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(54) **Device and method for displacing ground material under water**

(57) The invention relates to a device (1) for displacing underwater ground material by being towed over the ground. The device comprises a bearing construction (2,3) which is provided on a front side with connecting means (4) for attachment to a vessel, and on the rear side with a support construction (5) for supporting on the

ground, wherein the device (1) comprises at the rear side a scraper blade (7) which runs transversely of the towing direction and which is provided on both transverse outer ends with side plates (70,71). The invention likewise relates to a method for displacing ground material under water while making use of the device, and to a vessel provided with the device.

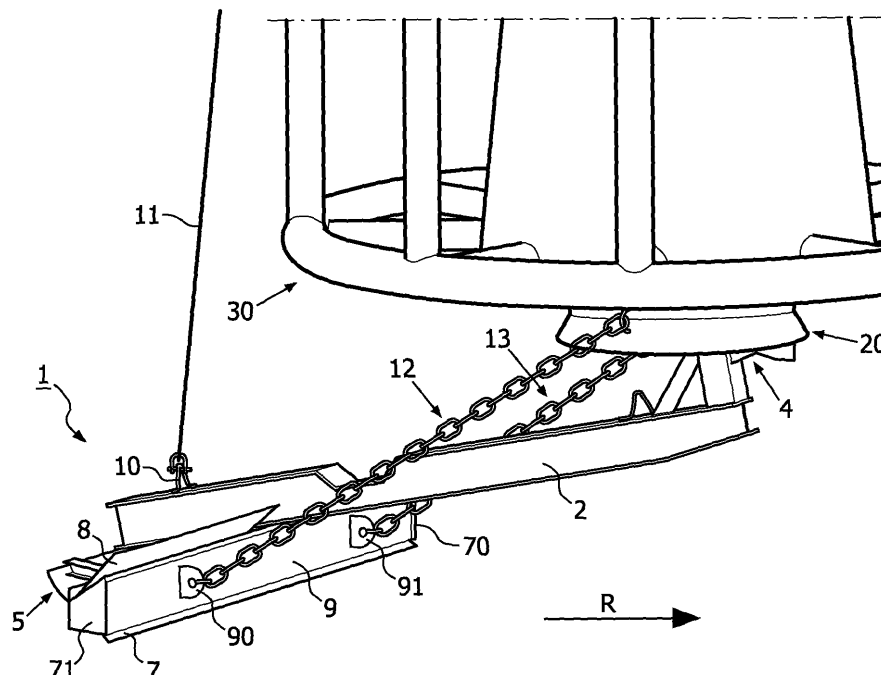


FIG. 3

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Description

[0001] The invention relates to a device for displacing underwater ground material. The invention also relates to a vessel provided with the device, and to a method for displacing underwater ground material.

[0002] For the purpose of depositing material, for instance in order to lay an underwater foundation, a vessel is generally used which is provided with a tubular member (also referred to as fall pipe) hanging under the vessel. The material for depositing is guided via the tubular member to the ground located under water. In order to obtain a (deposited) ground surface which does not undulate too much and is irregular, the vessel is advanced relatively slowly during depositing and/or the quantity of material guided through the fall pipe is limited per unit of time. These measures limit output however, and this is undesirable. In order to nevertheless bring the output to at least some extent to an acceptable level, the (deposited) ground surface can, if desired, be levelled by moving thereover a heavy box girder or H-beam. Such a measure does not always have the desired effect however, and particularly not when a relatively flat ground must be realized with variations in ground height in the order of magnitude of only 5-10 cm.

[0003] The invention has for its object to provide an improved device and method for displacing ground material under water, using which the ground surface can be levelled in effective manner.

[0004] The device according to the invention has for this purpose the features according to claim 1.

[0005] Because the device according to the invention comprises a bearing construction which is provided on a front side with connecting means for attachment to a vessel, and on the rear side with a support construction for supporting on the ground, wherein the device comprises at the rear side a scraper blade which runs transversely of the towing direction and which is provided on both transverse outer ends with side plates, it has been found that a relatively flat ground surface can be obtained in efficient manner. The bearing construction is preferably embodied such that a relatively rigid connection is obtained between the scraper blade and the fastening means. When the device is towed over the ground surface, the underside of the scraper blade will then bite into the ground surface, whereby (deposited) ground material will accumulate against the scraper plate. The scraper plate is preferably received in the bearing construction for this purpose such that it has an angle of inclination to the ground surface, wherein the scraper blade inclines to the rear (relative to the towing direction). The side plates at least partially prevent the accumulated ground material being able to escape to the sides of the scraper blade and coming to rest behind the device. In the case of an undulating ground surface the material accumulated against the scraper blade will, when it reaches a dip, at least partially fill this dip, thereby resulting in a levelling effect and creating a relatively flat ground surface. The

support construction arranged at the rear of the bearing construction prevents the scraper blade here moving prematurely into the dip, which can impede levelling or even make it impossible. When the device is towed over the ground, the support construction will glide or slide over already (partially) levelled ground surface. It is immaterial for proper operation of the device in which direction the undulation or irregularity of the ground extends relative to the towing direction of the scraper blade. In the case of an undulating ground surface wherein the undulations run more or less transversely of the towing direction, the known box girder or H-beam will tend to tilt sideways. The device according to the invention does not have this drawback. Higher depositing outputs are moreover possible due to the measures according to the invention.

