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(54) **Equipment and method mixing in loco for the formation of diaphragms**

(57) Described herein is excavation equipment for mixing *in loco* excavated soil and for the formation of diaphragms within the excavated hole of the type constituted by a plurality of rods for drilling soil (10) arranged alongside one another; each rod performs a rotary and translational motion about and along its own axis; supplied along the rods is a thickening fluid that exits with high kinetic energy through nozzles (23 and 24) made in positions corresponding to bits of a set of bits (11) located at the free ends of the rods (10) and rendered fixed in rotation and translation therewith; the bits are intercon-

nected and separated by means of fixed structures (16, 16') that guarantee non-interference and maintenance of the distance between them; the bit of each rod (10) is equipped, at its ends, with disaggregating means (14) and, at the centre, with means (18, 21) for mixing the soil and said aggregating fluid; the bits are enclosed at least partially within a quadrilateral caisson (12), designed to line the walls of the excavated hole as the equipment advances with the excavation in the soil; the nozzles (23, 24) are directed in positions corresponding to the «dead» areas of the caisson not reached by the bits (14).

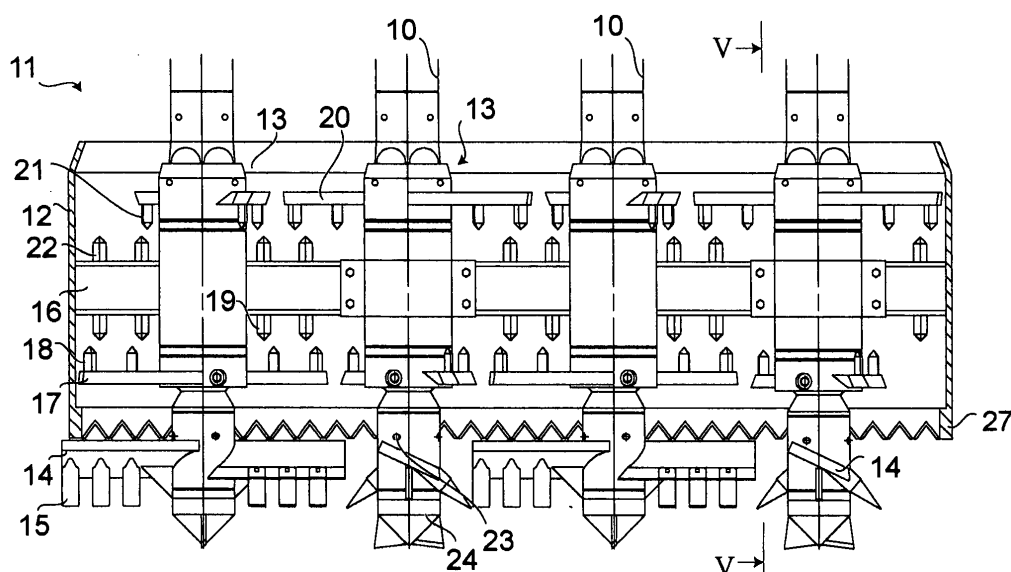


Fig. 3

Description

[0001] The subject of the invention is equipment and a method for mixing *in loco* for the formation of curtains, cutoff walls or similar diaphragms.

[0002] Techniques are known for mixing natural soil with aggregating fluids, for example with a base of water-cement or grout mixes, for the formation of columns of consolidated soil. Said mixes are made directly in the soil that is disgregated by means of mechanical bits, the rotation of which also brings about mixing with the aggregating fluid. This fluid, pumped at a pressure of 0.1-0.3 MPa, is conveyed through the drilling rods as far as the bit and exits in the proximity of the disgregating blades.

[0003] In more advanced versions of the method, the aggregating fluid is pumped at a pressure of 20-40 MPa and exits from special nozzles in the form of a jet with extremely high kinetic energy, which contributes markedly to the disgregation and mixing with the soil. The disgregating blades move in a mix already rendered soft by the action of the jets and can turn with less effort and at a higher speed, and guarantee a minimum diameter of the column and a high rate of advance (see, for example, the publications EP-1.045.073 and US-5.396.964).

[0004] Also known from the patent No. EP-1.452.645 is a method for the formation of diaphragms of soil mixed with aggregating fluids based upon equipment with drums rotating about horizontal shafts equipped with teeth. The horizontal cross section of the excavation is then rectangular in shape. The arrangement of a number of excavations alongside one another enables the construction of underground walls or curtains (diaphragms) of consolidated soil. In this case, the low pressure of the fluid and the fixed direction of delivery do not facilitate penetration or mixing.

[0005] The purpose of the present invention is the construction of diaphragms of soil consolidated by means of mixing with aggregating fluids, characterized by an excellent mixing quality and by a rate of advance enhanced by the action of jets with high kinetic energy.

