



(43) International Publication Date
25 August 2016 (25.08.2016)

- (51) International Patent Classification:
E02F 3/88 (2006.01) *E02F 5/10* (2006.01)
- (21) International Application Number:
PCT/NL2016/050110
- (22) International Filing Date:
17 February 2016 (17.02.2016)
- (25) Filing Language: English
- (26) Publication Language: English
- (30) Priority Data:
2014307 18 February 2015 (18.02.2015) NL
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seweg 57, 2594 AC Den Haag (NL).
- (81) Designated States (*unless otherwise indicated, for every
kind of national protection available*): AE, AG, AL, AM,
AO, AT, AU, AZ, BA, BB, BG, BH, BN, BR, BW, BY,

BZ, CA, CH, CL, CN, CO, CR, CU, CZ, DE, DK, DM,
DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT,
HN, HR, HU, ID, IL, IN, IR, IS, JP, KE, KG, KN, KP, KR,
KZ, LA, LC, LK, LR, LS, LU, LY, MA, MD, ME, MG,
MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM,
PA, PE, PG, PH, PL, PT, QA, RO, RS, RU, RW, SA, SC,
SD, SE, SG, SK, SL, SM, ST, SV, SY, TH, TJ, TM, TN,
TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW.

- (84) Designated States (*unless otherwise indicated, for every
kind of regional protection available*): ARIPO (BW, GH,
GM, KE, LR, LS, MW, MZ, NA, RW, SD, SL, ST, SZ,
TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, RU,
TJ, TM), European (AL, AT, BE, BG, CH, CY, CZ, DE,
DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU,
LV, MC, MK, MT, NL, NO, PL, PT, RO, RS, SE, SI, SK,
SM, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ,
GW, KM, ML, MR, NE, SN, TD, TG).

Published:

- with international search report (Art. 21(3))
- before the expiration of the time limit for amending the
claims and to be republished in the event of receipt of
amendments (Rule 48.2(h))

(54) Title: SUBMERSIBLE VEHICLE FOR PROVIDING A TRENCH IN A SUBSEA BOTTOM

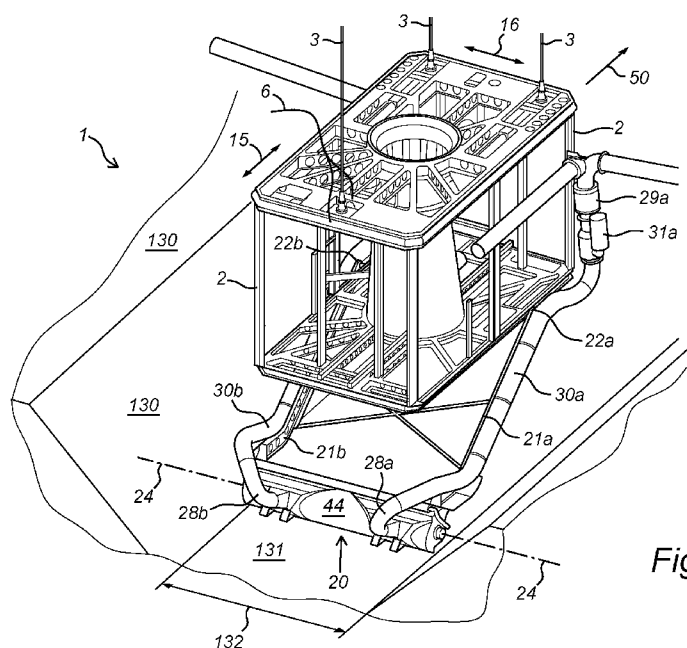


Fig. 3

(57) Abstract: A remotely operated submersible vehicle for preparing a trench in a subsea bottom is disclosed. The vehicle comprises a frame, hoisting and control cables for suspending the vehicle from a surface vessel, thrusters for manoeuvring the vehicle, and an elongated mechanical excavating tool extending across the width of the trench and connected to conveying means for carrying excavated seabed material to a position outside the trench. A method of preparing a trench using the vehicle is also described.

SUBMERSIBLE VEHICLE FOR PROVIDING A TRENCH IN A SUBSEA BOTTOM

BACKGROUND OF THE INVENTION

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The invention relates to a submersible vehicle, in particular to a remotely operated submersible vehicle, for entrenching elongate structures under water, such as pipelines or electrical cables for instance. The invention further relates to an assembly of a surface vessel and a submersible vehicle, as well as to a method of preparing a trench in
10 a subsea bottom. The vehicle and method are particularly suitable for entrenching a sea bed at depths below 300 m, as well as a highly undulated seabed.

Submersed pipelines may for instance be used for transporting crude petroleum and gas from a drilling site over long distances to an onshore or offshore collection location.

15 Electrical cables may be used to connect offshore wind farms to an onshore electricity network. To protect such elongate structures and prevent shifting due to current and/or a highly undulated seabed, pipelines are generally buried or entrenched beneath the seabed. In pre-laying methods, a trench is typically prepared before actual positioning of the elongate structure in the trench. In post-laying methods, an elongate structure is
20 typically positioned on a seabed and then sunk into the seabed by for instance fluidising the seabed along the desired trajectory of the elongate structure.

Known devices for entrenching an elongate structure in a seabed typically involve a vehicle that is positioned onto the seabed and propels itself over the seabed by wheels or
25 tracks for instance. Such vehicles are equipped with some kind of excavating means, such as high pressure water jets that aim at the seabed and fluidise and/or disrupt the seabed along the desired trajectory, or mechanical means such as a bucket.

Offshore wind farms are preferably located in rather windy and sometimes remote areas
30 to generate as much electricity as possible. This means that optimum trajectories for the elongate structures, in this particular example electrical cables, may run through difficult subsea areas. The same holds for oil and gas fields which are increasingly discovered in rough and remote areas. An example is the site of the Ormen Lange field in Norway which is remotely located at enormous seabed depths of between 850 and

1100 meters under the rough Norwegian Sea. In addition to depth, the subsea terrain also presents difficulties and ice-cold currents flow through a highly undulated seabed having high peaks and low valleys with peak-to-valley depth differences easily exceeding 10 m. A further difficulty comprises the seabed material itself which
5 comprises heavy compacted clay with undrained shear strength S_u of over 20 kPa to more than 50 kPa.

It is an object of the present invention to provide an improved submersible vehicle and method for providing a trench in a subsea bottom and entrenching elongate structures in
10 the seabed, in particular for seabed depths below 300 m and/or in highly undulated seabed bottoms.

BRIEF SUMMARY OF THE INVENTION

15 To this end, a remotely operated submersible vehicle according to claim 1 is provided. The vehicle comprises a frame, hoisting and control cables for suspending the vehicle from a surface vessel, thrusters for manoeuvring the vehicle, an elongated mechanical excavating tool connecting to the vehicle by a hinged connection and extending across the width of the trench, and conveying means for carrying away excavated seabed
20 material to a position outside the trench.

According to the invention, a method of preparing a trench in a subsea bottom is also offered, comprising the steps of lowering a submersible vehicle in accordance with the invention from a surface vessel towards a position close to the subsea bottom,
25 manoeuvring the mechanical excavating tool of the vehicle through the subsea bottom along a trajectory, and conveying the excavated seabed material to a position outside the formed trench. The submersible vehicle is suspended from the vessel by hoisting cables and the mechanical excavating tool is manoeuvred through the subsea bottom by advancing the vessel and towing the submersible vehicle with the vessel. The invented
30 vehicle therefore does not rest on the seabed, apart from the excavating tool that is connected to the vehicle by a hinged connection. The hinged connection between the vehicle frame and the mechanical excavating tool at least partly allows accommodating vertical movements of the vehicle frame induced by currents and heave of the vessel.

Since the vehicle hangs relatively freely from the surface vessel and does not rest on the seabed, it is particularly suitable for entrenching undulating and rough sea beds.

5 The thrusters provided on the submersible vehicle are primarily used to head and propel the vehicle in the right direction and/or to take up reaction forces induced by manoeuvring the excavating tool through the sea bed. Depending on soil properties, the power provided by the thrusters may need to be increased and adapted to the reaction forces incurred by the progression of the excavating tool through the sea bed.

10 The excavating tool is elongated and extends in a width direction of the trench to be formed. The excavating tool may have a width (the dimension along its elongation) about equal to a side dimension of the remotely operated vehicle. The width of the excavating tool may however also be larger or, preferably, smaller than a side dimension of the vehicle. The width of the excavating tool (and therefore also the width
15 of the trench to be formed) may be determined in view of the value of the reaction forces anticipated in trenching the sea bed. Reducing the width of the excavating tool will reduce these reaction forces.

In an embodiment, the excavating tool of the vehicle comprises an elongated support
20 member provided with cutting devices and rotatably mounted in a partly open housing, the rotation being provided around an axis extending in a longitudinal direction of the support member. The housing is partly open at a front side to provide access to the sea bed for the cutting devices. The housing may be provided with a rotatable visor part that allows further closing of the housing thereby reducing the surface of the access opening.

25 The housing may be provided with closable openings in its body to let in water. Excavated sea bed material is typically carried away by one or more suction pipes connected to the housing and the water inlet is useful when the pressure inside the housing tends to be reduced too much resulting from suction forces generated by the suction pumps.

30

The excavating tool may further comprise a water chamber that provides pressurized water to water jet nozzles directed to the cutting devices and adapted to remove clogged seabed material. The water jets may also aim at the sea bed upstream of the excavating

tool. This may fluidise or even remove sea bed material in front of the excavating tool and therefore reduces reaction forces.

