

Device for removing sludge and/or sand from the bottom of a water body.

5 This invention relates to a device for removing sludge and/or sand from the bottom of a water body.

The invention applies both to the removal of sludge and to the removal of an underlying sand layer up to a certain
10 depth. For the sake of simplicity, mainly the term sludge is used below, which also refers to the underlying sand layers.

More specifically, the method relates to the in situ pumping up of polluted sludge underwater with minimal turbulence.

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It is generally known that the sludge of maritime waterways may be polluted with toxic chemicals and heavy metals from accidental or illegal discharges or from the seepage of industrial sites, such as, for example, pollution by toxic
20 substances that are often present on the hull of a ship to repel the growth of marine organisms.

These harmful substances remain present in the sludge of port areas and maritime waterways. These pollutions around port
25 areas have a detrimental effect on the local indigenous marine organisms.

However, a problem is that current dredging techniques for removing sludge from the bottom of a water body are often
30 relatively inefficient in the sense that they create a lot of

turbulence, causing sludge churn as well as turbidity or muddiness in the water.

5 The water content in the sludge is increased by the churning during dredging. This is disadvantageous because to clean the pumped up sludge, the moisture content has to be completely or partially removed. An increased moisture content therefore makes the dredging process relatively more expensive and the cleaning of the pumped up sludge more time-consuming.

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Another disadvantage of the turbulence caused is that the churned polluted sludge spreads out over the water body due to resuspension of the sludge and possibly mixes with unpolluted sludge, while in fact the dredging and removal of
15 the sludge should remain in situ as much as possible.

In addition, the precipitation of the resuspended sludge completely disturbs or even completely destroys soil organisms.

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One consequence of the risk that a lot of turbulence is created using traditional sludge removal techniques, is that such polluted water bodies are left untouched by the authorities to avoid the risk of further dispersal through
25 churn and inefficient removal.

This implies that polluted port areas are not deepened or expanded any further, which means that these areas with potentially high economic value remain unused.

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In BE 1.018.005, BE 1.021.095 and BE 1.026.609 of the same inventor, techniques are already known for in situ dredging, using a diving bell which is pushed into the sludge to be removed and from which the caught sludge is pumped out.

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A disadvantage of said devices is that after the diving bell has pumped up all the sludge, the dredge pump needs to be switched off and the diving bell needs to be moved.

10 Therefore, with the known devices the works need to be interrupted every time to move the diving bell, whereby a lot of time is lost of course.

The purpose of the present invention is to further improve
15 these known techniques using a diving bell.

To this end, the present invention relates to a device for the underwater in situ removal of sludge and/or sand from the bottom of a water body, the device containing:

- 20 - a diving bell;
- means to get the base of the diving bell down to the layer of sludge to be removed;
- a dredge pump provided with an inlet for pumping up the sludge and/or an outlet to which a pipe is connected for
25 pumping the pumped up sludge and/or sand to a collector;
- a compressor for pumping gas under pressure into the space of the diving bell during dredging;
- a gas outlet for the compressed gas, said gas outlet being height adjustable in the diving bell because the outlet is
30 attached to a float that can float on the sludge,

characterised in that the diving bell is provided with a base, whereby at least a section of a sidewall of the bell is open on the underside from the base to form an opening in said sidewall.

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Thanks to the opening in the sidewall a new quantity of sludge will enter the diving bell through the opening every time the diving bell is moved or dragged across the bottom of the water body. In this way it is thus possible to pump up
10 sludge continuously, without the works having to be suspended when moving the diving bell.

Yet another big advantage of the device with compressor that is able to pump air or another gas in the space of the diving
15 bell is that a layer of air or gas is created above the surface of the sludge. This layer of air allows the works and the progress to be inspected visually by a diver or operator in the diving bell, or by an operator on land or above the water surface when the diving bell is provided with one or
20 more cameras.

The visual inspection allows unexpected obstacles such as big pieces of debris, unexploded explosives, waste or other matters that could interfere with the works or damage the
25 device and/or surroundings to be anticipated quickly.

Yet another major advantage is that the device reduces the turbulence during dredging to a minimum or even completely prevents it. This makes the device particularly useful for
30 dredging polluted layers of sludge, as said device prevents

such pollutions being churned and thus impossible to be removed.

As the device according to the invention can be moved
5 continuously and the sludge can also be pumped up continuously, the level of the sludge in the diving bell may vary and the float, and consequently also the water level in the diving bell, follows the level of the sludge in the diving bell.

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This ensures that water never flows out which at the same time prevents pollutions in the sludge from being washed out of the internal volume of the diving bell.

