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(54) **Electric hammer**

(57) An electric hammer (3), specifically designed for striking on a pile (4) to be driven in the ground; the electric hammer (3) comprises a permanent magnet electric motor having a rotor (6) mechanically connected to a device (11) for the movement transformation from a rotatory movement to an axial movement, and a striking hammer (17); the device (11) for the movement transformation axially moves the striking hammer (17) between a first and a second height.

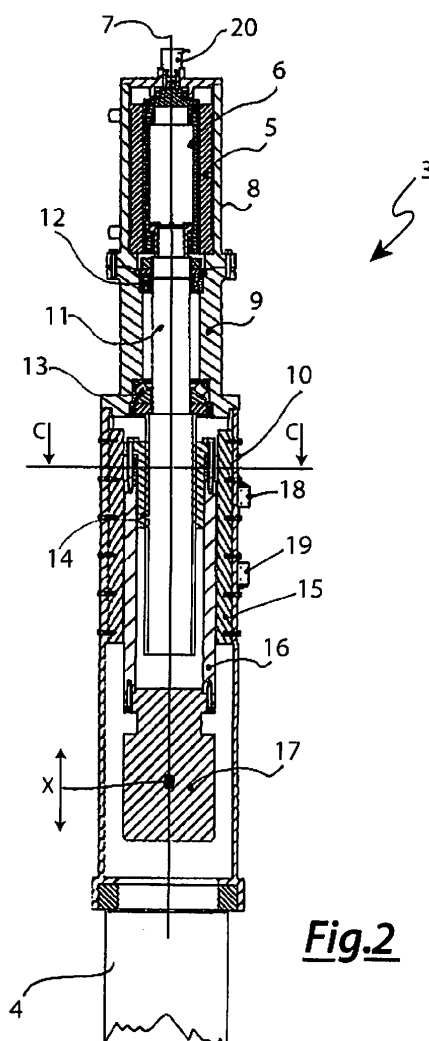


Fig.2

Description

[0001] The present invention relates to the field of electric hammers.

[0002] It is known that in the field of piling operating machines, the hammer used for driving piles generally is of the hydraulic type or of the internal combustion type.

[0003] In the first type, hydraulic energy is used, transferred through oil and devices such as pistons for moving the striking hammer the kinetic energy whereof transforms into a pulse after the impact against a casing mounted on the pile to be driven.

[0004] The main drawbacks of this solution are low energy efficiency that is around 70%, and the presence of hydraulic oil with all the disposal and pollution problems related to the same. Moreover, the speed of the striking hammer may at most be a little higher than that in free fall and thus, the energy that may be transferred with this type of hammers is limited and very heavy striking hammers are required for large sized piles. The effectiveness is further reduced in case of tilted processing since the force of gravity does not act in the same direction in which the striking hammer moves. The efficiency of common hydraulic hammers is about 70%.

[0005] In the second type, that is, in the case of internal combustion hammers, the striking hammer is moved using the explosion within a combustion chamber. The striking hammer acts as piston and is lifted thanks to the explosion within the combustion chamber, then by gravity it falls back, striking the casing on the pile to be driven, at the same time compressing the fuel mixture, again causing the explosion thereof. A Diesel cycle is thus triggered. This is probably the oldest and most widespread technology but the drawbacks are clear: strong noise and pollution due to the emission of NO_x, carbon monoxide (CO), hydrocarbons (HC), carbon dioxide (CO₂) and particulate, to the atmosphere. Moreover, it is not a very flexible system as it does not allow large variations in the frequency of impacts and thus an increase in productivity. This is because the operation is linked to the triggering of the Diesel cycle the speed whereof may only be varied by varying the amount of fuel introduced, but only within a small operating range.

[0006] Moreover, with some hammers that only use gravity for striking on a pile to be driven in the ground, it is not possible to operate with strong tilting since the force of gravity is mostly released onto the guides.

[0007] EP0265566B1 describes an electric hammer wherein a striking hammer is connected to an electromagnet that moves it; the impact of the striking hammer on a pile to be driven in the ground is determined by fall by gravity and thus, the impact force is a function of the height wherefrom the striking hammer starts for striking said pile.

[0008] CN2594318Y describes an electric hammer wherein an electric motor is indirectly coupled to a striking hammer, that is, through a reducer. Such solution is inefficient since the reducer cannot withstand the strikes

imparted by the striking hammer on the pile; otherwise, it may be broken in a short time. The reducer must be vibrationally isolated and in any case its presence imposes a mechanical complexity of the hammer described therein.

