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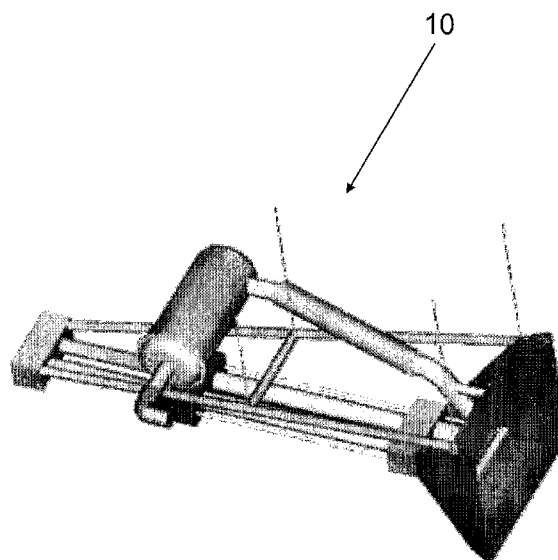
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(54) Title: SUBMERGIBLE DENSIFICATION CELL, SEDIMENT SEPARATOR AND SEDIMENT DENSIFICATION METHOD



(57) Abstract: The present invention relates to a sediment/water separator used to dredge sediment from the bottom of lakes, rivers, harbors, lagoons, tanks, dykes, reservoirs and seashore. The invention, also named submersible densification cell, dredges sediment of various types at various depths. Said sediment can vary as far as their consistency, contamination, stratigraphy, density, origin, concentration, granulometry and other aspects of its formation are concerned. The invention also relates to a sediment densification method which utilizes the submersible densification cell, resulting in an increase of 1.5 to 3 times (by weight) in the concentration of the dredged sediment, reducing the removed volume, the area necessary for deposition, and, as a result, accelerating the open-air drying process of the dredged sediment.



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Title: **"SUBMERGIBLE DENSIFICATION CELL, SEDIMENT SEPARATOR AND SEDIMENT DENSIFICATION METHOD"**

The present invention relates to a sediment/water separator used to dredge sediment from the bottom of lakes, rivers, harbors, lagoons, tanks, dykes, reservoirs, seashore and effluent treatment plants. It can also be used in the environmental field, in building construction, in chemistry and in other fields whenever the separation and removal of sediment particles are required.

**State of the Art**

Techniques for removing sediment particles deposited in the bottom of water reservoirs were developed in the prior art and are widely known and used nowadays.

Canadian patent application CA 2534156 describes an apparatus for sediment removal and a method for removing sediment from bodies of water by using a versatile and controllable device, in a manner that avoids generating unwanted turbidity. By using a suction pump and with the aid of compressed air, water and sediment drawn through a conduit are transported to retention containers and removed by tank trucks for subsequent treatment. The equipment which is the object of said Canadian application enables sediment removal from depths greater than 25 feet.

Patent application DE 4416591 concerns a method for cleaning polluted sediment in bodies of water and equipment for implementation of said method. During the operation, the equipment in question remains on a floatable platform while the sediment is sucked up from the bed with the aid of compressed air and conducted to a main pipe. The sediment is removed by mechanical, hydraulic or pneumatic means and then dried and transported for subsequent treatment. External turbidity is avoided through the use of light material which remains in water, forming a protective ring that isolates the working area.

Patent application WO 02/057551 describes a method for hydraulic subsea dredging of sediment from areas of the sea bottom, water reservoirs etc, including a first operational step in which the sediment is suc-

ked or pumped through a pipe to a second level located below the natural water surface utilized to enhance the required suction or pump capacity. At said second level, the sediment is stored in a container being accessible by mechanical equipment arranged over the water surface, from which container the sediment is removed by conventional pumps or by other conventional removal methods.

Document US 5421105 is directed to dredging, and, more particularly, to a closed circuit dredging system which circulates the water removed from a dredging area back to the dredging apparatus to mix with the dredged solids so as to prevent clogging of the dredging apparatus. The proposed system allows a continuous sediment dredging with a minimal disturbance of the surrounding areas, minimizing its influence on the ecosystem.

Although other relevant documents can be found in patent literature, the described equipment and removal methods share the same drawback, namely, the need for exhaustive subsequent treatment of the dredged material. Said subsequent treatment includes the utilization of large drying areas or dredged material sedimentation tanks, as solids must be separated off from the liquid portion which was also dredged.

The invention in question is within the abovementioned context. The invention described herein is named "submergible densification cell "; it dredges sediment from the bottom of water reservoirs at various depths, without causing turbidity of bodies of water and with simultaneous densification of dredged material, reducing the need for subsequent treatment aimed at separating off water from sediment.

The invention involves a pumping system equipped with a densification cell which is responsible for the densification of the solids encountered in the pumped water. The solid-liquid mixture obtained in the external tank will have a higher concentration of solids than the mixture which is traditionally obtained. In addition, said densification cell minimizes turbidity of the aqueous system, avoiding major damage to the ecosystem.

### **Objects of the Invention**

The present invention is directed to a submergible densification

cell the aim of which is to remove sediment from the bottom of lakes, rivers and other bodies of water. Said removal is preceded by densification, that is, higher concentration of said sediment so it can further be dredged from the bottom of said bodies of water.

5                    **Brief Description of the Invention**

The objects of the present invention are achieved by providing a submergible densification cell 10 comprising:

- a) a sediment collection area 1 having a front section 11 delimited by an area A1 and a back section 12 delimited by an area A2;
- 10 b) at least one suction and ejection pipe 2 associated with the back portion 12 of the sediment collection area 1;
- c) at least one suction pump associated with the suction and ejection pipe 2;
- d) an oscillator valve 4 associated with the suction and ejection pipe 2;
- e) A conduit to eject the dense sediment 5.

15                    wherein the relation between A1 and A2 of the front section 11 and of the back section 12 comprises an absolute value between 8 and 120.

In addition, the objects of the present invention are achieved by a sediment separator which comprises the above defined submergible densification cell 10.

20                    Further, the objects of the present invention are achieved by a sediment densification method which utilizes the above defined submergible densification cell 10.

**Brief Description of Drawings**

25                    The present invention will be further described in more details based on one example of execution represented in the drawings. The figures show:

Figure 1 – view in perspective of the submergible densification cell 10.

30                    Figure 2 – view in perspective of the sediment collection area 1 having a front portion 11 delimited by an area A1 and a back portion 12 delimited by an area A2.

Figure 3 - view in perspective of the sediment collection area 1

having a front portion 11 delimited by an area A1 in highlight and a back portion 12 delimited by an area A2 in highlight.

Figure 4 – schematic view of the sediment/water separation system including the submergible densification cell 10 and a vessel 80 with shroud lines.

Figure 5 – detailed view of the submergible densification cell 10, where the hydraulic piston 3, the oscillator valve 4, the suction and ejection pipe 2 and the conduit to eject the dense sediment 5 can be seen.

Figure 6 – view in perspective of the oscillator valve 4 associated with the suction and ejection pipe 2.

Figure 7 – front view of the sediment collection area 1 comprising a rotary mixer 6.

