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(54) Title: PLOUGH APPARATUS AND METHOD

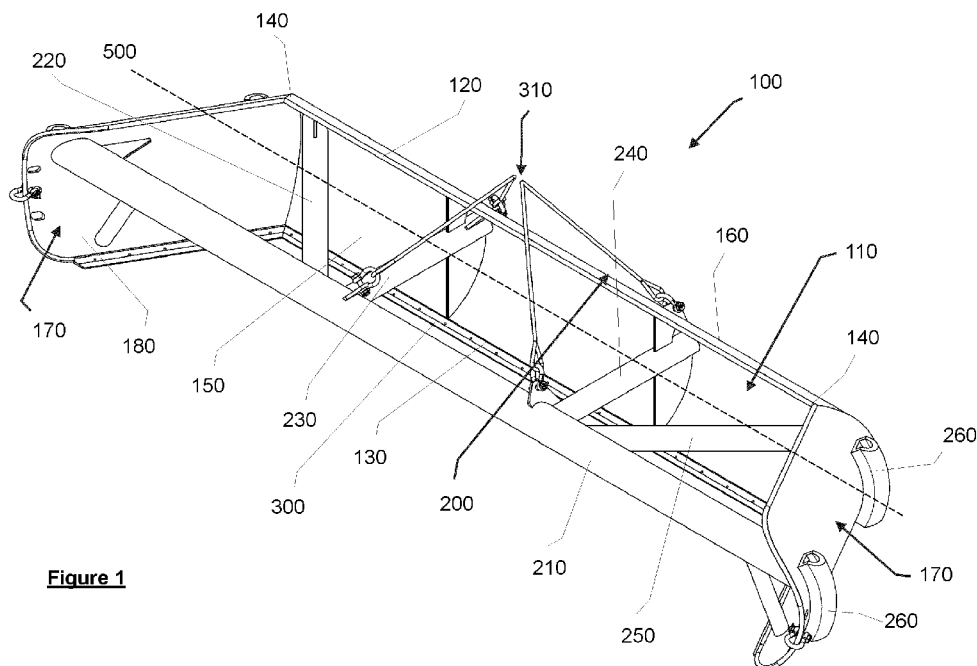


Figure 1

(57) **Abstract:** Plough apparatus for use underwater to displace sediment above a waterbed. The plough apparatus (100) comprises an elongate blade (110) comprising a concave leading face (150) to contain and move sediment and a connector (310) at a highermost point on the plough apparatus (100) for attachment to a vehicle for suspending the plough apparatus (100) underwater. The plough apparatus (100) further comprises a pair of plough wings (170) which extend forwardly from side edges (140) of the elongate blade (110) at an angle between coaxial and perpendicular with respect to the leading face (150). The method comprises suspending the plough apparatus (100) from a vehicle, moving the plough to contain sediment and drawing the sediment into an area of water whereby the sediment may be washed away by the natural movement of the water.

TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, WS,
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Declarations under Rule 4.17:

- *as to the identity of the inventor (Rule 4.17(i))*
- *as to applicant's entitlement to apply for and be granted a patent (Rule 4.17(ii))*
- *as to the applicant's entitlement to claim the priority of the earlier application (Rule 4.17(iii))*
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PLOUGH APPARATUS AND METHOD

[0001] This invention is plough apparatus for use underwater to displace sediment and a method of ploughing sediment underwater.

5 **[0002]** Waterways including harbours must be dredged frequently, because sediment builds up over time where it may become an obstacle to shipping. Dredging to remove the sediment may be undertaken by a range of different dredging apparatus and methods. For example, trailing suction hopper dredgers suck the sediment from the waterbed and deposit it on a ship for later disposal at
10 sea.

[0003] However, trailing suction hoppers are both expensive to obtain and operate, since they require the use of a large, specially constructed vessel to store then deposit the dredged sediment at sea. Furthermore, trailing suction hopper dredgers are unable to operate in particularly tight spaces.

15 **[0004]** In an alternative dredging method, sediment may be agitated using fluid injectors where the natural movement of the water then washes away the agitated sediment. Further, the agitated sediment may be pumped up into a higher water column. This further method is advantageous in harbours where the bed of the harbour is lower than that of the surrounding body of water, such as
20 the sea. Raising the agitated sediment allows for the sediment to then be washed out of the harbour by tidal waters.

[0005] However, the flow of water within harbours and waterways is not consistent and agitated sediment does not necessarily flush out of the harbour or other waterway by natural currents alone. Eddy currents in the area being
25 dredged, which could be for example within a harbour, recirculate the agitated sediment rather than draw it away. The flow of water may be restricted by obstacles and within shipping berths. In such cases, agitated sediment will not be removed by the flow of the water and will accumulate and re-settle.

