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(54) **System for evacuating sludge for a trench excavating machine**

(57) System for evacuating mud produced by a digging machine (10), wherein said machine comprises a digging head (11) arranged to dig the soil, a flexible bearing element (12) arranged to support the digging head during the normal operation of the machine itself, a winch (14) and a drum, about which at least part of such a flexible element (12) can be wound.

Such a system comprises a tank (V) for containing a fluid for mixing and removing the deposits being taken from the tank through a pumping station (P) and being introduced into the excavation in at least one supply duct (2). A mud extraction pump (4) directly associated with such a digging head (11), extracts the mud from the excavation via a mud evacuation tube (F).

The system is characterised in that it comprises at least one ejection duct (5) that receives the light fluid for mixing and removing the deposits from such a supply duct (2) to carry it near to the digging head (11), in such a way that said light fluid for mixing and removing the deposits is conveyed towards the mud evacuation tube (F) by at least part of the stabilising fluid.

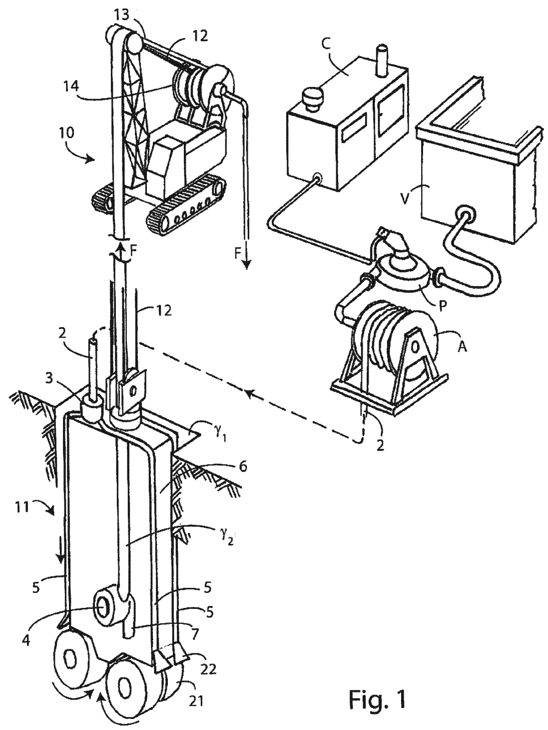

Fig. 1

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Description

[0001] The present invention relates to a system for evacuating excavation mud produced by a digging machine such as for example a milling machine or a cutter, that carry out deep earth excavations.

[0002] These machines aspirate the deposits produced, using a submersible pump housed in the digging machine itself. Usually the excavation site is prevented from collapsing by its being filled with a special mud which also serves as a deposit-transporting mud. The deposits are dragged away by the flow of pumped mud.

[0003] One of the main problems of this system is that as the depth increases, the head required at the pump increases progressively until it exceeds the limit of the pump itself. The pump, which is usually of the centrifuge type, initially finds a balance point at low head and high yield. As the depth increases it reduces its yield to increase the head to the required value, autonomously finding a new balance point.

[0004] In this way at falling yield, the quantity of deposits to be carried away also decreases and as a result the rate of advancement of the excavation slows down. Subsequently the percentage of solid deposits in the mud withdrawn must be reduced by producing less deposits, i.e. by intentionally slowing down the velocity of advancement of the excavation.

[0005] The performance of the system gradually declines until it falls to zero.

[0006] The solution of increasing pump performance is almost always impracticable as resulting dimensions would be incompatible with the reduced dimensions of the excavations and the space required for the digging head itself. Also the transmission of power to the pump, especially in the case of hydraulic transmission, is limited by the length and section of pipe that leads down to the pump from the surface.

[0007] Pump head (measured as pressure), as well as conduit load losses, must equal the product of depth and the difference of density between the mud pumped into the deposits tube and the mud in the excavation.

[0008] This head (P) is expressed as:

$$P = H^*(g_2-g_1) \qquad (1),$$

where H is depth, g_2 is the specific weight of pumped liquid containing the deposits, g_1 is the specific weight of the mud in the excavation, which can be considered constant during excavation.

[0009] Pipeline load losses, in the customary case of fixed length pipes partially wound onto a drum, are not highlighted here, being a constant value if the yield is constant. The mud in the pipe currently is mud in the excavation, rendered heavier due to the excavated deposits. In fact, g_2 is normally greater than g_1. Therefore currently, g_2 reduction is focused on so as to stay within the limits of the pump. This, as previously mentioned, is achieved at the cost of slowing down the advancing of the excavation.

[0010] A solution to this technical problem is described in the American patent application US2008-0296062 wherein, to control the pressure of the mud generated by penetration into the subsoil by means of drilling operations with a rotating drill bit, which operates in particular in submarine environments, a lower-density fluid immiscible with the drilled mud is introduced. An external pump positioned at the surface acts to bring the mud, mixed with this fluid, to the surface itself. The output yield is intermittent. The presence of lower-density fluid allows the mix evacuated by the surface pump to have an overall density lower than the mud produced during the bit drilling, and therefore mud pressure can be maintained between a minimum value of contrast of the acquifer pressure and a maximum value of break-up of the geological stratum.

[0011] The Applicant has observed that this solution is applied to drill bits which penetrate into submarine environments. The technology described in said patent is indeed from the field of petrochemistry, particularly the extraction of natural gas, petroleum and anything else from under the seabed, and is therefore far removed from the scope and the features of the present invention.

[0012] In such a solution, the mud extraction pump must of necessity be disposed on the surface of the hole and can therefore be selected in an optimum way for the required drilling parameters. This means that the geometric dimensions, the power supply and total performance are not limited by tight constraints. However, within the industrial field of the present invention, that is in the area of drilling machinery, and especially deep excavations and walls such as, for example, those produced with hydraulic or electric milling machines, or cutters, as the depth increases, the more difficult it is to evacuate the deposits (which increases with depth, with the differential between containment mud specific weights and those of pumped mud, with the required yield and with load losses) and, the excavation geometry and the machine volume being equal, the available space to house a pump is limited, so the performances thereof cannot be as powerful and efficient as the actual drilling requires. Actually in many conditions of excavation, the limit of the velocity of advancement is determined by the capacity of the pump, housed in depth in order to evacuate deposits.

[0013] Moreover, the aforementioned patent application US2008-0296062, being of a different scope of application, requires the use of drilling systems that are indispensable and characteristic of that type of application, where the presence of gas requires extra security measures. Equally if the excavation system can be considered simplified in this regard in respect of the scope claimed in US2008-0296062, it is considered that the excavation carried out with milling machines and cutters requires other devices, such as excavation direction correction systems, control panels, power supplies (hydraulic and/or electric), pressure compensation systems, cutting tools, and their regulation and control, which complicate the possibility of installing other components in every respect.