Figure 8 – view in perspective of the sediment compressor 7 in cooperation with the outlet conduit 5 and comprising an air inlet area 72 and a water outlet area 73.

Figure 9 – detailed view of the sediment compressor 7, of the outlet conduit 5 and of the draining cone 71.

Figure 10 – graph demonstrating the concentration values pursuant to table 1.

Figure 11 – view in perspective of a preferred embodiment of the sediment collection area 1.

Figure 12 – view in perspective of another preferred embodiment of the sediment collection area 1 which utilizes a lid 90.

### **Detailed Description of the Invention**

The invention relates to a submergible densification cell 10, also called a sediment/water separator, which dredges sediment from the bottom of water reservoirs and/or natural/artificial water courses. The invention can be used to dredge sediment from the bottom of lakes, rivers, harbors, lagoons, tanks, dykes, reservoirs, seashore and effluent treatment plants at various depths. Said sediment can vary as far as its consistency, contamination, stratigraphy, density, origin, concentration, granulometry and other geological aspects of its formation are concerned.

As no turbulent flow is verified with the use of the densification cell in question to dredge sediment 10, the use of plastic barriers, stoplogs or cutoffs - which are currently necessary in conventional dredging methods - can be eliminated. When the current methods are used, turbulent flow is verified in the aqueous or solvent medium due to the high speed of sediment dredging and sediment removal of said methods, which make the finest sediment particles whirl and scatter. If the sediment is contaminated, the problem becomes insoluble and any current dredging method becomes unfeasible. Thus, the densification cell provides the only viable solution to contaminated sediment dredging.

The advantage of the present invention lies in the fact that sediment can be removed without causing any turbulent flow in water or solvent. Accordingly, the use of plastic barriers, stoplogs or cutoffs - which are currently necessary in conventional dredging methods - can be eliminated. Furthermore, said method has another advantage because the concentration (by weight) of the dredged sediment is increased in 1.5 to 3 times, accelerating the open-air drying process of the dredged sediment and eliminating the need for a large deposition site, due to the significant reduction in volume at removal stage. On the other hand, the drying process of the sediment dredged through conventional methods requires a large deposition location and a much longer drying process.

The densification cell 10, object of the present invention, densifies in-water bottom sediment, separating off the solids from the water and increasing their concentration. The method reduces substantially the amount of water (or any other solvent) involved in the transportation of the sediment at the removal stage. The concentration of the bottom sediment increases from, for instance, 5% in average to 10% -15% at the removal stage. The densification cell 10 does not return the water to the sediment point of origin; drying occurs by evaporation. Open-air drying of a type of sediment whose increase in concentration (weight) occurs rapidly does not require large deposition locations due to the significant reduction in volume at the removal stage. Current conventional dredging with high flow rates of about 150 m<sup>3</sup>/h

has a concentration of about 1 percent and involves the use of a large amount of water for sediment removal, which must be recirculated. Thus, a large deposition location is required for the drying process that will be time-consuming (years).

5                   Due to its design, the densification cell 10 allows the utilization of the bodies of water (lakes, lagoons, rivers, etc.) during its operation, that is, at the removal stage. Due to the use of large amounts of water, the current dredging and removal methods demand temporary interruption in the utilization of the aquifers, resulting in disturbance and additional costs.

10                   Said cell 10 can operate at great depths. It works on flat ploughings and with accurate depth. The densification cell 10 removes the sediment with a precise depth. Dredging apparatus currently used in demolition sucks up sediment at a high flow rate, digging "caves" (wells) in an uncontrollable and inefficient manner.

15                   The densification cell of the present invention comprises:

a) a sediment collection area 1 having a front section 11 delimited by an area A1 and a back section 12 delimited by an area A2;

b) at least one suction and ejection pipe 2 associated with the back section 12 of the sediment collection area 1;

20                   c) at least one suction and ejection pump 3 associated with the suction and ejection pipe 2;

d) an oscillator valve 4 associated with the suction and ejection pipe 2 and

e) a conduit to eject the dense sediment 5, wherein the relation between the areas A1 and A2 comprises an absolute value between 8 and 120 .

25                   Preferably, the relation between areas A1 and A2 of the densification cell 10 of the present invention comprises an absolute value between 8 and 15. More preferably, the relation between areas A1 and A2 of the densification cell is 10.

30                   The densification cell 10 of the present invention causes primary densification, that is, an increase in the concentration of the fine submerged sediment. This is due to a drastic area reduction (around at least 8 times) of sections 11 and 12 of the sediment collection area 1 delimited by the areas

A1 and A2, as shown in figures 2 and 3, when said sediment undergoes the pressure generated by the suction and ejection pump (piston) 3, making it enter the front section 11 of the sediment collection area 1 delimited by area A1 which is, at least 8 times larger than area A2 which delimits the back section 12 of the sediment collection area 1. The great suppression generated by the loading in a confined space causes an increase in pressure between the sediment particles and the cell walls, expelling the interstitial water trapped in the sediment to the aqueous medium (in the event water is the predominant liquid medium).

Preferably, area A1 which delimits the front section 11 of the sediment collection area 1 of the densification cell 10 of the present invention has a maximum value of 50 m<sup>2</sup>. More preferably, area A1 has a maximum value of 8 m<sup>2</sup>. Even more preferably, area A1 has a value of 6 m<sup>2</sup>. Area A2 which delimits the back section 12 of the sediment collection area 1 of the densification cell 10 of the present invention has, preferably, a maximum value of 0.8 m<sup>2</sup>. More preferably, area A2 has a value of 0.3 m<sup>2</sup>. However, the relation between area A1 and area A2 must forcefully be an absolute value between 8 and 120, as previously mentioned.

So as to ensure suitable primary densification, that is, so as to ensure that a smaller amount of water enters the densification cell itself 10 through the "wall" of the dense material, said areas A1 and A2 should preferably lay parallel and distant to one another according to the following formula:

wherein: 
$$d \geq C \times Q \times \left( \frac{A_1}{A_2} \right)$$

*d* = distance between the areas [m]

*C* = constant of the material to undergo densification

*Q* = suction flow rate [m<sup>3</sup>/h]

*A*<sub>1</sub> = area 1 - area which delimits the front section 11 of the sediment collection area 1 [m<sup>2</sup>]

*A*<sub>2</sub> = area 2 - area which delimits the back section 12 of the se-

*sediment collection area 1 [m<sup>2</sup>]*

and:wherein:  $Q = v \times A_1$

*v = suction velocity [m/h]*

Constant C is an absolute value which ranges from 0.002 to  
5 0.004 and depends on the type of material to be introduced in the densifica-  
tion cell. For organic clay, the value of the constant C is approximately 0.002.  
For the mud generated in an effluent treatment plant, the value of C is a-  
round 0.003.

In the submergible densification cell 10 of the present invention,  
10 the front section 11 of the sediment collection area 1 and the back section 12  
of the sediment collection area 1 preferably keep a mutual distance of 2.0  
cm to 10 m. Preferably, the distance between the front section 11 of the se-  
diment collection area 1 and the back section 12 of the sediment collection  
area 1 ranges from 50 cm to 1.10 m. Even more preferably, the distance  
15 between the front section 11 of the sediment collection area 1 and the back  
section 12 of the sediment collection area 1 is 1.0 cm.

