(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) EP 4 282 747 A1

(12) EUROPEAN PATENT APPLICATION

(43) Date of publication:
29.11.2023 Bulletin 2023/48

(21) Application number: **22382506.8**

(22) Date of filing: **26.05.2022**

(51) International Patent Classification (IPC):
B63C 7/02 *(2006.01)* ***B63C 7/04*** *(2006.01)*
B66C 23/52 *(2006.01)*

(52) Cooperative Patent Classification (CPC):
B63C 7/04; B66C 21/00

(84) Designated Contracting States:
AL AT BE BG CH CY CZ DE DK EE ES FI FR GB GR HR HU IE IS IT LI LT LU LV MC MK MT NL NO PL PT RO RS SE SI SK SM TR
Designated Extension States:
BA ME
Designated Validation States:
KH MA MD TN

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(54) **UNDERWATER CABLE ROBOT**

(57) The present invention refers to an underwater cable robot preferably adapted as cleaning platform, capable of selectively and efficiently removing small and large debris from the seabed and the water column below, with minimal impact on the marine ecosystem. The cleaning platform comprises a floating barge or boat having an opening providing access to a water column below the floating barge, and a submergible frame fitted with a tool adapted for collecting debris underwater. At least three motor driven winches are attached to the floating barge or boat, and a system of cables extending through the opening of the floating barge or boat, connect the winches with the frame. A control unit controls the operation of the winches in a coordinated manner, such that by winding and unwinding the cables, the frame can be moved within a three-dimensional workspace below the floating barge or boat for collecting debris from the seabed and from the water column.

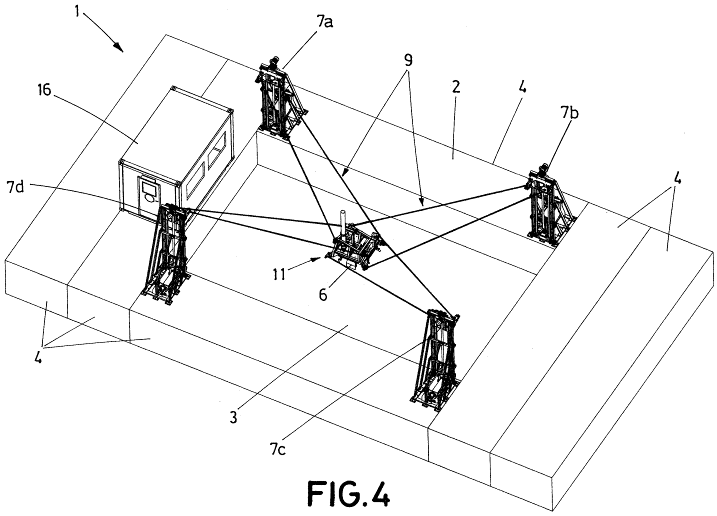

FIG.4

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Description

TECHNICAL FIELD

[0001] The present invention relates to an underwater cable robot adapted to carry out underwater works, such as: rescue, repair and preferably for seabed cleaning, being capable of selectively and efficiently removing small and large debris from the seabed and the water column, with minimal impact on the marine ecosystem.

STATE OF THE ART

[0002] Marine Litter (ML) poses a global challenge. It has been estimated that 86 million tonnes of plastics have accumulated in the world's oceans, while 4.6-12.7 million tonnes are added every year. Floating litter counts for only 1% of this amount. The rest is most probably either laying on the seabed or having been degraded in micro and nano plastics having potentially been eaten by marine life. Apart from plastics, fishermen also lift litter as diverse as bikes, households, tyres, paint containers, nets, polystyrene and so much more. Approximately 80% of ML comes from land-based sources, however, in some regions, sea-based sources (maritime works, shipping, fisheries) are very important. ML impacts not only the marine organisms and environment in many ways, but it also carries a risk to human health. It affects negatively vital economic sectors such as tourism, fisheries, aquaculture or energy supply.

[0003] The estimated damage cost from ML across the 21 Pacific Rim economies is €949 million annually in total, €273 million for the fishing industry, €209 million for the shipping industry and €467 million for marine tourism. At European level, the total quantified cost of ML ranges from €259 million to €694.7 million.

[0004] It is apparent that marine litter (ML) removal should be set out in the coastal line where depth is shallower than in offshore areas, and where ML density and integrity are higher. Since coastal areas host high level of biodiversity in a fragile ecosystem, any automated ML removal technologies have to be selective in its process to minimize its impact on this ecosystem.

[0005] Balance between the positive effect of avoiding microplastics degradation into micro/nano plastics and the potential negative effect of the own removal process must be found. The type of ecosystem, the efficiency and selectivity of the removal technologies and the frequency of the removal are key variables to this decision making.

[0006] Some solutions are under development and evaluation for ML floating on the surface or near the surface of both ocean and rivers.

[0007] Lots of research and systems for monitoring the ML on the seabed, but very few solutions to remove the ML accumulated on the seabed.

[0008] Existing solutions for ML removal on the seabed are considered either highly harmful (fishing trawling nets or dredges) for the marine ecosystem or inefficient (divers, small ROV).

[0009] Therefore, there is the need for highly efficient seabed and water column cleaning technologies that: are harmless to the marine environment, are specially adapted for cleaning the ML in the coastal line, and that take into account: the type of ecosystem, the efficiency and selectivity of the removal technologies and the frequency of the removal.

DESCRIPTION OF THE INVENTION

[0010] The invention is defined in the attached independent claim, and satisfactorily solves the above-described drawbacks of the prior art, by the provision of a cable-based underwater robot installed and operated from any suitable floating platform, such as: a barge, a boat, a catamaran, a vessel, or a pontoon, and fitted with suited tools to the task to be carried out.

[0011] In a preferred embodiment of the invention, the cable underwater robot is adapted for seabed cleaning, thus, it is provided with selective cleaning tools that allows the removal of large items on the seabed in a harmless way for the marine ecosystem, as well as floating plastics in the lower water column.

[0012] In more detail, an aspect of the invention refers to an underwater cable robot that comprises a floating platform such as a barge or boat, having a passing through opening providing access to a water column below the floating barge or boat and to the seabed.

[0013] The floating barge or boat includes a submergible frame fitted with a tool, which can be for example one of the followings: a gripper hydraulically or electrically operated, a drudge hose and head, or a robotic arm fitted with an end effector, so that the tool can collect, pick, grip, cut or suction debris underwater.

[0014] The floating barge or boat further comprises at least three motor driven winches attached to the floating barge or boat either directly or indirectly, preferably on the upper surface of the floating barge or boat, and a system of cables or tendons extending or extendable through the opening of the floating barge or boat, connecting the winches with the submergible frame through a set of pullies. The winches and the system of cables are arranged such that the frame can be kept suspended by the systems of cables below the floating barge or boat, when the frame is submerged, or above the floating barge or boat for configuring or maintenance of the frame, and during the barge or boat transportation.

[0015] In a preferred embodiment, the opening is formed in a central area of the floating barge or boat. Preferably, the opening has a rectangular configuration and there are four motor driven winches, such that, each winch is placed at a corner or nearby a corner of the rectangular opening.

[0016] The floating barge or boat includes a control unit adapted for controlling the operation of the winches in a coordinated manner, such that by winding and unwinding the cables from the winches, that is, by varying the length of the cables between the frame and the winches, the frame can be moved within a three-dimensional workspace and with at least six degrees of freedom below the floating barge or boat, for collecting debris from the seabed and from the water column or for performing any other required task.

[0017] In a preferred embodiment, the floating barge or boat comprises eight motor driven winches grouped in pairs, and the system of cables comprises a pair of cables for each pair of winches such that each cable of the same pair of cables, is individually winded in one of the winches of the same pair of winches. A free end of each one of the cables is connected to the robot's frame.

[0018] Preferably, the floating barge or boat comprises a supporting structure for each one of the winches, so that there are at least three supporting structures and preferably four supporting structures. The supporting structures are mounted on the floating barge or boat, wherein each supporting structure has a carriage movably mounted therein, such that each carriage can be moved up and down relative to the floating barge or boat.