[0014] Furthermore, the additional liquid intake system is constructed in a secondary plant arranged in depth, in which liquid and excavation mud are circuited and pumped to the exterior. Finally, the aim of patent US2008-0296062 is not to facilitate the operation of extracting the excavation mud, but to accurately control mud pressure at the point of excavation to stay within a minimum value that counters the interstitial pressure of the water within a geological stratum and a maximum value that can cause the said stratum to fracture. As the pressure of the mud is influenced by the need to raise said mud, and as the aforementioned limits are very close together and highly critical, the solution is to use an independent extraction system. Patent JP07-310322 is also known, which presents an excavation device with cutter wheels and a mud treatment plant in which the capacity of the liquid-solid separator is to be reduced and at the same time control of the stabilising mud within the excavation is to be improved. In order to make this dual function possible, JP07-310322 provides for insertion of a diaphragm or separator baffle able to seal the frame of the cutting body against the excavation walls, thereby creating two separate chambers, an upper one in which the stabilising mud is present, and a lower one containing fresh water. The reason for introducing fresh water is that, within the excavation site, there is no need to stabilise or shore up the excavation walls, and it is therefore much more economical and convenient to use water without bentonite or other additives, thus simplifying the liquid-solid separator plant. The use of water is not executed or correlated to possible increments in pump performance, nor is it carried out for that reason, it is used only to simplify the treatment plant.

[0015] While the mud remains still within the part of the excavation that functions to shore up the excavation walls, the separator baffle seals it off completely from the separate chamber into which the water is introduced. The two distinct pressures that are created within the two chambers are monitored by sensors and can be varied by means of a controller that acts on the bypass valves; in particular by acting on one of these bypass valves, it is possible to control the level of stabilising mud in the excavation and therefore the corresponding pressure value can be conformed to the target one.

[0016] Therefore, the aim of the said patent JP07-310322, as in the case of US2008-0296062, is not to facilitate the extraction of excavation mud, but to control the pressure thereof by aiming not to aspirate the stabilising mud, so as to simplify the liquid - solid separator.

[0017] Another problem with this technical solution is that caused by the presence of sealing members, the separator baffles, which tend to wear out due to rubbing against the wall and need frequent replacement. So for deep drilling this is not a productive solution because the going up and down times within the excavation are very high. In addition, a further problem is created by the control systems necessary for activating these baffles, requiring further plant to be mounted on the digging head and incurring costs for the hydraulic control of these functions. Lastly, as previously mentioned, the aim is not to increase pump performance for deep holes.

[0018] The aim of the present invention is to obviate the aforementioned disadvantages and in particular to provide an excavation mud evacuation system for a digging machine able to facilitate mud extraction even at great depths.

[0019] One aspect of the present invention relates to an excavation mud evacuation system for a digging machine having the features according to claim 1.

[0020] A further aspect of the present invention relates to a method for making excavations through heads for digging and removing the deposits, having the features of claim 11.

[0021] Other features of the system and method are the subject of the dependent claims.

[0022] The features and the advantages of this excavation mud evacuation system for a digging machine according to the invention will become more evident from the following description, which is for illustrative purposes and is non-limiting, referring to the attached figures, wherein:

- Fig. 1 is a schematic view of the system according to a first embodiment of the present invention;
- Fig. 2 is a schematic view of the system according to a second embodiment of the present invention;
- Fig. 3 is a schematic view of the digging head to which the system according to the present invention is applied;
- Fig. 4 is a detailed axonometric view of a lower part of the system, according to the first embodiment;
- Fig. 5 is a schematic view of a digging head to which the system according to another variant is applied;
- Fig. 5A is a schematic view of a digging head to which the system according to another variant is applied;
- Fig. 5B is a detailed axonometric view of an upper part of the system, according to another variant.

[0023] With reference to the cited figures, and in particular to Fig. 1, this system is applicable according to this invention to a digging machine 10, generally a crane or drilling apparatus, self-propelled, caterpillar, which comprises a digging head 11 arranged for excavating soil. This digging head is preferably a cutter or milling machine (hydraulic or electric milling machine) consisting of a main frame in the shape of a prism bearing at the base with two or more cutting horizontal axis wheels. Normally, a flexible bearing element is arranged to support the digging head during the normal operation of the machine itself.

[0024] This flexible bearing element can preferably be a cable, chain or belts, or another elongated member capable of being wound or unwound and capable of supporting the digging head 11.

[0025] In any case, in the remainder of the present description reference will be made, by way of non-limiting illustration, to a bearing cable 12.

[0026] The excavation and/or drilling machine 10 also includes at least one winch 14, at least one drum about which at least part of the bearing cable 12 can be wound. Each winch also comprises a motor arranged for actuating the corresponding drum. At least one second winder element 15 is necessary to move the pipelines 13 used for power supply and control (hydraulic tubes or electric cables) and the excavation mud discharge tube F (which is often inserted in a third and separate winder element).

[0027] The system according to the present invention comprises at least one tank V for containing the added light mixing fluid, which may be for example water, clean mud, bentonite mud, or a polymer-based fluid, or liquids of various types that are added more or less in order to obtain appropriately defined densities. In particular, this density will be lower than that of the stabilising fluid present in the excavation and, after their mixture with the deposits to be extracted or simply their transportation associated with the movement of the light fluid, a value g_2 will be reached that is very close to g_1, the density of the fluid in the excavation.

[0028] This light fluid is taken up from the tank by a pumping station P, preferably installed externally to the hole, and introduced into at least one supply duct 2. This supply duct goes underground, together with the hydraulic pipes supplying the excavation motors 13, the pump feeder pipes 13 and the mud evacuation tube F, until it arrives close to digging head 11.

[0029] This fluid supplied tube can be advantageously taken up on the surface by means of a winder device A.

[0030] This winder device A can be installed externally to and close to the hole, advantageously self-propelling. In one variant not shown, the same winder device can be located on the digging machine 10. Furthermore, a supply tube 2 can be connected to the mud evacuation tube evacuation tube F and both wound by a single winder.

[0031] According to the present invention, a mud extraction pump 4 is directly associated with the excavation milling machine frame 6, which is inserted into the ground and in which the light mud mixing fluid is provided in the excavation near the aspiration duct 7 of this pump via this at least one supply tube. Pump 4 is furthermore connected to the mud evacuation tube F. In the embodiment illustrated in Fig.1, supply tube 2 is connected to digging head 11 and is provided at its end with a collector/distributor 3 adapted for distributing the fluid in a plurality of ejection ducts 5 which receive the fluid from the supply tube 2, each of which ends near to the area of production of the deposits, the area in which the fluid is ejected, in such a way that the light fluid for mixing and removing the deposits is conveyed toward the mud evacuation tube F by at least part of the stabilising fluid. So the collector/distributor 3 is adapted for promoting transportation of the light fluid for mixing and removing deposits by the stabilising fluid present in the excavation.