The support member for the cutter devices is rotatable around an axis extending in a longitudinal direction of the support member. Such a support member may for instance
5 be embodied by a shaft onto which the cutter devices are provided. The support member in this embodiment is typically driven in a direction of rotation around its axis by a rotary motor. Suitable cutting tools to be provided on such a rotatable support member may be provided in many shapes. A suitable embodiment provides cutting devices
10 comprising a number of blades that extend in a plane perpendicular to the longitudinal direction of the support member. The blades not only cut the sea bed efficiently but also allow absorbing reaction forces incurred in a width direction of the vehicle, i.e. in a direction parallel to the longitudinal direction of the support member. The total number of blades may be selected within wide ranges. However, an embodiment wherein the
15 number of blades in the same perpendicular plane is from 2 to 8 is preferred, a number from 3 to 5 being particularly preferred.

Another preferred embodiment of the invention provides a submersible vehicle wherein the support member comprises an assembly of spiralling webs provided around the axis
20 of rotation of the support member and extending across the width of the trench. The assembly of spiralling webs may be rotatably mounted in the partly open housing, for instance by providing the housing with end plates in which a bearing coupling is provided. End plates of the assembly of spiralling webs are provided with a central shaft that is connected to the bearing coupling of the housing end plates. One or more rotary
25 motors are provided for actively driving the rotation of the support member. Since the vehicle according to the invention is free-floating, reaction forces incurred by manoeuvring the excavating tool through the sea bed are preferably kept as low as possible in order for the vehicle to keep its track along the envisaged trajectory. Driving the support member helps in limiting the reaction forces.

30

Another embodiment of the invention provides a submersible vehicle wherein the assembly of spiralling webs forms a cylindrical revolving body and the cutting devices comprise a number of blades that extend substantially tangentially to a circumferential surface of the revolving body. It is advantageous to rotate the support member, for

instance the assembly of spiralling webs, in a rotation direction in which the cutting devices overcut the sea bed material, i.e. attack the sea bed as an axe (as opposed to undercutting in which the cutting devices attack the sea bed as a shovel). In overcutting, a majority of the reaction forces generated by cutting the sea bed are absorbed by the natural weight or dead load of the support body.

In yet another embodiment, the blades are provided at a distance from the circumferential surface of the revolving body. A further embodiment provides a submersible vehicle wherein the blades are curved.

10

The number of cutting devices along the support member can be chosen within a wide range. It has been established that a number of cutting devices along the support member of from 10 to 50, and more preferably from 20 to 40 yields a good combination of cutting action and conveyance of the excavated sea bed material.

15

Another embodiment of the excavating tool comprises a dredge wheel rotatably supported by two support arms. An externally positioned hydraulic motor drives the dredge wheel, and a suction pipe is partly inserted in the dredge wheel to carry away excavated sea bed material. The dredge wheel is provided with a number of cutting tools provided on arms.

20

Another embodiment relates to an excavating tool comprising two or more dredge wheels rotatably supported by two support arms and arranged side by side. Internally positioned hydraulic motors drive each dredge wheel, preferably independently. Suction pipes are partly inserted in the dredge wheels to carry away excavated sea bed material. The dredge wheels are provided with a number of cutting tools provided on arms. This embodiment allows varying the total width of the dredge wheels in a convenient manner and therefore also the width of the trench to be formed.

25

The remotely operated submersible vehicle is suspended from a surface vessel substantially free-hanging. The vehicle may therefore experience vertical movements resulting from heave and other wave action. In order to be able to keep a substantially constant excavating depth, an embodiment of the submersible vehicle is equipped with an excavating tool comprising a support surface provided on a higher level than a

30

cutting surface of the excavating tool, and adapted to support the excavating tool on the sea bed. The height difference between the support surface and the cutting surface defines the cutting thickness or excavating depth.

- 5 A suitable embodiment of the support surface is provided by at least two sliding surfaces or skis, provided on both sides of the excavating tool, preferably in front (upstream) of the cutting devices. It is also possible to provide the excavating tool with a heel plate, as for instance used in a trailing suction dredger hopper, optionally provided with openings to take in water.

10

The sea bed materials excavated by the advancing excavator tool are removed at least partly by conveying means that connect to the excavator tool and carry away this material to a position outside the trench. A suitable embodiment of the submersible vehicle has conveying means comprising a duct that extends from the excavating tool to
15 the position outside the trench, and a pump connected to the duct. The duct may for instance comprise solid and flexible piping.

- The remotely operated submersible vehicle according to the invention may operate at great depths over 300 m, preferably over 350 m and more preferably over 400 m. In
20 order to avoid down time in having to bring up the vehicle, for instance because of clogging of the cutting devices, an embodiment is provided wherein the excavating tool comprises water jet nozzles directed to the cutting devices and adapted to remove clogged seabed material. To this end, the excavating device may be provided with a water chamber for collecting the necessary water.

25

- The pumps associated with the vehicle, and more in particular with the conveying means for carrying away the excavated sea bed material, can be of any available type or construction. In a preferred embodiment, the pumps comprise an ejector pump. Such ejector pumps lack many mechanical moving parts and operate by providing a water
30 stream in which the excavated material is carried away.

In another embodiment, the excavating tool and the conveying means are actively driven by a power supply provided on the vehicle. The remotely operated vehicle (ROV) is connected to the surface vessel by means of an umbilical comprising control

cables, which provides data communication and electric power for at least the thrusters, and optionally also for the cutting tools, the rotating support member, the propelling roll member and the pumps. In a useful embodiment, the ROV is further equipped with an hydraulic power pack to convert electric power supplied via the umbilical to hydraulic power to drive the thrusters and optionally other components of the device.

A further advantage of the invented submersible vehicle is that it is light and does not require a lot of power, apart from the power needed to advance the excavating tool through the sea bed. In a typical embodiment, the power supply is adapted to deliver a power ranging from 550 to 1000 kW. The submersible vehicle according to yet another embodiment comprises a control means for positioning the vehicle and in particular the excavator tool thereof relative to the seabed. The control and steering of the vehicle is performed on the surface vessel, which makes the vehicle a remotely operated vehicle.

The remotely operated submersible vehicle or ROV is used in a method of preparing a trench in a subsea bottom, comprising the steps of lowering the submersible vehicle from a surface vessel towards a position close to the subsea bottom, manoeuvring the mechanical excavating tool of the vehicle through the subsea bottom along a trajectory, and conveying the excavated seabed material to a position outside the formed trench.

The position close to the subsea bottom for instance ranges from less than 1 m to distances in the range of 1-10 m. The advantages of the invented ROV are particularly apparent in a method wherein the seabed comprises heavy clay with an undrained shear strength S_u of at least 20 kPa, and/or wherein the seabed is highly undulated with peak-to-valley depth differences exceeding 10 m.

It is explicitly mentioned that the embodiments disclosed in the present application may be combined in any possible combination of these embodiments, and that each separate embodiment may be the subject of a divisional application.

BRIEF DESCRIPTION OF THE DRAWINGS

The invention will now be elucidated in more detail with reference to the accompanying figures, without otherwise being limited thereto. In the figures:

Figure 1 is a perspective view of an embodiment of the submersible vehicle according to the present invention;

Figures 2A and 2B are side views of an excavating tool for use in the embodiment shown in Figure 1;

5 Figure 3 is a perspective view of the embodiment shown in figure 1 in operational mode;

Figure 4 is a rear view of the embodiment shown in figure 1 in operational mode;

Figure 5 is a front view of the excavating tool for use in the embodiment shown in Figure 1;

10 Figure 6A is a perspective view from the front of the excavating tool shown in Figure 5;

Figure 6B is a perspective view from the rear of the excavating tool shown in Figure 5;

Figure 7 is a perspective view from the front of the cutting tools of the excavating tool shown in Figures 5 and 6;

Figure 8 is a side view of the cutting tools shown in Figure 7;

15 Figure 9 a side view of a submersible remotely operated vehicle (ROV) without the excavating tool of the present invention;

Figures 10A and 10B schematically represent a front and side view respectively of another embodiment of an excavating tool according to the invention; and finally

Figures 11A and 11B schematically represent a front and side view respectively of yet

20 another embodiment of an excavating tool according to the invention.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

Figure 9 shows a submersible remotely operated vehicle (ROV) 1 for manoeuvring a
25 chute or channel 10 across a sea bed. The channel 10 may be used to dump materials onto a sea bed. The ROV 1 comprises a frame 2 having frame members extending in a longitudinal direction 15, a width direction 16 and a height direction 17 of the ROV 1. Hoisting cables 3 are connected to the frame 2 for suspending the ROV 1 from a surface vessel (not shown) and controlling the position of the ROV 1 in the vertical direction
30 17. The ROV 1 comprises a plurality of hydraulically driven thrusters 4, a first set of thrusters 4 being adapted for propelling the ROV 1 in a first horizontal direction (for instance the longitudinal direction 15) and a second set of thrusters 4 being adapted for propelling the ROV 1 in a horizontal direction perpendicular to the first direction (for instance the width direction 16). Hydraulic power is provided by means of an hydraulic

power pack 5 which receives electric power from the surface vessel by means of an umbilical 6, which may be integrated in one of the hoisting cables 3, and which supplies hydraulic power to a so-called common rail 7. Compensators 8 are provided to reduce, in a manner known *per se*, the pressure difference over the seals in the various hydraulic devices. The ROV 1 also comprises a dynamic positioning system 9, connected to the surface vessel via the umbilical 6. In some embodiments, the ROV 1 is arranged as the master, whereas the surface vessel is arranged as the slave, i.e. the ROV 1 is operated or programmed to follow a predetermined path and the surface vessel follows the submerged ROV 1. In other embodiments, the surface vessel is arranged as the master, whereas the ROV 1 is arranged as the slave, i.e. the surface vessel is operated or programmed to follow a predetermined path and the submerged ROV 1 follows the surface vessel.