[0006] To achieve this and other purposes that will emerge more clearly from what follows, the invention proposes providing equipment for mixing *in loco* for the formation of diaphragms according to Claim 1 and a method for carrying out mixing *in loco* for the formation of diaphragms using said equipment according to Claim 11.

[0007] The invention will now be described with reference to the attached plate of drawings, in which:

Figure 1 illustrates the side view of a first machine provided with equipment for excavation using rods for drilling soil, according to the invention;

Figure 2 is the front view of the set of rods/device of Figure 1;

Figure 3 and 4 are, respectively, the longitudinal cross-sectional view and plan view of the equipment according to the invention;

Figure 5 is the cross section according to the trace

V-V of Figure 3;

Figure 6 is the side view of a second machine provided with equipment for excavation using rods for drilling soil, different from that of Figures 1 and 2, but once again according to the invention;

Figure 7 is the front view of the set of rods/device of Figure 6;

Figure 8 is the side view of the second machine provided with equipment for excavation using rods for drilling soil, different from that of Figures 6 and 7, but once again according to the invention; and

Figure 9 and 10 are, respectively, the enlarged side view and enlarged front view of the equipment for excavation using rods for drilling soil, illustrated in Figure 8.

[0008] First of all, from Figures 1 and 2 it may be noted that the excavation equipment carried by the machine 9 consists of a plurality of vertical and parallel drilling rods 10 that perform a rotary motion about their own axes in opposed pairs, in the sense that each rod 10 turns in a direction opposite to the adjacent ones.

[0009] Positioned at the bottom end of the rods 10 is a set of bits 11 that may be seen more clearly in Figures 3, 4 and 5.

[0010] Arranged within a quadrilateral (rectangular) caisson 12 are bits 13 which, being fixed each to the bottom end of the rods 10, turn the first in a clockwise direction, the second in a counterclockwise direction, and so forth.

[0011] Each bit comprises, starting from the bottom up:

- a disgregating blade 14 provided with teeth 15, designed to remove the underlying soil;
- a non-rotating structure 16 for connection between the bits to keep the distance between them fixed; and
- a first rotating blade 17 with mixing members 18 set in the direction of the fixed structure 16.

[0012] The fixed structure is also equipped with mixing members 19 in positions interspersed with respect to those 18 of the blade 17, so as to entrap and break down (grind) the debris of larger dimensions.

[0013] A second mixing blade 20 is set between the fixed structure 16 and the disgregating blade 14.

[0014] Mixing members 21 are positioned under the second blade 20, and similar mixing members 22 are positioned under the fixed structure so that they too can entrap and break down (grind) the debris of larger dimensions.

[0015] First radial nozzles 23 conveniently find space for their accommodation between the disgregating blade 14 and the first mixing blade 17.

[0016] Second radial nozzles 24 are set in a downward direction under the disgregating blade 14. Both the first nozzles 23 and the second nozzles 24 turn together with the bits.

[0017] The nozzles 23 and 24 are supplied with an

aggregating fluid that arrives, through channels inside the rods 10, as far as the set of bits 11.

[0018] The set of bits 11 is, at least in part, enclosed in the caisson 12 constituted by a perimeter of vertical metal plates that delimit a rectangular section of excavation. The diameter of the blades is such as to excavate partially overlapping columns of diameter substantially equal to the smaller side of the rectangular section.

[0019] The areas at the four extreme corners 25 and the areas 26 not excavated by the bits, but in any case comprised within the rectangle, are demolished by the radial jets 23 of aggregating fluid, the position of which in height is at the level of the bottom rim 27 of the peripheral metal plates. The jets reach with their action up against said metal plates and are by these hindered or limited. The high kinetic energy with which the fluid is sprayed through the nozzles 23 and 24 is a determining factor in demolishing the soil in the «dead» areas of the caisson 12.

[0020] Arranged at the top end of the rods 10 (see Figures 1 and 2), substantially as far as the envisaged depth of the excavation, are motor means 28 and means of synchronism 29 (for example gears) designed to impart on the rods rotation at the same speed and each in a direction opposite to the adjacent ones.

[0021] In this way, the device is substantially balanced to rotation. The power-drive assembly is then guided on a tower-guide 30 that prevents undesirable rotation thereof. The height of said guide constitutes a limit to the depth of treatment that can be reached.

[0022] In an alternative embodiment illustrated in Figures 6 and 7, the rods 42 are decidedly shorter than the depth of excavation, but carry once again at their free ends the set of bits 11 previously described and contained within the caisson 12. The assembly 40, comprising the motors 28 and the means of synchronism (gears) 29 (they bear the same reference numbers as in Figures 1 and 2 since they correspond thereto) is then immersed in the mixture of soil and aggregating fluid and hangs from ropes 43 for the vertical movement of sinking and extraction. In this way the depths that can be reached are decidedly greater.

