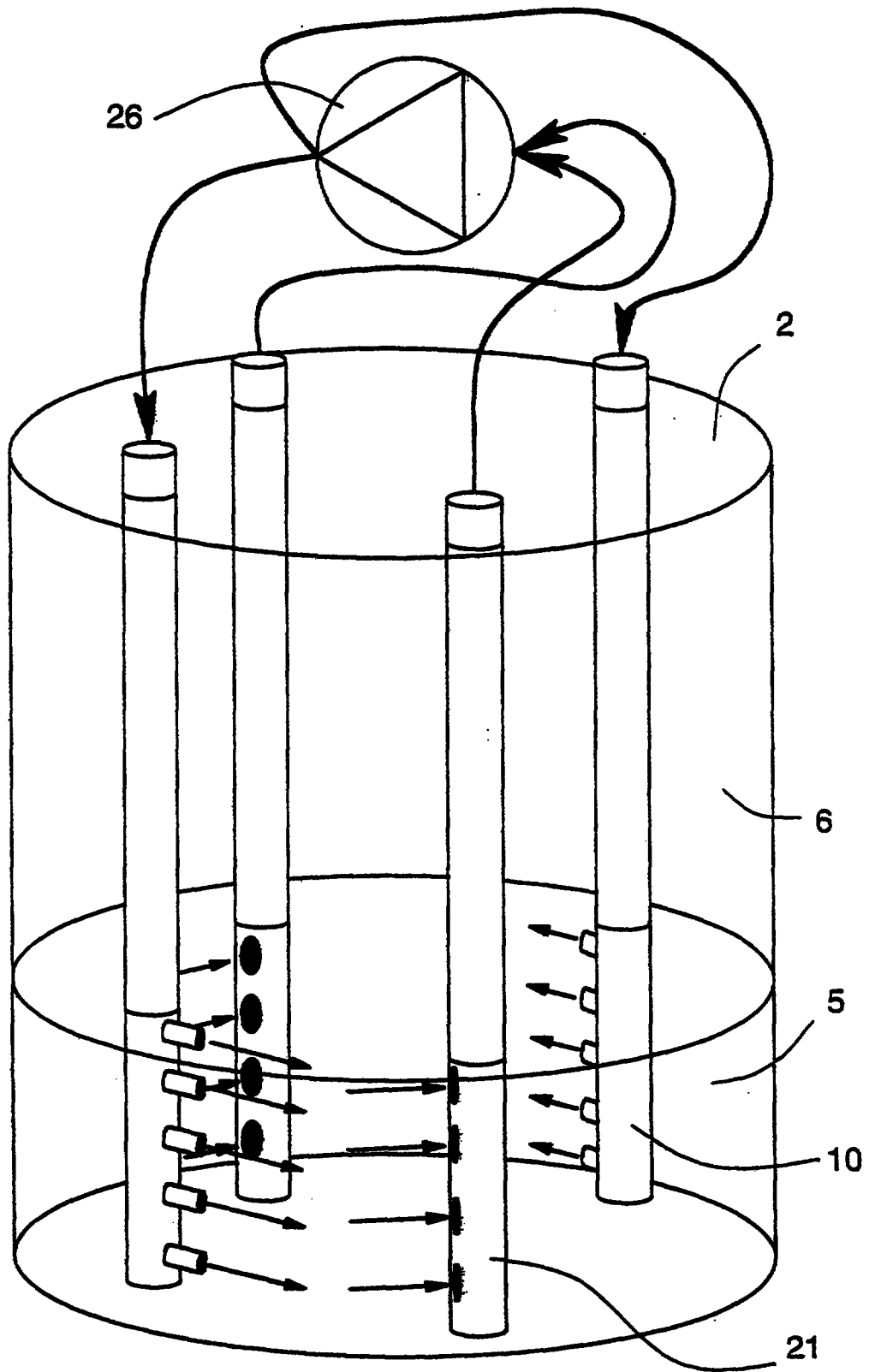


Fig. 19

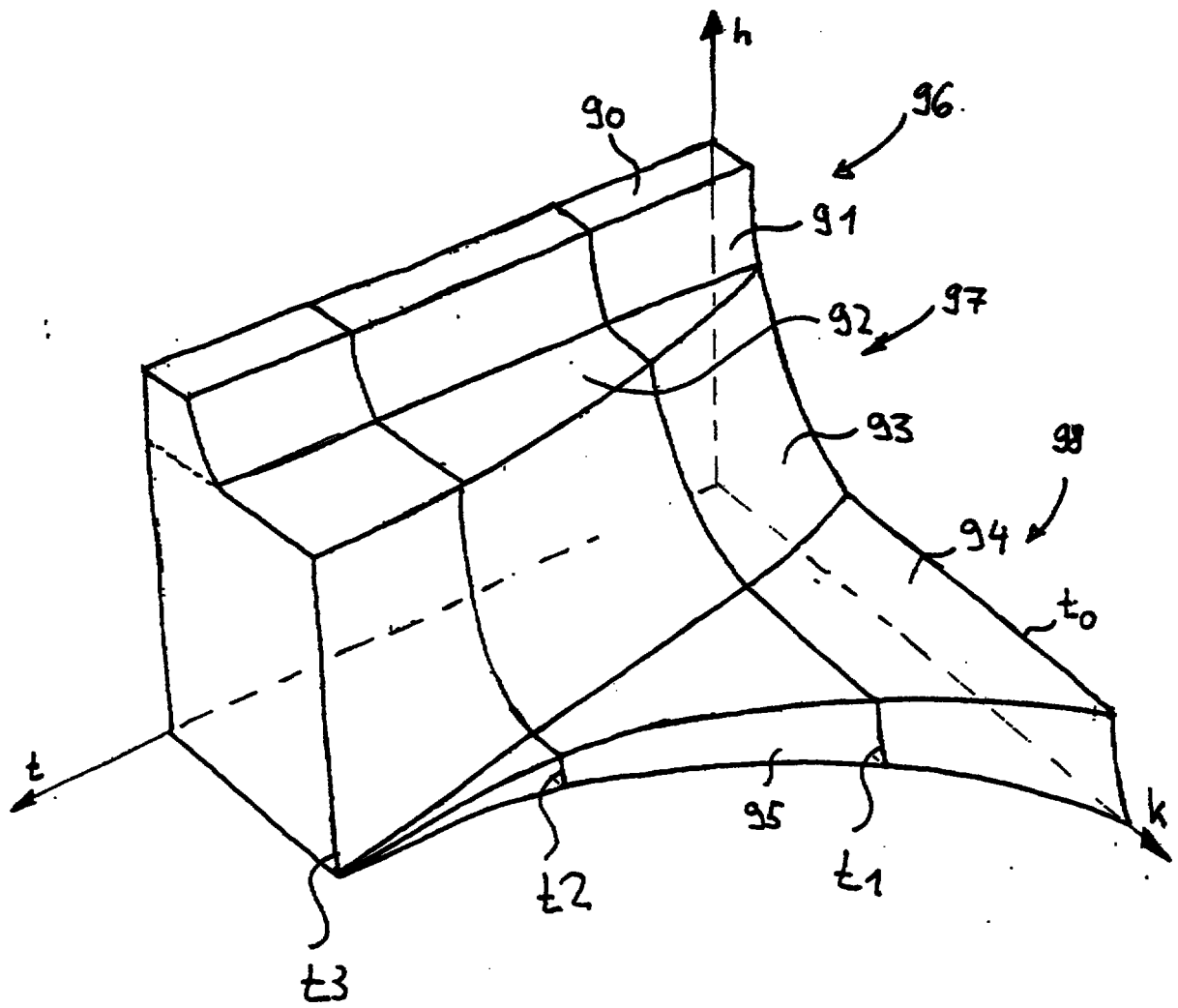


Fig. 20

Patented Apr 11, 1980

DECLARATION

I, Christoph Brogle, residing at Seestrasse 3, 8002 Zurich, Switzerland, do hereby declare that I am conversant with the English and German languages and am a competent translator thereof. I declare further that the following is a true and correct translation made by me into English of the German document attached hereto.