The ROV 1 in the embodiment shown further comprises a channel 10 providing a means to releasably accommodate the end of a fall pipe for instance (not shown). The channel 10 extends through the middle and, in this example, through the centre of gravity of the ROV 1. The channel 10 comprises an upper section 10A converging downwards and a lower section 10B converging upwards, the sections together defining a waist. At this waist, the channel 10 is provided with one or more friction elements, e.g. a plurality of the resilient blocks 11 that can be moved radially inwards to clamp a fall pipe and outwards to release a fall pipe by means of hydraulic cylinders 12 mounted about the outer wall of the channel 10. The present invention does not need to use the channel 10 of the ROV 1, nor a fall pipe end accommodated in said channel 10.

Figure 1 shows a first embodiment of a ROV 1 according to the invention. In all figures except figure 9, important components of the ROV 1 like the thrusters 4 and the power pack 5 have been omitted for clarity. The ROV 1 apart from comprising a frame 2, hoisting cables 3 and control cables 6 for suspending the vehicle from a surface vessel (not shown), and thrusters 4 for manoeuvring the ROV 1, as described above, further comprises an elongated mechanical excavating tool 20 at a rear side of the ROV 1. The rear side is defined with respect to the intended advancing direction 50 along the trench 131 to be formed. The excavating tool 20 is attached to the vehicle frame 2 by two arms (21a, 21b) that extend on both sides of the ROV 1 and connect to a lower frame member of the frame 2 by two hinges (22a, 22b). The hinged connection (22a, 22b) allows

rotating the excavating tool 20 from a position at rest, as shown in figure 1 for instance, to a working position, as shown in figure 3, in which the excavating tool 20 has been lowered to contact the sea bed 130 in order to make a trench 131 therein.

- 5 The excavating tool 20 extends across the width 132 of the trench 131, and comprises an elongated support member in the form of an assembly 25 of spiralling webs (25a, 25b, ...) provided around the axis of rotation and extending across the width 132 of the trench 131 in a longitudinal direction 26 of the support member. The spiralling webs (25a, 25b,...) are provided with a plurality of cutting devices in the form of blades 45.
- 10 The assembly 25 is rotatably mounted in a partly open housing 44, the rotation being provided around an axis 24 extending in the longitudinal direction 26. The assembly 25 is actively rotated around its longitudinal axis in a direction of rotation 27 by a rotary motor 43, thereby successively impacting the sea bed with the blades 45. The blades 45 not only cut the sea bed 130 efficiently to form a trench 131 but also help in advancing
- 15 the excavating tool 20 along the trench 131. As seen in figure 5, the cutting devices 45 are positioned about symmetrical with respect to a plane of symmetry 42, which helps in reducing reaction forces incurred in a width direction 16 of the ROV 1, i.e. in a direction parallel to the longitudinal direction 26 of the excavating tool 20. The assembly 25 may be supported further by a transverse plate member 62 positioned in
- 20 the symmetry plane 42

The assembly 25 of spiralling webs (25a, 25b,...) forms a cylindrical revolving body and the blades 45 extend substantially tangentially to a circumferential surface 48 of the revolving body, as shown in figure 8. The blades 45 are placed at a relatively small

25 distance 41 from the circumferential 48 surface of the revolving body. As shown in figure 7, the blades are slightly curved.

As best shown in figure 2, the housing 44 is open at a frontal side to provide an access opening between edges A and B of the housing 44 to the sea bed 131 (figure 2B). A

30 rotatable visor part 49 of the housing 44 allows closing the housing 44 further as shown in figure 2A, in which the access opening has been reduced to between the edge A of the housing 44 and an edge C of the housing 44.

The excavating tool 20 may further comprise a water chamber 60 that provides pressurized water to water jet nozzles (61a, 61b) directed to the cutting devices 45 and adapted to remove clogged seabed material.

- 5 The ROV 1 may experience vertical movements in the direction 17 (see figure 9) resulting from heave and other wave action. To keep a substantially constant excavating depth, the excavating tool 20 may comprise a support surface in the form of two sliding surfaces or skis 63a (see figure 6B), provided on both sides of the excavating tool 20. The skis 63a are provided on a higher level than a cutting surface 64 of the excavating
10 tool 20 and support the excavating tool 20 on the sea bed 130. The height difference between the support surface provides by the skis 63a and the cutting surface 64 defines the cutting thickness or excavating depth.

- The sea bed materials excavated by the advancing excavator tool 20 in the towing
15 direction 50 are removed by conveying means in the form of two ducts (28a, 28b) arranged on either side of the ROV 1 and extending from the housing 44 for the support member and cutting devices 45 to two sidecasting positions (51a, 52a) outside the trench 131 via additional ducts (29a, 29b) arranged on a front part of the frame 2. In operation, the rigid parts (28a, 28b) and (29a, 29b) are interconnected by two flexible
20 pipe segments (30a, 30b). Conveying of excavated sea bed material through the ducts (28, 29, 30) is driven by ejector pumps (31a, 31b). Such ejector pumps (31a, 31b) operate by providing a water stream in the ducts (28a, 28b) that entrains excavated material.

- 25 In order to prepare a trench 131 in a subsea bottom 130, the ROV 1 is lowered from a surface vessel (not shown) by unrolling the hoisting cables 3 from winches provided on the vessel until the ROV 1 is in a position relatively close to the subsea bottom 130. The mechanical excavating tool 20 is then brought in contact with the sea bed 130 by rotating the arms (21a, 21b) around the hinged connections (22a, 22b) until the
30 excavating tool 20 hits the sea bed bottom 130 and blades (25a to 25d) penetrate the sea bed 130 (figure 3). Rotating the arms (21a, 21b) can for instance be done by suspending the arms (21a, 21b) from cables (not shown) provided on winches (not shown) of the ROV 1. The ROV 1 is then manoeuvred through the subsea bottom 130 along a trajectory in the towing direction 50 whereby sea bed material is loosened by the cutting

- devices 45 of the assembly 25 of spiralling webs, and conveyed by the ducts (28, 29, 30) to the sidecast positions ((51a, 51b) outside the formed trench 131. In this process, the ROV 1 does not rest on the seabed 130, apart from the excavating tool 20. The hinged connection (22a, 22b) between the vehicle frame 2 and the mechanical
- 5 excavating tool 20 allows accommodating vertical movements of the ROV 1 induced by currents and heave of the vessel. The thrusters 4 of the ROV 1 are used to head the ROV 1 along the intended trajectory of the trench 131 and offer the propelling power to the excavating tool 20.
- 10 The invention is not restricted to the specific excavating tool 20 described above which uses an assembly 25 of spiralling webs. Figures 10 and 11 show representative embodiments of the excavating tool 20. The excavating tool 20 of figure 10 comprises a dredge wheel 70 rotatably supported by two support arms (71a, 71b). An externally positioned hydraulic motor 72 drives the dredge wheel 70. A reinforced suction pipe 73
- 15 is partly inserted in the dredge wheel 70 to carry away excavated sea bed material. The dredge wheel is provided with a number of cutting tools 74 provided on arms 75. Cutting depth 77 of the dredge wheel is about half the diameter 76 thereof. Typical diameters are of the order of 1-2 m.
- 20 Another embodiment is shown in figure 11. The excavating tool 20 of figure 11 comprises two dredge wheels (70a, 70b) rotatably supported by two support arms (71a, 71b). Two internally positioned hydraulic motors (72a, 72b) drive each dredge wheel (70a, 70b) independently. Two reinforced suction pipes (73a, 73b) are partly inserted in the dredge wheels (70a, 70b) to carry away excavated sea bed material. The dredge
- 25 wheels are provided with a number of cutting tools 74 provided on arms 75. This embodiment allows increasing the total width 78 of the dredge wheels in a convenient manner and therefore also the width 132 of the trench to be formed.

The invention is not restricted to the above-described embodiments, which can be

30 varied in a number of ways within the scope of the claims.

CLAIMS

1. Remotely operated submersible vehicle for preparing a trench in a subsea bottom, the vehicle comprising a frame, hoisting and control cables for suspending the vehicle from a surface vessel, thrusters for manoeuvring the vehicle, an elongated mechanical excavating tool connecting to the vehicle by a hinged connection and extending across the width of the trench, and conveying means for carrying away excavated seabed material to a position outside the trench.
2. Submersible vehicle according to claim 1, wherein the excavating tool comprises an elongated support member provided with cutting devices and rotatably mounted in a partly open housing, the rotation being provided around an axis extending in a longitudinal direction of the support member.
3. Submersible vehicle according to claim 2, wherein the support member comprises an assembly of spiralling webs provided around the axis of rotation and extending across the width of the trench.
4. Submersible vehicle according to claim 2 or 3, wherein the assembly of spiralling webs forms a cylindrical revolving body and the cutting devices comprise a number of blades that extend substantially tangentially to a circumferential surface of the revolving body.
5. Submersible vehicle according to claim 4, wherein the blades are provided at a distance from the circumferential surface of the revolving body.
6. Submersible vehicle according to claim 4 or 5, wherein the blades are curved.
7. Submersible vehicle according to any one of claims 2-6, wherein the number of cutting devices along the support member is from 10 to 50, more preferably from 20 to 40.
7. Submersible vehicle according to any one of the preceding claims, wherein the excavating tool comprises a support surface provided on a higher level than a cutting

surface of the excavating tool, and adapted to support the excavating tool on the sea bed.

8. Submersible vehicle according to claim 7, wherein the support surface
5 comprises at least two sliding surfaces provided on both sides of the excavating tool.