[0023] For the eventuality of caving-in of the walls or early hardening of the aggregating mixture hindering extraction of the device immersed in the treated soil, located at its top are milling systems 44 capable of disaggregating the aforesaid obstacles and enabling extraction of the equipment from the ground.

[0024] For the orientation of the system at the start of excavation a known guide device is used. It is constituted by an external guide 45 hanging from the machine (crane), with hollow prismatic cross section, and an internal guided element 46, also with prismatic cross section. The external guide is orientable by means of a motor-driven assembly 47 at the point of suspension. When the disaggregating device or set of bits 11 is out of the soil and even when it is buried for the first few metres of drilling, the two guides 45 and 46 are engaged. At greater

depths, the device becomes independent and guides itself along the walls of the excavation made. For control of the direction of excavation guide devices 48 are used, which are also known, such as for example those described in the patent No. EP-0.791.690.

[0025] Located in the external guide are drums 27 for winding thereon hydraulic pipes 28 (or electrical cables) that supply power for the device.

[0026] Figures 8, 9 and 10 show a variant of the embodiment of Figures 6 and 7, in which, in order not to create an obstruction of the section of excavation, the mechanical means of synchronism 29 are eliminated and replaced with known (hydraulic or electrical) systems 50 for controlling the speed of the various motors 28.

[0027] Said systems do not ensure a perfect synchronism, so that the bits of the device 11 must have blades arranged at different heights to prevent any accidental interference.

[0028] Also the motors 28 are located at different heights to facilitate the vertical movements of the device within the mixture of soil and aggregating fluid.

[0029] In particular, the lateral rods 42' are longer than the central ones 42'' (which are almost inexistent), so that the central motors 28'' will be located lower than the lateral ones 28'.

[0030] As may be noted more clearly in Figures 9 and 10, the set of bits 11 has - unlike what has been described with reference to Figures 3, 4 and 5 - two fixed overlapping and parallel structures 16' and 16''. In this way, the set of bits carried by the left-hand long rod 42' and the one carried by the right-hand short rod 42'' can be sent back in 51 by the top structure 16'' and be carried by the bottom structure 16' so as to project further on the outside of the caisson 12, but at the same time as not to interfere with the individual bits of the set of bits carried by the right-hand long rod 42' and the one carried by the left-hand short rod 42'', which, instead, are carried by the top structure 16'' and sent back in 52 by the bottom one 16'.

Claims

1. Excavation equipment for mixing *in loco* the excavated soil and for the formation of diaphragms within the excavated hole of the type constituted by a plurality of rods for drilling soil (10) arranged alongside one another, each rod performing a rotary and translational motion about and along its own axis; said equipment being **characterized in that** supplied along the rods is a thickening fluid that exits with high kinetic energy through nozzles (23 and 24) made in positions corresponding to bits of a set of bits (11) located at the free ends of the rods (10) and rendered fixed in rotation and translation therewith; the bits are interconnected and separated by means of fixed structures (16, 16') that guarantee non-interference and maintenance of the distance between them; the bit of each rod (10) being equipped, at its ends, with

disgregating means (14) and, at the centre, with means (18, 21) for mixing the soil and said aggregating fluid; the bits being enclosed at least partially within a quadrilateral caisson (12), designed to line the walls of the excavated hole as the equipment advances with the excavation in the soil; the nozzles (23, 24) being directed in positions corresponding to the «dead» areas of the caisson not reached by the bits (14).

2. The excavation equipment according to Claim 1, **characterized in that** the drilling rods (10) are equipped with rotary motion about their own axis in opposed pairs.

3. The excavation equipment according to Claim 1, **characterized in that** connected to each rod (10) is a bit of the set of bits (11) comprising, starting from the bottom up:
 - a disgregating blade (14) provided with teeth (15), designed to remove the underlying soil;
 - a non-rotating structure (16) for connection between the bits to keep the distance between them fixed;
 - a first rotating blade (17) with mixing members (18) oriented in the direction of the fixed structure (16); the fixed structure also being equipped with mixing members (19) in positions interspersed with respect to those (18) of the first blade (17); and
 - a second mixing blade (20) being set between the fixed structure (16) and the disgregating blade (14);

mixing members (21) being positioned under the second blade (20) and similar mixing members (22) being positioned under the fixed structure.

4. The excavation equipment according to Claim 3, **characterized in that** the aggregating fluid is sprayed through first radial nozzles (23), set between the disgregating blade (14) and the first mixing blade (17), and second radial nozzles (24), which are oriented in a downward direction under the disgregating blade (14); both the first (23) and the second nozzles (24) rotating together with the bits.