15 In this way, only the sludge that is caught in the diving bell is dredged without disturbing the sludge all around.

In a preferred embodiment the base extends up to a distance from the geometric extension of the sidewall in which the
20 opening is provided.

Preferably, the base is also provided with an opening which connects with the opening in the sidewall, such that sludge can also enter the diving bell in this way.

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The opening in the sidewall with the opening in the base connected thereto ensure that the diving bell forms a kind of dredging head, which can continuously scoop and pump up sludge when it is dragged or moved over the bottom of the
30 water body.

Preferably, however, the base is not completely open, such as with the traditional dredging devices, as this increases the risk of the sludge washing out to the surroundings around the
5 diving bell.

Preferably, the float with the outlet thereon is suspended in the diving bell by means of a chain or the like. The length of said chain is such that when the diving bell is taken out
10 of the water, the underside of the float is located approximately at the level of the lower edge of the aforementioned sidewall in which the opening is provided.

As this means the gas outlet can never be lower than the
15 lower edge of the sidewall, no gas can escape from the diving bell under any circumstance, which could cause an unwanted flow of the water through the sludge.

Thanks to the outlet of the compressed gas being arranged
20 moveably, the air above the sludge or sand will be able to escape freely via the outlet when the diving bell is moved through the sludge or the sand, such that the diving bell can be filled with sludge or sand to the maximum extent without the water or gas being expelled through the opening in the
25 sidewall and/or base.

The outlet will always be above the sludge or sand to be removed and the float, together with the movable outlet and the supply of the compressed gas, ensure that the water level
30 and the pressure above the water in the diving bell are self-

regulating.

Indeed, the air in the diving bell will be able to escape through the outlet, whereby the water level will stabilise at
5 the level of the upper edge of the outlet.

As the float and therefore the outlet mounted thereon follow the level of the sludge, the level of the water will also follow the level of the sludge or sand and therefore the
10 level of the sludge or sand and the level of the water will decrease together as more sludge or sand is pumped out.

Because both levels drop at the same time, there is no flow of water through the sludge to the outside, such that the
15 pollution cannot escape to the outside and, in other words, during dredging, the pollution is retained inside the diving bell.

Such automatic regulation of the level and pressure is very
20 simple and very effective as has already been demonstrated in closed trials.

According to a practical embodiment, the aforementioned outlet is formed by the open end of a pipe which, through an
25 opening at the top of the diving bell, gives access to the environment and, for example, is led upwards to the water surface via a further pipe to prevent turbulence and turbidity caused by rising air bubbles or to be able to purify toxically charged air if necessary.

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Preferably, the float is such that it floats on the sludge or sand, but still does not have sufficient buoyancy to, together with the weight of the pipe, float the compressed gas outlet on the water.

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The float, for example, is formed by a sufficiently dimensioned sheet to support the weight of the pipe on the sheet on the sludge or sand.

10 According to a simple practical embodiment, the pipe is formed by a rigid metal tube which rests and is attached to the float with one end and with the other end releases into the outside environment of the diving bell via a flexible coupling at the top of the diving bell.

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Preferably, the dredge pump is attached at a fixed location in the diving bell such that it is moved through the sludge together with the diving bell and the inlet of the dredge pump is situated at the level of the lower free edge of the
20 diving bell.

To obtain the aforementioned balance in the diving bell, a compressor is used, the pressure of which is set to a maximum pressure that is higher than the pressure of a water column
25 with a height equal to the difference in level between the water surface of the water body and the base of the diving bell.

Optionally, the diving bell can be provided with one or more
30 water jets near the base that are powered by a jet pump which

injects water into the sludge or sand, which can be useful when the sludge is a hard substance.

To move the diving bell through the sludge, for example, a
5 hydraulic crane or excavator with a hydraulic unit that
supplies the hydraulic power to drive the dredge pump and the
optional jet pump, whereby the diving bell is suspended from
the crane's arm and the crane can move the diving bell, can
be used. Alternatively the diving bell can be moved by means
10 of a towing cable or the like.

For example, the hydraulic crane is installed on a work boat
or pontoon or a quay, together with the aforementioned
compressor.

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The means to initially get the diving bell down to the bottom
of the layer of sludge may also comprise the aforementioned
crane. Initially, prior to the start of the works, the crane
can lower the diving bell into the water, whereby an angle is
20 formed between the base of the diving bell and the horizontal
or the bottom of the water body, until the opening of the
diving bell is driven partially into the layer of sludge.
Subsequently the crane can return the diving bell back to a
horizontal position and drag or move the diving bell whereby
25 the dredging process can be started. Initially a kind of
"scoop movement" is thus made with the diving bell to drive
the opening of the diving bell into the layer of sludge and
"scoop in" sludge or sand.