[0006] A preferred embodiment of the device according to the invention is **characterized in that** the scraper blade is provided on the upper side thereof with a guide plate directed obliquely forward (relative to the towing direction) and extending transversely of the towing direction. The guide plate ensures that the ground material accumulated against the scraper blade does not tend to flow over the scraper blade, which would impair the efficiency of levelling. The scraper blade, the guide plate and the two side plates together form a container-like whole in which the ground material can temporarily accumulate. It is advantageous to be able to adjust the volume of the inner space of the container subject to, among other factors, the ground condition. For this purpose the container is preferably provided with a cover plate extending substantially vertically (in normal use) between the scraper blade and the guide plate. The volume available for ground material can be adjusted by varying the position of the cover plate in the container.

[0007] The scraper blade of the device can for instance be plate-like, if desired curved, and is preferably bounded on a bottom part thereof by a cutting edge for the purpose of cutting into the ground material. If desired, the scraper blade can also be provided with injection means for injecting water, wherein the injection means are formed by an array of nozzles arranged at the position of the bottom part of the scraper blade. During towing of the device over the ground water is injected under high pressure via the nozzles into the ground material, whereby this latter is fluidized and the efficiency of the device is further improved. The scraper blade is preferably provided on the underside (on a bottom part thereof) with at least one tooth, this being particularly advantageous in the levelling of harder ground surfaces.

[0008] The support construction of the device according to the invention can be embodied in various ways. It is thus possible to embody the support construction as a (semi)cylindrical transverse beam which slides with its peripheral surface over the ground surface as the device advances. It is also possible for the support construction to comprise a wheel which can travel over the ground. This embodiment is recommended because the frictional resistance with the ground is reduced. The support con-

struction is preferably situated behind the scraper blade (relative to the towing direction) and more preferably on the rear side of the bearing construction.

[0009] A further preferred variant of the device according to the invention has the feature that the bearing construction is provided at the rear side with fastening means for a hoisting cable for the purpose of lowering and raising the device. An accurate height positioning of the device, and particularly of the bottom part of the scraper blade, relative to the ground surface can in this way be obtained.

[0010] The invention likewise relates to a method for displacing ground material under water. In the invented method a device connected to a vessel, which device comprises a bearing construction which is provided on a front side with connecting means for attachment to the vessel, and on the rear side with a support construction for supporting on the ground, wherein the device comprises at the rear side a scraper blade which runs transversely of the towing direction and which is provided on both transverse outer ends with side plates, is lowered by means of a hoisting cable from the vessel to a position in the vicinity of the ground surface, and moved forward by the vessel, wherein the scraper blade cuts into and displaces the ground material.

[0011] The invention likewise relates to a vessel provided with a device according to the invention as described above. According to the invention the device is attached to the vessel by means of the connecting means situated on a front side of the bearing construction. It is advantageous here to characterize the vessel in that the vessel comprises a towing member which extends under water and to which the device is attached. Most preferably the towing member comprises a tubular member (a fall pipe) which is intended for the purpose of depositing material onto the underwater ground through the tubular member. Using such a vessel material can be deposited on the ground and subsequently levelled in the same operation to form a relatively flat ground. Other constructions can then be built thereon.

[0012] The invention likewise relates to a method for depositing material on a ground situated below water level, wherein the material for depositing is guided from a vessel to the ground via a tubular member hanging down under the vessel for this purpose, while a remotely controllable steering device positions the tubular member relative to the ground lying below water level, provided that, before, during and/or after depositing of the material, the ground is levelled by displacing ground material with a device which is connected to the vessel and which comprises a bearing construction provided on a front side with connecting means for attachment to the vessel and on the rear side with a support construction for supporting on the ground, wherein the device comprises at the rear side a scraper blade which runs transversely of the towing direction and which is provided on both transverse outer ends with side plates.

[0013] In yet another preferred embodiment of the invention the device is connected at the rear side thereof

to a hoisting cable which can be operated from the vessel. The device (and the scraper blade) can be lowered and raised herewith, wherein the device rotates as a whole around the attachment to the vessel, or the fall pipe of the vessel. In this preferred embodiment the bearing construction comprises at the rear side fastening means for a hoisting cable. The hoisting cable can be connected at the other end to the vessel or to any other structure. It is thus possible for instance to provide the vessel with a so-called Remote Operated Vehicle (ROV) and to connect the hoisting cable thereto. The remotely controllable ROV is mounted on the vessel at the position of the lower part of a fall pipe. The ROV comprises a central chute mounted telescopically relative to the lower part of the fall pipe. The up and downward movement of the ship can be compensated by means of cables such that the ROV is situated a constant distance from the ground. If desired, the ROV can comprise outward foldable carrier arms which are provided with sensors of diverse nature (such as for instance ultrasound echo sensors) and/or cameras. The (position of the) device according to the invention and other parts can hereby be made visible. For control of the ROV, and so for the correct positioning of the lower outer end of the fall pipe, the ROV is generally provided with propulsion motors. Because the positioning of the ROV and the fall pipe can be accurately determined, this is also the case for the device, which is after all connected to the fall pipe.

[0014] In order to enable precise adjustment of the height of the device and the scraper blade, the vessel is preferably **characterized in that** the vessel comprises means for measuring and controlling the tensile force in, and/or the payed-out length of the hoisting cable. By measuring and controlling the tensile force in, and/or the payed-out length of the hoisting cables according to the invention before, during and/or after forward movement, the ground material is displaced substantially without problem in exceptionally efficient and accurate manner.