9. Submersible vehicle according to any one of the preceding claims, wherein the conveying means comprise a duct that extends from the excavating tool to the position outside the trench, and a pump connected to the duct.
10

10. Submersible vehicle according to any one of the preceding claims, wherein the excavating tool comprises water jet nozzles directed to the cutting devices and adapted to remove clogged seabed material.

11. Submersible vehicle according to claim 9 or 10, wherein the pump comprises an ejector pump.
15

12. Submersible vehicle according to any one of the preceding claims, wherein the excavating tool and the conveying means are actively driven by a power supply on the vehicle.
20

13. Submersible vehicle according to claim 12, wherein the power supply is adapted to deliver a power ranging from 300 to 500 kW.

14. Submersible vehicle according to any one of the preceding claims, comprising a control means or connectable to control means for positioning the vehicle and in particular the excavator tool thereof relative to the seabed.
25

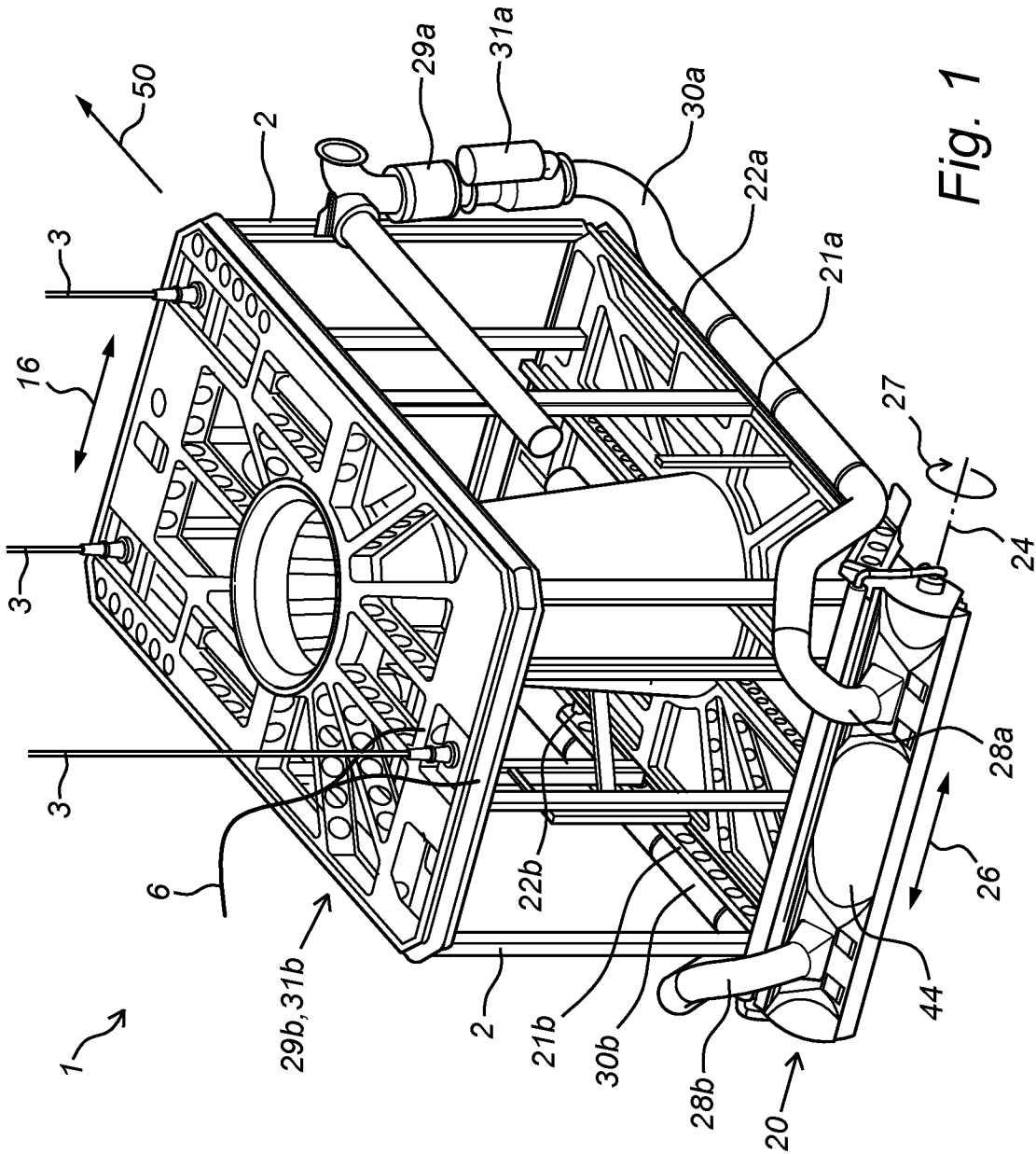
15. Assembly of a surface vessel and a submersible vehicle according to any one of the preceding claims, suspended from the vessel by hoisting and control cables.
30

16. Method of preparing a trench in a subsea bottom, comprising the steps of lowering a submersible vehicle in accordance with any one of claims 1-14 from a surface vessel towards a position close to the subsea bottom, manoeuvring the

mechanical excavating tool of the vehicle through the subsea bottom along a trajectory, and conveying the excavated seabed material to a position outside the formed trench.

17. Method according to claim 16, wherein the seabed comprises heavy clay with an
5 undrained shear strength S_u of at least 20 kPa.

18. Method according to claim 16 or 17, wherein the seabed is highly undulated with peak-to-valley depth differences exceeding 10 m.



