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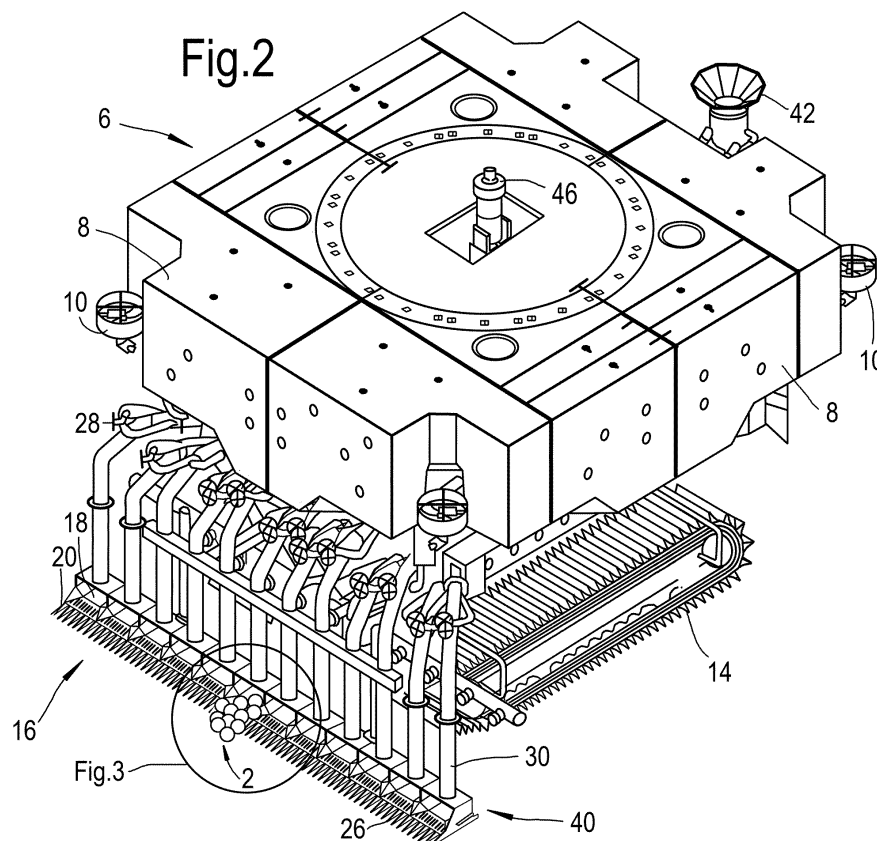
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(54) **APPARATUS FOR REMOVING NODULAR MATERIAL FROM THE SEABED AND FOR SEPARATING SAID NODULAR MATERIAL**

(57) A vehicle (6) apparatus for removing material from the seabed is disclosed. The vehicle comprises first thrusters (10) for moving the vehicle vertically and second thrusters (12) for moving the vehicle horizontally. A collector unit removes material from the seabed, and a latching mechanism (42) is adapted to be connected to

a riser to enable removed material to be transported to a vessel on the surface. The separator comprises tines that in some embodiments comprise ridges. The separator comprises a water jet configured to move material towards the inlet and to remove smaller material.



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Description

[0001] The present disclosure relates to an apparatus for removing material from a floor of a body of water, or separating material, for example, nodules from other materials, for example, sediment, and in particular seabed sediment.

[0002] Nodules of material including minerals and rare metals form on the seabed in significant depths of water. It is known to mine such material by means of a mining apparatus which rests on the seabed and is supplied with electrical power from a surface vessel via an umbilical cable, wherein the apparatus is connected to a conduit known as a jumper hose, via which the nodular material can be pumped to the surface vessel by means of a riser pump, or other means.

[0003] Known apparatus of this type suffers from a number of drawbacks. Firstly, manipulators or remotely operated vehicles (ROVs) are required to assist in connecting the apparatus to the jumper hose. Also, because the weight of the apparatus as it is lowered from the surface vessel to the seabed and raised from the seabed is supported by the umbilical cable, significant mechanical strengthening of the umbilical cable is necessary. The mechanical reinforcement necessary for the umbilical cable generally has poor heat conducting properties, as a result of which the umbilical cable insulation heats up, which in turn limits the electrical power which can be supplied to the apparatus. In addition, the catenary curve of the reinforced umbilical cable is similar to that of the jumper hose used to transport the nodular material to the surface, as a result of which there is a risk of collision between the umbilical cable and a conduit during operation of the apparatus. A further disadvantage of known such apparatus is the difficulty of operation of the apparatus in very soft ground.

[0004] Preferred embodiments of the present disclosure seek to overcome one or more of the above disadvantages.

[0005] According to an aspect of the present invention there is provided an apparatus for removing nodular material from a floor of a body of water, the apparatus comprising: moving means for moving the apparatus relative to a floor of a body of water; material removing means for removing nodular material from the floor of the body of water, wherein the material removing means comprises at least one inlet and floor engaging means for engaging the floor of the body of water, wherein the floor engaging means comprises a plurality of protrusions.

[0006] Aptly the protrusions will be longer than wide with the longer length, the longitudinal axis orientation, protruding, outwards from the apparatus, in the direction of travel. In this way the protrusions may act as a sieve. The protrusions will be spaced apart, for example, spaced apart in the range of 1 centimetre to 3 centimetres from each other. Aptly spaced apart along the longitudinal length or a portion of the longitudinal length of the plurality of protrusions. The nodular material tends to be

in clumps, nodules, aptly wider in largest diameter than the spacing between the protrusions of the invention. Therefore the protrusions when engaged with the floor of the body of water, moved through the floor of the body of water, nodules, or nodule material in clumps of the usual size found, are separated from the non-nodular material. Non-nodular material, for example, sediment, may fall off the sides of the protrusions, for example through the space between the plurality of protrusions. The protrusions may be pointed in some embodiments to aid travelling through the floor of the body of water. In this way during use the plurality of protrusions lift up the nodules away from sediment of the floor of the body of water.

[0007] In some embodiments the plurality of protrusions are adapted to be arranged forwards of at least one said inlet in a direction of travel of the apparatus and to extend substantially in a direction of travel of the apparatus.

[0008] In some embodiments the material removing means comprises at least one surface inclined in use relative to the floor of the body of water. The at least one surface inclined in use relative to the floor of the body of water may in some embodiments comprise a flat surface that is orientated at an incline. In some embodiments the inclined surface may comprise a wedge shaped structure that comprises a flat bottom surface horizontal with the floor of the body of water and an upper surface that is inclined relative to the floor of the body of water, inclined in direction from the direction of travel. In other words the thinner part of the wedge shape structure is at the direction of travel end and the thicker part of the wedge shaped structure is at the opposition end. In some embodiments the material removing means, or tines, are configured to be inclined. In some embodiments the material removing means, or tines, are configured to comprise an upper surface that is inclined. The upper surface here mentioned is when in use relative to the floor of the body of water that the upper surface is opposite the surface facing the floor of the body of water. In some embodiments the inclined surface is the upper surface of one or more of: the tines; the separator; or material removing mean.

[0009] In some embodiments there is not an inclined surface. In some embodiments the tines are raised when a nodule is located on the tine, letting the non-nodular material fall away.

[0010] In some embodiments the at least one surface inclined in use relative to the floor of the body of water, inclines in the direction away from the direction of travel.

[0011] In some embodiments the at least one surface inclined in use relative to the floor of the body of water, inclines in direction towards at least one inlet. Ideally the nodular material when on the separator, material removing means or tines is moved towards an inlet of the apparatus. The inlets are useful for collecting and subsequently storing or transporting the nodular material. In some embodiments the inlets are configured to be in use orientated or positioned above the separator or material

removing means and may comprise a suction system and conduit to transport nodules. In some embodiments the inlets may comprise an aperture to a conduit. In some embodiment the nodules may enter the inlet by gravity.

[0012] In some embodiments the at least one surface inclined in use relative to the floor of the body of water comprises the plurality of protrusions adapted to be arranged forwards of at least one said inlet in a direction of travel of the apparatus and to extend substantially in a direction of travel of the apparatus.

[0013] In some embodiments the material removing means comprises a separator. In some embodiments the material removing means is a separator. The separator or material removing means may comprise the floor engaging means.

[0014] In some embodiments the separator, or material removing means, comprises at least one aperture therethrough for enabling non-nodular material to pass therethrough and preventing said nodular material from passing therethrough. This allows the relatively larger nodular material, or nodules, to be retained on the surface of the separator, to subsequently be moved to the inlets, while allowing the relatively smaller non-nodular material, for example, sediment, to pass through the apertures.

[0015] In some embodiments at least one of the plurality of protrusions comprise at least one notch on the upper surface of the said at least one of the plurality of protrusions. The upper surface is the upper surface when in use, the opposite side or surface to the side nearest to, or facing the floor of the body of water.

[0016] In some embodiments the notch is a groove or channel. In some embodiments the notch is a groove or channel across the longitudinal axis of one or more of the plurality of protrusions or tines.

[0017] In some embodiments at least one of the plurality of protrusions comprise more than one notch. In some embodiments every protrusion of the plurality of protrusions comprise at least one notch. In specific embodiments each protrusion of the plurality of protrusions comprise more than one notch. Aptly most, all or nearly all protrusions of the plurality of protrusions, or tines will have more than one notch. The notches aid preventing the nodules rolling or sliding off the plurality of protrusions thus aid transport of the nodules to the inlets, therefore the more the better.

[0018] In some embodiments the at least one surface inclined in use relative to the floor of the body of water, comprises at least one notch on the upper surface of the at least one surface inclined relative to the floor of the body of water.

[0019] In some embodiments the at least one notch comprises a vertical side or edge. In some embodiments the at least one notch comprises a vertical side or edge, when in use. In some embodiments the notch is configured that in use comprises a vertical side or edge. In use the separator may be orientated that the notch comprises an edge, or side, that is vertical relative to the floor of the body of water. Having an edge, or side, of the notch that

is vertical aids prevention of the nodular material rolling, or sliding down the surface of the separator. The vertical edge, or side, may form a lip that aids prevention of the nodular material or nodules sliding or rolling off the separator; tines or plurality of protrusions of the separator. In some embodiments the notch is configured to form a lip to hinder in one direction, items from sliding or rolling beyond the notch.

[0020] In some embodiments the at least one notch comprises an inclined surface, inclined moving away from the direction of travel. In some embodiments the at least one notch comprises an inclined surface relative to the floor of the body of water in use, inclined moving away from the direction of travel. In some embodiment the notch is configured that in use comprises an inclined surface relative to the floor of the body of water. In some embodiment the notch is configured that in use comprises an inclined surface relative to the floor of the body of water, that inclines away from the direction of travel.

[0021] In some embodiments the at least one notch is V shaped from a cross-sectional view. The cross-sectional view here referred to is the cross-sectional view across the longitudinal axis of the protrusion or tine. The V shape aids preventing the nodular material, or nodule, from falling off the separator; or protrusion or tine of the separator.

[0022] In some embodiments the sides of the at least one notch do not protrude above the surface of the plurality of protrusions, or tines or separator.

[0023] In some embodiments the at least one notch is configured to hinder sliding or rolling of an object partially located within the notch, in one direction but not in the opposition direction.

[0024] In some embodiments the notch comprises two sides wherein the side nearest the direction of travel of the apparatus is vertical.

[0025] In some embodiments the notch comprises two sides wherein the side nearest the direction of travel of the apparatus is configured to form an abutment. Therefore aiding prevention of items partially contained in the nodule from rolling or sliding beyond the notch in the direction of travel of the apparatus.

[0026] In some embodiments the notch extends across the longitudinal axis of the upper surface of at least one plurality of protrusions. Again this may aid preventing the nodular material, or nodule, from falling off the separator; or protrusion or tine of the separator. In some embodiments the notch extends across at least a portion across the width of the protrusion. The width being the shorter across dimension of the protrusion with the longer diameter of the protrusion being the length.

[0027] In specific embodiments the notch will extend across the entire width of the protrusion, of the plurality of protrusions, or tine.

[0028] The notches may assist nodules, or the like, to travel along the tines, separator or plurality of protrusions in the direction away from the direction of travel but hinder the travel of nodules in the same direction as that of the

direction of travel of the apparatus. The configuration of the notches assist this advantage.

[0029] In some embodiments the at least one of the plurality of protrusions comprise a plurality of notches. Having a plurality of notches increases the aid of preventing the nodular material, or nodule, from rolling, sliding or falling off the separator; or protrusion or tine of the separator.

[0030] In some embodiments the floor engaging means of the separator comprising a plurality of protrusions, comprise tines. Herein, the term plurality of protrusions and tines are equivalents, and are used interchangeably.

[0031] In some embodiments the tines are held together at a surface of the tines that is opposite the surface facing the direction of travel. Aptly the tines act as a fork or sieve to enable raising or separating of the relatively larger nodules, of nodular material from the relatively smaller non-nodular material, for example sediment of the floor of the body of water.

[0032] In some embodiments the at least one inlet comprises an inlet in fluid communication with a container, or in fluid communication with a container via a conduit wherein the conduit is in communication with a container. Inlets suitable with the present invention are further described below.

[0033] In some embodiments the apparatus further comprises a water jet or water pump or waterjet system. In some embodiments the waterjet comprises at least one conduit.

[0034] In some embodiments the water jet may have a pump located on or within, or in communication with, the apparatus, or vehicle. In some embodiments the pump of the water jet is configured to pump water via a conduit to the general location of the separator. In some embodiments the water jet is configured to pump water towards at least one inlet. In some embodiments the water jet is configured to pump water towards a notch. In some embodiments the water jet is configured to pump water towards at least one tine in also a direction opposite the direction of travel. In particular embodiments, the pump and conduits are configured to pump water to the inclined surface or the separator, or the plurality of protrusions, or the tines, or any combination thereof: separator, protrusions, inclines surface or tines. The conduits of the water jets may comprise a "U" shaped configuration in part. This may aid directing the water from the water jet. Aptly the water jet comprises at least one outlet through which the water is expelled. Aptly the water jet will use the water surrounding the apparatus of the body of water however the apparatus may comprise a source of water or other fluid.

[0035] In some embodiments the water jet comprises at least one outlet. In specific embodiments the water jet may comprise outlets at one or more of the plurality of protrusions or tines.

[0036] In some embodiments at least one outlet of the water jet is directed towards an inlet of the apparatus. In

some embodiments at least one of the outlet of the water jet is directed in the opposition direction to the direction of travel. In some embodiments the majority of the outlets of the water jet are directed towards an inlet of the apparatus. In some embodiments the majority of the outlets of the water jet are directed in the opposition direction to the direction of travel. In some embodiments, all of the water jets are directed towards an inlet of the apparatus. In some embodiments all of the outlets of the water jet are directed in the opposition direction to the direction of travel. In some embodiments, all of the water jets are directed towards an inlet of the apparatus. By describing that the outlets are direct at or to or towards means that outlet is configured that when the water is ejected or expelled from the outlet of the water jet that the water will be directed to or at or towards that particular stated direction. Advantageously having the water jet directed away from the direction or travel; to the opposition direction of the direction of travel; or towards an inlet; may assist moving the nodules or nodular material towards an inlet to be collected by the apparatus. The force of the water jet may actually move the nodules or nodular material along the protrusions or tines, and/or up the inclined surface, or generally towards the inlets of the apparatus. Also advantageously having the outlets directed upwards, to some degree at least, helps remove non-nodular material, for example, sediment from the nodular material, therefore separating the non-nodular material from the nodular material. The nodular material being pushed along towards the inlets, or at least the direction of the inlets of the apparatus and the non-modular material being blown away from the apparatus.

