

Mechanical hammering tool for use in oil wells

Field of the invention

5 The present invention relates to a hammering tool for use in oil wells, in particular a mechanical hammering tool (jar) to be used to perform various operations where there is a need for a powerful and varied hammering force. The invention also relates to a method for the use of the tool.

10 Background to the invention

As long as oil drilling has existed, different well service tools have been used with the objective of delivering a powerful blow for carrying out a certain operation, for example, in the collecting of various equipments in the well,
15 breaking of glass plugs in the well, in the opening or closing of a production valve in the well or similar operations.

Initially, the so called Spang jars or tubular jars were used, which originally are composed of a steel body that is accelerated a certain distance before it
20 abruptly stops mechanically and thereby delivers a hammering energy. These are commonly used where there is a need for one blow only of relatively little force as the acceleration is normally manual in that a person pulls on a taut wire.

25 More refined versions have gradually been introduced where one has either a typical mechanical jar or hydraulic jar where a much higher kinetic energy can be pre-stressed in the wire before the release. These often use a so-called accelerator fitted over itself as a spring packet that stores/accumulates the kinetic tension force energy relatively near the jar as opposed to only using the
30 kinetic tension energy in a taut wire. The taut wire will be much slower to accelerate the jar as the wire can be many thousand meters long.

Today, primarily two kinds of jars, also called hammering tools, are used in the industry, namely mechanical and hydraulic jars. Both have advantages and

disadvantages in use.

With the mechanical jars, a certain release force is pre-set, which leads to the tool delivering a certain hammering energy when it comes up to the tension force that has been pre-set. This will then deliver a blow immediately the tension force has been reached. Mechanical jars have no seals where one can close off the well pressure, but they have a simple design.

The disadvantages are that the hammering force is limited to the pre-set value before the tool went into the well and the tension release force must be set/verified with a suitable tool before use.

Hydraulic jars have the advantage in that they give an optional hammering power dependent on the pre-stressing force and that no preparations with the pre-stressing of the release force are necessary before use.

The disadvantages with the use of hydraulic jars are that these have a more complex construction; they are more expensive, require more maintenance and must be overhauled more often. In addition, there is a risk of locking the well pressure inside the tool if leakages occur. A given holding time is also required for each hammering (typically 0.5-2 min) that can result in the job taking an unnecessary long time if many blows are required to carry out the operation.

The wells that are drilled today are both longer and deeper than before. This leads to both the pressure and temperature increasing in these wells. With operations furthest down in these wells, mechanical jars will be preferred for safety reasons, although it will undoubtedly be most operationally appropriate to use hydraulic jars with the functional advantages they have.

NO20120728 shows a re-setting arrangement for cable operated hammering pipes. A mechanical hammering tool is shown where a given, but adjustable, release force, can be changed in that the sending of the tool down will rotate a circular J-slot casing/setting mechanism to the next step and thereby change the compression distance on a release spring and change the release force.

The adjustment operation of the next step must be carried out manually.

The J-slot casing/setting mechanism has a changing axial length position dependent on the twisting orientation. This makes it difficult to make major changes to the release force as this must go through several steps to come to

the required release force. With the release, the lower trunk section will be led upwards and the trunk lock will engage with a groove in the housing, the upper trunk section comes lose from the lower trunk section and is led further up until it meets the upper edge of the housing.

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US 4919219 describes a mechanical hammering tool where a given, but adjustable, release force can be altered if necessary in that a downwards pushing with a given force will rotate a circular J-slot to the next step and thereby change the compression distance on a release spring and thereby also

10 alter the release force. As with NO20120728, one must, in this publication, consciously carry out an adjustment operation to the next release step according to need. The J-slot casing/setting mechanism is rotary and has a changing axial length position dependent on the orientation of the twisting.

15 The present invention distinguishes itself from the prior art publications in that they have fixed release steps within a certain interval where the adjustment to the next step must be carried out physically and deliberately by the operator as opposed to the present invention where the adjustment of the release force is an integrated part of normal jar operation.

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The present application is derived and developed to overcome the weaknesses of the known method and to achieve further advantages.

Summary of the invention

25 The invention provides a cable-operated hammering tool for downhole operations, comprising

- an extended cylinder with an axially through-going internal opening in the cylinder,
- a hammering part arranged in a first section of the cylinder, said hammering

30 part is fitted with a detachable coupling for connection with downhole equipment

- a release strut arranged in a second section of the cylinder, said release strut is connected to a surface installation via a cable,
- said hammering part is detachably coupled to the cylinder by at least, one locking unit in a locked position of said locking unit. The invention is distinctive

in that the cable operated hammering tool further comprises a force spring that is in contact with the release strut for the pre-biasing of said release strut by movement of said release strut in a first direction, that said release strut is displaceable in a second opposite direction, said release strut being coupled to said locking unit , so that when said release strut is moving in said second direction it is displacing said locking unit from said locked position and thereby releasing the hammering part from the cylinder. This provides a hammering tool where the release force is easy to pre set by the force spring to any desired compression distance in the hammering tool. The compression distance is not limited by a number of fixed positions as j-slot. The pre set force determine the force of the stroke in the hammering tool.

