

## A DRILLING RIG INCLUDING A DEVICE FOR CONNECTING A DEVICE FOR MEASURING VERTICALITY

### Background of the invention

5       The present invention relates to the field of measuring the verticality of the movement of a drilling rig.

      Measuring the verticality of a drilling rig conventionally consists in continuously or periodically  
10   measuring any departures from the vertical of a drilling rig that is intended in particular to cut trenches of great depth and small width, typically equal to the width of the drilling rig.

      Such rigs are particularly, but not exclusively,  
15   rotary drum drilling rigs. They are described in particular in Document FR 2 211 027. The drilling rig is suspended from a hoist by means of cables. The rig continues to move downwards progressively as the rotary drums cut the trench.

20       For certain kinds of work, the trench may present great depth, which may be as much as one hundred meters or more. It is generally necessary for the trench to present great accuracy concerning its verticality, in particular because the final trench is usually the result  
25   of juxtaposing vertical boreholes. The accuracy that is required may be of millimeter order in the horizontal direction for each meter of depth of the trench.

      In particular because of irregularities of the terrain in which the trench is to be made, there exist  
30   major risks of the drilling rig deviating from its vertical path, with this risk increasing as the depth of the borehole increases.

      There therefore exists a real need to have systems that make it possible to monitor the verticality of the  
35   movements of the machine, by detecting any departures from the desired vertical path.

To solve this problem, Document EP 0 841 465 proposes a device for continuously measuring the verticality of a drilling rig, which device also makes it possible to detect twisting movements or crabwise movements of the rig.

The drilling rig described in that document thus includes a device for measuring the verticality of the movement of a drilling rig for cutting a vertical trench from the surface of the ground, said rig comprising a top end secured to means for supporting the rig while it is being lowered, a bottom end, and a vertical longitudinal axis,

the device further comprising:

- two small-section cables, each cable having a first end fastened to the top end of the rig, the two fastening points being different;
- means for keeping said cables tensioned;
- two guide means arranged above the surface of the ground to ensure, at least at the measurement instants, that the portion of each cable that is arranged in a horizontal plane is kept stationary in said plane while the rig is being lowered, said guide means defining two fixed reference points in a spatial relationship with said fastener points when they are in said horizontal plane;
- means for measuring in two mutually orthogonal horizontal directions the angles of inclination of the portion of each cable extending between said fastener points and said guide means;
- means for measuring the lengths of the portions of cable extending between the fastener points and the guide means while the rig is being lowered;
- means secured to the rig to measure the angles of inclination of the longitudinal axis of said rig in two mutually orthogonal horizontal directions; and
- processor means for using said measured lengths and said measured angles of inclination to calculate the

movements of the two cable fastener points in said orthogonal directions and for using the calculated movements of the fastener points of the two cables and the two measured angles of inclination of the vertical axis of the rig to calculate the movements of two different fixed points of the bottom end of said rig.

It can be understood that by continuously measuring the length of the cables between the top end of the rig and the fixed guide means, and by measuring angles of inclination at the ends of the cables fastened to the rig, it is possible to calculate continuously the coordinates of the two fastener points of the cables and thus to calculate any departures in position of the cables from the reference positions defined using the two fixed guide means. In that document, provision is made for an inclinometer to be arranged between one end of the cable and a swivel system fastened to the rig.

Although such a system is entirely satisfactory, it has sometimes been found that the device lacks robustness, which can be harmful to the accuracy of the measurements.

#### Object and summary of the invention

An object of the invention is to provide a drilling rig that remedies the above-mentioned drawbacks.

To do this, the invention provides a drilling rig for cutting a vertical trench from the surface of the ground, the rig comprising:

- a frame having a top portion secured to a support device for carrying the frame; and

- a verticality measurement device comprising at least a first cable and at least a first inclinometer, one end of the first cable being connected to the top portion of the frame and to the first inclinometer.

In characteristic manner, the drilling rig further comprises at least one first connection device comprising:

- a support fastened to the frame; and
- a body connected to the support via a swivel link;

the first inclinometer and the first cable being fastened to the body while being arranged on opposite sides of the swivel link.

