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(54) **HAMMERING DEVICE AND A METHOD FOR OPERATING A HAMMERING DEVICE**

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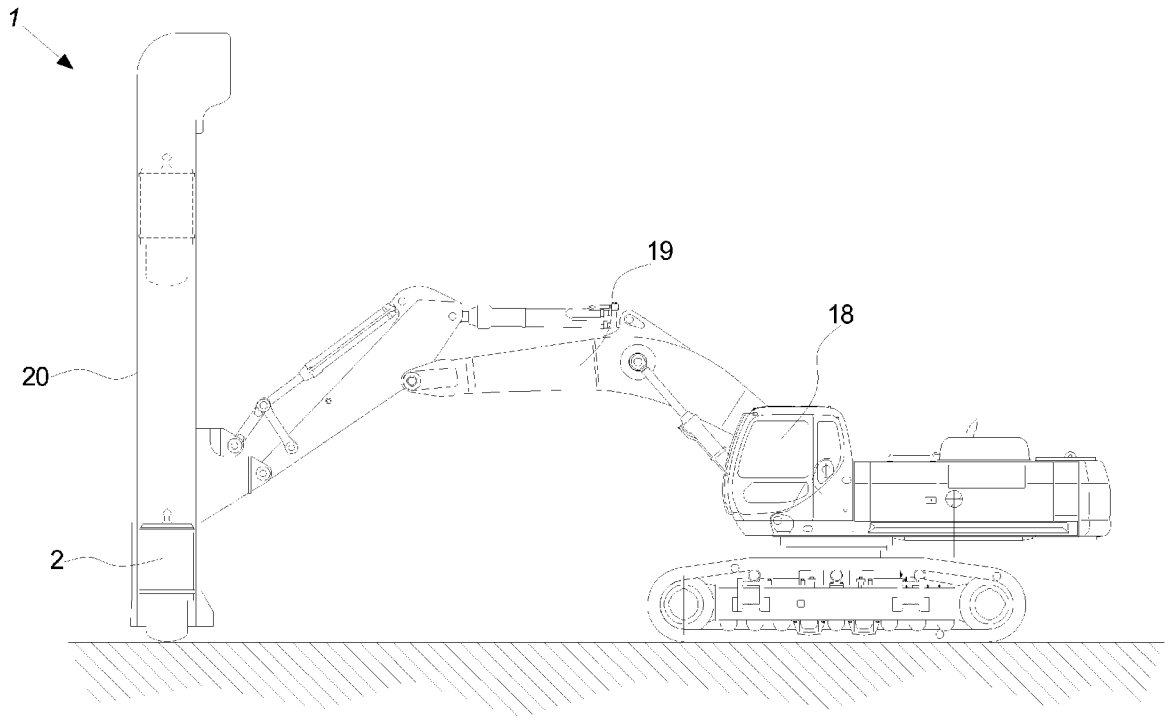
(57) **ABSTRACT**

Disclosed is a hammering device (**1**) comprising a hammer (**2**) connected to a winch (**3**) by means of cable means (**4**), wherein the rotation of the winch (**3**) is driven by one or more hydraulic motors (**5**), and wherein the hammering device (**1**) further comprises position detection means (**6**) for detecting a position of the hammer (**2**). Furthermore, a method for operating a hammering device (**1**) is disclosed.