[0019] Each carriage is provided with at least one pulley, and each cable of the system of cables run on a pulley, so that, by moving the carriages up and down relative to the barge or boat, the system of cables can be elevated or lowered with respect to the barge or boat, so that the underwater cable driven robot can be operated in two configurations namely: parking and working position, thus, the operability of the cable robot is improved in that it is easy to: assemble, set-up and maintain while it is out of the water during the translation of the floating barge or boat to different hot spots (parking position), and having the submergible frame inside the water for ML removal operations (working position).

[0020] The supporting structures and the system of cables are configured such that the submergible frame, can be pulled upwards through the opening and be placed above the floating barge or boat or just above water for assembling and/or maintenance of the cable robot's frame, and during the translation of the floating barge or boat to different working areas. For this purpose, the control unit is further adapted for controlling the movement of the carriages in a coordinated manner with the winches.

[0021] Preferably, each of the four supporting structures is arranged at the corner of a rectangular area parallel to the floating barge or boat, and they extend upwards from the upper surface of the floating barge or boat which is generally flat.

[0022] The robot's frame is additionally fitted with at least one of the following items: a submergible camera adapted for capturing images of the robot's tool, a sensor for measuring the speed of the robot's frame underwater, a sensor for measuring the altitude of the robot's frame with respect to the seabed, an Inertial Measuring Unit for measuring displacements and orientation of the robot frame, and a depth sensor for measuring the depth of the robot's frame.

[0023] An advantage of the invention is that due to the supporting structures with the vertically movable carriages, any type of floating barge or boat can be used because the operation of the cable robot is independent of the floating barge or boat height, and it would always allow two operational positions, namely: parking and working position.

[0024] In a preferred implementation, the floating platform is a barge constructed using a set of standardized pontoons, that is, pontoons of the same shape and dimension, normally rectangular prismatic bodies, that allow a modular construction by properly arranging and anchoring the pontoons to configure a desired design of the barge.

[0025] The underwater cable robot described above, features high efficiency in the seabed cleaning process, as the robot's frame can be moved accurately on the wavy seabed surface, with much higher motion capabilities (six degree of freedom controlled) than known underwater cleaning technologies, and in a selective manner to ensure environmental sustainability. The cable robot's frame can be either remotely controlled by an operator that targets each identified marine litter (ML) item and decides when to activate the collection tool for grabbing the ML, thus, avoiding wiping the seabed indiscriminately.

[0026] Therefore, some of the main advantages of the invention are listed below:

<u>Selectivity for minimal environmental impact:</u>

[0027]

- High accuracy of the cleaning tool positioning, provided by the cable-driven robot, so that currents would have little impact and the swell effects on the floating barge or boat would be mostly compensated by the robot control unit.
- Human decision to collect the ML: not processing all the seabed surface indiscriminately.
- The cable robot doesn't touch the seabed! Only its feet or anchors are in contact with the seabed, but even this impact can be removed using propellers on the barge and a Dynamic Positioning System.

<u>Efficiency:</u>

[0028]

- Fast scanning of the area using sensors and camera to quickly identify and localize the litter to remove.
- A fast motion of the robot tool or end effector, reduces the time required to clean-up the selected area: using electrical motors on the barge to pull the cables is much more efficient that propellers of a ROV that has to fight against buoyancy and currents.
- A high efficiency of the removal: cleaning of the area using the vacuum system is continuous: no need to

go back to the boat or to an underwater station to empty a small bag: the litter is sent directly to the barge or boat. When grasping is required for large litter, the velocity of the cable robot is key to avoid losing time in the motion towards the crane basket.

Flexibility and modularity:

[0029]

- A high flexibility of operation: the cable robot can operate from a few meters of the surface up to a depth roughly defined by the width of the platform. The modular barge concept allows to easily customize the size of the platform, and thus its maximum operating depth.

Advantages over prior art solutions:

[0030]

- High efficiency compared with divers, Autonomous ROV or Rover with an arm or small onboard suction device.
- It is not affected by currents and buoyancy.
- It does not require to go back and forth to the boat or to a larger container on the seabed to empty the small onboard robot container.
- Large autonomy.
- It is not affected by the umbilical cable weight and inertia that amplifies the drift and control issues of ROV.
- Large working space, and mobility is not limited by rocks, slopes, or wavy terrain.

BRIEF DESCRIPTION OF THE DRAWINGS

[0031] To complete the description and in order to provide a better understanding of the invention, a set of drawings is provided. These drawings form an integral part of the description and illustrate embodiments of the invention, which should not be interpreted as restricting the scope of the invention, but just as examples of how the invention can be carried out. The drawings comprise the following figures:

Figure 1.- shows a perspective of an exemplary implementation of an underwater cable robot according to the invention, with the frame in the parking position.

Figure 2.- shows a side elevational view of the underwater cable robot of Figure 1.

Figure 3.- shows also a side elevational view, with the frame in the working or cleaning position.

Figure 4.- shows a perspective view from above of the underwater cable robot.

Figure 5.- shows a top plant view of the underwater cable robot in another configuration.

Figure 6.- shows another perspective view of the underwater cable robot in another configuration.

Figure 7.- shows several views of the robot's frame, Figure 7A is a perspective view from front view, Figure 7B is another perspective view from back view, and Figure 7C is a bottom view.

Figure 8.- shows a perspective view of a supporting structure.

Figure 9.- shows in perspective view the underwater cable robot while cleaning the seabed.

DESCRIPTION OF WAYS OF CARRYING OUT THE INVENTION

[0032] Figure 1 shows an underwater cable robot adapted as seabed cleaning platform (1) according to a preferred embodiment of the invention, wherein the platform (1) comprises a floating barge (2) having a passing through opening (3) providing access to a water column below the floating barge (2).

[0033] As shown for example more clearly in **Figures 4** and **5,** the floating barge (2) is formed by a set of commercially available pontoons (4) of standard shape and dimension, that allow a modular construction, so that by properly arranging and anchoring the pontoons (4), the desired configuration of the floating barge (2) is obtained.

[0034] The floating barge (2) is designed for still waters and sea operations, and its stability is ensured by anchor feet or wire anchors, depending on the depth of the seafloor to be cleaned. The maximum depth of operation is directly correlated to the width of the floating barge (2).

[0035] The floating barge (2) can be transported from one working area to another by a tugboat, for example by means of a tug with azimuthal twin propeller propulsion that provide excellent navigational capabilities in internal waters close to the coastline.

[0036] Alternatively, the seabed cleaning platform (1) is fitted with an onboard propulsion system and position stabilization using Dynamic Positioning to avoid anchoring devices, using the tugboat only for precision navigation when required.

[0037] The seabed cleaning platform (1) further includes a submergible frame (11) fitted with tools (6) adapted for collecting debris underwater such as: a hydraulic or electric gripper for collecting large objects and an aspiration tool for collecting small debris, and at least three supporting structures (7a,7b,7c,7d) mounted on the upper surface of floating barge (2), and preferably extending upwards for example orthogonally, from the upper surface of the floating barge (2).

[0038] Preferably, there are four supporting structures (7a,7b,7c,7d) and each one of them is arranged at the corner of a rectangular area parallel or coplanar with the floating barge (2) as better shown in **Figure 5,** wherein the opening (3) is rectangular and it is formed in an inner or central area of the floating barge (2). Each supporting structure (7a,7b,7c,7d) is arranged nearby or at the corner of the rectangular opening (3). In other preferred embodiments, the floating barge may have other configuration, for example a U-shape.

[0039] The seabed cleaning platform (1) includes four pairs of motor driven winches (8a,8b,8c,8d), such as each pair of winches is placed also at a corner of the rectangular opening (3), preferably mounted on the barge (2) or together with one supporting structure (7a,7b,7c, 7d).

[0040] The seabed cleaning platform (1) includes a system of cables or tendons (9) that can extend through the opening (3) of the floating barge (2), connecting the pairs of winches (8a,8b,8c,8d) with the frame (11) through a set of pullies (17a,17b,17c,17d), such that the frame (11) can be kept suspended by the systems of cables (9) below the floating barge when the frame (11) is submerged for cleaning operations as shown in **Figure 3** (working position), or above the floating barge (2) for assembling and/or maintenance of the frame (11), or while transporting the seabed cleaning platform (1), as show in **Figure 1** (parking position). In the parking position, not only the frame (11) is out of the water, but also the tool (6) and the systems of cables (9).