[0032] Each of the ejection ducts preferably ends near to the spaces between the teeth 25 of the digging drums that, with their rotation, accompanying the flow, together with the stabilising mud and deposits, toward the suction mouths 8 of the mud suction pump 4. Furthermore, the presence of the stabilising mud, which is found above the area in which the light fluid is introduced, creates a current towards the suction mouth, capable of conveying the light fluid introduced near the wheels, in the same direction. By modulating the quantity of light fluid introduced between a minimum and a maximum value (for example close to the maximum pump output at the depth reached) it is possible to optimise the efficiency of pumping of the deposits by modulation of the density of the fluid resulting from mixing of the light one introduced and the stabilising one already present in the excavation. In an alternative embodiment, the light fluid ejection ducts 5 end near the upper area of the cutter wheels and posterior to said wheels, which ducts are equipped with solid-section or appropriately tapered ends, like the diffusers 22 in Fig. 4, or are in the is form of a nozzle to aim the flow of light fluid in a precise direction at higher pressure. In another variant, a single ejection duct 5, coincident with the duct 2, arrives centrally within the excavation area, between the wheels 21.

[0033] In another variant, the ejection duct 5 that receives the light fluid for mixing and removing the deposits, coincides with the end segment of the supply tube 2 from which the light mixing fluid goes out. In general, for the purposes of the present invention, "ejection tube" can also be used to mean merely an opening or mouth of the supply duct from which this fluid goes out.

[0034] In this way, apart from the principle effect of carrying light liquid at lower density and therefore limiting the density g_2 of the pumped liquid, greater cleanliness of the drums bearing the excavation teeth is achieved, which teeth frequently become clogged with clay deposits. The mixing fluid introduced transports the deposits to the area of the suction duct 7, promoting their evacuation.

[0035] In the case wherein the ejection ducts 5 consist of nozzle end segments or are any way fed at sufficient pressure, it is then possible to arrange these segments in an area along the digging head 11, far enough away from the wheels 21.

[0036] In another variant, the supply tube 2 that carries the light fluid can arrive up to the lower base to deliver it into a central area in proximity to the wheels, or can be ducted lower down in the previously described areas of excavation and pump aspiration. Again, the ejection ducts 5 that run vertically as far as the wheels may be single (at least one for each side) and end for example with a central diffuser or, alternatively, finish with a terminal collector, which directs the flow in the most advantageous directions.

[0037] In another variant, appropriate conveyors 9, limit and partially separate the area of flow of the light fluid, stopping or limiting its dispersion into the stabilising fluid present in the upper part of the excavation. In Figs. 1 and 2, a draft form is shown wherein the width of the cutting wheels 21 is close to that of the frame, so that a transit of heavy stabilising mud stays on the periphery, creating a current towards the suction mouth. In Fig. 3, however, a draft is shown wherein the thickness of the cutter wheels 21 is much greater than that of the frame, therefore it is advantageous to laterally confine, by means of the conveyors 9, the flow of introduced light liquid, to avoid dispersion thereof and promotes transportation by means of the wheels. These conveyors 9 are advantageously made of deformable material such as thin sheet steel, sheets of rubber or plastic polymers, or they may be rigid and hinged relative to the digging head 11, possibly equipped with an elastic return. This feature permits to leave a free space, in the event of a collapse of the hole, for deposits descending from above to be drawn off.

[0038] Pump 4 is advantageously arranged inside the body of the cutter in such a position as to collect the deposits and mud moved by the excavation teeth.

[0039] In the embodiment illustrated in Fig. 2, a couple of supply ducts 51 are inserted into the mud evacuation tube F downstream of the pump 4.

[0040] In this way, the excavation mud and deposits is mixed, diluted and made lighter with addition of a light and low density liquid. This system does not risk dispersing the light mud in the excavation and particular diaphragms or conveyors are not required.

[0041] The supply duct 51 may also be single, in this case the transit section will be appropriately sized. It is evident that this solution can work with a much reduced yield of light fluid compared to the solution previously described and this implies an advantage in terms of space for the pipelines 51, which can therefore have a much smaller diameter and at least be managed not as an additional tube on adjunctive winder but be located within the group of hydraulic tubes and excavation device electric control cables with all the advantages and simplification of plants. Obviously, performance and the benefits in terms of pump output will be reduced compared to the initial solution.

[0042] In a preferred embodiment, this at least one supply duct 51 arrives onto a collector 24 having diffuser and ejector functions. The fluid introduced on the collector 24, preferably orientated from low to high (with a 180° curve) facilitates the raising of the material in the mud duct F, by virtue of its orientation and the low density of the fluid introduced. In this case also, as in the previous one, the pumped fluid that flows within the pump delivery duct, conveys the light fluid in the direction of the exit.

[0043] In one variant, the supply ducts 51 can arrive upstream of the pump 4, along the aspiration duct 7. In this way, the light mixing fluid will not be dispersed and it will cross the pump 4, conveying deposits and mixing with excavation mud which will convey it towards the direction of the exit.

[0044] Such an embodiment of the system can advantageously be used in combination with the previous system or that described at the beginning, using light fluid in aspiration and further diluting it along the evacuation duct.

[0045] This combination, represented in Figs. 5, 5A and 5B, is particularly advantageous when the production and transportation of deposits are very elevated. By varying the proportion of the two flows, advantages are obtained principally in respect of head or principally in yield. Moreover, by introducing a second flow onto the delivery, it is possible to reduce the fluid output on aspiration and consequently reduce the dimensions of the pipelines.

[0046] The system thus described is independent of excavation depth and pump output because it is possible to select how to regulate the densities of the two fluids: g_2 pumped and g_1 in the excavation, it is possible to obtain values such that these densities are equal and the term expressed by their difference is cancelled out. Referring to formula (1), we actually obtain: (g_2-g_1) =0 and therefore the head P=0.

[0047] In this way, by pumping lighter liquid than that present in the excavation, it is possible to increase the quantity of transportable deposits in much greater measure compared with the current situation, it being possible to maintain yield and density close to the maximum values compatible with pump.

[0048] This term (g_2-g_1) can be varied according to requirements and in particular can become negative to improve excavation performance as depth increases, which is the opposite of what usually happens. In this case the density of the pumped fluid g_2 must be less than the density of the fluid present in the excavation. Different techniques can be used to achieve this and can be used in combination one with the other to complete the effects:

- To reduce light fluid density so that the term g_2 can be small.
- To implement the density g_1 of the fluid present in the excavation, for example with top-ups carried out from the top or using internal channels to take the top-up also deep down.
- To reduce the quantity of deposits transported by the light fluid and pumped as final fluid of density g_2.

[0049] The excavation mud must however remain heavy, and the solution must be applicable in the preferential form indicated in Fig. 1, and the conveyance of clean light mud directly to the excavation area. The yield of this fluid can be equal to or a little higher than the fluid yield removed.

[0050] Any yield in excess of light liquid, could rise within the excavation and mix with the fluid in the hole, causing gradual lightening thereof and lowering its density g_1. This value may be monitored with appropriate equipment and controlled with more dense mud top-ups to re-establish the required g_1 value. Furthermore, this mud is partially aspirated by the pump so the top-up is necessary in every case. In addition or alternatively to the top-up system, it is known to use surface aspiration systems, positioned at the top of the hole, where the liquid with the lightest g_1 is concentrated and can be drawn off. This system combined with the previous one enables the level of liquid within the excavation to be kept constant. Another advantage of this system is linked to the fact that it exploits the current of stabilising mud and the movement of the wheels to convey the light liquid toward the exit duct, avoiding the need to seal the whole area above the wheels with movable elements subject to wear. Also the exploitation of the partial aspiration of stabilising mud achieves a further advantage of containing the quantity of light fluid to be introduced in proximity to the excavation head 11, proportionately reducing the dimensions of pipelines.

