

Dredging arrangement for dredging material from an underwater bottom

TECHNICAL FIELD

5 The invention relates to a dredging arrangement for dredging material from an underwater bottom, the dredging arrangement comprising a drag head and a suction pipe, the drag head comprising a drag head body which is attachable to the suction pipe, the drag head comprising at least one moveable part, such as a visor and a valve, which can be controlled to change the dredging characteristics of the drag head.

10 The invention further relates to a dredging vessel comprising such a dredging arrangement and a method for dredging material from an underwater bottom using such a dredging arrangement.

BACKGROUND

15 Dredging is often done by dragging a drag head over an underwater bottom by a dredging vessel, such as a trailing suction hopper dredger vessel. The drag head is connected to the vessel by means of a suction pipe. The drag head is lowered to the underwater bottom by one or more hoisting wires, possibly in combination with cranes or gantries. One or more pumps are provided to suck bottom material from the underwater bottom via the drag head,
20 the suction pipe into a hopper of the dredging vessel.

 The hoisting wires may be controlled by winches which may be equipped with heave compensation means to counteract wave induced vessel motion and variations in bottom height.

 During dredging, the dredging conditions will vary, for instance as a result of
25 - changing draught of the dredging vessel as a result of loading process,
 - changing underwater bottom conditions (underwater dunes etc.),
 - changing water level as a result of wave and tidal movement, and
 - changing soil type.

From the prior art dredging arrangements are known in which the dredging arrangement can be controlled to adapt to changing conditions, including to prevent choking when too much material and too little water gets into the suction pipe. U.S. Pat. No. 366,468 discloses a dredging apparatus which uses a simple valve which can open automatically or may be operated by a cable or rod if choking occurs. Similarly, U.S. Pat. No. 528,022 discloses a valve which may be operated by an operator pulling on a rope to allow water to flow in and cut up the choking material. The dredging arrangement may be adapted on board of a vessel before being lowered to the underwater bottom. Alternative solutions require active components mounted on the dredging arrangement, which can require expensive and fragile components and power to be supplied to active components. Also, the use of hydraulic fluid forms an environmental risk.

SUMMARY

It is an object to provide a drag head which can be adapted to changing dredging condition in an easy and reliable way.

Therefore, according to an aspect, there is provided a dredging arrangement for dredging material from an underwater bottom, the dredging arrangement comprising a drag head and a suction pipe, the drag head comprising a drag head body which is attachable to the suction pipe, the drag head comprising at least one moveable part, such as a visor or a valve, which can be controlled to change the dredging characteristics of the drag head, wherein the dredging arrangement comprises a wire connector and a transferring device, the wire connector being connectable to a wire via which a pulling force can be applied, wherein the transferring device is arranged to transfer the pulling force to at least one moveable part.

The pulling force may be applied by a wire controller positioned on board of a dredging vessel. The wire controller may be arranged to give out or take in wire and to control a pulling force exerted on the wire. The wire controller may be formed by or may comprise a winch. If the winch is the only wire controller then this winch has to be operated in constant tension mode, that means that the winch is giving out and taking in wire constantly to compensate the constantly changing difference between drag head and vessel or gantry.

The wire and the wire controller may also be provided by a heave compensator, for instance known from the prior art, now controlled differently, i.e. now also used for controlling the dredging characteristics of the drag head besides its main function to tension the wire (preventing slackening of the wire).

As further explained with reference to the drawings, the wire controller may also comprise a combination of a winch and a separate heave compensator. In other words, the wire controller may comprise a first wire control device and a second wire control device, wherein the first wire control device, e.g. formed by a winch, is arranged to lift and lower the dredging arrangement including the suction pipe and to prevent that the second control device gets out of its working range, and wherein the second wire control device, e.g. formed by a heave compensator, is arranged to dynamically take in or give out wire and/or to dynamically adapt the pulling force to control the moveable parts to adapt to changing dredging conditions.

In that case the constantly changing dredging conditions are compensated by the second wire control device (heave compensator) and the first wire control device is operated when the second wire controller reaches its maximum or minimum position.

The wire controller (first and/or second) is used to control the length of the wire and the pulling force acting on the wire. The wire is primary used to hoist the dredging arrangement, e.g. to lower it to the seabed and to hoist it to its top position where it will be able to put it to its resting position on board.

When the drag head is making contact to the seabed, the pulling force in the wire is reduced to keep the drag head in contact with the bottom. The remaining force (between lifting force of the dredging arrangement and the minimum force to prevent slackening of the wire) will be dynamically controlled to adjust the dredging characteristics of the drag head.

In use, for the purposes of this invention, the pulling force may be controlled dynamically in a range wherein it is less than the force required for lifting the dredging arrangement from the underwater bottom and more than a minimum force to prevent slackening of the wire. The second wire control device may therefore be made less strong than the first wire control device, as the second wire control device is not used to lift the dredging arrangement from the underwater bottom.

In use, the winch control device may be used to constantly adjust the pulling force to control the moveable parts of the drag head.

The drag head may comprise a drag head body, which is open at a side directed towards the material to be dredged to allow dredging material to be sucked into the drag head and a connection to a suction pipe to transport the dredging material away from the drag head, for instance towards a hopper on board of a dredging vessel.