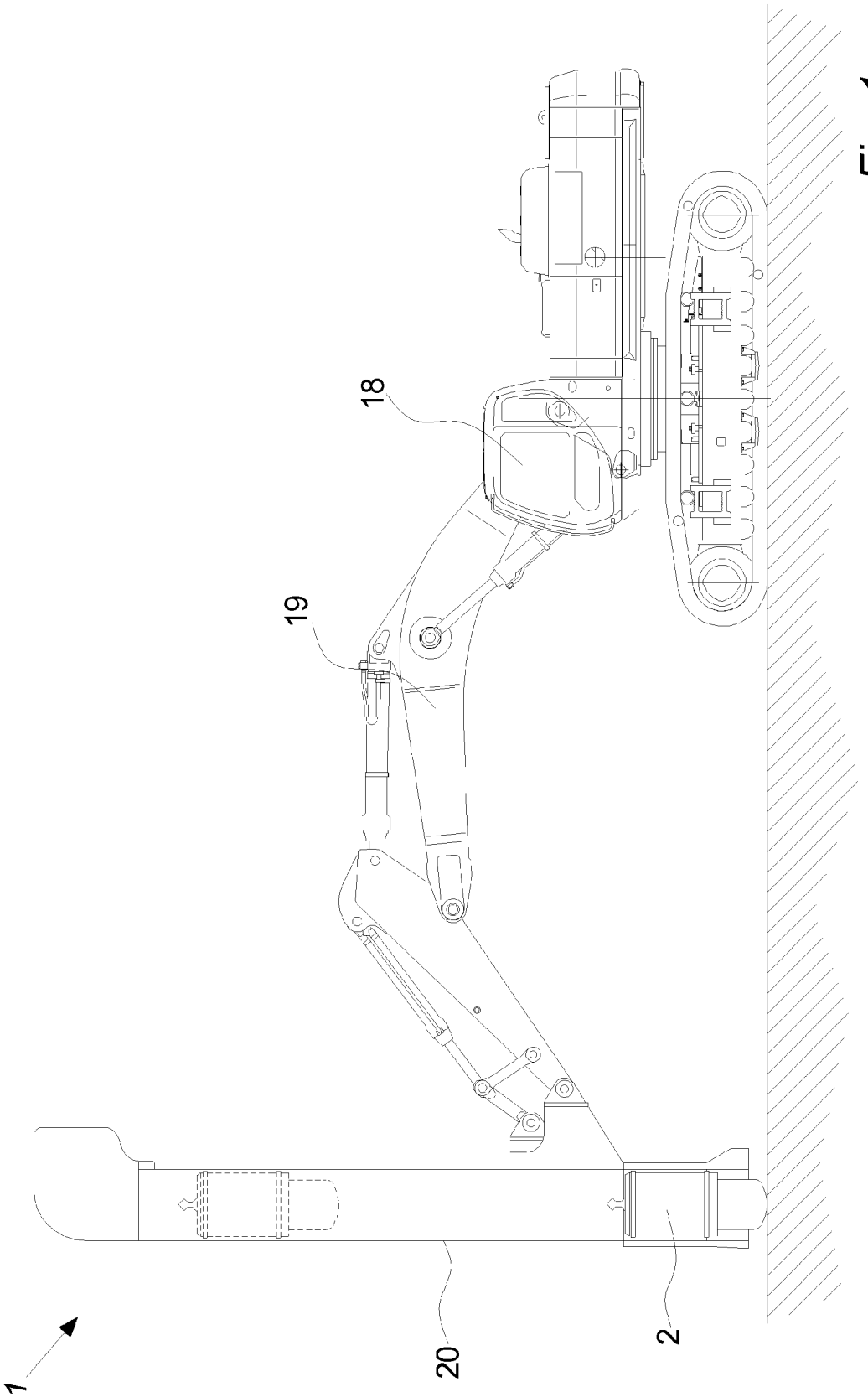


Fig. 1

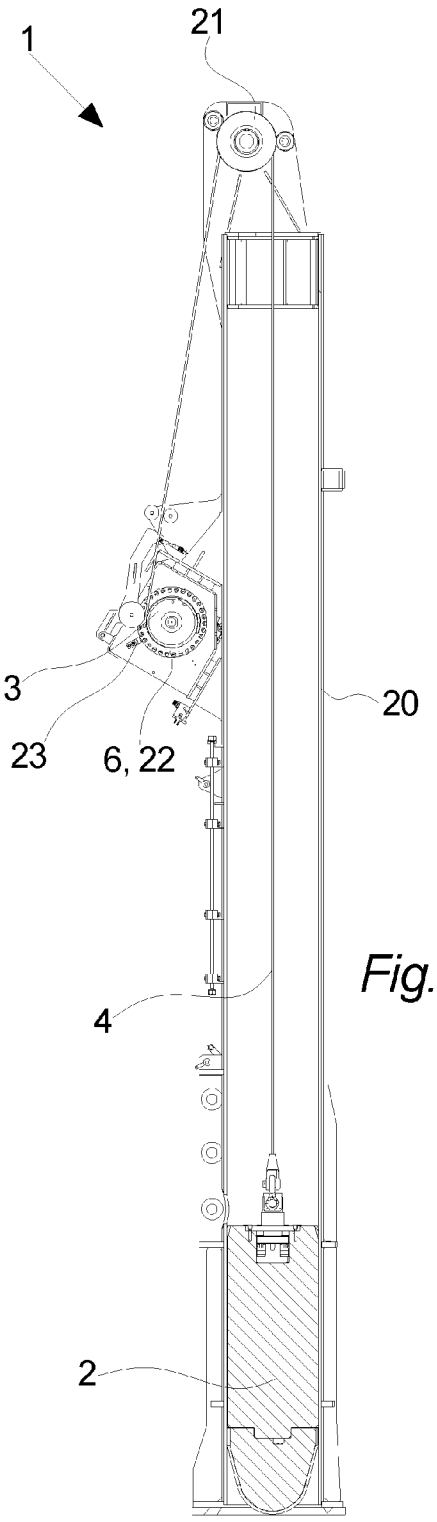


Fig. 3

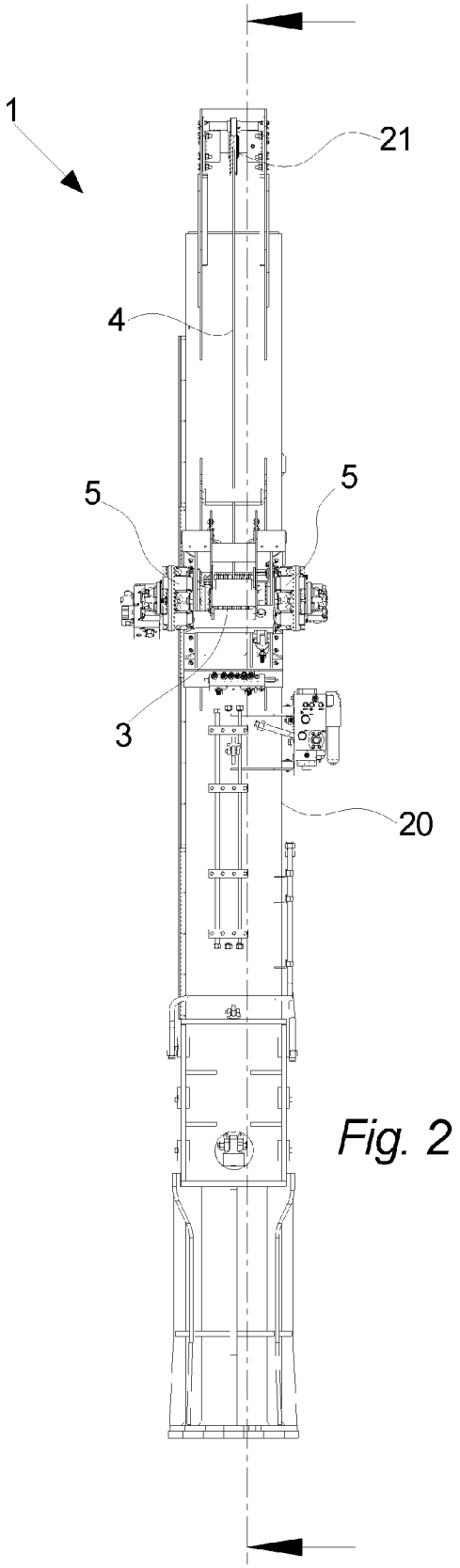


Fig. 2

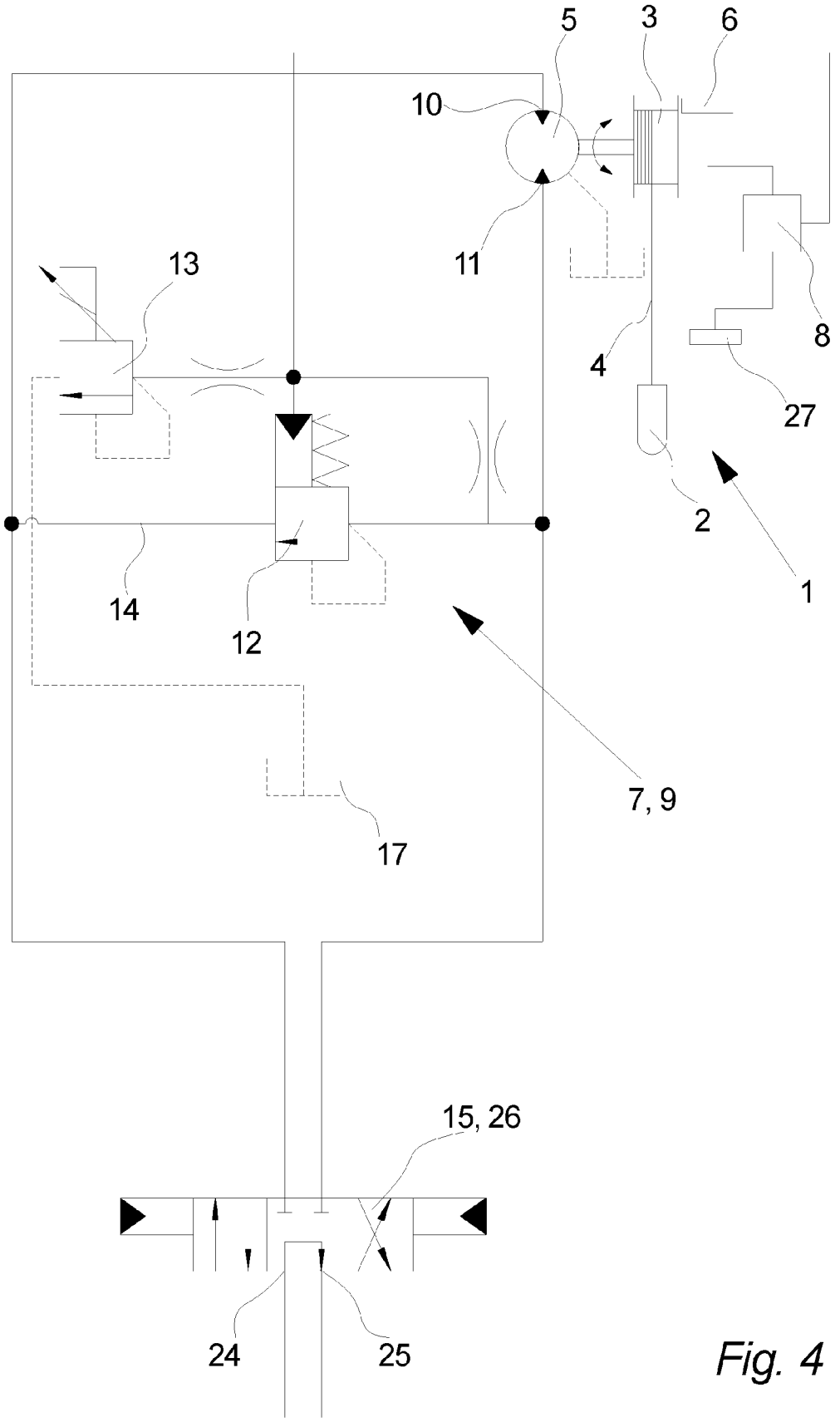


Fig. 4

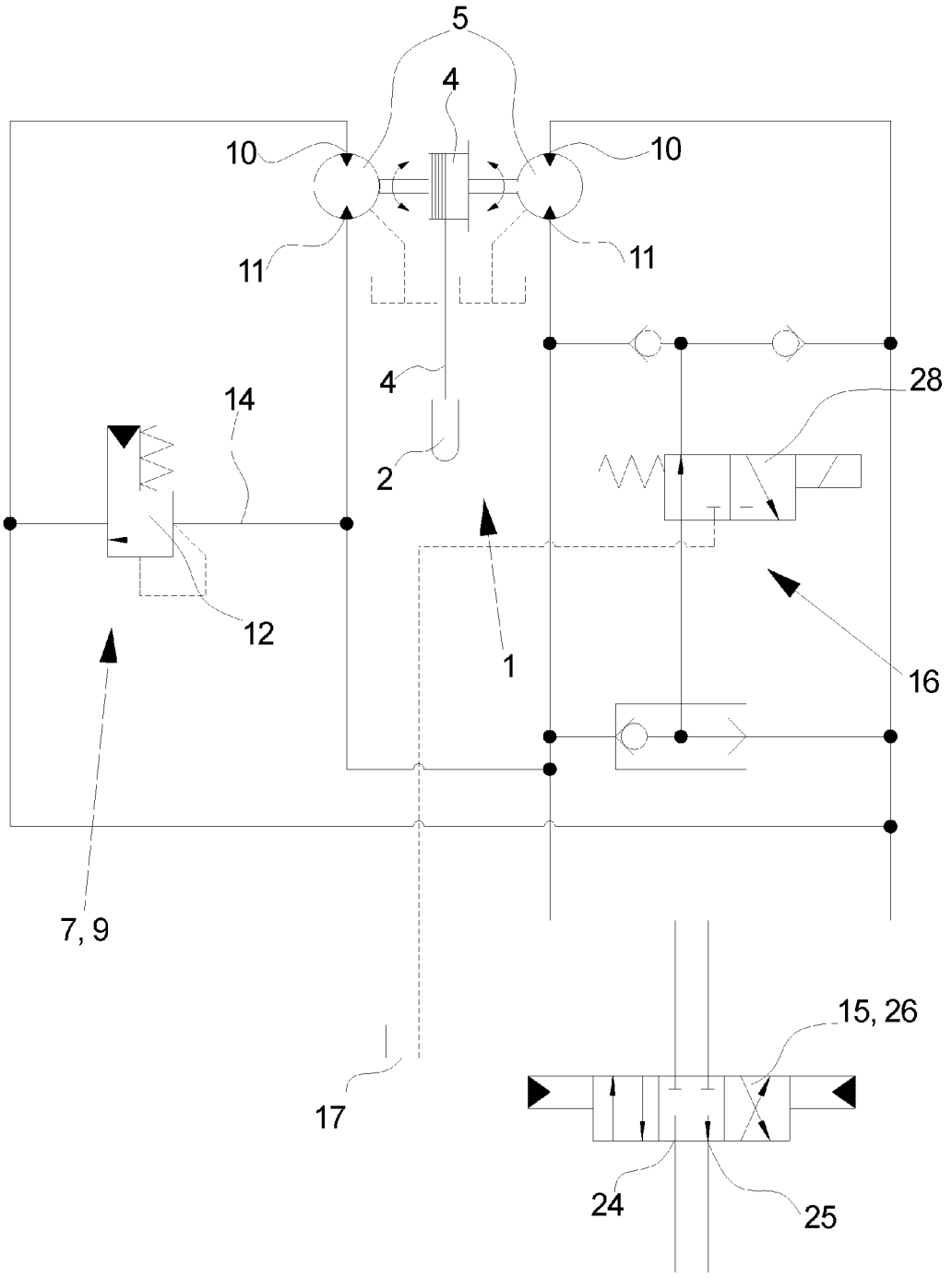


Fig. 5

HAMMERING DEVICE AND A METHOD FOR OPERATING A HAMMERING DEVICE

FIELD OF THE INVENTION

[0001] The invention relates to a hammering device comprising a hammer connected to a winch by means of cable means. The invention further relates to a method for operating a hammering device.

BACKGROUND OF THE INVENTION

[0002] Hammering devices such as pile drivers, breakers, hydraulic hammers and the like are used for a number of purposes e.g. in the mining and quarry industry for breaking boulders and the like, in the steel industry for ladle deskulling, for slag crushing or for other purposes such as breaking up large concrete surfaces like runways, roads and factory floors.

