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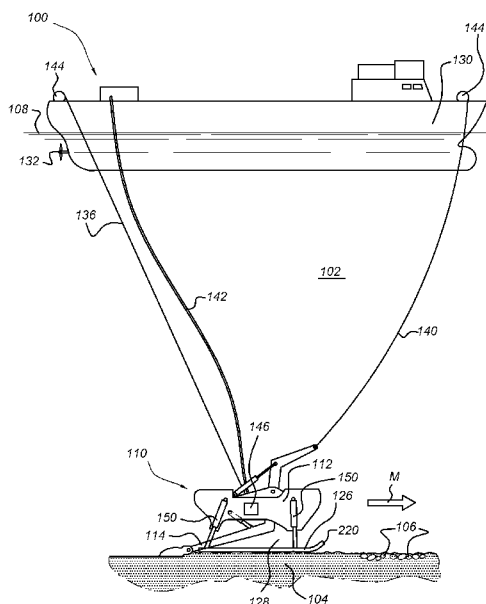
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(54) Title: DEVICE FOR COLLECTING MATERIAL FROM A FLOOR SURFACE OF A WATER COLUMN

Fig 1a



(57) Abstract: The present invention relates to a device (110) for collecting material (106) from a floor surface (104) of a water column (102). The device (110) comprises an excavation tool (114), a frame (112) for supporting the excavation tool (114) and at least one support surface (126) on a bottom side (128) of the frame (112) for supporting the device (110) when positioned on the floor surface (104). The orientation of at least one support surface (126) with respect to the frame (112) is adjustable.

**Device for collecting material from a floor surface of a water column****TECHNICAL FIELD**

5 The present invention relates to a device for collecting material from a floor surface of a water column, wherein the device comprises

- an excavation tool;
- a frame for supporting the excavation tool;
- at least one support surface on a bottom side of the frame for supporting the device when positioned on the floor surface.

10 The invention further relates to a combination for collecting material from a floor surface of a water column, wherein the combination comprises at least one vessel and such a device.

**BACKGROUND**

15 Mining and dredging tools for collecting material from a floor surface of a water column are known from the prior art. The material may be referred to as minable material or as dredging material.

For instance, Dutch patent application NL7810890 describes a dredging tool that can be moved over a seafloor. The dredging tool is provided with a suction draghead  
20 with a suction mouthpiece, and may be pulled by a vessel or may be self propelling. The dredging tool comprises a frame with horizontal gliders for guiding the dredging tool over the seafloor.

Dutch patent application NL8403722 describes a plough or the like for removing ground material from a seafloor. The plough is dragged by means of tow lines along the  
25 bottom of a watercourse. The plough is mounted on a frame. The frame comprises two sliding strips extending in a moving direction of the plough.

Such known devices have the disadvantage that they are unsuitable for use in versatile conditions, such as on an uneven seafloor or on a relatively soft seafloor. A soft seafloor will not be able to support the weight of the device and the device will  
30 sink into the seafloor.

## SUMMARY

It is an object to provide a device for collecting material from a floor surface of a water column that is more versatile in its employability under various seafloor conditions and which is able to work on relatively soft seafloors.

- 5        According to an aspect this object is achieved by a device for collecting material from a floor surface of a water column, wherein the device comprises
- an excavation tool;
  - a frame for supporting the excavation tool;
  - at least one support surface on a bottom side of the frame for supporting the
- 10       device when positioned on the floor surface, wherein the orientation of at least one support surface with respect to the frame is adjustable.

Such a device may be used as a mining device and/or as a dredging device.

- Such a device can be operated on relatively soft seafloors. In use, the at least one
- 15       support surface is in physical contact with the floor surface, while moving along it. The support surfaces may be relatively large in order to prevent the device from sinking into the floor.

- The adjustability of the orientation of the support surfaces with respect to the frame allows the device to move over the floor surface even when uneven and to adjust
- 20       the support surfaces to different floor conditions.

The term orientation as used with respect to the support surfaces comprises the distance of the support surfaces with respect to frame of the device, the angle with respect to the device and the position of the support surfaces with respect to the frame.

- It will be understood that many types of excavation tools may be used, such as a
- 25       suction head, a draghead, a cutterhead, a bucket wheel etc.

- In an embodiment at least one support surface comprises a leading edge, being curved upwardly. Such an upwardly curved leading edge prevents the device from diving into the floor. The support surfaces may have a shape which is elongated in a moving direction of the device. The support surfaces may for instance be formed as a
- 30       ski, for instance two or more parallel skis. By providing the support surfaces of the device as hydro dynamically favorable shaped support structures, e.g. elongated skis,

friction between the floor surface and the bottom side of the device that results from dragging the device along the floor surface is reduced.

According to an embodiment the device comprises at least two elongated support surfaces which both have a longitudinal body axis, the longitudinal body axes being  
5 substantial parallel to each other, whereby the excavation tool is positioned in between the two longitudinal body axes. The elongated support surfaces may be formed as skis. The longitudinal body axes may run parallel to a moving direction of the device. The elongated support surface may comprise two substantially parallel side edges, a leading edge and a trailing edge. The longitudinal axis may run from the leading edge to the  
10 trailing edge. The excavation tool may be positioned in between the elongated support surfaces, but may also be positioned before the leading edge or behind the trailing edge, in between the longitudinal body axes of the elongated support surfaces.

By providing support surfaces on opposite sides of the excavation tool, the device is effectively stabilized. In use, the support surfaces may be substantially horizontal.  
15 The two support surfaces and the excavation tool may be arranged next to each other in a direction substantially perpendicular to a moving direction. Such a configuration prevents the device from turning on its side.

According to an embodiment the device comprises at least two support surfaces, wherein the orientations of the respective support surfaces with respect to the frame are  
20 independently adjustable. This provides a highly versatile and stable device that can be operated on various types of seafloors, also comprising relatively uneven seafloors.

According to an embodiment the heights of the respective support surfaces are independently adjustable with respect to the frame. The term height is used here to indicate a direction that is substantially perpendicular to the surface of the support  
25 surfaces. In use, the support surfaces can thus be moved in a direction substantially perpendicular to the floor surface.

Such a device can move in a stable way along an uneven floor surface. The height of the different support surface parts with respect to the frame can be adjusted to keep the frame of the device in a relatively stable horizontal orientation.

30 This may in particular be advantageous when mining or dredging along and close to an earlier mined or dredged trench. One or more support surfaces may be in the earlier mined or dredged trench, while one or more other support surface parts may be

on a part of the seafloor that is not mined or dredged. In order to prevent the device from being unstable or even turning on its side, the support surfaces outside the trench may be positioned higher with respect to the support surfaces that are in the trench.

According to an embodiment a distance between two support surfaces in a  
5 direction substantially perpendicular to a moving direction of the device is adjustable. According to this embodiment, the span of the support surfaces may be adjusted. The span is the width of the device measured in a direction substantially perpendicular to a moving direction.