[0015] By measuring the payed-out length it is possible to determine whether the scraper blade is in contact with the ground surface or not. By likewise providing means for controlling the tensile force in the hoisting cable or hoisting cables it is possible to determine whether the scraper blade has become jammed or is otherwise not functioning properly. It will however be particularly the ROV which fulfils this function, among other reasons because in many cases too little difference in tensile force will occur in the fall pipe wires before or during levelling when a device is substantially completely filled with ground material. The roll and pitch measurement on the ROV will be able to indicate more specifically whether the scraper blade has become jammed. Echo sensors can also be utilized to determine whether irregularities are occurring. The echo sensors are preferably arranged on two measuring bars running 90 degrees relative to each other. It is also possible to use a camera when the water is sufficiently clear.

[0016] The vessel applied in the device according to

the invention can be any vessel suitable for displacing ground material under water. If desired, use can be made of vessels equipped with per se known positioning systems, such as for instance so-called DP/DT (Dynamic Positioning/Dynamic Tracking) vessels.

[0017] The measuring means for the tensile force in the hoisting cable applied in the device according to the invention are per se known. It is thus possible, when hydraulic winches are applied for raising and lowering the cable from the vessel, to determine the tensile force in the cable by means of measuring the hydraulic pressure. It is also possible to measure the tensile force by guiding the cable over a pulley disposed on the vessel and measuring the force developed on the pulley. If desired, more than one hoisting cable can be applied. It is also possible to further stabilize the device with traction cables arranged for instance between the bearing construction and the underside of the towing member.

[0018] The means applied in the device according to the invention for measuring the payed-out length of the towing and/or hoisting cables are per se known. It is thus possible, when hydraulic winches are applied for raising and lowering the cables from the vessel, to determine the payed-out length from a rotation speed measurement of the winch drum. It is also possible to measure and vary the payed-out length by applying a hydraulic cylinder, which changes the effective cable length during changes in the swell.

[0019] The device according to the invention will now be further elucidated on the basis of the description of the accompanying figures, without otherwise being limited thereto. The reference numerals relate to the accompanying figures. Herein:

figure 1 shows a top view of a device according to the invention;

figure 2 is a cross-sectional side view of the device as shown in figure 1 along line A-A';

figure 3 is a perspective view of the device according to the invention connected to the fall pipe of a vessel; figures 4A-4C show side views of different positions the device can occupy;

figure 5 is a perspective view of the device according to the invention during operation;

figure 6A shows a cross-sectional side view of another embodiment of the device according to the invention;

figure 6B is a perspective view of the device as shown in figure 6A; and

figure 6C is a cross-section along line B-B' of the embodiment shown in figure 6B.

[0020] Referring to figures 1 and 2, an embodiment of a device 1 according to the invention is shown. Device 1 comprises a bearing construction which in the present embodiment is constructed from a drawbar 2 in the form of an I-profile, and a transverse beam 3 in the form of an H-profile rigidly connected to drawbar 2. Drawbar 2 can

of course also comprise an H-profile. Drawbar 2 and transverse beam 3 are mutually connected via for instance a welded connection. Drawbar 2 is provided on the front side with connecting means 4 for attachment to a vessel. Fastening means 4 comprise a web plate 40 in which is arranged an eye 41. Device 1 can thus be connected pivotally by means of a pin-hole connection to a part of a vessel. Bearing construction (2, 3) is provided on the rear side with a support construction 5 for supporting on ground 6. In the shown embodiment variant support construction 5 comprises a semi-cylindrical tubular beam 50 which slides with its peripheral surface over ground surface 6 during forward movement of device 1. Tubular beam 50 is fixed by means of support profiles (51, 52) to bearing construction (2, 3). In another embodiment (not shown) support construction 5 comprises a set of wheels which can travel over ground 6. Bearing construction (2,3) is further provided at the rear with fastening means 10 for a hoisting cable 11 for the purpose of lowering and raising the device. Device 1 is provided at the rear with a scraper blade 7 running transversely of towing direction R. Scraper blade 7 is provided on both transverse outer ends with side plates (70, 71) which, if desired, run partially at an incline. If desired, scraper blade 7 is provided on the underside with cutting teeth 72. Scraper blade 7 is provided on the top side thereof with a guide plate 8 directed obliquely upward and extending transversely of towing direction R. Guide plate 8 ensures that ground material accumulated against scraper blade 7 does not flow over scraper blade 7. Scraper blade 7, guide plate 8 and the two side plates (70, 71) together form a container-like whole in which the ground material cut away by scraper blade 7 can temporarily accumulate. As shown in figure 1, the foremost web plate of H-profile 3 forms a cover plate 9 extending substantially vertically (in normal use) between scraper blade 7 and guide plate 8. The volume available for ground material thus comprises the space between scraper blade 7, cover plate 9 and guide plate 8. The available volume can be readily adjusted by changing the relative position of said components. If desired, the device, and in particular cover plate 9, can be provided with fastening means (90, 91) for respective traction cables (12, 13) as shown in figure 3. In such a preferred embodiment the cover plate 9 forms a structural part of support construction 3 because cover plate 9 has to withstand the forces exerted by traction cables (12, 13). Traction cables (12, 13) can be fastened on the other side to a part of a vessel, and in particular to fall pipe 20 of a vessel, and provide for a better alignment of device 1 during towing over the ground 6.