[0037] In some embodiments at least one outlet of the water jet is directed upwards in configuration. Advantageously this helps move the nodular material generally which can be help move the nodular material up the incline surface and generally towards the inlets of the apparatus. Also advantageously having the outlets directed upwards, to some degree at least, helps remove non-nodular material, for example, sediment from the nodular material, therefore separating the non-nodular material from the nodular material. The nodular material being pushed along towards the inlets, or at least the direction of the inlets of the apparatus and the non-modular material being blown away from the apparatus.

[0038] In some embodiments at least one outlet of the water jet is directed, in configuration, in the opposite direction of travel of the apparatus in use. This also enables the water expelled from the outlet of the water jet to move the nodules on the tines, or the like, towards the inlets.

[0039] In some embodiments the water jet or water jet system is separate from the tines or separator. In some embodiments the water jet comprises one or more conduits and one of more outlets positioned above the tines or separator. When the outlets of the water jet are positioned or orientated in use above the times or separator the water expelled from the water jet may assist in pushing the nodules on the tines or separator to the inlets for

collection of the nodules. In specific embodiments the water jets comprise one or more conduits that comprise U shape meaning generally similar in shape to the capital latin letter "U".

[0040] In specific embodiments the waterjets comprise one or more conduits that comprise one or more outlets configured to expel water towards one or more of: the tines; the separator; a notch and an inlet. Therefore assisting moving the nodules on a tine, partially at least in a notch or the separator to the inlets.

[0041] In specific embodiments at least one notch comprises at least one outlet of the water jet. In specific embodiments at least one notch comprise an outlet of the water jet, wherein the water jet is directed backwards. Backwards herein is used to mean generally the opposition direction to the direction of travel. In addition directed backwards means the outlet is configured to expel the water from the outlet backwards, away from the direction of travel of the apparatus in use. In specific embodiments at least one notch comprise an outlet of the water jet, wherein the waterjet is directed upwards. Upwards here means generally up, away from the floor of the body of water but does not necessarily require to be vertical from the floor of the body of water. In addition directed upwards means the outlet is configured to expel the water from the outlet upwards, away from the direction of travel of the apparatus in use.

[0042] In some embodiments the outlet of the water jet is configured to expel water in an upward direction. In some embodiments the outlet of the water jet is configured to expel water in a backward direction, away from the direction of travel of the apparatus in use. In some embodiments the out let of the water jet is configured to expel water towards one or more of: an inlet; a tine; a protrusion of a plurality of protrusions; a separator; an inclined surface as herein described; a nodule on the apparatus; and/ or a notch; or any combination thereof, the before mentioned.

[0043] In specific embodiments the at least one notch comprises an outlet of the water jet on a vertical side or edge of the notch. In specific embodiments the at least one notch is configured that in use comprises an outlet of the water jet on a vertical side or edge of the notch. In specific embodiments the at least one notch comprises an outlet of the water jet wherein the outlet faces away from the direction of travel. In specific embodiments the at least one notch comprises an outlet of the water jet wherein the outlet faces backwards, away from the direction of travel. In specific embodiments the at least one notch comprises an outlet of the water jet that faces towards an inlet of the apparatus. Advantageously having an outlet of the water jet within a notch, or on the vertical edge, or side, of the notch, or point/ facing backwards within a notch, lessens the risk that sediment or the like, will enter the outlets of the water jets causing blockage, especially when the apparatus is moving forward.

[0044] In some embodiments the force, or pressure, of the water jet is in the range of 200000 Pascals to

1000000 Pascals (2 to 10 bar). In specific embodiments the force, or pressure, of the water jets are in the range of 20000 Pascals to 1100000 Pascals (2 to 11 bar); or 50000 Pascals to 900000 Pascals (5 to 9 bar); or 600000 Pascals to 700000 pascals (6 to 7 bar). The force, or pressure, of the water jet referred to herein is the force or pressure, of the water moving within the water jet and initially leaving the water jet. Advantageously this force, or pressure, of the water jet may assist in moving the nodules and nodular material in a controlled manner along, the protrusions or nodules; or up the incline surface or at least towards in a general direction towards the inlets of the apparatus without blowing the nodular material away, or off of the apparatus. Advantageously, the force of the water jet is strong enough to separate the non-nodular material from the nodular material assisting in blowing the non-modular material off of the apparatus. Advantageously the water jet assist in preventing the nodules or nodular material from rolling, sliding or falling off the tines or apparatus.

[0045] In specific embodiments each, or alternative in position, of the plurality of protrusions or tines, comprise at least one outlet of the water jet. In specific embodiments each tine comprises at least two outlets of the water jet. In specific embodiments each notch on each protrusion or tine comprises and outlet of a water jet. In other embodiments it is envisaged that different combinations of notches to tines, and outlets to notches may exist.

[0046] In specific embodiments at least one protrusion, or tine, comprises at least one conduit in fluid communication with a water jet supply, and at least one outlet. In specific embodiments at least on notch comprises an outlet in fluid communication with a water jet source via a conduit.

[0047] In some embodiments the moving means is a vehicle. In some embodiments the apparatus comprises a vehicle. In some embodiments the vehicle is a vehicle for working underwater. In some embodiments the vehicle is a remote control vehicle. In some embodiments the vehicle is as herein described. The apparatus as herein described is suitable for use with the vehicle as herein described, and the features of either are combinable.

[0048] In another aspect of the invention there is provided a method of separating nodular material from non-nodular material comprising the steps of: using an apparatus as described herein, for separating nodular material from a floor of a body of water, or non-nodular material, for example, sediment.

[0049] In another aspect of the present invention there is provided a method of separating nodular material from non-nodular material comprising the steps of:

engaging the floor of the body of water with a separator wherein the separator comprises a plurality of protrusions;
moving the separator, at an inclined angle from the floor of the body of water, through a portion of the

floor of a body of water such that the plurality of protrusions protrude in a forward direction to the direction of travel; whereby the forward movement of the separator through the floor of the body of water pushes the nodular material up the inclined upper surface of the separator towards an inlet, wherein the inlet is in communication with a container.

[0050] In another aspect of the present invention there is provided a method of separating nodular material from non-nodular material comprising the steps of:

engaging the floor of the body of water with a separator wherein the separator comprises a plurality of protrusions;
moving the separator, through a portion of the floor of a body of water such that the plurality of protrusions protrude in a forward direction to the direction of travel; whereby the forward movement of the separator through the floor of the body of water pushes the nodular material along an upper surface of the separator towards an inlet, wherein the inlet is in communication with a container.

[0051] In some embodiments the method further comprises the step of: forcing at least a portion of non-nodular material to fall off the sides of the plurality of protrusions, or through the gaps between the plurality of protrusions, or at least away from the apparatus.

[0052] In some embodiments the method further comprising the step of:
moving the nodular material along the plurality of protrusions, or the separator, or tines, by use of a water jet. Aply the nodular material may be moved along the incline surface of the apparatus; and/ or along the plurality of protrusions or tines; and/ or towards an inlet of the apparatus.

[0053] In some embodiments the method further comprising the step of:

moving the nodular material by use of a water jet wherein the pressure, or force, from the water jet is in the range of 200000 Pascal to 1000000 Pascals (2 to 10 bar). Aply other ranges of the pressure or force of the water jets may be used for example: 20000 Pascals to 1100000 Pascals (2 to 11 bar); or 50000 Pascals to 900000 Pascals (5 to 9 bar); or 600000 Pascals to 700000 pascals (6 to 7 bar).

[0054] In some embodiments the method further comprises the step of directing the water jet outlets backwards toward the opposite direction from travel. In some embodiments the method further comprises the step of directing the water from the outlets backwards toward the opposite direction from travel. In some embodiments the method further comprises the step of directing the water jet outlets backwards away from direction from travel. In some embodiments the method further comprises the step of directing the water from outlets backwards away from direction from travel. Directing the water from the

water jets, or outlets from the water jets backwards helps assist to move the nodular material towards the inlets of the apparatus.

[0055] In some embodiments the method further comprises directing the water jet outlets upwards in a direction away from the floor of the body of water. Water from the water jets being directed upwards may assist in moving the nodular material up the inclined surface but also may assist in blowing away non-nodular material away from the apparatus, or at least off the separator.

[0056] In specific embodiments the method further comprises directing the water jet outlets backwards toward the opposite direction from travel and upwards in a direction away from the floor.

[0057] The person skilled in the art will understand that upwards need not be limited to only vertical and that backwards need not be limited to only horizontal, but that generally up and generally backwards is what is meant her to offer the advantages.

[0058] According to an aspect of the disclosure, there is provided an apparatus for separating nodular material from non-nodular

material, the apparatus comprising:-

at least one container for receiving liquid containing nodular material and non-nodular material;

at least one respective inlet for enabling liquid containing nodular material and non-nodular material to enter at least one said container;

at least one respective first outlet for enabling liquid to exit at least one said container; and

at least one respective second outlet for enabling liquid to exit at least one said container, wherein at least one said second outlet is arranged at a greater height than at least one said first outlet provided on the corresponding said container, and entry of liquid via at least one said inlet into the container causes reduction in velocity of the liquid.

[0059] By providing at least one respective second outlet for enabling liquid to exit at least one said container, wherein at least one said second outlet is arranged at a greater height than at least one said first outlet provided on the corresponding said container, and entry of liquid via at least one said inlet into the container causes reduction in velocity of the liquid, this provides the advantage of enabling the reduction in liquid velocity to be such that the concentration of nodular material in liquid exiting at a first outlet increases and the concentration of non-nodular material in liquid exiting at a second outlet increases. In the case of removal of nodular material from the seabed, this provides the further advantage that the amount of undesired non-nodular material removed to a surface vessel is reduced, thereby reducing the environmental impact of returning non-nodular material which has been removed to a surface vessel to the seabed, for example by making it viable to transport such non-nodular material to shore.

[0060] The apparatus may further comprise barrier means for obstructing a shortest path from at least one said inlet to at least one said second outlet.

[0061] This provides the advantage of making it more difficult for nodular material than non-nodular material to reach a second outlet, thereby minimising loss of nodular material, and increasing the concentration of nodular material in the vicinity of at least one first outlet.

[0062] The barrier means may comprise at least one plate.

[0063] The barrier means may cause liquid to travel from at least one said inlet to at least one said second outlet by passing under said barrier means.

[0064] This provides the advantage of enabling nodular material to be urged towards at least one said first outlet while making it difficult for nodular material to reach the second outlet, thereby minimising loss of nodular material, and increasing the concentration of nodular material in the vicinity of at least one first outlet.

[0065] The apparatus may further comprise flow redirecting means for redirecting flow of liquid towards at least one said first outlet.

[0066] This provides the advantage of increasing the concentration of nodular material in the vicinity of one or more first outlets while minimising turbulence of flow, thereby providing better control of the process for separating nodular material from non-nodular material.

[0067] The flow redirecting means may comprise a curved surface.

[0068] At least one said container may comprise a respective body tapering towards at least one said first outlet.

[0069] This provides the advantage of increasing concentration of nodular material in the vicinity of one or more first outlets, thereby increasing the efficiency of the process for separating nodular material from non-nodular material.

[0070] At least one said container may comprise a lower surface inclined towards at least one said first outlet.

[0071] This provides the advantage of increasing concentration of nodular material in the vicinity of one or more first outlets, thereby increasing the efficiency of the process for separating nodular material from non-nodular material. This is especially the case when the apparatus is vibrating in use.

[0072] At least one said inlet may be directed towards a substantially central portion of a said container in a direction transverse to a direction extending from at least one said inlet to at least one said first outlet.

[0073] This provides the advantage of concentrating flow of liquid containing nodules towards one or more first outlets, while minimising turbulence, thereby increasing the efficiency of the process for separating nodular material from non-nodular material.

[0074] At least one said inlet may define a nozzle.

[0075] This provides the advantage of assisting in reducing the velocity of liquid containing nodular material and non-nodular material, thereby assisting the separa-

tion process.

[0076] The apparatus may further comprise pump means for directing liquid to at least one said inlet and/or directing liquid out of at least one said first outlet and/or directing liquid out of at least one said second outlet.

[0077] According to another aspect of the disclosure, there is provided an apparatus for removing nodular material from a floor of a

body of water, the apparatus comprising:-
moving means for moving the apparatus relative to a floor of a body of water;
material removing means for removing nodular material from the floor of the body of water;
connector means adapted to be connected to a conduit to enable said removed nodular material to be transported to a vessel on the surface of the body of water; and
an apparatus for separating nodular material from non-nodular material as defined above.

[0078] According to a further aspect of the disclosure, there is provided an apparatus for removing material from a floor of a body of water, the apparatus comprising:

first moving means for moving the apparatus substantially vertically relative to a floor of a body of water;
second moving means for moving the apparatus substantially horizontally relative to the floor of the body of water;
material removing means for removing material from the floor of the body of water; and
connector means adapted to be connected to a conduit to enable said removed material to be transported to a vessel on the surface of the body of water.

[0079] By providing first moving means for moving the apparatus substantially vertically relative to a floor of a body of water and second moving means for moving the apparatus substantially horizontally relative to the floor of the body of water, this provides a number of significant advantages. Firstly, no manipulator or remotely operated vehicle (ROV) assistance is required to enable the apparatus to be connected to the conduit. The advantage is also provided that the first moving means enables the apparatus to operate more effectively on very soft ground. The advantage is also provided that deployment of the apparatus to the sea bed can take place without the use of a taut umbilical, as a result of which less reinforcement of the umbilical is necessary, thereby enabling more electrical power to be supplied to the apparatus via the umbilical, while also enabling the apparatus to be deployed a greater distance from the surface vessel. The advantage is furthermore provided of enabling the appa-

ratus to be more quickly exchanged for another apparatus for maintenance purposes, while also enabling the apparatus to be manoeuvred more easily and without using the umbilical, thereby enabling more thorough material removal to be carried out.

[0080] The first moving means may comprise at least one thruster.

[0081] The second moving means may comprise at least one thruster.

[0082] The second moving means may comprise a plurality of tracks.

[0083] This provides the advantage of enable steering of the apparatus on very soft ground.

[0084] The apparatus may further comprise buoyancy means for reducing the weight of the apparatus in water.

[0085] This provides the advantage of assisting operation of the first moving means. In addition, the advantage is provided that less mechanical strengthening of the umbilical cable is necessary, as a result of which larger electrical power can be delivered to the apparatus as a result of reduced heating of the umbilical cable insulation. Also, as a result of the different catenary curve of the umbilical cable having less mechanical reinforcement, it is easier to separate the umbilical cable from the conduit, as a result of which the likelihood of collision between the umbilical cable and the conduit during operation of the apparatus is minimised.

[0086] The apparatus may further comprise containment means for containing said removed material prior to transport thereof to a vessel.

[0087] According to a further aspect of the disclosure, there is provided an apparatus for removing nodular material from a floor of a body of water, the apparatus comprising:

moving means for moving the apparatus relative to a floor of a body of water;

material removing means for removing nodular material from the floor of the body of water; and

connector means adapted to be connected to a conduit to enable said removed nodular material to be transported to a vessel on the surface of the body of water;

wherein the material removing means comprises at least one inlet and floor engaging means for engaging the floor of the body of water, wherein the floor engaging means comprises a plurality of protrusions adapted to be arranged forwards of at least one said inlet in a direction of travel of the apparatus and to extend substantially in a direction of travel of the apparatus.