[0009] The object of the present invention therefore is to describe an electric hammer free from the drawbacks described above.

[0010] According to the present invention, an electric hammer is provided as described in the first claim.

[0011] The invention shall now be described with reference to the annexed drawings, which illustrate a non-limiting exemplary embodiment thereof, wherein:

- figure 1 shows an operating machine and the device according to a first preferred embodiment thereof;
- figure 2 shows the main section of the device in detail;
- figure 3 shows a sectional view of the view of figure 2.

[0012] With reference to figure 1, reference numeral 1 indicates an operating machine 1, comprising an antenna 2 whereon electric hammer 3 object of the present invention is installed. A pile 4 to be driven is present underneath electric hammer 3.

[0013] Pile 4 to be driven may be made of metal or prefabricated concrete.

[0014] The purpose of electric hammer 3 is to drive pile 4 into the ground. Electric hammer 3 has the possibility of translating along antenna 2 and is moved by a rope connected to a winch of machine 1, not shown.

[0015] With reference to figure 2, in electric hammer 3 there is a stator element, or stator 5 of an electric motor with a high specific torque [Nm/A], which exhibits electric windings capable of generating a suitable magnetic field. Rotor 6, with a cylindrical shape, is made with permanent magnets (for example rare earths), arranged as plates around the rotor structure and is free from windings; the permanent magnets, suitably energized by the magnetic field generated by stator 5, tend to rotate relative to axis 7. External casing 8, which is fixed and not rotating, constrains stator 5 imparting the necessary reaction thereto and connecting to an intermediate element 9 first and then to a frame 10 that exhibits means for constraining to antenna 2, leaving electric hammer 3 free to translate along antenna 2.

[0016] Rotor 6 is connected to a device 11 capable of transforming the rotatory movement into an axial movement. In the specific case, it is a recirculation ball screw 11; screw 11 is subject to a rotatory movement and is supported by a pair of bearings 12, 13 capable of withstanding the loads involved; screw 11 is associated to a female screw 14 that exhibits an axial movement when screw 11 is rotating. Said axial movement of female screw 14 is oriented along an axis X of maximum extension of electric hammer 3.

[0017] Screw 11 and female screw 14 exhibit a helical groove wherein balls (not shown) slide. Recirculation ball

screws 11, which are devices known in the field, exhibit very high efficiency, excellent dynamic behaviour and excellent shock resistance. Such screws 11, in fact, exhibit efficiency above 99%. It is also possible to use other devices, such as operating screws; however, in this case, considerably lower efficiency and dynamicity may be accepted.

[0018] It is necessary to prevent the rotation of female screw 14 through guiding elements 15 constrained to frame 10. The guiding elements therefore provide an anti-rotation function for allowing the linear movement of female screw 14.

[0019] As shown in figure 3, guiding elements 15 are arranged in an opposite position relative to each other, radially arranged about the circumference of electric hammer 3, on two axes orthogonal to each other.

[0020] Female screw 14 is then connected to an extension element 16 which is in turn connected to a striking hammer 17.

[0021] A translational motion of striking hammer 17 is thus obtained by actuating rotor 6, which strikes pile 4. The impact imparts the required energy to the pile to be driven in the ground. A casing (not shown in the annexed figures) is often interposed between striking hammer 17 and pile 4, and in particular on the lower end of same striking hammer 17; such casing exhibits a plurality of damping elements required for keeping the pile in the correct position and reducing the energy that is released to the frame.

[0022] As pile 4 is driven in the ground, electric hammer 3 follows the movement thereof continuing to generate impacts that finally cause the complete driving thereof.

[0023] Rotor 6 is subject to an alternating rotatory movement (for example in a clockwise direction first and in a counter-clockwise direction after; or vice versa) and consequently, striking hammer 17 is subject to an alternating translational motion, as it is directed downwards (for striking pile 4) and then upwards again. Hammer 17 may move from a maximum height position to a minimum height position relative to the ground. The two extreme positions of maximum and minimum height, respectively, are detected by two position sensors 18, 19.

[0024] An encoder 20 is further provided for detecting the angular position of the rotor and thus know where the striking hammer is. The striking hammer generates the impact, both by the effect of the thrust by the force of gravity, and by the effect of the thrust actively given by female screw 14 of recirculation ball screw 11 actuated by rotor 6.