[0003] A hammering device typically comprises a very heavy hammer head traveling inside a hammer guide e.g. in the form of a large tube. The device further comprises some sort of lifting mechanism arranged to lift the hammer to a certain height where after the hammer head is released and by free fall (i.e. gravity pull) is brought to impact on an object whether it be a pile, a rock or other objects which need to be crushed or impacted.

[0004] Typically, the hammer head will have a weight of from a couple of tonnes to more than 10 tonnes and in order to make such hammering devices economically attractive, it is necessary to design the device so that it is able to create a certain number of full impacts per minute.

[0005] E.g. from the international patent application WO 2008/106964 A1 it is known to lift the hammer by means of a wire running through a block and tackle. When the hammer is dropped it is released from the wire and will have to be reattached to the wire before it can be lifted again. However, this system is time consuming and the releasable device coupling the hammer to the wire is expensive and vulnerable.

[0006] Thus, from Japanese patent application JP 56046025 it is therefore known to form the hammer lifting mechanism by means of a winch driven by a hydraulic motor. To drop the hammer a short circuit flow path is established between the input port and the output port of the hydraulic motor. However, when the hammer reaches impact the inertia of the motor, the winch and particularly the heavy duty wire will entail that the wire will overshoot. The wire that has been unwound may tangle up, it may inflict damaging sharp bends to the wire and it increases the time it takes to prepare the hammer for the next impact.

[0007] It is therefore an object of the present invention to provide a cost-efficient hammering device technique alleviating the abovementioned drawbacks.