5. The excavation equipment according to Claims 1 and 4, **characterized in that** the caisson (12) is constituted by a perimeter of vertical metal plates that delimit a rectangular section of excavation; the diameter of the blades of the bits being such as to excavate partially overlapping columns of diameter substantially equal to the smaller side of the rectangular section; the areas at the four extreme corners (25) and the areas (26) not excavated by the bits, but in any case comprised within the rectangle, being demolished by the radial jets (23) of aggregating flu-

id, the position of which in height is at the level of the bottom rim 27 of the perimetral metal plates.

6. The excavation equipment according to Claim 1, **characterized in that** the rods are substantially as long as the depth of the excavation that it is intended to obtain.

7. The excavation equipment according to Claim 1, **characterized in that** the rods are much shorter than the depth of the excavation that it is intended to obtain.

8. The excavation equipment according to Claim 7, **characterized in that** means are provided for controlling the speed of the motors (28) that set in rotation the rods that do not ensure a perfect synchronism; consequently the individual bits of the set of bits (11) have the blades arranged at different heights to prevent any accidental interference, and also the motors (28) are located at different heights to facilitate the vertical movements of the device within the mixture of soil and aggregating fluid.

9. The excavation equipment according to Claim 8, **characterized in that** the lateral rods (42') are longer than the central ones (42''), so that the central motors (28'') are set lower than the lateral ones (28').

10. The excavation equipment according to Claim 9, **characterized in that** the set of bits (11) has two fixed overlapping and parallel structures (16' and 16''); consequently the set of bits carried by the left-hand long rod (42') and the one carried by the right-hand short rod (42'') are sent back in (51) by the top structure (16') and carried by the bottom structure (16''), whilst the individual bits of the set of bits carried by the right-hand long rod (42') and the one carried by the left-hand short rod (42'') are carried by the top structure (16') and sent back in (52) by the bottom one (16'').

11. A method for mixing *in loco* excavated soil during the formation of diaphragms within the excavated hole using equipment according to the preceding claims, in which, whilst the rods (10) advance in the hole in the earth that is progressively excavated by the disgregating bits, the caisson (12) copies with its outer walls the quadrilateral hole that the disgregating bits (14) make, and the nozzles (23, 24) directed in positions corresponding to the «dead» areas of the caisson not reached by the bits (14) complete the disgregation of the soil in said «dead» areas.