[0051] The excavation area, in the form represented in Fig. 4, can be partially separated from that excavated and filled with heavy mud. This is achieved above all with the direction to introduce light fluid into the area of deposits production, with rotary movement of the wheels, with the flow of stabilising mud in the hole, and possibly with a partial physical separation, using for example the conveyor baffles 9. Advantageously, these conveyors enable the light fluid introduced to be contained in a zone between the excavation walls, the cutter wheels and the aspiration tube 7 of pump 4.

[0052] In this way, the efficiency of aspiration of the light fluid that conveys the deposits is guaranteed and the leakage of light liquid is maximally limited or reduced to zero. Also the light fluid introduced and the deposits will be found toward the aspiration holes 8 of the duct 7, increasing the system's efficiency. Conveniently, in contrast to that which is represented in Fig. 1, the structure of the frame of the digging head 11 can be built with hollow tubular which allow the light fluid to flow in their interior, until they bring it to the areas near to the pump's suction ducts. In the combined version where the fluid input is both upstream and downstream from the pump, this can be also introduced by a only one of the supply ducts 2 indicated in Fig.s 1 and 2 and by an appropriate collector 3 for derivation of the light flow that can be remotely operated, the outputs of the two branches can be selectively controlled, giving priority to one, the other or both.

[0053] The preferred excavation procedure provides for introduction of the digging head 11 in the pilot hole to start drilling operations. Immediately or starting at a certain quota, external pump P is turned on which crosses the at least one supply line 2, draws from a suitable tank or external silo V, a light fluid of controlled density, to introduce near the submerged pump 4 housed on the digging head 11. The input of light mud can take place in a low area, near wheels 21 placed under the frame, in an area below the excavation and near pump 4 suction duct 7, or it can be near the delivery of pump 4, downstream from it or as a combination of both systems. The light fluid input, in all the ways previously described, is conveyed by at least the stabilising mud flow which is pumped in part out of the excavation and that in its movement conveys the light fluid in the direction of the exit. In the first method described, with reference to Fig. 1, the rotary movement of the wheels causes a containment flow conveying the light input fluid toward the exit duct through pump 4. Finally, also in the case described in reference to Fig. 4, also conveyors 9 work to convey light fluid toward exit duct F of pumped mud.

[0054] In the hole, there is a sensor at least at a depth that detects excavation mud density, equal to g_1. Conveniently this sensor can be mobile or connected at the top of digging head 11, at a fixed point.

[0055] A second sensor is connected at the bottom near the suction mouth or alternatively on the delivery line to measure the density of suctioned mud g_2. The density of light mud can be ascertained outside the excavation, for example near storage tank V.

[0056] During the excavation, all the advancement velocity parameters, rotation speed, submerged pump yield and pressure, density of fluids and yield of light fluid, are monitored by a control panel (not shown) that displays data in real-time to the operator during excavation.

[0057] In particular, the density g_2 of pumped fluid and the density g_1 of excavation mud are measured and the yield of light mixing fluid is varied during the phase where fluid is introduced into the excavation when the differential element (g_2-g_1) moves away from the required value.

[0058] In fact, when the difference between the two densities, such as when the differential element (g_2-g_1) moves away from the required value (for example 0), the yield of light fluid can be varied to increase the amount of the introduced low density material and to allow a better deposits removal, or density of light fluid can be reduced (lighter mud, additives, ...) or again increase the density g_1 of the fluid in the excavation with the top-up of more dense fluid or reduce digging speed. Reducing digging speed produces a small quantity of deposits which subsequently decreases pumped fluid density g_2.

[0059] Therefore, to sum up, excavation method according to the present invention has the following phases:

- the insertion of the head in the ground which is to be excavated;
- during the excavation phase, a light mixing fluid is to be introduced into the excavation having a lower density than the density of the mud contained in the aforementioned excavation,

- the extraction of at least the mixing fluid, part of the stabilising fluid and excavation deposits transported by it by said extraction pump 4 associated directly with digging head 11,

- conveyance of light fluid through the stabilising fluid present in the excavation, toward exit duct F.

[0060] In these working phases the mixing fluid is supplied directly to the area near digging head 11.
[0061] In another variant, supply duct 2 arrives close to the digging head 11, releasing the light mixing fluid downwards orienting it toward the excavation area. Preferably this supply duct 2 is mobile and positionable inside the excavation section in order to direct it in the best direction. In this case ejection duct 5 which receives the light mixing fluid and removal of deposits, coincides with the end segment of supply duct 2, from which the light mixing fluid goes out.
[0062] In another variant, supply duct 2 is provisionally fixed to digging head 11, and can be unhooked or hooked intentionally using known devices.
[0063] From the description, the control system characteristics and advantages for a soil excavation and/or drilling machine are clear which is the purpose of this invention. The system is independent of depth or pump yield.
[0064] The (g2-g1) differential term can be cancelled out to cancel the head, allowing the submerged pump to stop leakage guaranteeing the minimum required yield for the removal of heavier deposits.
[0065] The (g2-g1) differential term can be cancelled out to aid the submerged pump to increase its performance as it gets deeper.
[0066] It is possible to obtain a greater cleaning of the excavation teeth, which, consequently will always be in optimal excavation conditions increasing their efficiency.
[0067] It is possible to combine different solutions for pump upstream and downstream inlet in order to obtain combined advantages in yield and head.
[0068] The system does not require secondary plants for removing deposits, but the same ducts present on machine F are used.

Claims

1. System for evacuating mud produced by a digging machine (10),
wherein said machine comprises

• a digging head (11) arranged to dig the soil,
• a flexible bearing element (12) arranged to support the digging head during the normal operation of the machine itself,
• at least one winch (14) and at least one drum, about which at least part of such a flexible element can be wound (12),

such a system comprising

• at least one tank (V) for containing a mixing fluid, having a lower density than the density of the mud contained in the excavation, such a light fluid for mixing and removing the deposits being taken from the tank through a pumping station (P) and being introduced into the excavation in at least one supply duct (2),
• a mud extraction pump (4) directly associated with such a digging head (11) and connected to mud evacuation tube (F), **characterised in that** it comprises

at least one ejection duct (5) that receives the light fluid for mixing and removing the deposits from such a supply duct (2) to carry it near to the digging head (11), in such a way that said light fluid for mixing and removing the deposits is conveyed towards said mud evacuation tube (F) by at least part of the stabilising fluid.

2. System according to claim 1, wherein the supply duct (2) is connected to the digging head (11) and is provided at its end with a collector/distributor (3), adapted for selectively distributing fluid in a plurality of ejection ducts (5), each of which ends near to the area of production of the deposits, said collector/distributor (3) being adapted to promote the transportation of the light fluid for mixing and removing the deposits by the stabilising fluid present in the excavation.