THE INVENTION

[0008] The invention provides for a hammering device comprising a hammer connected to a winch by means of cable means, wherein the rotation of the winch is driven by one or more hydraulic motors, and wherein the hammering device further comprises position detection means for detecting a position of the hammer.

[0009] Providing the hammering device with position detection means for detecting the actual position of the hammer is advantageous in that it enables that a braking procedure may be commenced before the hammer reaches impact. Hereby, it is possible to reduce or completely avoid that the cable means overshoots and the hammer can therefore be lifted again immediately after impact, which among other severely increases the capacity of the hammering device.

[0010] It should be emphasised that the term "cable means" in this context should be interpreted as any kind of line, rod, rope, wire, chain or any other kind of cable suitable for lifting a very heavy hammer and for being wound around a winch.

[0011] It should be also emphasised that the term "position detection means" in this context should be interpreted as any kind of incremental encoder, absolute encoder, tachometer, revolution-counter, RPM gauge or any kind of contact or none-contact sensors capable of detecting position (by means of distance detection or detecting increments) e.g. by means of laser, light, sound, magnetism, radar or any other kind of position detector capable of detecting the actual position of a hammer in a hammering device.

[0012] In an aspect of the invention, said hammering device further comprises winch rotation braking means.

[0013] Providing the hammering device with winch rotation braking means is advantageous in that such means enables simple and inexpensive braking means.

[0014] In an aspect of the invention, said hammering device further comprises control means for activating said winch rotation braking means in accordance with an input from said position detection means.

[0015] Activating the winch rotation braking means in accordance with the actual position of the hammer is advantageous in that it enables a more controlled and precise braking process.

[0016] In an aspect of the invention, said control means comprises reset means for resetting said position detection means when said hammer reached impact.

[0017] In an aspect of the invention, said hammering device further comprise impact position detection means for detecting when said hammer reached impact.

[0018] Each time the hammer is dropped on an object, the object will most likely deform, break or at least move so that if the same object is hit several times, the impact position will typically move further and further down. However, if the braking process is started at the same position each time, the brake system will absorb too much energy before the hammer reaches impact on succeeding strikes, which will strain the braking system and reduce the energy in the impact. Thus, it is advantageous to ensure that the impact position is detected by an impact sensor and that the braking procedure of a subsequent strike is commenced on the basis of this impact position.

[0019] The impact position could e.g. be detected by monitoring the oil pressure in the hydraulic motor circuit, by means of strain gauges on/at the winch or cable means, by means of accelerometers, acoustic monitors or by other means.

[0020] In an aspect of the invention, said hammering device comprises direct short circuit flow path means for optionally creating a direct short circuit flow path between an input port and an output port of said hydraulic motor.

[0021] Short circuiting the hydraulic motor is a fast and efficient way of enabling that the hammer may drop substantially freely.

[0022] In an aspect of the invention, said winch rotation braking means comprises short circuit flow path blocking means for blocking a flow through said short circuit flow path.

[0023] Blocking the flow through the short circuit flow path is a fast and efficient way of providing winch rotation braking

means. Furthermore, it is relatively easy to control the braking process by means of such short circuit flow path blocking means and in contrast to ordinary brake means such as disk brakes or drum brakes, the short circuit flow path blocking means does substantially not comprise wear parts.

[0024] In an aspect of the invention, said direct short circuit flow path means comprises overpressure relieve means.

[0025] If the braking process is initiated to early or by mistake, substantially all the energy of the falling hammer could be absorbed by the short circuit flow path blocking means and/or the direct short circuit flow path means. This could lead to a dangerous increase of the pressure in the direct short circuit flow path and it is therefore advantageous to provide the direct short circuit flow path means with overpressure relieve means.

[0026] In an aspect of the invention, said overpressure relieve means is arranged to relieve the pressure in said direct short circuit flow path if said pressure exceeds 700 Bar, preferably if said pressure exceeds 500 Bar and most preferred if said pressure exceeds 300 Bar.

[0027] If the pressure in the direct short circuit flow path is too low when it is relieved, the brake will be inefficient and if the pressure is too high the risk of damage due to overpressure is increased. Thus, the present pressure levels present an advantageous relation between efficiency and safety.

[0028] In an aspect of the invention, said direct short circuit flow path means comprises refilling means for increasing the pressure in said short circuit flow path.

[0029] When the hammer is accelerating and when the short circuit flow path blocking means are deployed, there is a significant risk of cavitation in the hydraulic circuit—particularly in the hydraulic motor. However, by increasing the pressure in the short circuit flow path by means of refilling means this risk is severely reduced.

[0030] In an aspect of the invention, said winch is driven by more than one hydraulic motor.

[0031] Two or more hydraulic motors will typically be less expensive that a single hydraulic motor with equivalent capacity—particularly in relation to the present heavy duty hydraulic motors—and driving the winch by means of two or more hydraulic motors will also provide reciprocity to the lifting system—thus increasing the safety level of the system.

[0032] In an aspect of the invention, at least one of said more than one hydraulic motor comprises freewheeling means.

[0033] Providing the additional motor(s) with freewheeling means is advantageous in that the freewheeling means enables that substantially no energy is absorbed by these motors during the drop—thus increasing the capacity of the hammering device.

[0034] In an aspect of the invention, said freewheeling means comprises means for connecting an output port of said hydraulic motor to tank means.