In the submergible densification cell 10 of the present invention,  
the water/sediment mixture is sucked by a suction and ejection pump 3 as-  
sociated with the suction and ejection pipe 2. The suction and ejection pump  
20 3 of the submergible densification cell 10 comprises at least a piston. Prefe-  
rably, the submergible densification cell 10 of the present invention compri-  
ses two pistons; each of said piston is located inside its respective suction  
and ejection pipe 2.

In a preferred embodiment of the present invention, the two pis-  
25 tons which comprise the suction and ejection pump 3 work alternately, that  
is, while one piston sucks up the sediment and places it inside the suction  
and ejection pipe 2, the other piston makes the inverse movement, that is, it  
expels the sediment that has already been sucked up and sends it to the ou-  
tlet conduit 5 through an oscillator valve 4.

30 The oscillator valve 4 connects the piping 2 which is responsible  
for propelling the sediment towards the outlet conduit to eject the dense se-  
diment 5. Said valve 4 is called oscillator valve because of its alternating

functions of interconnecting a section of the suction and ejection pipe 2 to the outlet conduit 5, and interconnecting the other section of the suction and ejection pipe 2 to the outlet conduit, according to the movement of the piston 3 at the time, as shown in figure 6. After going through the outlet conduit 5, the sediment can be placed on the shore of the water reservoirs. Prior to riparian placement, the dense sediment can also be directed to a sediment compressor 7.

Preferably, but not compulsorily, the submergible densification cell 10 can comprise a sediment compressor 7 which works in cooperation with the outlet conduit 5. The sediment compressor described herein is composed of a dredging cone 71, an air inlet area 72 and a water outlet area 73.

The sediment compressor 7 is responsible for a more effective water/solid separation and is preferably used to densify sediment with a(n) (absolute) density close to the environment it belong in. In the case of water-mixed sediment, the densities may reach 1.00 kg/liter (from 1.03 to 1.10 kg/liter).

The mode of operation of the sediment compressor 7 and of the densification cell 1 itself is based on the same principle. In other words, there also occur a drastic reduction in diameter and an arch formation (clogging) over a membrane which is intermittently cleaned by air injection. The air injection is intermittent. For example, it occurs every 30 seconds and is 1 second long. The sediment compressor 7 receives the mixture which was pressurized by the suction pump 3. It also receives compressed air pressure through the air outlet area 72, which expels the exuding water from the compressor 7 through the water outlet area 73.

Sediment whose density is very similar to its surrounding medium requires more pressure to become dense. Therefore, the compressor plays an essential role in the process.

From the compressor 7, the sediment is pumped out of the densification cell 10 at a flow rate of up to 1500 m<sup>3</sup>/h approximately. It is then transferred through a conduit 74 toward the shore of the river or the lake, where it is dumped, for the drying process to start.

As the concentration of the sediment removed by the submergible densification cell 10 is higher than the concentration of the sediment removed by the apparatuses described in the prior art, its drying time is reduced.

5 In a preferred embodiment of the present invention, the submergible densification cell 10 is also equipped with a rotary mixer 6 responsible for mixing the sediment with rather variable stratigraphy in its granulometry, such as, for instance, a clean sand strip sedimented on fine mud. Due to its draining characteristics, the sand needs to be internally mixed in the densification cell so as to be transported with the fine mud. In fact, if it were not for the mixing process, the fine mud would cross the sand layer during the suction process, due to sand compactation. The rotary mixer 6 disaggregates the sand grains, making the fine mud transport the sand to the arch wherefrom it is subsequently transported through the piping.

15 The rotary mixer 6 comprises a set of steel blades 61 arranged in rays and helicoidally distributed, having constant speed and forming a 45° angle in relation to one another, in two opposite halves, from the ends to the center. The direction of rotation causes the sand-mud mixture to be transported while it is mixed and accumulate in the center of the collection area (Area A1). The rotary mixer 6 is located inside the sediment collection area 1. Its operation does not affect the medium and does not generate water turbidity.

20 A screen (not depicted) can be placed close to the rotary mixer. The function of said screen is to prevent bigger objects other than mud from entering and damaging the densification cell, impairing its operation.

25 The present invention also relates to a sediment separator comprising a submergible densification cell 10 like the one described in the present invention.

The present invention is further directed to a sediment densification method, which utilizes a submergible densification cell 10 comprising:

- 30 a) a sediment collection area 1 having a front section 11 delimited by an area A1 and a back section 12 delimited by an area A2;
- b) at least one suction and ejection pipe 2 associated with the back section

- 12 of the sediment collection area 1;
- c) at least one suction and ejection pump 3 associated with the suction and ejection pipe 2;
- d) an oscillator valve 4 associated with the suction and ejection pipe 2 and
- 5 e) a conduit to eject the dense sediment 5, wherein the relation between the areas A1 and A2 comprises an absolute value between 8 and 120 .

The sediment densification method of the present invention occurs, preferably, at a maximum flow rate of 1500 m<sup>3</sup>/h and, more preferably, at a maximum flow rate of 50 m<sup>3</sup>/h. Even more preferably, the maximum suction flow rate of the sediment densification method of the present invention is

10 10 m<sup>3</sup>/h .

As aforementioned, the concentration of the water/sediment mixture is closely related to the suction velocity, and, accordingly, to the inlet flow rate. Table 1 below and figure 10 (graph generated from table 1) show

15 the results obtained from a practical example in which the densification cell 10 and the sediment densification method of the present invention were used. As shown, within the flow rate range used, the concentration of the mixture increased according to the increase in the sediment suction flow rate.

**TABLE 1**

<i>Q ( m<sup>3</sup>/h )</i>	<i>Concentration (%)</i>
<i>0,195</i>	<i>15,4</i>
<i>0,268</i>	<i>16,4</i>
<i>0,284</i>	<i>0</i>

20 The data described in table 1 were obtained during the dredging of a 26 liter water-sediment mixture from a randomly assigned ploughed area at the bottom of a lake. On said dredging, a densification cell having the following dimension was utilized:

- *Area A1 = 0.3 m<sup>2</sup>*
  - *Area A2 = 0.0025 m<sup>2</sup>*
  - *Distance between the planes of the areas d = 0.5 m*
- 25 Suitable flow rates, that is, lower than 1500 m<sup>3</sup>/h flow rates, in-

crease the efficiency of the method and prevent the sediment from being detached from the bottom of the bodies of water. For instance, lower than 1 m/min inlet speeds concomitant with the collection area  $A1 = 2 \text{ m}^2$  and area  $A2 = 0,2 \text{ m}^2$  cause a pressure arc on the sediment, that is, an outlet congestion between the outlet area and the cell walls 10. Accordingly, new sediment particles are additionally dragged, through the inlet area  $A1$  (collection) to the arch by the movement of the cell 10 against the bottom deposits. The new sediment layers are dehydrated and regularly and continuously pumped out up to the end.