The Amendments made under Article 34 of PCT

Signed this 27 October, 1998


Christoph Brogle

have a jelly-like consistency and are nothing else than a heavy fraction of crude oil, the components of which are very mixable with crude oil or lighter components of crude oil or are soluble in these. The sediments, however, also contain foreign matter in form of e.g. stones or pieces of metal, mostly rust.

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For a long time, the sediments in crude oil containers as described above have been unwanted material which still today is removed from the vessels with corresponding cleaning media, mostly aqueous solutions of detergents, is
10 deposited of in more or less sensible manner or is destroyed. An example is shown in the publication US-1,978,015 (Erdman) in which a device and a method for cleaning a tank are described. The device is a rigidly mounted installation with which, after emptying the tank, a cleaning liquid or vapour is introduced for the removal of residues which have collected on the floor. The
15 liquid containing the dissolved residues are then removed by suction. Thus, the floor of the vessel is cleaned. The outlets for the cleaning medium are arranged in oblique manner and are designed such that the liquid can be sucked back through them. They have the capacity to make the introduced liquid swirl. A further example for the cleaning of a tank is shown in the
20 publication US-A-2,574,958 (Carr) according to which a kind of raft floats on the oil. On the bottom side of the raft, a mixing propeller for moving the oil is attached.³ The propeller is driven hydraulically from the outside of the tank via pressure lines. The raft is held by a cable arranged through the tank and such is prevented from floating away and from colliding with the wall of the
25 vessel due to the propeller which acts like the propeller of a ship. The mixing effect is questionable; later on, mixing propellers have been built into the vessel walls at regular distances from each other and this method is still used for smaller tanks. However, with all the means as mentioned above, recovering the crude oil bound in the residues has never been considered.

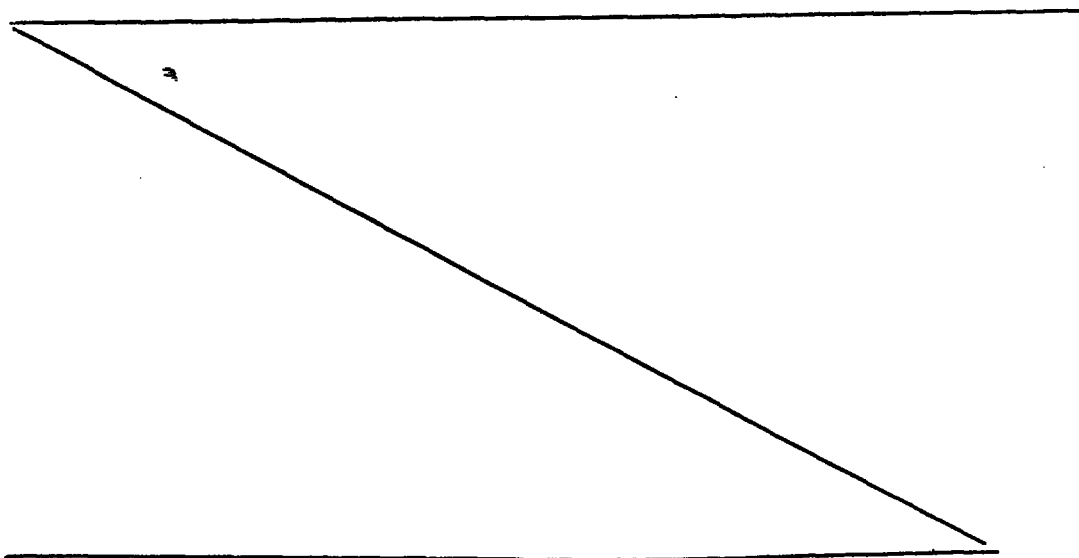
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More recently, in patent application EP-160805, a method has been described with which this kind of sediment in crude oil containers or similar storage or transport vessels can be brought into a recyclable form. For this purpose, crude oil is injected into the sediment by means of rotating heads with nozzles which heads are introduced into the sediment. Thus, over a large area the sediment is swirled round and distributed in the liquid, is made to move is dissolved at least partly. Hereby, it proves to be advantageous to match the activities of the individual nozzle heads to each other, such that due to opposite rotation, the vortices created by each nozzle head create currents.