[0035] If no oil is supplied to the input port of the hydraulic motor and the output port is connected to tank the hydraulic motor will after one full revolution will be emptied and a vacuum will be established inside the motor. This is advantageous in that the motor will absorb very little energy and in that the vacuum will aid in refilling the motor once it is pressurised again.

[0036] In an aspect of the invention, said position detection means comprise a rotary encoder.

[0037] Using a rotary encoder is a simple and efficient way of detecting the position of hammer by detecting the rotations of the winch.

[0038] In an aspect of the invention, said rotary encoder is connected to a winch shaft around which said winch rotates.

[0039] Hereby is achieved an advantageous embodiment of the invention.

[0040] The invention further provides for a method for operating a hammering device. The method comprises the steps of:

[0041] lifting a hammer of the hammering device to a predetermined initial position by means of winch means driven by at least one hydraulic motor,

[0042] dropping the hammer by creating a direct short circuit flow path between an input port and an output port of the hydraulic motor, and

[0043] breaking or reducing a flow through the short circuit flow path before the hammer reaches impact.

[0044] It is advantageous to initiate the braking process before the hammer reaches impact in that it is hereby possible to avoid or reduce that the cable means overshoots when the hammer reaches impact.

[0045] In an aspect of the invention, said method further comprises the step of detecting a position of said hammer at least during said drop.

[0046] Detecting the position of the hammer during the drop is advantageous in that this enables that the braking process can be initiated more precisely and efficiently.

[0047] Furthermore, detecting e.g. the initial position is advantageous in that it hereby is possible to determine the energy delivered by the drop and detecting the impact position is advantageous in that it hereby is possible to initiate the braking process more accurately at the next drop.

[0048] In an aspect of the invention, said flow through said short circuit flow path if broken or reduced in response to said detected position of said hammer.

[0049] Reducing the flow through the direct short circuit flow path in response to the detected position of the hammer is advantageous in that this enables that the flow can be reduced or completely broken just before the hammer reaches impact and thereby ensure that the kinetic energy of the rotation/motion of the winch and cable means is absorbed by the winch rotation braking means—thus reducing the risk of the cable means overshooting.

[0050] In an aspect of the invention, said position of said hammer is detected in relation to the latest impact position of said hammer.

[0051] In an aspect of the invention, said breaking or reducing said flow through said direct short circuit flow path is initiated in response to the latest impact position of said hammer.

[0052] It is advantageous to initiate the braking process in relation to the latest impact position of the hammer in that this ensures that the braking process may be initiated at the right time just before the current impact position.

[0053] In an aspect of the invention, said predetermined initial position is selected manually by an operator.

[0054] Different objects or different circumstances demand strikes of different energy and since the hammering device of the present invention comprises hammer position detection means it is advantageous to enable that the initial position of the hammer is chosen by the operator to ensure that a more correct amount of energy is delivered at each stroke.

[0055] In an aspect of the invention, said hammering device is a hammering device according to any of the previously mentioned hammering devices.

FIGURES

[0056] The invention will be described in the following with reference to the figures in which

[0057] FIG. **1**. illustrates a hammering device mounted on a heavy duty excavator, as seen from the side,

[0058] FIG. **2** illustrates a hammering device, as seen from the front,

[0059] FIG. **3** illustrates a cross section through a hammering device, as seen from the side,

[0060] FIG. **4** illustrates the hydraulic diagram of a hammering device comprising a single hydraulic motor, and

[0061] FIG. **5** illustrates the hydraulic diagram of a hammering device comprising two hydraulic motors.

DETAILED DESCRIPTION

[0062] FIG. **1** illustrates a hammering device **1** mounted on a heavy duty excavator **18**, as seen from the side.

[0063] In this embodiment the excavator **18** weighs in excess of **50** ton in order to be able to handle the large hammering device **1** mounted on the arm **19** of the excavator **18**.

[0064] However in another embodiment the hammering device **1** could be mounted on an excavator **18** of another weight—both lesser or greater—, the hammering device **1** could be mounted on another mobile or stationary apparatus such as a crane, a forklift, a digger or similar or the hammering device **1** could be arranged stationary or be provided with means for making it self-propelling.

[0065] In this embodiment the hammering device **1** is supplied with oil pressure from the excavators internal oil pump but in another embodiment the hammering device **1** could be provided with its own independent oil pressurizing means or pressurized oil could be supplied from a pressurizing source external to both the excavator **18** and the hammering device **1**.

[0066] Typically the hammering device **1** is first mounted on the arm **19** of the excavator **18** and the hammering device **1** is connected to the hydraulic system and/or the electrical system of the excavator **18**. The operator will then initiate that the hammering device **1** will lift the hammer **2** inside the hammer guide means **20** up to an initial position. The initial position—i.e. the height to which the hammer **2** is initially lifted—could be chosen by the operator, it could be defined on basis of the latest impact position, it could be a fixed position inside the hammer guide means **20** or the initial position could be chosen or determined in another way. The excavator **18** then moves the hammering device **1** to the place of use and places the hammering device **1** so that the hammer guide means **20** rests on the object to be hammered on or places the bottom of the hammer guide means **20** immediately above the object. The operator then initiates the hammering process in the form of a single blow, a predefined series of blows or that the hammering process continues until the operator stops it again.

[0067] In the hammering process the hammer **2** is first dropped from its initial position where after gravity will pull the hammer **2** downwards until the hammer **2** hits the object over which the hammering device **1** is placed. Immediately thereafter the hammer **2** is lifter up to the initial position and e.g. dropped again. In an embodiment the actual impact position is determined each time the hammer **2** hits the object and the initial position is then adjusted accordingly to ensure that the hammer **2** travels substantially the same distance each time and thus delivers substantially the same amount of energy. The travel distance could also be continuously adjusted by the operator.