The wire connector may be attached to the lower end of the suction pipe or to the drag head body.

The transferring device may be connected to the lower end of the suction pipe or to the drag head body and to the moveable part in order to transfer pulling force exerted by the wire towards the moveable part.

5 The wire connector may be formed by a ring or the like to which a wire can be connected. The wire connector may be connected to the transferring device.

By pulling the wire the moveable parts can be influenced, for instance be moved or the moving behavior of the moveable parts, as will be explained in more detail below. The moveable parts are moved with respect to the drag head body.

This allows easy and direct control of moveable parts of the drag head .

10 According to an embodiment a biasing device is provided exerting a biasing force on the at least one moveable part and wherein the wire connector and the transferring device are arranged such that the transferred pulling force opposes the biasing force.

15 The wire can be pulled by the wire controller. Pulling is done in a direction away from the wire connector. Because the biasing force and the transferred pulling force of the wire are oppositely directed, the position of the moveable part can be adjusted. Also, as long as the transferred pulling force is less than the biasing force, the position of the moveable part is not changed, but the behavior of the moveable part can be adjusted, i.e. the spring characteristics of the moveable part can be adjusted. The transfer device may be arranged to reduce the pulling force, i.e., the transferred pulling force is less than the pulling force in the wire.

20 According to an embodiment the at least one moveable part is a visor, the visor being rotatable with respect to the drag head body about a rotational axis which, in use, is substantially horizontal and perpendicular to a dredging direction.

25 The visor can be used to control the dredging characteristics of the drag head, such as the excavation depth (layer thickness) and the ratio between water and sand being dredged. By controlling the pulling force, the position and/or behavior of the visor can be controlled.

The visor may be provided at the trailing end of the drag head body.

Instead of rotational visors, visors may be used which are moveable in another manner, such being slideable, translational or are arranged to perform a combination of a rotational and translational movement.

30 According to an embodiment the drag head comprises a biasing device exerting a biasing force on the visor such that the visor is biased in a downward direction.

The downward direction may be a rotational downward direction.

Such a biasing device may be applied to force the visor to follow the contour of the underwater bottom and to deal with obstacles present on the underwater bottom. Also, the biasing device can be used to set the excavation depth.

5 The biasing device may for instance be an additional weight positioned on the moveable part to bias it in a downward direction.

The biasing device may be adjustable to set the biasing force. Also, a force transferring construction may be used to transfer the biasing force to the moveable part. The force transferring construction may be adjustable to set a moment of force exerted to the moveable part.

10 The biasing device is connected to the visor and to the drag head body and/or suction pipe.

According to an embodiment the biasing device comprises at least one of a mechanical spring, an hydraulic spring, a gas spring.

15 This is an advantageous way to provide a biasing force. In this way, the visor is provided with spring characteristics, which will contribute to the capability of the visor to follow the contour of the under bottom. Also, no energy supply is needed to the dredging arrangement. The moving characteristic of the visor (flexible or stiff) will depend on the spring constant, the pulling force, the gravitational force and the ground force.

20 The mechanical spring may for instance be a torsion spring, a rubber element or a coil or helical spring.

The hydraulic spring and gas spring may comprise a compressible chamber in which a fluid or gas is comprised.

According to an embodiment the wire connector and the transferring device are positioned such that the transferred pulling force opposes the biasing force.

25 One end of the wire can be connected to the wire connector. The other end may be connected to the wire controller, which is arranged to pull the wire with a controllable pulling force, thereby at least partially cancelling the biasing force. This allows to change the relative position of the visor with respect to the drag head body and/or to adjust the moving behavior of the visor, i.e. the spring constant describing the behavior of the visor (its deflection in response to forces exerted on the visor, such as by the underwater bottom).

30 According to an embodiment the moveable part is a valve provided to open and close an opening in the drag head or lower part of the suction pipe to allow water to enter .

The valve (also known as water flap or water valve) may be used to control the amount of water entering the drag head. The admission of water to the drag head makes it possible to

control the dredging process. According to the prior art, the valve usually opens towards the outside by active control of hydraulic or pneumatic means (cylinders). According to these embodiments, the valve opens towards the inside while the differential pressure at which the valve opens can be adjusted by the pulling wire force.

5 The valve may also open in any other suitable manner. The valve may for instance open to the outside, may open in a sliding manner or may open by rotation, where part of the valve rotates to the outside and part of the valve rotates to the inside.

10 The opening may be provided in the drag head and the valve may be attached to the drag head to open and close the opening. The opening may also be provided in the lower end of the suction pipe and the valve may be attached to the suction pipe to open and close the opening in the suction pipe.

According to an embodiment the drag head or suction pipe comprises a biasing device exerting a biasing force on the valve such that the valve is biased towards a closed position.

15 According to an embodiment the wire connector and the transferring device are positioned such that the transferred pulling force opposes the biasing force.

By pulling the wire, the biasing force is counteracted and thus reduced enabling the valve to open.