The support surfaces may be moved further apart in case the floor surface is  
10 uneven. By moving the support surfaces relatively far apart from each other, the device is made more stable and the risk of turning on its side is reduced.

When the device is stored on a vessel, or being transported, for instance between the floor surface and a vessel, the support surfaces may be moved to a position in which they are relatively close to each other, to provide a relatively small, easy manageable  
15 device.

According to an embodiment the at least one support surface comprises at least one steering support surface which is rotatable about a rotation axis, the rotation axis being substantially perpendicular with respect to the steering support surface. By providing the device with one or more steering support surfaces, the device can be  
20 steered over the floor surface. By rotating the one or more steering support surfaces, the device can make a left or right turn. The steering support surfaces may be used to make the device follow a predetermined pattern.

According to an embodiment at least one support surface is provided with a hinge axis extending in a moving direction of the device when in use, the hinge axis forming  
25 two support surfaces parts which can be orientated under a variable angle with respect to each other. By changing the variable angle, the characteristics of the device may be altered. The two support surfaces parts can be orientated under a variable angle with respect to each other thereby creating a groove that will help keeping the device at its intended course. However, the support capability of the will become less.

30 According to an embodiment the device is arranged to be operated in a first and a second working mode, wherein:

- in the first working mode, the excavation tool is operated substantially coplanar with at least one of the support surfaces allowing the device to be operated in a sledge mode wherein the device is moved along and in contact with the floor surface, and

- 5       - in the second working mode, the excavation tool is operated at a vertical distance below at least one support surface allowing the device to be operated in a gliding mode wherein the device is moved along and at the vertical distance above the floor surface.

A device that can be operated in both a sledge mode and a gliding mode is highly  
10       versatile. The sledge mode is a stable mode of operation in which the at least one support surfaces are in physical contact with the floor surface, while moving along it. This sledge mode is available when the floor is sufficiently dense for supporting the weight of the device. The establishment of contact with the floor surface renders the device less sensitive to seafloor currents. The support surfaces may be relatively large  
15       in order to prevent the device from sinking into the floor.

Nevertheless, the floor surface of an underwater region may locally vary in structure and density, affecting the surface supporting capacity required for carrying the device. If the device encounters a floor surface region which supporting capability is too small to bear the device, then the device's mode of operation can be changed to the  
20       gliding mode, without having to refit the combination and/or to deploy a different type of device. The height adjustability of the excavation device from the first working position to the second working position compensates for the different height at which the device operates with respect to the floor surface of the water column in the gliding mode, as compared to the sledge mode.

25       The second working mode may also be used in case an obstacle is in the path of the device. The device may then shortly change from the first to the second working mode to glide over the obstacle. This may be achieved by pulling the device in an upward direction using the towing cable, which will be explained in more detail below.

According to an embodiment the excavation tool comprises an excavation head  
30       that is attached to the frame by means of an excavation conduit, the device further comprising a height controller arranged to adjust the height of the excavation head with respect to the frame. An excavation head provides an efficient configuration for

hydraulic excavation, which configuration can be easily lowered to a desired distance with respect to the device.

The height controller may be arranged to adjust the position of the excavation head, i.e. the height with respect to the frame, to ensure that the excavation head  
5 follows the contour of the floor surface. The height controller may be arranged to do this when the device is working in the first and second working mode. Alternatively or additionally, the height controller may be arranged to change the position of the excavation head between the first working mode and the second working mode.

The device may comprise a controller or may be arranged to receive control  
10 signals from a remote controller (for instance provided on a nearby vessel), to adjust the position of the excavation head relative to the frame during operation. Adjustment of the position of the excavation head may be done based on height measurements of the floor surface performed during operation. Such height measurement may comprise measuring the contour of the floor surface. The position of the excavation head may be  
15 controlled accordingly. Alternatively, the height measurements may be performed at an earlier time.

According to an embodiment the height controller comprises a pressure compensation controller for controlling the pressure exerted by the excavation tool on the floor surface during operation. The height controller may further contribute to the  
20 performance of the device and combination, by providing a controlled compensation mechanism for the pressure that is exerted by the excavation tool on the floor surface. Provided that the excavation tool is in contact with the floor surface during operation of the device, the compensation pressure can then be continuously optimized to provide a maximum material yield. The pressure compensation controller can be used to control  
25 position and pressure of the excavation tool. The pressure compensation controller may also be used to compensate swell.

According to an embodiment the excavation tool comprises an excavation aperture, the device further comprising a position controller for adjusting an orientation of the excavation aperture.

30 According to an embodiment the device comprises a suspension rod which is with one end connected to the frame and comprises a connection member on the other end, the connection member being arranged to be connected to a towing cable, wherein

the suspension rod is connected to the frame via a hinge connection allowing the suspension rod to rotate with respect to the hinge connection. The device has a body axis (A) which is defined to correspond to a direction of movement of the device in use along the floor surface. The device comprises an adjustable suspension rod that is  
5 arranged to mechanically connect a towing cable. The suspension rod may point in a forward direction (i.e. the direction) and may be under a variable angle  $\alpha$  with respect to the body axis of the device within a vertical plane and/or within a horizontal plane.

Such an adjustable suspension rod allows controlling the angle  $\alpha$  under which the towing cable exerts a towing force on the device during movement along the floor  
10 surface. Adjustability of the angle  $\alpha$  between the adjustable suspension rod and the frame of the device, provided by an adjustable suspension (e.g. by hydraulics), allows to adjust the device to different seafloor conditions. By changing the angle  $\alpha$ , the way the force exerted by the towing cable is transferred to the device with respect to the centre of gravity of the device can be changed. Furthermore, by providing dynamic  
15 adjustability of the variable angle  $\alpha$  during operation the stability of the device may be improved.

According to an embodiment the device comprises a plurality of actuators to adjust the orientation of the at least one support surface of which the orientation with respect to the frame is adjustable. The actuator may be any kind of suitable actuator,  
20 that is operated by an energy source, such as electrical current, hydraulic fluid pressure, and is arranged to convert the available energy into movement to change the orientation of the respective support surface. Each adjustable support surface may be controlled by one or more actuators.

According to a further aspect there is provided a combination for collecting  
25 material from a floor surface of a water column, wherein the combination comprises

- at least one vessel, provided with vessel propulsion means for moving the at least one vessel along a water surface of the water column;
- a device arranged to be moved along the floor surface;
- at least one cable for connecting at least one vessel to the device,

30 wherein the device is a device according to the above.

The at least one cable may comprise at least one of a towing cable, a riser cable and an umbilical cable.

Such a combination provides a highly versatile combination, which can be operated in many different circumstances, such a relatively soft and uneven seafloors.

The floor surface of an underwater region may locally vary in structure and density.

5        When operated at great depths, more than one vessel may be used. A first vessel may be positioned substantially above the device and may be arranged to be connected to the device via an umbilical and/or a riser. A second vessel (towing vessel) may be located at a certain distance from the first vessel in a moving direction of the device and may be arranged to tow the device along the seafloor.