[0021] The operation of the device according to the invention is illustrated in figures 4A, 4B, 4C and 5. The figures show the bottom outer end of a fall pipe 20 of a vessel. Fall pipe 20 serves as towing member for device 1 and extends to below the water surface. Fall pipe 20 is height-adjustable. Device 1 is connected pivotally to fall pipe 20 by means of pin-hole connection 4. The vessel

is further provided with a so-called "Remote Operated Vehicle" (ROV) 30. The remotely controllable ROV 30 comprises a central chute 31 mounted telescopically relative to the lower part of fall pipe 20. The up and downward movement of the ship can be compensated by means of cables (not shown) such that ROV 30 is situated a constant distance from ground 6. If desired, ROV 30 can comprise outward foldable carrier arms (not shown) provided with sensors of diverse nature (such as for instance ultrasound sensors) and/or cameras. The (position of the) device 1 can hereby be made visible. For control of the ROV, and so for the correct positioning of the lower outer end of fall pipe 20, propulsion motors (not shown) are provided on the ROV. Because the positioning of ROV 30 and fall pipe 20 can be accurately determined, this is also the case for device 1, which is after all connected to fall pipe 20.

[0022] In order to set into operation and displace levelling device 1 under water, it is provided with a hoisting cable 11 (or a plurality of hoisting cables). According to the invention device 1 is suspended from a hoisting cable 11 which runs via a hoisting pulley to a hoisting gear, for instance a hydraulic winch, situated on the vessel. Device 1 can be lowered and/or raised by means of hoisting cable 11 by respectively lengthening or shortening the pay-out length of said cable 11. The adjustment of the pay-out length of hoisting cables 11 takes place in known manner by means of the hoisting gear. Fixed if desired to the winch is a buoy which ensures that hoisting cable 11 remains suspended relatively tightly along ROV 30, and cannot therefore become entangled with the ROV or the device itself.

[0023] When device 1 is set into operation the fall pipe 20 is raised slightly so that device 1 moves just clear of the floor 100 on which device 1 has been transported, as shown in figure 4A (position A). Hoisting cable 11 is also pulled up by the winch so that in this position the device 1 is lifted just slightly off the floor 100. Floor 100 is then moved away and the winch can lower device 1 from the position shown in figure 4A, via an intermediate position B shown in figure 4B, to position C. Fall pipe 20 can be simultaneously raised so that device 1 is displaced further to the centre of chute 31. Because device 1 is connected to fall pipe 20 with chains (12, 13), additional certainty is provided in unexpected situations, for instance in the case connection 4 breaks. In such a case device 1 can still be brought to the surface without the help of third parties.

[0024] The height of scraper blade 7 can be set precisely by suspending the underside of ROV 30 a determined distance above the ground surface to be levelled. A typical distance is for instance 1.5 m. Scraper blade 7 hereby cuts through ground 6 at the desired height. In the shown embodiment variant the distance from the lower edge of scraper blade 7 to the connection 4 to fall pipe 20 is five times greater than the distance from the lower edge of scraper blade 7 to the sliding surface of support construction 5 on the ground 6. This 'lever' provides for

an exceptionally precise adjustability of the desired height. This measure, wherein the distance from the lower edge of scraper blade 7 to the connection 4 to fall pipe 20 has a determined ratio greater than 1 to the distance from the lower edge of scraper blade 7 to the sliding surface of support construction 5 on the ground 6, also ensures that the swell has less influence on the height adjustment of scraper blade 7. The above stated ratio is preferably greater than 3, more preferably greater than 5, most preferably greater than 10. At a ratio of 5 the lower edge of the scraper blade will descend 4 cm if ROV 30 comes to hang lower.

[0025] Device 1 is towed forward over the ground surface 6 in a towing direction R via the tensile force of fall pipe 20, wherein hoisting cable 11 has a tensile force such that it is relatively tight and device 1 is situated in partially lowered position, as shown in figures 4C and 5. The bottom part, and in particular tooth(teeth) 72 of scraper blade 7, makes the first contact with ground material 6. As device 1 is towed forward, scraper blade 7 will cut into ground material 6, this cutting being caused by the weight of device 1 under water, by the tensile force transmitted by fall pipe 20, and particularly in that the cutting surface of scraper blade 7 forms an angle with the ground surface which differs from zero. The displacement of the ground material 6 is realized by the tensile force produced by means of the vessel. As shown in figure 5, an undulating ground 6 is levelled in efficient manner. The ground material scraped by device 1 from a top 61 of the undulating ground 6 is transported over a distance to another part of ground 6, in particular a deeper-lying area 62. Thus created behind the device (relative to towing direction R) is an at least partially levelled ground surface 60. It has been found that, using the device according to the invention, higher-lying parts of a relatively small area and for instance only 0.5 m high can be made as good as flat with only one movement. Higher-lying parts of a lesser height and a relatively large area (which thus form a relatively gentle slope) can generally also be levelled in one movement using the device. If desired, the device is towed a number of times over a ground for levelling if the result is not sufficient after one movement. In the case of more gentle slopes it is recommended to lower fall pipe 20 somewhat further (for instance through a distance of 20 cm) than the above stated exemplary height of 1.5 m, in order to achieve the desired result. During the levelling or grading the device 1 is preferably pulled through to the end over substantially the whole surface for levelling. If the device is raised too early, elevated portions of displaced ground material (for instance in the form of a slope) may then be created.