30 The aforementioned angle between the base of the diving bell

and the horizontal or the bottom of the water body prior to the start of the works may vary between 5 and 15°, but preferably amounts to 7 to 8°.

5 To allow the crane operator to see or know what he or she is doing, in addition to the aforementioned cameras, means may also be provided for gauging the depth of the diving bell in the layer of sludge or sand and/or means to measure the thickness of the layer of sludge and/or means to measure or
10 assess the density and/or composition of the layer of sludge. More specifically the aforementioned means may comprise instruments that require a layer of air to function correctly. Said means may be very diverse, for example capacitive, inductive or optical measurement instruments,
15 sonar or ultrasound, a depth scale, pressure sensors, etc.

The invention also relates to a use for the in situ underwater dredging of sludge or sand using a device according to the invention.

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With the intention of better showing the characteristics of the invention, some preferred embodiments according to the present invention are described hereinafter by way of an example, without any limiting nature, with reference to the
25 accompanying drawings, wherein:

figure 1 schematically shows a device according to the invention at the start of the dredging;
figure 2 shows the device of figure 1 at the start of
30 the dredging;

figure 3 shows the device of figure 1 during a successive phase of the dredging;
figure 4 shows an alternative embodiment of a device according to the invention.

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The device 1 shown in figure 1 by way of an example according to the invention contains the following elements in this case:

- 10 - a hydraulic crane 2 arranged on a work boat or pontoon 3;
- 15 - a diving bell 5 (for reasons of clarity shown in cross-section) with an internal space 6 and a base 7, said diving bell being suspended on the arm 4 of the crane 2, whereby at least a section of a sidewall 8 of the diving bell 5 is open on the underside from the base 7 to form an opening 9 in the sidewall 8 and whereby in this case the base 7 extends up to a distance from the geometric extension of the sidewall 8 in which the opening 9 is provided;
- 20 - a dredge pump 10 which is attached in the space 6 of the diving bell 5 by means of a rigid suspension 12 and which is provided with an inlet 13 for pumping up the sludge 13 and an outlet 14 to which a pipe 15 is connected to pump the pumped up sludge to a collector 16;
- 25 - a hydraulic motor 17 for driving the dredge pump 10, said motor 17 being connected via pipes 18 to the hydraulic unit 19 of the crane 2;
- 30 - a compressor 20 which is installed on the pontoon 3 to pump air under pressure during dredging via a supply

pipe 21 and a passage 22 in the upper wall 23 into the space 6 of the diving bell 5.

- 5 - a discharge pipe 24 to evacuate the pumped air through a gas outlet 25 from the diving bell 5 to the open air above the water level 26, whereby the part of the discharge pipe 24 in the diving bell 5 is made as a rigid metal tube 24a connected with one end via a flexible coupling 24b to the part 24c of the discharge pipe 24 on the outside of the diving bell 5, in such a way that the tube 24a with the gas outlet 25 on the other end can rotate down and up around the flexible coupling 24b;
- 10 - a float 27 that can float on the sludge 13 and to which the end of the tube 24a with the outlet 25 is attached;
- 15 - a chain 28 with which the lowest end of the tube 24b in the diving bell 5 is suspended and the length of which is such that the freedom of movement of the float 27 is restricted to the situation as shown in figure 1 whereby the underside of the float 8 is on the same level as the lowest edge 9 of the diving bell 5 in which the opening 9 is provided.
- 20

The use of the device 1 according to the invention is simple and as follows.

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With the hydraulic crane 2 the diving bell 5 is pushed down and lightly tilted such that the base 7 of the diving bell forms an angle α with the horizontal of approximately 7°. Said angle may vary between 5° and 15°. Said angle ensures
30 that the opening 9 faces the sludge 13.

When the diving bell 5 reaches the level of the sludge 14, as in the initial situation in figure 1, the diving bell 5 is driven further in the sludge 13 down to a depth A, such that
5 sludge 13 enters the diving bell 5 through the opening 9.

Subsequently, the base 7 of the diving bell 5 is returned to a horizontal position, as shown in figure 2, and dragged in the direction of the arrow F such that a layer of sludge 13
10 enters the internal space 6 of the bell 5.

The float 27 comes to lie on top of the layer of sludge, whereby the tube 24b rotates up around the flexible coupling 24c, driven by the float 27.

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Because the space 6 in the diving bell 5 above the sludge 13 is always connected to the outside air, as the level of the sludge 14 rises in the space 6 of the diving bell 5, the air is expelled.