10        At smaller depths, the first and second vessel may be one and the same vessel.

The towing cable may be provided to pull the device along the floor surface, for instance by moving the towing vessel in the desired direction. More than one towing cable may be provided.

For instance, a first towing cable may be connected to a bow of the towing vessel and a second towing cable may be connected to a stern of the towing vessel. The first  
15        towing cable may be used to drag the device when the towing vessel is moved in a forward direction, the second towing cable may be used to drag the device when the towing vessel is moved in a backward direction. This embodiment is especially useful when only one vessel is used.

20        The riser cable may be provided to transport material from the device to the vessel. The riser cable may be a flexible riser tube. Alternatively, the middle part of the riser cable may be formed by a rigid riser pipe. The umbilical cable may be provided to provide the device with energy and/or operating instructions.

According to an embodiment at least one vessel comprises a winch mechanism  
25        for carrying the towing cable, the winch mechanism arranged for altering a vertical distance between the at least one vessel and the device. The winch mechanism for the towing cable provides a controllable height i.e. the vertical distance between the device and the vessel, which is required for positioning the device on the seafloor. By giving out more towing cable, the device will be positioned further behind the towing vessel,  
30        and the towing force exerted on the device will be more in the horizontal plane. Thus, by controlling the winch mechanism, the direction of the force exerted on the device can be changed.

## BRIEF DESCRIPTION OF THE DRAWINGS

Embodiments will now be described, by way of example only, with reference to the accompanying schematic drawings in which corresponding reference symbols indicate corresponding parts, and in which:

- 5           - Figures 1a – 1d schematically depict a side view of a device according to an embodiment,
- Figures 2a – 2d schematically depict further embodiments.

The figures are only meant for illustrative purposes, and do not serve as restriction of the scope or the protection as laid down by the claims.

10

## DETAILED DESCRIPTION

The device according to an embodiment of the invention is designed as a mining tool or dredging tool for use on great water depths of more than 100 meter.

- 15           The embodiments explained below refer to a mining tool. However, it will be understood that these embodiments may also be used as a dredging tool. The difference between these two applications of the device are mainly determined by the way the collected material is processed onboard the mining or dredging vessel.

- 20           FIG. 1a schematically shows a side view of a mining combination 100 for collecting material 106 from a floor surface 104 of a water column 102. The mining combination 100 shown comprises a ship or vessel 130 with vessel propulsion means 132 for moving the vessel 130 along a water surface 108 of the water column 102. The vessel propulsion means 132 may be any known system, e.g. screw or jet based, for propelling the vessel 130. The mining combination 100 may also comprise more than one vessel, especially in cases wherein the mining device is operated at great depths.

- 25           The mining combination 100 further comprises a mining device 110 that is arranged to be moved along the floor surface 104. In FIG.1a, the mining device 110 is shown during mining operation in a sledge mode in which the mining device 110 is dragged along and in contact with the floor surface 104 in a direction M, while being towed by the vessel 130 via a towing cable 140. The mining device 110 comprises a
- 30           frame 112 forming the main body of the device, which frame 112 comprises at least one support surface 126 on a bottom side 128 of the frame 112 for supporting the mining device 110 when positioned on the floor surface 104 of the water column 102.

The orientation of at least one support surface 126 is adjustable with respect to the frame 112. Actuators 150 are provided to change the orientation of the support surfaces 126.

It is noted that Fig. 1a – c show a side view of the mining device and therefore  
5 only show one support surface 126. It will be understood that a second support surface 126 is provided on the other side of the mining device not shown in the Figures. In fact, the mining device may comprise more than two support surfaces 126.

The mining device also has an excavation tool 114 with an excavation aperture, which excavation tool 114 is attached to and/or supported by the frame 112. This  
10 excavation tool 114 is arranged to remove the material 106 from the floor surface 104 of the water column 102. It will be understood that any suitable type of excavation tool may be used.

The mining combination 100 further comprises at least one cable 136, 140, 142 for mechanically connecting the vessel 130 to the mining device 110. The mining  
15 combination 100 may have at least one of a towing cable 140, a riser cable 142 and an umbilical cable 136. An additional support cable (not shown) may be provided, which connects the vessel 130 to the mining device 110. The towing cable 140 is provided in order for the vessel 130 to be able to haul or drag along the mining device 110 in the vessel's direction of motion. More than one towing cable 140 may be provided. For  
20 instance, the towing cable 140 may be connected to a bow of the vessel 130 and a further towing cable (not shown) may be connected to a stern of the vessel 130. The towing cable 140 may be used to drag the mining device 110 when the vessel 130 is moved in a forward direction; the further towing cable may be used to drag the mining device 110 when the vessel 130 is moved in a backward direction.

25 Alternatively, the towing cable 140 may be connected to a first vessel, while the riser cable 142 and the umbilical cable 136 may be connected to a second vessel.

The riser cable 142 may be provided in order to transport mined material from the mining device 110 to the vessel 130. The riser cable 142 may be a flexible riser cable 142. Alternatively, the middle part of the riser cable may be formed by a rigid riser  
30 pipe. The umbilical cable 136 may serve to provide the mining tool with energy and/or operating instructions.

The one or more vessels 130 in the mining combination 100 may further have one or more winch mechanisms 144. One of the winch mechanisms 144 may carry the towing cable 140 and may be used to transport the mining device from the water surface 108 to the floor surface 104. During use, the winch mechanism 144 may be  
5 used to change the vertical position of the mining device with respect to the vessel 130.

The winch mechanism 144 may be provided that is arranged for altering a vertical distance between the vessel 130 and the mining device 110, by hauling in or veering out the towing cable 140 in a controlled manner. The change in this vertical distance between the vessel 130 and the mining device 110 may be required for  
10 changing the operational mode of the mining vessel 110 the sledge mode and the gliding mode, or for adapting to large height variations of the floor surface 104, or to follow the contour of the seafloor.

The mining device 110 may comprise a control unit 146 that is arranged to adjust  
15 the orientation of the support surfaces 126 with respect to the frame 112 by controlling the actuators 150.

For instance, the control unit 146 may be arranged to actively monitor the functioning of the mining device 110 and control the orientation of the support surfaces 126 with respect to the frame 112 by controlling the actuators 150. The control unit 146  
20 may be arranged to function as a standalone control unit 146 that for instance monitors the orientation of the mining device 110 and controls the support surfaces 126 in response to that, for instance to prevent the mining device from falling or to keep the mining device level. The control unit 146 may also be arranged to receive instructions via the umbilical cable 136.

25 As the floor surface 104 may be uneven, continuous adjustment of the orientation of the support surfaces 126 with respect to the frame 112 may be required.