[0006] Ploughs are used underwater as part of an alternative form of dredging
30 generally for the purpose of waterbed levelling. Sometimes they may be used after a dredging operation, such as that done by a trailing hopper suction dredger. For example, KR101455373B1 describes a plough for use after a dredging

operation comprising a plough blade, a solid frame and a cutting blade on the underside of the plough blade. The plough is dragged along the waterbed by a boat or other vehicle, whilst the cutting blade slices through solid sediment on the waterbed. The purpose of this plough is to level the waterbed by cutting through
5 raised sections of sediment and depositing it in troughs, rather than actually removing any sediment.

[0007] An alternative plough is described in US2014/0237634A1 where the dredger blade is disposed within a frame. The frame includes skids to suspend the plough above sediment. The plough blade includes a cutting edge at a lower
10 edge thereof to slice through sediment. Vehicles on land drag the plough across the waterbed so that sediment is dragged onto the land for disposal.

[0008] The present invention provides apparatus and a method which solves the present problem.

[0009] According to the present invention there is provided plough apparatus
15 for use underwater to displace sediment above a waterbed comprising an elongate blade comprising a concave leading face to contain and move sediment, and a connector at a highest point on the plough apparatus for attachment to a vehicle for suspending the plough apparatus underwater, wherein the plough apparatus further comprises a pair of plough wings which extend forwardly from
20 side edges of the elongate blade at an angle between coaxial and perpendicular with respect to the leading face.

[0010] Plough apparatus according to the current invention is able to mitigate the problems associated with prior art dredgers and methods because it is able to draw sediment from areas where the natural flow of water does not remove
25 the sediment. This sediment may have previously been agitated or suspended during a dredging operation, and would not be captured by traditional dredging methods. Furthermore, plough apparatus according to the present invention is able to fit into narrow areas and does not require specially adapted vehicles to be used. Plough apparatus according to the present invention may be suspended
30 from the winch of a service vessel which will be common to ports, harbours and the like. Such a plough is also inexpensive to operate when compared to trailing suction hopper dredgers.

[0011] The blade of the present plough apparatus comprises a concave leading face so that when operated sediment is contained by the blade. In particular, the sediment contacting the concave leading face during use folds back on itself and is contained by the blade. Were the elongate blade to be planar, the sediment would wash over the top of the blade as it is dragged through the water and would not be contained. The concave face of the elongate blade may have a horizontal principal axis. The side edges of the elongate blade may be curved.

[0012] The plough apparatus may further comprise a flange disposed at a top edge of the elongate blade, the flange extending away from the leading face to define a sediment containment area between the flange and the leading face. The flange therefore may provide structural strength to the blade, and also provide an overhang that may prevent sediment from breaking over the top of the elongate blade. Furthermore, the connector may be disposed, at least in part, on the flange. The flange may be defined by the curvature of an upper edge of the elongate blade.

[0013] The plough apparatus further comprises a pair of plough wings which extend from the side edges of the elongate blade. The pair of plough wings extend forwardly from the elongate blade at an angle between coaxial and perpendicular with respect to the leading face. The angle of the wings relative to the plane of the leading face may vary depending on the intended use and the nature of the material being ploughed. The angle may be between 10 and 80 degrees from the perpendicular relative to the plane of the leading face, or between 20 and 70 degrees from the perpendicular, or between 30 and 60 degrees from the perpendicular, or 40 to 50 degrees from the perpendicular. In some embodiments the wings may be moveable between different angles to optimise containment and breadth of area to plough, or may be fixed at a particular angle. The pair of plough wings help to contain the sediment as it is ploughed and prevent sediment from washing around the sides of the blade and therefore increases the capacity of the plough for containing and ploughing sediment. The pair of plough wings may comprise a concave leading face. The flange, if present, may also be disposed at an upper edge of the wings and extend

away from the wings to define a sediment containment area between the flange, the wings and the leading face of the elongate blade. The flange may be defined by the curvature of the upper edge of the elongate blade.

[0014] The present plough apparatus may comprise at least one support beam to support the elongate blade. The at least one support beam may comprise a cross-member beam arranged parallel to the elongate blade that connects the pair of plough wings. Such a support beam would prevent the pair of plough wings from being forced apart due to water resistance as the plough is dragged through the water in use. There may be provided a plurality of further support beams which extend between the elongated blade, pair of plough wings and cross-member beam or any combination thereof. The cross-member and/or each support beam may be made of metal tubing and reinforce the structure and load bearing capacity of the plough apparatus.

[0015] The connector may be disposed, at least in part, on the at least one support beam. The connector may be disposed, at least in part, on the elongate blade, or, at least in part, disposed on both the at least one support beam and the elongate blade. Connectors on the elongate blade and cross beam may be for suspension from the vehicle.

[0016] A further connector may be provided on each of the wings for attachment to the vehicle. The further connectors may be disposed on distal edges of the wings and may be for connection to a different part of the vehicle than the connector at the highest point on the plough apparatus. In use, the highest connector of the plough apparatus may be attached to the vehicle via an A-frame at the rear of the vehicle and the further connectors may be attached towards the front of the vehicle. The depth of the plough apparatus can be controlled from the A-frame and the connection to the vehicle via the further connectors stabilises and pulls the plough.