10           The shape of the densification cell 10 can vary according to the flow rate and the type of sediment. Said shape variation is achieved by changing the relation between  $A1$  and  $A2$  and the distance between said areas (corresponding to the front section 11 and the back section 12 of the sediment collection area 1) so a better yield is obtained. Preferably, areas  $A1$  and  $A2$  have a square shape because experiments carried out proved that the square shape was the shape that enabled formation of the pressure arch between the cell walls and facilitated ploughing. However, other shapes can be used.

20           The water/sediment separator or submergible densification cell 10 operates by submersion, densifying the sediments in order to obtain concentrations that are higher than the traditionally obtained ones. The equipment is hydraulic-mechanical and no chemical flocculants or binders are required for the sediment densification or dehydration to occur.

25           The cable system 81 that can be utilized in the operation of the submergible densification cell 10 of the present invention is part of the equipment and can be seen in figure 4. One end of the cable 82 anchored to the submergible berth has a snatch block 83 connected to a drag cable 84 that comes from the hydraulic winch at the vessel; the other end is anchored to the densification cell 10. This minimizes the wave effect and enables sediment removal according to a desired alignment and considerable directed thrust.

30           In a preferred embodiment of the invention shown in figure 11 the

sediment collection area has at least an arch-shaped or cylinder-shaped front portion 11 delimited by an area A1 and an arch-shaped or cylinder-shaped back portion 12 delimited by an area A2.

5 In another preferred embodiment of the invention, as shown in figure 12, the front section 11 delimited by area A1 is partially covered by a lid 90, whose purpose is to annul any turbidity that might be generated by the oscillator valve operation 4.

10 Having described an example of the invention with reference to its preferred embodiment, it is to be understood that the scope of the present invention embraces other possible variations, being limited solely by the appended claims, including the possible equivalents therein.

**CLAIMS**

1. Submersible densification cell (10) comprising:

- a) a sediment collection area (1) having a front section (11) delimited by an area A1 and a back section (12) delimited by an area A2;
- 5 b) at least one suction and ejection pipe (2) associated with the back section (12) of the sediment collection area (1);
- c) at least one suction and ejection pump (3) associated with the suction and ejection pipe (2);
- d) an oscillator valve (4) associated with the suction and ejection pipe (2);
- 10 e) a conduit to eject the dense sediment (5).

characterized in that the relation between areas A1 and A2 comprises an absolute value between 8 and 120.

2. Submersible densification cell (10) according to claim 1 characterized in that the relation between areas A1 and A2 comprises an absolute value between 8 and 15.

3. Submersible densification cell (10) according to claim 2 characterized in that the relation between areas A1 and A2 is 10.

4. Submersible densification cell (10) according to any one of the claims 1 to 3, characterized in that the front section (11) of the sediment collection area (1) has a maximum area of  $50\text{m}^2$ .

5. Submersible densification cell (10) according to claim 4, characterized in that the front section (11) of the sediment collection area (1) has a maximum area of  $8\text{ m}^2$ .

6. Submersible densification cell (10) according to claim 5, characterized in that the front section (11) of the sediment collection area (1) has a maximum area of  $6\text{ m}^2$ .

7. Submersible densification cell (10) according to any one of the claims 1 to 6, characterized in that the back section (12) of the sediment collection area (1) has a maximum area of  $0.8\text{ m}^2$ .

8. Submersible densification cell (10) according to claim 7, characterized in that the back section (12) of the sediment collection area (1) has a maximum area of  $0.3\text{ m}^2$ .

9. Submersible densification cell (10) according to any one of the claims 1 to 8, characterized in that the front section (11) and the back section (12) keep a mutual distance of 2.0 cm to 10 m.

5 10. Submersible densification cell (10) according to claim 9, characterized in that the front section (11) and the back section (12) keep a mutual distance of 50 cm to 1.1m.

11. Submersible densification cell (10) according to claim 10, characterized in that the front section (11) and the back section (12) keep a mutual distance of 1m.

10 12. Submersible densification cell (10) according to any one of the claims 1 to 11, characterized in that it also comprises a rotary mixer (6).

13. Submersible densification cell (10) according to any one of the claims 1 to 12, characterized in that it also comprises a sediment compressor (7) that cooperates with the outlet conduit (5).

15 14. Submersible densification cell (10) according to claim 13, characterized in that the sediment compressor comprises a dredging cone (71), an air inlet area (72) and a water outlet area (73).

20 15. Submersible densification cell (10) according to any one of the claims 1 to 14, characterized in that the suction and ejection pump (3) comprises at least a piston (31).

16. Sediment separator, characterized in that it comprises a submersible densification cell (10) defined in any one of the claims 1 to 15.

17. Sediment densification method, characterized in that it utilizes a submersible densification cell (10) as defined in any one of the claims 1 to 16.

25 18. Sediment densification method according to claim 17, characterized in that said densification occurs at a maximum suction flow rate of  $1500 \text{ m}^3/\text{h}$ .

30 19. Sediment densification method according to claim 18, characterized in that said densification occurs at a maximum suction flow rate of  $50 \text{ m}^3/\text{h}$  (close to the actual value).

20. Sediment densification method according to claim 19, characterized in that said densification occurs at a maximum suction flow rate of  $10 \text{ m}^3/\text{h}$ .

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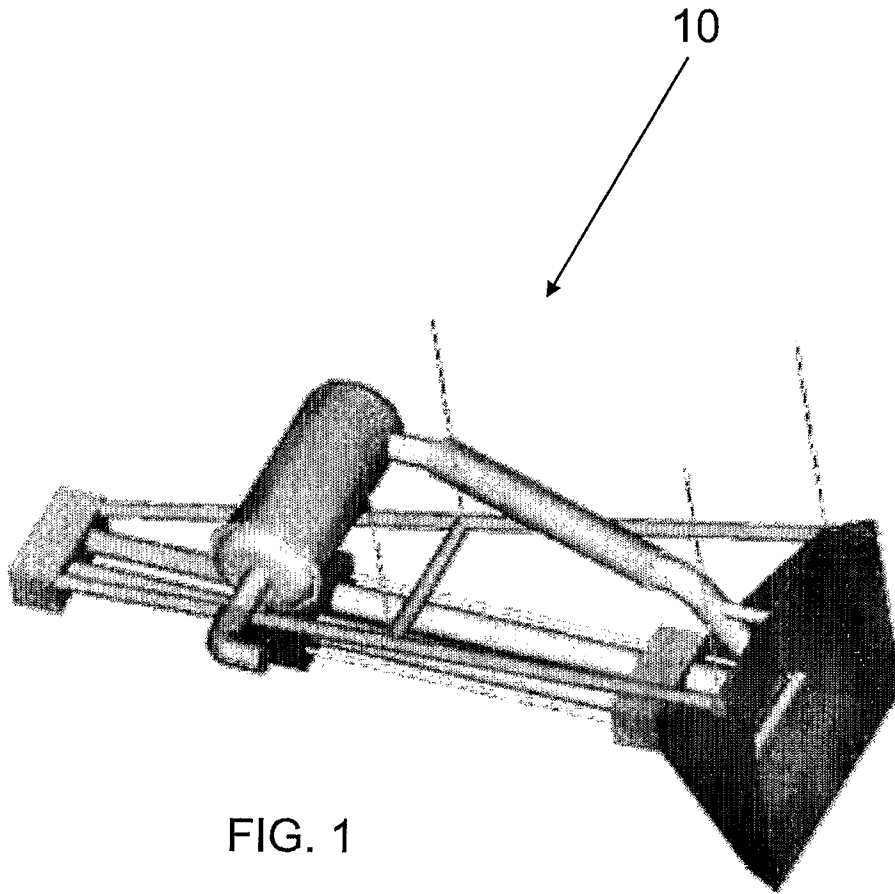