[0088] By providing floor engaging means comprising a plurality of protrusions adapted to be arranged forwards of at least one said inlet in a direction of travel of the

apparatus and to extend substantially in a direction of travel of the apparatus, this provides the advantage of enabling nodular material on the surface of the sea bed to be collected, while minimising the disturbance of the sea bed, thereby minimising the environmental impact of removing the nodular material. The further advantage is provided that the lower extent of disturbance of the seabed causes less drag, thereby resulting in less energy consumption.

[0089] The protrusions may comprise a plurality of tines.

[0090] The apparatus may comprise at least one first aperture arranged rearwards of at least one said inlet in a direction of travel of the apparatus for allowing nodular material to pass therethrough.

[0091] This provides the advantage of preventing the inlet becoming blocked by nodular material in the event of failure of the apparatus to remove the nodular material to the conduit.

[0092] The apparatus may further comprise separator means arranged adjacent at least one said inlet for separating nodular material from non-nodular material of the floor of the body of water.

[0093] By providing separator means for separating nodular material from non-nodular material of the floor of the body of water, this provides the advantage of minimising the amount of unwanted non-nodular material, such as sediment, of the floor of the body of water which is transported to the surface, thereby minimising energy consumption, and avoiding the environmental impact of returning to the sea bed non-nodular material which has previously been removed to the surface.

[0094] The separator means may include at least one surface inclined in use relative to the floor of the body of water and having at least one second aperture therethrough for enabling non-nodular material to pass therethrough and preventing said nodular material from passing therethrough.

[0095] The apparatus may further comprise suction means for removing nodular material from at least one said inlet.

[0096] The suction means may be adapted to reverse the direction of flow of water therethrough.

[0097] This provides the advantage of assisting clearing of blockages.

[0098] Generally in some embodiments in use, the engaging means or tines will sieve through the floor of the body of water and nodules as well as sediment will be retained on the tines, or plurality of protrusions of the apparatus. In embodiments with one or more notches the notches help prevent the nodules sliding or rolling forward. In embodiments with a water jet, with one or more outlets, in some embodiments the outlets will be configured to be directed generally towards the inlets of the apparatus for the nodules. In some embodiments with water jet outlets the outlets are configured to force water along the upper surface of the tines, or plurality of protrusions. In some embodiments with water jet outlets the

outlets are configured to force water along the upper surface of the inclined surface. Thus in these embodiments with a water jet, the water expelled from the outlet of the water jet can move the nodules to the one or more inlets of the apparatus.

[0099] By the term "diameter" are used herein this is used to mean the longest across length or dimension of an object.

[0100] By the term "directed" as used herein with references to the outlet or outlets of the water jets is used to mean configured, that the outlet is configured, to expel the water or liquid in a particular direction. And in a method, when referring to the water or liquid, the term includes able to expel the water in a particular direction.

[0101] By the term "floor of the body of water" as used herein that this term may be interchangeable with seabed, and includes fresh water bodies of water too.

[0102] By the term "horizontal" as used herein the person skilled in the art will understand that this does not need to be exactly horizontal but horizontal enough to have the desired function.

[0103] By the term "notch" as used herein this term is used to mean an indentation on an edge or surface, for example on the tine. The term also includes a groove or channel.

[0104] By the term "V shaped" as used herein this term is used to mean a general similarity in shape to the latin alphabet letter "V". Likewise "U" shape refers to the capital latin letter "U".

[0105] By the term "vertical" as used herein the person skilled in the art will understand that this does not need to be exactly vertical but vertical enough to have the desired function.

[0106] By the terms "water jet" or "water jet system" or the like, as used herein these terms are used to mean an apparatus suitable for expelling water in a desired direction. Aptly the water jet will include a pump mechanism, or other means to move the water and at least one outlet where the water or liquid will be expelled. The term "water" here also includes liquids.

[0107] Any one or more features of any aspect, embodiment or example may be combined with any other one or more features of any other aspect, embodiment or example, described herein.

[0108] Embodiments will now be described, by way of example only and not in any limitative sense, with reference to the accompanying drawings, in which: -

Figure 1 is a rear and side perspective view of a nodule mining apparatus of a first embodiment;

Figure 2 is a front and side perspective view of the nodule mining apparatus of Figure 1;

Figure 3 is a detailed view of part of the nodule mining apparatus of Figure 2;

Figure 4 is a front view of the apparatus of Figure 1

with a collector unit having ducts in an unfolded condition;

Figure 5 is a side view of the apparatus of Figure 4;

Figure 6 is a front view of the apparatus of Figure 1 with the collector unit having ducts in a folded condition;

Figure 7 is a side view of the apparatus of Figure 6;

Figure 8 shows the apparatus of Figure 1 being lowered to the seabed;

Figure 9 shows the apparatus of Figure 1 connecting to a riser;

Figure 10 shows the apparatus of Figure 1 harvesting nodules;

Figure 11 is a front view of an apparatus of a second embodiment with a collector unit having ducts in an unfolded condition;

Figure 12 is a side view of the apparatus of Figure 11;

Figure 13 is a front view of the apparatus of Figure 11 with the collector unit having ducts in a folded condition;

Figure 14 is a side view of the apparatus of Figure 13;

Figure 15 is a front perspective view of a separator apparatus of the apparatus of Figure 11;

Figure 16 is a rear perspective view of a separator apparatus of Figure 15; and

Figure 17 is a cross sectional view of the tank of the separator apparatus of Figure 15.

Figure 18 is a cross sectional view of one particular embodiment showing one of the plurality of protrusions, or tines, showing notches.

Figure 19 is another embodiment showing a cross-sectional view of one of the plurality of protrusions, or tines, showing the water jet conduits and water jet out-lets.

Figure 20 is of another embodiment showing a top view of three of the plurality of protrusions or tines.

Figure 21 is to another embodiment showing a cross sectional view of one of the plurality of protrusions and an external conduit, of the water jet.

[0109] Referring to Figures 1 to 10, an apparatus em-

bodying the present disclosure for removing nodular material 2 (Figure 3) from the seabed 4 (Figure 8) comprises a nodule mining vehicle 6 having buoyancy members 8 for reducing the weight of the vehicle 6 in water, first moving means in the form of first thrusters 10 for moving the vehicle 6 vertically relative to the seabed 4, and second moving means in the form of second thrusters 12 for moving the vehicle 6 horizontally relative to the seabed 4 when not directly in contact with the seabed 4. The vehicle 6 is also provided with tracks 14 for moving the vehicle 6 relative to the seabed 4 when the vehicle 6 is in contact with the seabed 6, and for steering the vehicle 6.

[0110] Material removing means in the form of a collector unit 16 is provided forward of the tracks 14, and has a plurality of inlets 18 for receiving nodular material 2 removed from the seabed 4. The collector unit 16 has separator means for separating nodular material 2 from non-nodular material such as sediment in the form of a ramp 20 having a surface 22 inclined relative to the seabed 4, and second apertures 24 for allowing sediment to pass through the second apertures 24 while preventing the nodules 2 from passing through the second apertures 24. Floor engaging means comprising protrusions in the form of tines 26 engages the seabed 4 and engages nodules 2 located on the seabed 4 to assist their entry into the collector unit 16. The tines 26 are arranged forwards of the inlets 18 and extend forwardly of the vehicle 6 in the direction of travel of the vehicle 6. This enables the tines 26 to engage nodules 2 such that the nodules 2 slide up ramps 20 into inlets 18, while minimising disturbance of the seabed 4, thereby minimising the environmental impact of the nodule collection process.

[0111] The collector unit 16 is provided with suction means in the form of eductors 28 connected via respective ducts 30 to the inlets 18 for removing nodules 2 from the inclined surface 22 of the ramp 20. The ducts 30 lead to containment means in the form of a tank 32 having an inclined bottom surface 34 to enable the nodules 2 to collect at the rear of the tank 32 where they are contained prior to being pumped to the surface by means of a dredge pump 36 and further pumps (not shown) on a riser 38 via which the nodules 2 are transported to the surface. The eductors 28 can reverse the flow of water through the conduits 30 to assist in clearing blockages.

[0112] The collector unit 16 is also provided on its rear surface with first apertures 40, to enable nodules 2 to pass therethrough in the event of blockage of one or more of the ducts 30. This prevents the respective ducts 30 from becoming blocked, by preventing the nodules 2 from blocking the inlets 18 as the vehicle 6 moves forwards.

[0113] The outlet of the dredge pump 36 is connected to connecting means in the form of a latching mechanism 42 to enable the vehicle 6 to be connected to the riser 38 to enable the nodular material 2 to be pumped from the tank 32 to a vessel located on the surface. The latching mechanism 42 extends generally vertically and is pivotably mounted to the vehicle 6. This enables the vehicle

6 to easily rotate through 180 degrees at the end of a track to enable more effective harvesting of nodules 2 to take place.

[0114] The operation of the vehicle 6 will now be described with reference to Figures 8 to 10.

[0115] Initially, the vehicle 6 is lowered from a surface vessel (not shown) by means of an umbilical cable 44 connected to a suspension point 46 to the seabed 4. As shown in Figure 8. The vehicle 6 then lifts from the seabed 4 by means of the first thrusters 10 and second thrusters 12 to enable the latching mechanism 42 of the vehicle 6 to connect to the riser 38. The vehicle 6 then returns to the seabed 4 and moves along the seabed 4 by means of the second thrusters 12 and/or tracks 14 to harvest nodules 2, as shown in Figure 10.

[0116] Referring to Figures 11 to 17, in which parts common to the embodiment of Figures 1 to 10 are denoted by like reference numerals but increased by 100, a vehicle 106 of a second embodiment is shown. The vehicle 106 has a collector unit 116 including separately foldable collector ducts 130 which can be moved between a folded condition (Figures 13 and 14), to enable the vehicle 106 to be more compact as it is being deployed to the sea bed, and an unfolded condition (Figures 11 and 12), in which the lateral width of the collector unit 116 is at its maximum. The collector ducts 130 are connected to conduits 150 (Figures 12, 14) which in turn are connected to inlets 152 to a separator apparatus, including the tank 132, for separating nodules from non-nodular material such as silt or sediment. The inlets 152 are directed towards a laterally central region of the tank 132.

[0117] The separator apparatus is shown in more detail in Figure 17. The tank 132 has a body 154 which is tapered from the inlets 152 towards a first outlet 156 arranged at a lower part of the tank 132. The inlets 152 into the tank 132 define nozzles 158, which cause the velocity of water 160 containing nodules and non-nodular material to be reduced as it enters the tank 132. As a result, nodules tend to settle towards the bottom 134 of the tank 132, while non-nodular material remains in suspension in the water.

[0118] Directing water containing nodules towards a laterally central part of the tank 132, in cooperation with the tapered tank body 154, minimises turbulence in the flow of water containing nodules, which in turn minimises the extent to which settling of nodules in the vicinity of the first outlet 156 is disturbed. The tank 132 is also provided with flow redirecting means in the form of a curved upper plate 162, for redirecting flow of water containing nodules towards the first outlet 156, while minimising turbulence in the water flow. The tank 132 has an inclined lower surface 134, also extending towards the first outlet 156, which causes nodules to tend to move along the lower surface 134 towards the first outlet 156, especially when the separator apparatus is vibrating when in use.

[0119] Second outlets 164 are provided at a greater height than the first outlet 156, and a direct path from the inlets 152 to the second outlets 164 is blocked by means

of barrier means in the form of baffle plates 166 arranged at an upper part of the tank 132. As a result, as water containing nodules and non-nodular material is pumped into the tank 132, the nodules have a greater tendency to collect around the first outlet 156, whereas non-nodular material such as silt or sediment can reach the second outlets 164 by passing under the baffle plates 166, so that non-nodular material in suspension can reach the second outlets 164, but it is very difficult for nodules to reach the second outlets 164. In this way, by suitable control of the pumping rate of water out of the first outlet 156 and second outlets 164, the concentration of nodules in water pumped from the first outlet 156 is maximised, and the concentration of nodules in water pumped from the second outlets 164 is minimised. This has the result of minimising the quantity of unwanted non-nodular material pumped to the surface via the riser 38, thereby reducing the environmental impact of returning such material to the seabed, especially if the quantity of such non-nodular material is sufficiently small to enable it to be transported to the shore.

[0120] The Figure 18 embodiment shows a cross sectional view, across the longitudinal length of one of the plurality of protrusions or tines (26) according to one embodiment of the present invention. As can be seen this tine (26) in this embodiment comprises 5 notches (25). These notches have a vertical side or edge in this embodiment. Also in this embodiment the notches are V shaped in the cross sectional view, when across the longitudinal axis of the tine (26). In this embodiment one side of the V shape is relatively vertical relative to the floor of the body of water in use. Also in this embodiment the notches are all completely across the width of the tine (26), forming a channel or groove. The notches (25) may assist nodules to travel along the tines (26) in the direction away from the direction of travel but hinder the travel of nodules in the same direction as that of the direction of travel D of the apparatus. The direction of travel of the apparatus in use is shown by the arrow D.

[0121] The Figure 19 shows a cross sectional view, across the longitudinal axis of one of the plurality of protrusions, or tines (26) of another embodiment of the present invention. In this embodiment the tine (26) has 5 notches (25). Other embodiments may have a different number of notches (25). In this embodiment each notch (25) has an outlet (27) from the conduit (29) of the water jet. There is also shown the inlet (31) for water to travel from the pump and/ or water source of the water jet system (31). The direction of travel of the apparatus in use is indicated by the arrow D. The notches (25) are configured in this embodiment to hold one or more nodules (2) aiding prevention of the nodule (25) rolling or sliding towards the front, or towards the direction of travel D. The substantially vertical surface of the notches (25) does not protrude above the surface of the tine and therefore does not hinder movement of the nodule away from the direction of travel of the apparatus. In this embodiment each notch (25) has an outlet (27) of the water jet (31) but in

other embodiments not all notches (25) may have an outlet of the water jet (31). Again in this embodiment the notches (25) have a vertical side /edge and are generally v shaped in a cross sections view across the longitudinal axis of the tine (26). In this embodiment the notches (25) extend across the entire width of the tine (26). In this embodiment shown the notches (25) are configured such that one side of the V shaped notch is vertical relative to the floor (4) of the body of water. The other side of the V shaped notch is the inclined surface of the tine (26). Therefore the notches (25) do not hinder travel of the nodules (2) towards the inlets, away from the direction of travel D of the apparatus, but do hinder the nodules from rolling, sliding or generally traveling in the direction of travel D of the apparatus. As can be seen in this embodiment the outlets (27) of the water jet (31) are directed or pointed generally backwards away from the direction of travel D, are configured to point in this direction. Also as can be seen in this embodiment the outlets (27) of the water jet (31) are configured, directed or pointed generally upwards, relative to the floor (4) of the body of water. As can be seen in the figure 19 embodiment that the tine (26) is partially below the seabed or floor (4) of the body of water. Part of the notch (25) also forms the incline surface 20. In use the tines (26) are moved forward in the direction D with the tines 26 engaging with the floor of the body of water (4). Nodules in the portion of the floor of the body of water (4) that the tines (26) engage with will be lifted onto the tines (26). Non-nodular material for example sediment, which tends to be much smaller in size, for example its largest diameter, relative to nodules (2) may largely pass through the spacing between the tines (26) as the apparatus (1) moves forward. The water pump (31) when switched on may help move the nodule (2) up and back along the tines (26). The spacing between the tines (26) is configured that the nodular material is mostly larger in largest diameter than the spacing between tines (26). In this particular embodiment the spacing between the tines (26) is 2 centimetres. Other embodiments may have different spacing between the tines (26) and indeed the spacing may vary along the length of the tines (26). In use when the water jets (31) are switched on water enters the tines (26) at the inlet (31) and travels along the conduit 29, shown in dashed or broken lines in this figure 19 embodiment, before exiting the conduit (29) at the various outlets (27). The tines (26) during use may be orientated at an incline to the floor (4) of the body of water.