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In the position of figure 2, the supply and discharge of the compressed air in the space 6 of the diving bell 5 automatically reaches a balance of the level 29 of the water 30 in the diving bell 5 which is approximately equal to the upper edge 31 of the gas outlet 25 and thus at a fixed height
25 B above the level 29 of the sludge 14 in the diving bell 5.

When the dredge pump 10 is driven, the sludge 13 that is caught in the diving bell 5 is pumped out to the collector
30 17.

As the diving bell 5 is continuously moved and the sludge 13 is continuously pumped out, the level of the sludge 13 in the diving bell 5 may vary and the float 27, and consequently also the level 29 of the water 30 follows the level of the sludge 13 in the diving bell.

This means that water is never expelled that could otherwise cause pollutions present in the sludge 13 to be washed out.

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In this way, only the sludge 13 that is caught in the diving bell 5 is dredged without disturbing the sludge 13 all around.

15 The level 29 of the water 30 above the level of the sludge therefore depends on the height of the upper edge 31 of the outlet 25 and can therefore be regulated by positioning it higher or lower in relation to the float 27.

20 As the diving bell 5 is continuously moved and the dredge pump 10 continuously pumps out sludge 13, the device 1 according to the invention offers enormous time savings compared to the known devices for removing sludge 13.

25 Preferably, the float 27 is designed to float on the sludge 13, but does not have sufficient buoyancy in water to, together with the weight of the pipe 24b, float on the water, such that the float 27 can drop on to the sludge 13.

30 To this end, the float 27 can be made as a simple sheet

dimensioned in such a way that the pressure exerted by the sheet on the sludge by the weight of the tube 24b is less than the load-bearing capacity of the sludge.

- 5 Alternatively, the tube 24b may also be replaced by a flexible hose, the lowest end of which is attached to the float 27 and whereby if necessary the float 27 is weighted to allow it to sink into the water on to the sludge.
- 10 The compressor 21 is set such that the maximum pressure is higher than the pressure of a water column with a height equal to the difference in level C between the water level 26 of the water body and the base 7 of the diving bell 5.
- 15 After all the sludge 13 of the upper layer of sludge is pumped out, the diving bell 5 may possibly remove an underlying sand layer 13' with a greater density down to a certain depth. The diving bell 5 must then make another "scoop movement" whereby the base 7 forms an angle with the
- 20 horizontal and is driven in the underlying sand layer 13' until the underlying sand 13' enters the diving bell 5 through the opening 9 and after which the diving bell 5 can be returned to a horizontal position and moved while dredging out the underlying sand layer 13'.
- 25
- The crane 2 and the compressor 20 do not necessarily have to be mounted on a pontoon 3, but can also be installed on a work boat or a quay, for example.
- 30 It is clear that instead of the hydraulic crane 2 other means

are also possible for floating the diving bell 5 into the sludge and moving it.

The dredge pump 10 does not necessarily need a fixed position in the diving bell 5, but can, for example, be attached to a device that can move the dredge pump 11 in the diving bell 5.

Several dredge pumps 10 may also be provided.

10 Figure 3 shows a successive phase of the dredging process whereby a part of the sludge 13 on the bottom of the water body is already pumped out.

Figure 4 shows an alternative embodiment of a device 1 according to the invention which, in relation to the device in figure 1, is provided with the following extra elements:

- means to gauge the depth A of the diving bell 5 in the sludge 13, such as for example a depth scale 32 on a sidewall 8 of the diving bell 5 and a camera 33 to enable the crane operator in the crane 2 to see what is going on in the diving bell 5;
- means (not shown) to gauge the thickness of the layer of sludge, e.g. by means of sonar;
- an installation to generate a water jet to breach hard sludge in the diving bell 5, in other words, to break it up;
- a jet pump 34 with an inlet 35 on the outside of the diving bell 5 and an outlet 36 connected with pipes 37 to passages 38 on the underside of the sidewall 8 of the diving bell 5, such that a water jet is generated in a

horizontal direction;

- the jet pump 34 is provided with a hydraulic motor 39 which is also connected to the hydraulic unit 20 of the crane 2.

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The present invention is by no means limited to the devices described by way of an example and shown in the figure, but, a device and a method for removing sludge according to the invention can occur in all kinds of ways, without departing
10 from the scope of the invention.

Claims.

