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(54) SUCTION DEVICE FOR THE REMOVAL OF MUDDY AND/OR VISCOUS SEDIMENT STRATIFIED ON THE BOTTOM OF A STORAGE TANK BOTTOM

(57) This concerns a suction device (1) for the removal of muddy and/or viscous sediment stratified on the bottom of storage tanks

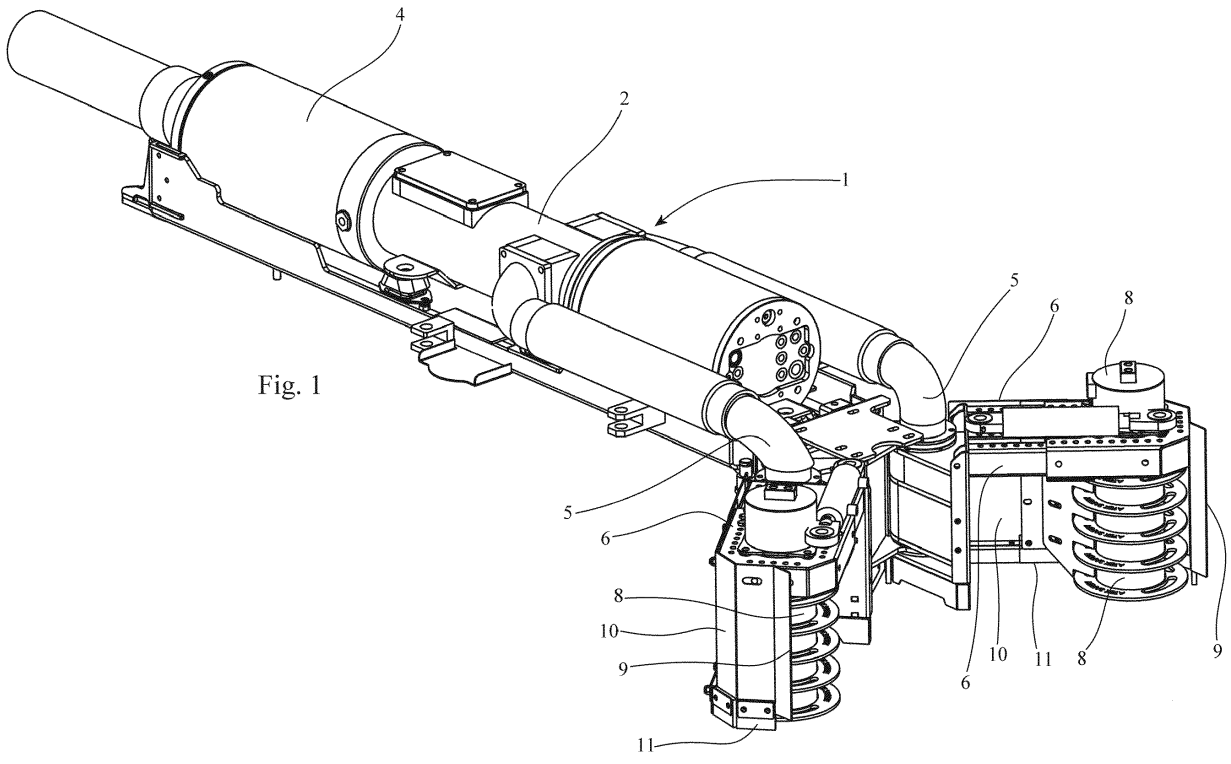

Fig. 1

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Description

[0001] The object of this invention is a suction device for the removal of muddy and/or viscous sediment stratified on the bottom of storage tanks

Prior art

[0002] In large industrial plants there are often storage tanks for petroleum products, generally above ground with vertical cylindrical wall products. These tanks are sometimes very large, up to a diameter of 100 meters and generally have a flat or slightly inclined bottom, made of carbon steel with a surface treatment of paint or with a covering of fiberglass or the like.

[0003] Over time, a heavy, muddy and bituminous sediment forms inside, with a consistency so viscous that it cannot be pumped or moved with the systems envisaged for the normal process flow; for this reason it is necessary to cyclically provide a stop with the emptying of the tank from the liquid phase in order to remove this sediment and then start again with the normal storage process.

[0004] Normally these activities provide for the entry of personnel and machinery from the side of the cylindrical mantle through cylindrical doors with an internal passage diameter of about 600 mm; this is why this measurement is in fact the standard required by the market for this type of equipment.

[0005] There is also the need for this technology not only in hydrocarbon storage tanks but in many other situations of flat bottom tanks, closed or open, where there are problems of toxicity, explosiveness, chemical or biological or radioactive risk.

[0006] The tanks inside are confined spaces classified as Atex zone 0 environments at risk of explosion and therefore the use of no man-entry solutions with suitable Atex marking is mandatory to perform the sediment removal and subsequent cleaning activities.

[0007] Currently the sediment is removed through the use of suction pneumatic conveying systems generated by vacuum pumps on self-expelling or by volumetric transfer pumps positioned outside near the inlet doors to the tanks.

[0008] The remote-controlled robots available on the market work connected via a flexible suction hose to self-expelling blowpipes positioned far away from the tank because they are not Atex and therefore cannot enter environments, such as tanks, that have a risk of explosion.

[0009] Sometimes volumetric pumps placed outside the tanks are used, since they are not classified as Atex zone 0, whose intake duct is moved manually inside the tanks, this solution, as well as from a technical point of view, since it has a limited radius of action, is always opposed because there are people inside said tanks.

[0010] The practice of employing mechanical transport systems, using mechanical skid steer loaders or other manual loading systems, is much less frequent now due to the risk to human personnel.

[0011] From a technical point of view the manual solution that uses mechanical earth-moving vehicles (transformed to adapt to the different conditions that are faced inside the tanks in terms of dimensions and gaseous emissions) would be the most efficient, as the sediment with a consistency very similar to a very dense and pasty solution is detached from the mass and loaded onto the skid-steer loaders to be transferred to the outside, however it is not productive due to the considerable size of the bottom which means lengthy times are required to move small fractionated quantities outside time and time again.

[0012] It is also conceivable only for situations in which there is free access from the outside (and not restricted by the limited entry passage) and there is no danger of explosion and the atmosphere is breathable.

[0013] Unlike the solution described above, there is an alternative solution that uses depression, with a maximum limit of -0.9 bar to convey the sludge through a long flexible rubber hose (which can extend in length even to 50-75 meters based on capacity) up to self-expurgation; however the productivity of this solution can be very limited because it depends on:

- length and diameter of the suction pipe;
- suction air flow generated by the self-discharge;
- sludge temperature and viscosity conditions.

[0014] Any solution on the suction side requires that once the sedimentation tank is filled, it must be emptied, and therefore the suction process must be interrupted.

[0015] A different possibility is the use of a volumetric pump (which instead has a maximum limit of 5-6 bar) which has the advantage of a continuous operation in the time in which the pump can work without the stops due to the movement of the material outside the tank; this greater efficiency provides a considerable reduction in the time required for emptying a tank, but is limited by the fact that the suction port of the suction pipe must be under a constant head.

[0016] However, both the solution that uses the depression and the solution that uses a volumetric pump have proven to be unsuitable for delivering the sludge sediment directly to the outside, as this is excessively dense and viscous.

Object of the invention

[0017] The object of this invention is to overcome the drawbacks of the prior art.