[0122] Figure 20 shows a top view of three protrusions of the plurality of protrusions, or three tines. In practice aptly most embodiments would comprise more protrusions (26) but this embodiment is for illustrative purposes. As can be seen in this embodiment there are outlets (27) from the water jet (31) positioned in the notches (25). The lines (25) across the tines (26) are the substantially vertical side /edge of the notches (25), similar to those seen in Figure 19 from a different view. Also shown in this figure are optional features of a separate inclined

surface (22) comprising apertures (24). Other embodiments of the invention need not be limited to having this separate inclined surface (22) and apertures (24). There is also shown in this Figure 20 embodiment is the direction of travel of the apparatus in use indicated by the arrow D. Not shown, but the inlets of the apparatus may be located above the inclined surface 22, and/ or above the apertures 24, or tines (26) relative to the floor of the body of water in use, and may comprise a suction system with conduit to transport the nodules to a container for storage or transport. Other embodiments may have a different collection system or means to collect, transport and store the nodules. Not shown in this figure 20 is that the outlets (27) of the water jet system (31) are fluidly connected to the pump of the water jet (31) via conduits (29) similarly to the conduits (29) shown in figure 19. The conduits (29) are within the tines (26) in this Figure 20 embodiment. In use the nodules are pushed along by the water jets in the opposite direction from the direction of travel D of the apparatus.

[0123] Figure 21 shows another embodiment of the present invention where the water jet system (31) with conduit (29) and outlet (27) is separate from the plurality of protrusions or tines (26). Not shown in this figure is how the conduit (29) of the water jet is in fluid communication with the water jet pump and water source. However a person skilled in the art can foresee that the water is able to travel along the conduit (29) and be expelled from the outlet (27). Also seen in this embodiment is notches (25) although other embodiments with a separate conduit (29) orientation/ water jet system (31) may not necessarily have notches (25), or comprise a different number of notches (25). In this figure 21 embodiment the outlet (27) is directed backwards, meaning is configured such that the water will be expelled backwards from the direction of travel, facing the opposition direction to the direction of travel. In this figure 21 embodiment the outlets also facing towards an inlet (not shown in this figure) of the apparatus. Thus again the water jet is orientated to assist in moving nodules on the plurality of protrusions or tines towards the inlet or inlets of the apparatus. In practice as the tine (26) engages with the floor (4) of the body of water, nodules (2) gather on the lower portion of the tine (26) and may be moved upwards and backwards by the force and pressure of the water jet system (31) from the water from the outlet (27) of the water jet (31).

[0124] It will be appreciated by persons skilled in the art that the above embodiment has been described by way of example only and not in any limitative sense, and that various alterations and modifications are possible without departure from the scope of the disclosure as defined by the appended claims.

[0125] Further Non-limited, Examples:

1. An apparatus for separating nodular material from non-nodular material, the apparatus comprising:-

at least one container for receiving liquid containing nodular material and non-nodular material;
at least one respective inlet for enabling liquid containing nodular material and non-nodular material to enter at least one said container;
at least one respective first outlet for enabling liquid to exit at least one said container; and
at least one respective second outlet for enabling liquid to exit at least one said container, wherein at least one said second outlet is arranged at a greater height than at least one said first outlet provided on the corresponding said container, and entry of liquid via at least one said inlet into the container causes reduction in velocity of the liquid.

2. An apparatus according to example 1, further comprising barrier means for obstructing a shortest path from at least one said inlet to at least one said second outlet.

3. An apparatus according to example 2, wherein the barrier means comprises at least one plate.

4. An apparatus according to example 2 or 3, wherein the barrier means causes liquid to travel from at least one said inlet to at least one said second outlet by passing under said barrier means.

5. An apparatus according to any one of the preceding examples, further comprising flow redirecting means for redirecting flow of liquid towards at least one said first outlet.

6. An apparatus according to example 5, wherein the flow redirecting means comprises a curved surface.

7. An apparatus according to any one of the preceding examples, wherein at least one said container comprises a respective body tapering towards at least one said first outlet.

8. An apparatus according to any one of the preceding examples, wherein at least one said container comprises a lower surface inclined towards at least one said first outlet.

9. An apparatus according to any one of the preceding examples, wherein at least one said inlet is directed towards a substantially central portion of a said container in a

direction transverse to a direction extending from at least one said inlet to at least one said first outlet.

10. An apparatus according to any one of the preceding examples, 5
wherein at least one said inlet defines a nozzle.

11. An apparatus according to any one of the preceding examples, 10
further comprising pump means for directing liquid to at least one said inlet and/or directing liquid out of at least one said first outlet and/or directing liquid out of at least one said second outlet.

12. An apparatus for removing nodular material from a floor of a 15
body of water, the apparatus comprising:-

moving means for moving the apparatus relative to a floor of a body of water; material removing means for removing nodular material from the floor of the body of water; 20
connector means adapted to be connected to a conduit to enable said removed nodular material to be transported to a vessel on the surface of the body of water; and 25
an apparatus for separating nodular material from non-nodular material according to any one of the preceding examples. 30

13. An apparatus for removing material from a floor of a body of 35
water, the apparatus comprising:

first moving means for moving the apparatus substantially vertically relative to a floor of a body of water; 35
second moving means for moving the apparatus substantially horizontally relative to the floor of the body of water; 40
material removing means for removing material from the floor of the body of water; and
connector means adapted to be connected to a conduit to enable said removed material to be transported to a vessel on the surface of the body of water. 45

14. An apparatus according to example 13, wherein the first moving means comprises at least one thruster. 50

15. An apparatus according to example 13 or 14, wherein the second moving means comprises at least one thruster. 55

16. An apparatus according to any one of examples 13 to 15, wherein the second moving means comprises a plu-

rality of tracks.

17. An apparatus according to any one of examples 13 to 16, further comprising buoyancy means for reducing the weight of the apparatus in water.

18. An apparatus according to any one of examples 13 to 17, further comprising containment means for containing said removed material prior to transport thereof to a vessel.

19. An apparatus for removing nodular material from a floor of a body of water, the apparatus comprising:

moving means for moving the apparatus relative to a floor of a body of water; material removing means for removing nodular material from the floor of the body of water; and connector means adapted to be connected to a conduit to enable said removed nodular material to be transported to a vessel on the surface of the body of water; wherein the material removing means comprises at least one inlet and floor engaging means for engaging the floor of the body of water, wherein the floor engaging means comprises a plurality of protrusions adapted to be arranged forwards of at least one said inlet in a direction of travel of the apparatus and to extend substantially in a direction of travel of the apparatus.

20. An apparatus according to example 19, wherein the protrusions comprise a plurality of tines.

21. An apparatus according to example 19 or 20, further comprising at least one first aperture arranged rearwards of at least one said inlet in a direction of travel of the apparatus for allowing nodular material to pass therethrough.

22. An apparatus according to any one of examples 19 to 21, further comprising separator means arranged adjacent at least one said inlet for separating nodular material from non-nodular material of the floor of the body of water.

23. An apparatus according to example 22, wherein the separator means includes at least one surface inclined in use relative to the floor of the body of water and having at least one second aperture therethrough for enabling non-nodular material to pass therethrough and preventing said nodular material from passing therethrough.

24. An apparatus according to any one of examples

19 to 23, further comprising suction means for removing nodular material from at least one said inlet.

25. An apparatus according to example 24, wherein the suction means is adapted to reverse the direction of flow of water therethrough.

Claims

1. An apparatus for removing nodular material from a floor of a body of water, the apparatus comprising:

- moving means for moving the apparatus relative to a floor of a body of water;
- material removing means for removing nodular material from the floor of the body of water; wherein the material removing means comprises at least one inlet and, floor engaging means for engaging the floor of the body of water, wherein the floor engaging means comprises a plurality of protrusions.

2. An apparatus as claimed in claim 1, wherein the plurality of protrusions are:

- a) adapted to be arranged forwards of at least one said inlet in a direction of travel of the apparatus and to extend substantially in a direction of travel of the apparatus; and/ or,
- b) tines.

3. An apparatus as claimed in either claim 1 or 2 wherein the material removing means comprises:

- a) at least one surface inclined in use relative to the floor of the body of water; and/ or,
- b) at least one aperture; and/ or,
- c) a separator.

4. An apparatus as claimed in any preceding claim wherein the at least one surface inclined in use relative to the floor of the body of water:

- a) Inclines relative to the floor of the body of water in direction opposite the direction of travel; and / or,
- b) inclines in direction towards at least one inlet; and / or,
- c) inclines in direction away from the direction of travel in use.

5. An apparatus as claimed in any preceding claims wherein the plurality of protrusions are adapted to be arranged forwards of at least one said inlet in a direction of travel of the apparatus and to extend substantially in a direction of travel of the apparatus.

6. An apparatus as claimed in any preceding claims wherein at least one of the plurality of protrusions comprise at least one notch on the upper surface of the said at least one of the plurality of protrusions.

7. An apparatus as claimed in any preceding claims wherein the at least one surface inclined in use relative to the floor of the body of water, comprises at least one notch on the upper surface of the at least one surface inclined relative to the floor of the body of water.

8. An apparatus as claimed in either claim 6 or 7 wherein at least one of the notches extends across the entire width of at least one of the plurality of protrusions

9. An apparatus as claimed in any one of claims 6, 7 or 8 wherein the at least one notch comprises:

- a) a vertical side when orientated in use; and / or,
- b) a V shape when viewed in a cross-sectional view across the longitudinal axis.

10. An apparatus as claimed in any preceding claims wherein the apparatus further comprises a water jet.

11. An apparatus as claimed in claim 10, wherein the water jet comprises at least one outlet and wherein at least one outlet of the water jet is configured to be directed:

- a) towards an inlet of the apparatus; and/ or,
- b) upwards relative to the floor of the body of water; and/ or,
- c) backwards away from the direction of travel.

12. An apparatus as claimed in any one of claims 6 to 11 wherein at least one notch comprises at least one outlet of a water jet.

13. An apparatus as claimed in any one of claims 1 to 12 where at least one protrusion of the plurality of protrusions, or tines, comprises a conduit wherein the conduit is in fluid communication with a source of water of a water jet, and in communication with an outlet of a water jet.

14. An apparatus as claimed in any preceding claim wherein the moving means is a vehicle.

15. A method of separating nodular material from non-nodular material comprising the steps of:

- engaging the floor of the body of water with a separator wherein the separator comprises a plurality of protrusions;
- moving the separator, at an inclined angle rela-

tive from the floor of the body of water, through
a portion of the floor of a body of water such that
the plurality of protrusions protrude in a forward
direction to the direction of travel; whereby the
forward movement of the separator through the
floor of the body of water pushes the nodular
material up the inclined upper surface of the sep-
arator towards an inlet, wherein the inlet is in
communication with a container, further com-
prising the step of moving the nodular material
along the plurality of protrusions towards an inlet
by using a water jet.