[0041] The system of cables (9) comprises a pair of cables for each pair of winches (8a,8b,8c,8d), such that each cable of the same pair of cables is individually winded in one of the winches of the same pair of winches.

[0042] Each supporting structure (7a,7b,7c,7d) is provided with a carriage (10a,10b,10c,10d) movably mounted with the respective supporting structure (7a,7b,7c,7d), such that each carriage (10a,10b,10c,10d) can be moved up and down relative to the floating barge (2).

[0043] In an alternative embodiment, the supporting structure (7a,7b,7c,7d) and the respective carriage (10a, 10b,10c,10d), are configured in a way that the carriages (10a,10b,10c,10d) can be moved down within the opening (3) right onto the water level.

[0044] In addition, each carriage (10a,10b,10c,10d) is fitted with a pair of pulleys (17a,17b,17c,17d), in a way that each pulley of the pair is associated with a winch of the respective pair of winches, so that one cable of the system of cables (9) is winded in a winch and runs on the respective pulley. Therefore, the system of cables (9) and in turn the frame (11), can be moved up and down relative to the floating barge (2) by moving up and down in a coordinated manner the carriages (10a,10b,10c, 10d).

[0045] As shown in **Figures 6** and **9,** the seabed cleaning platform (1) can incorporate a crane (13) mounted on the floating barge (2) for hoisting a basket (14). The crane (13) lands the basket (14) on the seabed and the tool (6) of the frame (11) carry out the fine manipulation of the litter to be deposited in the basket (14), and when full, the basket is lifted onto the floating barge (2).

[0046] A power generator (15), a control room (16) including electric equipment and an operator's room, an aspiration system including a vacuum hose (12) and a filtering cage (18), are also mounted on the floating platform (2).

[0047] As represented with more detail in **Figures 7A - 7C,** the frame (11) has a main structure (5), such a free end of each one of the eight cables of the system of cables (9) is connected to the robot's frame (11) at distant connection points (B1, B2, B3, B4, B5, B6, B7, B8) of the main structure (5), preferably placed at the vertex of the main structure (5).

[0048] The system of cables (9) is arranged in a cross-configuration as better show in **Figure 5,** wherein the term cross-configuration means that each cable of the system of cables (9) intersects, from a top plan view as shown in **Figure 5,** with one of the consecutive cables of an adjacent supporting structure (7a,7b,7c,7d).

[0049] Other equipment of the seabed cleaning platform (1) such as: a set of sensors and cameras for manual, automatic and teleoperated operations, in particular sensors for measuring the depth of the robot's frame, and for measuring displacements and orientation of the robot frame, are also attached to the frame (11). In addition, the frame (11) integrates: the water-vacuum hose (12) that allow removal of small debris on the seabed as well as floating plastics in the lower water column. No filtering will be performed by the robot frame (11), as water flow will be directed to the platform where the filtering can be carried out at thew filtering cage (18). Water, sand, seaweed, shells are thrown overboard back to the water.

[0050] The frame (11) also integrates a tool (6) in this case consisting of a hydraulic or electric gripper that allow removal of large items such as: bikes, households, tyres, paint containers, nets, polystyrene and similar objects.

[0051] Furthermore, the frame (11) is fitted with underwater perception sensors that allow visual-feedback to the operator for the teleoperated robot control.

[0052] The frame (11) and its main structure (5), features a compact size to avoid collisions with any object (rocks, etc.) while it moves on the seabed, and it has an excellent capability to balance off-centred to withstand water current forces at different depths of the water column and at seabed.

[0053] In addition, the supporting structures (7a,7b,7c, 7d) are instrumented with RTK-GPS, force sensors for the cables, and inclinometers/IMU to measure the oscillatory effect of the swell.

[0054] The frame (11) is designed as a compact but heavy structure in order to be used in harsh outdoor and maritime environment, protecting all the devices attached to it, and with the centre of gravity at its bottom area or as close as possible, to withstand forces due to sea currents at different depths of the water column and at the seabed.

[0055] Furthermore, the seabed cleaning platform (1) has a control unit (not shown) adapted for controlling the operation of the winches (8a,8b,8c,8d) in a coordinated manner, such that by winding and unwinding the cables from the winches, that is, by controlling the length and tension of the cables, the frame (11) can be moved within a three-dimensional workspace below the floating barge (2) with at least six degrees of freedom in an accurate and stable fashion, for collecting debris from the seabed and from the water column, as represented in Figure 9.

[0056] The control unit is also adapted for controlling the operation of the carriages (10a,10b,10c,10d), so that when the carriages are in their elevated position, the frame (11) is placed above the floating barge (2) through the opening (3), and when the carriages are in their lower position, the frame (11) is submerged for cleaning work.

[0057] The above-described configuration of the seabed cleaning platform (1) maximizes the three-dimensional working space of the frame (11). The working space is defined by a set of positions (displacements in the cartesian axes: X, Y, Z and rotations: Rx, Ry, Rz) that can be reached for the frame (11) once contact points (A's) and connection points (B's) (Figure 1), the cable arrangement and the maximum cable tensions to support external forces, have been defined.

[0058] As identified in Figure 1: contact points (A1, A2, A3, A4, A5, A6, A7, A8) also called drawing points, are the points of last contact between cables and pullies (as there is relative movement between cables and associated pully). Connection points (B1, B2, B3, B4, B5, B6, B7, B8), are attachment points between the cables and the robot's frame (11). Cable arrangement is the distance between A and B points in each cable.

[0059] The working space also depends on the size of the floating barge (2). Having four supporting structures (7a,7b,7c,7d) for fixing eight pullies in pairs, means that a working space with a prismatic rectangular shape is created. Location of A and B points and cable arrangements have been established with the aim of maximizing the working space of the cable robot. Maximizing means having the best ratio between the footprint of the cable robot (physical location of the A points) and the extreme locations of the frame (11) in the workspace.

[0060] Due to the maximum cable tension allowable, the B points of the upper side of the robot's frame (11) can be at minimum aprox 1.5 m distanced from the A points. The robot's frame (11) cannot go higher from this position, because in that case the cable tensions would be over limit established. The height of the supporting structures (7a,7b,7c,7d), is defined taking into account the maximum cable tension and the location of the robot's frame (11) with respect to the floating barge (2).

[0061] For the cleaning operation, the platform (1) can work in two modes, manual teleoperated mode, and semi-autonomous teleoperated mode, as described below:

Manual teleoperation mode: a human operator sitting in front of a computer would look at the images from the underwater cameras and sensors and would use joysticks to remotely drive the cable robot towards the litter and activate/regulate the suction or the grasping. A collision detection algorithm would ease the job of the operator avoiding collisions between the cable robot and the seabed.

Semi-autonomous teleoperated mode: the aim of this mode is to reduce the complexity and associated fatigue of the operator by generating robot-trajectories to execute pre-defined movements or reach autonomously specific points of interest.

[0062] **Figure 9** shows the seabed cleaning platform (1) while cleaning the seabed. This task can be performed in different modes, namely: aspiration in the water column, aspiration on the seabed and cable robot performing in pre-defined trajectories on the seabed.

[0063] The operation procedure of the seabed cleaning platform (1) is as follows:

Step 1: A boat carrying a multi-beam sonar makes a scan of the seabed. An expert identifies hotspots of ML accumulation.

Step 2: Once these hotspots are localized on an RTK-GPS map, the cleaning platform is moved above it using a tugboat.

Step 3: Positioning and anchoring of the floating barge. If the cleaning spot is inside a harbour or lagoon, the platform deploys its anchoring feet to fix its position on the seabed. If the spot is in a deeper costal area (up to 20m), anchors with cables and winches are used to stabilize the platform position.

Step 4: Browsing of the water column in automated mode with the cable robot, with the vacuum end-effector. At the same time as, floating plastics are collected in the water column, the multi-beam sonar scans the seabed and computes a high accuracy 3D Digital Terrain Model of the seabed area below the platform. This map, in combination with additional data provided by RTK-GPS sensors will be used by the operator to decide which robot end-effector to use, and by the robot controller to compute possible collisions with the seabed and to avoid the robot motion in that direction.