Fig. 1b shows a more detailed view of the mining device 110 for collecting minable material 106 from a floor surface 104 of a water column 102. The mining  
30 device 110 comprises a hull or frame 112 forming the body of the mining device 110, and presenting the basic structure for mounting various components. The mining device 110 further comprises an excavation tool 114 that is at least partially mechanically

connected to and/or supported by the frame 112, and arranged to remove the minable material 106 from the floor surface 104. The mining device 110 in Fig. 1b further has at least one support surface 126 on a bottom side 128 of the frame 112, for supporting the mining device 110 when positioned on the floor surface 104. The excavation tool 114  
5 has an excavation aperture 206.

The mining device 110 is arranged to be operated in a first and a second working mode, wherein:

- in the first working mode, the excavation tool 114 is operated substantially coplanar with at least one of the support surfaces 126 allowing the mining device 110  
10 to be operated in a sledge mode wherein the mining device 110 is moved along and in contact with the floor surface 104, and
- in the second working mode, the excavation tool is operated at a vertical distance below a lowest one of the at least one support surface 126 allowing the mining device 110 to be operated in a gliding mode wherein the mining device 110 is moved  
15 along and at the vertical distance above the floor surface 104. The second working mode is shown in more detail in Fig. 1c.

In the first working mode the excavation aperture 206 is positioned in a first working position, i.e. substantially coplanar with at least one of the support surfaces 126, while in the second working mode, the excavation aperture 206 is positioned in a  
20 second working position, i.e. at a vertical distance d1 below a lowest one of the at least one support surface 126.

The “first working position” is defined as the position and orientation of the excavation aperture 206 in which it is positioned coplanar with at least one of the  
25 support surfaces 126, as shown in FIG.1b. This first working position of the excavation aperture 206 allows the mining device 110 to be operated in a “sledge mode” wherein the mining device 110 is moved along and in contact with the floor surface 104, and

The “second working position” is defined as the position and orientation of the excavation aperture 206 in which it is positioned at a vertical distance below a lowest  
30 one of the at least one support surface 126. The second working position of the excavation aperture 206 allows the mining device 110 to be operated in a “gliding mode” wherein the mining device 110 is moved along and at the vertical distance d1

above the floor surface 104. This second working position and corresponding gliding mode are illustrated in FIG. 1c.

The excavation tool 114 shown in FIGs. 1a-c may have a excavation head 204, for example a suction draghead that is towable behind the mining device 110 and in  
5 contact with the floor surface 104 of the water column 102. The excavation aperture 206 may be located on the excavation head 204.

The excavation head 204 of the mining device 110 is attached to the frame 112 by means of a suction conduit 202. This suction conduit 202 may be formed by or incorporated in a rigid or partially rigid arm or beam structure.

10

The mining device 110 further comprises a suction height controller 212 for moving the excavation aperture 206 between the first working position and the second working position, corresponding to the sledge mode and the gliding mode respectively. The suction height controller 212 may be any suitable kind of actuator. The suction  
15 height controller 212 may be arranged to adjust the position of the excavation aperture 206 during operation to follow the surface contour of the water floor 104 within one of the working modes.

Control unit 146 may be arranged to control the suction height controller 212 to change the position of the excavation aperture 206 relative to the frame 112 during  
20 operation.

As shown in Fig. 1d, the suction height controller 212 may further be formed by a seabed level compensator or pressure compensation controller for controlling the pressure or force  $F$  exerted by the excavation head 204 on the floor surface 104 for the  
25 mining device 110 during operation.

The suction height controller 212 may comprise a hydraulic actuator 216 with a pressure sensor 215. The moving end of the hydraulic actuator 216 may be connected to a rope 213 which is guided over two pulleys 214, one being fixedly attached to the frame 112 of the mining device 110, the other being moveably attached to the hydraulic  
30 actuator 216. The rope 213 also being attached to the suction conduit 202. The hydraulic actuator 216 may be used to control the upward force  $F'$  exerted by the rope

213 to the suction conduit 202, thereby controlling the force  $F$  that is exerted on the seafloor by the excavation head 204.

The suction height controller 212 may contribute to the performance of the mining device 110, by maintaining a steady pressure or force  $F$  warranting a constant mining output. Provided that the excavation head 204 is in contact with the floor surface 104 during operation of the mining device 110, the compensation pressure can then be continuously optimized to provide a maximum material suction yield. The pressure compensation controller may function in both the first and second working mode.

The mining device 110 may comprise a plurality of support surfaces 126, for instance two or more support surfaces 126 provided on opposite sides of the excavation aperture 206. In use, the support surfaces 126 may be substantially horizontal i.e. parallel to the floor surface 104 of the water column 102. For example, two support surfaces 126 and the excavation tool 114 may be arranged next to each other in a direction substantially perpendicular to a mining or moving direction ( $M$ ).

In the first working mode, such a configuration prevents the mining device 110 from capsizing. In the second working mode, such support surfaces 126 provide flow guiding areas, improving hydrodynamic properties and stabilizing the mining device 110 while moving above the floor surface 104.

The support surfaces 126 of the mining device 110 may be formed as elongated support structures, e.g. skis or glide members 126. The support surfaces 126 may have a relatively high support area to prevent the mining device from sinking into the floor surface.

The support surfaces 126 may comprise leading edges 220 that are curved upwardly, like a ski, for preventing the mining device 110 operated in the first working mode from being dragged into the floor surface 104.

Further shown in FIGs. 1b-1c is that the mining device 110 comprises an adjustable suspension 214 that is arranged to mechanically connect a towing cable 140

to the mining vessel 110. The orientation of the adjustable suspension 214 may be varied.

The adjustable suspension may be positioned under a variable angle  $\alpha$  with respect to the mining or moving direction M within a vertical plane. Alternatively, the adjustable suspension may be positioned under a variable angle (not shown) with respect to the mining or moving direction M within a horizontal plane. In other words, the adjustable suspension may be moved up and down and/or from left to right with respect to position where it is connected to the frame. By varying the orientation of the suspension rod from left to right the direction of the mining device may be steered.

The connection to the frame 112 may be via a hinge connection allowing the suspension rod to rotate with respect to the hinge connection. The hinge connection may be any type of suitable hinge connection, such as a ball joint.

The adjustable suspension 214 allows control of the angle  $\alpha$  under which the towing cable 140 exerts a towing force on the mining vessel 110 during movement along the floor surface 104. The angle  $\alpha$  is defined as the angle between the adjustable suspension 214 and a body axis A that is defined by the direction of movement of the mining vessel 110 along the floor surface 104 of the water column 102. The adjustability of the adjustable suspension 214 may for example be achieved by one or more hydraulic cylinders 304 attached to the frame 112. The adjustability of the angle  $\alpha$  between the adjustable suspension 214 and the frame 112 of the mining vessel allows alternation between the first and second working modus.

Furthermore, by providing dynamic adjustability of the variable angle  $\alpha$  during mining operation, better trim control, i.e. stabilizing the orientation of the mining device 110 with respect to the floor surface 104 during operation, may be achieved.