FIG. 1

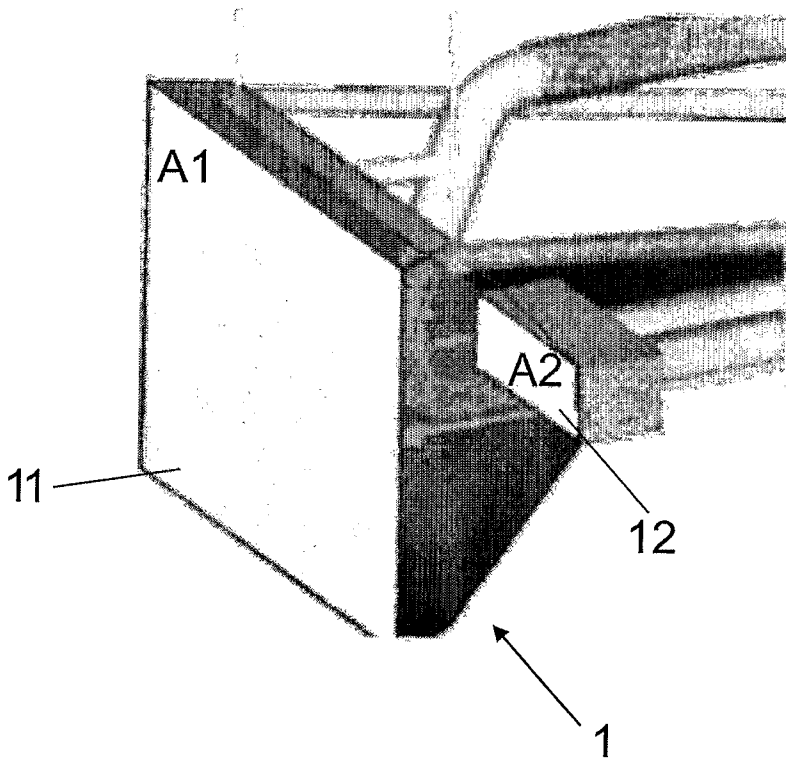


FIG. 2

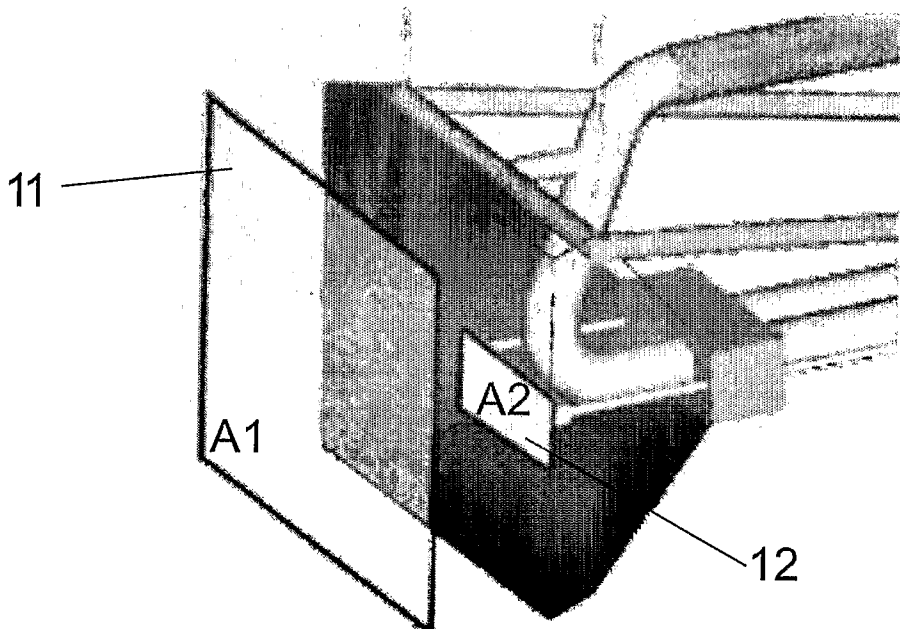


FIG. 3

FIG. 4

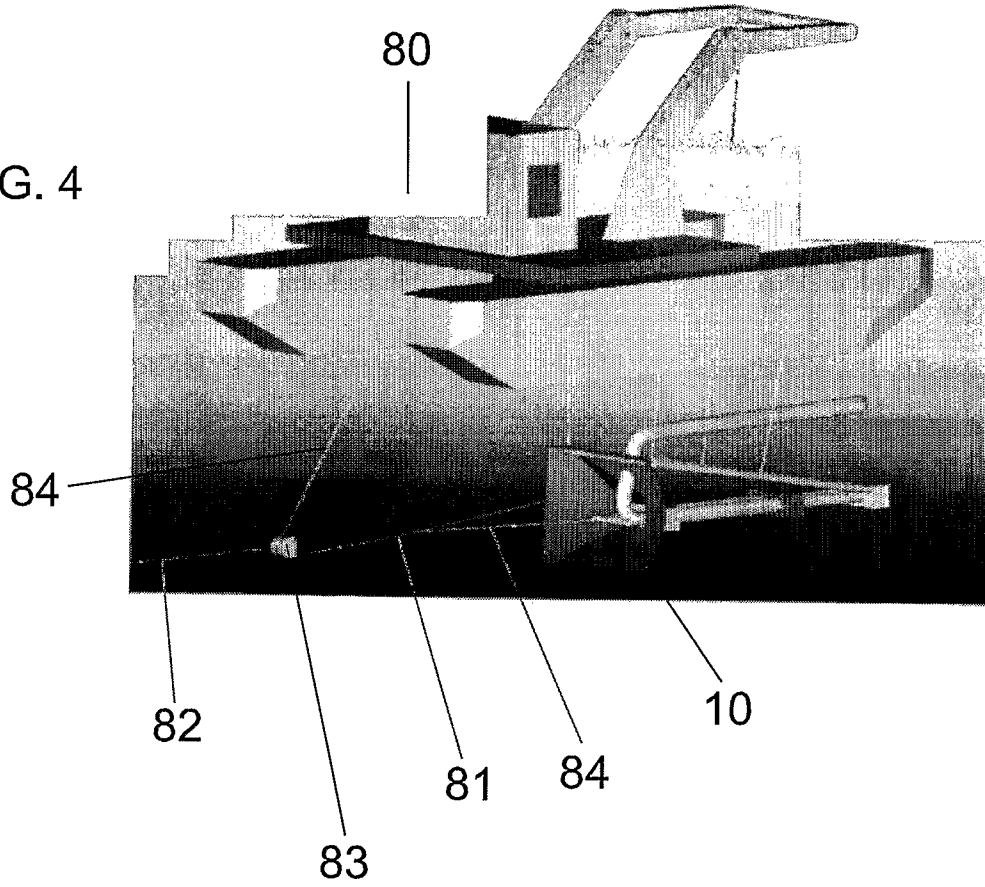
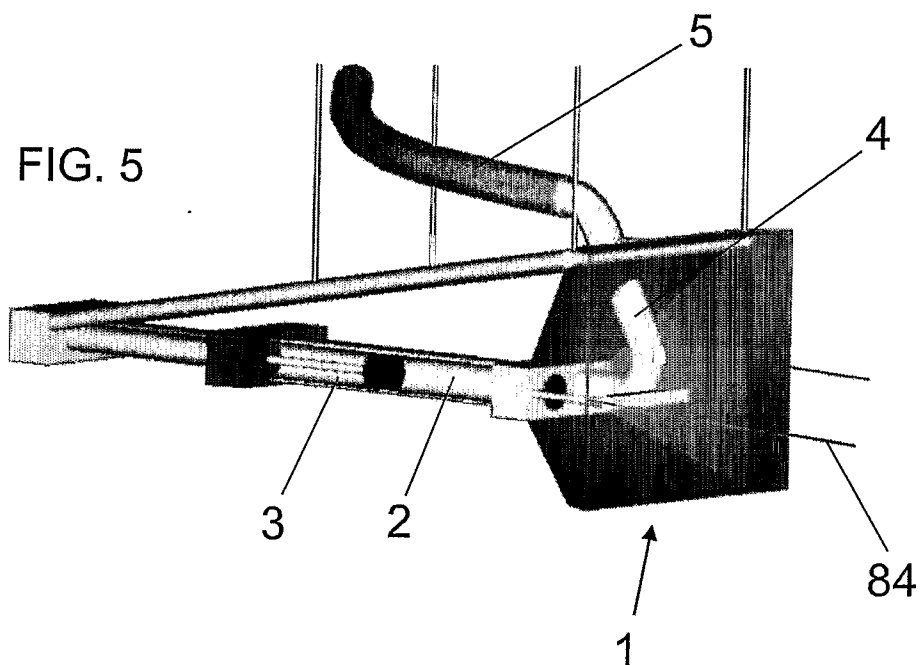


FIG. 5



