



(12) **EUROPEAN PATENT APPLICATION**

(43) Date of publication:
08.09.2010 Bulletin 2010/36

(51) Int Cl.:
E02D 17/13 (2006.01) E02F 3/26 (2006.01)

(21) Application number: **10155427.7**

(22) Date of filing: **04.03.2010**

(84) Designated Contracting States:
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 SE SI SK SM TR
Designated Extension States:
AL BA ME RS

(71) Applicant: **Casagrande SpA**
33074 Fontanafredda (PN) (IT)

(72) Inventor: **Casagrande, Mauro**
33077, Sacile (PN) (IT)

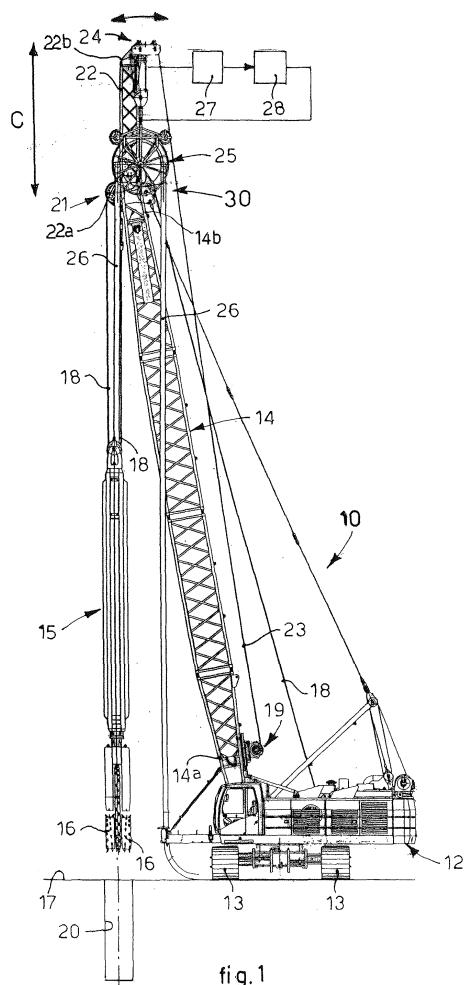
(74) Representative: **Petraz, Gilberto Luigi et al**
GLP S.r.l.
Piazzale Cavedalis 6/2
33100 Udine (IT)

(30) Priority: **05.03.2009 IT UD20090053**

(54) **Excavation apparatus**

(57) Excavation apparatus (10) comprising excavation means (15), first support means (21) able to support and move the excavation means (15) in a substantially vertical direction, a mobile arm (14) extending upward and having a lower end (14a) connected to a cab or turret (12) and an upper end (14b) on which said first support means (21) are disposed, flexible pipes (26) comprising means to suck up and/or remove detritus and/or means to drive said excavation means (15), winding/unwinding means (25) for said flexible pipes (26), second support means (24) provided to support and move said winding/unwinding means (25) in said vertical direction. The excavation apparatus (10) comprises at least an extension element (22), oblong in shape, extending upward and provided with a lower end (22a) connected to the upper end (14b) of said mobile arm (14) and with an upper end (22b) in substantial correspondence with which said second support means (24) are disposed and supported, said extension element (22) being normally positioned in a substantially vertical direction. The distance between the upper end (14b) of the mobile arm (14) and the upper end (22b) of the extension element (22) that supports said second support means (24) defines a supplementary vertical travel of said winding/unwinding means (25) such that said flexible pipes (26) are able to extend in height to a greater extent than the extension in height of said mobile arm (14), so as to increase the depth of excavation that said excavation means (15) can achieve. Articulation means (30) are provided to connect rotatably said extension element (22) to said mobile arm (14) so that said extension element (22) is selectively mobile in order to displace said second support means (24) in a manner coordinated with the displacement of the mobile arm (14), so as to keep said excavation means (15) ver-

tical substantially in every operating condition, even when the depth of the excavation is increased.



Description

FIELD OF THE INVENTION

[0001] The present invention concerns an excavation apparatus. In particular, the excavation apparatus according to the present invention allows to maintain its excavation means vertical.