20 One end of the wire can be connected to the wire connector. The other end may be connected to the wire controller, which is arranged to pull the wire with a controllable pulling force, thereby at least partially cancelling the biasing force. This allows to open and close the valve and/or to change the relative position of the valve with respect to the drag head body or suction pipe and/or to adjust the moving behavior of the valve, i.e. the spring constant describing the behavior of the valve.

25 According to an embodiment the transferring device comprises one or more pulleys and a transferring cable being guided by the one or more pulleys, wherein the wire connector is connected to one of the pulleys being a moveable pulley, the transferring cable being arranged to transfer the pulling force from the wire connector to the moveable part.

According to an embodiment the transferring device comprises a hydraulic force transmitter. Possibly, the hydraulic force transmitter comprises an actuator.

30 According to an embodiment the transferring device comprises a lever which is connected to the wire connector and to the at least one moveable part.

The lever may be rotatably mounted to the drag head body or to the lower end of the suction pipe. Levers are suitable for transferring the pulling force to the moveable part.

According to an aspect there is provided a dredging vessel comprising a dredging arrangement for dredging material from an underwater bottom, the dredging arrangement comprising a drag head and a suction pipe, the drag head comprising a drag head body which is connected to the dredging vessel by means of the suction pipe, the drag head comprising at least one moveable part, such as a visor or a valve, which can be controlled to change the dredging characteristics of the drag head, wherein the dredging vessel comprises a wire connectable to the dredging arrangement for lifting and lowering the dredging arrangement from and to the underwater bottom, wherein the dredging arrangement comprises a wire connector and a transferring device, the wire connector being connectable to the wire via which a pulling force can be applied, wherein the transferring device is arranged to transfer the pulling force to the at least one moveable part.

The dredging vessel may be a trailing suction hopper dredger (TSHD).

According to an embodiment the dredging vessel comprises a wire controller, the wire controller being arranged to exert a controllable pulling force on the wire.

The wire controller may be formed as already described above. It may comprise a first wire control device and a second wire control device which work in cooperation with each other. The second wire control device is dynamically controlled during dredging, while the first wire control device is operated in case the second wire control device reaches an end position, i.e. a minimum and maximum position. In that case, the first wire control device and the second wire control device are operated oppositely, to bring the second wire control device back to the centre of its working area. The first wire control device may be formed by a winch, while the second wire control device may be formed by a heave compensator. Both may be positioned on (the deck of) the dredging vessel.

The wire controller is arranged to control a pulling force in a range wherein it is less than the force required for lifting the drag head from the underwater bottom and more than a minimum force to prevent slackening of the wire. The wire controller comprises means for dynamically controlling a pulling force during dredging.

The wire controller may also be arranged to exert a pulling force sufficient to lift the drag head from the underwater bottom.

According to an embodiment the dredging vessel comprises a gantry via which the wire can be guided from the wire controller to the dredging arrangement.

According to an embodiment the wire controller also functions as hoisting device for lowering and lifting the dredging arrangement towards and from the underwater bottom.

As described above, the wire controller may comprise first wire controller suitable for lifting and lowering the dredging arrangement and second wire controller for controlling the moveable parts and to compensate for heave motion.

5 Once the dredging arrangement is in position on the underwater bottom, the wire controller may control the pulling force in a range less than needed for lifting the dredging arrangement from the underwater bottom, but sufficient for controlling the position of the moveable part and/or moving behavior of the moveable part, while the wire is kept under tension.

10 According to an aspect there is provided a method for dredging material from an underwater bottom using a dredging arrangement, the dredging arrangement comprising a drag head and a suction pipe, the drag head comprising a drag head body which is attached to the suction pipe, the drag head further comprising at least one moveable part, such as a visor and a valve, which can be controlled with respect to the drag head body to change the dredging characteristics of the drag head, the dredging arrangement being connected by a wire
15 to the wire controller to lift and lower the dredging arrangement from and to the underwater bottom, wherein the method comprises

a) lowering the dredging arrangement to an underwater position with the drag head positioned on the underwater bottom,

20 b) dredging by dragging the drag head over the underwater bottom in a dredging direction by means of a dredging vessel,

the dredging arrangement comprising a wire connector and a transferring device, the wire connector being connectable to the wire via which a pulling force can be applied by the wire controller, wherein the transferring device is arranged to transfer the pulling force to the at least one moveable part, wherein the method further comprises:

25 b1) controlling the wire controller to dynamically control a pulling force exerted on the wire during dredging.

As a result, the position and/or moving behavior of the moveable part can be controlled during dredging.

30 During lifting and lowering, the pulling force is at least equal to a lifting force required for lifting the dredging arrangement. As a result, during lifting and lowering the moveable parts will be pulled to an end position. For instance, in case the moveable part is the visor, the visor will be in its most upward position during lifting and lowering. During dredging the pulling force will be less than the required lifting force but more than a minimum force to

prevent slackening of the wire and the visor can thus be controlled between its upper end position and its lower end position by controlling the wire.

According to an embodiment the pulling force is controlled dynamically during dredging in a range which lies below the lifting force required for lifting the dredging arrangement from the underwater bottom and more than a minimum force to prevent slackening of the wire.

According to an embodiment, the wire controller comprise first wire controller and second wire controller, and action a) is performed by the first wire controller and action b1) is performed by the second wire controller.