[0026] Referring to figures 6A-6C, yet another embodiment of a device 1 according to the invention is shown. Device 1 comprises a bearing construction which in the present embodiment is constructed from two drawbars 200 and a transverse beam 300 connected rigidly to drawbars 200 by means of bolt connections. Transverse beam 300 is provided on both transverse outer ends with

side plates (710, 711) which, if desired run partially at an incline. The side plates are also supported by support arms (712, 713). Drawbars 200 are provided on the front side with connecting means 400 for attachment to a vessel. Fastening means 400 comprise a pivoting connection. Bearing construction (200, 300) is provided on the rear side (relative to the towing direction R) with a support construction 500 for supporting on the ground 6. In the shown embodiment variant support construction 500 comprises a curved beam which slides with its peripheral surface over ground surface 6 during the forward movement of device 1. The curved beam 500 is fixed to bearing construction (200, 300) by means of support profiles (510, 520). Bearing construction (200, 300) is further provided at the rear side with fastening means (not shown) for a hoisting cable for the purpose of lowering and raising the device. Device 1 is provided at the rear side with a scraper blade 700 running transversely of towing direction R. Scraper blade 700 is provided on the upper side thereof with an upward directed guide plate 800 extending transversely of towing direction R. Guide plate 800 ensures that ground material accumulated against scraper blade 700 does not flow over scraper blade 700. Scraper blade 700, guide plate 800 and the two side plates (710, 711) together form a container-like whole in which the ground material cut away by scraper blade 700 can temporarily accumulate. Drawbars 200 are fixed to transverse beam 300 at a distance from ground surface 6, as shown in figure 6A. This produces a better levelling action.

[0027] In order to improve the stability of the shown preferred variant of device 1, it can be weighted, for instance by being provided with a ballast chamber, the weight of which can be adjusted by for instance admitting ballast water via a conduit. In order to increase the rigidity of the device, the shown preferred variant can, if desired, be provided with strengthening beams.

[0028] The invention is not limited to the above described embodiments, and modifications could be made thereto to the extent these derive in self-evident manner from the appended claims.

Claims

1. Device for displacing underwater ground material by being towed over the ground, which device comprises a bearing construction which is provided on a front side with connecting means for attachment to a vessel, and on the rear side with a support construction for supporting on the ground, wherein the device comprises at the rear side a scraper blade which runs transversely of the towing direction and which is provided on both transverse outer ends with side plates.
2. Device as claimed in claim 1, **characterized in that** the scraper blade is provided on the upper side there-

of with a guide plate directed obliquely upward and extending transversely of the towing direction.

3. Device as claimed in claim 1 or 2, **characterized in that** the scraper blade is provided on the underside with at least one tooth.
4. Device as claimed in any of the foregoing claims, **characterized in that** the bearing construction is provided at the rear side with fastening means for a hoisting cable for the purpose of lowering and raising the device.
5. Device as claimed in any of the foregoing claims, **characterized in that** the support construction comprises a wheel which can travel over the ground.
6. Vessel provided with a device as claimed in any of the claims 1-5.
7. Vessel as claimed in claim 6, **characterized in that** the vessel comprises a towing member which extends under water and to which the device is attached.
8. Vessel as claimed in claim 7, **characterized in that** the towing member comprises a tubular member which is intended for the purpose of depositing material onto the underwater ground through the tubular member.
9. Vessel as claimed in any of the claims 6-8, **characterized in that** the vessel comprises means for measuring and controlling the tensile force in, and/or the payed-out length of the hoisting cable.
10. Method for displacing ground material under water, wherein a device connected to a vessel, which device comprises a bearing construction which is provided on a front side with connecting means for attachment to the vessel, and on the rear side with a support construction for supporting on the ground, wherein the device comprises at the rear side a scraper blade which runs transversely of the towing direction and which is provided on both transverse outer ends with side plates, is lowered by means of a hoisting cable from the vessel to a position in the vicinity of the ground surface, and moved forward by the vessel, wherein the scraper blade cuts into and displaces the ground material.
11. Method for depositing material on a ground situated below water level, wherein the material for depositing is guided from a vessel to the ground via a tubular member hanging down under the vessel for this purpose, while a remotely controllable steering device positions the tubular member relative to the ground lying below water level, provided that, before, during

and/or after depositing of the material, the ground is levelled by displacing ground material with a device which is connected to the vessel and which comprises a bearing construction provided on a front side with connecting means for attachment to the vessel 5 and on the rear side with a support construction for supporting on the ground, wherein the device comprises at the rear side a scraper blade which runs transversely of the towing direction and which is provided on both transverse outer ends with side plates. 10