As illustrated in FIG.1b, the excavation tool 114 may comprise a suction pump 222, and a suction conduit 202 connecting the excavation head 204 to suction pump 222. The suction pump 222 may be mounted within the frame 112 and may be connected to the riser cable 142.

Fig's 2a – d schematically depict that the orientations of the at least two support surfaces 126 are independently adjustable with respect to the frame 112 by means of

the plurality of actuators 150. Each support surface may be connected to the frame 112 by one or more actuator 150.

Fig. 2a schematically depicts a view of part of the mining device in a mining direction, showing that the heights of the respective support surfaces 126 are  
5 independently adjustable with respect to the frame 112. The support surface 126 depicted on the left hand side is positioned in a higher position than the support surface 126 on the right hand side. The support surface 126 on the right had side may be positioned in a trench that is created by the mining device.

Fig. 2b schematically depicts a view of part of the mining device in a mining  
10 direction, showing that the distance between two support surfaces 126 in a direction substantially perpendicular to a moving direction of the mining device is adjustable. The support surfaces 126 are shown in a position that is relatively far apart. Also shown (dotted lines) is that the support surfaces 126 may be positioned closer to each other. Actuators (not shown) may be provided to execute this movement.

Fig. 2c schematically depicts a view of part of the mining device in a mining or  
15 moving direction, in which the at least one support surface 126 comprise at least one steering support surface 126' which is rotatable about a rotation axis R, the rotation axis being substantially perpendicular with respect to the steering support surface 126. Actuators (not shown) may be provided to execute this movement. In Fig. 2c in total  
20 four support surfaces 126 are provided of which only two are shown in the side view presented in Fig. 2c.

Fig. 2d schematically depicts a further embodiment and schematically depicts a support surface 126'' which is provided with a hinge axis 171 in a mining or moving direction M, creating two support surface parts. The support surface parts can be  
25 orientated under a variable angle  $\varphi$  with respect to each other, the angle  $\varphi$  being measured in a direction substantially perpendicular to the mining or moving direction. Actuators (not shown) may be provided to change the variable angle  $\varphi$  between the support surface parts.

By changing angle  $\varphi$ , the characteristics of the mining device may be altered. By  
30 choosing a value for  $\varphi$  smaller than  $180^\circ$ , the hinge axis 171 may function as a groove that will help keeping the mining device at its intended course and will prevent the mining device from deviating from its intended course. The smaller the angle  $\varphi$ , the

better this groove will function. As a trade off, choosing a smaller value for  $\phi$  will reduce the capability of the support surface 126'' to function relatively soft seafloors.

5 The above described mining combination 100 allows mining work at depths of more than 100 meters. The described mining combination 100 may in principle also be used in shallow waters.

The mining device may be self propelling or may be towed by a vessel. In an embodiment, the mining device comprises a propulsion means for propelling the mining device in at least one direction with respect to the floor surface.

10

The descriptions above are intended to be illustrative, not limiting. It will be apparent to the person skilled in the art that alternative and equivalent embodiments of the invention can be conceived and reduced to practice, without departing from the scope of the claims set out below.

15

## CLAIMS

1. Device (110) for collecting material (106) from a floor surface (104) of a water column (102), wherein the device (110) comprises
  - 5 - an excavation tool (114);
  - a frame (112) for supporting the excavation tool (114);
  - at least one support surface (126) on a bottom side (128) of the frame (112) for supporting the device (110) when positioned on the floor surface (104),  
**characterized in that** the orientation of at least one support surface (126) with  
10 respect to the frame is adjustable.
2. Device according to claim 1, wherein the device is arranged to be operated in a first and a second working mode, wherein:
  - 15 - in the first working mode, the excavation tool (114) is operated substantially coplanar with at least one of the support surfaces (126) allowing the device (110) to be operated in a sledge mode wherein the device (110) is moved along and in contact with the floor surface (104), and
  - in the second working mode, the excavation tool (114) is operated at a vertical distance below at least one support surface (126) allowing the device (110) to be  
20 operated in a gliding mode wherein the device (110) is moved along and at the vertical distance above the floor surface (104).
3. Device according to claim 1 or 2, wherein the excavation tool (114) comprises an excavation head (204) that is attached to the frame (112) by means of an  
25 excavation conduit (202), the device (110) further comprising a height controller (212) arranged to adjust the height of the excavation head (204) with respect to the frame.
4. Device according to any one of the preceding claims, wherein the device  
30 comprises a suspension rod which is with one end connected to the frame (112) and comprises a connection member on the other end, the connection member being arranged to be connected to a towing cable (140),

wherein the suspension rod is connected to the frame (112) via a hinge connection allowing the suspension rod to rotate with respect to the hinge connection.

- 5 5. Device according to any one of the preceding claims, wherein at least one support surface (126) comprises a leading edge (220), being curved upwardly.
6. Device according to any one of the preceding claims, wherein at least one support surface (126'') is provided with a hinge axis (171) extending in a moving  
10 direction (M) of the device when in use, the hinge axis (171) forming two support surface parts which can be orientated under a variable angle ( $\varphi$ ) with respect to each other.
7. Device according to any one of the preceding claims, comprising at least two  
15 elongated support surfaces (126) which both have a longitudinal body axis, the longitudinal body axes being substantially parallel to each other, whereby the excavation tool is positioned in between the two longitudinal body axes.
8. Device according to any one of the preceding claims, comprising at least two  
20 support surfaces (126), wherein the orientations of the respective support surfaces (126) with respect to the frame (112) are independently adjustable.
9. Device according to any one of the claims 7 – 8, wherein the heights of the  
25 respective support surfaces (126) are independently adjustable with respect to the frame (112).
10. Device according to any one of the claims 7 – 9, wherein a distance between two support surfaces (126) in a direction substantially perpendicular to a moving  
30 direction of the device is adjustable.
11. Device according to any one of the preceding claims, wherein the at least one support surface (126) comprises at least one steering support surface which is

rotatable about a rotation axis (R), the rotation axis (R) being substantially perpendicular with respect to the steering support surface.

- 5 12. Device (110) according to any one of the preceding claims, as far as depending on claim 3, wherein the height controller (212) comprises a pressure compensation controller (216) for controlling the pressure exerted by the excavation tool (114) on the floor surface (104) for the device (110) during operation.
- 10 13. Device (110) according to any one of the previous claims, wherein the excavation tool (114) comprises an excavation aperture, the device further comprising a position controller (210) for adjusting an orientation of the excavation aperture (206).
- 15 14. Device according to any one of the preceding claims, comprising a plurality of actuators (150) to adjust the orientation of the at least one support surface (126) of which the orientation with respect to the frame is adjustable.
- 20 15. Combination (100) for collecting material (106) from a floor surface (104) of a water column (102), wherein the combination (100) comprises
- at least one vessel (130), provided with vessel propulsion means (132) for moving the at least one vessel (130) along a water surface (108) of the water column (102);
  - a device (110), arranged to be moved along the floor surface (104);
  - 25 - at least one cable (140, 142, 136) for connecting at least one vessel (130) to the device (110),
- characterized in that** the device (110) is a device according to any one of the claims 1 – 14.
- 30 16. Combination (100) according to claim 15, wherein the at least one cable comprises at least one of a towing cable (140), a riser cable (142) and an umbilical cable (136).