[0018] A main object of the present invention is to make available a system capable of intelligently and continuously conveying the material deposited on the bottom of the tank right into the pump suction port without there having to be inside the tank to be cleaned.

[0019] A further object is to make available a system which makes said material manageable by the said

pump.

[0020] An important object of the present invention is to make available a system that makes the material manageable made continuously available at the suction port of the pump.

[0021] Another important object of the present invention is to have a system that can continuously operate without stopping for changing the external storage tank.

[0022] An important object of the present invention is that of a system which may not be limited by the dimensions of the inlet mouth.

[0023] A further object of the present invention is to make available a system that can adapt to the consistency characteristics and amount of the sediment.

[0024] An important object of the present invention is that of a system that can operate even in the presence of explosive atmospheres.

[0025] A different object of the present invention is that of a system which is not limited by the distance at which the removal operations of the bottom sludge must be carried out.

[0026] All the aforesaid objects and others which will become more apparent from the continuation of the description are obtained from the invention characterised by the features highlighted in the claims.

Explanation of the invention

[0027] The invention consists of a suction device for removing stratified muddy and/or viscous sediments on the bottom of a storage tank comprising a volumetric pump on board a remote-controlled self-propelled vehicle able to move inside a tank without the supervision of an operator, where the delivery pipe of the aforementioned pump pushes the material to be conveyed to the outside of the tank to be cleaned, and where intake duct is continuously fed with material to be removed by a pre-treatment system of the bottom sludge, and where said pre-treatment system is near the suction tube of the aforementioned pump and comprises at least one rotating tool, for example a screw, or a series of spaced apart coaxial disks, supported by at least one arm mobile that is able to move said rotary tool closer to and away from at least one suction mouth of the suction pipe.

[0028] In other words, the present invention allows a tank to be cleaned without the supervision of the operator with all the automatic adjustment devices necessary for the transfer of the bottom sludge mounted on board, and is configured as an automatic system for the pre-treatment of the bottom sludge, mounted on board a self-propelled vehicle that can move inside the tank to transfer the sludge to the outside through a cavity pump.

[0029] The device of the invention comprises a self-propelled vehicle which supports a cavity pump specifically designed to be able to operate in an environment with the continuous presence of flammable gases and vapours; the device is remotely controlled without the presence of the operator with an automatic priming system that keeps the suction mouth of the pump supercharged in order to maximise productivity and allow the pump to work in the specific conditions without dry-running or loss of suction. In fact, good priming of the pump is essential to have the pump operate in the absence of cavitation and subsequent mechanical and dynamic flow vibrations. The cavity pump has a good priming capacity and can generate a large pumping pressure (5-6 bar) but it is essential that the material is mechanically brought up to fill the suction pipe so as not to lose priming and work with full tube.

[0030] To achieve this effect, a system consisting of at least one arm that can be opened by hydraulic cylinders carrying at least one rotating tool, for example a rotating vertical auger, has been provided to haul the viscous fluid towards the suction mouth.

[0031] Usually crude oil or derived products form a sediment that often has characteristics of high viscosity and mechanical consistency similar to a bituminous product, which opposes being sucked or pumped with normal systems. To allow this sediment (often called SLOP OIL) to be pumped or sucked through a flexible rubber pipe, it must be worked mechanically with systems that cut it and mix it at high speed, making it similar to a mud with viscosity suitable for pumping.

[0032] Advantageous characteristics of the invention Advantageously, said rotating tool has a vertical axis with the suction mouth located near the bottom of the tank to be cleaned, ensuring that the pre-treated sludge, which has gained a consistency that can now be suctioned, keeps the pump continually primed.

[0033] Advantageously, the movable arm, moved by a hydraulic cylinder, is hinged with an axis parallel to the rotation axis of the rotating tool, thereby being able to widen the radius of action of said tool and confer a further action of getting the pre-treated sludge close to the suction inlet.

[0034] Advantageously, said rotary tool can slide in a controlled manner along said movable arm in order to be able to widen or restrict the attachment cross-section of the removal device according to the nature, consistency and quantity of the sludge present.

[0035] Advantageously, at the end of the movable arm, with a profile approximately parallel to the rotation axis of said arm, there is a cutting/separation/detachment blade for the cutting of the material to be pre-treated with respect to the solid mass of the untreated sludge, thus managing to bring the appropriate amount of material to be treated by the rotary tool, mechanically detaching it from the viscous bond of the rest of the sludge.

[0036] Advantageously, said rotary tool is equipped with a series of fixed combs, interposed between said rotating disks or a movable oscillating blade for detaching from the auger to clean and detach the material that was sticking to it, keeping the same rotation speed.

[0037] Eventually, a free-rotating orthogonal cutting system is provided, which separates the material from the auger and forces it towards the suction port of the

pump.

[0038] Advantageously, the direction of rotation of the rotating tool is reversible on command, due to the need for detachment and/or bringing the pre-treated sludge close to the suction inlet.

[0039] Advantageously, the movable arm has a continuous confinement wall which extends for at least a part of the longitudinal extension of the rotating tool and is positioned on the opposite side to the suction mouth (with respect to the rotating tool) establishing a confined space for a continuous and prolonged treatment of the sludge bringing it to the proper consistency.

[0040] Advantageously, said confinement wall extends from the movable arm to the bottom of the tank and ends with a flexible rubber/plastic scraping profile that scrapes along the bottom of the tank to bring the pre-treated material closer to the suction mouth.

[0041] Advantageously, said movable arms during their movement are opened in a position some distance away from the suction mouth and counteract the overturning moments which may occur due to the working and/or of the disconnected or uneven bottom acting as stabilisers, resting with their ends facing the bottom and away from the centre of gravity of the device and counteracting these overturning moments.

[0042] All the aforesaid advantages and others which will appear in the following description are more clearly illustrated with reference to the drawings and to an exemplary and non-limiting embodiment set forth below.

Brief description of the drawings

[0043] The technical characteristics of the invention, according to the aforementioned objects, can be clearly seen from the content of the claims below and the relative results will be apparent in the detailed description that follows with reference to the drawings, which illustrate a purely exemplary and non-limiting embodiment, in which:

fig. 1 shows the suction device for removing stratified muddy and/or viscous sediments at the bottom of a storage tank, object of the invention, according to a perspective view from above;
fig. 2 shows the device of fig. 1 according to a plan view from above;
fig. 3 shows the device of fig. 1 from a side plan view;
fig. 4 shows the front part of the device of fig. 1 in an enlarged manner;
fig. 5 shows the front part of the device of fig. 1 in an enlarged manner seen from a different perspective with respect to that shown in fig. 4;
fig. 6 shows the device of the invention according to a frontal and top perspective view, which highlights the movable arms in an open configuration and with the rotating tools supported at the free ends of said movable arms extended to their maximum extension;
fig. 7 shows what is shown in fig. 6 with the mobile arms slightly rotated towards a closed situation;
fig. 8 shows what is shown in fig. 6 with the mobile arms retracted to the minimum extension, bringing the mobile tools close to the suction mouth;
fig. 9 shows what is shown in fig. 6 with the movable arms completely rotated to the closed configuration, in which the movable tools are placed close together in a juxtapositioned manner;
fig. 10 shows what is shown in fig. 6, but fitted with a rotating tool equipped with screw-type cutting edges, with respect to what is shown in figures 6 to 9, where the rotating tool has cutting edges configured as rotating disks.

[0044] Detailed description of an exemplary preferred embodiment The drawings show a double front rotary auger system with metal cutting edges that carry out a demolition of the compact sediment front, pushing the material towards the double suction front corresponding to the two suction ports of the pump.