According to an embodiment, action b1) comprises temporarily operating the first and second wire controller in opposite directions.

This is done when the second wire controller reach an end of its working range. By operating temporarily the first and second wire controller in opposite directions, the second wire controller are brought back to the centre of its working range. The term temporarily is used that this is done a relatively short period during action b1) to reset the second wire controller.

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:

FIG. 1 schematically shows an embodiment of a dredging vessel according to an embodiment,

FIG.'s 2a – 2d show different embodiments of the dredging arrangement and

FIG.'s 3a, 3b and 4 schematically show further embodiments of the dredging arrangement.

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.

DETAILED DESCRIPTION

Fig. 1 schematically depicts a dredging vessel 1 according to an embodiment. The dredging vessel 1 comprises a drag head 10 which is attached to the dredging vessel 1 via a suction pipe 2. The suction pipe 2 comprises a hinge point.

The drag head 10 and the suction pipe 2 are shown in a lowered position with the drag head 10 resting on an underwater bottom 6. In use, the dredging vessel 1 sails in a dredging direction DD and drags the drag head 10 over the underwater bottom 6.

5 The drag head 10 and the suction pipe 2 are connected to a wire 4, the wire 4 being controlled by a wire controller 5. Half way the suction pipe 2, the suction pipe 2 may be connected to a further wire 4' controlled by a further wire controller 5'. The further wire and wire controller is mainly used for lifting and lowering the suction pipe 2.

10 The wire controller 5 comprises a first wire control device, in this case formed by a controllable winch 51. The wire controller 5 may further comprise a control unit 55 or the like to control the winch 51. The winch 51 is used to lower and lift the dredging arrangement from the vessel 1 to the underwater bottom 6 and vice versa by giving out or taking in the wire 4.

15 The wire controller 5 comprises a second wire control device, in this case formed by a number of pulleys 52 on board the vessel 1 to guide the wire 4. The second wire control device comprises means for dynamically controlling a pulling force exerted on the wire 4 during dredging. Second wire control device for dynamically controlling a pulling force may for instance be formed by providing at least one of the pulleys 52 in a moveable manner, moveable in a direction perpendicular to the rotational axis of the pulley 52 by an actuator 53. In Fig. 1, the actuator 53 is an hydraulic actuator comprising a cylinder and a piston which can move up and down the cylinder. The moveable pulley 52 is connected to the cylinder. The
20 actuator 53 is also under control of the control unit 55. The actuator 53 and the moveable pulley 52 may be provided by hardware similar to a heave compensator. However, according to the embodiments provided here, the actuator 53 and the moveable pulley 52 are controlled differently to control moveable parts of the dredging arrangement, as will be explained in more detail below.

25 The control unit 55 may be a standalone control unit or may be arranged to cooperate with other remote control units. The control unit 55 may be a computer. The control unit 55 may also be arranged to receive instructions from an operator via a user interface.

The drag head 10 comprises two main parts: the drag head body 11 and the visor 12. The drag head body 11 is on one side connected to the suction pipe 2 via an appropriate
30 connection 13. The drag head body 11 and the (lower end of the) suction pipe 2 may also be formed as one piece.

The drag head body 11 may have any suitable shape and its main purpose is to form a chamber in which an underpressure can be created to vacuum up dredging material from the underwater bottom 6. A pump 21 may be provided to create the required underpressure. The

pump 21 may be positioned on board of the dredging vessel 1 (as shown in Fig. 1) and/or at or nearby the drag head 10. The drag head 10 may comprise jet nozzles 22 to create a water jet to loosen the underwater bottom 6. A jet pump 23 and a jet pipe lane 24 may be present.

The visor 12 is a moveable part of the drag head 10. The visor 12 is moveable with respect to the drag head body 11 to change the dredging characteristics of the drag head 10. The visor 12 is moveable with respect to the drag head body 11, in this embodiment rotatable about a rotational axis RA, which runs perpendicular to the plane of the drawing of Fig. 1. The visor 12 is provided on a trailing end of the drag head body 11. In use, the rotational axis RA runs substantially horizontal in a direction perpendicular to the dredging direction DD.

The drag head 10 may comprise a further moveable part formed by a valve 14. As shown in Fig. 1, the valve 14 is attached to drag head body 11 and is arranged to open and close an opening 18 in the drag head body 11. Alternatively, the valve 14 may be attached to the (lower end of the) suction pipe 2 and be arranged to open and close opening 18 in the suction pipe 2.

The moveable parts 12, 14 can both move with respect to the drag head body 11 respectively to the suction pipe 2 and are both provided to change the dredging characteristics of the drag head 10. For instance, moving the visor 12 to a lower position (rotating counter clockwise in Fig. 1), results in deeper dredging and a higher sand-water ratio. Opening the valve 14 results in a lower sand-water ratio.

During dredging, the dredging circumstances will change, for instance as a result of increased draught of the dredging vessel 1, uneven underwater bottom 6, changing dredging depth (distance between underwater bottom 6 and water surface) as a result of wave and tidal movement, changing soil type.