[0025] This type of electric motors is often called "*direct drive*" as they exhibit an architecture that allows using them directly connected to the load without putting any reducers before. This greatly simplifies the mechanics. Moreover, these motors exhibit very high torques and therefore, combining the thrust generated by this motor with the thrust due to the force of gravity acting on the striking hammer it is possible to obtain a transfer of high specific energy using light striking hammers.

[0026] The advantages of the electric motor are known in the light of the above description. In particular, since it is a fully electric device, it does not require hydraulic oil and thus it solves the environment pollution problem related to the emissions of diesel tilt hammers and to the disposal of hydraulic oils in hydraulic tilt hammers.

[0027] Moreover, since it is an electric device, the electric hammer object of the present invention is suitable and especially adapted for being used on a fully electric, and thus low-environment impact, machine. This makes it adapted for any operation in closed environments wherein it is not possible to directly introduce exhaust gases to the environment nor it is possible to use too noisy devices.

[0028] The use of intelligent *direct drive* electric motors allows controlling the dynamics of the strikes, adapting it to the ground for obtaining the highest driving efficacy. Strike frequency and impact energy may be varied as desired, obtaining a synergic effect of the gravitational component, which in any case would not be avoided, with a strength imparted by the rotation of rotor 6, which is therefore adjustable; in this case, the user may advantageously operate the electric hammer according to the present invention through controls electrically connected to a data processing unit. At least the position of striking hammer 17 may be monitored and detected continuously, via software, through encoder 20, electrically connected to the data processing unit.

[0029] Moreover, it is possible to use the modern software techniques for energy recovery in the steps wherein the hammer needs to be braked. In fact, at the end of each strike the hammer must be lifted again, braked and thrust again in the direction of pile 4. During the braking step, rotor 5 and stator 6 operate as a current generator, for example supplying a battery (not shown in the annexed figures).

[0030] By combining the force of gravity with the thrust of the *direct drive* motor system and recirculation ball screw it is possible to obtain impacts that may not be obtained with traditional systems, which would require large striking hammers and would therefore be very slow. This adds up to the fact that the lack of reduction means reduces the mechanical complexity of electric hammer 3 compared to the prior art, thus making it less expensive to manufacture and equally free from failures due to complex and delicate mechanical components.

[0031] Finally, electric hammer 3 object of the present invention may be effectively operated also in strongly tilted conditions, being able to use not only the gravitational force action but also the active one of motor 6 and of recirculation ball screw 11.

[0032] A further advantage of electric hammer 3 object of the present invention is that rotor 6 does not require wiring or electric power that should have to be transmitted through complex and delicate sliding contacts. In fact, the required magnetic field is directly generated by permanent magnets.

[0033] Finally, mechanically, electric hammer 3 object

of the present invention is very simple, with few components and therefore with minimal maintenance, while ensuring a very high overall efficiency, higher than 90%.

[0034] Some variations, changes and additions that are clear to a man skilled in the art may be applied to the device described above without departing from the scope of protection provided by the annexed claims.

Claims

1. Electric hammer (3), specifically for striking on a pile (4) to be driven in the ground; said electric hammer (3) being **characterized in that** it comprises a permanent magnet electric motor having a rotor (6) mechanically connected to a device (11) for the movement transformation from a rotatory movement to an axial movement; said electric hammer (3) comprising also a striking hammer (17); the device (11) for the movement transformation, moving axially said striking hammer (17) from a first to a second height; said striking hammer (17) being susceptible of striking in use said pile (4).
2. Electric hammer according to claim 1, wherein said device (11) for the movement transformation is a recirculation ball screw.
3. Electric hammer according to claim 2, comprising also a pair of bearings (12, 13); said pair of bearings (12, 13) supporting said recirculation ball screw.
4. Electric hammer according to claim 1, comprising also a female screw (14) axially movable along a direction of maximum extension of said electric hammer (3).
5. Electric hammer according to claim 4, comprising also an extension means (16) mechanically connecting said female screw (14) to said striking hammer (17).
6. Electric hammer according to claim 1, comprising a damping casing associated to said striking hammer (17).
7. Electric hammer according to claim 1, wherein said rotor (6) features a rotatory movement alternatively in a clockwise direction and in a counter-clockwise direction.
8. Electric hammer according to claim 1, wherein said electric motor is associated to said device (11) for the movement transformation without the interposition of reducing means.
9. Electric hammer according to claim 1, wherein said permanent magnets are positioned all around said

rotor (6) and comprise rare earths.