3. System according to claim 2, wherein each of the ejection ducts (5) ends near to the spaces between the teeth (25) of the digging drums that accompany its flow, together with the stabilising mud and deposits, toward respective suction mouths (8) of the mud suction pump (4).

4. System according to claim 1, wherein the supply duct (2) is inserted into the mud evacuation tube (F) downstream of the pump (4).

5. System according to claim 1, wherein the supply duct (2) is inserted into the mud evacuation tube (F) upstream of the pump (4).

6. System according to claim 1, wherein such a mixing fluid is water, a bentonite mud, or a polymer-based fluid.

7. System according to claim 1, wherein the flow of low-density mixing fluid is conveyed toward the suction area by conveyors(9) fixed to the digging head (11).

8. System according to claim 7, wherein the conveyors (9) partially separate the digging area crossed by the low-density mud from the rest of the excavation full of higher- density stabilising fluid.

9. System according to claim 7, wherein the conveyors are made from deformable material such as steel sheet of low thickness, sheets of rubber or of plastic polymers.

10. System according to claim 7, wherein the conveyors (9) are hinged rigid elements.

11. Method for making excavations through heads for digging and removing the deposits through a pump associated with the digging head,
comprising the following steps:

- inserting such a head in the ground in which it is wished to make the excavation;
- during the step of making the excavation, introducing a light mixing fluid into the excavation itself, having a lower density than the density of the mud contained in the aforementioned excavation,
- extracting at least such a mixing fluid, part of the stabilising fluid, and excavation deposits through such an extraction pump (4) directly associated with such a digging head (11) and connected to a mud evacuation tube (F), **characterised in that** such a mixing fluid is supplied directly to the area close to the digging head (11) and that said light fluid is conveyed by the stabilising fluid present in the excavation, toward said mud evacuation tube (F).

12. Method for making excavations as in claim (11), wherein said fluid for mixing and transporting deposits is fed close to the suction (7) of the pump (4) directly in the excavation area.

13. Method for making evacuations as in claim (11), wherein said mixing fluid is fed close to the delivery of the pump (4).

14. Method for making evacuations as in claim (11), wherein said mixing fluid is fed both close to the delivery of the pump (4) and in its suction.

15. Method for making evacuations as in claim (11), further comprising the step of measuring the density g_2 of the pumped fluid and the density g_1 of the excavation mud and of varying the output of the light mixing fluid during the step of introducing the fluid itself into the excavation when the differential term (g_2-g_1) deviates from the target value.

16. Method according to claim 15, wherein such a varying step comprises reducing the density of the light fluid so that the term g_2 can be small.

17. Method according to claim 15 wherein such a varying step comprises increasing the density g_1 of the fluid present in the excavation, for example with top-ups carried out from the top or using internal channels to take the top-up also deep down.

18. Method according to claim 11, also comprising the step of reducing the amount of deposits that are transported by the light fluid and pumped as final fluid of density g_2, reducing digging speed.