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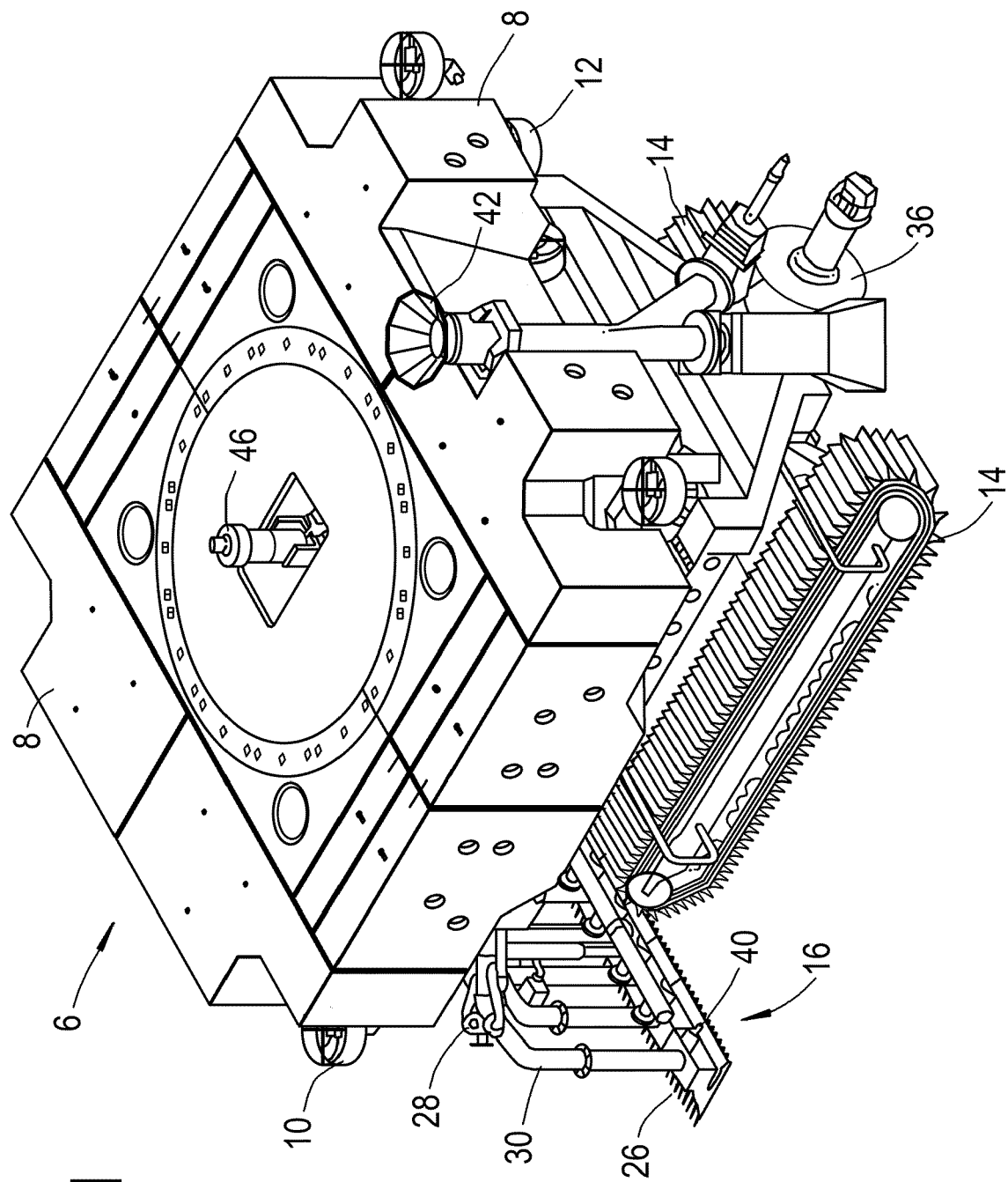
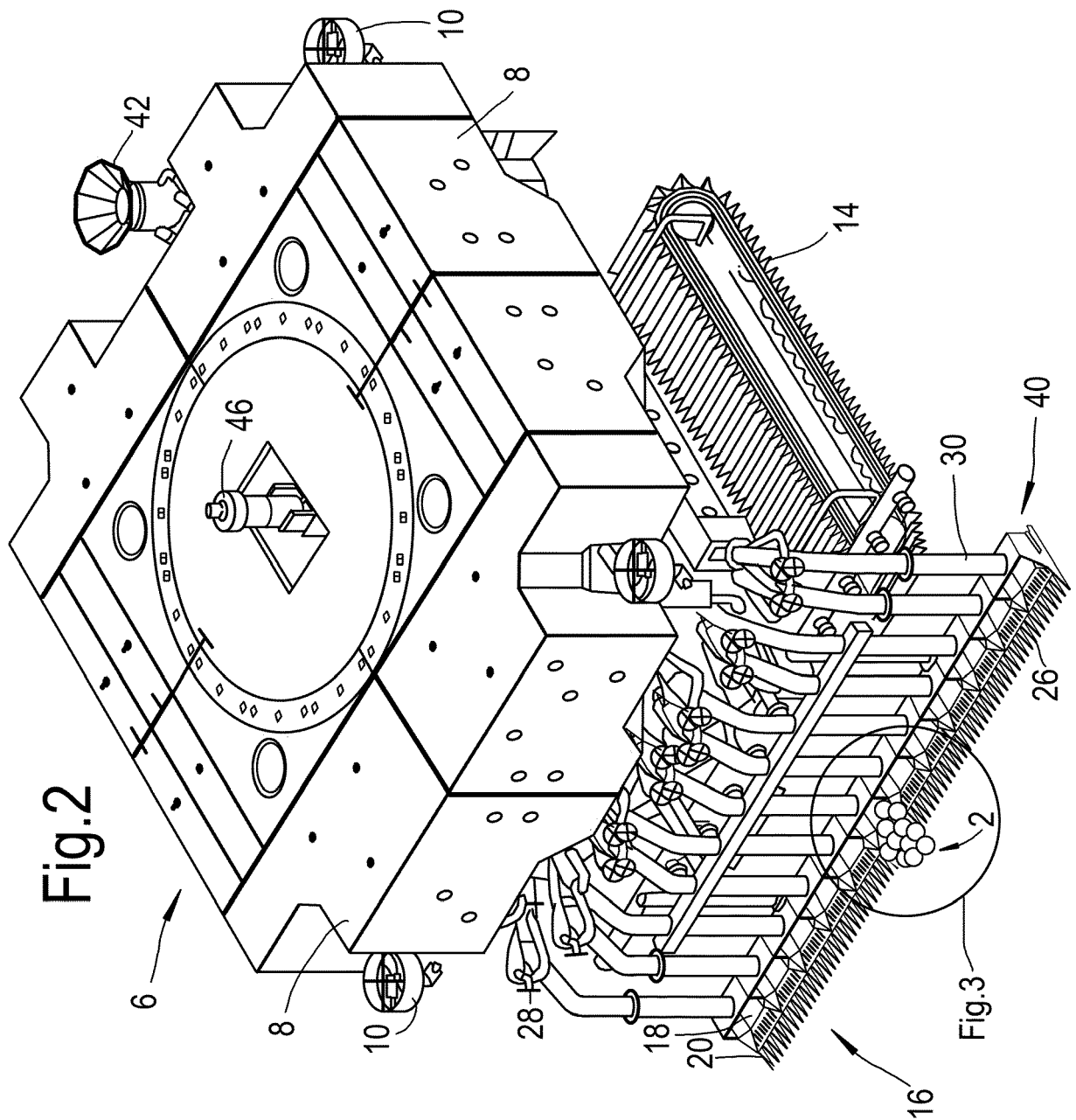