[0017] At least one support beam may be disposed on the leading and/or a trailing face of the elongate blade.

[0018] Ploughing underwater requires the plough to be disposed on or near to the waterbed, which can be problematic in a harbour since the waterbed is rarely flat and will often comprise solid debris such as rocks. Ploughs may contact

the solid debris during the course of ploughing and drag said debris such as rocks along with the sediment. This may damage the plough or at least cause the effectiveness of the plough to be reduced. Furthermore, some rocks on the waterbed may be lifted from a lying to an upright position when ploughed so that they then present an obstacle to shipping. Therefore, a pliable skirting may extend from the underside of the apparatus. The deformable nature of the skirting allows the apparatus to pass over rocks and debris without disturbing them. A pliable skirting may therefore also minimise the disruption to the waterbed. Alternatively, the plough may comprise a cutting blade at a lower edge thereof, which extends from the leading face. Such a cutting blade will cut through any stiff sediment that is encountered, particularly if the waterbed is uneven.

[0019] According to a second aspect of the present invention there is provided a method of ploughing sediment underwater comprising the steps of suspending plough apparatus as previously described from a vehicle attached to the plough by the connector; moving the plough apparatus so that sediment is contained by the leading face of the elongate blade; drawing the sediment into an area of water whereby the sediment may be washed away by the natural movement of the water. The plough may be lowered from the vehicle to the waterbed, and is then dragged by the vehicle so that sediment is contained. The method may be used on any sediment that is suitably weak or has a low density and which can be moved easily by the plough. The method may comprise an initial step of agitating the sediment so that it is soft enough to be ploughed. The sediment could be agitated with water injectors or similar.

[0020] So that it may be better understood, the present invention will now be described by way of example only, with reference to the following figures in which:

[0021] Figure 1 shows a side, top perspective of plough apparatus according to the present invention;

[0022] Figure 2 shows a top view of the plough apparatus of Figure 1;

[0023] Figure 3 shows a front view of the plough apparatus of Figures 1 and 2;

[0024] Figure 4 shows a cross-sectional side view of the plough apparatus of Figures 1 to 3;

[0025] Figure 5 shows an alternative plough apparatus according to the present invention; and

5 **[0026]** Figure 6 shows a flow diagram of the method according to the present invention.

[0027] With reference to Figures 1 to 4, there is shown plough apparatus generally indicated 100. The plough apparatus 100 comprises an elongate blade, generally indicated 110 comprising a horizontal principal axis indicated with
10 broken line 500. Elongate blade 110 comprises an upper edge 120, a lower edge 130 and side edges 140, and further comprises a concave leading face 150 and a convex trailing face 160.

[0028] Extending from the side edges 140 of the elongate blade 110 are a pair of plough wings generally indicated 170. Both plough wings 170 have a
15 concave leading face 180 with a horizontal principal axis. The wings 170 are angled between a coaxial and perpendicular angle relative to the plane of the leading face 150 of the elongate blade 110.

[0029] A flange 200 is defined by the upper edge 120 of the elongate blade 110 and pair of plough wings 170 and extends away from the leading faces 150
20 and 180 thereof. Flange 200 strengthens the plough blade 110 and wings 170 and also provides a further surface to contain ploughed sediment in use.

[0030] To further support the plough 100, a support beam comprising cross member 210 extends between distal ends of the wings 170. Cross member 210 is made from tubular steel and prevents the wings 170 from being forced apart
25 by water resistance in use. Further support beams 220, 230, 240 and 250, also made from tubular steel, extend from cross member 210 to the leading face 150 of the blade 110. Additional support bars 260 are provided on the trailing face of the wings 170. Ribs 270 provide extra support for the support beams 220, 230, 240, 250 attached to the leading face 150 of the elongate blade 110.

30 **[0031]** As best shown in Figures 1, 3 and 4, a sediment cutting blade generally indicated 300 is disposed on the lower edge 130 of the elongate blade 110. The cutting blade 300 extends along the length of the elongate blade 110.

and the wings 170. The cutting blade is there to slice through raised patches of sediment encountered by the plough 100. Alternatively, as shown in Figure 5, there is shown plough apparatus generally indicated 360 which comprises a pliable skirting 370 instead of a cutting blade. Pliable skirting 370 is made from rubber and deforms when encountering underwater debris to protect the underside of the plough 360 whilst not moving the debris to a position where it can become an obstacle.

[0032] A connector, generally indicated 310, comprises a series of eyelets 320 to which are connected to shackles 330. The shackles are attachable to cables for suspension from a vehicle. In this example, four connection points are provided. Two further eyelets 340 and shackles 350 are provided on distal edges of the wings 170 for connection to a separate point on the vehicle. The plough apparatus 100 can be suspended from connector 310, and stabilised and dragged via a connection to the vehicle from eyelets 340 and shackles 350.

[0033] The plough according to the present invention is used according to the following method of ploughing sediment as show in Figure 5, wherein the method comprises the following steps:

[0034] At Step 410, plough apparatus as previously described is suspended from a vehicle attached to the plough via the connector.