[0045] The system shown has mechanical protections certified to work in the presence of an explosive atmosphere, and has two degrees of freedom to maximise the work front in all conditions:

- □ horizontal opening movement of the two arms (right and left) to work on a front wider than the width of the machine; the working width is adjustable and this adjustment is obtained by moving the working axis of the rotating auger horizontally with respect to the rotation axis of the arm; the very movement of the arm closing induces a further effect of pushing the muddy material towards the two suction pipes;
- □ clockwise and counter-clockwise rotation of the two vertical speed-controlled augers that are automatically controlled by the system for adjusting the maximum pressure of the pumping fluid. A direction of rotation represents the normal working direction of the augers that mix and convey the material towards the suction pipe; the opposite direction of rotation has the function of freeing the mechanism from possible foreign bodies that can stop the free rotation or the closure of the two arms.

[0046] With reference to the drawings, the suction device 1 comprises a cleaning device 2 supported by moving devices 3 consisting of a self-propelled crawler-type vehicle. The suction device must have a sufficiently compact cross-section so that it can pass through the manhole on the side walls of the large tanks from which the suction device must clean the bottom.

[0047] In fact the bottom of such tanks requires periodic cleaning, which consists of mechanically removing the viscous sludge to the outside of the tank by means of the device of the invention designed to operate in areas at risk of explosion and remotely controlled.

[0048] The cleaning device 2 comprises a volumetric pump 4 with two suction mouths 5 facing towards the

bottom and positioned close to it.

[0049] In fact, it is very important that the volumetric pump 4 always works at full capacity, avoiding idling which could lead to cavitation and overheating, situations which should always be avoided in areas at risk of explosion. Therefore the position close to the floor of the suction mouth provides the best priming in combination with the other characteristics of the invention.

[0050] On the side of each suction mouth 5 a movable arm 6 is hinged with a vertical axis which can move with a rotary movement by means of an actuator 7 that acts on the arm 6 itself and with an opposite point of application on the fixed structure of the cleaning device 2. Advantageously, said actuator 7 is a hydraulic cylinder. Supported and sustained on each movable arm 6 there is a rotating tool whose peripheral profile is made to rotate and enters in sliding contact with the stratified and viscous sediments to realise a mechanically pre-treated mud so as to have such characteristics (viscosity, consistency, stickiness, fluidity) to be able to feed the volumetric cavity pump 4 and to be conveyed through a duct with a suitable cross-section outside the tank.

[0051] Preferably, as disclosed in the drawings, said rotary tool is an auger screw. The direction of rotation of the rotating tool can be changed to meet the different needs that arise during the execution of the various work phases, where one direction is preferable for the processing and treatment of the stratified sediment and the opposite direction for conveying of said pre-treated sludge towards the suction mouth 5 or to free the cochlea from flooding.

[0052] It is also envisaged that this auger may be moved along the longitudinal extension of this movable arm 6 to adapt to the nature and characteristics of the material that is encountered as sediments to improve productivity.

[0053] In fact, also the movement of the movable arm 6 with a rotation in the direction of the suction mouth 5 helps to keep the pump primed and to maintain a quantity of material in the suction ducts to avoid idling.

[0054] If required, the rotary tool can assume the configuration of a series of rotating spaced disks, whose circumferential edge attaches to and is placed in contact with the untreated sediment, fluidifying it and making its characteristics suitable for the relative suction.

[0055] Sometimes, given the nature of the material to be removed, this is shown as a combined colloidal assembly that can only be detached by means of a partitioning realised by the blade 9 arranged at the free end of the movable arm 6.

[0056] Advantageously, this blade 9 with a profile that extends from the height of the movable arm towards the bottom approaching it, for a rotary movement of the movable arm is able to section off the untreated parts of the base to make it available for pre-treatment of the tool of the rotating tool 8.

[0057] Said movable arm 6 is also equipped with a confinement wall 10 arranged adjacent to the outer profile of the auger on the side opposite to that facing the suction mouth, limiting and collecting the pre-treated material towards the auger and being able to act both as a definition of the space for the continuous and repeated treatment of the same material and as a tile for moving this material towards the suction mouth.

[0058] Finally, said confining wall is has, on the edge facing the bottom of the tank, a scraper 11, which is an extension of the confinement wall itself, scraping the bottom without ruining it as it is made of a flexible rubbery/plastic material.

Claims

1. Suction device for the removal of muddy and/or viscous sediment stratified on the bottom of a storage tank comprising a volumetric pump (4) on board a self-propelled remote controlled vehicle able to move inside a tank without the supervision of an operator, whose delivery piping, of the aforesaid pump, presses the material to be conveyed outside the tank to be cleaned, and whose suction duct is continuously fed with material to be removed from a pre-treatment system of the foundations, where said pre-treatment system located near the suction mouth (5) of the aforesaid pump (4) and comprising at least one rotating tool (8), such as for example a screw, or a series of spaced apart and coaxial discs, supported by at least one movable arm (6), capable of bringing said rotary tool (8) closer to and away from at least one suction mouth (5) of the aspiration pipe.

2. Suction device according to claim 1, **characterised by** the fact that said rotating tool (8) has a vertical axis with respect to the suction mouth (5) located near the bottom of the cleaning tank.

3. Suction device according to claim 1, **characterised by** the fact that said movable arm (6) is moved by an actuator (7) and is hinged with an axis parallel to the rotation axis of the rotating tool (8).

4. Suction device according to claim 1, **characterised by** the fact that said movable arm (6) constitutes a sliding guide of said rotating tool (8) being able to slide in a controlled manner along said movable arm (6).

5. Suction device according to claim 1, **characterised by** the fact that at the end of the movable arm (6), with a profile approximately parallel to the axis of rotation of said movable arm (6), there is a cutting/separating/detaching blade (9) for sectioning the material to be pre-treated with respect to the substantial mass of the untreated sludge.

6. Suction device according to claim 1, **characterised**

by the fact that said rotary tool (8) has a series of fixed combs, interposed between said rotating discs or has an oscillating movable blade detaching from the auger screw for cleaning and detaching the material sticking to it maintaining the same speed of rotation.

7. Suction device according to claim 1, **characterised by** the fact that said rotating tool (8) is equipped with a free rotation cutting system that detaches the material from the auger screw and directs it in a forced manner towards the suction port of the pump.

8. Suction device according to claim 1, **characterised by** the fact that said rotary tool (8) has a reversible direction of rotation upon command.

9. Suction device according to claim 1, **characterised by** the fact that the movable arm (6) has a continuous confinement wall (10) that extends for at least a part of the longitudinal extension of the rotating tool (8) and positioned on the side opposite the suction mouth (5), with respect to the rotating tool (8), defining a confined space for a continuous and prolonged action of treatment of the same foundations bringing it to the appropriate consistency.

10. Suction device according to claim 1, **characterised by** the fact that said confinement wall (10) extends from the movable arm (6) to the bottom of the tank and ends with a scraper (11) consisting of a flexible rubber/plastic scraping profile which scrapes the bottom of the tank.

11. Suction device according to claim 1, **characterised by** the fact that said movable arms (6) during movement are opened in a position away from the suction mouth (5) and counter the overturning moments which may arise due to the work and/or disconnected or uneven bottom, acting as stabilizers, resting with their end facing the bottom and away from the barycentre of the device (1) and counteracting said overturning moments.