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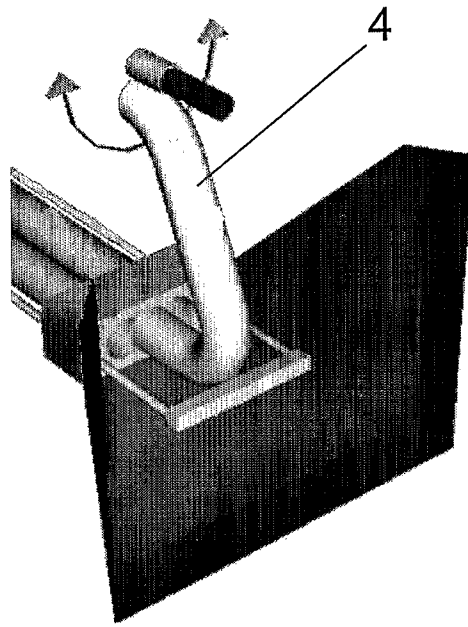


FIG. 6

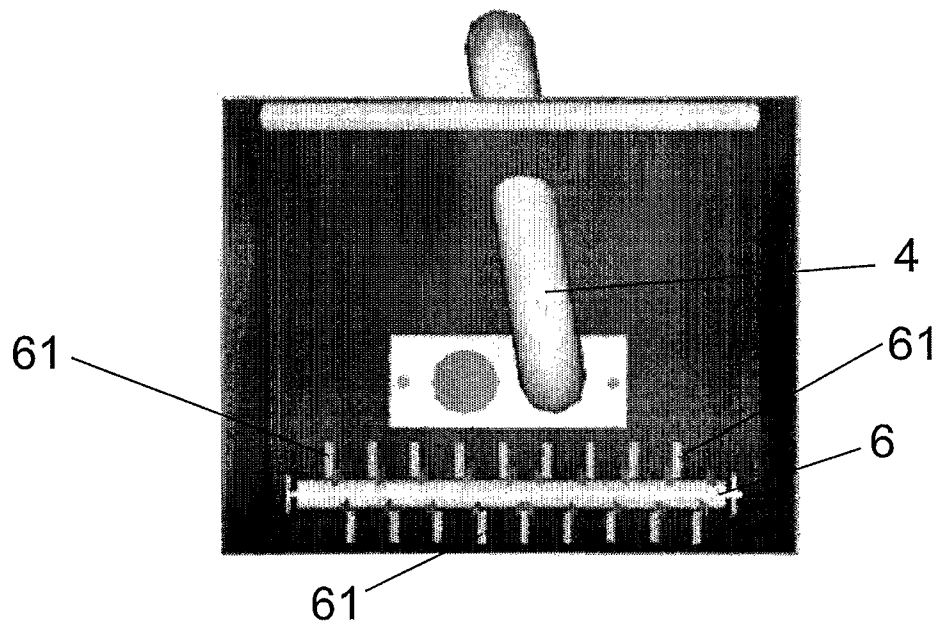
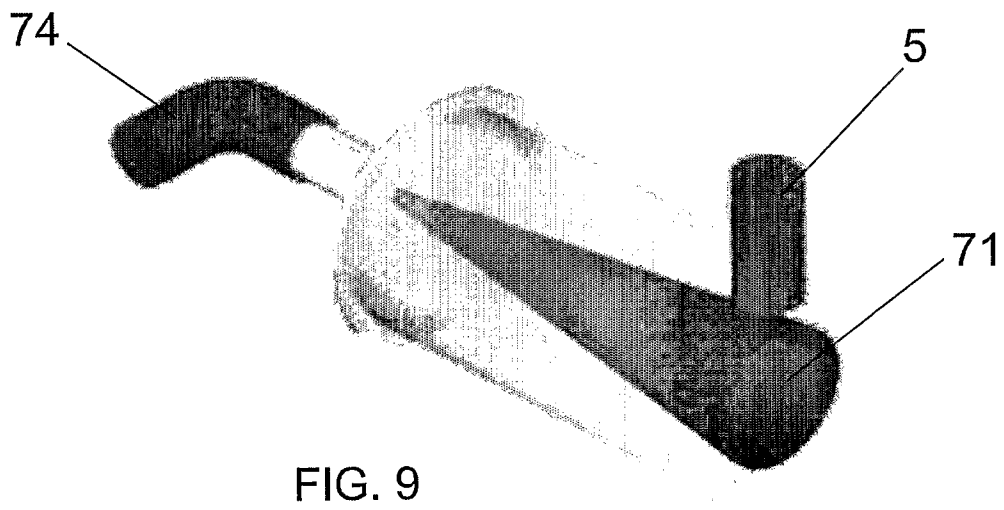
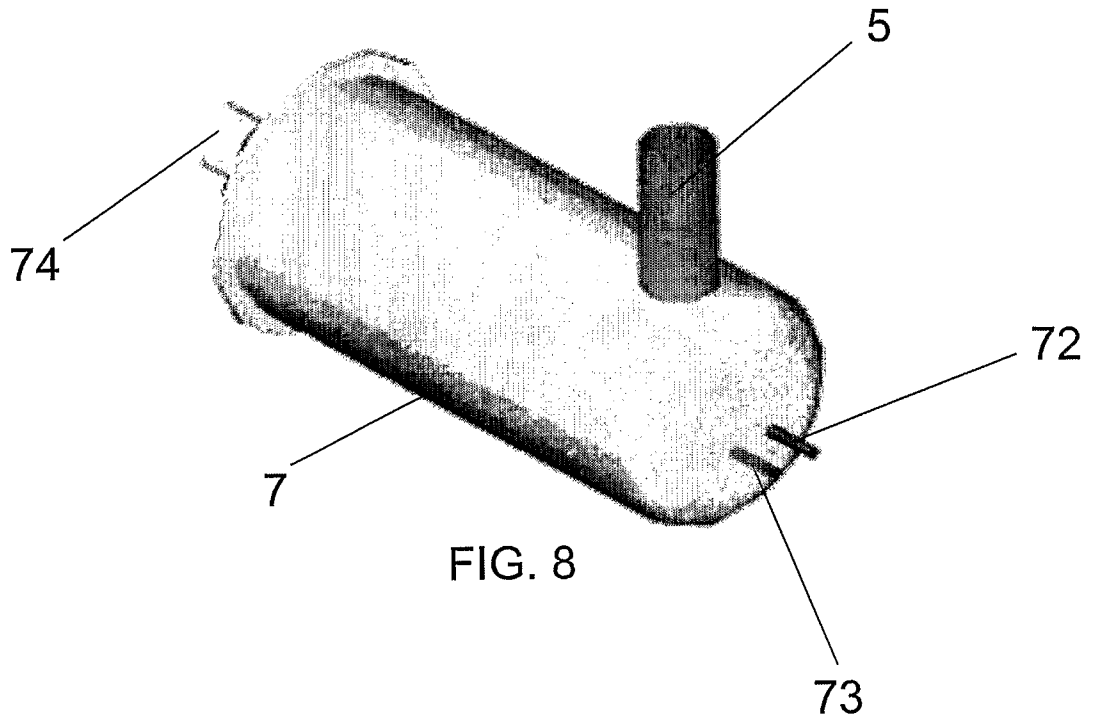