10. Electric hammer according to claim 1, wherein said electric motor comprises a stator (5) constrained to an external casing (8) of said electric motor, fixed and not rotating.
11. Electric hammer according to claim 10, wherein said casing (8) is constrained to a frame (10) of said electric hammer (3); said frame (10) being susceptible of connecting in use said electric hammer (3) to an antenna (2) of an operating machine (1) leaving to the electric hammer (3) the possibility of translating along the antenna (2).
12. Electric hammer according to any of the preceding claims, comprising also position sensor means (18, 19); said position sensor means (18, 19) detecting a first and a second end position of a stroke of said striking hammer (17).
13. Electric hammer according to claim 1, wherein said striking hammer (17) moves with a speed and force exerted at least by said electric motor.
14. Electric hammer according to claim 13, wherein said striking hammer (17), in use, is susceptible of striking on said pile (4) with a combined action of gravity and movement induced by said electric motor.
15. Operating machine (1) for driving piles (4), comprising an electric hammer (3) according to any of the claims 1-14.

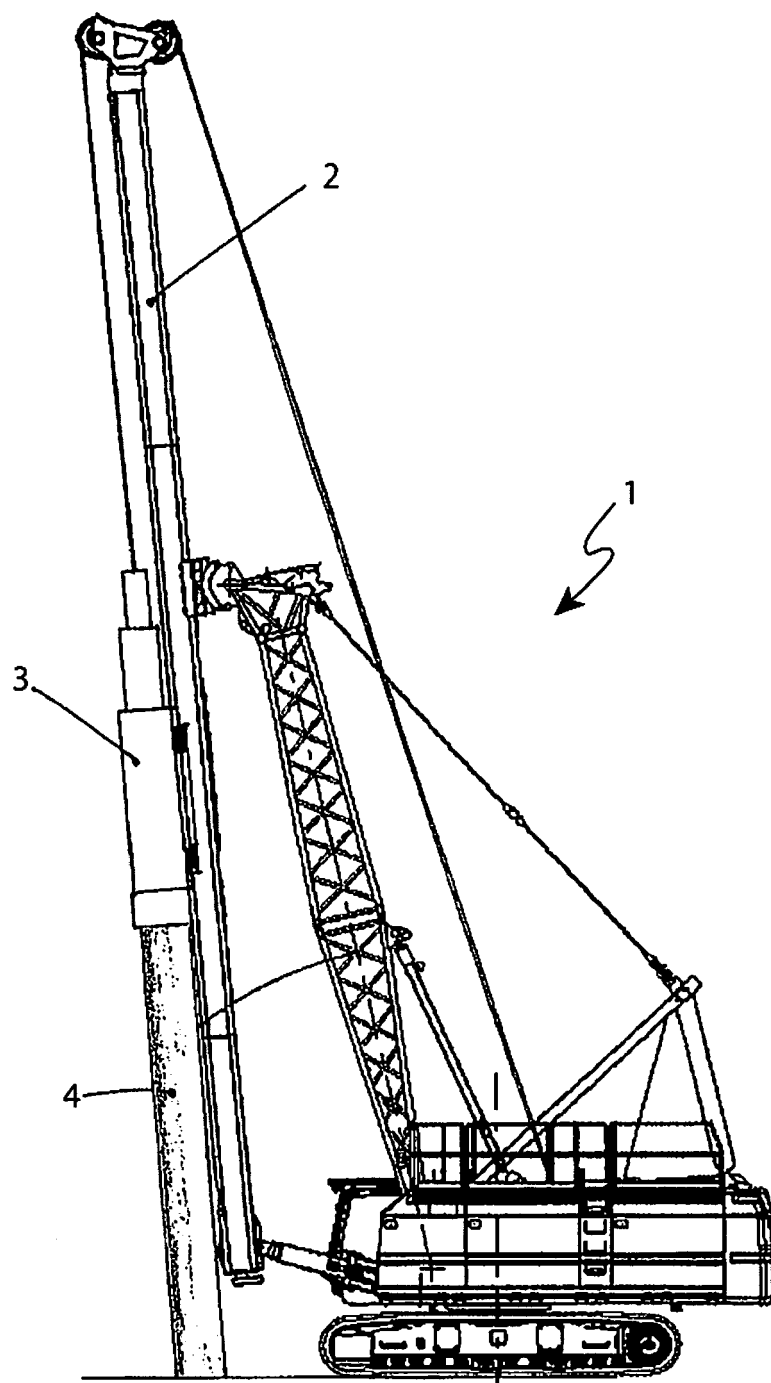


Fig.1

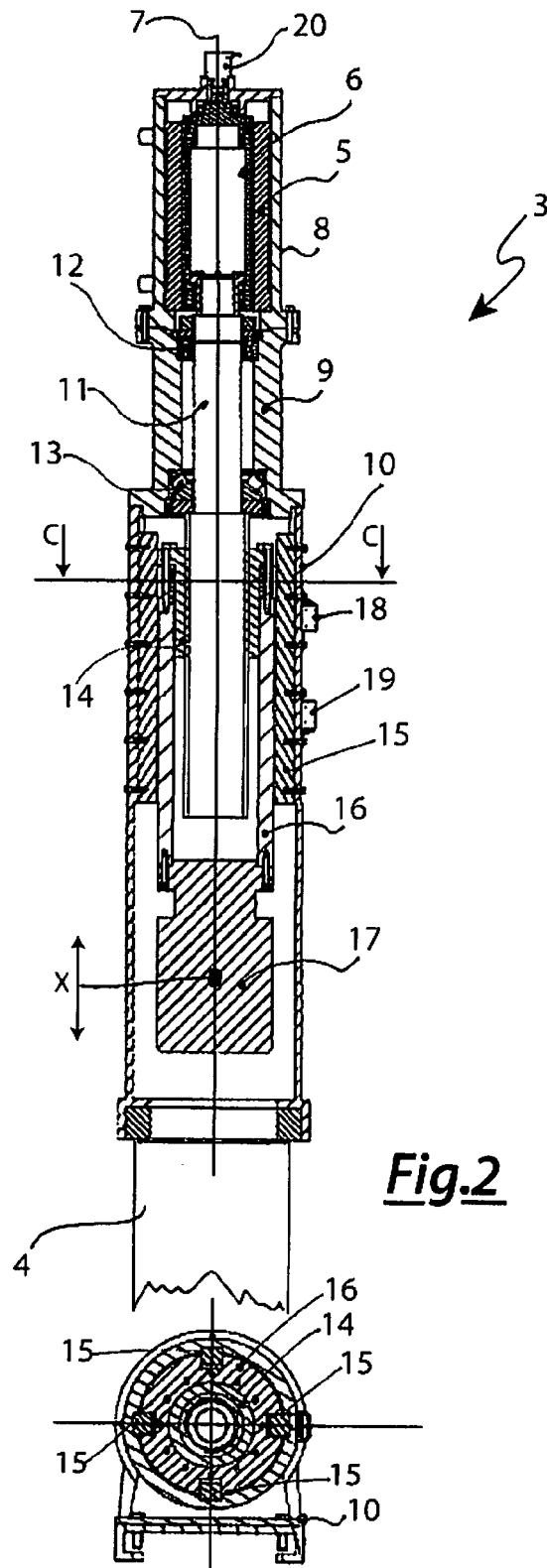


Fig.2

Fig.3



EUROPEAN SEARCH REPORT

Application Number
EP 11 19 1756

DOCUMENTS CONSIDERED TO BE RELEVANT			
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
A	FR 2 581 100 A1 (MARTELEC [FR]) 31 October 1986 (1986-10-31) * the whole document *	1-15	INV. E02D7/06
A	----- CN 2 594 318 Y (DING YAN [CN]) 24 December 2003 (2003-12-24) * the whole document *	1-15	
			TECHNICAL FIELDS SEARCHED (IPC)
			E02D
The present search report has been drawn up for all claims			
Place of search Munich		Date of completion of the search 15 March 2012	Examiner Geiger, Harald
CATEGORY OF CITED DOCUMENTS X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document		T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons & : member of the same patent family, corresponding document	

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EPO FORM 1503 03/02 (P04/C01)

**ANNEX TO THE EUROPEAN SEARCH REPORT
ON EUROPEAN PATENT APPLICATION NO.**

EP 11 19 1756

This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report.
The members are as contained in the European Patent Office EDP file on
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15-03-2012

Patent document cited in search report		Publication date	Patent family member(s)	Publication date
FR 2581100	A1	31-10-1986	NONE	

CN 2594318	Y	24-12-2003	NONE	

REFERENCES CITED IN THE DESCRIPTION

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- CN 2594318 Y [0008]