According to the embodiments provided here and explained in further detail below, the dredging arrangement comprises a wire connector 15 which is connectable to the wire 4 to control the moveable parts 12, 14 by means of the wire 4. The wire connector 15 is preferably dimensioned in such a way that lifting and lowering of the dredging arrangement is possible i.e. is strong enough to allow lifting and lowering.

According to the embodiments, the dredging arrangement further comprises a transferring device 16 for transferring a pulling force exerted on the wire 4 to one or both of the moveable parts, such as visor 12 or valve 14. The wire controller 5 and in particular the means for dynamically controlling a pulling force (second wire control device) are used to dynamically control a pulling force exerted on the wire 4 during dredging to control the moveable parts 12, 14. By transferring the pulling force in the wire 4 to a moveable part, the

moveable parts 12, 14 can be controlled by the wire controller 5, and in particular by the second wire control device for dynamically controlling the pulling force.

Fig. 1 shows an example wherein the transferring device 16 comprises one or more pulleys 161 and a transferring cable 162 being guided by the one or more pulleys 161. The transferring device is similar to the transferring device shown in Fig. 2a, and will be explained below with reference to Fig. 2a. The transferring device 16 may be arranged to ensure that the transferred pulling force is reduced with respect to the pulling force in the wire 4 to prevent the visor from being pulled to its upper most position as a result of the minimum pulling force needed to prevent the wire from slacking.

Alternatively, the wire 4 may be directly connected to the visor 12, preferably in situations wherein the minimum pulling force needed in the wire 4 to prevent slackening is below the force needed to lift the visor 12.

However, in the embodiment shown in Fig. 2a, one of the pulleys 161 is a moveable pulley, moveable in a direction perpendicular to a rotational axis of the moveable pulley 161. Although not shown, it will be understood that guiders may be present to guide the moveable pulley in the direction perpendicular to the rotational axis. The wire connector 15 is connected to the moveable pulley 161 thereby transferring the pulling force from the wire 4, via the wire connector 15 and the transferring device 16 to the visor 12.

In the embodiments shown, the wire controller 5, in particular the second wire control device for dynamically controlling the pulling force in the wire 4 can be used during dredging to adjust the pulling force in the wire 4 and thus the force exerted on the visor 12 via the transferring device 16. If the wire controller 5 increases the pulling force exerted to the wire 4, the moveable pulley 161 will move upward, thereby causing the transferring cable 162 to pull the visor 12 upward against the gravity, suction force and possibly a biasing force. If the transferred pulling force is large enough to lift the visor 12, the position of the visor 12 can be adjusted. However, even if the transferred pulling force is not large enough to move the visor 12 to a new position, the gravity, suction force and possibly biasing force may at least partially be cancelled, resulting in a different behavior of the visor 12. By controlling the pulling force dynamically during dredging, the dredging characteristics of the drag head 10 can be adjusted during dredging.

In the embodiments described below depicted in Fig.'s 2a – 2d, the visor 12 is biased. Biasing device 17 is provided for this purpose on the dredging arrangement. The biasing device 17 is provided on the visor 12 and on the drag head body 11 or lower end of the suction pipe 2 such that the visor 12 is biased in a direction towards the underwater bottom 6.

The biasing device 17 exerts a biasing force on the visor 12 pushing the visor in a downward direction, in this case such that it tends to rotate in a downward direction towards the underwater bottom 6.

5 The transferring device 16 is provided to transfer the pulling force on the wire 4 to the visor 12 such that the transferred pulling force opposes the biasing force, i.e. cancels or at least partially cancels the biasing force, suction force and gravity acting on the visor 12.

Different embodiments are shown wherein the moveable part is the visor 12 in Fig.'s 2a – 2d and which will be explained in more detail below.

10 Fig. 2a shows an embodiment comprising a transferring device 16, comprising one or more pulleys 161, at least one of the pulleys 161 being a moveable pulley 161 and a transferring cable 162 being guided via the one or more pulleys 161. Different to Fig. 1 is that the dredging arrangement comprises a biasing device 17, biasing the visor 12 in a downward direction by a spring 179, e.g. a mechanical spring, connected to the visor 12 and the drag head body 11 and/or lower end of the suction pipe 2. The (mechanical) spring is normally
15 mounted on top of the drag head 10 and may also be formed by a plurality of parallel springs, e.g. one on the left and one at the right side with respect to the dredging direction DD.

Fig. 2b shows an embodiment wherein the transferring device 16 comprises an hydraulic force transmitter, comprising two coupled hydraulic cylinders. The hydraulic force transmitter comprises a first hydraulic cylinder 164 and a first moveable piston 165 inside the
20 first hydraulic cylinder 164. The first hydraulic cylinder 164 is with one end connected to the moveable part, in this embodiment the visor 12, and with its other end connected to the drag head body 11.

Again, a biasing device 17 is provided, biasing the visor 12 in a downward direction by a (mechanical) spring 179 connected to the visor 12 and the drag head body 11 and/or lower
25 end of the suction pipe 2.

The hydraulic force transmitter comprises a second hydraulic cylinder 166 and a second moveable piston 167 inside the second hydraulic cylinder 166. The second hydraulic piston 167 is connected to the wire 4 by the wire connector 15.