BACKGROUND OF THE INVENTION

[0002] An excavation apparatus is known, comprising a crane of the self-propelled type, for example provided with tracks, and equipped with an arm that maneuvers excavation means, for example of the type having two pairs of milling wheels with horizontal axes and substantially parallel, during use, to the excavation surface, so as to excavate diaphragms, ditches, trenches, wells or other.

[0003] For example, diaphragms are usually in-depth perforations with a rectangular section which are made, continuously, in a vertical direction in the ground and have different functions, such as for example of a structural type, as in the perimeter walls of an underground building, as foundations, as in surface offices, or again with a waterproofing function, as in works on dams.

[0004] The excavation means are associated with the arm by means of a first winch which, when the apparatus is inactive, keeps the excavation means suspended with respect to the ground and, when the apparatus is operating, allows the excavation means to be moved forward and/or raised vertically by a predefined travel in order to dig the excavation in depth. The known apparatus also provides a second winch which supports and moves, in coordination with the movement of the excavation means, winding/unwinding means, for example drums, reels or suchlike, for flexible pipes, connected to the excavation means, for example but not only in order to suck up and remove the excavation detritus, and/or tubes for oil-dynamic and/or electric commands to drive the excavation means.

[0005] In order to obtain very deep excavations, in said known apparatus it is necessary to increase the travel of the excavation means along the vertical direction with respect to the excavation surface. To this purpose it is known to use either a larger size excavation apparatus so as to support a corresponding arm having a greater size and length, or to use an extension of the arm, keeping the size of the excavation apparatus unchanged.

[0006] Using a large size excavation apparatus has the disadvantage that it increases bulk and costs.

[0007] Another disadvantage is that the extension of the arm, keeping the size of the excavation apparatus unchanged, entails a reduction in the capacity of the latter. This in turn entails a reduction in the extraction force available to the excavation means and therefore a reduced efficiency in extraction, especially if the excavation means remained jammed on the walls of the excavation.

[0008] In the known excavation apparatus, moreover, if it is necessary to correct the working interaxis, the position of the arm is adjusted, that is, it is moved to a position with a different inclination with respect to a work position inclined with respect to the excavation surface, for example in a range that goes from about 75° to about 85°. The adjustment of the arm has the disadvantage that it causes a further reduction in the range of the apparatus, limiting its available extraction force.

[0009] In this case, the transverse stresses generated by the aforesaid pipes and/or hoses on the excavation means, after the arm has been displaced from its initial position, do not allow the excavation means to be kept vertical in every operating condition. This causes a lack of accuracy of the excavation.

[0010] Other known excavation apparatuses are described in documents JP-U-06035391 and JP-U-04057583.

[0011] Purpose of the present invention is to achieve an excavation apparatus which, with the same size and range, allows to keep the excavation means vertical, substantially in every operating condition, allowing to make deep and accurate excavations.

[0012] The Applicant has devised, tested and embodied the present invention to overcome the shortcomings of the state of the art and to obtain these and other purposes and advantages.

SUMMARY OF THE INVENTION

[0013] The present invention is set forth and characterized in the independent claims, while the dependent claims describe other characteristics of the invention or variants to the main inventive idea.

[0014] In accordance with the above purpose, an excavation apparatus according to the present invention comprises excavation means, first support means able to support and move the excavation means in a substantially vertical direction, a mobile arm having a lower end connected to a cab or turret, and an upper end on which said first support means are disposed.

[0015] The excavation apparatus also comprises flexible pipes comprising means to suck in and/or remove detritus, and/or drive means for said excavation means, winding/unwinding means for said flexible pipes and second support means provided to support and move said winding/unwinding means in said vertical direction.

[0016] According to the present invention, the excavation apparatus also comprises at least an extension element, oblong in shape, provided with a lower end connected to the upper end of said mobile arm and with an upper end in substantial correspondence with which said second support means are disposed and supported, said extension element normally being positioned in a vertical direction.

[0017] In some embodiments of the present invention, the distance between the upper end of the mobile arm and the upper end of the extension element that supports

said second support means defines a supplementary vertical travel of said winding/unwinding means, such that said flexible pipes extend in height to a greater extent than the extension in height of said mobile arm, so as to increase the depth of the excavation that can be achieved by said excavation means.