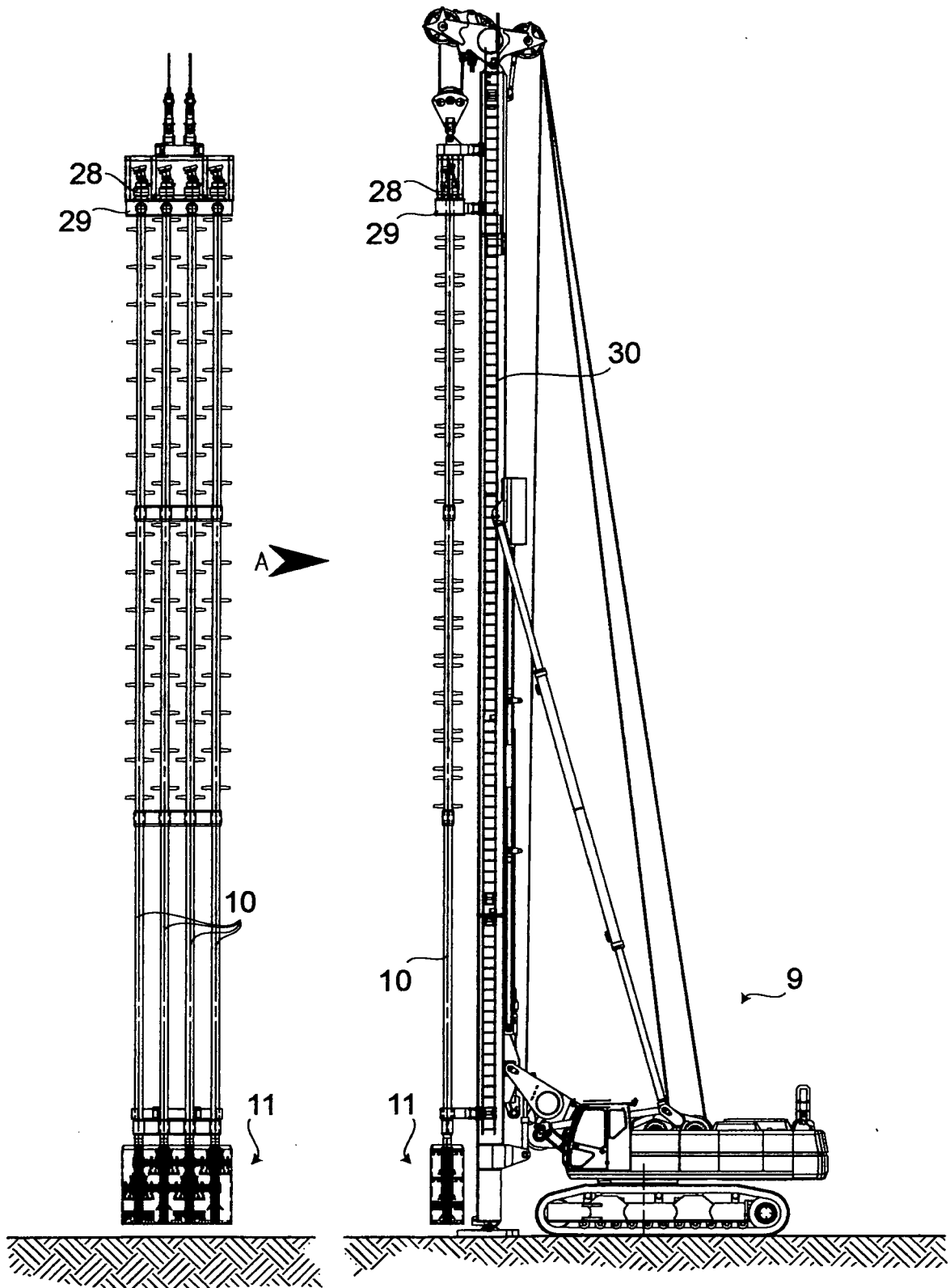


Fig. 2

Fig. 1

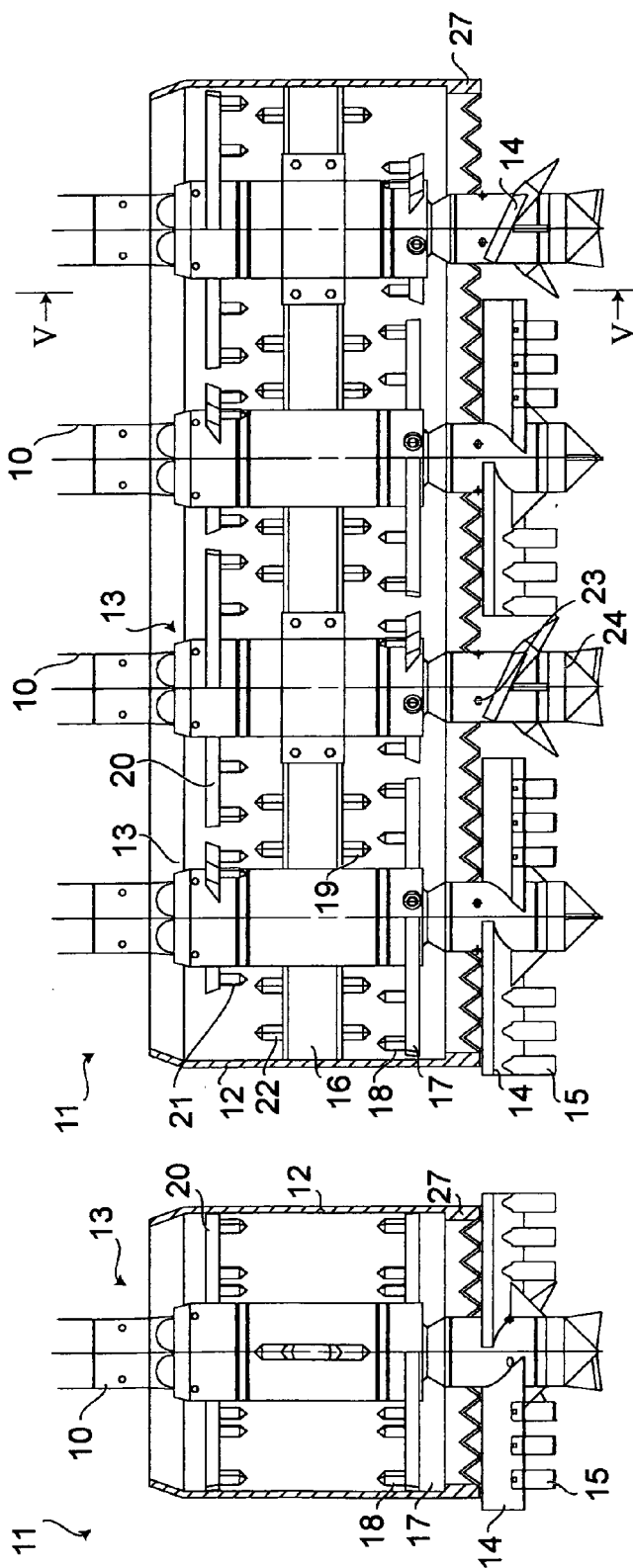