Step 5: The operator selects and/or installs the desired end-effector on the cable robot and starts performing the cleaning of the area either by manual teleoperation or by shared autonomy teleoperation. The litter is selectively removed minimizing cleaning impact on the ecosystem.

Step 6: When satisfied with the cleaning, the platform is transported to the next area of interest.

[0064] Although the main purpose of the platform (1) is collecting marine litter, it could also be used for rescue operations or repair works underwater.

Claims

1. Underwater cable robot (1), comprising:

   a floating barge or boat (2) having an opening (3) providing access to a water column below the floating barge or boat (2),
   a submergible frame (11) fitted with a tool (6) adapted for performing underwater works,
   at least three motor driven winches (8a,8b,8c, 8d) attached to the floating barge or boat (2),
   a system of cables (9) extending through the opening (3) of the floating barge or boat (2) and connecting the winches (8a,8b,8c,8d) with the frame (11) by a set of pullies (17a, 17b, 17b, 17c), wherein the winches (8a,8b,8c,8d) and the system of cables (9) are arranged such that the submergible frame (11) is sustained by the systems of cables (9),
   a control unit adapted for controlling the operation of the winches (8a,8b,8c,8d) in a coordinated manner, such that by winding and unwinding the cables (9), from the winches (8a,8b,8c,8d), the frame (11) can be moved within a three-dimensional workspace below the floating barge or boat (2) for performing underwater works.

2. Underwater cable robot (1) according to claim 1, comprising at least three supporting structures (7a, 7b,7c,7d) mounted on the floating barge or boat (2), each supporting structure (7a,7b,7c,7d) provided with a carriage (10a,10b,10c,10d) movably mounted with the supporting structure (7a,7b,7c,7d), such that each carriage (7a,7b,7c,7d) can be moved up and down relative to the floating barge or boat (2), and wherein each carriage (7a,7b,7c,7d) is fitted with at least one pulley (17a,17b,17c,17d), and wherein each cable of the system of cables (9) runs on a pulley, such that the system of cables (9) can be moved up and down relative to the floating barge or boat (2) with the movement of the carriages (10a, 10b,10c,10d).

3. Underwater cable robot (1) according to claim 1 or 2, comprising four pairs of motor driven winches (8a, 8b,8c,8d), and wherein the system of cables (9) comprises a pair of cables for each pair of winches (8a, 8b,8c,8d), such that each cable of the same pair of cables is individually winded in one of the winches of the same pair of winches.

4. Underwater cable robot (1) according to claim 2, wherein the supporting structures (7a,7b,7c,7d) and the system of cables (9) are configured such that the frame (11) can be pulled upwards through the opening (3) and be placed above water level within the opening (3) or above the upper surface of the floating barge or boat (2), in order to carry out assembly and/or maintenance works in the frame (11) or while transporting de cable robot (1).

5. Underwater cable robot (1) according to claims 3 or 4, wherein the control unit is further adapted for controlling the movement of the carriages (10a,10b,10c, 10d) in a coordinated manner with the winches (8a, 8b,8c,8d) for moving the system of cables (9) and the frame (11) up and down.

6. Underwater cable robot (1) according to any of the preceding claims, wherein each one of the supporting structures (7a,7b,7c,7d) is arranged at the corner of a rectangular area parallel to the floating barge or boat (2).

7. Underwater cable robot (1) according to any of the preceding claims, further comprising: vision means adapted to capture imagines of the seabed and water column under the floating barge or boat (2).

8. Underwater cable robot (1) according to any of the preceding claims, wherein the opening (3) is formed in a central area of the floating barge or boat (2).

9. Underwater cable robot (1) according to claims 2 and 8, wherein the opening (3) is rectangular and each pair of winches (8a,8b,8c,8d) is placed at a corner of the rectangular opening (3).

10. Underwater cable robot (1) according to any of the claims 3 to 9, wherein the upper surface of the floating barge or boat (2) is generally flat, and wherein at least a part of each of the supporting structures (7a,7b,7c,7d) extend upwards from the upper surface of the floating barge (2).

11. Underwater cable robot (1) according to any of the preceding claims, wherein the tool (6) is one of the following: a gripper hydraulically or electrically operated, or a water-vacuum hose, or a robotic arm fitted with an end effector.

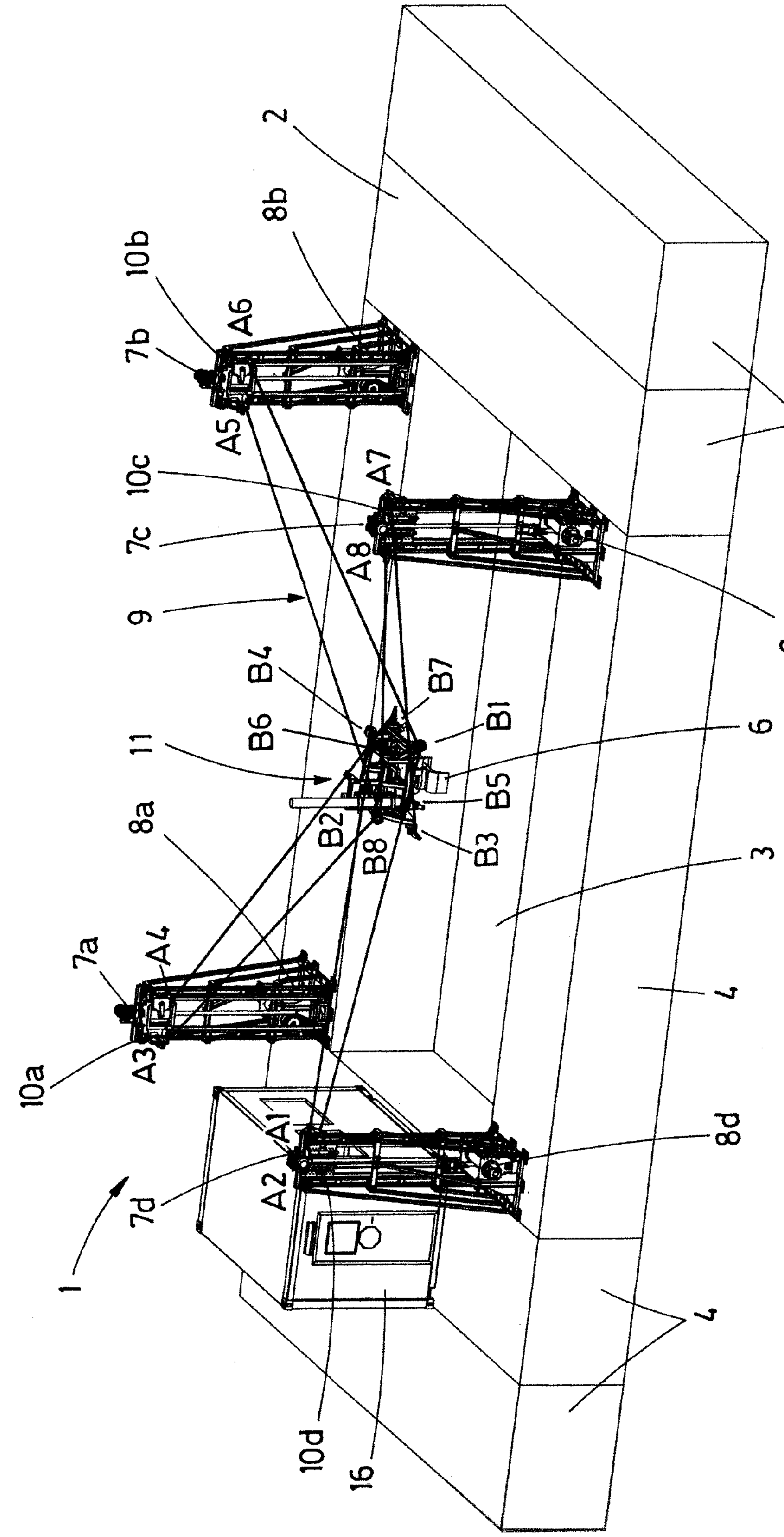
12. Underwater cable robot (1) according to any of the preceding claims, wherein the floating barge (2) is formed by a plurality of pontoons (4) of the same shape and dimension arranged and anchored to configure the floating barge (2).