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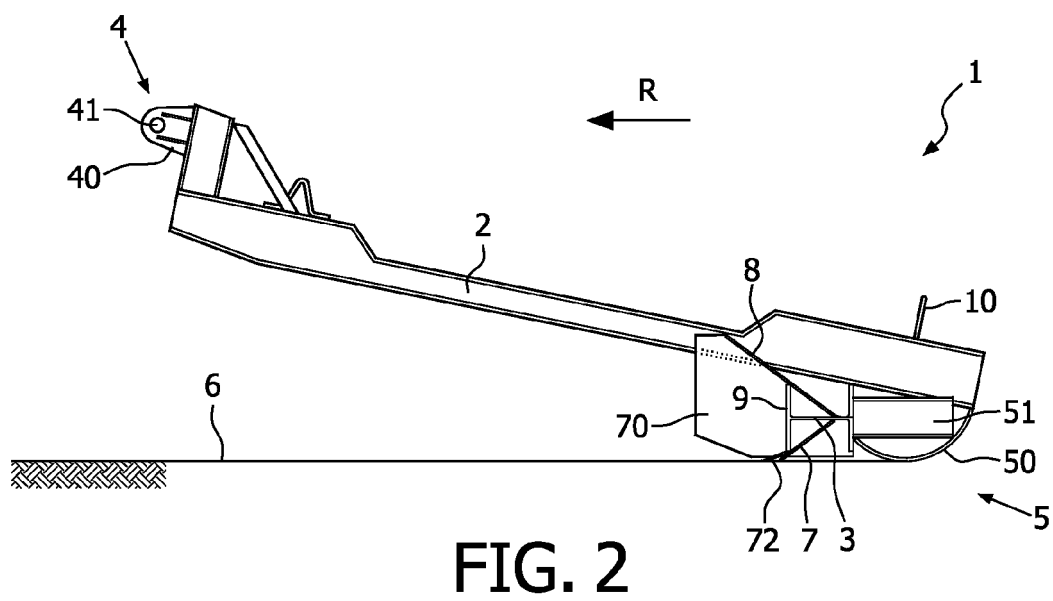
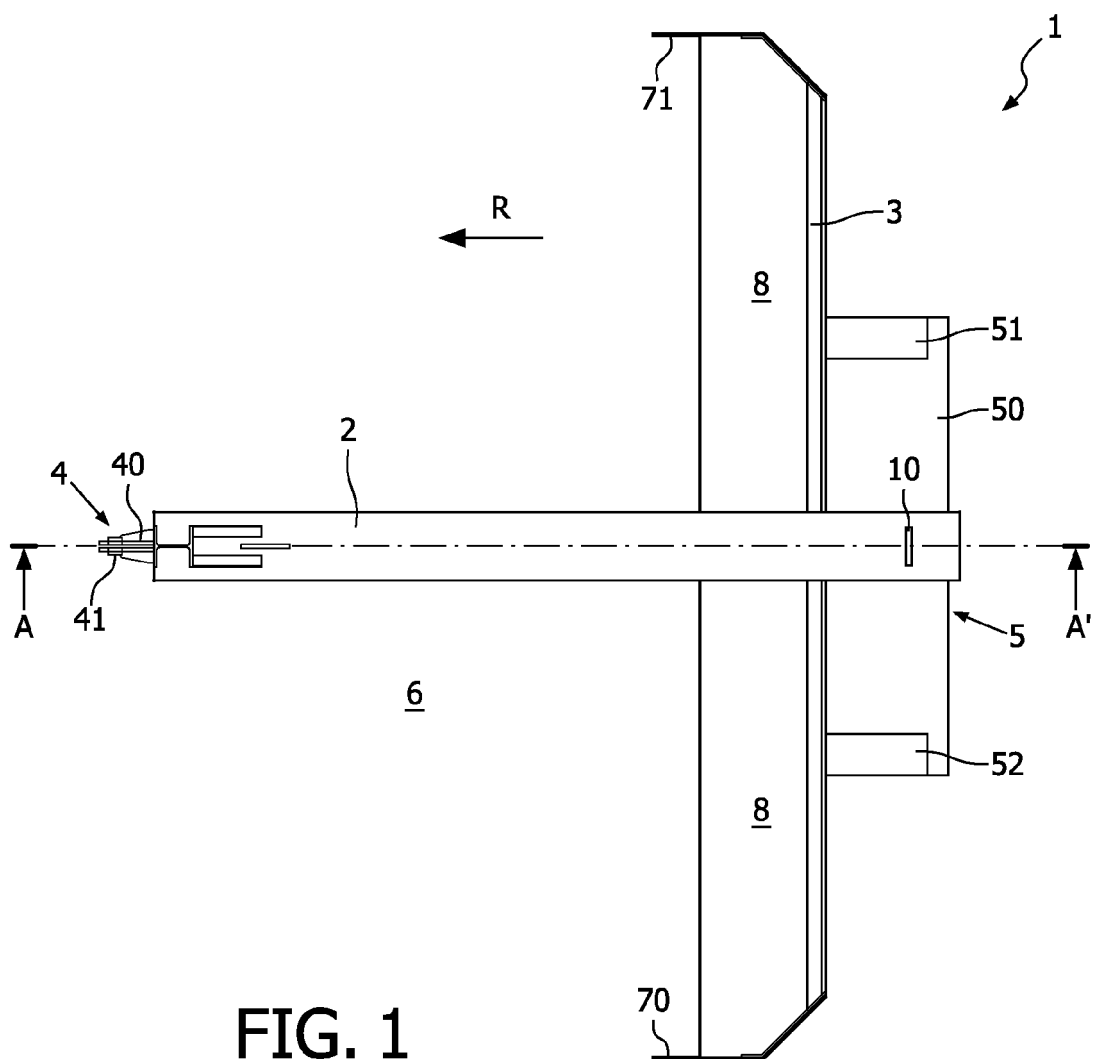
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