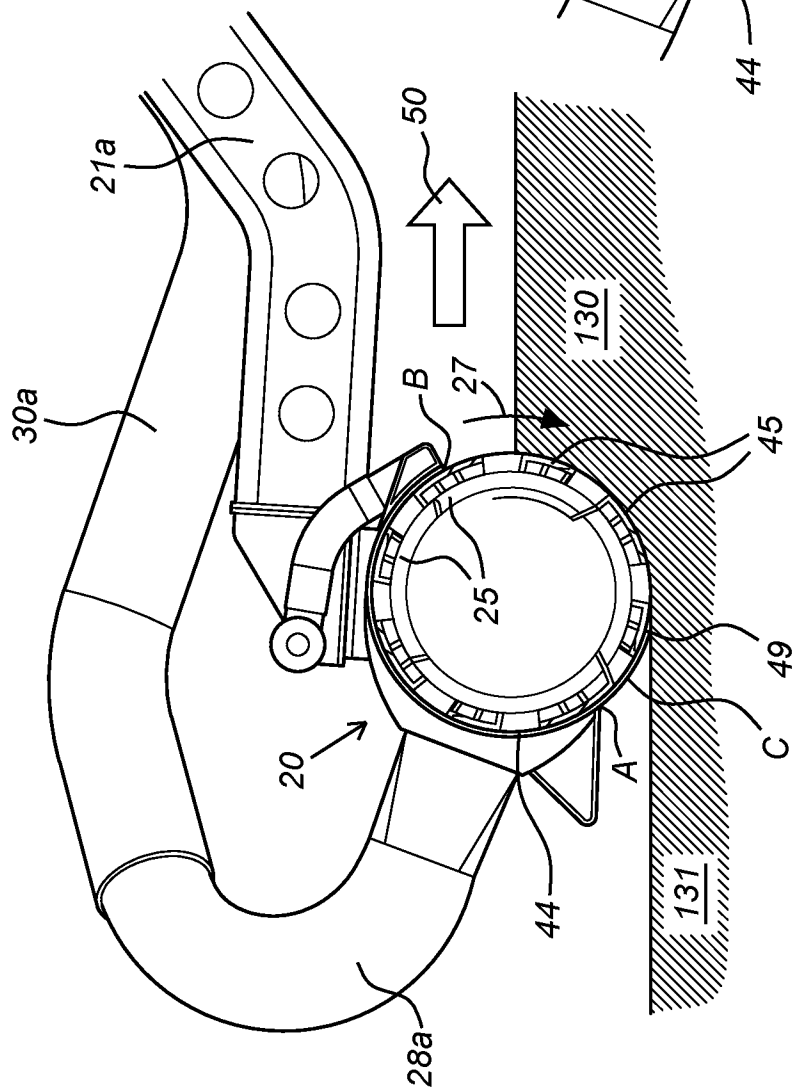


Fig. 2A

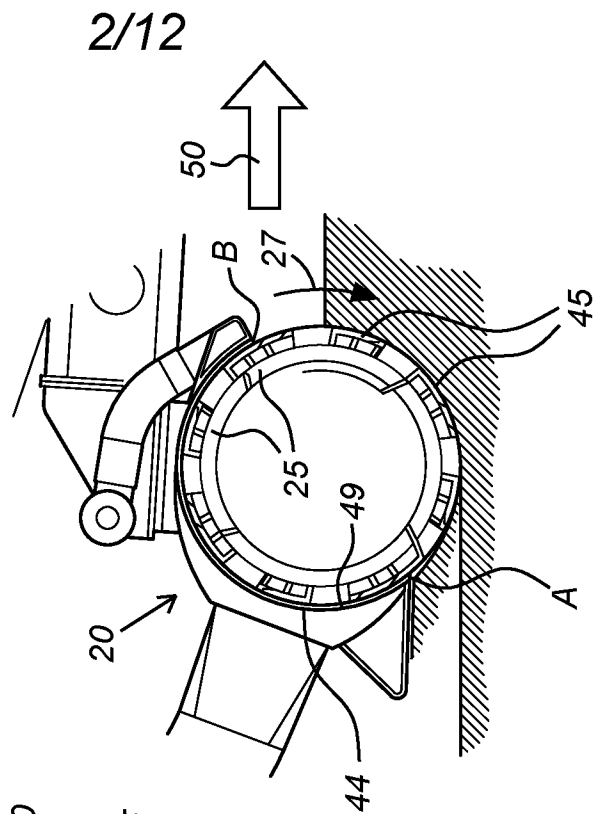
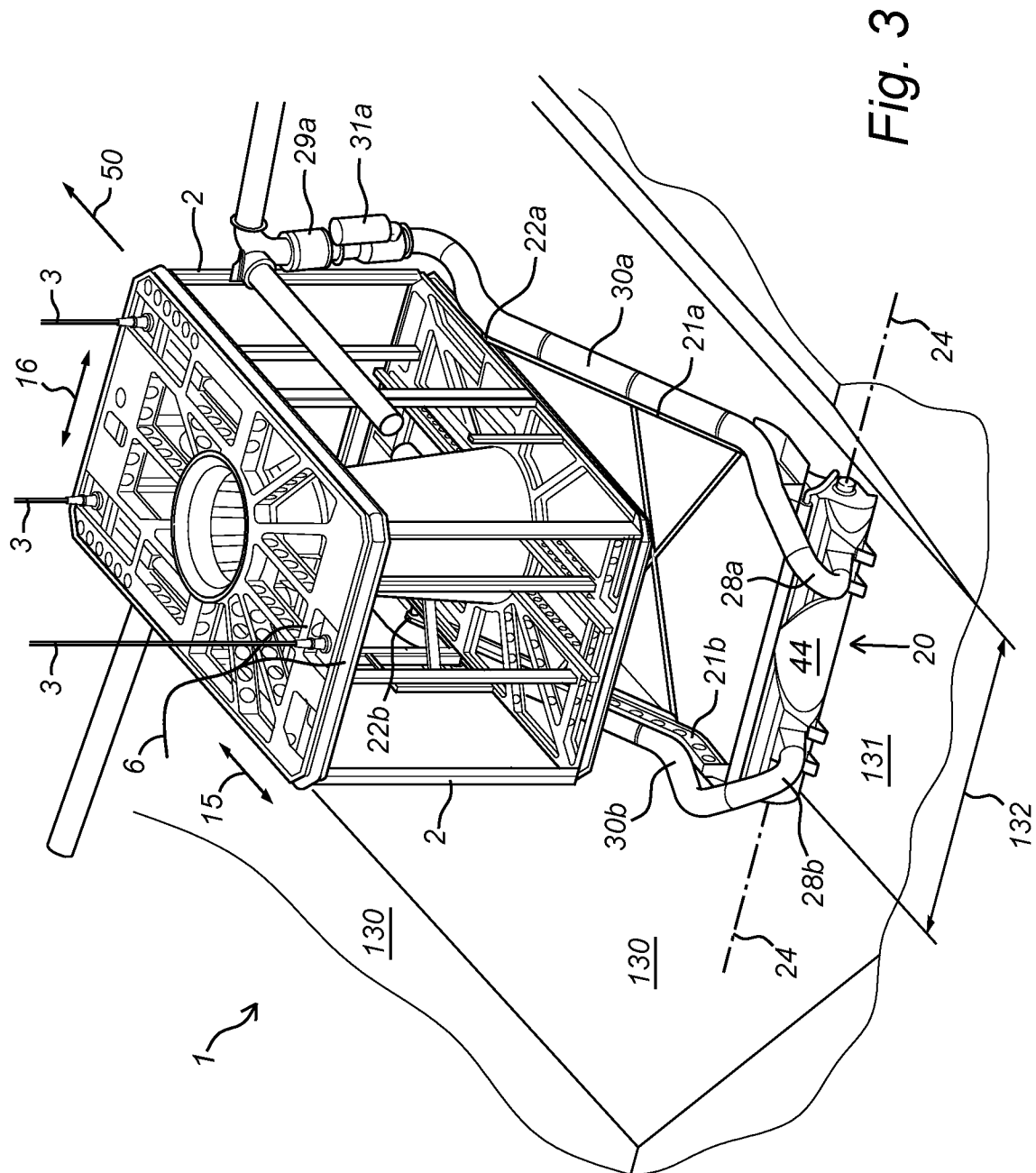


Fig. 2B

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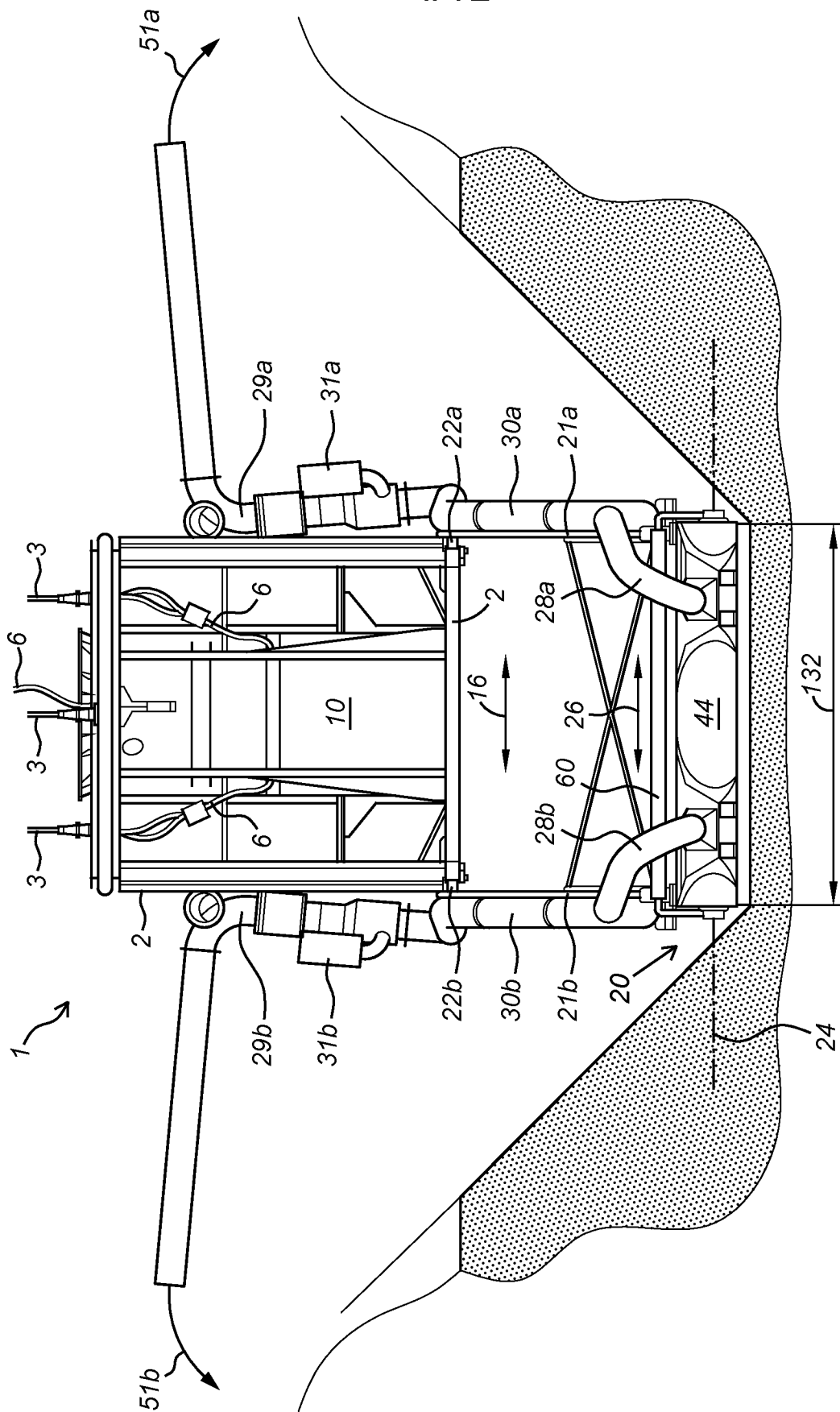