Fig. 5

Fig. 3

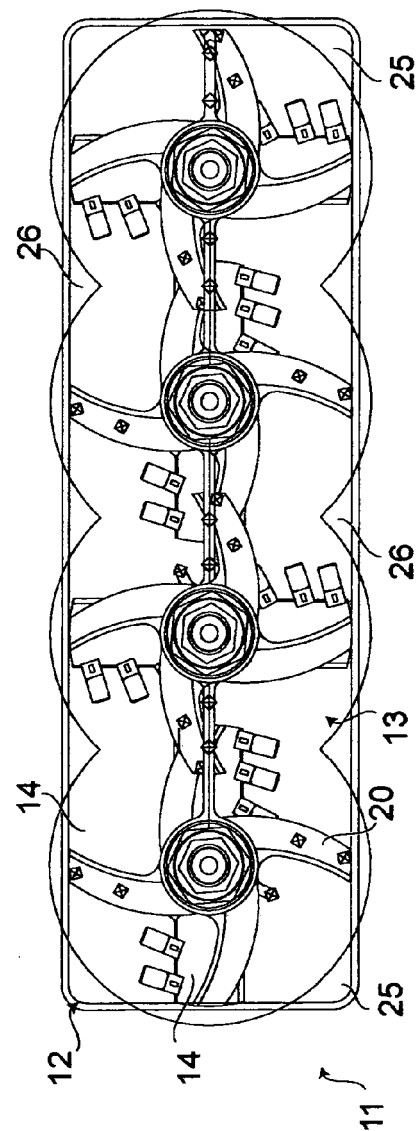


Fig. 4

Fig. 7