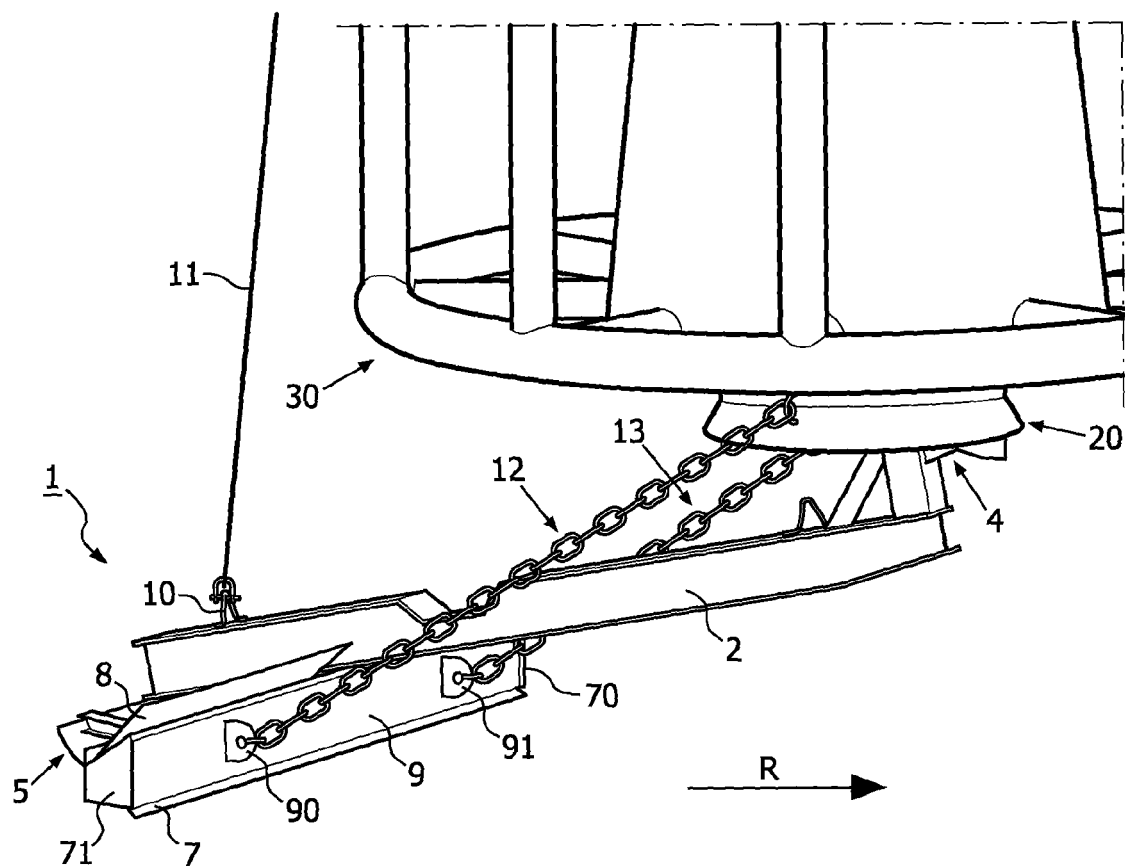
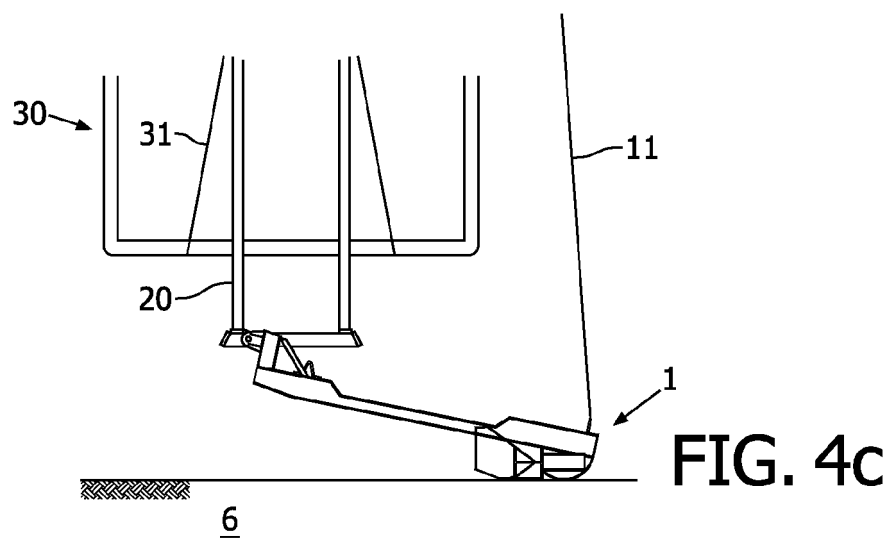
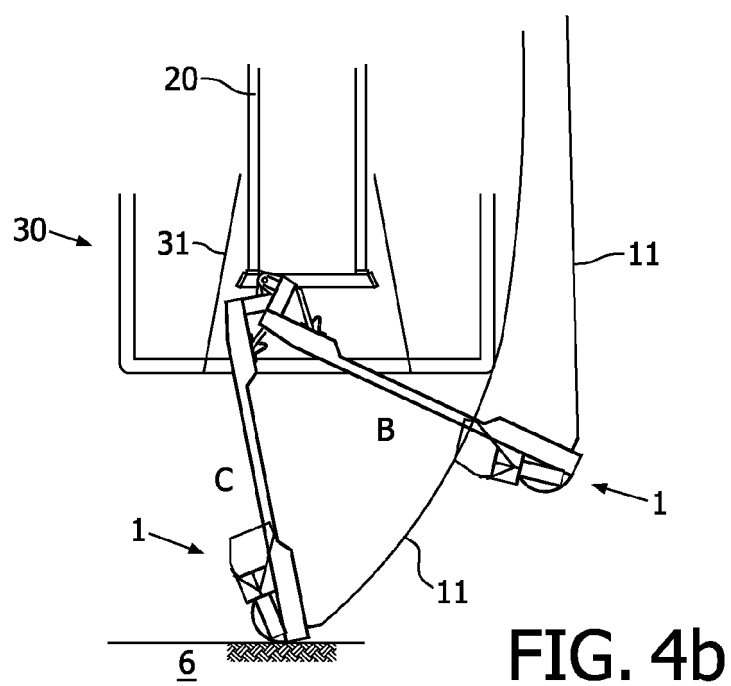
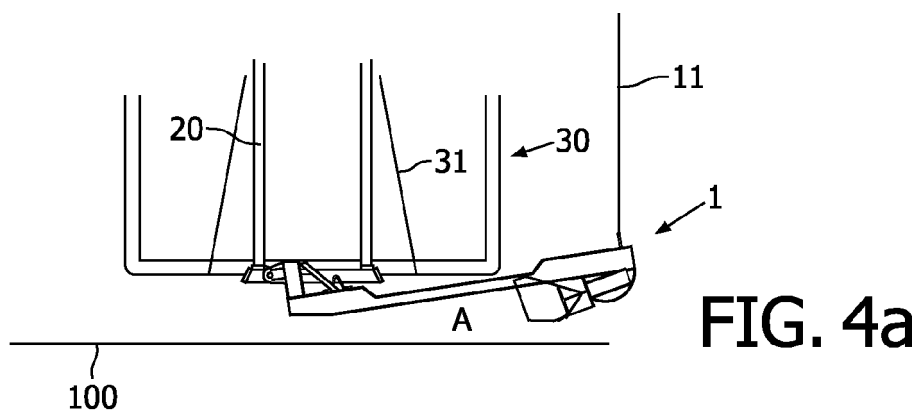