13. Underwater cable robot (1) according to claim 7, wherein the frame (11) has a main structure (5), and

wherein a free end of each one of the cables is connected to the robot's frame (11) at distanced connection points (B1, B2, B3, B4, B5, B6, B7, B8) at the main structure (5), and, wherein, preferably, the connection points (B1, B2, B3, B4, B5, B6, B7, B8) at the frame (11), are placed at the vertex of the main structure (5).

14. Underwater cable robot (1) according to any of the preceding claims, wherein the robot's frame (11) is additionally fitted with at least one of the following items: vision means, a submergible camera adapted for capturing images of the robot's tool, a sonar, and a depth sensor for measuring depth of the robot's frame.

15. Underwater cable robot (1) according to any of the preceding claims, adapted as seabed cleaning platform, and wherein the tool (6) is adapted for collecting debris underwater.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2
3
4
4
4
6
7a
7b
7c
7d
8a
8b
8c
8d
9
10a
10b
10c
10d
11
16
A1
A2
A3
A4
A5
A6
A7
A8
B1
B2
B3
B4
B5
B6
B7
B8

FIG.1

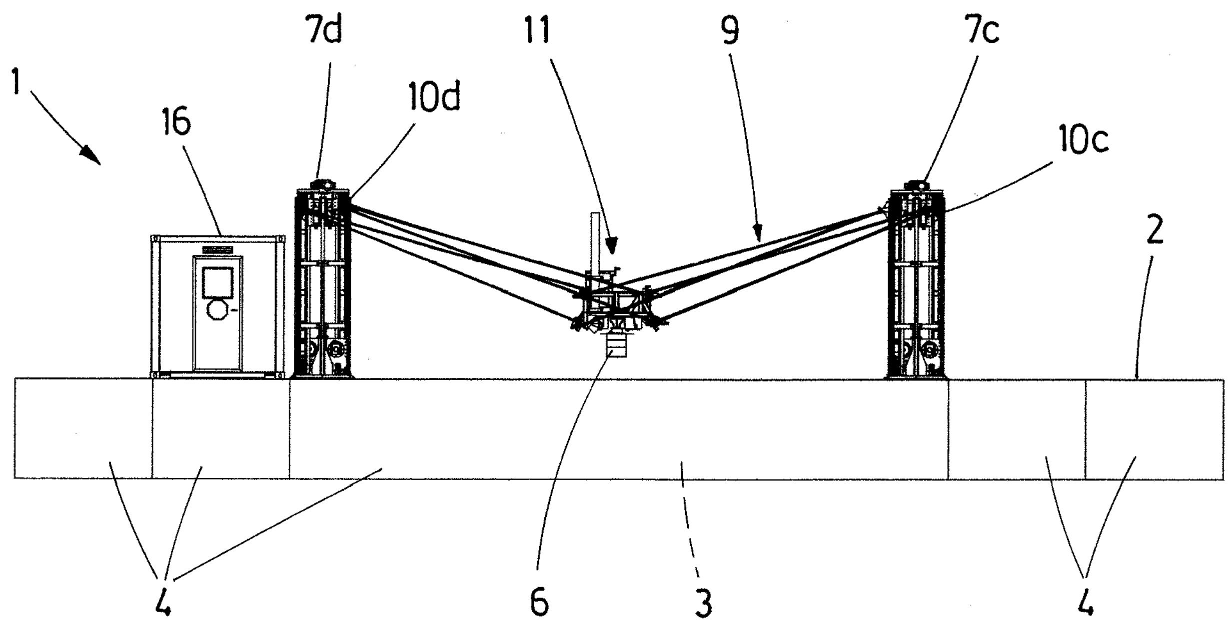


FIG. 2

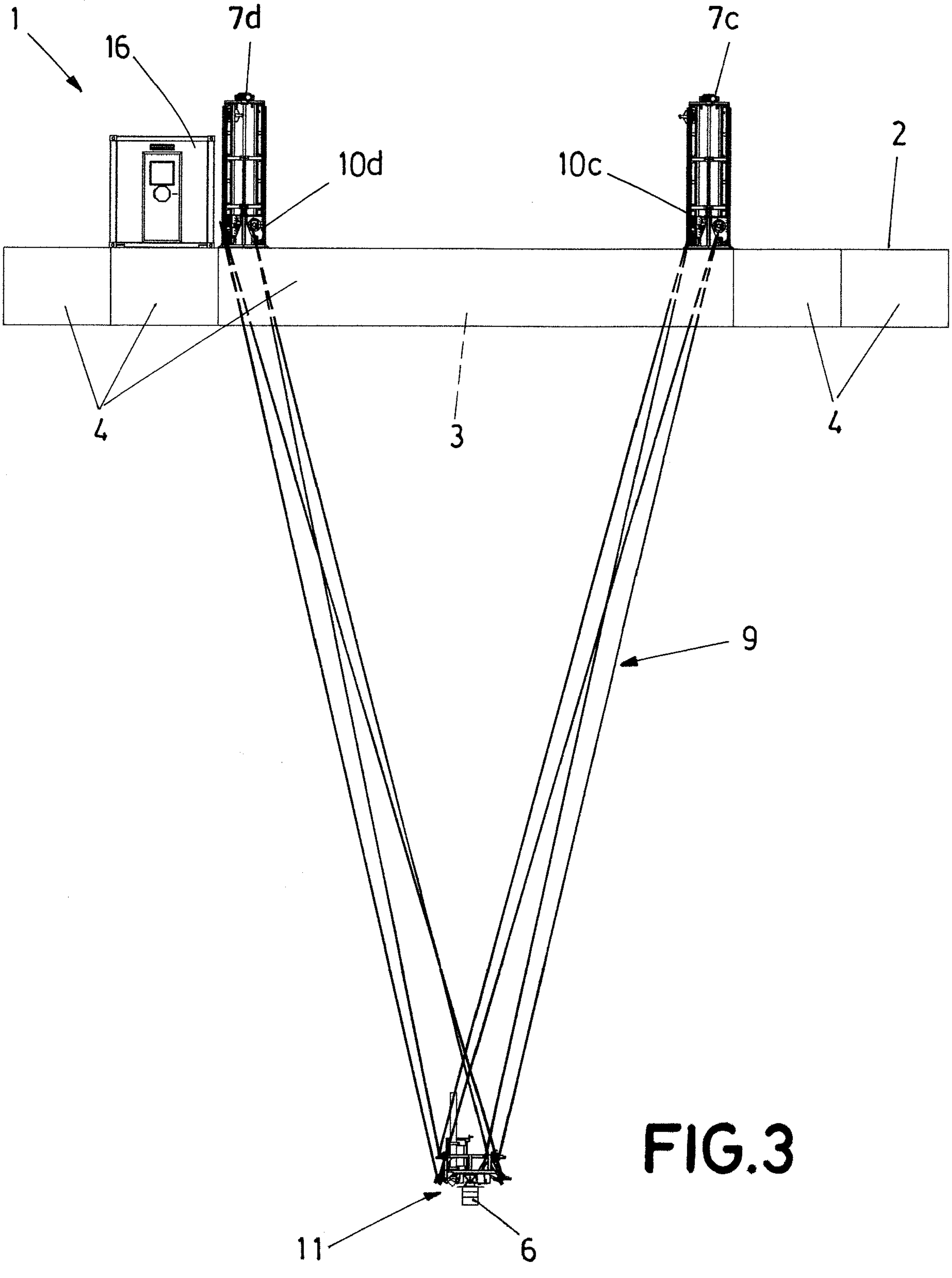


FIG.3

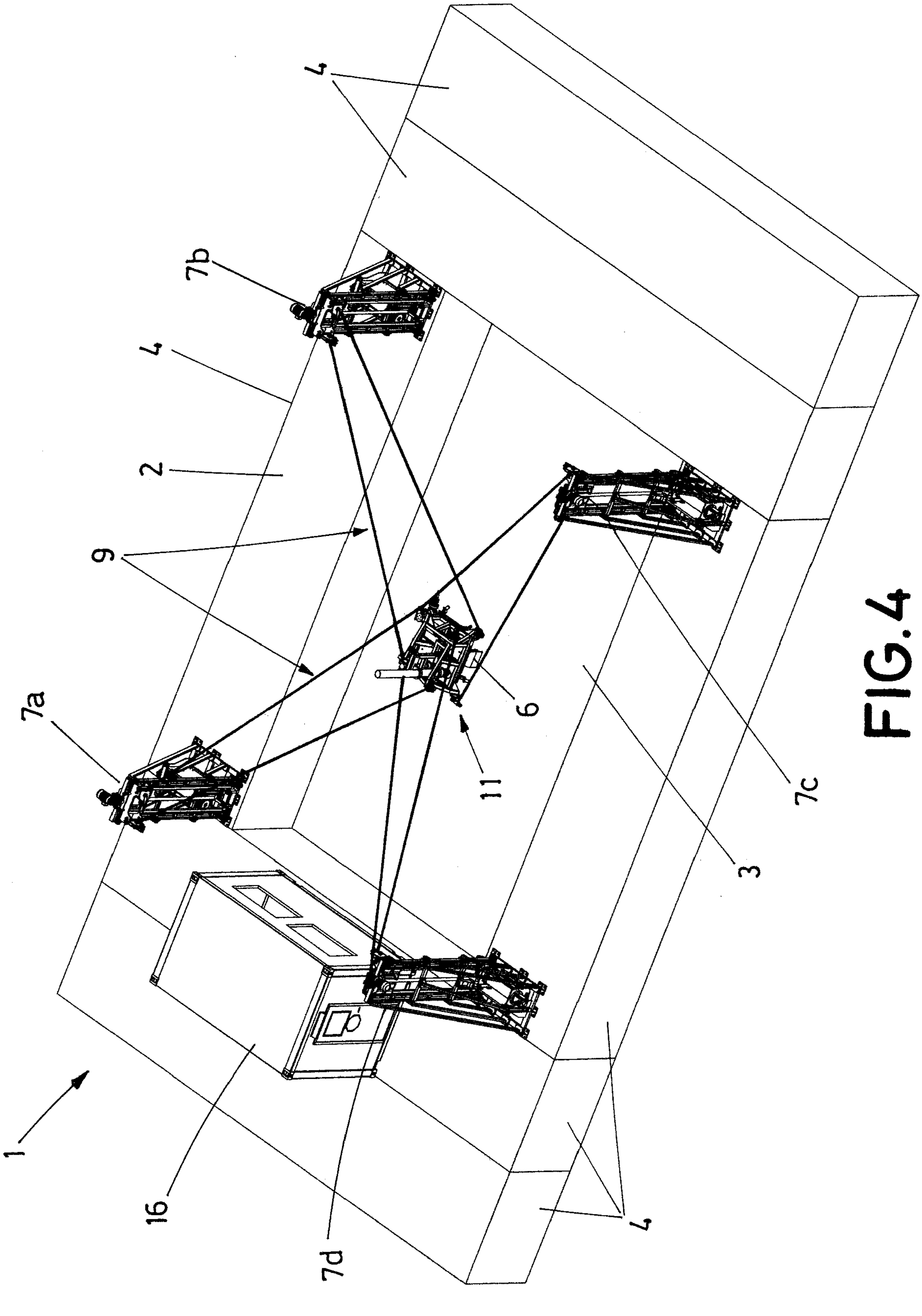


FIG. 4

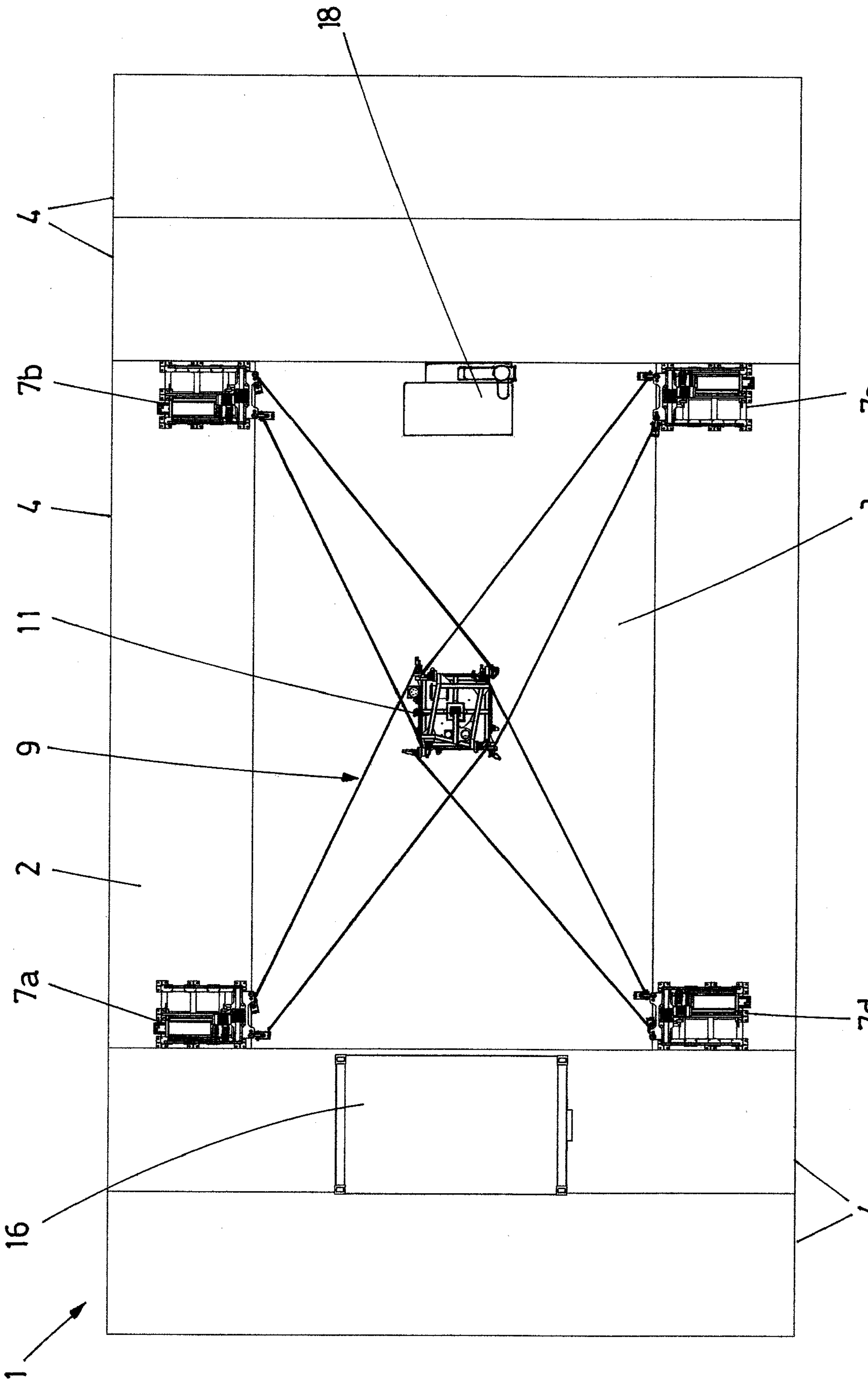


FIG.5

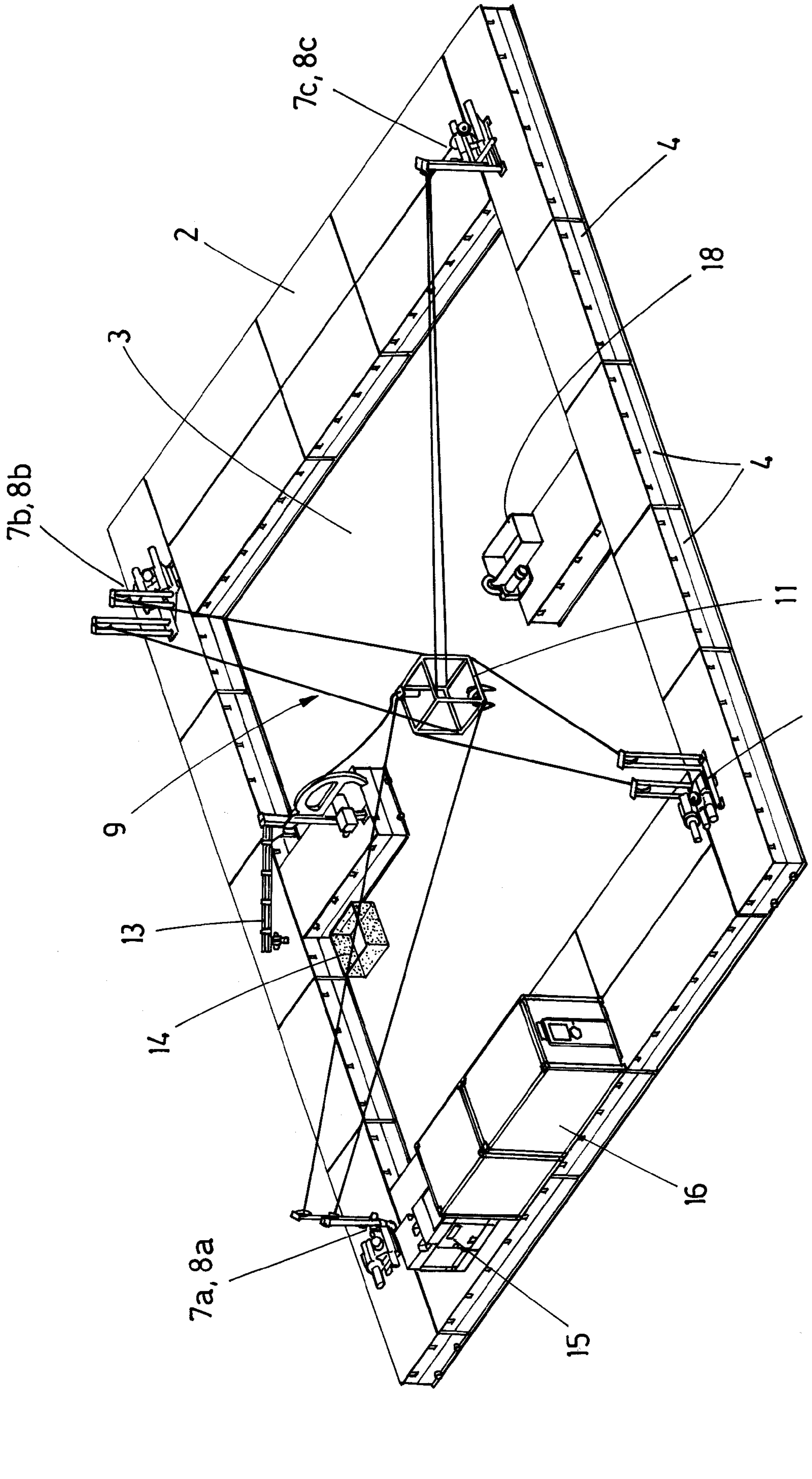


FIG.6

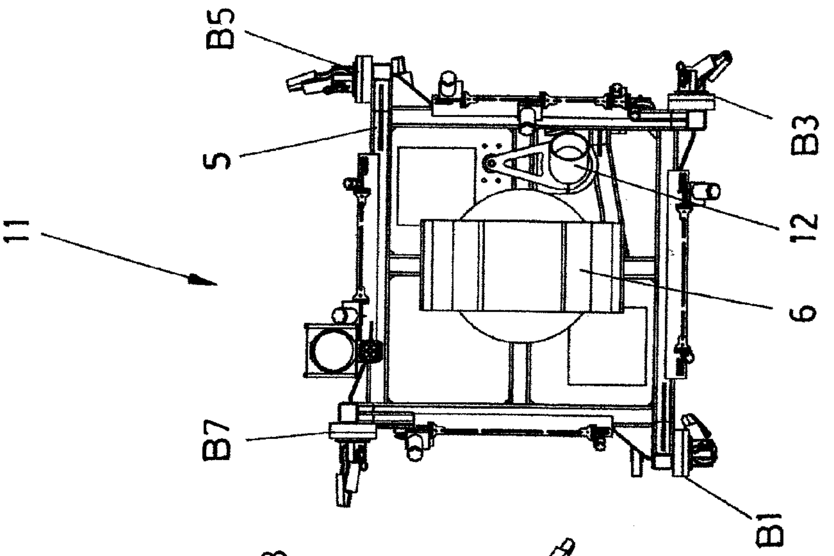


FIG.7C

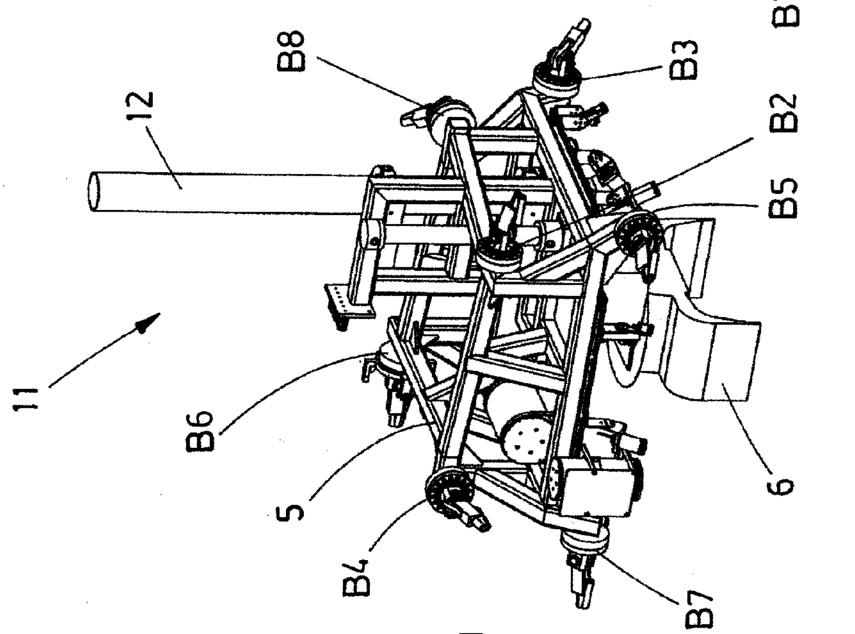


FIG.7B

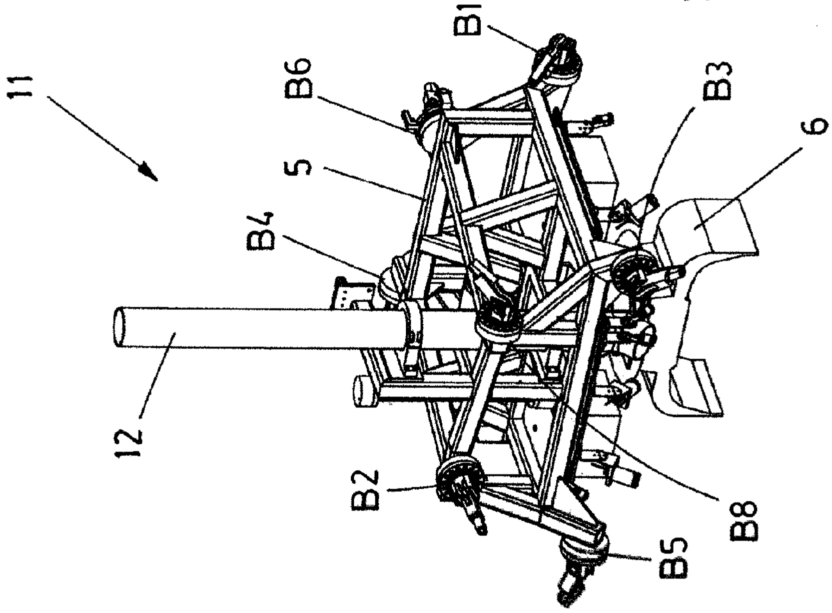
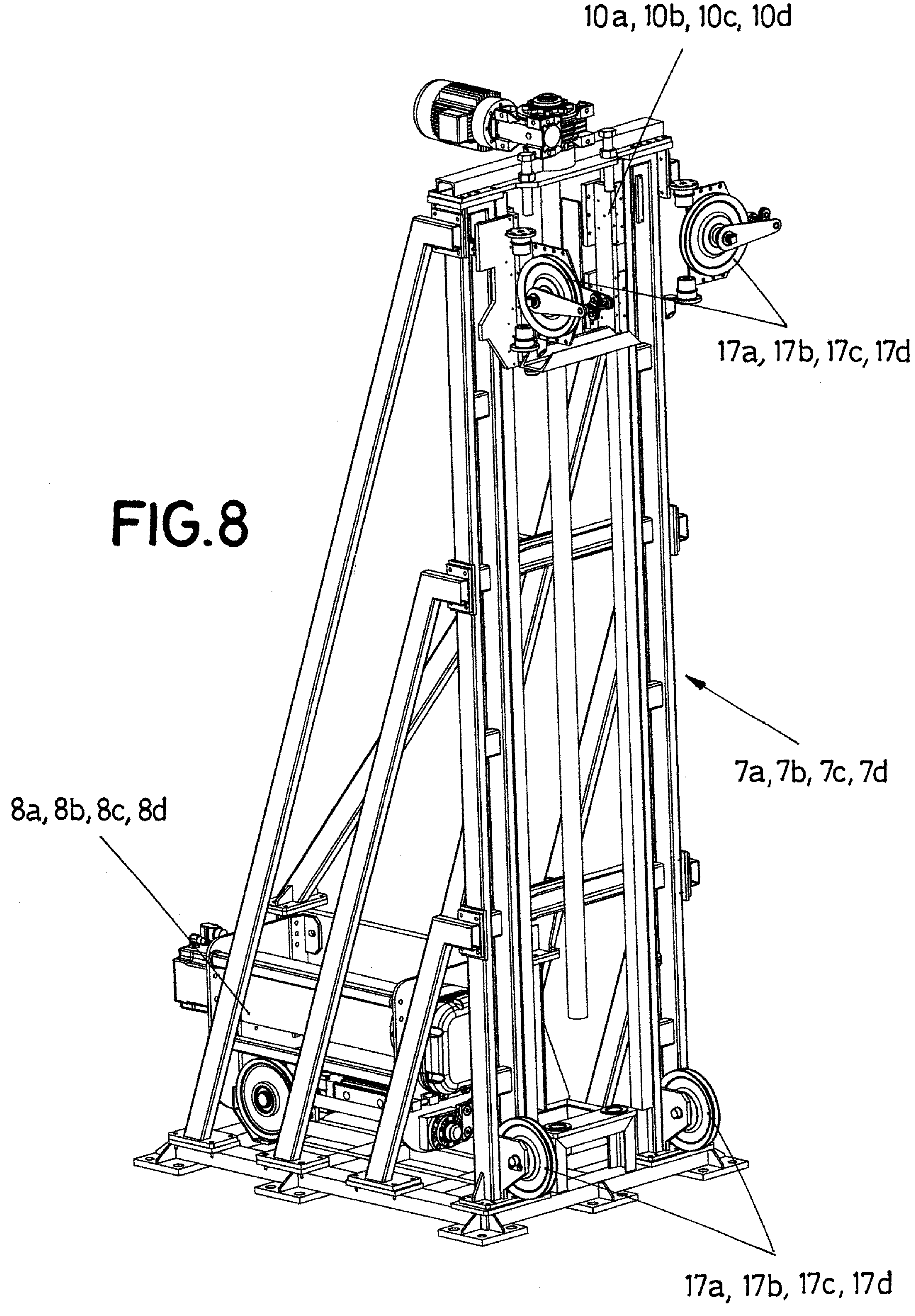


FIG.7A