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From the named publication (EP-160805) it can be seen that the described method is rather complicated. The reason for this is the necessary use of rotating lances with which a region as large as possible is treated with injected oil and with which the vortices are to be achieved. Regarding the use of energy and in particular regarding the device and the method for assembling it, the whole thing is relatively costly. Means, i.e. drives, for rotating the lances are required. The diluting media, the fresh crude oil must be introduced through these same lances. For the desired forming of eddies, controlling means are required to control the direction of rotation of the lances. Furthermore, this type of rotating lance is complicated mechanically and thus

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NEW CLAIMS

1. Method for recovering crude oil from thickened crude oil or from sludgy to compact sediments of crude oil in vessels in which crude oil is stored and/or transported by treating the sediment with crude oil or refinery products as solvent and at least partly liquefying and dissolving it, whereby the solvent is pressed out of nozzles (11) in order to form a current (37) which erodes the sediment (3) and dissolves it as far as it can be dissolved, characterized in that a plurality of directed liquid jets of crude oil or of derivatives thereof is created, the jets being ejected from nozzles (11) on lances (10) which are immersed in the tank (1) of crude oil, which nozzles (11) are at choice orientated such that in similar and superimposed zones the liquid jets (R) are ejected such that between them the surrounding medium gradually unites to form a joint current (37) in the desired direction.
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9. Device for carrying out the method according to one of claims 1 to 8, which device comprises at least one hollow body with a connection for supplying it with a liquid and with nozzles for ejecting the liquid under pressure, characterized in that over a part of the length of the hollow body a plurality of fixedly arranged nozzles (11) are provided, the nozzles being directed radially outward and at a distance to each other, in that these nozzles (11) are orientable or orientated such that liquid jets (R) are created at least part of the jets being substantially parallel and in that the device further comprises means (25) for rotating all the radially orientated nozzles (11) around a
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mutual axis substantially perpendicular to the ejection direction in order to interact with further devices of the same kind.

14. Arrangement of devices according to claims 9 to 13 in a vessel for 5
carrying out the method according to claim 1 wherein a plurality of
nozzles (11) is positioned in pairs on each current line of a pair of
current lines (S_1/S_2) of a created liquid current or of a current to be
created and wherein the nozzles are orientated such that a
horizontal, radial component (R_r) of the injecting direction of one 10
nozzle (11) of a pair of nozzles positioned one on each of the two
current lines is directed in an acute angle towards the injection
direction of the other nozzle of the pair and between the nozzles of a
further pair following downstream, the liquid jets (R) driving the
surrounding medium in a common direction and uniting with it to 15
form a joint current (37) and wherein for supplying the lances with
liquid one or several pumps (26) are connected to the lances (10)
and wherein for supplying the pump/s (26) with liquid, one or several
immersion pipes (21) are arranged with their suction side immersed
in the layer (5) to be made to flow or connections for sucking liquid 20
from outside of said layer are provided.

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3. Method according to claim 1 or 2, characterized in that above the sediment layer (3) a substantially horizontal liquid current more or less closed in itself is created by injecting the liquid from a plurality of nozzles (11) arranged above the surface of the sediment into the liquid resting above the sediment (3), whereby the injection direction (R) of all the nozzles is directed downward at an angle of 0 to 10 degrees in relation to the vertical and comprises a horizontal, tangential component (R_t) which is orientated tangentially to a current line of the liquid current and in the current sense. 5 10
4. Method according to claim 2 or 3, characterized in that the direction of injection of at least part of the nozzles has a horizontal, radial component (R_r) which is smaller than the horizontal, tangential component (R_t). 15
5. Method according to one of claims 1 to 4, characterized in that a substantially horizontal liquid current in form of a circular current around a current center (34) is created by a plurality of 20 correspondingly positioned ejection points.
6. Method according to claim 5, characterized in that a predetermined layer in the liquid column of the vessel is stimulated to a circular current which forms a shear plane to other sections or layers such that these other sections are substantially undisturbed by the current and ^{do not} start flowing themselves. 25 30

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7. Method according to one of claims 1 to 6, characterized in that the liquid driving the current is taken from the layer with the circular current.