30 The hydraulic force transmitter further comprises a fluid reservoir 168 to compensate for differences in volumes of the first and second hydraulic cylinders 164, 166 when the pistons are moving.

The first and second hydraulic cylinders 164, 166 are in fluid communication with each other, such that movement of the first moveable piston 165 and second moveable piston 167 are coupled: movement of the second moveable piston 167 will result in movement of the first

moveable piston 165. Fluid conduits 169 are provided. A first fluid conduit 169 connects the underchamber 173 in the first hydraulic cylinder 164 (formed under the first piston 165) to the second underchamber 171 in the second hydraulic cylinder 166 (formed under the second piston 167). A second fluid conduit 169 connects the upperchamber 172 in the first hydraulic cylinder 164 (formed above the first piston 165) to the second upperchamber 170 in the second hydraulic cylinder 166 (formed above the second piston 167).

Pulling the wire 4 will result in a pulling force being exerted on the second piston 167. The second piston 167 will move upward, pushing the hydraulic fluid out of the second upperchamber 170 of the second hydraulic cylinder 166 into the first upperchamber 172 of the first hydraulic cylinder 164, causing the second piston to move thereby transferring the pulling force to the moveable part, in this embodiment the visor 12, counteracting the biasing force.

Of course, the first and second hydraulic cylinders 164, 166 may be provided by a plurality of parallel cylinders.

Normally the first hydraulic cylinder 164 is mounted on top of the drag head 10.

Fig.'s 2c and 2d show embodiments wherein the transferring device 16 comprises a lever 163, 163' which is connected to or comprises the wire connector 15 and is connected to the at least one moveable part 12, 14. The lever is rotatably connected to the drag head body 11 or to the lower end of the suction pipe 2.

Again, biasing device 17 is provided, biasing the visor 12 in a downward direction by a mechanical spring 179 connected to the visor 12 and the drag head body 11 and/or lower end of the suction pipe 2.

Fig. 2c shows an embodiment wherein the lever 163 is formed as an angled rod or bar, which rotatably connected to the lower end of the suction pipe 2 at its angle. A first end of the lever 163 is connected to the moveable part, for instance by means of a rod or by means of a cable or wire 176 as shown in Fig. 2c. A second end of the lever 163, opposite the first end, is connected to the wire 4 via the wire connector 15.

Of course, a plurality of parallel levers 163 may be provided, which are each connected to the wire 4.

Fig. 2d shows an embodiment wherein the lever 163' is with one end rotatably connected to the lower end of the suction pipe 2 and with a second end, opposite the first end, rotatably connected to the moveable part, for instance by means of a cable or wire or by means of a rod 176 as shown in Fig. 2d. Wire connector 15 is provided halfway the lever

163'. Of course, the wire connector 15 may be provided at any other suitable position along the lever 163', to achieve an optimal balance of forces and moments of force.

In general, the transferring device 16 may be dimensioned such that a desired and suitable transfer rate of pulling force into transferred pulling force is achieved. In the
5 embodiments shown in Fig. 's 2c and 2d this may be achieved by selecting the dimensions of the lever 163, 163'. In the embodiment shown in Fig. 2b, this may be done by selecting the dimensions of the hydraulic cylinders 164, 166. In the embodiment shown in Fig. 2a this may be achieved by positioning of the pulleys 162.

10 Fig. 's 3a and 3b show alternative embodiments wherein the moveable part is the valve 14. The valve 14 is shown as a rotatable member, rotatable about an axis of rotation R1. The valve 14 may rotate between a closed and an opened position. The valve 14 as shown in Fig. 3a and 3b is shown in an opened position. It is noted that the part of the valve rotating towards the inside of the dredging arrangement is larger than the part of the valve rotating towards the
15 outside of the dredging arrangement.

The transferring device 16 is similar to the transferring device as shown in Fig. 2c. A lever 141 is connected to the valve 14 which is rotatable connected to lever 163 by a rod 176. Also connected to rod 176 is biasing device 17, in this embodiment formed by a mechanical spring 179, which is with its other end connected to the drag head body 11. As will be
20 explained below, in the embodiment of Fig. 3b both the visor 12 and the valve 14 will be controlled.

Optionally the embodiment shown in Fig. 3a may comprise a further spring provided between the visor 12 and the drag head body 11.

The biasing device 17 biases the valve to its closed position. By controlling the pulling
25 force, which opposes the biasing force, the under pressure needed to open the valve 14 can be controlled. Also, the valve 14 can be opened by exerting a pulling force which is large enough to overcome the biasing force. It will be understood that other transferring devices 16, such as shown in Figures 1 – 2d may be used as well.

Fig. 3b allows to control both the visor 12 and the valve 14, as the biasing device is
30 provided by a mechanical spring 179a provided between the drag head body 11 and the valve 14 and by a second mechanical spring 179b provided between the visor 12 and the drag head body 11. The visor 12 is connected to the force transferring device 16 via an additional rod 176'.

The use of the embodiments shown will now be described in more detail.

The biasing force acting on the visor 12 exerted by the biasing device 17 pushes the visor 12 downwards, for instance with a force of 8 ton and an arm of 0.5 meter, resulting in a downward moment of 4 tonm, not taking into account the force of gravity and the suction force.