[0018] Using the extension element allows to position the winding/unwinding means at a height with respect to the ground that is greater than the height at which the winding/unwinding means of known excavation apparatuses are normally positioned. This allows to use longer flexible pipes. There is therefore an increase in the travel of the winding/unwinding means in the vertical direction with respect to the excavation surface which allows a coordinated increase in the travel of the excavation means in the same direction, and the latter can therefore achieve deeper excavation depths.

[0019] Furthermore, using the extension element allows to keep the length of the arm unchanged, thus keeping the range of the excavation apparatus also unchanged, which allows to keep an efficient extraction force available.

[0020] In other embodiments of the present invention, articulation means are provided to connect said extension element rotatably to said mobile arm, so that the extension element is selectively and angularly mobile so as to displace the second support means in a manner coordinated with the displacement of the mobile arm, so as to keep said excavation means vertical substantially in every operating condition, including when the depth of the excavation is increased.

[0021] According to a variant of the present invention, the excavation apparatus comprises means to detect the inclination, able to provide information on the inclination of the extension element.

[0022] According to a variant of the present invention the extension element is able to be moved also according to the inclination of the excavation apparatus with respect to the ground or to an excavation surface.

[0023] In this way, by means of the excavation apparatus according to the present invention, it is possible to cancel, substantially in every operating condition, the transverse components produced by the flexible pipes on the excavation means, following a movement of the mobile arm able to correct the work interaxis of the excavation means. This allows to keep the excavation means vertical, for example with respect to the corresponding excavation surface, and therefore to increase the depth and accuracy of the excavation.

[0024] During the movement of the arm, the extension element is moved according to the information arriving from the means to detect the inclination with respect to the mobile arm so as to correct the positioning of the second support means and therefore to keep the excavation means vertical.

[0025] The present invention also concerns a method to increase the depth of the excavation and to control the verticality of the excavation means of an excavation ap-

paratus. The method comprises:

- a first step of moving said excavation means, by means of first support means supported by an upper end of a mobile arm, in a substantially vertical direction;
- a second movement step of moving, in said vertical direction, flexible pipes comprising means to suck up and/or remove detritus and/or means to drive said excavation means, by means of winding/unwinding means supported by second support means.

[0026] According to one feature of the present invention, the method comprises:

- a third step of moving the winding/unwinding means in a supplementary vertical travel that extends beyond said upper end of the mobile arm, such that the flexible pipes are extended in height to a greater extent than the extension in height of the mobile arm, so as to increase the depth of excavation that can be achieved by the excavation means;
- a fourth step of moving the second support means with respect to the mobile arm by means of an extension element that extends upward from the upper end of the mobile arm so as to cause the supplementary vertical travel of the winding/unwinding means; the movement of the second support means is performed in a manner coordinated with a displacement of the mobile arm during the excavation, so as to keep the excavation means vertical substantially in every operating condition, including when the depth of the excavation is increased.

[0027] According to a variant of the present invention, the method provides to detect the relative inclination of the extension element that moves the second support means with respect to the mobile arm and to move the extension element with respect to the mobile arm according to said inclination

[0028] According to another variant, the method comprises at least a step in which the extension element is moved according to the inclination of the excavation apparatus with respect to an excavation surface.

BRIEF DESCRIPTION OF THE DRAWINGS

[0029] These and other characteristics of the present invention will become apparent from the following description of a preferential form of embodiment, given as a non-restrictive example with reference to the attached drawings wherein:

- fig. 1 is a lateral view of an excavation apparatus according to the present invention;
- fig. 2 is a lateral view of the apparatus in fig. 1 in a second operating condition.

DETAILED DESCRIPTION OF A PREFERENTIAL FORM OF EMBODIMENT

[0030] With reference to the attached drawings, an excavation apparatus 10 according to the present invention is used to excavate diaphragms 20, ditches, trenches, wells or other.