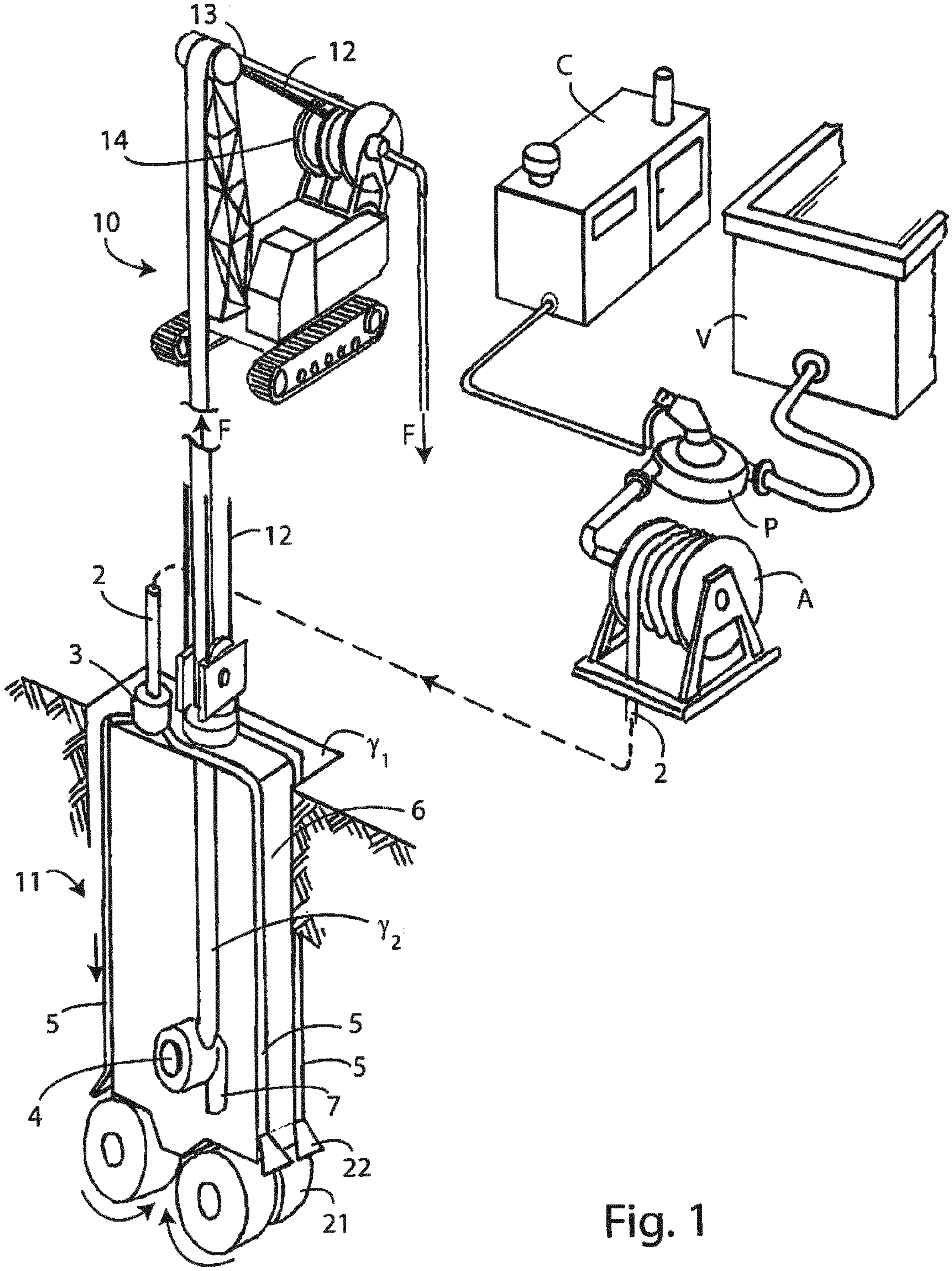

Fig. 1

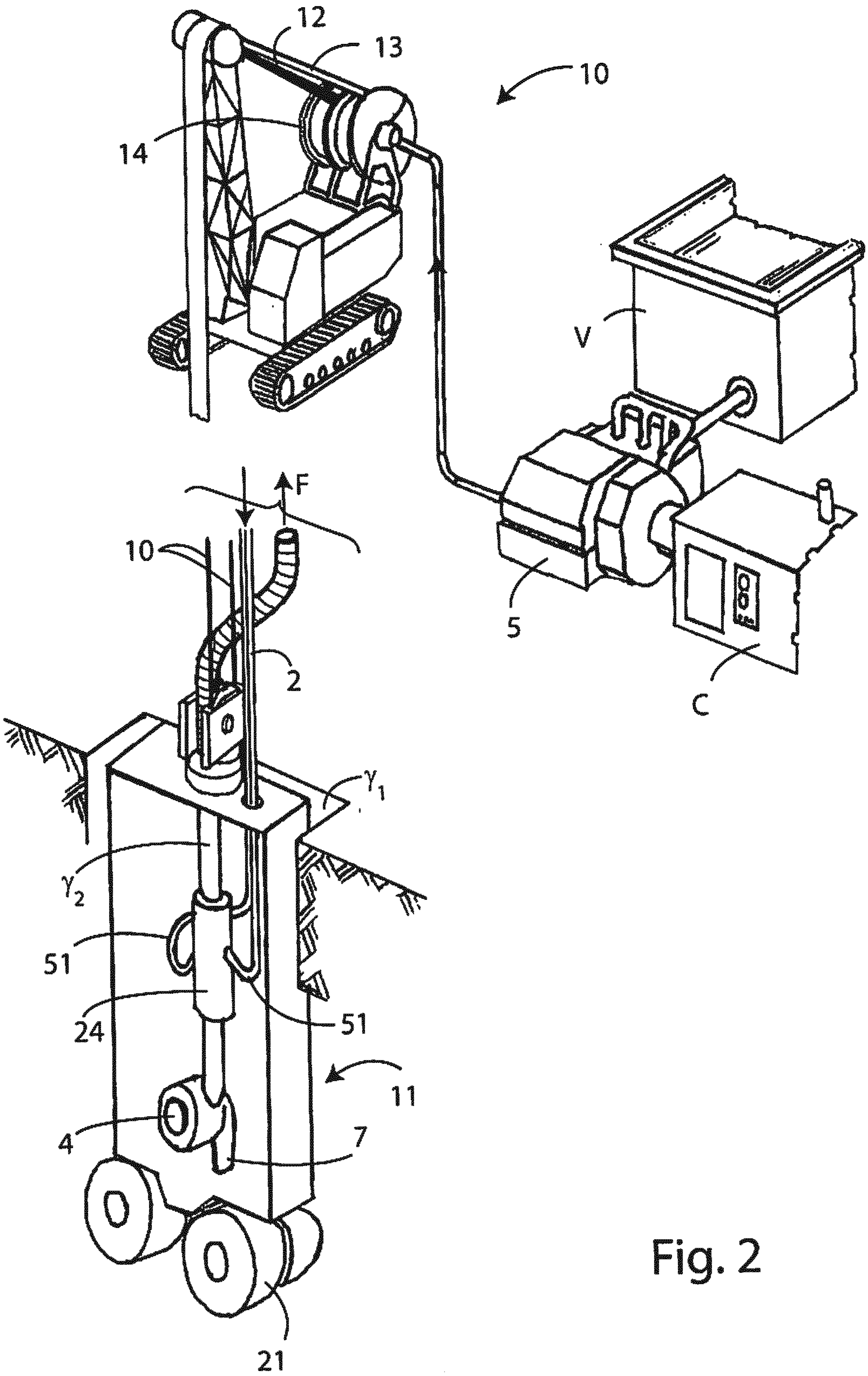

Fig. 2

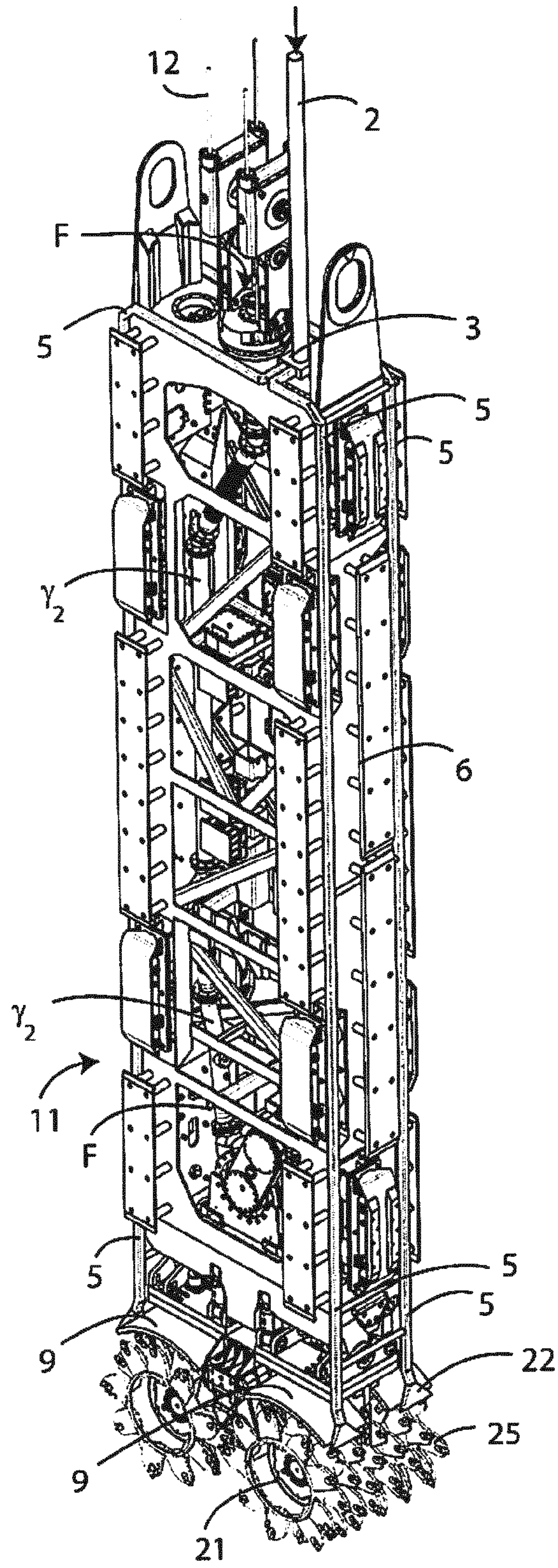

Fig. 3

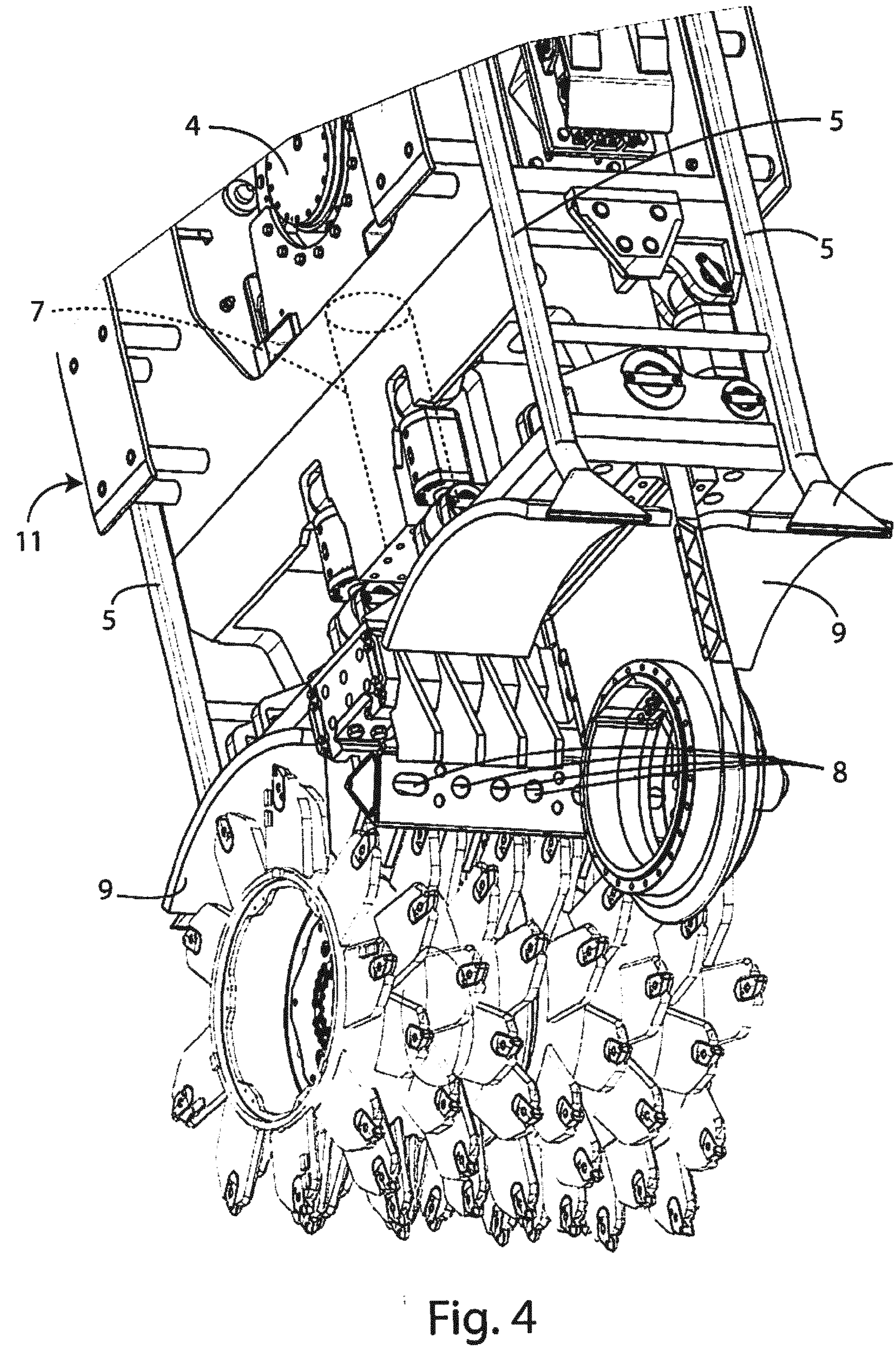

Fig. 4