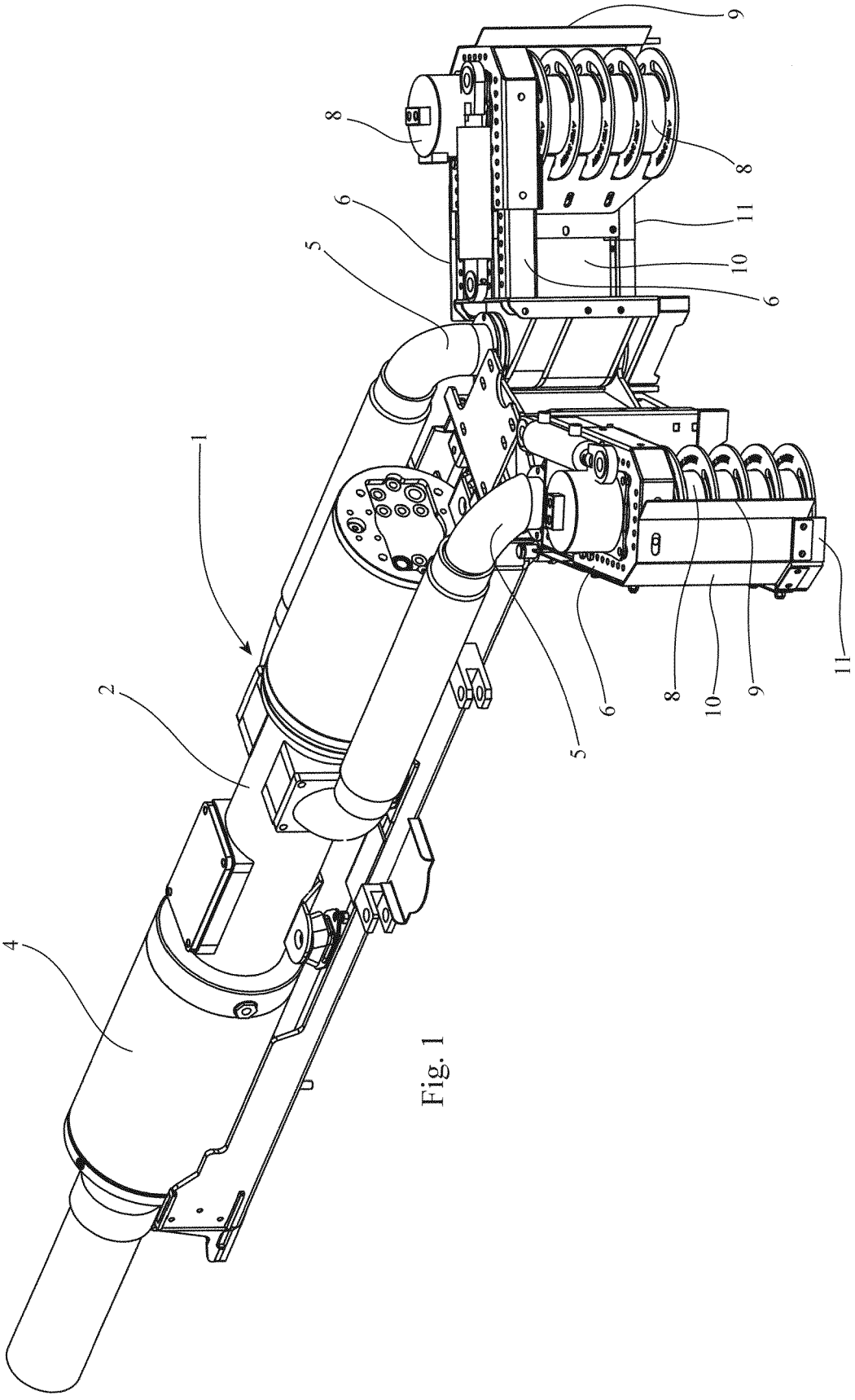

Fig. 1

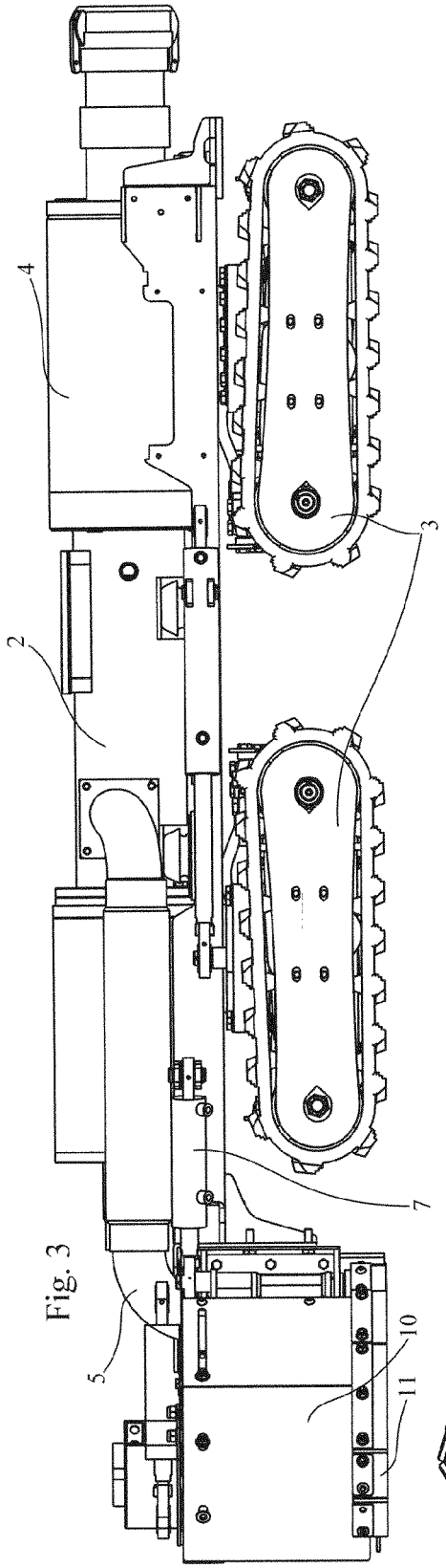

Fig. 3

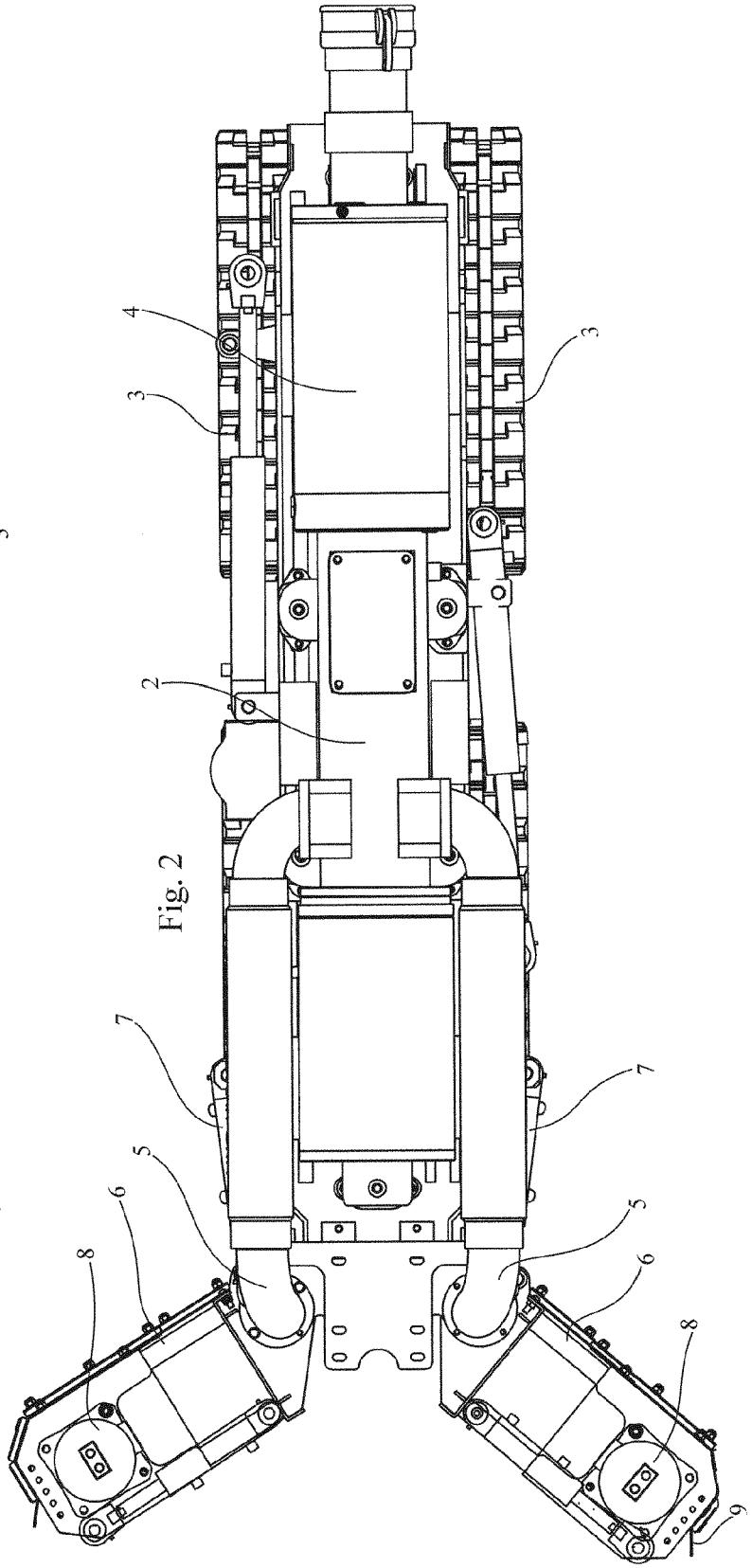

Fig. 2

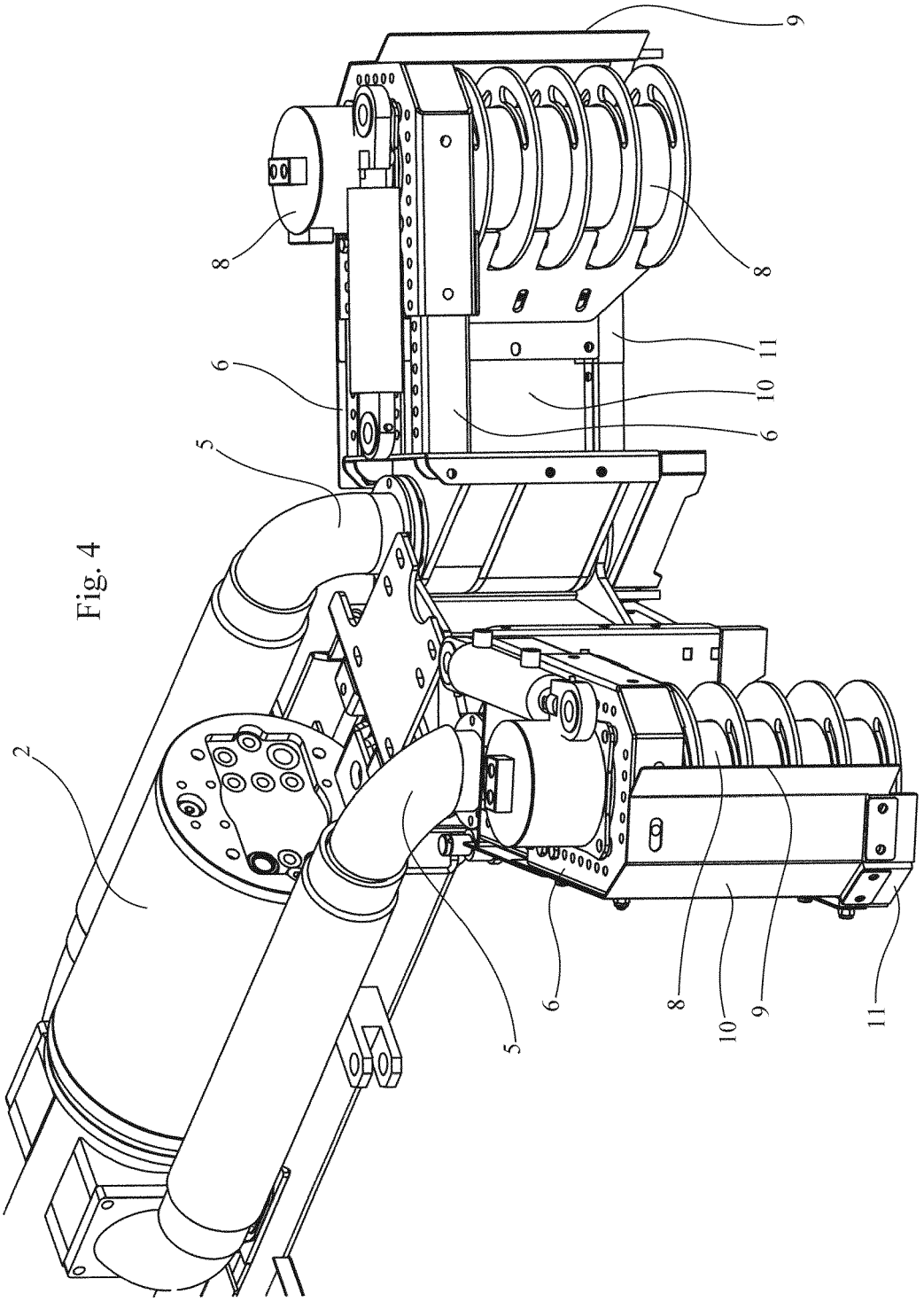