[0031] The excavation apparatus 10 in this case is of the crane type and comprises a command and driving cab 12, or turret, provided at the lower part with tracks 13 to move the excavation apparatus 10 and a mobile arm 14 disposed in correspondence with the front part of the cab 12. The excavation apparatus 10 also comprises an excavation tool 15, in this case comprising two pairs of milling wheels 16 with horizontal axes and substantially parallel, during use, with the excavation surface 17. The excavation tool 15 is kept suspended vertically, that is, plumb, by means of cables 18 of a first winch device, not visible in the drawings, disposed in this case substantially in correspondence with the central part of the command and driving cab 12. The first winch device is able to keep the excavation tool 15, able to be used to make the excavation, suspended, and to move it in a substantially vertical direction, that is, plumb, with respect to the excavation surface 17, by means of first pulley means 21. The first pulley means 21 are disposed substantially around an upper end 14b of the mobile arm 14.

[0032] The excavation apparatus 10 comprises an extension element 22, disposed substantially along the vertical of the excavation tool 15. In particular, the extension element 22 is connected, in correspondence with a lower end 22a, to the upper end 14b of the mobile arm 14 by means of articulated joints 30, for example of the hinge type, levers or other. It is understood that the extension element 22 can also be constrained to the mobile arm 14 by means of any other type of joint whatsoever which allows the extension element 22 to move with respect to the mobile arm 14.

[0033] The excavation apparatus 10 also comprises one or more elements 27 to detect the inclination, such as for example inclination sensors, inclinometers or such-like, able to detect the absolute inclination of the extension element 22 and to transmit the information relating to said inclination to processing and control means 28. It is understood that the inclination detection elements 27 can detect a relative inclination with respect to a predetermined reference direction. The processing and control means 28 are able to activate actuation means in order to correct the inclination of the extension element 22 so as to reduce or eliminate the transverse components that act on the excavation tool 15, following a displacement of the mobile arm 14, and therefore to keep the excavation tool 15 vertical. The processing and control means 28 can be disposed, for example but not only, in correspondence with the command and driving cab 12.

[0034] The excavation apparatus 10 also comprises, in correspondence with a lower end 14a of the mobile arm 14, a second winch device 19, whose cables 23 are

able to support, by means of second pulley devices 24 disposed in correspondence with an upper end 22b of the extension element 22, and substantially misaligned with respect to the first pulley devices 21, at least a pair of winding/unwinding devices 25, such as drums, reels or other analogous devices, for flexible pipes 26 connected to the excavation tool 15.

[0035] The flexible pipes 26 are used to suck up the excavation detritus and/or to deliver a fluid to remove the detritus. The flexible pipes 26 also comprise hoses for oil-dynamic and/or electric commands to drive the excavation tool 15. Using the extension element 22 allows to position the winding/unwinding devices 25 at a height from the ground that is greater than the height from the ground of known winding/unwinding devices. In fact, the second pulley devices 24 move the winding/unwinding devices 25, according to necessity, in a supplementary vertical travel C corresponding to the linear extension of the extension element 22 beyond the mobile arm 14, to allow an extension of the flexible pipes 26 to a greater extent than the extension in height of the mobile arm 14 (figs. 1 and 2).

[0036] The winding/unwinding devices 25 are disposed on opposite sides with respect to the extension element 22 and when the excavation apparatus 10 is inactive, they keep the flexible pipes 26 substantially under tension.

[0037] The second winch device 19 is able to move the winding/unwinding devices 25 in a substantially vertical direction with respect to the excavation surface 17.

[0038] The excavation apparatus 10 according to the present invention functions as follows.

[0039] The excavation tool 15, commanded by the first winch device, is moved in the vertical direction with respect to the excavation surface 17 in order to make the excavation. At the same time, the second winch device 19 is activated, which moves the winding/unwinding devices 25 in the vertical direction with respect to the excavation surface 17. After the winding/unwinding devices 25 have been lowered, a corresponding release of the flexible pipes 26 is determined, which therefore follow in coordination the lowering of the excavation tool 15. Due to the disposition of the winding/unwinding devices 25, also determined by the length of the extension element 22, the length of the flexible pipes 26 is greater than the length of the pipes used in the state of the art and therefore the excavation tool 15 performs a greater travel, coordinated with the travel C of the winding/unwinding devices 25, as shown in fig. 2. It is therefore possible to achieve very deep excavations.