Fig. 4

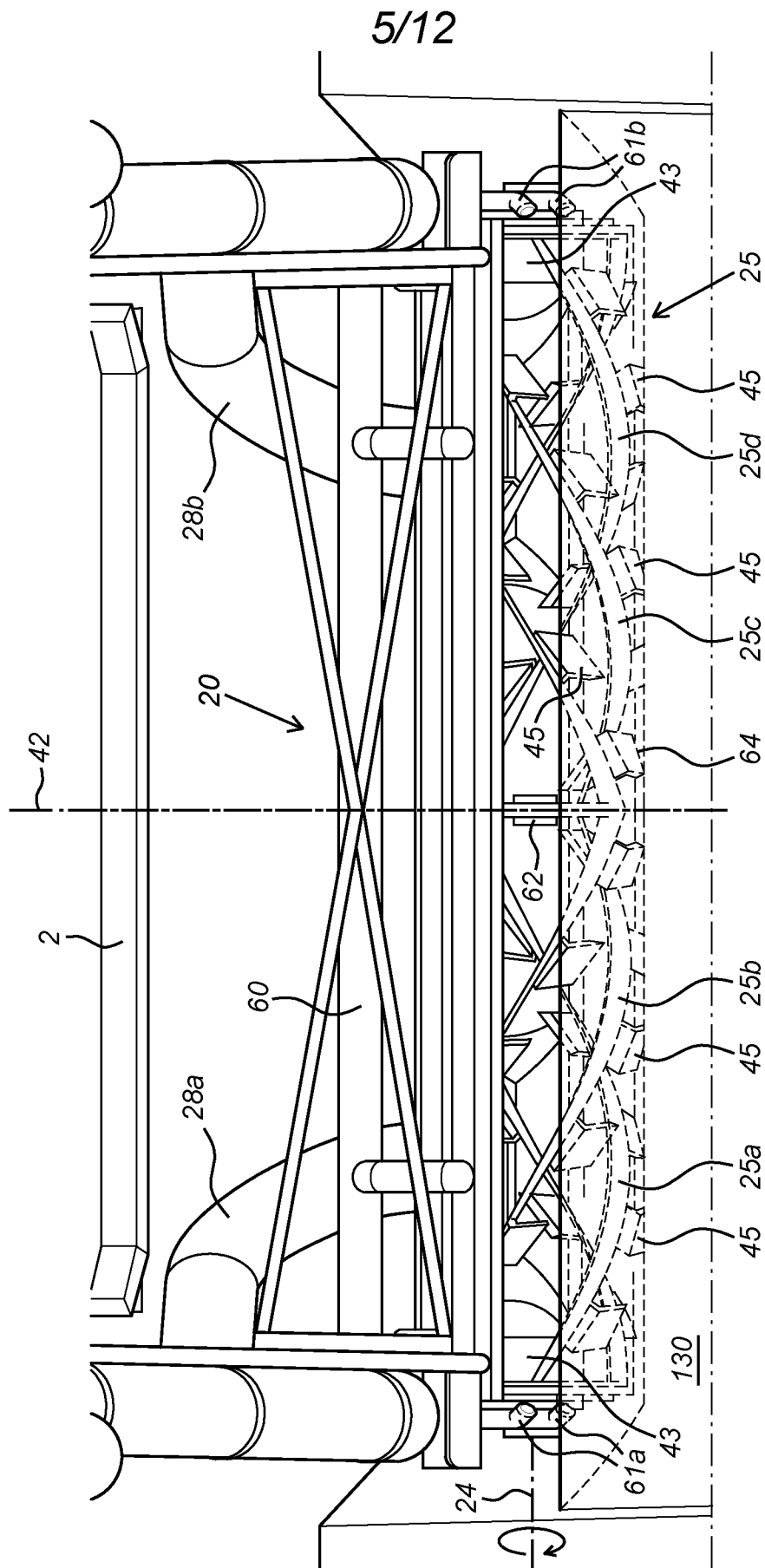


Fig. 5

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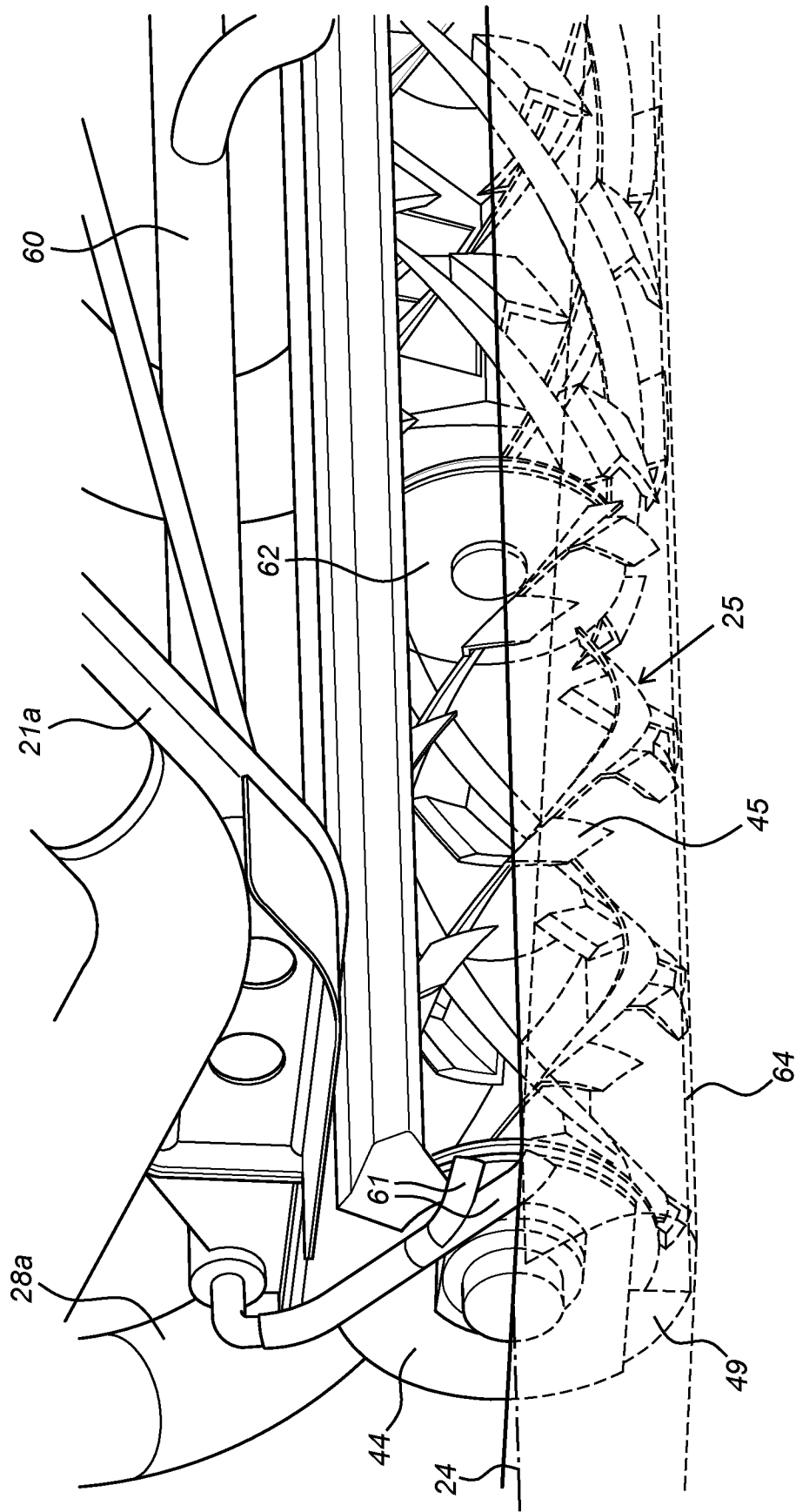


Fig. 6A

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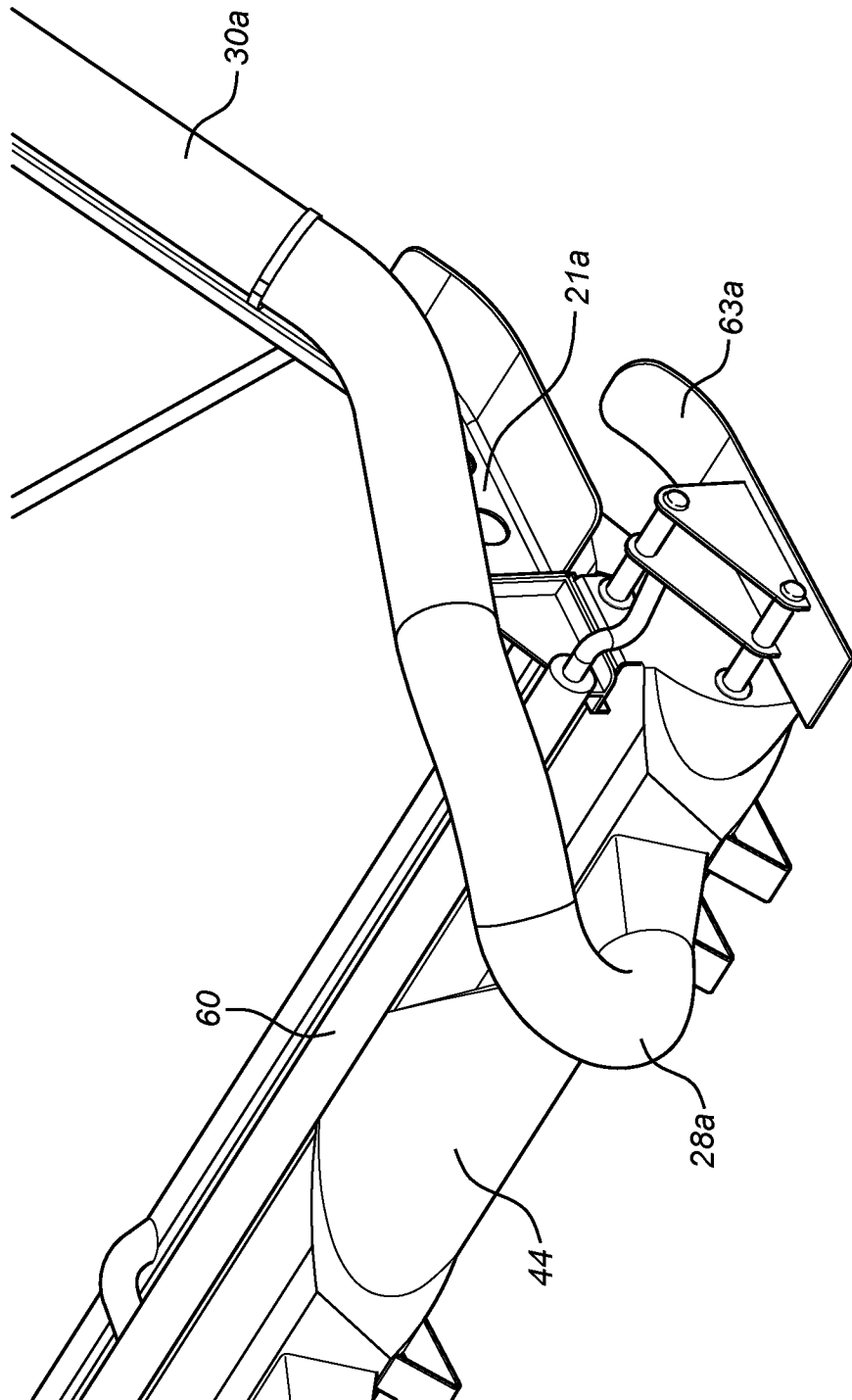