17. Combination according to claim 16, wherein at least one vessel (130) comprises a winch mechanism (144) for carrying the towing cable (140), the winch mechanism arranged for altering a vertical distance between the at least one vessel (130) and the device (110).

*Fig 1a*

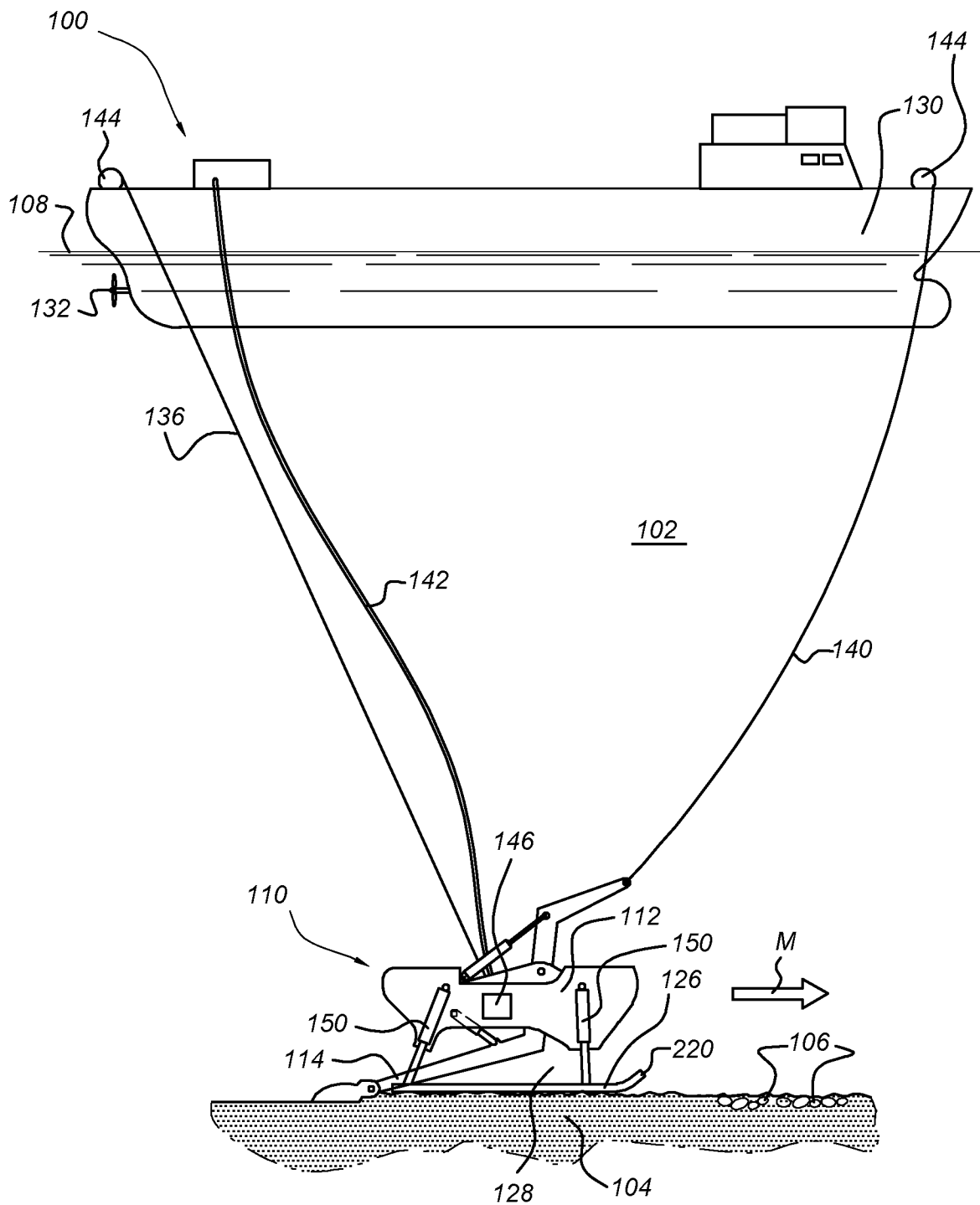


**Fig 1b**

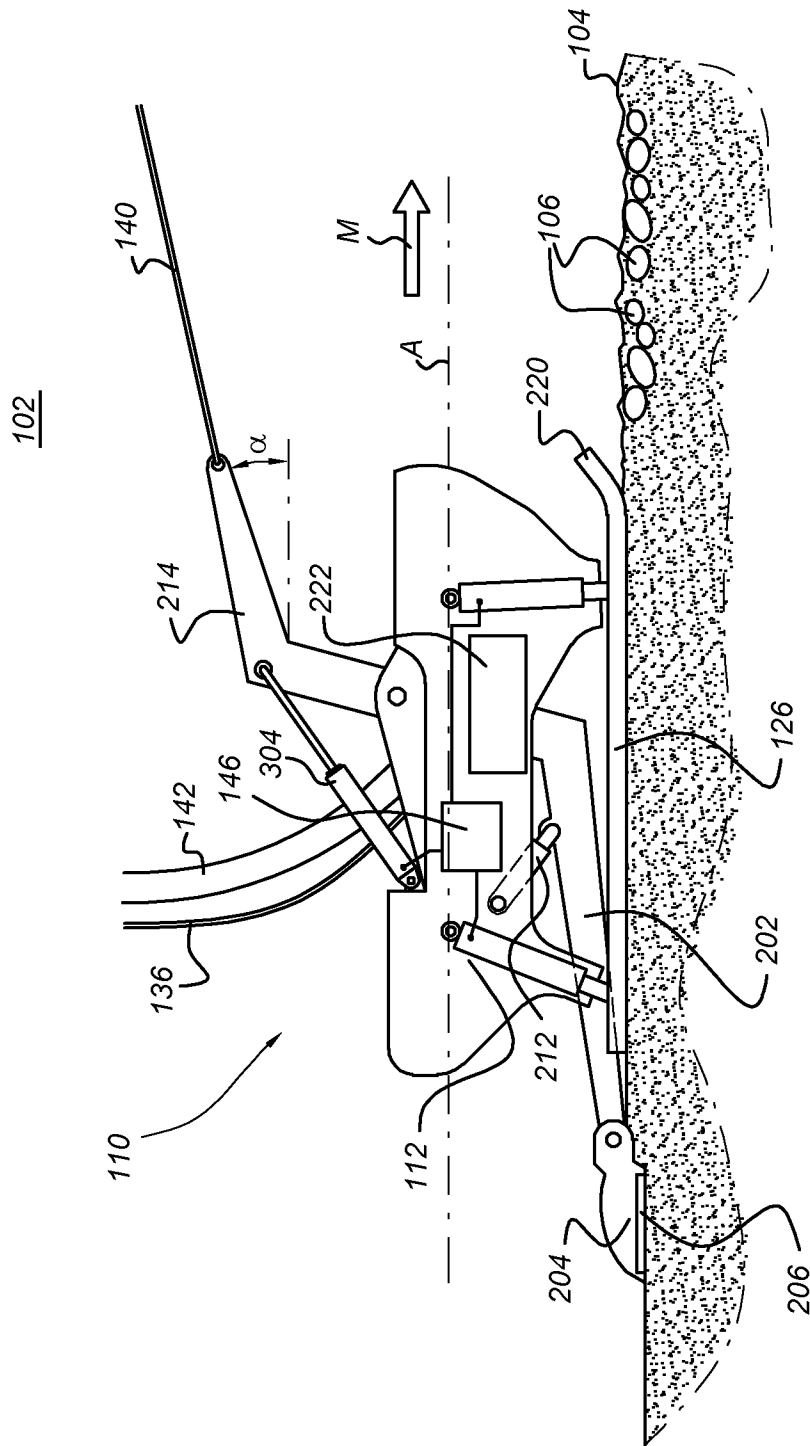


**Fig 1c**

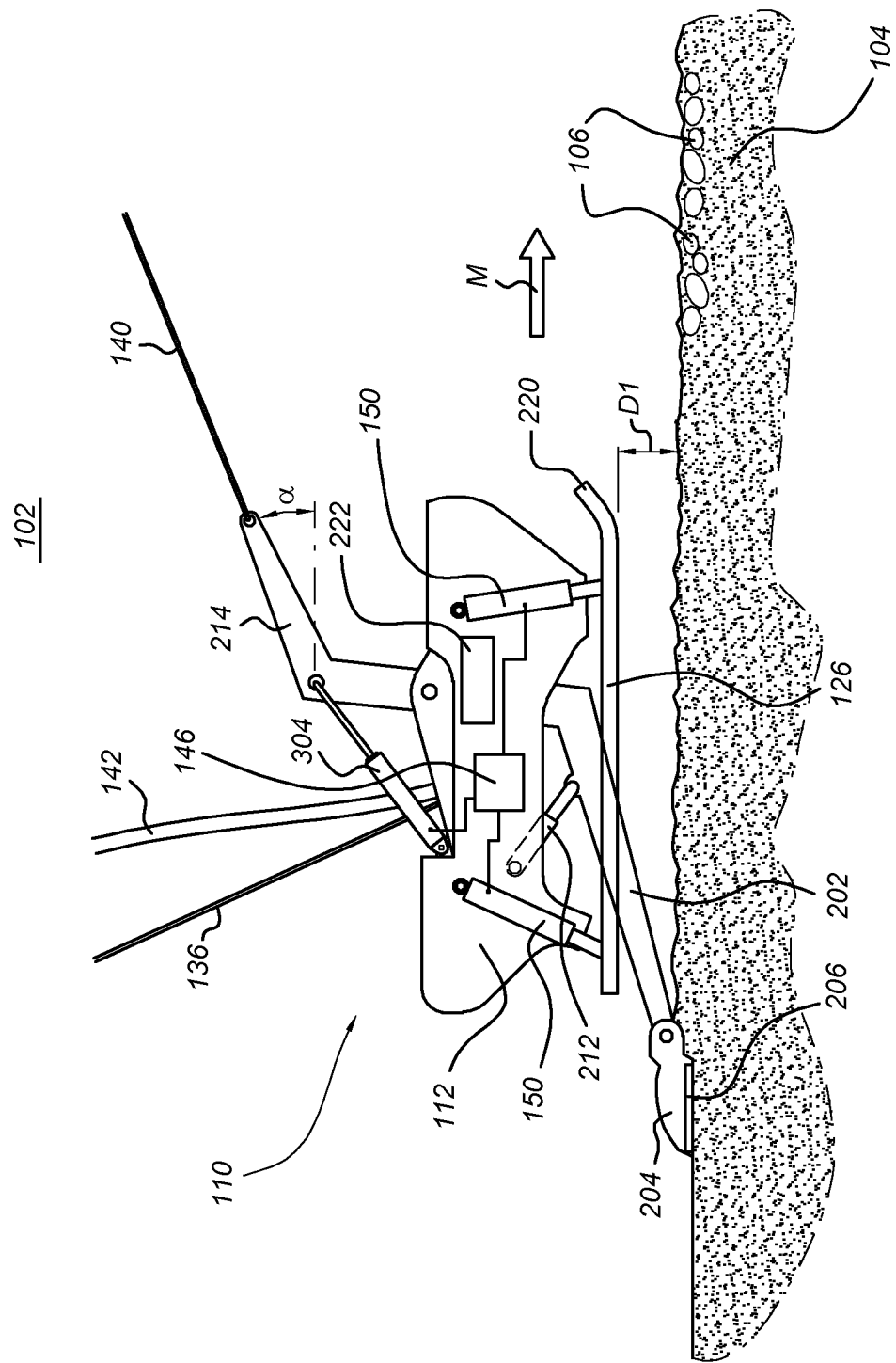