[0035] At Step 420, the plough apparatus is moved so that sediment is contained by the leading face of the elongate blade.

[0036] At Step 430, the sediment is drawn into an area of water whereby the sediment may be washed away by the natural movement of the water.

[0037] In additional optional steps, the sediment is agitated prior to moving it with the plough. In particular, the sediment is agitated with a water injector.

CLAIMS

1. Plough apparatus for use underwater to displace sediment above a waterbed comprising:
 - 5 an elongate blade comprising a concave leading face to contain and move sediment; and
 - a connector at a highest point on the plough apparatus for attachment to a vehicle for suspending the plough apparatus underwater; wherein
 - the plough apparatus further comprises a pair of plough wings which
 - 10 extend forwardly from side edges of the elongate blade at an angle between coaxial and perpendicular with respect to the leading face.
2. Plough apparatus as claimed in claim 1, wherein the concave face of the elongate blade has a horizontal principal axis.
3. Plough apparatus as claimed in claim 1 or claim 2, comprising a flange
- 15 disposed at a top edge of the elongate blade, the flange extending away from the leading face to define a sediment containment area between the flange and the leading face.
4. Plough apparatus as claimed in any preceding claim, wherein the pair of plough wings comprise a concave leading face.
- 20 5. Plough apparatus as claimed in preceding claim, comprising a flange disposed at a top edge of the pair of plough wings, the flange extending away from the pair of plough wings to define a sediment containment area between the flange, the pair of plough wings and the leading face of the elongate blade.
6. Plough apparatus as claimed in any preceding claim, further comprising
- 25 at least one support beam to support the elongate blade.
7. Plough apparatus as claimed in claim 6, wherein the at least one support beam comprises a cross-member beam arranged parallel to the elongate blade that connects the pair of plough wings.
8. Plough apparatus as claimed in claim 6 or claim 7, wherein a plurality of
- 30 support beams extend between the elongate blade, wings, cross-member and support beams or any combination thereof.

9. Plough apparatus as claimed in any of claims 6 to 8, wherein the connector is disposed on the at least one support beam.
10. Plough apparatus as claimed in any preceding claim, comprising a further connector on each of the plough wings for attachment to a vehicle for suspending
5 the plough apparatus underwater.
11. Plough apparatus as claimed in any preceding claim wherein at least one support beam is disposed on the leading and/or a trailing face of the elongate blade.
12. Plough apparatus as claimed in any preceding claim, wherein pliable
10 skirting extends from the underside of the apparatus.
13. A method of ploughing sediment underwater comprising the steps of:
suspending plough apparatus as claimed in any preceding claim from a vehicle attached to the plough via the connector;
moving the plough apparatus so that sediment is contained by the leading
15 face of the elongate blade;
drawing the agitated sediment into an area of water whereby the sediment may be washed away by the natural movement of the water.
14. The method as claimed in claim 13, further comprising the step of agitating the sediment prior to ploughing it.
- 20 15. The method as claimed in claim 14, wherein the sediment is agitated with a water injector.

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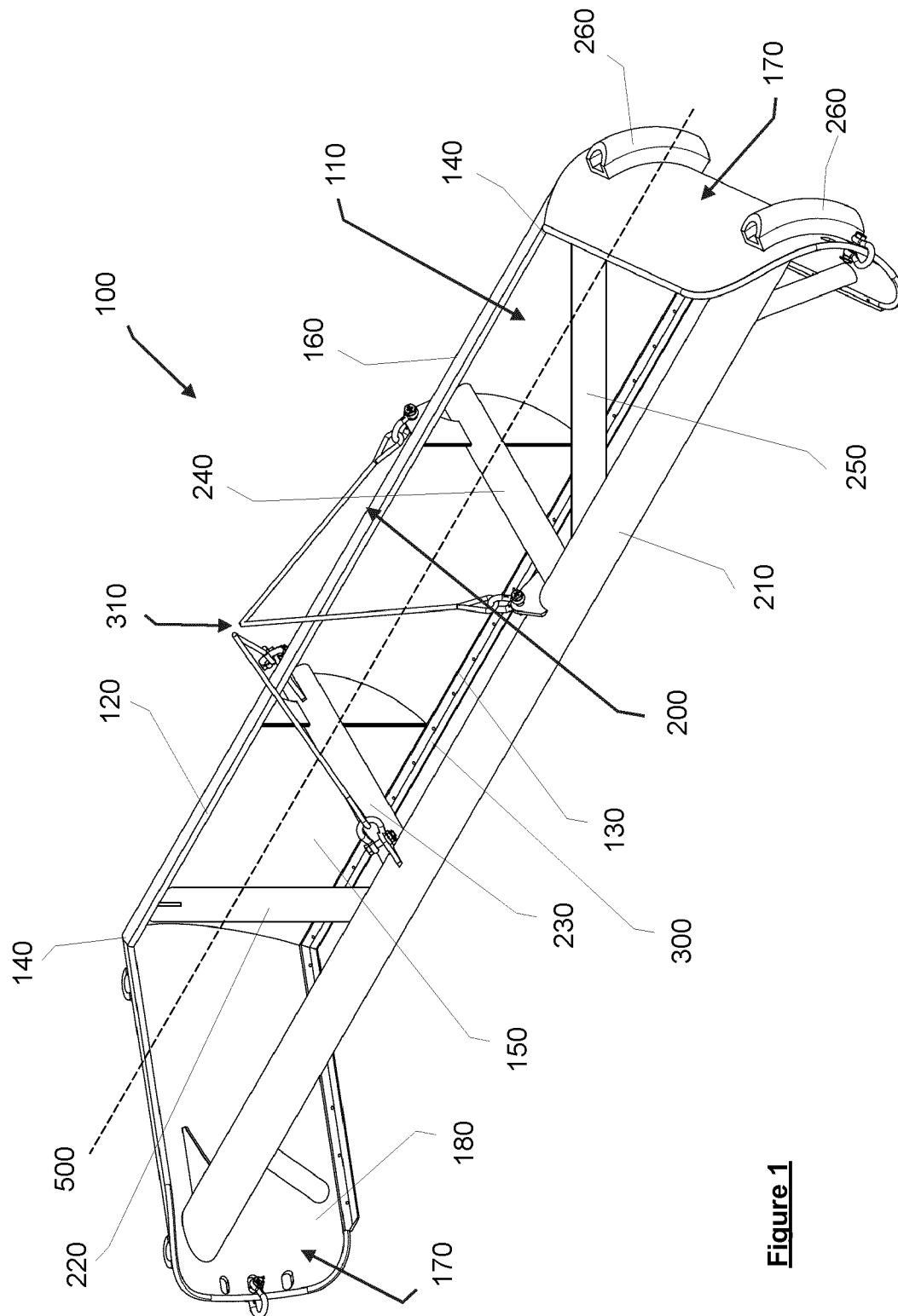