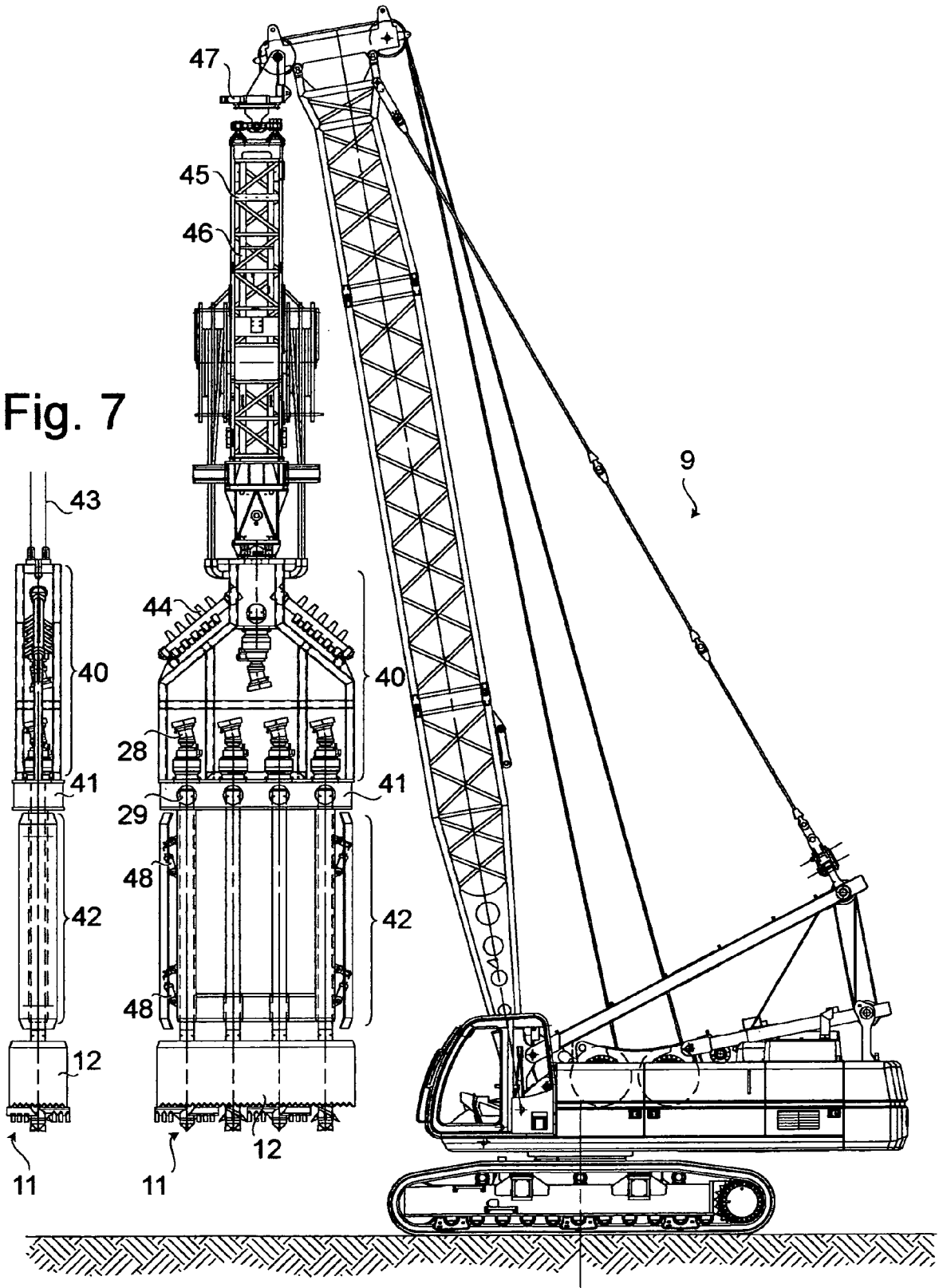
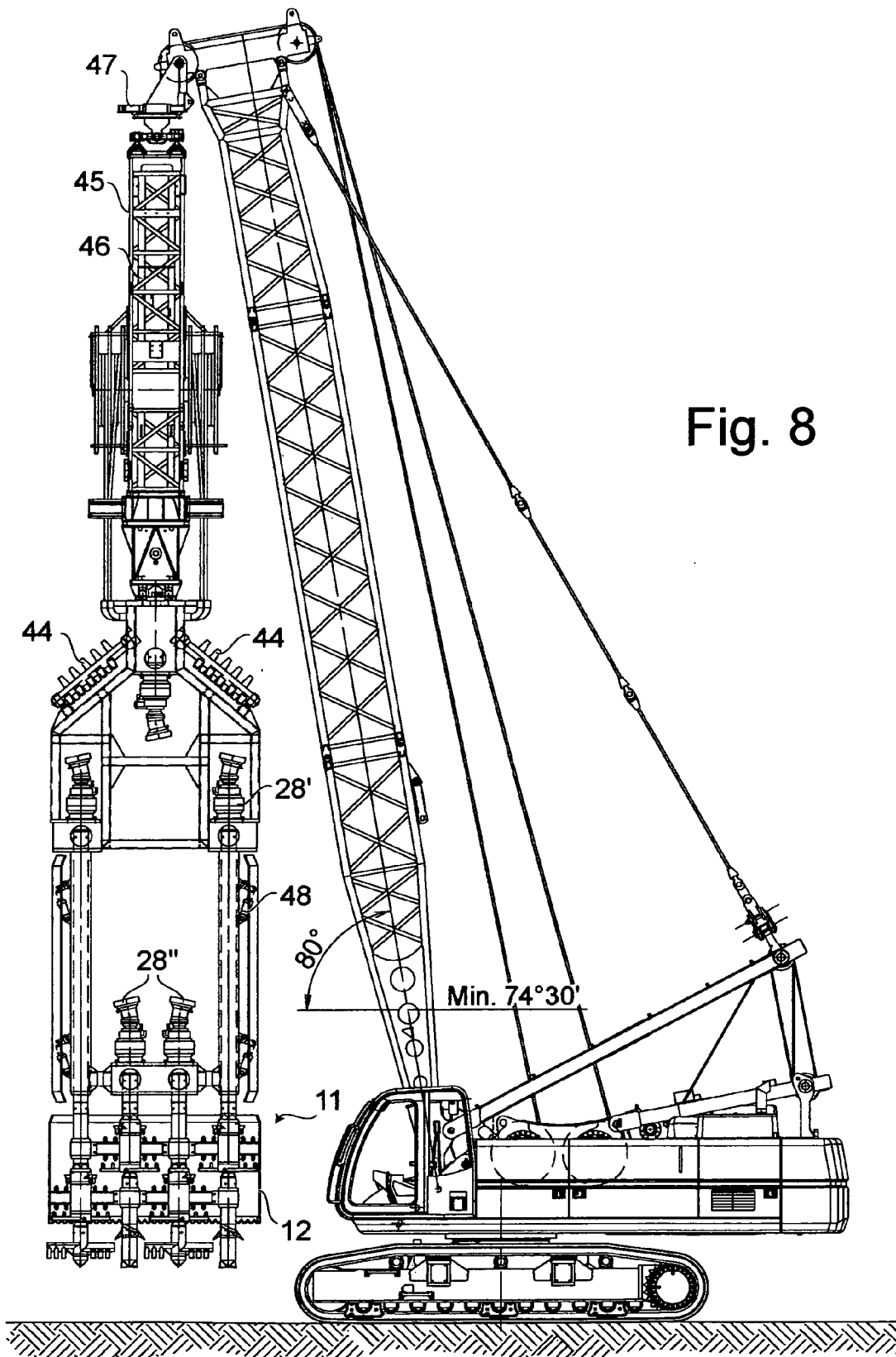