Fig. 4

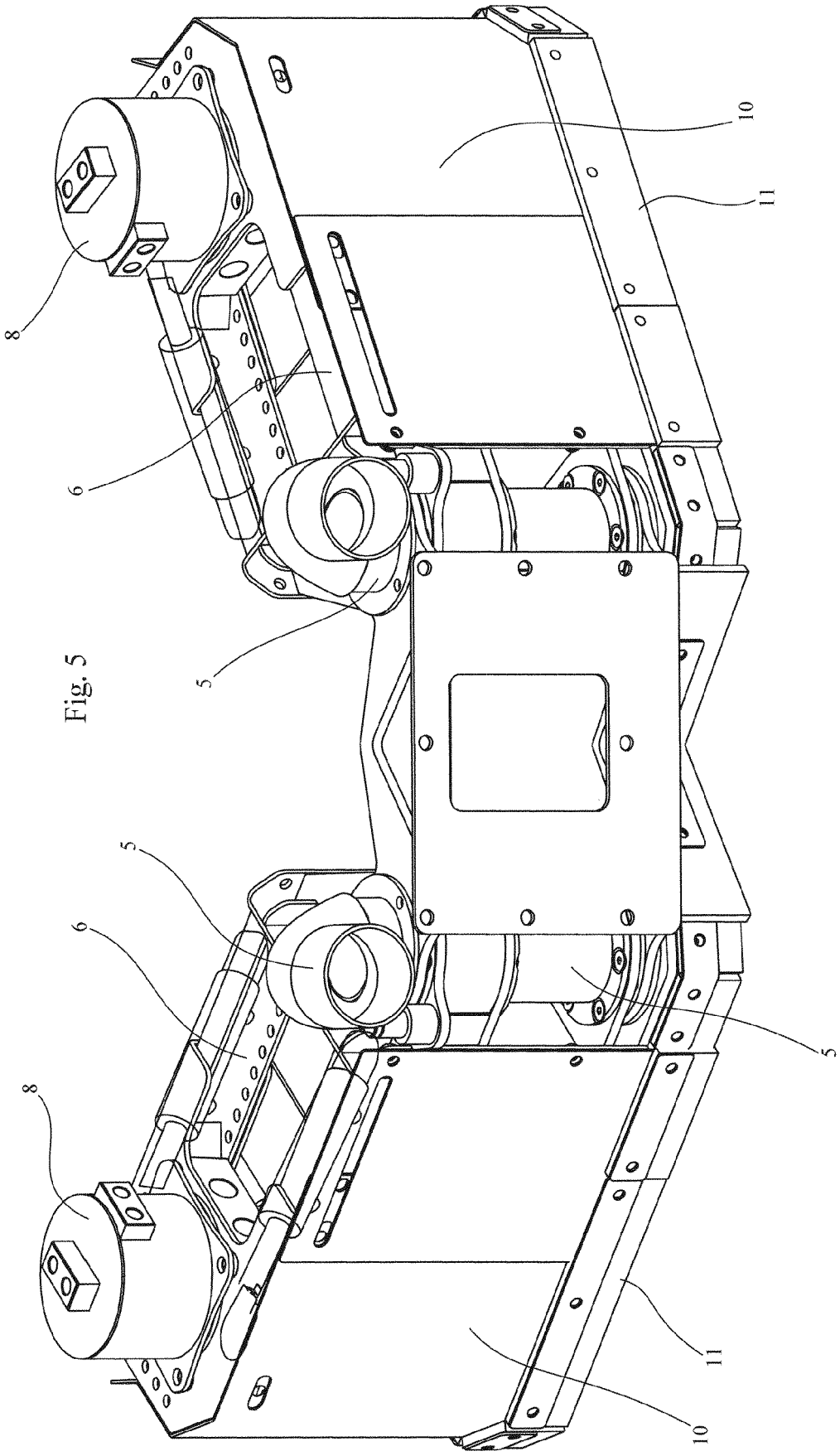

Fig. 5

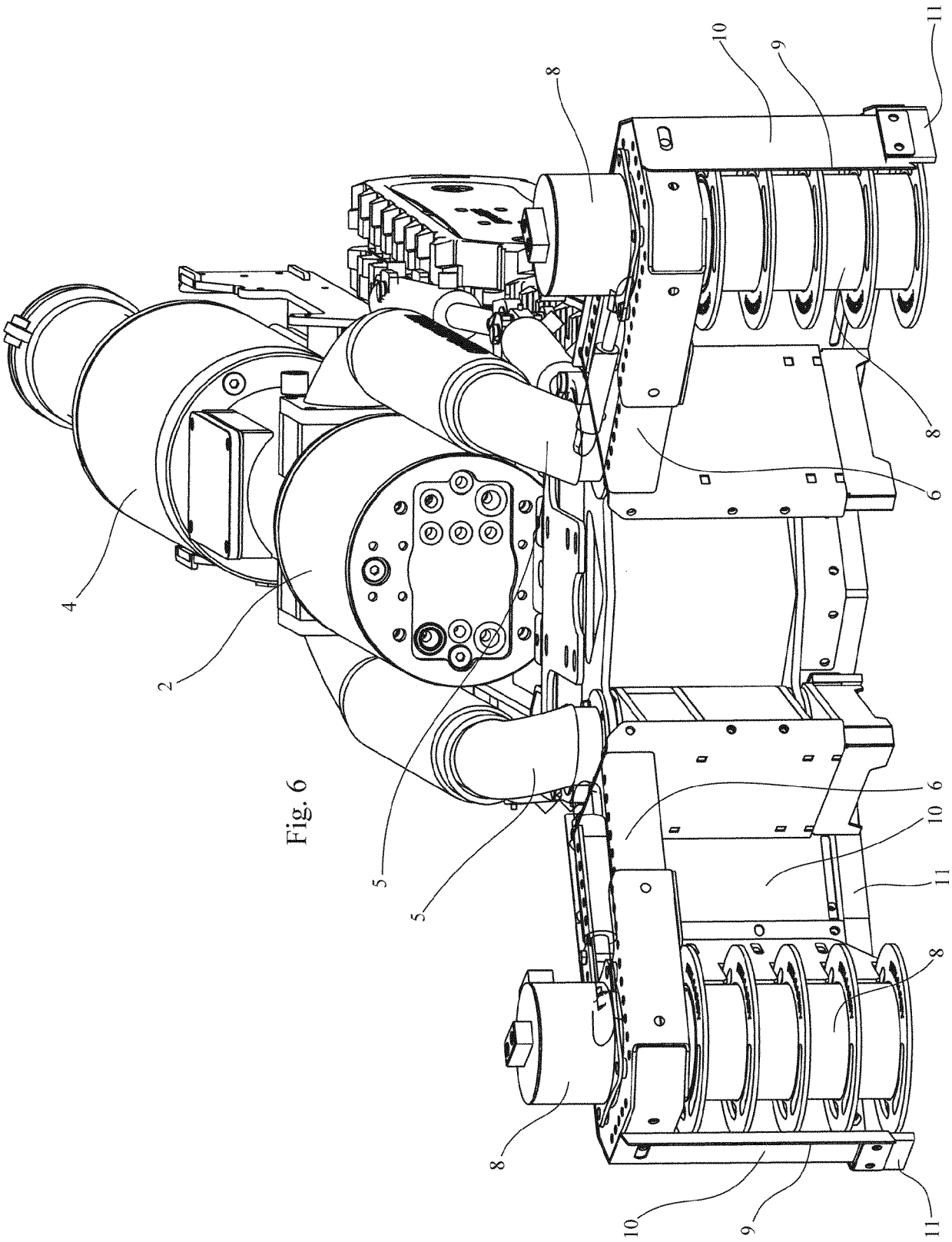

Fig. 6

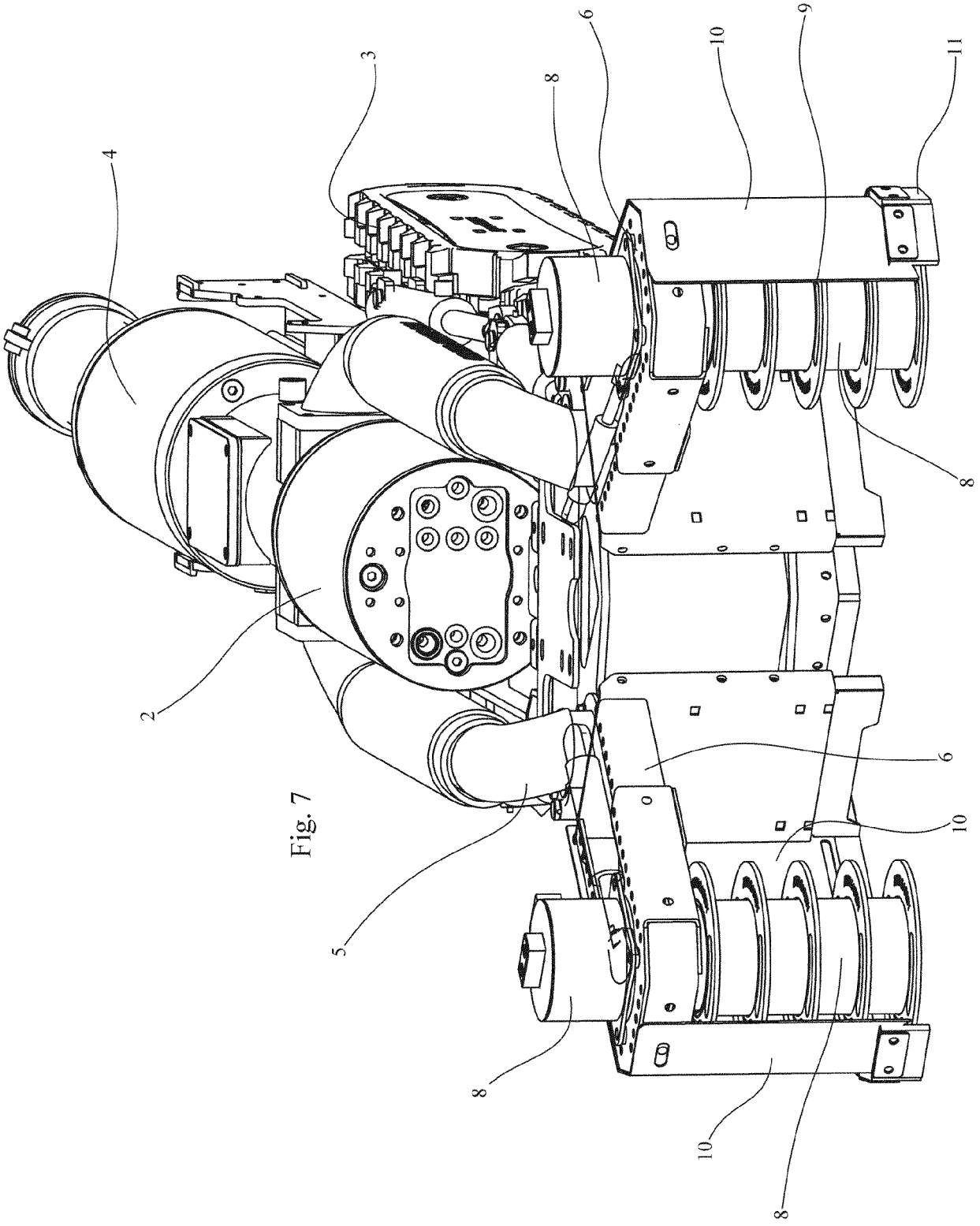

Fig. 7