Figure 1

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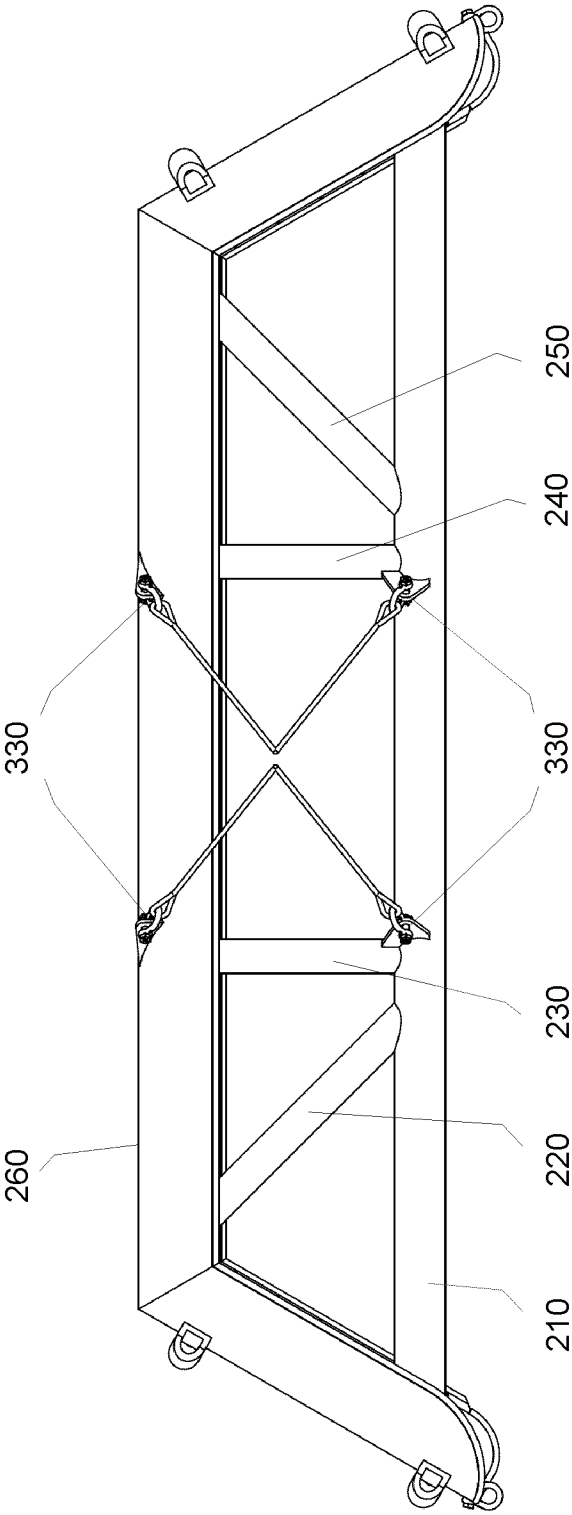