By means of the invention, the tensioned first cable exerts traction on the frame via the swivel link and no longer via the inclinometer as in the prior art. This direct link between the first cable and the frame enhances applying tension and keeping tensioned, thereby having the effect of improving the accuracy of the measurements.

It can also be understood that the inclinometer is arranged beneath the swivel link, such that the tension acting on the first cable is taken up by the swivel link and no longer by the inclinometer as in the prior art, thereby improving the robustness of the measurement device.

Advantageously, the frame also includes a bottom portion that is provided with an excavator device.

Advantageously, the body includes a fastener member for holding the end of the first cable. An advantage of the fastener member is to facilitate connecting and disconnecting the first cable to and from the first connection device, thereby facilitating maintenance operations, e.g. in the event of the first cable breaking.

Advantageously, the body is provided with a duct into which the first cable is inserted. The duct serves to guide insertion of the first cable into the body, thereby making it easier to connect. Preferably, the duct is inside a tube that co-operates with the fastener member.

Advantageously, the support includes a fastener portion for fastening the support to the frame, and said fastener portion is arranged between the end of the first cable and the swivel link.

An advantage is to be able to place the swivel link and the first inclinometer inside the frame, thereby contributing to reducing their exposure to pieces of excavated ground that are to be found in the trench.

5 Specifically, it can be understood that the first inclinometer and the swivel link are arranged under the fastener fastening, thereby enabling the first inclinometer and the swivel link to be housed inside the volume of the frame.

10 In other words, this advantageous configuration serves to protect the swivel link and the first inclinometer by reducing their exposure to pieces of excavated ground that are to be found in the trench.

15 Preferably, the fastener portion includes a plate having a central opening, and the body extends through the central opening.

Advantageously, the body includes a first end carrying the first inclinometer and a second end remote from the first end, the support including a guide portion surrounding the second end of the body.

An advantage of this guide portion is to limit movement of the body inside the guide portion. The guide portion also has the function of protecting the body, e.g. against falling stones.

25 Preferably, the guide portion includes an annular element of axis passing through the swivel link.

The annular element forms an annular abutment that serves to limit the angle through which the body can pivot relative to the frame. The annular element also contributes to protecting the second end of the body.

30 Preferably, the second end of the body has a disk into which the above-mentioned duct leads. The disk presents a diameter greater than that of the tube and serves to further limit movement of the body.

35 Advantageously, the frame presents a longitudinal direction, and the axis of the guide portion is parallel to the longitudinal direction of the frame.

Advantageously, the first connection device includes at least one housing in which the swivel link is arranged, and at least one sealing bellows arranged between the housing and the body.

5 It can be understood that the tube of the body and the first inclinometer are arranged on opposite sides of the housing. In addition, the sealing bellows has the function of protecting the element constituting the swivel link, in particular when drilling is performed in  
10 mud.

Advantageously, the center of gravity of the assembly constituted by the first connection device and the first inclinometer is situated in the swivel link.

Preferably, said drilling rig is a cutter having  
15 cutter drums that rotate about axes perpendicular to the longitudinal axis of the frame.

#### Brief description of the drawings

The invention can be better understood on reading  
20 the following description of an embodiment of the invention given by way of non-limiting example, and with reference to the accompanying drawings, in which:

- Figures 1 and 2 show a prior art drilling rig;
- Figure 3 shows a prior art connection device;
- 25 - Figure 4 is a perspective view of a connection device in accordance with the invention;
- Figure 5 is an axial section view of the Figure 4 device; and
- Figure 6 shows a drilling rig of the invention  
30 including a pair of Figure 4 connection devices.

#### Detailed description of the invention

With reference to Figures 1 to 3, there follows a description of a prior art device for measuring  
35 verticality and that is mounted on a drilling rig.

These figures show a drilling rig 10, e.g. of the rotary drum cutter type. The rig essentially comprises a

frame 12 and two rotary drums 14 and 16. The rig is shown in a trench 18, which it is in the process of cutting.