5 The pulling force exerted on the wire 4 is transferred by the transferring device 16 opposing the biasing force, resulting in an upward moment of force. The pulling force can be controlled dynamically during dredging.

10 In case no substantial pulling force is exerted, the resulting upward moment resulting from the transferred pulling force will be negligible. The visor 12 rests on the underwater bottom 6 with a moment of force of 4 tonm.

15 If the transferred pulling force is increased but the resulting upward moment resulting from the transferred pulling force is in the range of 0 – 4 tonm, the visor 12 will not rotate upward by the transferred pulling force only, but the visor 12 can move upwards when the ground force moment exceeds the moments of biasing device minus transferred pulling force moment, which will result in a smaller excavation depth. This will also result in a different behavior of the visor 12 when meeting obstacles.

 If the pulling force is increased such that the resulting upward moment resulting from the transferred pulling force exceeds the 4 tonm, the visor 12 will be lifted and rotate upward. This results in maximum upwards position of the visor 12 with respect to the drag head.

20 When the visor 12 is in its lowest position and the transferred pulling force is smaller than the downward force on the visor (gravity + suction force + biasing force – ground force), the visor will not move upward, but remains in its lowest position. Varying the pulling force will result in a varying moving behavior of the visor. Increasing the pulling force will result in a more flexible visor behavior, which can be lifted more easily by the ground forces.

25 When the visor 12 is in its highest position and the transferred pulling force is greater than the downward force on the visor (gravity + suction force + biasing force – ground force), the visor will not move downward, but remains in its highest position. Varying the pulling force will result in a varying moving behavior of the visor. Decreasing the pulling force will result in more flexible visor behavior.

30 By varying the pulling force of the wire 4, the visor can be positioned in an intermediate position. The position of the visor depends on the sum of all forces, including the transferred pulling force, counter force of the underwater bottom 6 (ground force), suction force and the gravity all acting on the visor. The sum of these forces determines the position of the visor 12 during dredging. In this intermediate position the production of the drag head 10 can be

controlled by changing the pulling force. If the production is too high (i.e. visor 12 is in a too low position), the pulling force has to be increased and vice versa.

There are two modes in which the dredging arrangement can be operated.

In a force control mode, the biasing force is relatively small with respect to the ground force. The force control mode results in a dredging arrangement which can follow contours of the underwater bottom 6 relatively well as it responds to changing dredging conditions, for instance visor 12 will respond to a changing ground force, without active control during dredging. During dredging the exact position of the moveable parts 12, 14 may be unknown, but this is not very relevant. The pulling force can be controlled by monitoring the production.

In a position control mode, the biasing force is relatively large with respect to the ground force. In such a mode, controlling the pulling force and balancing the transferred pulling force with the biasing force allows to control the position of the moveable part 12, 14 and thereby the production of the drag head. The ground force has little influence on the position of the moveable parts 12, 14. This allows to control the production accurately, although for instance the visor 12 will not be able to follow contours of the underwater bottom 6 very smoothly. For instance, if the production is too high (visor angle is too large), the pulling force may be increased to lift the visor 12 and vice versa.

A further embodiment is shown in Fig. 4. The embodiment shown in Fig. 4 comprises a similar transferring device 16 as shown in Fig. 2c. The biasing device 17 is with one end connected to the lever 163 and with its other end to the drag head body 11 or lower end of the suction pipe 2. The biasing force exerts a biasing force opposing the pulling force.

First end of the lever 163 is connected to the visor 12, for instance by means of a rod 176. Rod 176 is however not directly connected to the visor 12, but via a lever 181 which can move between a lower stop 182 and an upper stop 183. This provides lever 181 with a free moving range, in which the visor can be controlled in a force control mode. Once the lever 181 abuts to one of the stops 182, 183, the visor 12 is in a position control mode.

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.

CLAIMS

1. Dredging arrangement for dredging material from an underwater bottom (6), the dredging arrangement comprising a drag head (10) and a suction pipe (2), the drag head (10) comprising a drag head body (11) which is attachable to the suction pipe (2), the drag head (10) comprising at least one moveable part (12, 14), such as a visor or a valve, which can be controlled to change the dredging characteristics of the drag head (10),

wherein the dredging arrangement comprises a wire connector (15), a wire controller (5) and a transferring device (16), the wire connector (15) being connectable to a wire (4) via which a pulling force can be applied, wherein the transferring device (16) is arranged to transfer the pulling force to the at least one moveable part (12, 14), and the wire controller (5) is arranged to exert a controllable pulling force on the wire (4) and also functions as hoisting device for lowering and lifting the dredging arrangement towards and from the underwater bottom (6).

2. Dredging arrangement according to claim 1, wherein a biasing device (17) is provided exerting a biasing force on the at least one moveable part (12, 14) and wherein the wire connector (15) and the transferring device (16) are arranged such that the transferred pulling force opposes the biasing force.

3. Dredging arrangement according to any one of the preceding claims, wherein the at least one moveable part is a visor (12), the visor (12) being rotatable with respect to the drag head body (11) about a rotational axis (RA) which, in use, is substantially horizontal and perpendicular to a dredging direction (DD).