Fig.1



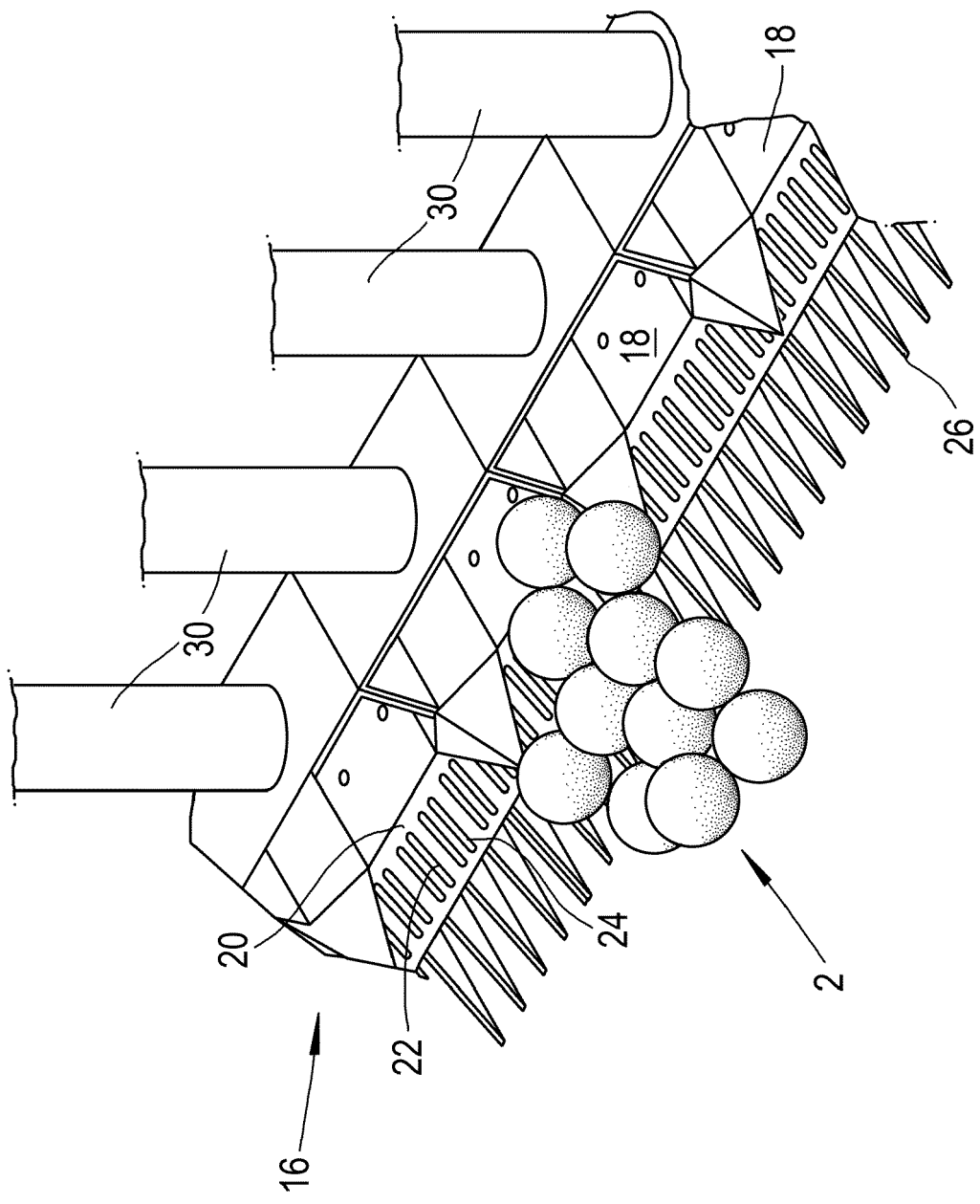


Fig.3

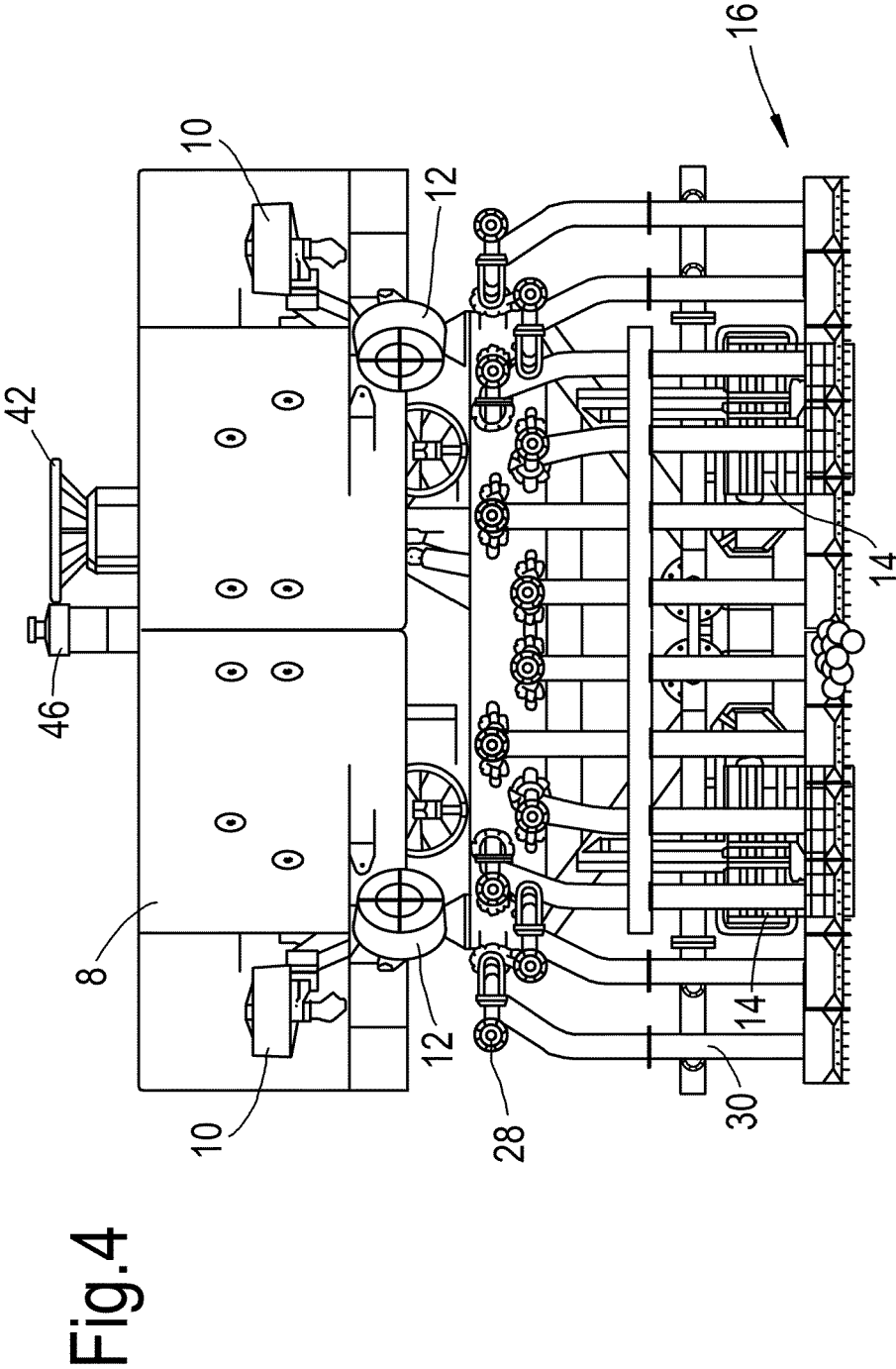


Fig.5

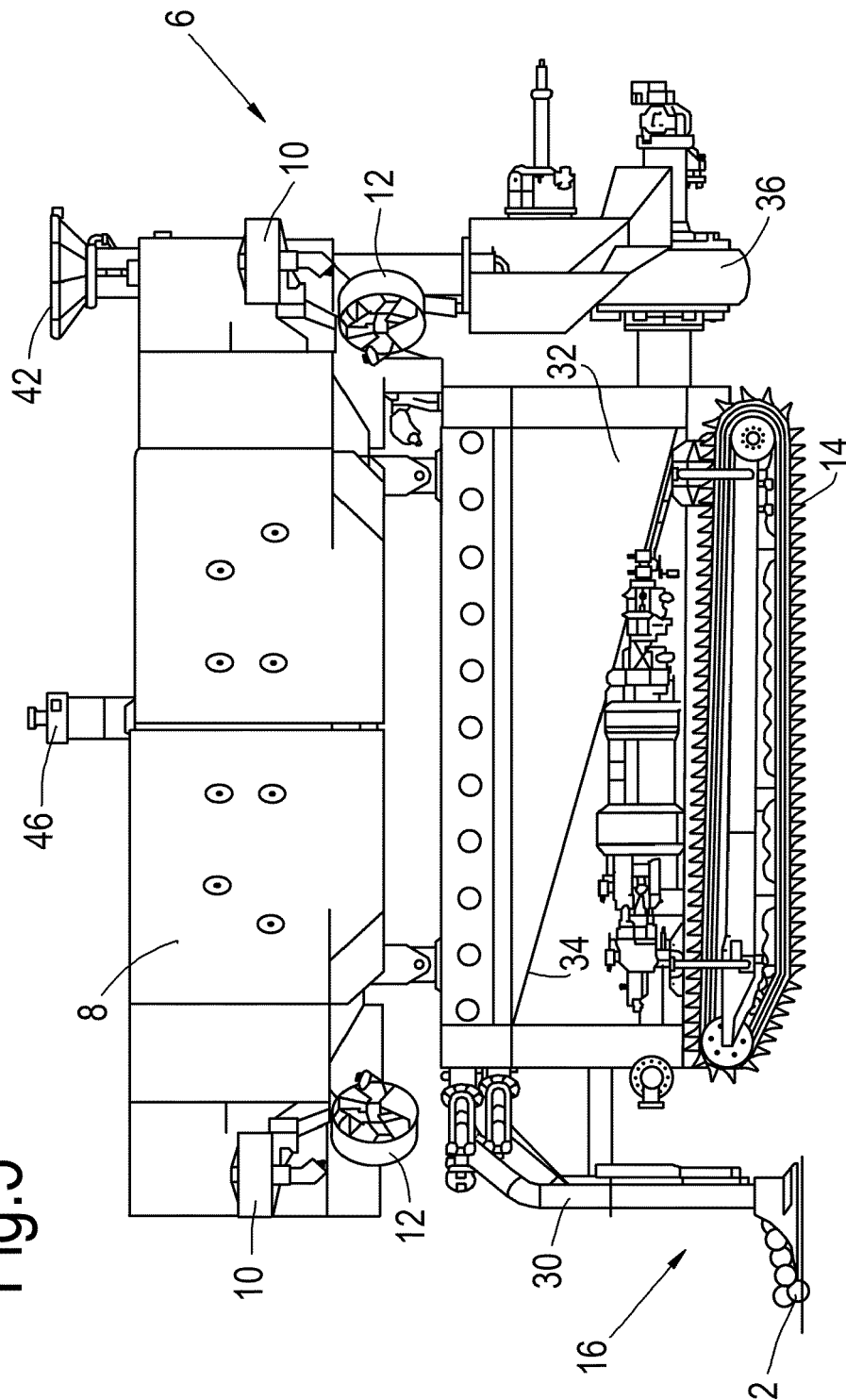


Fig.6

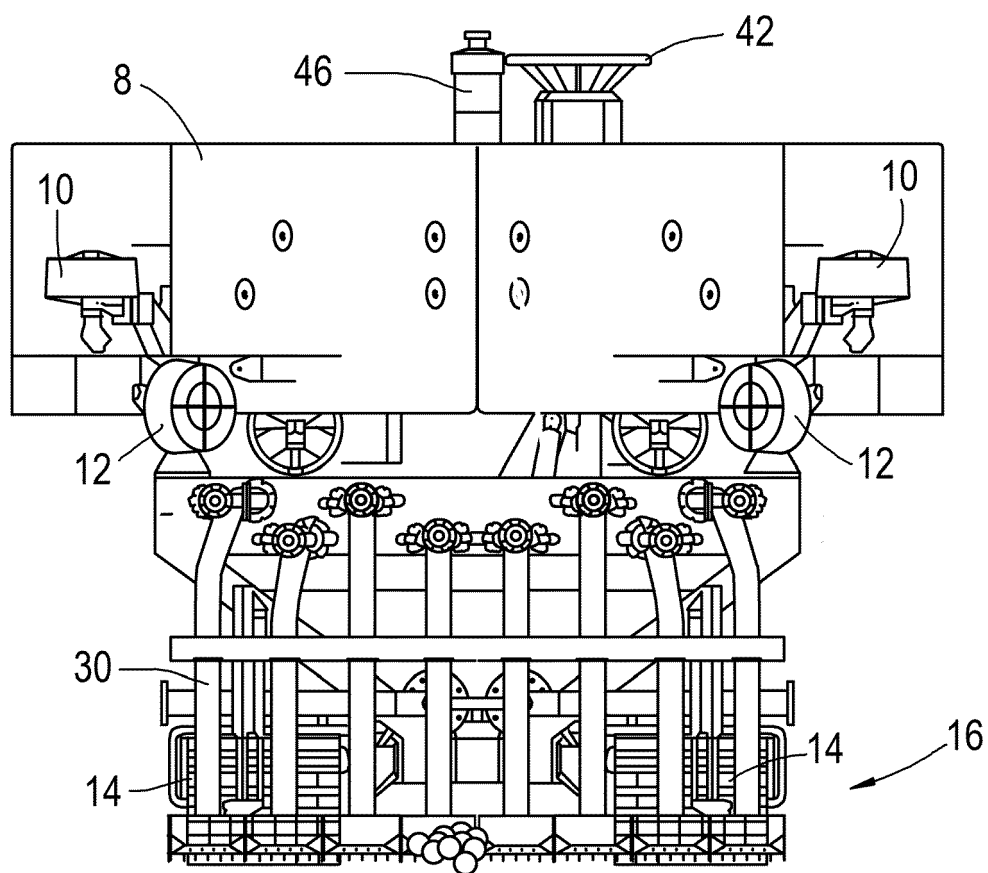
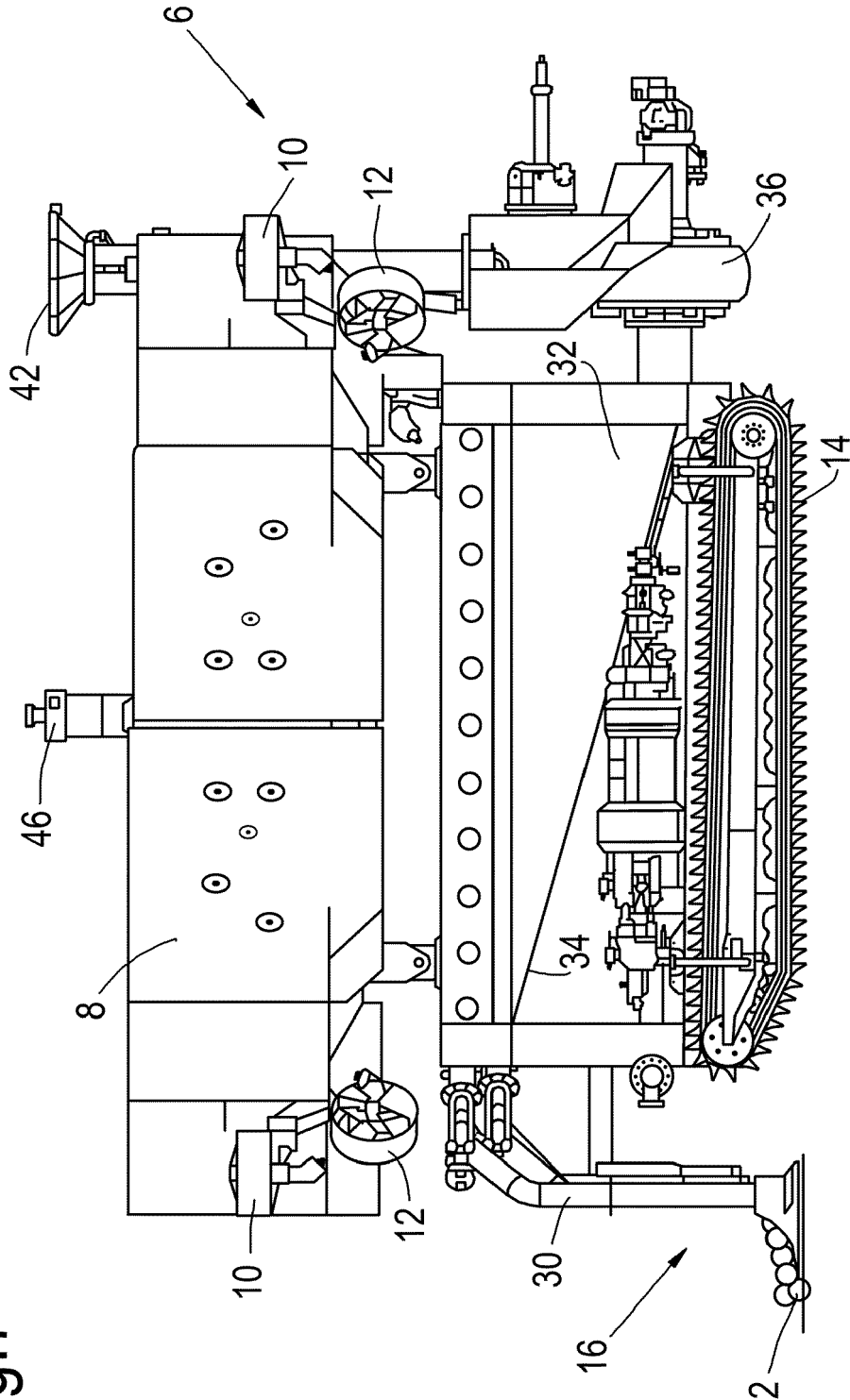


Fig.7



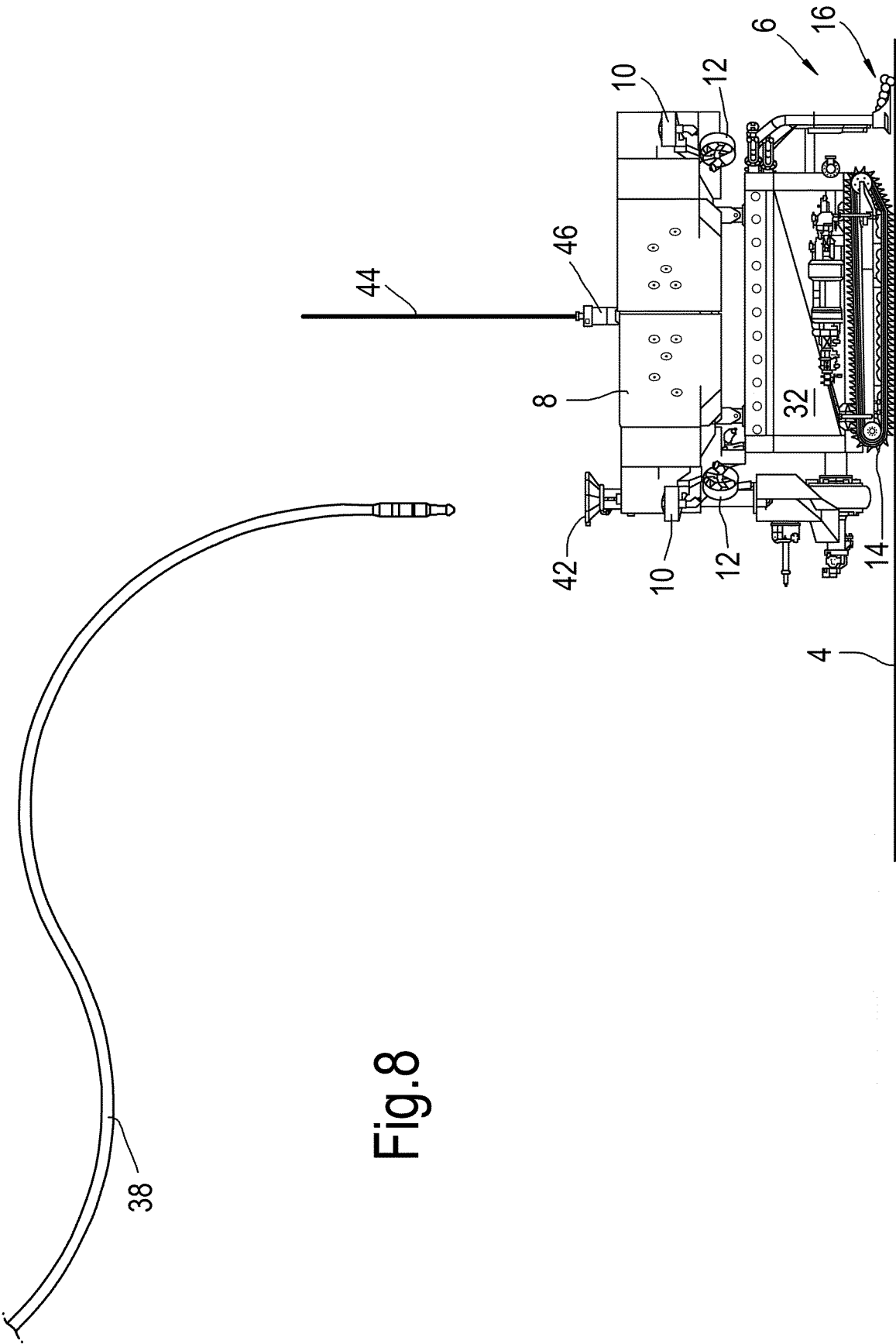
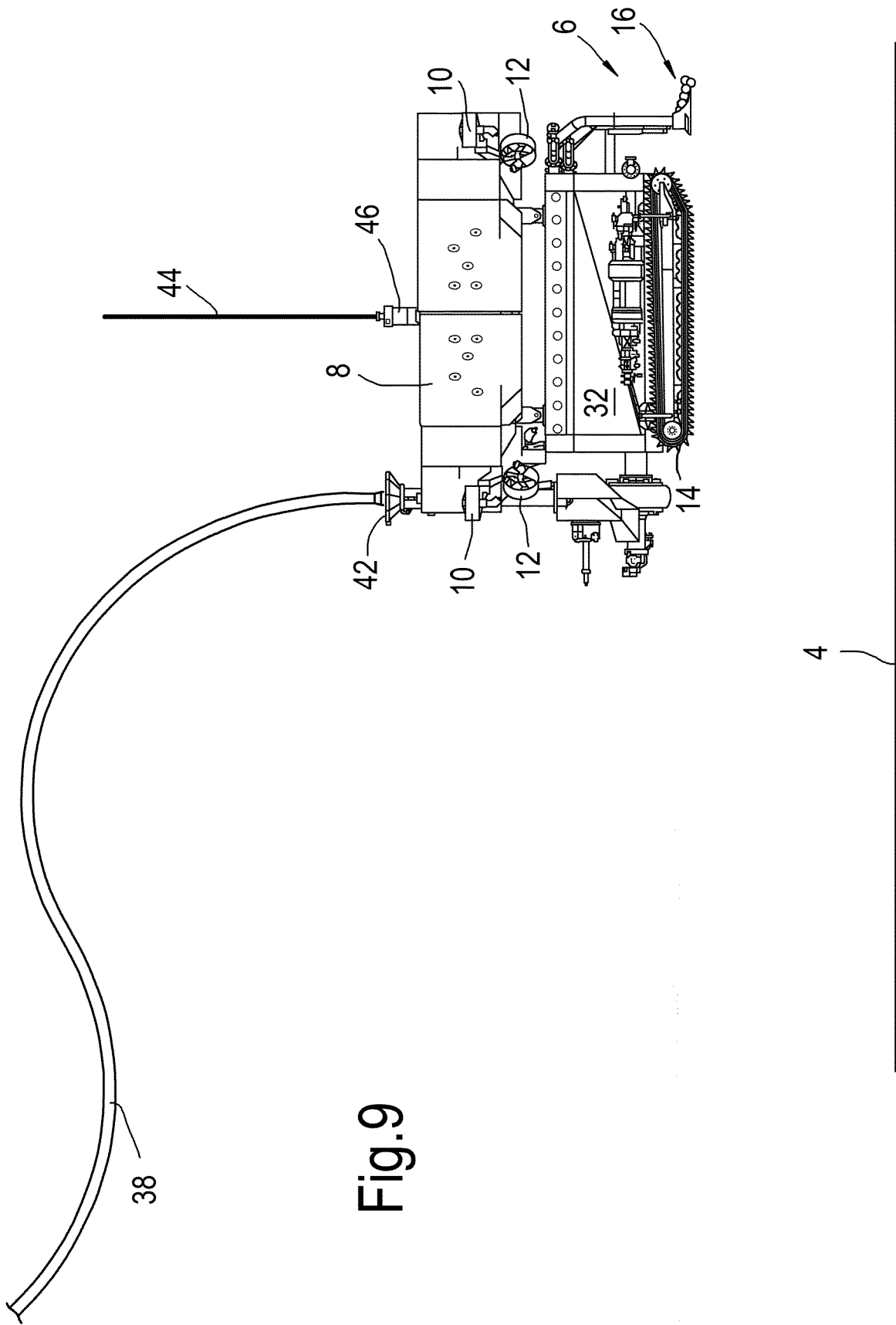