FIG. 7

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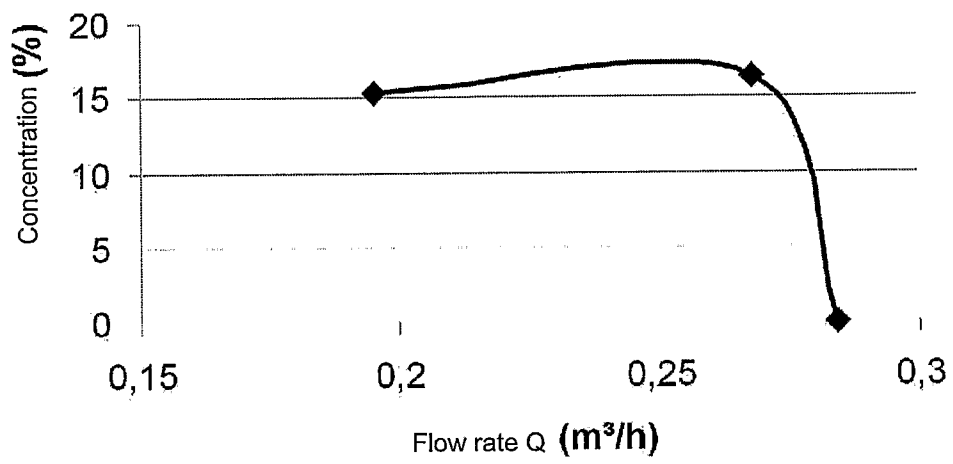


FIG. 10

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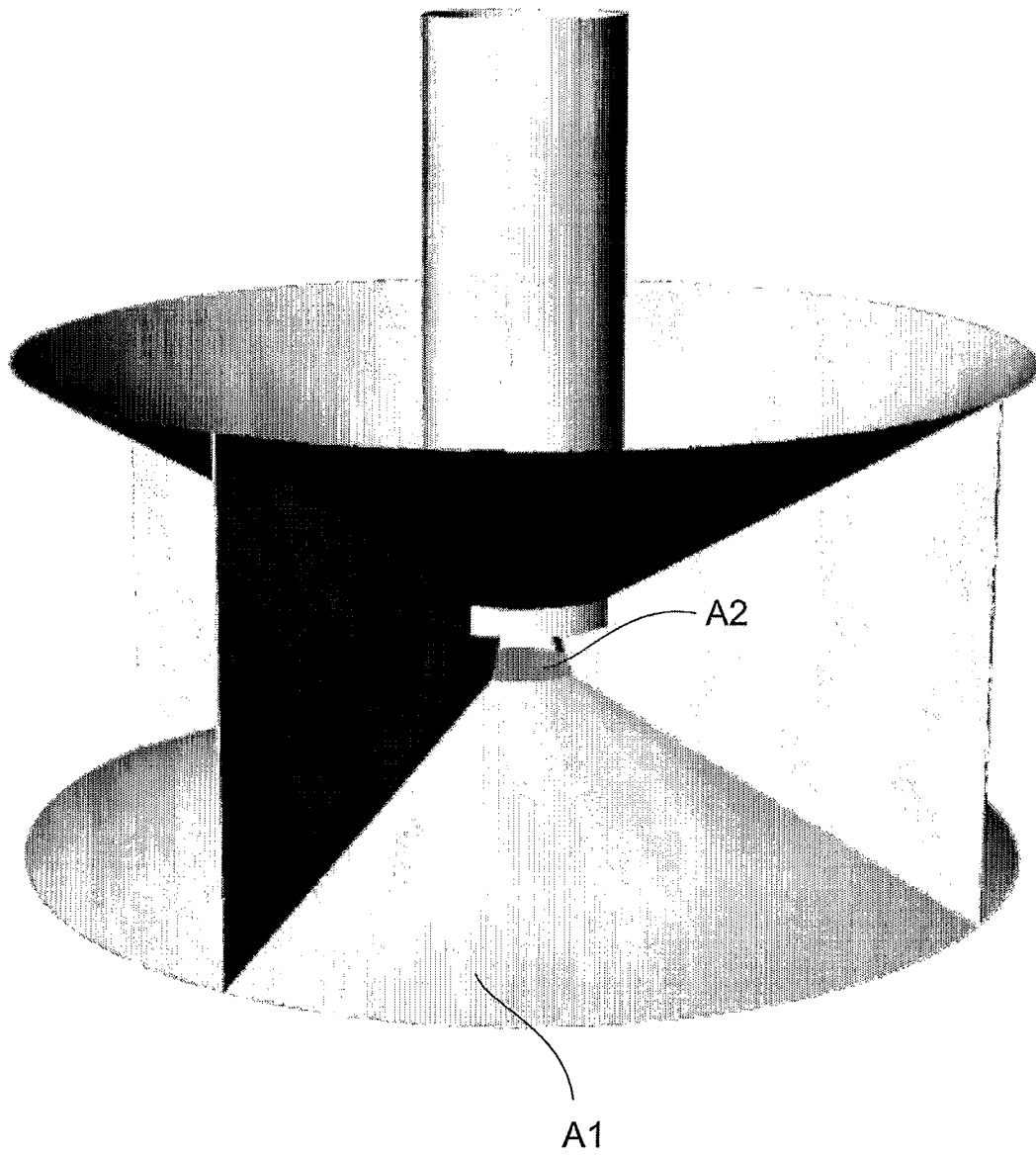