Figure 2

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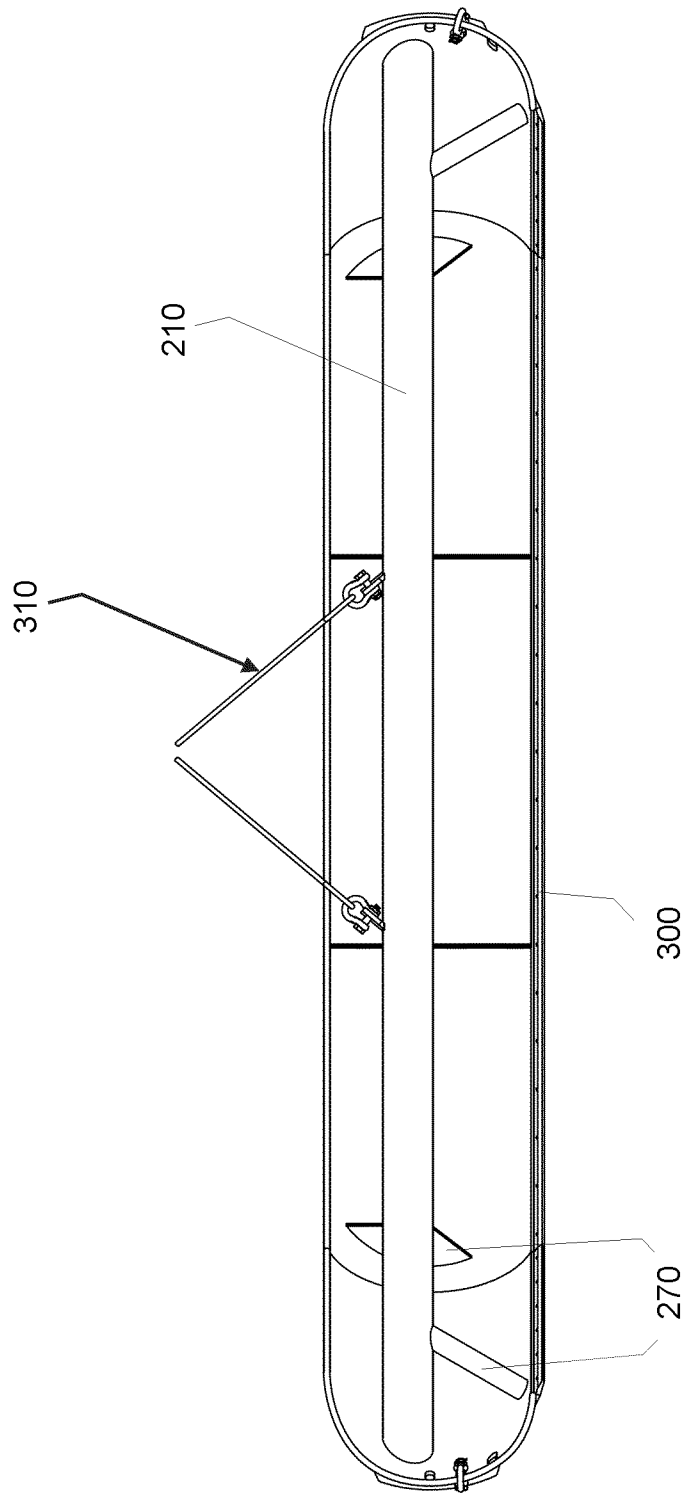