- 1.- Device for the in situ underwater removal of a layer of
5 sludge (13) and/or sand (13') from the bottom of a water
body, the device (1) containing:
- a diving bell (5);
 - means (2) to get the base (7) of the diving bell (5) on to
the layer of sludge (13) to be removed;
 - 10 - a dredge pump (10) provided with an inlet (12) for pumping
up the sludge (13) and/or an outlet (14) to which a pipe (15)
is connected for pumping the pumped up sludge (13) and/or
sand (13') to a collector;
 - a compressor (20) for pumping gas under pressure into the
15 space (6) of the diving bell (5) during dredging;
 - a gas outlet (25) for the compressed gas, said gas outlet
(25) being height adjustable in the diving bell because the
outlet (14) is attached to a float (27) that can float on the
sludge (13),
 - 20 **characterised in that** the diving bell (5) is provided with a
base (7), whereby at least a section of a sidewall (8) of the
diving bell (5) is open on the underside from the base (7) to
form an opening (9) in said sidewall (8).
- 25 2.- Device according to claim 1, characterised in that the
base (7) extends up to a distance from the geometric
extension of the sidewall (8) in which the opening (9) is
provided.
- 30 3.- Device according to any one of the previous claims,

characterised in that the float (27) with the outlet (14) thereon is suspended in the diving bell (5) by means of a chain (28) or the like, whereby the length of said chain (28) is such that when the diving bell (5) is taken out of the water, the underside of the float (27) is located approximately at the level of the lowest edge of the aforementioned sidewall (8) in which the opening (9) is provided.

4.- Device according to any one of the previous claims, characterised in that the gas outlet (25) is formed by the open end of a discharge pipe (24) which leads to the surrounding through an opening at the top of the diving bell (5).

5.- Device according to claim 4, characterised in that the pipe (24) discharges above the water level (26) of the water body.

6.- Device according to any one of the previous claims, characterised in that the upper edge of the gas outlet (25) is located at a small height above the float.

7.- Device according to any one of the previous claims, characterised in that the float (27) is such that it floats on the sludge (13), but does not have sufficient buoyancy to allow the compressed gas outlet to float on the water, together with the weight of the pipe (24) and the gas outlet (25).

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8.- Device according to claim 7, characterised in that the float (27) is formed by a sufficiently dimensioned sheet to bear the weight of the pipe (24) on the sheet on the sludge (13).

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9.- Device according to any one of the previous claims, characterised in that the pipe (24) is formed by a rigid metal tube (24a) which rests on the float (27) with one end and is attached to it and with the other end opens out via a flexible coupling (24b) at the top of the diving bell (5) to the environment of the diving bell (5).

10.- Device according to any one of the previous claims, characterised in that the dredge pump (10) is mounted in the space of the diving bell (5).

11.- Device according to claim 10, characterised in that the dredge pump (10) is attached at a fixed location in the diving bell (5) with its inlet (12) on the level of the base (7) of the diving bell (5).

12.- Device according to any one of the previous claims, characterised in that the maximum pressure to which the compressor (20) is set is higher than the pressure of a water column with a height equal to the difference in level between the water surface of the water body and the base (7) of the diving bell (5).

13.- Device according to any one of the previous claims, characterised in that near the base (7) of the diving bell

(5), the device is provided with a water jet that is powered by a jet pump (34) which injects water into the sludge (13).

14.- Device according to claim 13, characterised in that the
5 jet pump (34) is mounted on the outside of the diving bell (5) and via pipes (37) is connected to passages (38) in the sidewall (8) of the diving bell (5), said pipes (37) in the diving bell (5) leading in a direction perpendicular to said sidewall (8).

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15.- Device according to any one of the previous claims, characterised in that the means (2) to drive the diving bell (5) in the sludge (13) are formed by a hydraulic crane (2) with a hydraulic unit (19) that supplies the hydraulic power
15 to drive the dredge pump (10) and the optional jet pump (34).

16.- Device according to claim 15, characterised in that the hydraulic crane (2) is arranged on a work boat or a pontoon (3), together with the aforementioned compressor (20).

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17.- Device according to any one of the previous claims, characterised in that it is provided with one or more cameras (33) and/or means (32) to gauge the depth of the diving bell (5) in the layer of sludge (13) and/or that the device is
25 provided with means to determine the density and/or composition of the layer of sludge.

18.- Device according to claim 17, characterised in that the means (32) to gauge the depth of the diving bell (5) in the
30 sludge (13) are formed by a depth scale (32) on the sidewall

(8) of the bell (5) and a camera (33).

19.- Device according to any one of the previous claims,
characterised in that it is provided with means to gauge the
5 thickness of the layer of sludge (13).

20.- Use of a device according to any one of the previous
claims, characterised in that the device (1) is used for
removing a layer of sludge (13) and/or sand (13') from the
10 bottom of a water body.