Fig. 8



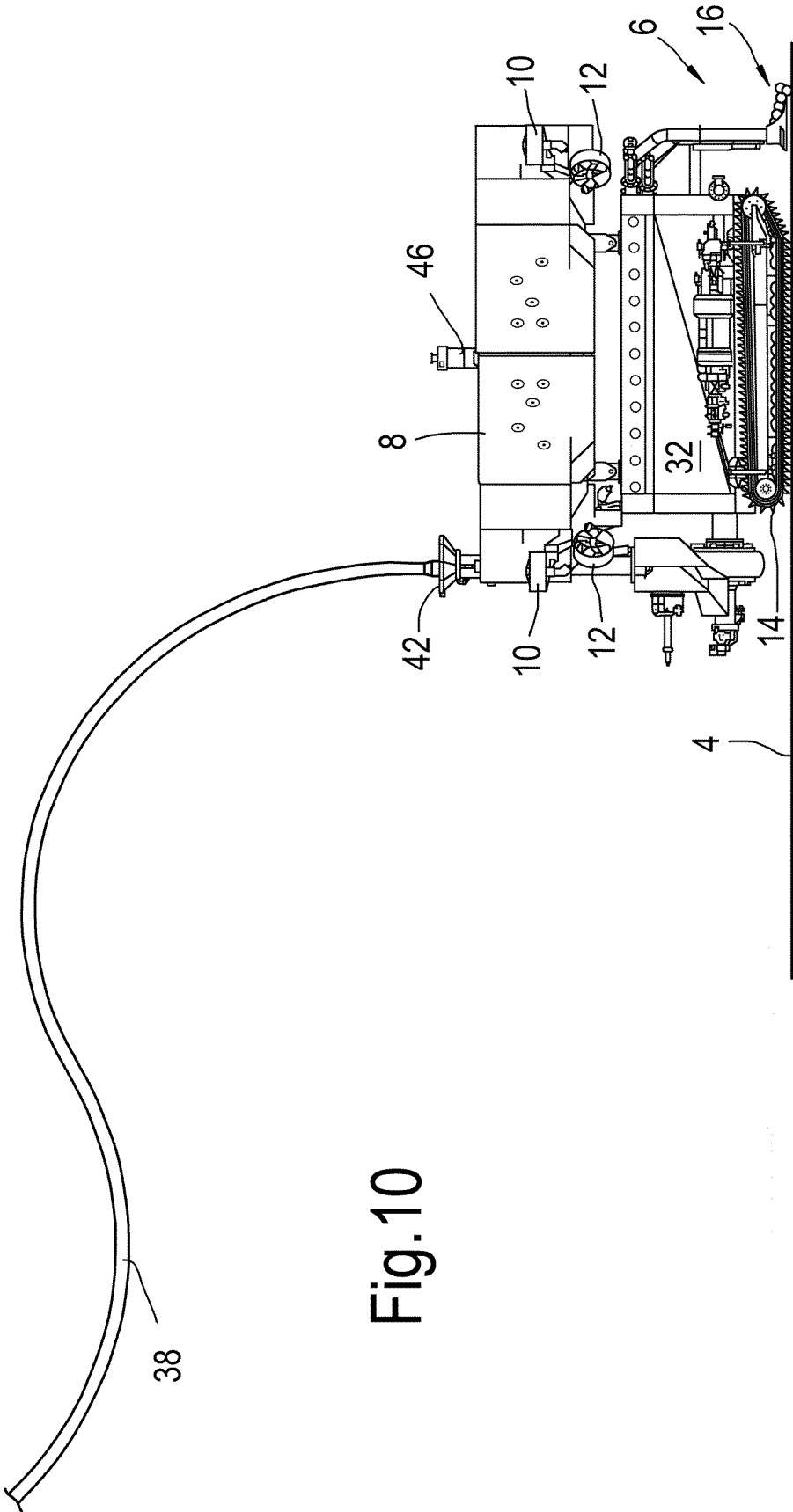
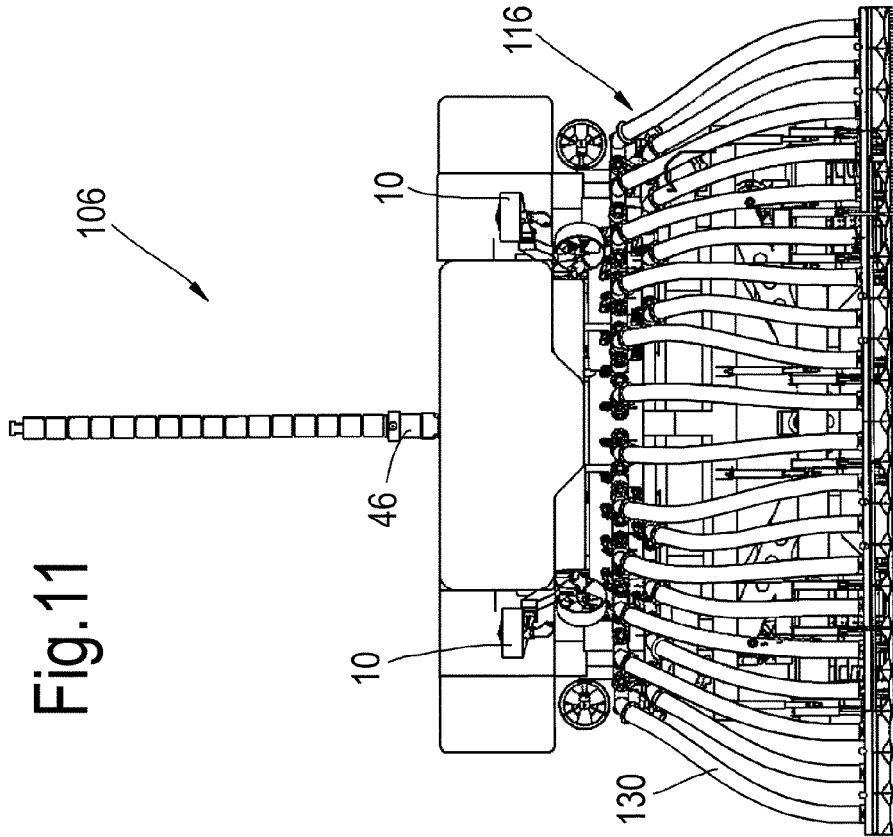
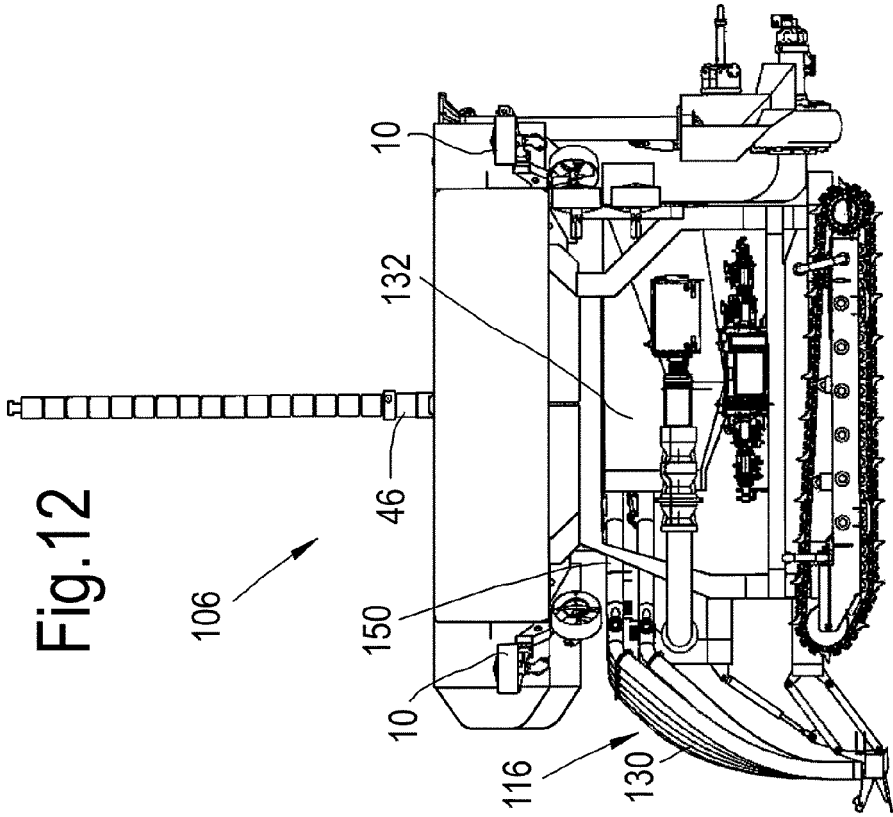


Fig.10



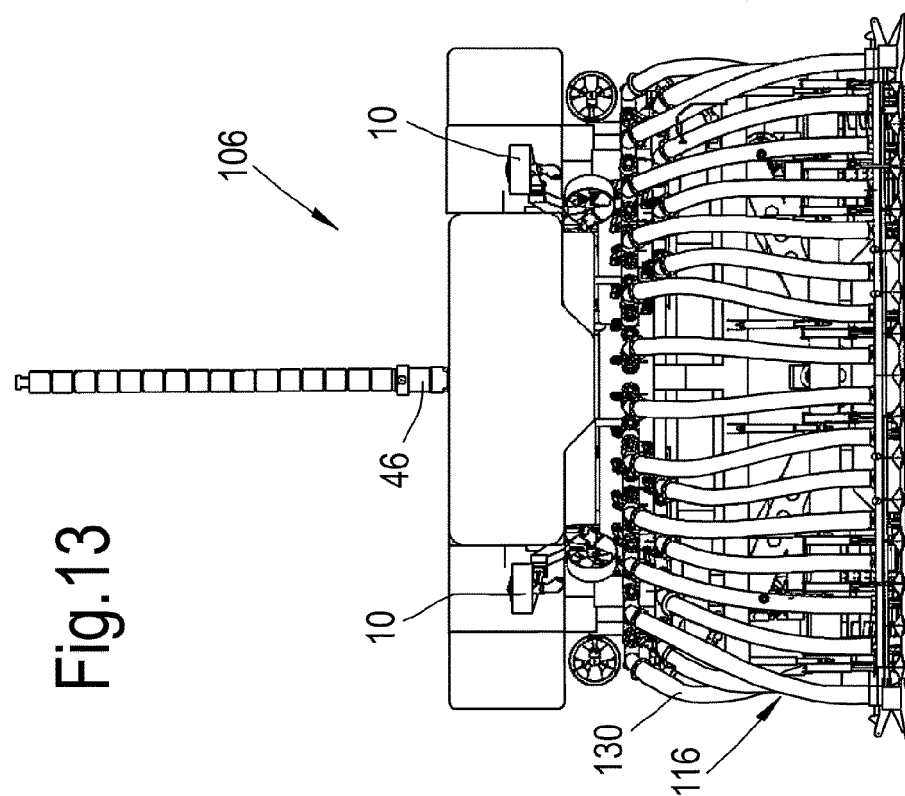
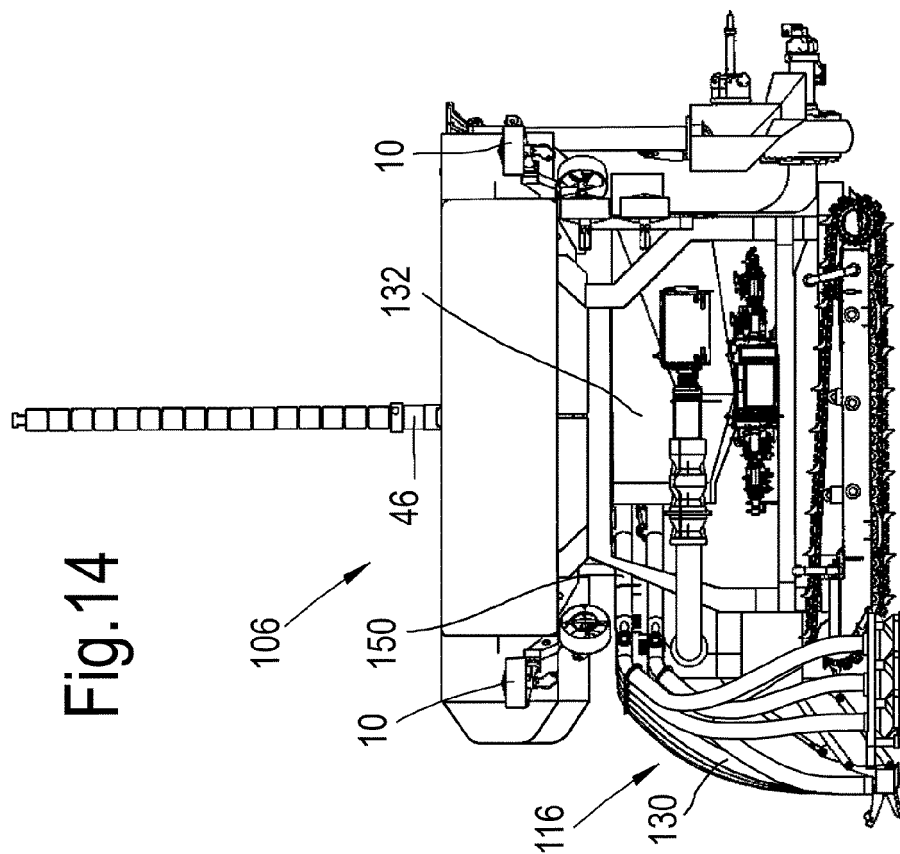