Figure 3

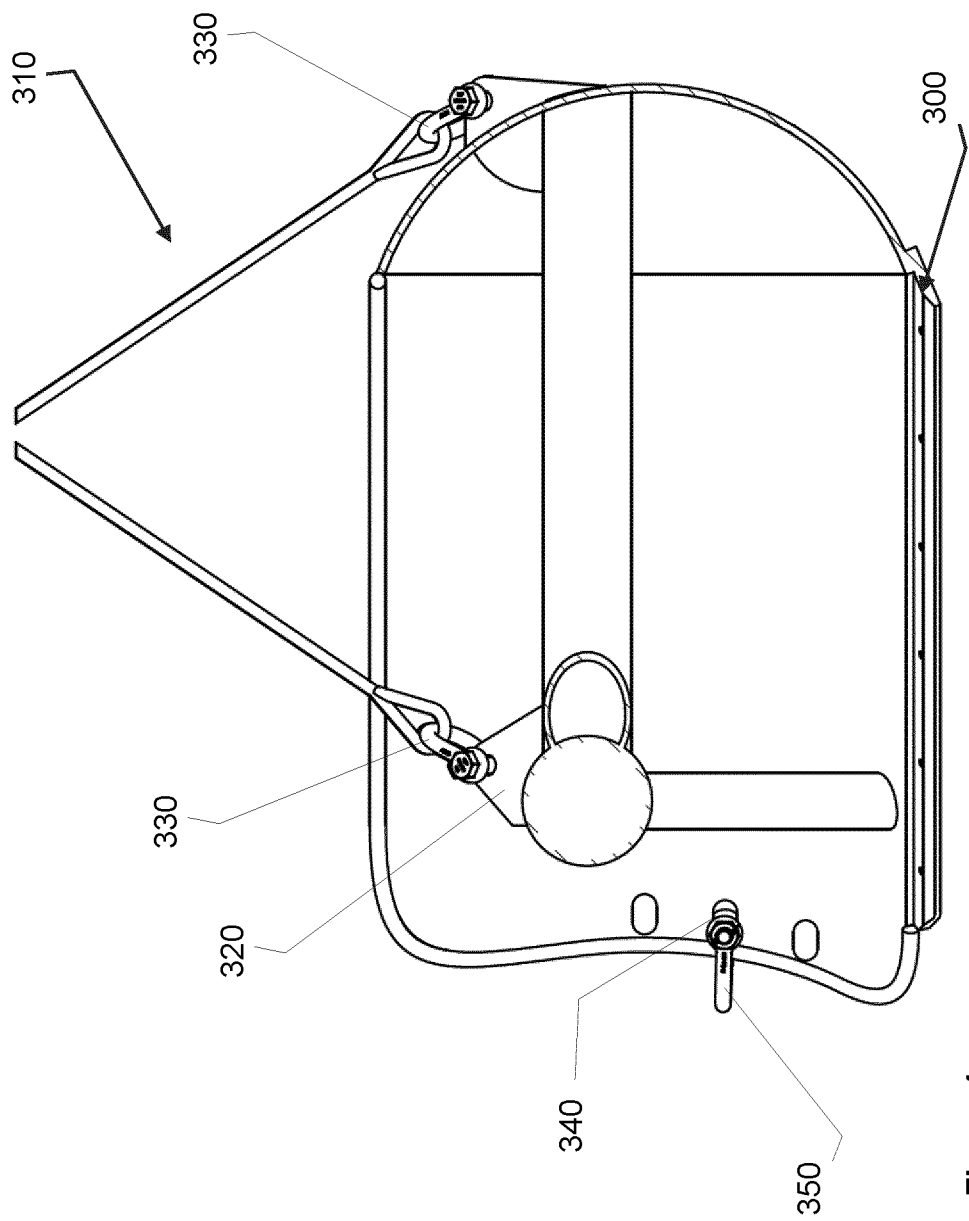


Figure 4

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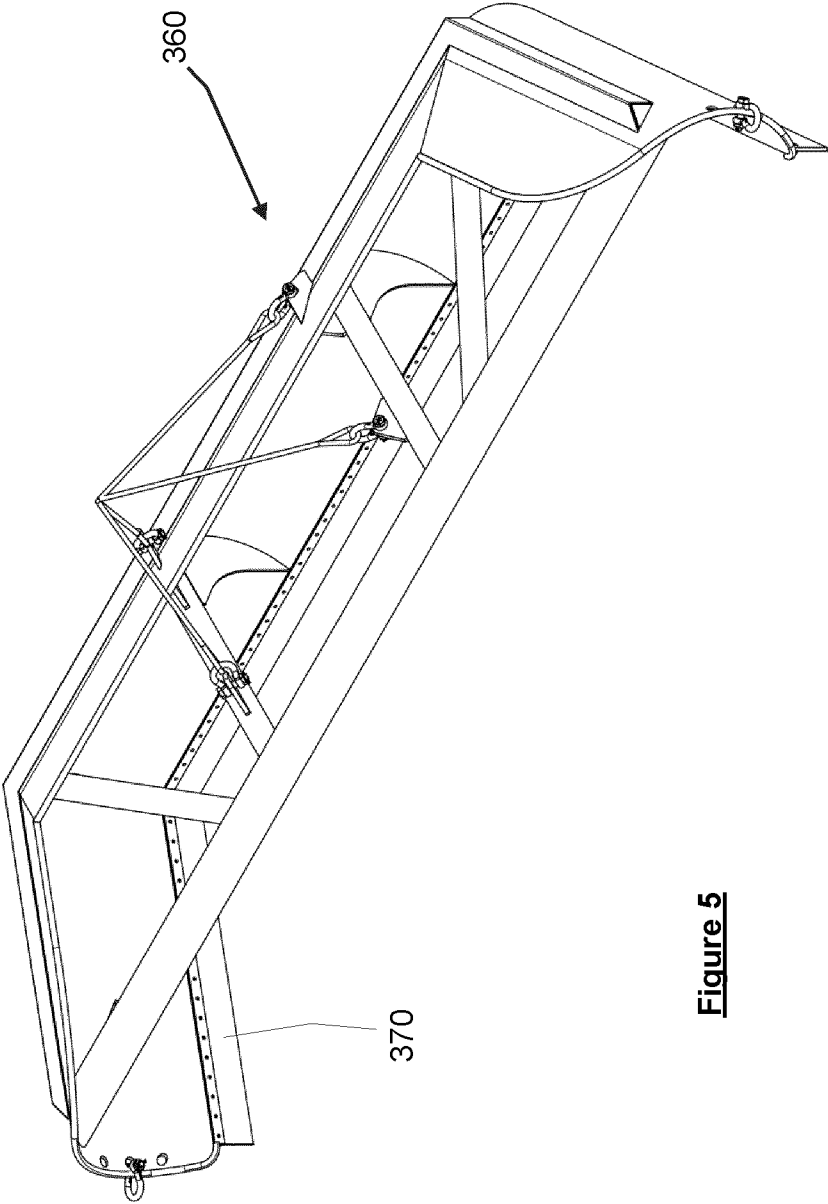
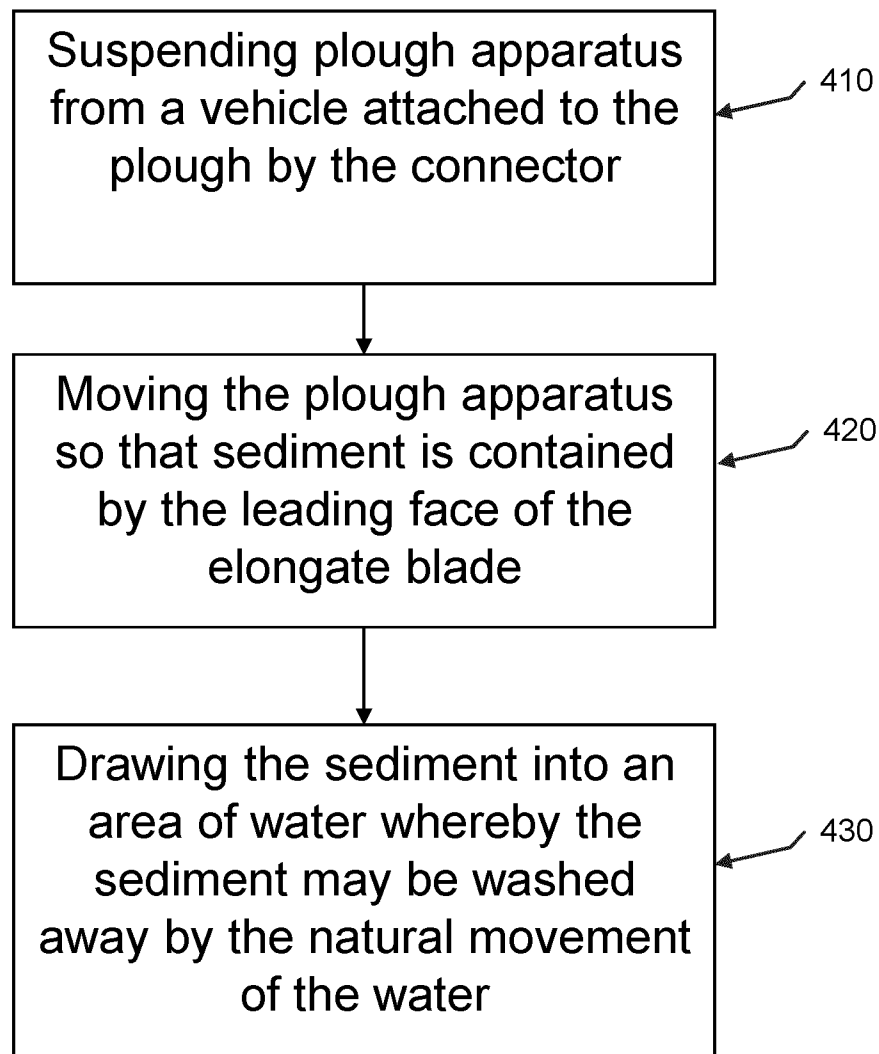


Figure 5

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**Figure 6**

INTERNATIONAL SEARCH REPORT

International application No
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A. CLASSIFICATION OF SUBJECT MATTER		
INV.	E02F5/10	E02F5/28
		E02B3/02
		E02F5/00
ADD.		
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 E02C 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 practicable, search terms used)		
EPO-Internal, WPI Data		
C. DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
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A	the whole document	7

Y	US 3 028 698 A (SCHMITT ANTHONY W) 10 April 1962 (1962-04-10)	1-6,8-13
A	abstract; figures 1-5	7
	column 4, lines 6-23	

Y	FR 2 356 775 A1 (AEROWATT ETUDES [FR]) 27 January 1978 (1978-01-27)	1-6,8-15
	abstract; figures 1-2	

Y	KR 101 455 373 B1 (DAEWOO ENG & CONSTR CO LTD [KR]) 4 November 2014 (2014-11-04)	1-6,8-13
	cited in the application	
	abstract; figures 1-4	

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☒ Further documents are listed in the continuation of Box C.		
☒ See patent family annex.		
* Special categories of cited documents :		
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"&" document member of the same patent family		
Date of the actual completion of the international search		Date of mailing of the international search report
13 June 2024		26/06/2024
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INTERNATIONAL SEARCH REPORT

International application No

PCT/EP2024/057082

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	US 2021/310212 A1 (WALDNER MICHEAL JUSTIN [CA]) 7 October 2021 (2021-10-07) abstract; figures 1-4 -----	1 - 6, 8 - 15

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No
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