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8. Method according to one of claims 1 to 6, characterized in that the liquid is crude oil or a refinery product and has a same or a smaller concentration of components of higher molecular weight than the crude oil positioned above the sediment (3).

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9. Device for carrying out the method according to one of claims 1 to 8, which device comprises at least one hollow body with a connection for supplying it with a liquid and with nozzles (11) for ejecting the liquid under pressure, characterized in that over a part of the length 15 of the hollow body a plurality of nozzles (11) are provided the nozzles being arranged fixedly and distanced from each other and being directable or directed such that substantially parallel liquid jets can be created with the aid of at least part of the nozzles being joint.

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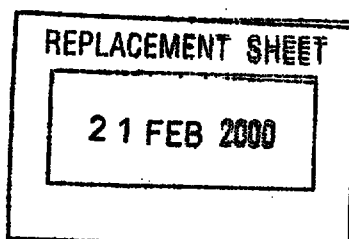
10. Device according to claim 9, characterized in that the nozzles (11) comprise means for changing the direction of ejection and are arranged on substantially vertical, hollow, pipe shaped lances (10) to 25 be introduced into the vessel.

11. Device according to claim 9 or 10, characterized in that the vertically arranged device resting on the part facing the floor of the vessel has 30 an ejection direction (R) of each nozzle (11) orientated horizontally

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CLAIMS

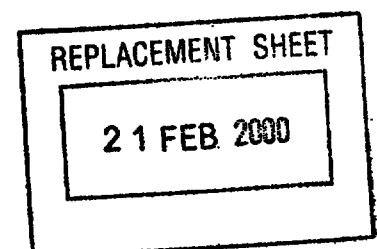
1. Method for recovering crude oil from thickened crude oil or from sludgy to compact sediments of crude oil in vessels in which crude oil is stored and/or transported by treating the sediment with crude oil or refinery products as solvent and at least partly liquefying and dissolving it, whereby the solvent is pressed out of nozzles (11) in order to form a current (37) which erodes the sediment (3) and dissolves it as far as it can be dissolved, characterized in that a plurality of directed liquid jets of crude oil or of derivatives thereof is created, the jets being ejected from nozzles (11) on lances (10) which are immersed in the tank (1) of crude oil, which nozzles (11) are at choice orientated such that in similar and superimposed zones the liquid jets (R) are ejected such that between them the surrounding medium gradually unites to form a joint current (37) in the desired direction.
2. Method according to claim 1, characterized in that a liquid current flowing substantially horizontally is created in the liquid above the sediment layer (3) by injecting the liquid to be injected into the crude oil (2) resting above the sediment (3) from a plurality of nozzles (11) directed in the same sense, whereby the injection direction (R) of all nozzles is substantially horizontal or slightly inclined towards the floor of the vessel and comprises a horizontal component (R_h) tangential to the radius of the vessel which component is tangential to a current line of the liquid current and pointing in the current sense.

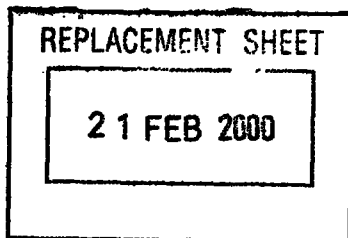


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☐	Description : paged to paged
☒	Claim(s) : paged 34 to paged 38
☐	Drawing(s) : paged to paged
☐	Abstract : paged to paged
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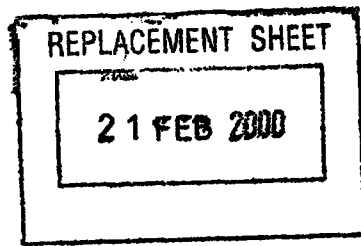