[0040] The inclination detection elements 27, when the excavation apparatus 10 is operating, detect the absolute inclination of the extension element 22 and transfer said information to processing and control means 28, so as to correct the position of the extension element 22, that is, of its inclination with respect to the mobile arm 14, so as to reduce or eliminate the transverse components acting on the excavation tool 15, which are produced by the

flexible pipes 26 following a movement, even minimal, of the arm 14 with respect to an initial inclination, or position, with which the mobile arm 14 was positioned at the start of the excavation, or to correct possible small displacements of the apparatus 10. This allows to keep the excavation tool 15 substantially vertical with respect to the excavation surface 17.

[0041] It is clear that modifications and/or additions of parts may be made to the excavation apparatus as described heretofore, without departing from the field and scope of the present invention.

[0042] It is also clear that, although the present invention has been described with reference to some specific examples, a person of skill in the art shall certainly be able to achieve many other equivalent forms of excavation apparatus, having the characteristics as set forth in the claims and hence all coming within the field of protection defined thereby.

Claims

1. Excavation apparatus comprising excavation means (15), first support means (21) able to support and move said excavation means (15) in a substantially vertical direction, a mobile arm (14) having a lower end (14a) connected to a cab or turret (12) and an upper end (14b) on which said first support means (21) are disposed, flexible pipes (26) comprising means to suck up and/or remove detritus and/or means to drive said excavation means (15), winding/unwinding means (25) for said flexible pipes (26), second support means (24) provided to support and move said winding/unwinding means (25) in said vertical direction,
characterized in that it comprises at least an extension element (22), oblong in shape, provided with a lower end (22a) connected to the upper end (14b) of said mobile arm (14) and with an upper end (22b) in substantial correspondence with which said second support means (24) are disposed and supported, said extension element (22) being normally positioned in a substantially vertical direction.
2. Apparatus as in claim 1, **characterized in that** the distance between the upper end (14b) of the mobile arm (14) and the upper end (22b) of the extension element (22) that supports said second support means (24) defines a supplementary vertical travel (C) of said winding/unwinding means (25) such that said flexible pipes (26) are able to extend in height to a greater extent than the extension in height of said mobile arm (14), so as to increase the depth of excavation that said excavation means (15) can achieve.
3. Apparatus as in claim 1 or 2, **characterized in that** it comprises articulation means (30) to connect ro-

tably said extension element (22) to said mobile arm (14) so that said extension element (22) is selectively mobile in order to displace said second support means (24) in a manner coordinated with the displacement of the mobile arm (14), so as to keep said excavation means (15) vertical substantially in every operating condition, even when the depth of the excavation is increased.

4. Apparatus as in any claim hereinbefore, **characterized in that** it comprises inclination detection means (27), able to provide information on the inclination of the extension element (22).
5. Apparatus as in any claim hereinbefore, **characterized in that** said extension element (22) is also able to be moved according to the inclination of said excavation apparatus (11) with respect to an excavation surface (17).
6. Apparatus as in any claim hereinbefore, **characterized in that** said extension element (22) is connected to said mobile arm (14) by means of hinge-type articulated joints.
7. Apparatus as in any claim from 1 to 5, **characterized in that** said extension element (22) is connected to said mobile arm (14) by means of lever-type articulated joints.
8. Apparatus as in claim 4, **characterized in that** it also comprises processing and control means (28) able to receive and process said information arriving from said inclination detection means (27) and to activate the movement of said extension element (22).
9. Method to increase the excavation depth and to control the verticality of excavation means (15) in an excavation apparatus (10) comprising:
 - a first step of moving said excavation means (15), by means of first support means (21) supported by an upper end (14b) of a mobile arm (14), in a substantially vertical direction;
 - a second movement step of moving, in said direction, flexible pipes (26) comprising means to suck up and/or remove detritus and/or means to drive said excavation means (15), by means of winding/unwinding means (25) supported by second support means (24),
characterized in that it also comprises:
 - a third step of moving said winding/unwinding means (25) in a supplementary vertical travel (C) that extends beyond said upper end (14b) of said mobile arm (14), such that said flexible pipes (26) are extended in height to a greater extent than the extension

in height of said mobile arm (14), so as to increase the excavation depth that can be achieved by said excavation means (15);
- a fourth step of moving said second support means (24) with respect to said mobile arm (14) by means of an extension element (22) that extends upward from the upper end (14b) of said mobile arm (14) so as to cause said supplementary vertical travel (C) of the winding/unwinding means (25), said fourth step of moving said second support means (24) being performed in a manner coordinated with a movement of the mobile arm (14) during the excavation, so as to keep said excavation means (15) vertical substantially in every operating condition, including when the depth of the excavation is increased.