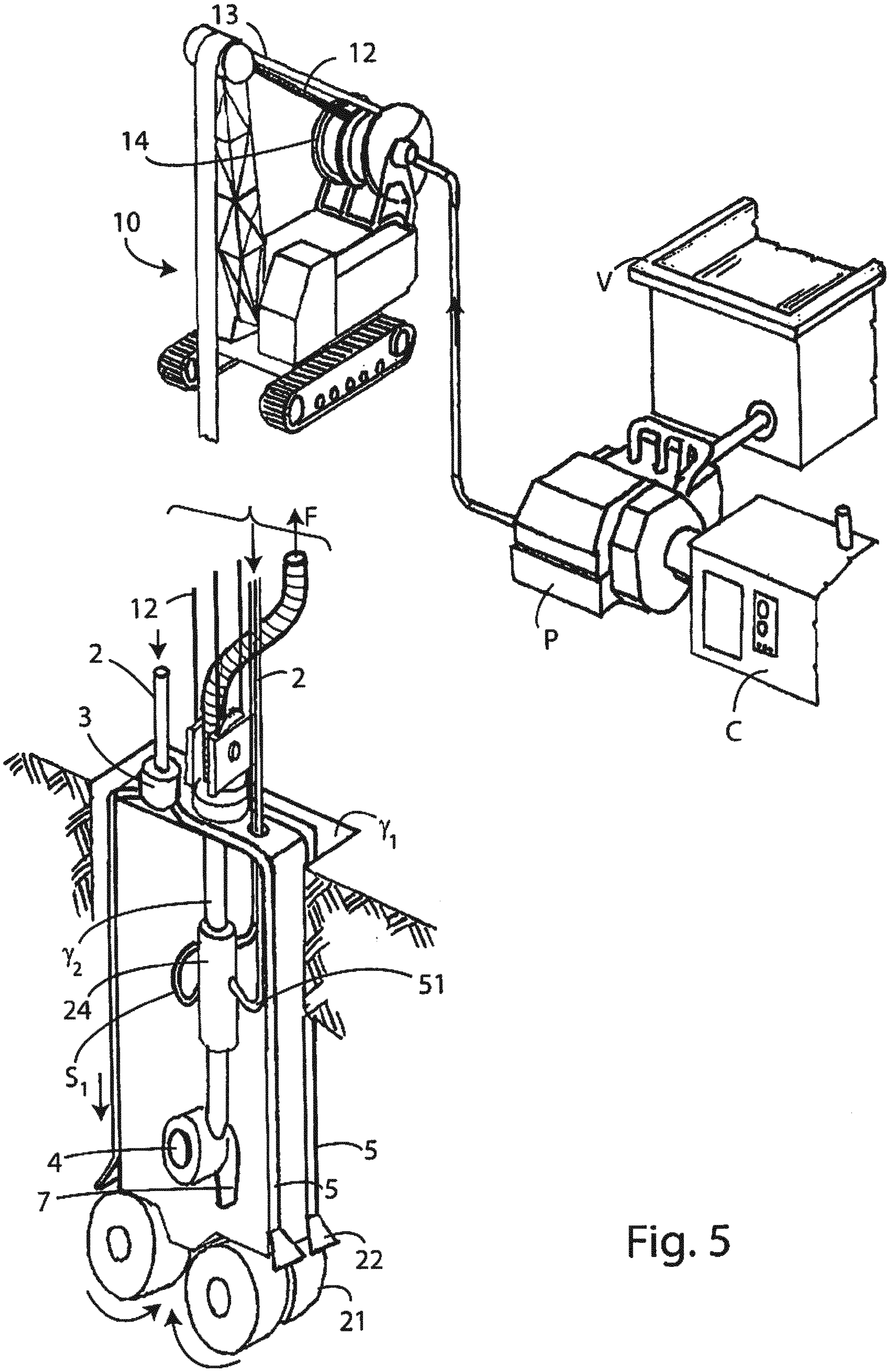

Fig. 5

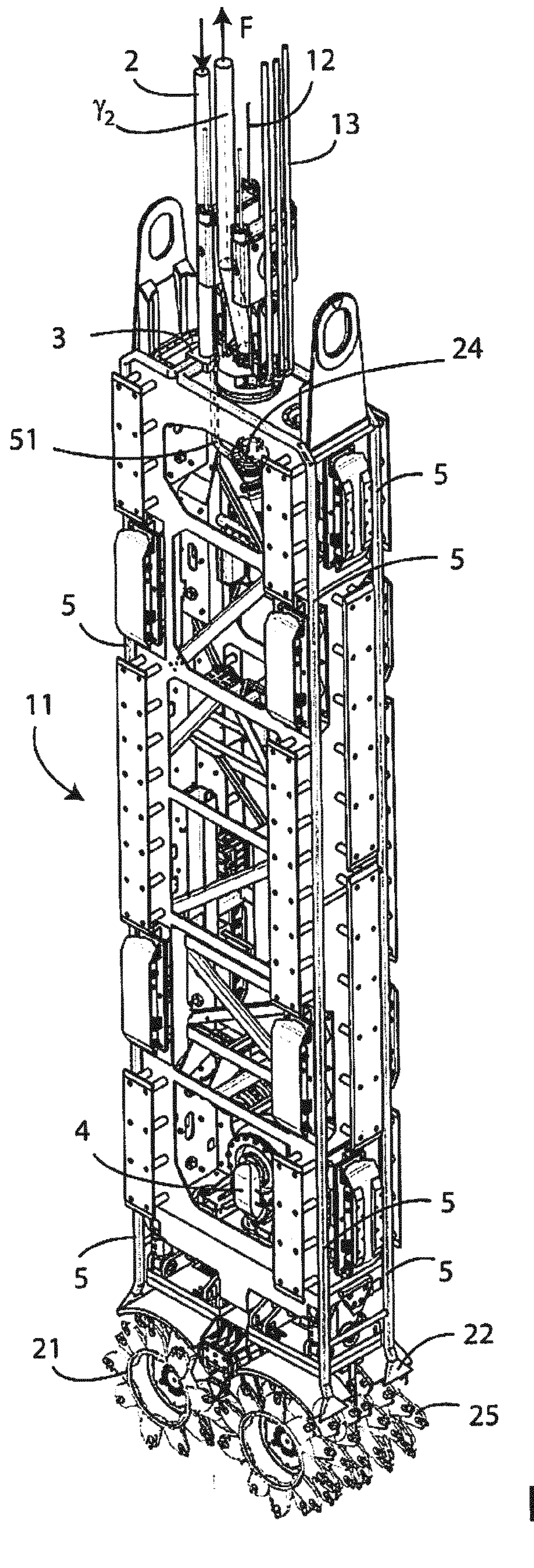

Fig. 5A

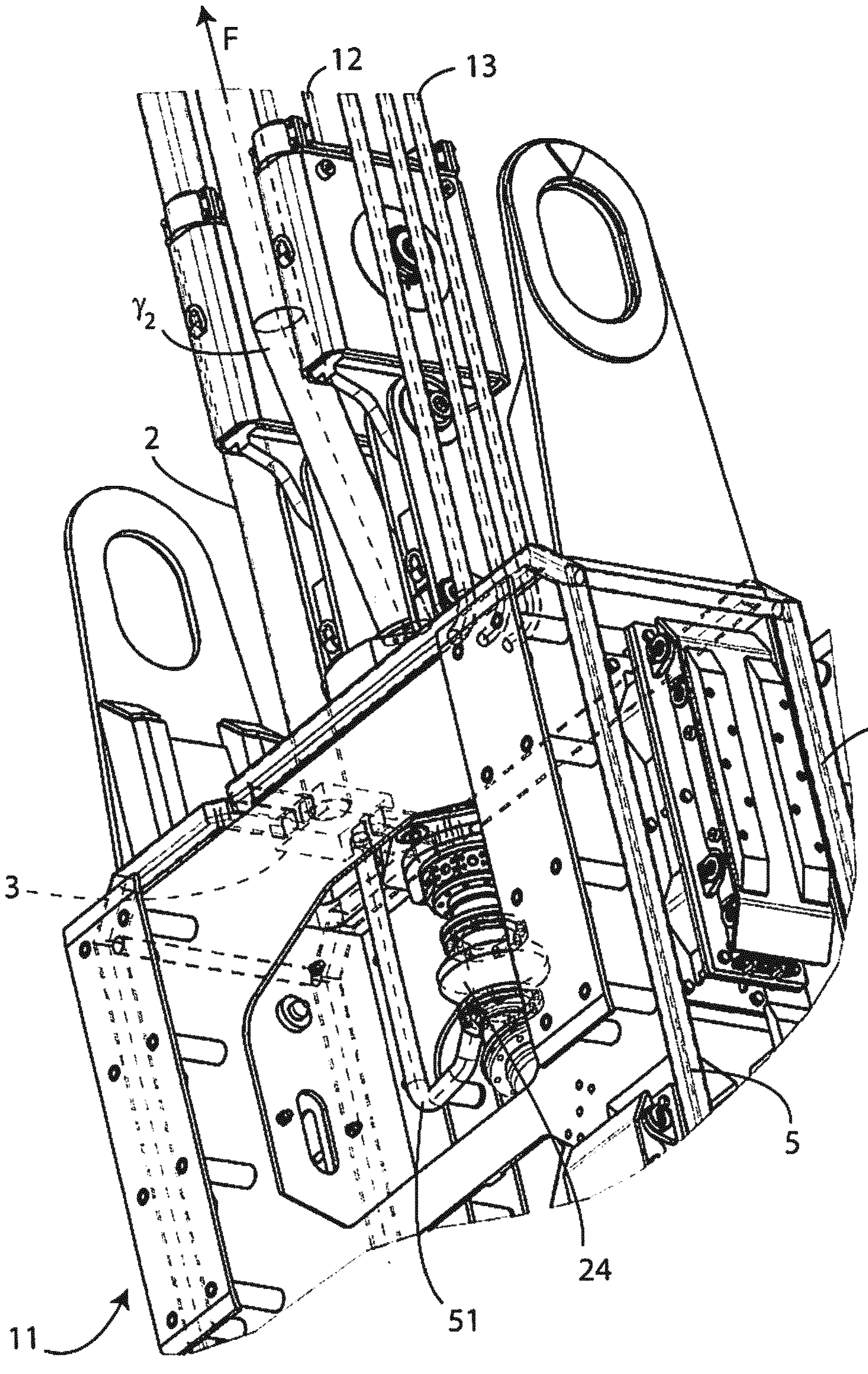

Fig. 5B

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EUROPEAN SEARCH REPORT

Application Number
EP 12 18 9536

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Place of search	Date of completion of the search	Examiner
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