[0068] FIG. **2** illustrates a hammering device **1**, as seen from the front.

[0069] In this embodiment the hammer guide means **20** are formed as a tube i.e. an elongated cylinder having an inside diameter a little greater than the outer diameter of the hammer **2**. The hammer guide means **20** ensures that the hammer **2** travels up and down along a predefined path and in another embodiment the hammer guide means **20** could instead or also comprise rails, guidance or other or the tube and/or the hammer **2** could be formed with a square, a polygonal, an oval or another cross section.

[0070] In this embodiment the hammering device **1** is provided with a winch **3** arranged on the outside of the hammer guide means **20**. The winch means **3** is in this embodiment driven by two hydraulic motors **5** arranged on either sides of the winch **3**. In another embodiment the winch **3** could be driven by another number of hydraulic motors **5** such as one, three, four or more or the winch **3** could be driven by one or more hydraulic motors **5** in combination with another motor type such as a combustion engine, an electrical motor or other.

[0071] In this embodiment the hammering device **1** only comprises a single winch **3** but in another embodiment the hammering device **1** could comprise more than one winch means **3** such as two, three or more e.g. coupled in parallel.

[0072] FIG. **3** illustrates a cross section through the hammering device **1** disclosed in FIG. **2**, as seen from the side.

[0073] In this embodiment the hammer **2** is connected to the winch **3** by means of cable means **4** extending from the winch **3** and up around a pulley **21** arranged at the upper end of the hammer guide means **20** and down to the hammer **2** inside the hammer guide means **20**. However in another embodiment the winch **3** could be arranged at the the upper end of the hammer guide means **20** thus rendering the pulley **21** superfluous.

[0074] In this embodiment the hammering device **1** is also provided with means for braking the rotation of the winch **3** when the hammer **2** is dropping. In this embodiment these means are not provided to prevent the hammer **2** from reaching impact but to initiate a braking process just before the hammer **2** reaches impact to prevent that the cable means overshoots. The winch rotation baking means (not shown) will be discussed in details in relation with FIG. **4**.

[0075] To determine the actual position of the hammer **2**, the hammering device **1** is in this embodiment also provided with position detection means **6**. In this embodiment the position detection means **6** are formed as a rotary encoder comprising an encoder disk **22** and an inductive proximity sensor **23** detecting the holes in the encoder disk **22** as they rotate by. However in another embodiment the position detection means **6** could comprise another type of rotary encoder e.g. connected to the pulley **21** instead, it could comprise another type of position detectors such means distance sensors detecting the position of the hammer **2** by means of sound, ultrasound, light, laser, radar or other or the actual position of the hammer **2** could be detected in a multitude of other ways.

[0076] However, in another embodiment the hammering device **1** could be formed without position detection means **6**.

It such an embodiment the braking process could be initiated by means of a timer, in response to a particular sensor being activated or manually by an operator.

[0077] FIG. **4** illustrates the hydraulic diagram of a hammering device **1** comprising a single hydraulic motor **5**.

[0078] The present hydraulic diagram is stripped down to the bare essentials but in this embodiment the hammering device **1** comprises a hammer **2** connected to a winch **3** through cable means **4**. The winch **3** is in this embodiment driven by a single hydraulic motor **5**. Oil pressurizing means is connected to an inlet port **24** of a directional valve **26** and the outlet port **25** of the directional valve **26** is connected to tank. Thus, when the directional valve **26** is changed to the left chamber, pressurized oil will be led to an input port **10** of the hydraulic motor **5** and the output port **11** of the hydraulic motor **5** is connected to tank, which will make the winch **3** rotate and lift hammer **2** upwards. If it for some reason was needed to lower the hammer **2**—e.g. in case of repair, maintenance or other—the directional valve **26** could be changed to the right chamber so that the direction of the oil flow through the hydraulic motor **5** is reversed.

[0079] Typically the directional valve **26** is first changed to the left chamber to lift the hammer **2** and when the initial position has been reached the directional valve **26** is changed back to center position to lock the hammers position.

[0080] In this embodiment the hammering device **1** is also provided with direct short circuit flow path means **9** comprising a direct short circuit flow path **14** and short circuit flow path blocking means **12** in the form of an on/off valve. When the hammer **2** needs to be dropped, the short circuit flow path blocking means **12** is activated so that that flow is established through the direct short circuit flow path **14**. The position detection means **6** continuously detects the hammers position and just before impact, the control means **8** will initiate that the short circuit flow path blocking means **12** closes or starts to close the direct short circuit flow path **14** again to ensure that the cable means do not overshoot after impact.

[0081] In this embodiment the hammering device **1** is further provided with an impact sensor **27** for detecting when impact occurs. This information is fed to the control means **8** and the initial position of the succeeding drop is then calculated in response to the latest impact position.

[0082] If the braking procedure is turned on too early and the short circuit flow path blocking means **12** closes—or almost closes—the direct short circuit flow path **14** before the hammer **2** reaches impact, the oil pressure in the circuit could rise to dangerous levels.

[0083] Thus, in this embodiment the direct short circuit flow path means **9** comprises overpressure relieve means **13** in the form of a pressure valve that will bleed oil from the circuit to tank means **17** if the pressure exceeds an predefined level. However, in another embodiment the overpressure relieve means **13** could be located differently in the circuit and/or the function could be integrated with an exciting valve.