FIG.8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17a, 17b, 17c, 17d
7a, 7b, 7c, 7d
8a, 8b, 8c, 8d
17a, 17b, 17c, 17d

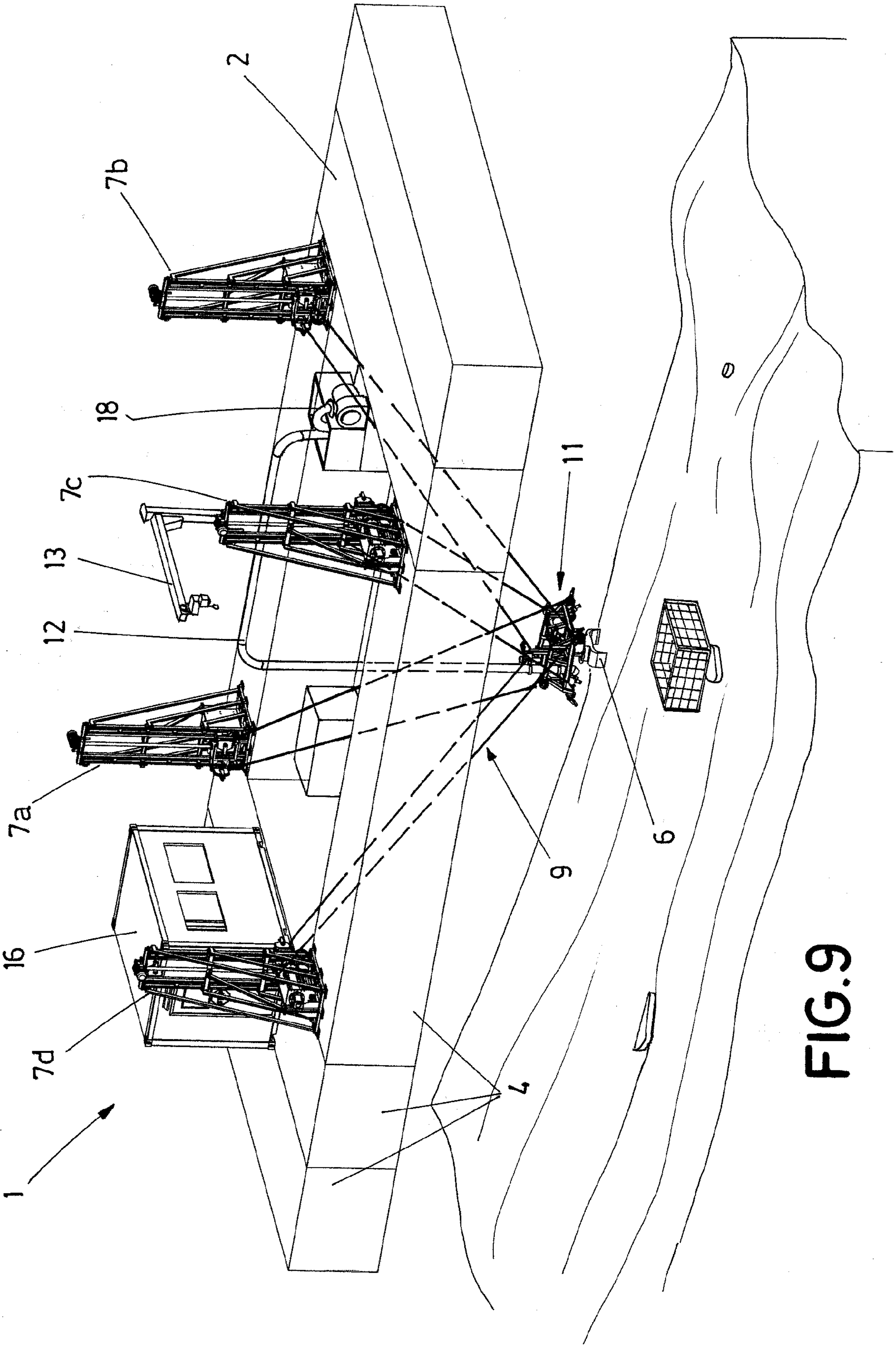

FIG.9

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Application Number
EP 22 38 2506

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The present search report has been drawn up for all claims

1

Place of search	Date of completion of the search	Examiner
The Hague	17 November 2022	Blazquez Lainez, R

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