Fig. 6B

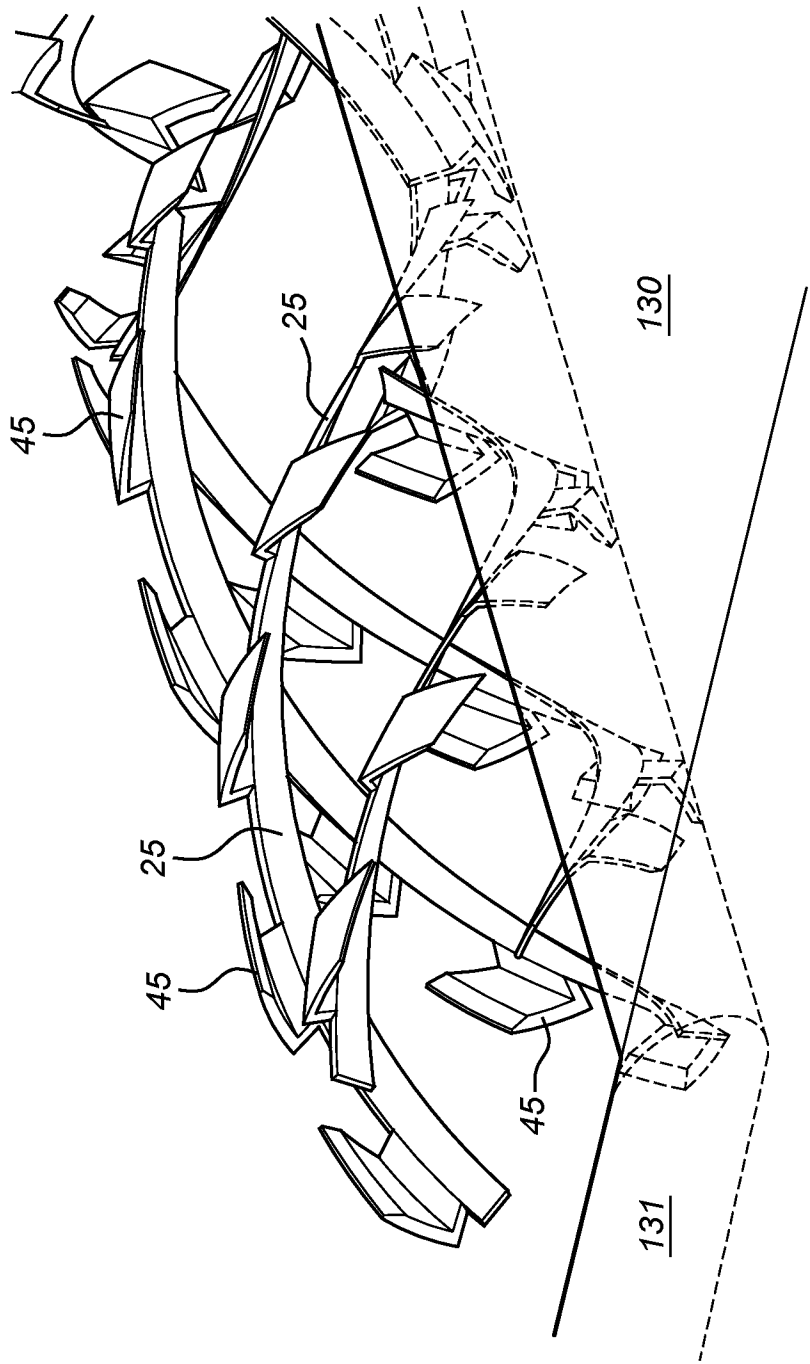


Fig. 7

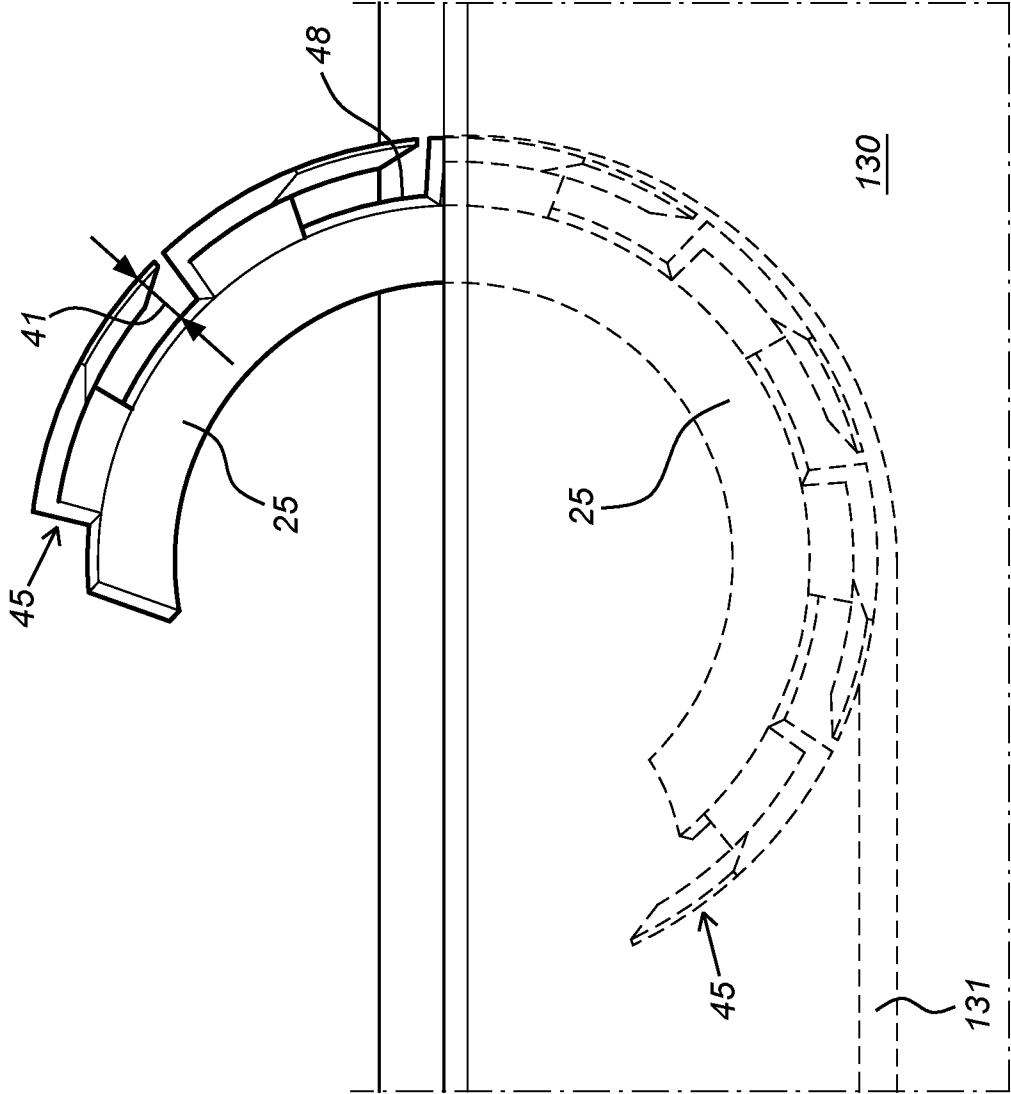


Fig. 8

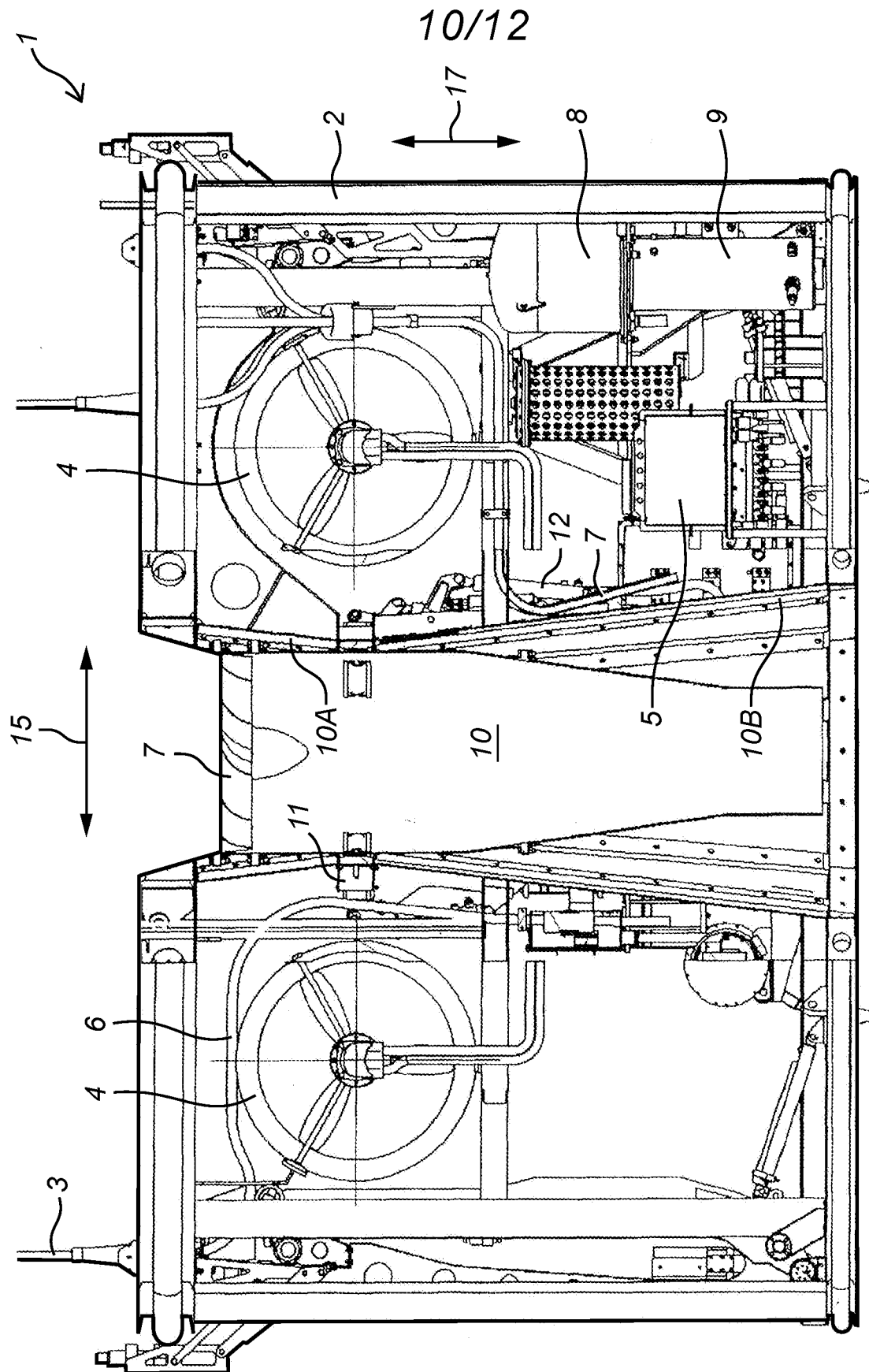


Fig. 9

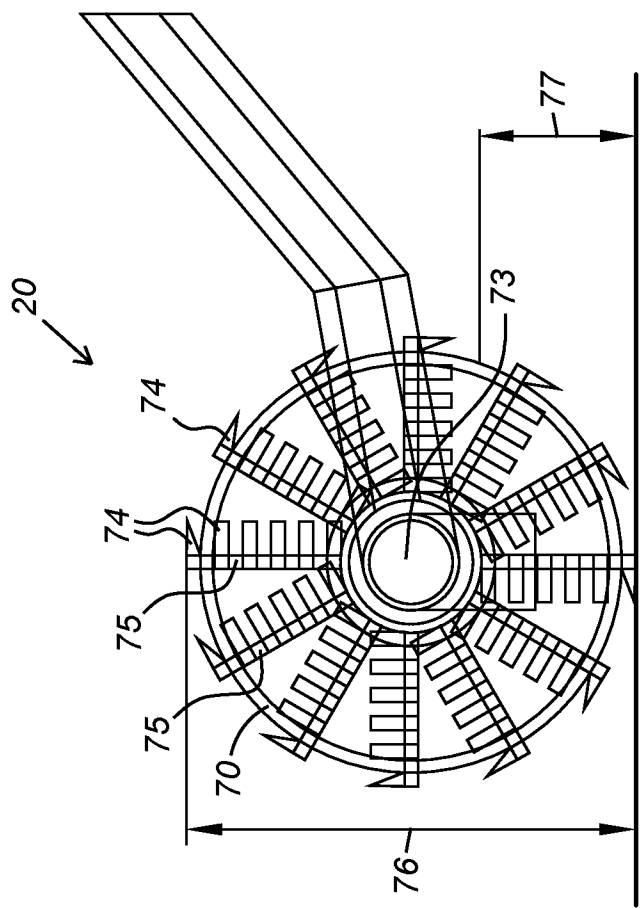


Fig. 10B

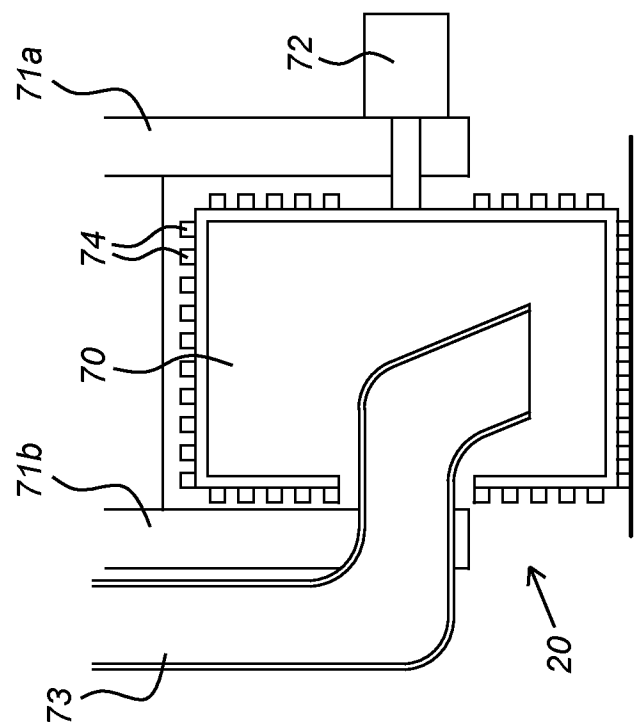
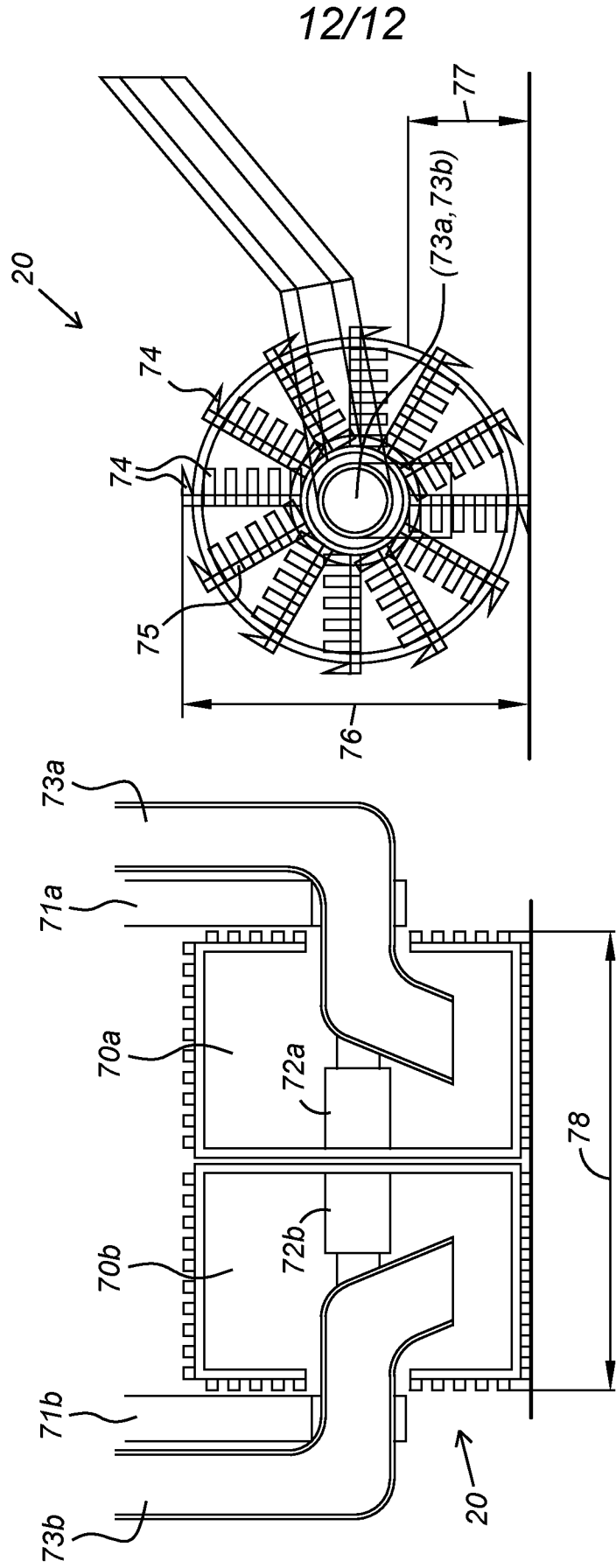


Fig. 10A



INTERNATIONAL SEARCH REPORT

International application No
PCT/NL2016/050110

A. CLASSIFICATION OF SUBJECT MATTER
INV. E02F3/88 E02F5/10
ADD.

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
E02F

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	WO 01/92650 A1 (SOIL MACHINE DYNAMICS LTD [GB]; REECE JOHN PETER [GB]) 6 December 2001 (2001-12-06) the whole document	1-18
X	WO 01/92649 A1 (SOIL MACHINE DYNAMICS LTD [GB]; ATKINSON PAUL ROBERT [GB]) 6 December 2001 (2001-12-06) the whole document	1-18
X	US 8 333 535 B1 (WHITESIDE STEVE [US] ET AL) 18 December 2012 (2012-12-18) the whole document	1-18
X	US 8 864 415 B1 (WHITESIDE STEVEN K [US] ET AL) 21 October 2014 (2014-10-21) the whole document	1-18
	-/--	



Further documents are listed in the continuation of Box C.



See patent family annex.

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Date of the actual completion of the international search

2 June 2016

Date of mailing of the international search report

14/06/2016

Name and mailing address of the ISA/

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Faymann, L

INTERNATIONAL SEARCH REPORT

International application No
PCT/NL2016/050110

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
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X	----- WO 2004/055276 A1 (SEATOOLS B V [NL]; HOOS FRANK [NL]) 1 July 2004 (2004-07-01) the whole document -----	1-18

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No

PCT/NL2016/050110

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