[0084] To reduce the risk of cavitation in the hydraulic motor **5** during the drop the circuit is in this embodiment provided with refilling means **15** to ensure that the pressure in the circuit at all times during the drop is higher than the loss/resistance. I.e. in this embodiment the directional valve **26** is opened slightly in lifting direction to pressurize the circuit slightly. However, in another embodiment the refilling means **15** could comprise a dedicated valve connected to the common oil pressurising means or to dedicated oil pressurising means.

[0085] FIG. **5** illustrates the hydraulic diagram of a hammering device **1** comprising two hydraulic motors **5**.

[0086] In this embodiment the winch **3** is driven by a first hydraulic motor **5** which is setup as explained under FIG. **4** and a second hydraulic motor **5** comprising freewheeling means **16**. The freewheeling means **16** comprises a tank valve **28** that selectively can connect the output port **11** of the second hydraulic motor **5** to tank means **17**. Thus, when the hammer **2** has to be dropped the short circuit flow path blocking means **12** and the tank valve **28** is substantially simultaneously activated so that the oil in the second hydraulic motor will be forced out of the output port **11** of the second hydraulic motor **5** and towards the tank means **17**.

[0087] Since the directional valve **26** is in closed centre position no oil is fed to the second hydraulic motor **5** during freewheeling and vacuum will then be established inside the motor **5**.

[0088] The invention has been exemplified above with reference to specific examples of hammering devices **1**, winches **3**, position detection means **6** and other. However, it should be understood that the invention is not limited to the particular examples described above but may be designed and altered in a multitude of varieties within the scope of the invention as specified in the claims.

LIST

[0089] **1**. Hammering device
[0090] **2**. Hammer
[0091] **3**. Winch
[0092] **4**. Cable means
[0093] **5**. Hydraulic motor
[0094] **6**. Position detection means
[0095] **7**. Winch rotation braking means
[0096] **8**. Control means
[0097] **9**. Direct short circuit flow path means
[0098] **10**. Input port of hydraulic motor
[0099] **11**. Output port of hydraulic motor
[0100] **12**. Short circuit flow path blocking means
[0101] **13**. Overpressure relieve means
[0102] **14**. Direct short circuit flow path
[0103] **15**. Refilling means
[0104] **16**. Freewheeling means
[0105] **17**. Tank means
[0106] **18**. Excavator
[0107] **19**. Arm of excavator
[0108] **20**. Hammer guide means
[0109] **21**. Pulley
[0110] **22**. Encoder disk
[0111] **23**. Inductive proximity sensor
[0112] **24**. Inlet port of directional valve
[0113] **25**. Outlet port of directional valve
[0114] **26**. Directional valve
[0115] **27**. Impact sensor
[0116] **28**. Tank valve

1. A hammering device comprising
a hammer connected to a winch by means of cable means,
wherein the rotation of said winch is driven by one or more hydraulic motors, and
wherein said hammering device further comprises position detection means for detecting a position of said hammer.

2. A hammering device according to claim **1**, wherein said hammering device further comprises winch rotation braking means.

3. A hammering device according to claim 1, wherein said hammering device further comprises control means for activating said winch rotation braking means in accordance with an input from said position detection means.

4. A hammering device according to claim 3, wherein said control means comprises reset means for resetting said position detection means when said hammer reached impact.

5. A hammering device according to claim 1, wherein said hammering device comprises direct short circuit flow path means for optionally creating a direct short circuit flow path between an input port and an output port of said hydraulic motor.

6. A hammering device according to claim 2, wherein said winch rotation braking means comprises short circuit flow path blocking means for blocking a flow through said short circuit flow path.

7. A hammering device according to claim 5, wherein said direct short circuit flow path means comprises overpressure relieve means.

8. A hammering device according to claim 7, wherein said overpressure relieve means is arranged to relieve the pressure in said direct short circuit flow path if said pressure exceeds 700 Bar, preferably if said pressure exceeds 500 Bar and most preferred if said pressure exceeds 300 Bar.

9. A hammering device according to claim 5, wherein said direct short circuit flow path means comprises refilling means for increasing the pressure in said direct short circuit flow path.

10. A hammering device according to claim 1, wherein said winch is driven by more than one hydraulic motor.

11. A hammering device according to claim 10, wherein at least one of said more than one hydraulic motor comprises freewheeling means.

12. A hammering device according to claim 10, wherein said freewheeling means comprises means for connecting an output port of said hydraulic motor to tank means.

13. A method for operating a hammering device, said method comprising the steps of:

lifting a hammer of said hammering device to a predetermined initial position by means of winch means driven by at least one hydraulic motor,

dropping said hammer by creating a direct short circuit flow path between an input port and an output port of said hydraulic motor, and

breaking or reducing a flow through said direct short circuit flow path before said hammer reaches impact.

14. A method according to claim 13, wherein said method further comprises the step of detecting a position of said hammer at least during said drop.

15. A method according to claim 14, wherein said flow through said direct short circuit flow path if broken or reduced in response to said detected position of said hammer.

16. A method according to claim 15, wherein said breaking or reducing said flow through said direct short circuit flow path is initiated in response to the latest impact position of said hammer.

17. A method according to claim 13, wherein said predetermined initial position is selected manually by an operator.

18. A method according to claim 13, wherein said hammering device is a hammering device according to claim 1.

* * * * *