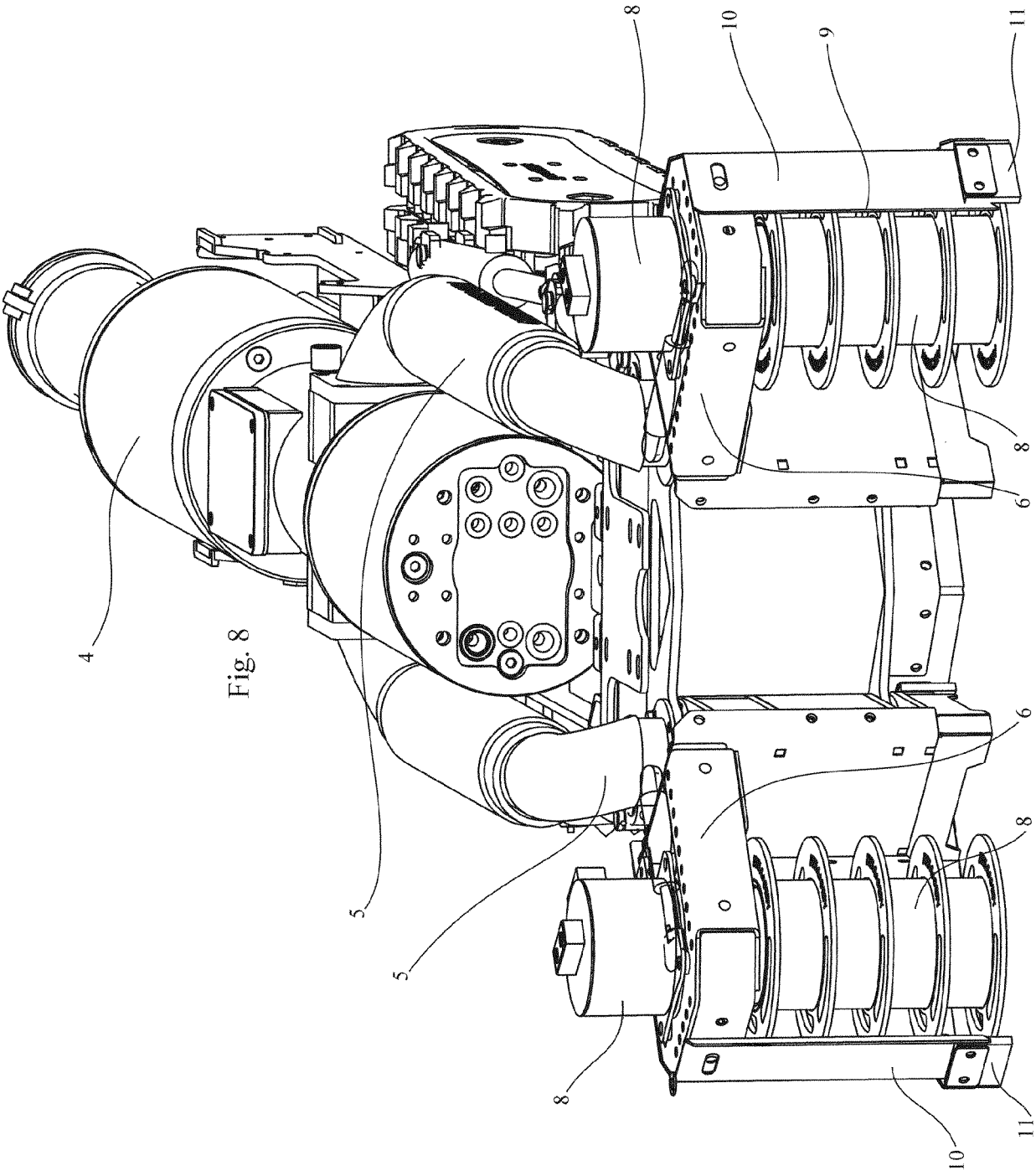

Fig. 8

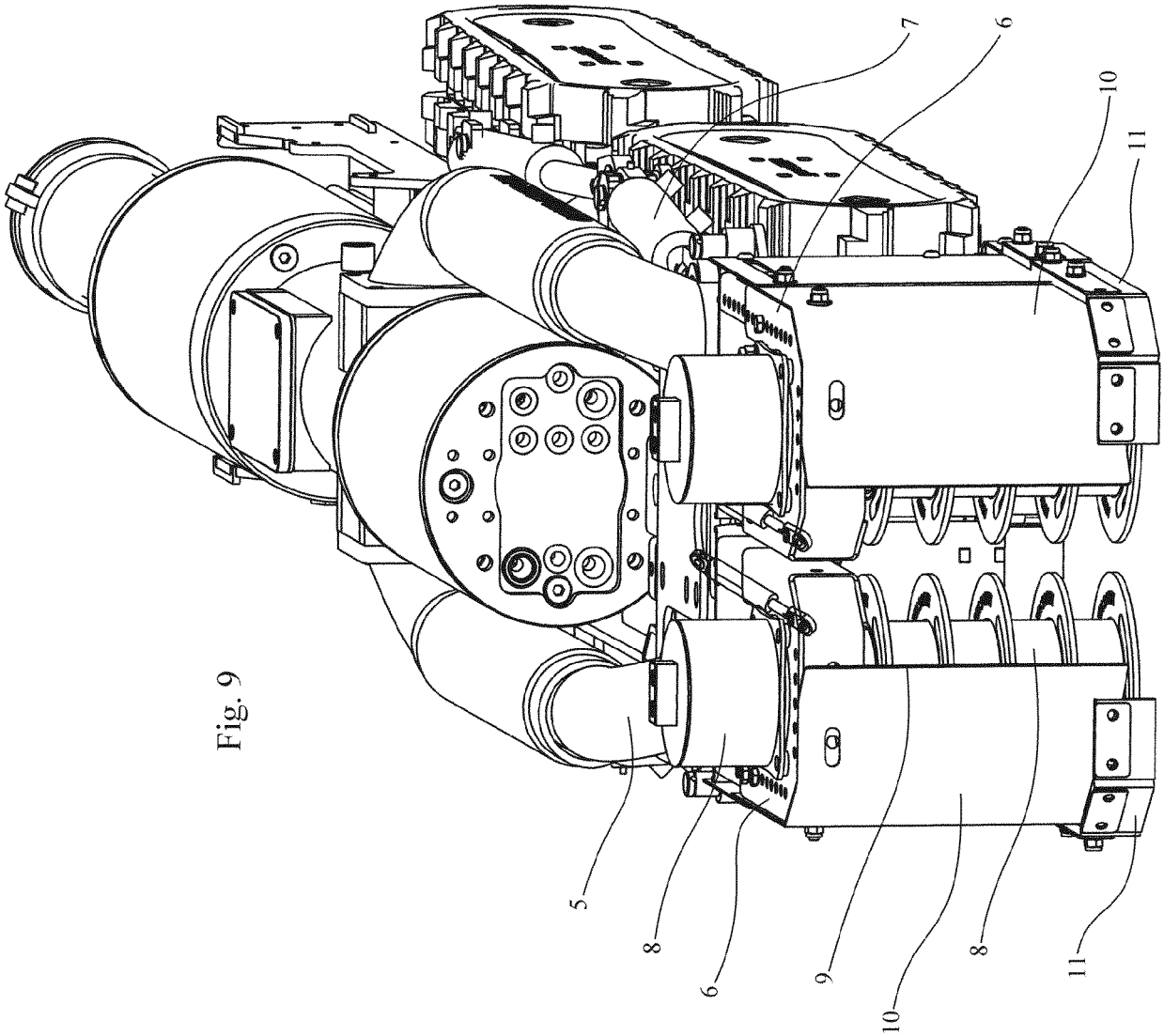

Fig. 9

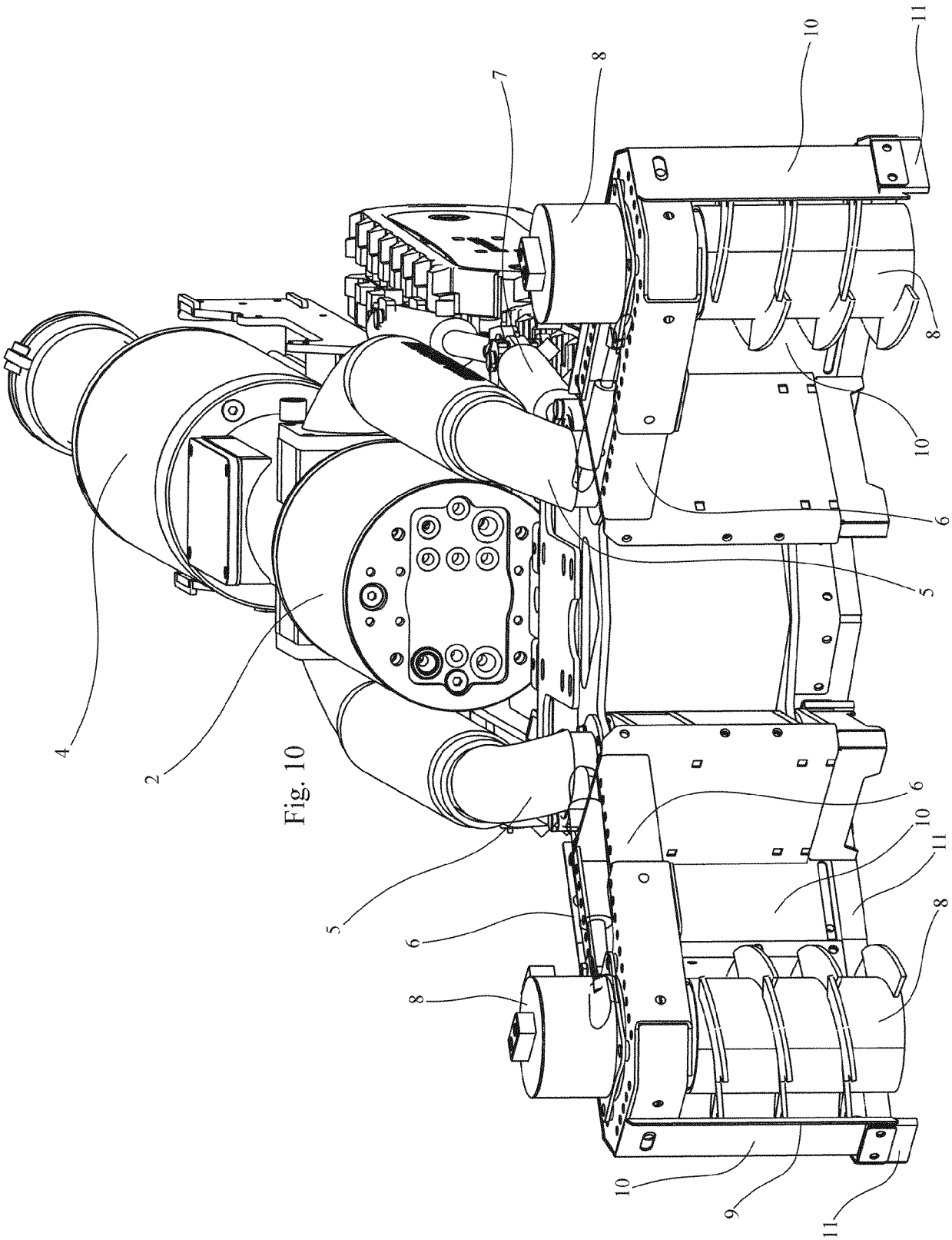

Fig. 10

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EUROPEAN SEARCH REPORT

Application Number
EP 19 17 0952

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The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
The Hague	30 August 2019	Plontz, Nicolas

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
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