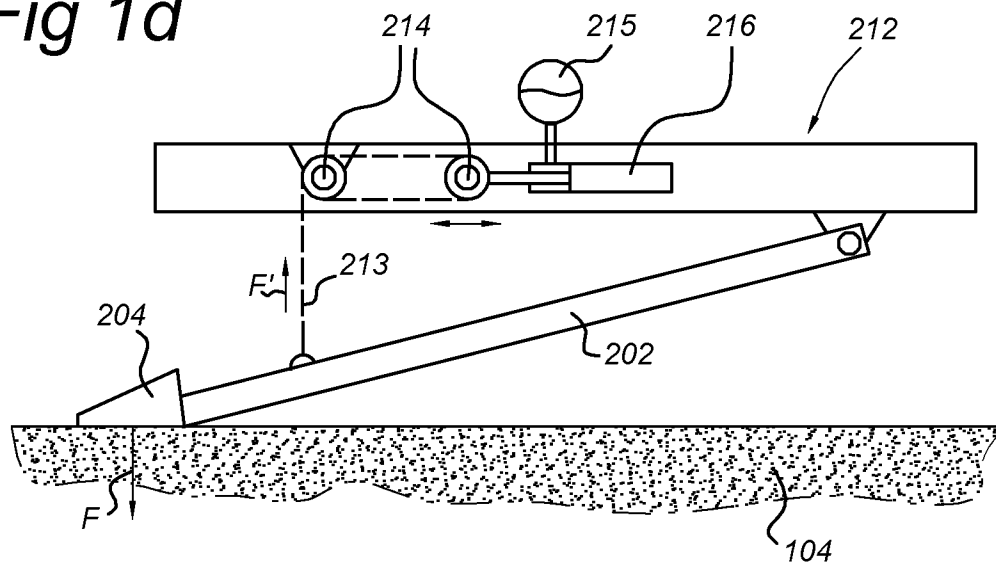
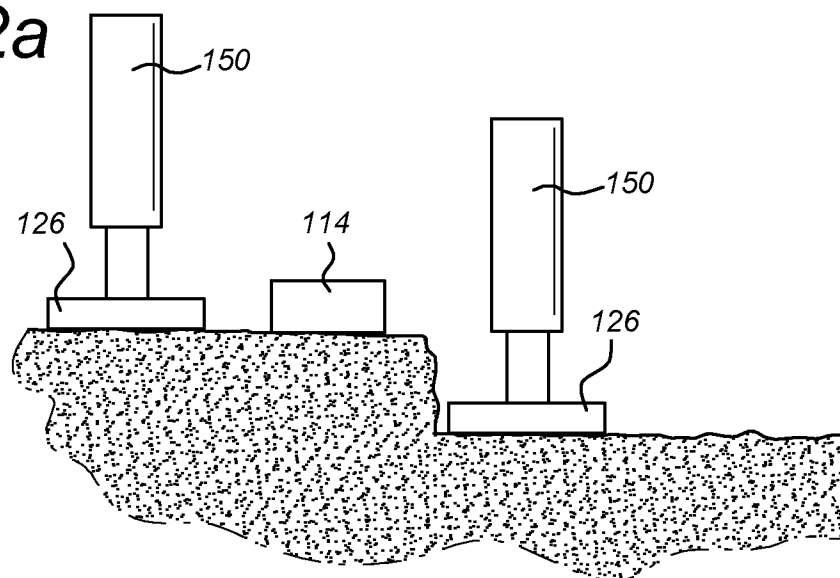
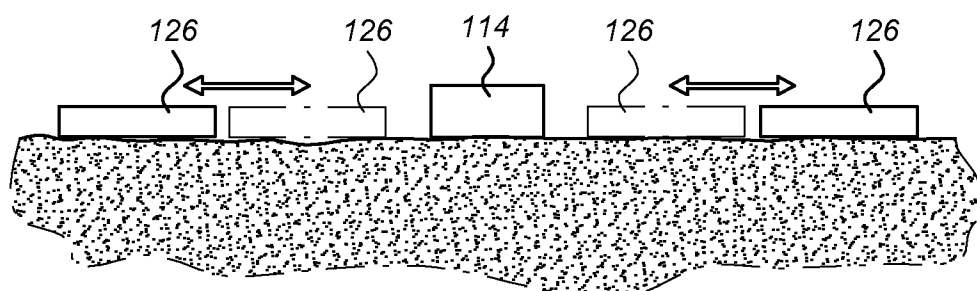
*Fig 1d**Fig 2a**Fig 2b*

**Fig 2c**

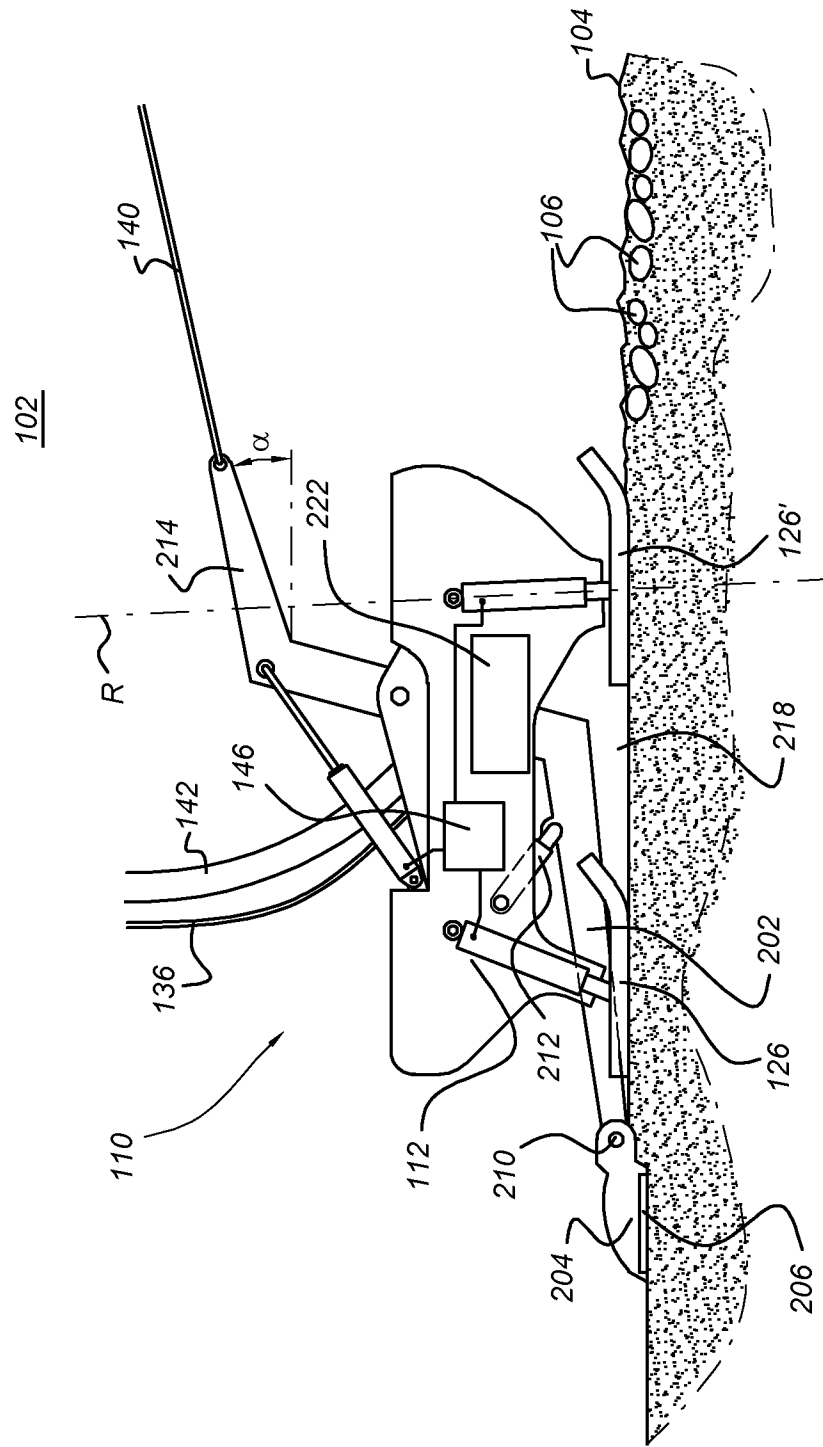


*Fig 2d*