Fig.11

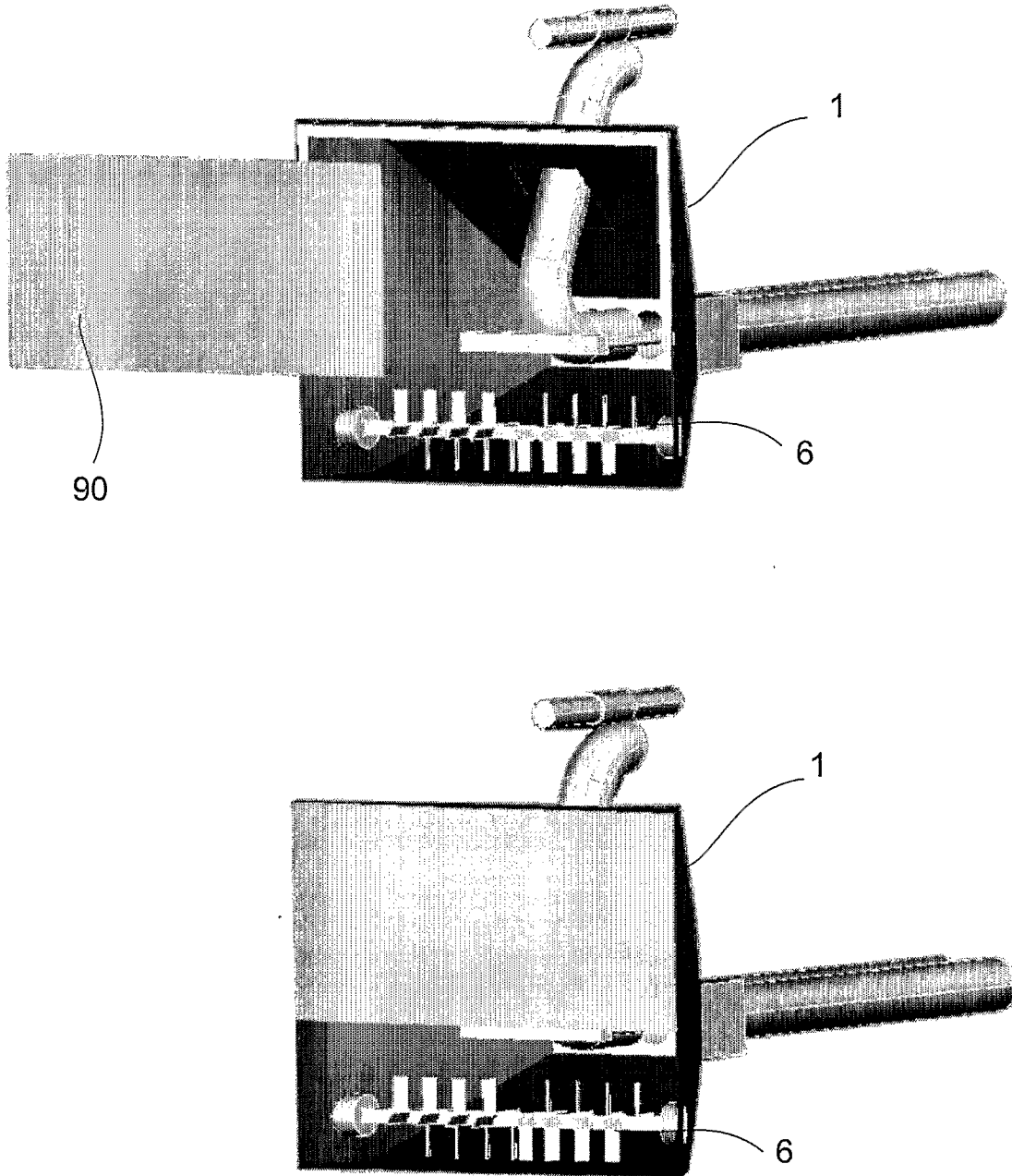


Fig.12

**INTERNATIONAL SEARCH REPORT**

International application No  
PCT/BR2007/000192

**A. CLASSIFICATION OF SUBJECT MATTER**  
INV. E02B3/02 E02F5/00 E02F7/00 E02F3/92

According to International Patent Classification (IPC) or to both national classification and IPC

**B. FIELDS SEARCHED**  
Minimum documentation searched (classification system followed by classification symbols)  
E02F E02B

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)  
EPO-Internal

**C. DOCUMENTS CONSIDERED TO BE RELEVANT**

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	JP 02 248535 A (ONODA CHEM IND CO LTD) 4 October 1990 (1990-10-04)	1-11, 15-20
Y	abstract; figure 1	12-14
Y	US 6 209 965 B1 (BORNS DAVID J [US] ET AL) 3 April 2001 (2001-04-03)	1-11, 15-20
Y	figure 2	
Y	US 5 970 635 A (WILMOTH DARYL [US]) 26 October 1999 (1999-10-26)	1-11, 15-20
Y	figure 2	
Y	US 3 659 712 A (CHAPLIN MERLE P) 2 May 1972 (1972-05-02)	1-11, 15-20
	figures 1,7,8	
	-/--	

Further documents are listed in the continuation of Box C.

See patent family annex.

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Date of the actual completion of the international search  19 October 2007	Date of mailing of the international search report  16/11/2007
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Name and mailing address of the ISA/ European Patent Office, P.B. 5618 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Tx. 31 651 epo nl, Fax: (+31-70) 340-3016	Authorized officer  Bultot, Coralie
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## INTERNATIONAL SEARCH REPORT

International application No  
PCT/BR2007/000192

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	GB 2 025 484 A (VNI EX K I KOMMUNALNOGO MASCH) 23 January 1980 (1980-01-23) figure 1 -----	1-11, 15-20
Y	JP 62 204810 A (KUBOTA LTD) 9 September 1987 (1987-09-09) abstract; figure 1 -----	12-14

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Information on patent family members

International application No PCT/BR2007/000192
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			JP 7121325 B	25-12-1995