10. Method as in claim 9, **characterized in that** it provides to detect the relative inclination of said extension element (22) that moves said second support means (24) with respect to said mobile arm (14) and to move said extension element (22) with respect to said mobile arm (14) according to said inclination

11. Method as in claim 9 or 10, **characterized in that** it also comprises at least a step in which said extension element (22) is moved according to the inclination of said excavation apparatus (11) with respect to an excavation surface (17).

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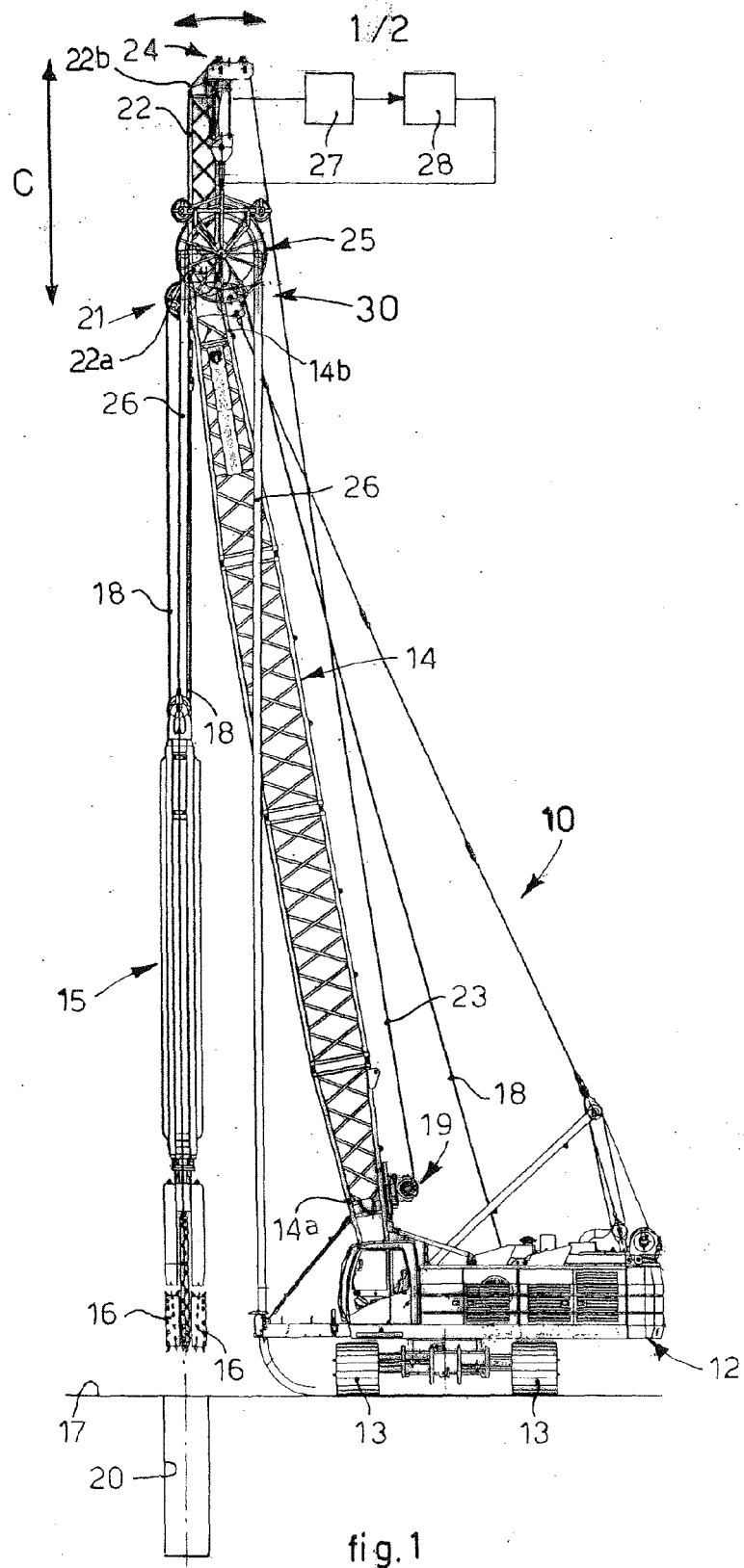
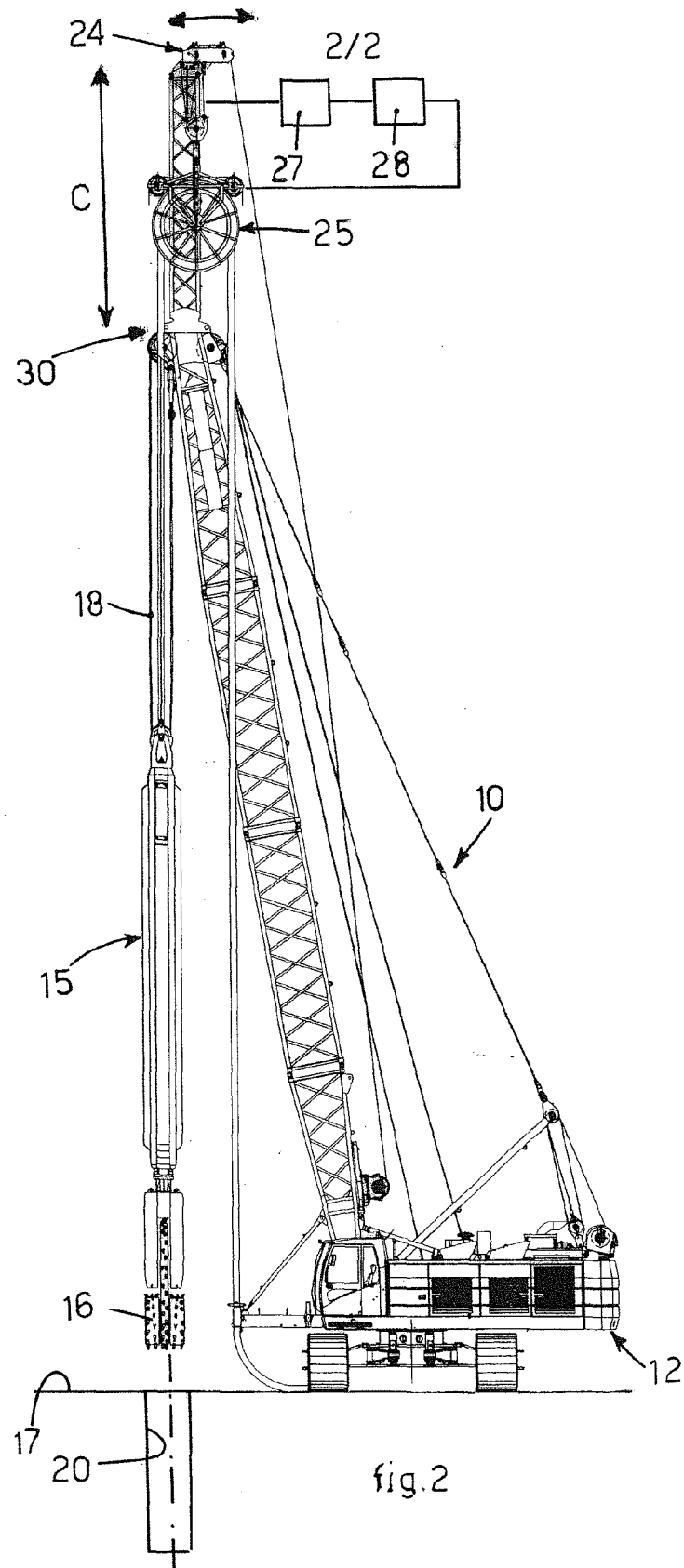


fig.1



REFERENCES CITED IN THE DESCRIPTION

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