3. Method according to claim 1 or 2, characterized in that above the sediment layer (3) a substantially horizontal liquid current more or less closed in itself is created by injecting the liquid from a plurality of nozzles (11) arranged above the surface of the sediment into the liquid resting above the sediment (3), whereby the injection direction (R) of all the nozzles is directed downward at an angle of 0 to 10 degrees in relation to the vertical and comprises a horizontal, tangential component (R_t) which is orientated tangentially to a current line of the liquid current and in the current sense.
4. Method according to claim 2 or 3, characterized in that the direction of injection of at least part of the nozzles has a horizontal, radial component (R_r) which is smaller than the horizontal, tangential component (R_t).
5. Method according to one of claims 1 to 4, characterized in that a substantially horizontal liquid current in form of a circular current around a current center (34) is created by a plurality of correspondingly positioned ejection points.
6. Method according to claim 5, characterized in that a predetermined layer in the liquid column of the vessel is stimulated to a circular current which forms a shear plane to other sections or layers such that these other sections are substantially undisturbed by the current and do not start flowing themselves.





7. Method according to one of claims 1 to 6, characterized in that the liquid driving the current is taken from the layer with the circular current.
8. Method according to one of claims 1 to 6, characterized in that the liquid is crude oil or a refinery product and has a same or a smaller concentration of components of higher molecular weight than the crude oil positioned above the sediment (3).
9. Device for carrying out the method according to one of claims 1 to 8, which device comprises at least one hollow body with a connection for supplying it with a liquid and with nozzles for ejecting the liquid under pressure, characterized in that over a part of the length of the hollow body a plurality of fixedly arranged nozzles (11) are provided, the nozzles being directed radially outward and at a distance to each other, in that these nozzles (11) are orientable or orientated such that liquid jets (R) are created at least part of the jets being substantially parallel and in that the device further comprises means (25) for rotating all the radially orientated nozzles (11) around a mutual axis substantially perpendicular to the ejection direction in order to interact with further devices of the same kind.
10. Device according to claim 9, characterized in that the nozzles (11) comprise means for changing the direction of ejection and are arranged on substantially vertical, hollow, pipe shaped lances (10) to be introduced into the vessel.
11. Device according to claim 9 or 10, characterized in that the vertically arranged device resting on the part facing the floor of the vessel has an ejection direction (R) of each nozzle (11) orientated horizontally



or downward at an angle (α) and having a horizontal, tangential component (R_t) parallel to a liquid surface which horizontal tangential component is tangential to a current line of the liquid current to be driven, is orientated in flowing direction and is larger than a horizontal, radial component (R_r).

12. Device according to one of claims 9 to 11, characterized in that the lances (10) comprise on their ends facing the floor of the vessel at least one row of nozzles (11) extending over the lance length, the nozzles being arranged at a distance from each other, which nozzle row has a length of between 2 and 5 meters such that part of the nozzles (11) are positioned above the sediment surface when the lance rests on the floor of the vessel.
13. Device according to one of claims 9 to 12, characterized in that a guide (22) is allocated to each of the lances the guide being slotted at least in the outlet region of the nozzles and the lances (10) being arranged in the guide and being adjustable for nozzle orientation with the guide by being pivotable around their longitudinal axis.
14. Arrangement of devices according to claims 9 to 13 in a vessel for carrying out the method according to claim 1 wherein a plurality of nozzles (11) is positioned in pairs on each current line of a pair of current lines (S_1/S_2) of a created liquid current or of a current to be created and wherein the nozzles are orientated such that a horizontal, radial component (R_r) of the injecting direction of one nozzle (11) of a pair of nozzles positioned one on each of the two current lines is directed in an acute angle towards the injection

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direction of the other nozzle of the pair and between the nozzles of a further pair following downstream, the liquid jets (R) driving the surrounding medium in a common direction and uniting with it to form a joint current (37) and wherein for supplying the lances with liquid one or several pumps (26) are connected to the lances (10) and wherein for supplying the pump/s (26) with liquid, one or several immersion pipes (21) are arranged with their suction side immersed in the layer (5) to be made to flow or connections for sucking liquid from outside of said layer are provided.