Fig. 6



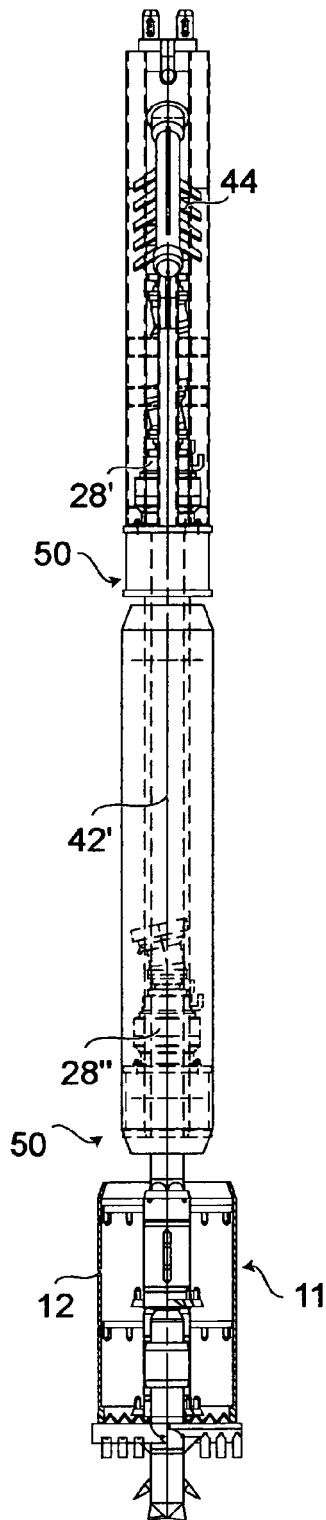


Fig. 10

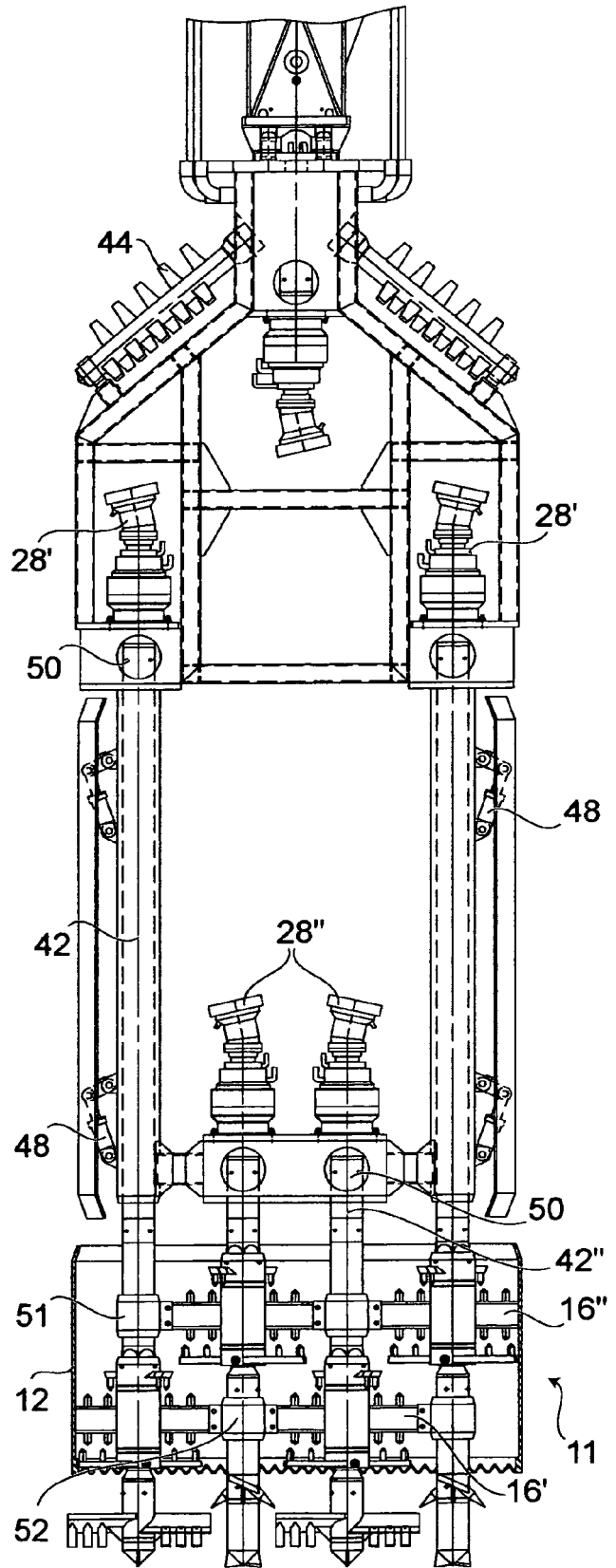


Fig. 9



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Application Number
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