Fig.15

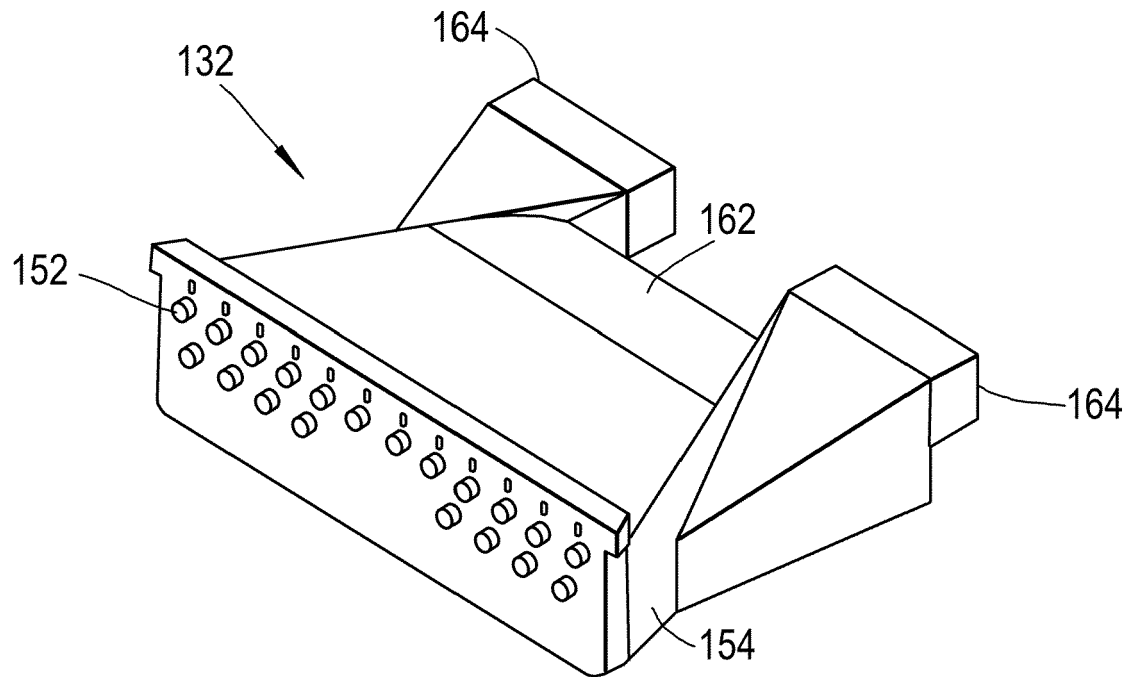


Fig.16

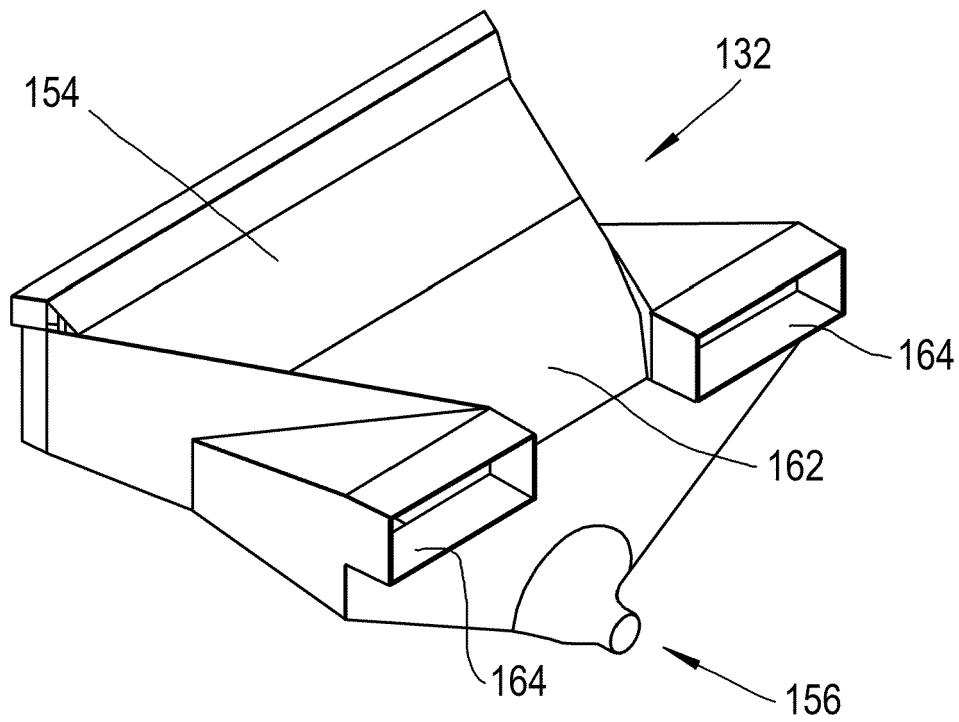
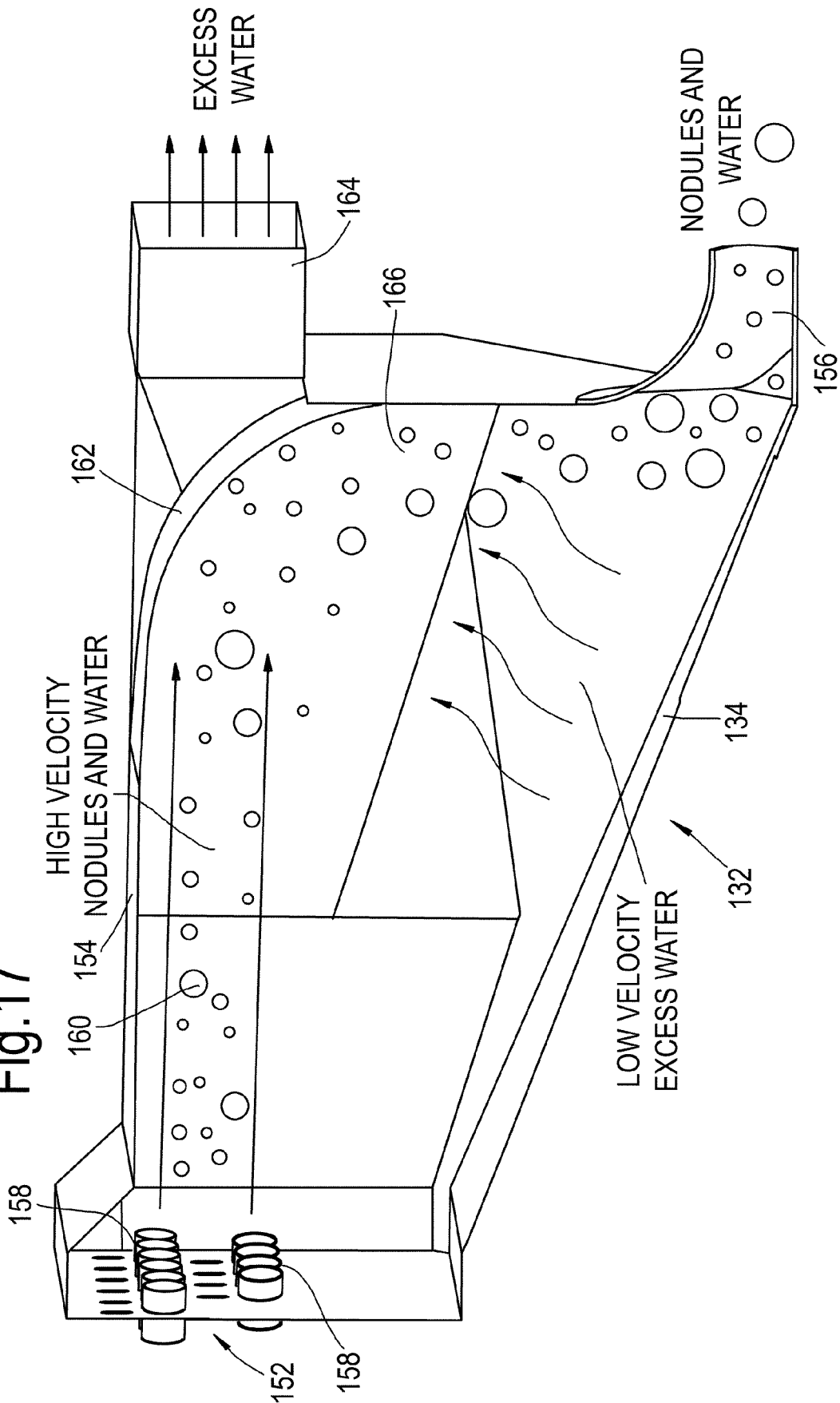


Fig.17



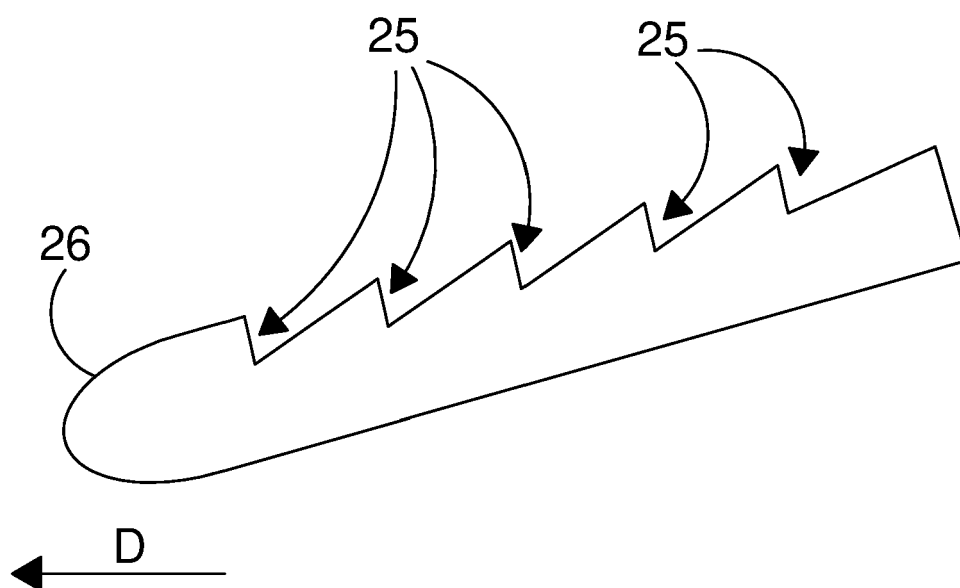


FIG. 18

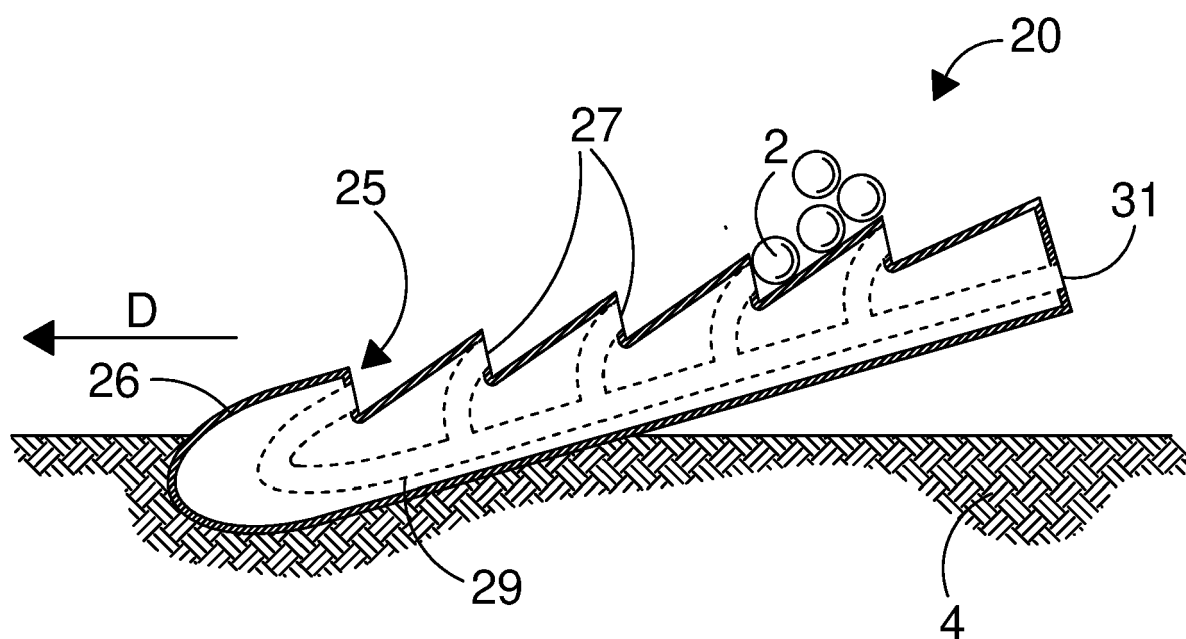


FIG. 19

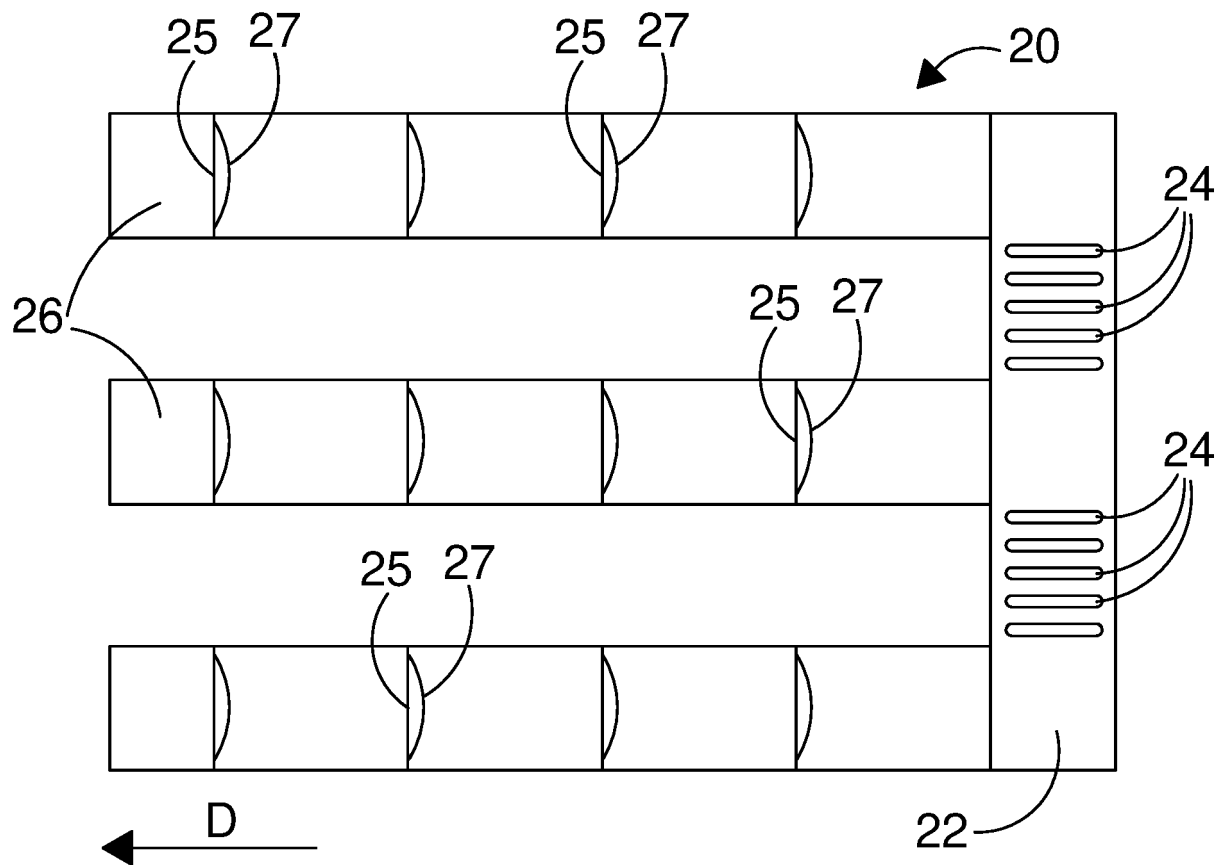


FIG. 20

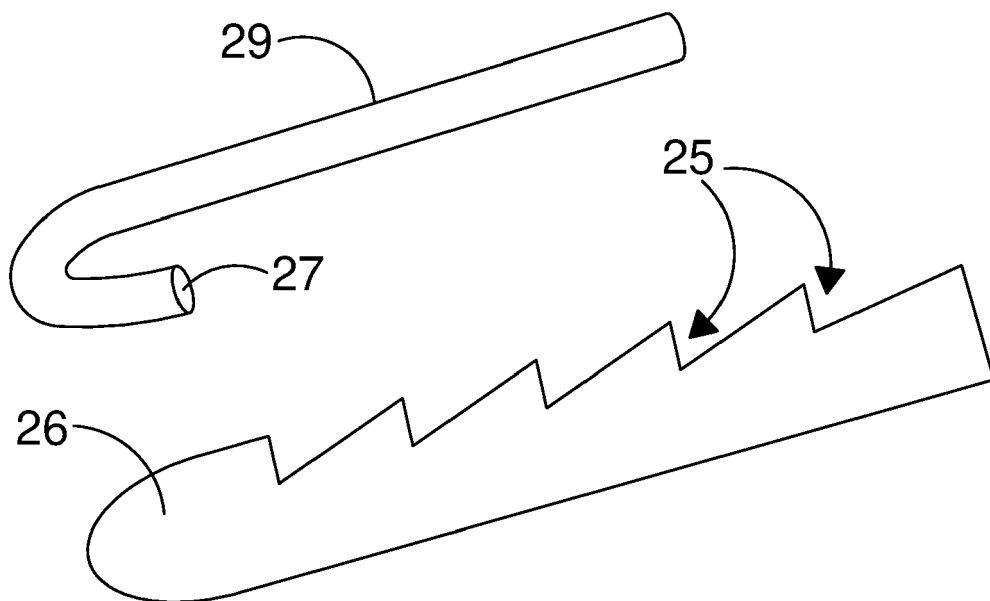


FIG. 21



EUROPEAN SEARCH REPORT

Application Number

EP 22 21 6355

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Place of search	Date of completion of the search	Examiner
Munich	10 May 2023	Ferrien, Yann
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