5 The rig 10 is suspended from a hoist 20 by a block and tackle, not shown.

10 In the invention, first and second cables 22 and 24 have their first ends 22a and 24a fastened respectively at two different points A and B at the top end 26 of the frame 12 of the drilling rig. The cables 22 and 24 are of small section so as to present little stiffness. This does not present any drawback since they do not support the drilling rig.

15 Preferably, but not necessarily, the points A and B are arranged in the midplane of the frame of the drilling rig in its width direction, i.e. in the direction of its long dimension in horizontal section.

20 The other end 22b, 24b of each cable 22, 24 is mounted on a drum 28 carried by the hoist 20. The drum is fitted with a system serving to keep the cables 22 and 24 tensioned while the drilling rig is being lowered.

25 Furthermore, provision is made for each cable to have a device 30 for measuring the length of cable that has been wound out while the drilling rig is being lowered. It is thus possible continuously to know the depth Z of the drums 14 and 16 of the drilling rig relative to the surface of the ground S in which the trench 18 is being excavated.

For further explanation about the operation of said device, reference may be made to Document EP 0 841 465.

30 Figure 3 shows in greater detail how the end 22a of the cable 22 is fastened to the top end 26 of the frame 12 of the drilling rig in the prior art. The fastener device has a bottom plate 31 secured to the top end 26 and fastened to the point A.

35 The plate 31 is connected to an inclinometer 32 by means of a swivel system 34. The inclinometer is secured to the end 22a of the first cable 22. The information

provided by the inclinometer 32 corresponds to the angles of inclination of the terminal portion of the first cable 22, and that information is not disturbed by any twisting of the cable or by any stiffness of the cable in its

5 fastening zone.

The present invention provides an alternative to the prior art connection device shown in Figure 3.

Figure 4 shows an embodiment of a first connection device 100 in accordance with the present invention.

10 This first connection device 100 comprises a support 102 that is configured to be fastened to the top portion 12a of the frame 12. For this purpose, the support 102 has a fastener portion 104 for fastening the support to the frame, by means of bolts 108.

15 The first connection device 100 also has a body 110 that is connected to the support 102 via a swivel link 112, that can be seen better in the section view of Figure 5.

The body 110 has a fastener member 120 for holding  
20 the end 22a of the first cable 22. As can be seen from Figure 5, the body 110 has a tube 121 that is provided with a duct 122 of diameter that is slightly greater than the diameter of the first cable. The first cable 22 is inserted in the duct 122 so that the end 22a, or at least  
25 an end portion, of the cable, is engaged with the fastener member 120.

In this example, the fastener member 120 comprises a plurality of screws 121 for securing the end 22a of the first cable 22 to the body 110.

30 The fastener member also has a passage 123 arranged in continuity with the duct 122 in which the end 22a of the first cable 22 is inserted.

With reference to Figure 5, it can be seen that the fastener portion 106 has a plate 107 with a central  
35 opening 109, the body 110 extending through said central opening 109. This central opening 109 presents a cross-section that is substantially circular.

The first connection device 100 also has a first inclinometer 32 that is fastened to the body 110.

More precisely, in accordance with the invention, the first inclinometer 32 and the end 22a of the first cable 22 are fastened to the body 110 on opposite sides of the swivel link 112.

In this example, the swivel link 112 has a center 0 and it is constituted by a first pivot link 140 having a pivot axis I extending transversely to the longitudinal direction X of the duct 122. This first pivot link 140, visible in Figure 5, is associated with a second pivot link 142 that presents a second pivot axis J perpendicular to the first pivot axis I and likewise perpendicular to the longitudinal direction X of the duct 122. The pivot axes I and J intersect at the center 0 of the swivel link.

By means of the swivel link 112, the assembly constituted by the body 110 and the first inclinometer 32 can swivel relative to the support 102.

Furthermore, the body 110 has a first end 110a carrying the first inclinometer 32. In this example, the first inclinometer 32 is fastened to a support 33. The support 33 is itself connected to movable element 143 of the swivel link 140, this movable element 143 itself being fastened to a rod 111 of the body 110. This rod 111 is secured to the fastener member 120, which is itself secured to the tube 121.