4. Dredging arrangement according to claim 3, wherein the drag head (10) comprises a biasing device (17) exerting a biasing force on the visor (12) such that the visor (12) is biased in a downward direction.

5. Dredging arrangement according to claim 4, wherein the biasing device (17) comprises at least one of a mechanical spring, an hydraulic spring, a gas spring.

6. Dredging arrangement according to any one of the claims 4 - 5, wherein the wire connector (15) and the transferring device (16) are positioned such that the transferred pulling force opposes the biasing force.
- 5 7. Dredging arrangement according to any one of the claims 1 - 2, wherein the moveable part is a valve (14) provided to open and close an opening (18) in the drag head (10) or lower part of the suction pipe (2) to allow water to enter .
8. Dredging arrangement according to claim 7, wherein the drag head (10) or suction pipe
10 (2) comprises a biasing device (17) exerting a biasing force on the valve (14) such that the valve (14) is biased towards a closed position.
9. Dredging arrangement according to claim 8, wherein the wire connector (15) and the
15 transferring device (16) are positioned such that the transferred pulling force opposes the biasing force.
10. Dredging arrangement according to any one of the preceding claims, wherein the transferring device (16) comprises one or more pulleys (161) and a transferring cable (162) being guided by the one or more pulleys (161), wherein the wire connector (15) is connected
20 to one of the pulleys (161) being a moveable pulley, the transferring cable (162) being arranged to transfer the pulling force from the wire connector (15) to the moveable part (12, 14).
11. Dredging arrangement according to any one of the claims 1 – 9, wherein the transferring
25 device (16) comprises a hydraulic force transmitter (164, 165, 166, 167).
12. Dredging arrangement according to any one of the claims 1 – 9, wherein the transferring device (16) comprises a lever (163, 163') which is connected to the wire connector (15) and to the at least one moveable part (12, 14).
30
13. Dredging vessel (1) comprising a dredging arrangement for dredging material from an underwater bottom (6), the dredging arrangement comprising a drag head (10) and a suction pipe (2), the drag head (10) comprising a drag head body (11) which is connected to the dredging vessel (1) by means of the suction pipe (2), the drag head (10) comprising at least

one moveable part (12, 14), such as a visor or a valve, which can be controlled to change the dredging characteristics of the drag head (10), wherein the dredging vessel (1) comprises a wire (4) connectable to the dredging arrangement for lifting and lowering the dredging arrangement from and to the underwater bottom (6),

5 wherein the dredging arrangement comprises a wire connector (15), a wire controller (5) and a transferring device (16), the wire connector (15) being connectable to the wire (4) via which a pulling force can be applied, wherein the transferring device (16) is arranged to transfer the pulling force to the at least one moveable part (12, 14), and wherein the wire controller (5) is arranged to exert a controllable pulling force on the wire (4) and also
10 functions as hoisting device for lowering and lifting the dredging arrangement towards and from the underwater bottom (6).

14. Dredging vessel (1) according to any one of the claims 13, wherein the dredging vessel (1) comprises a gantry (3) via which the wire (4) can be guided from the wire controller (5) to
15 the dredging arrangement.

15. Method for dredging material from an underwater bottom (6) using a dredging arrangement, the dredging arrangement comprising a drag head (10) and a suction pipe (2), the drag head (10) comprising a drag head body (11) which is attached to the suction pipe (2),
20 the drag head (10) further comprising at least one moveable part (12, 14), such as a visor and a valve, which can be controlled with respect to the drag head body (11) to change the dredging characteristics of the drag head (10), the dredging arrangement being connected by a wire (4) to wire controller (5) to lift and lower the dredging arrangement from and to the underwater bottom (6), wherein the method comprises

25 a) lowering the dredging arrangement to an underwater position with the drag head (10) positioned on the underwater bottom (6),

 b) dredging by dragging the drag head (10) over the underwater bottom (6) in a dredging direction (DD) by means of a dredging vessel (1),

 the dredging arrangement comprising a wire connector (15) and a transferring device
30 (16), the wire connector (15) being connectable to the wire (4) via which a controllable pulling force can be applied by the wire controller (5), wherein the transferring device (16) is arranged to transfer the pulling force to the at least one moveable part (12, 14), wherein the method further comprises:

b1) controlling the wire controller (5) to dynamically control a pulling force exerted on the wire (4) during dredging.

5 16. Method according to claim 15, wherein the pulling force is controlled dynamically during dredging in a range which lies below the lifting force required for lifting the dredging arrangement from the underwater bottom (6) and more than a minimum force to prevent slackening of the wire (4).

10 17. Method according to any one of the preceding claims 15 – 16, wherein the wire controller comprise first wire controller (51) and second wire controller (52), and wherein action a) is performed by the first wire controller (51) and action b1) is performed by the second wire controller (52).

15 18. Method according to claim 17, wherein action b1) comprises temporarily operating the first and second wire controller (52, 53) in opposite directions.

19. Method for dredging material from an underwater bottom (6) using a dredging arrangement according to any one of the claims 1 – 12 or using a dredging vessel according to any one of the claims 13 – 14.