FIG. 3



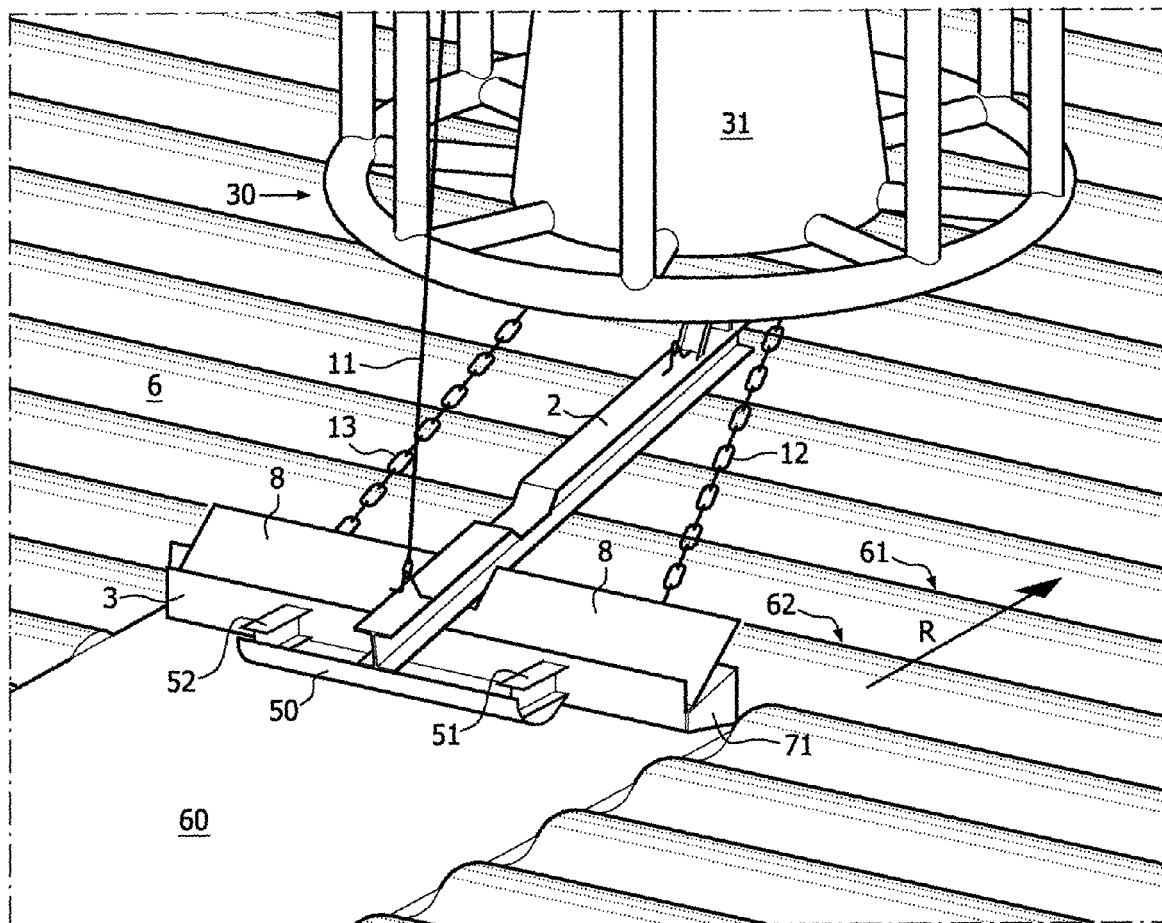


FIG. 5