The body 110 also has a second end 110b remote from the first end 110a. This second end 110b is situated at the end of the tube 121 remote from the fastener member 120. The support 102 also has a guide portion 150 that surrounds the second end 110b of the body 110. This guide portion 150 includes an annular element 152 of axis C passing through the center 0 of the swivel link.

This annular element 152 is connected to the plate 107 by junction elements 154.

The frame also presents a longitudinal direction L, and the axis C of the annular element 152 is parallel to the longitudinal direction L of the frame, as shown in Figure 6.

5        With reference once more to Figure 5, it can be seen that the body 110 has a disk 160 that is installed at the end of the tube 121, the disk 160 including a channel 162 in communication with the duct 122, and an outlet orifice 164 of frustoconical shape leading to the outside.

10       It can also be understood that the annular element 152 serves to limit angular movement about the center O of the swivel link, and in this example the angular movement as seen from the vertex O of a cone lies in the range  $5^{\circ}$  to  $9^{\circ}$ , and is preferably about  $7^{\circ}$  or  $8^{\circ}$ .

15       With reference once more to Figure 5, it can be seen that the first connection device 100 has a housing 170 containing the swivel link 112, and a sealing bellows 172 that is arranged between the housing and the body 110 in order to protect the elements constituting the swivel  
20       link 112.

      In this element, the center of gravity G of the assembly constituted by the first connection device 100 and the first inclinometer 32 is situated at the swivel link 112, in the proximity of the center O of said swivel  
25       link. By means of this provision, the connection device does not impede movement of the cable 22, thus making it possible to obtain verticality measurements that are very accurate.

      With reference to Figure 6, it can be seen that the  
30       frame is provided with the first connection device 100 as described above and with a second connection device 100', identical to the first connection device 100. As explained above, the plates of the first and second connection devices 100 and 100' are fastened to the frame  
35       12.

## CLAIMS

1. A drilling rig for cutting a vertical trench from the surface of the ground, the rig comprising:
- a frame having a top portion secured to a support device for carrying the frame; and
  - a verticality measurement device comprising at least a first cable and at least a first inclinometer, one end of the first cable being connected to the top portion of the frame and to the first inclinometer;
- wherein the drilling rig further comprises at least one first connection device comprising:
- a support fastened to the frame; and
  - a body connected to the support via a swivel link;
- and wherein the first inclinometer and the first cable are fastened to the body while being arranged on opposite sides of the swivel link.
2. The drilling rig according to claim 1, wherein the body includes a fastener member for holding the end of the first cable.
3. The drilling rig according to claim 1 or claim 2, wherein the body is provided with a duct into which the first cable is inserted.
4. The drilling rig according to any preceding claim, wherein the support includes a fastener portion for fastening the support to the frame, and wherein said fastener portion is arranged between the end of the first cable and the swivel link.
5. The drilling rig according to claim 4, wherein the fastener portion includes a plate having a central opening, and wherein the body extends through the central opening.

6. The drilling rig according to any preceding claim,  
wherein the body includes a first end carrying the  
first inclinometer and a second end remote from the  
first end, and wherein the support includes a guide  
5 portion surrounding the second end of the body.

7. The drilling rig according to claim 6, wherein the  
guide portion includes an annular element of axis  
passing through the swivel link.

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8. The drilling rig according to claim 7, wherein the  
frame presents a longitudinal direction, and wherein the  
axis of the annular element is parallel to the  
longitudinal direction of the frame.

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9. The drilling rig according to any preceding claim,  
wherein the first connection device includes at least  
one housing in which the swivel link is arranged, and  
at least one sealing bellows arranged between the  
20 housing and the body.

10. The drilling rig according to any preceding claim,  
wherein the center of gravity of the assembly  
constituted by the body and the first inclinometer is  
25 situated in the swivel link.

11. The drilling rig according to any preceding claim,  
wherein the frame also includes a bottom portion  
provided with an excavator device.

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12. The drilling rig according to any preceding claim,  
wherein said drilling rig is a cutter.