The invention relates to a cable operated hammering tool for downhole operations, comprising an extended cylinder with an axially, through-running opening internally in the cylinder,

- a hammering part is arranged in the lower section of the cylinder and is fitted with a detachable coupling for the connection with downhole equipment,
- a release strut is arranged in an upper section of the cylinder that is connected to a cable which is coupled to a surface installation,
- the hammering part is detachably fastened to the cylinder with the help of, at least, one locking body. The invention is special in that the release strut is functionally coupled to a force spring for the pre-stressing of this by movement in a first direction, and also functionally coupled to the, at least, one locking body for the release of this by movement in the opposite, second direction.

Advantageous embodiments of the invention are given in the dependent claims 1-10.

A method for the operation of a hammering tool for downhole operations, said hammering tool comprising

- a cylinder with an axially through-going internal opening in the cylinder, where said cylinder is fitted with an internal cylinder edge,
- a hammering part arranged in a first section of the cylinder and fitted with a

detachable coupling for the connection with downhole equipment, said hammering part is fitted with a hammering edge,

-a release strut arranged in a second section of the cylinder is adapted to be connected to a surface installation via a cable

5 - said hammering part is detachable coupled to the cylinder by at least one locking unit in a locked position of said locking unit

- at least one locking body is arranged between the cylinder and the hammering part, adapted to couple said cylinder and hammering part together The method is distinctive in that the method comprising the following steps:

10 a) the release strut is moved a distance in a first axial direction to compress a force spring to a pre stressing force, said force spring is arranged between the cylinder and the release strut,

b) the release strut is moved a distance in the axially opposite direction and the at least one locking unit is moved a distance from the at least one locking body

15 so that the pre-stressing diminishes

c) the at least one locking body is released from the cylinder housing

d) the pre-stressing force in the force spring causing said cylinder to move a distance in the first axial direction

20 The invention also relates to a method for use of a hammering tool in downhole operations, comprising

-an extended cylinder with an axially, through-going opening internally in the cylinder, said cylinder is fitted with an internal cylinder edge,

25 -a hammering part arranged in the lower section of the cylinder and fitted with a detachable coupling for the connection to downhole equipment, said hammering part is fitted with a hammering edge.

-a release strut is arranged in the upper section of the cylinder and is connected to a cable that is connected to a surface installation.

30 -cylinder and hammering part are initially coupled together by the locking body that is pre-tensed with the help of a release mechanism or a locking unit:

The method is special in that it comprises the following steps:

- a) the release strut is pushed a distance in a first axial direction to a force spring arranged between the cylinder, and the release strut is compressed to the desired pre-stressing force,
- 5 b) the release strut is pushed a smaller distance in the axially opposite direction and the release mechanism is led a distance from the locking bodies so that the pre-stressing diminishes,
- c) the locking bodies are released from the cylinder housing,
- d) the pre-stressing force in the force spring leads the cylinder a distance in the first axial direction,
- 10 e) the lower edge in the cylinder hits the hammering edge in the hammering part so that a blow is generated in the tool,
- f) the release strut is pulled back by the force spring and the, at least, one release mechanism is pulled towards the locking bodies, the locking bodies are brought back in the engagement with the cylinder in its initial position.
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Advantageous methods of the invention are given in the dependent claims 12-13.

The advantages with the invention in relation to existing solutions are, among
20 other things, that:

- The hammering tool has a simpler design than traditional hammering tools.
- It immediately provides a blow when the wanted tension force has been reached.
- 25 -There are no seals where the well pressure can be closed in.
- The hammering tool of the invention provides optional hammering power dependent on the pre-stressing force in that the blow happens immediately when the tension force diminishes by about 5%.
- The hammering tool according to the invention has more freedom in choice of hammering power. There are no fixed positions which the
30 hammering tool must choose for each blow.

-The tool can be used without an accelerator as this function is integrated in the tool. This means that the tool is more compact and builds less than traditional hammering tools.

5 -The hammering tool can also be used in both shallow waters and deep waters.

-The hammering tool can be both single-acting and double- acting.

Short description of the figures

10 These and other characteristics will be clear from the following description of a preferred embodiment, given as a non-limiting example, with reference to the associated figures, where:

Figure 1 is a schematic presentation of a single-acting mechanical hammering tool according to the invention.

15 Figure 2 is a detailed section of the release mechanism in the hammering tool according to the invention.

Figures 3.1-3.10 are schematic presentations of individual components of the hammering tool.

20 Figure 4.1-Fig 4.6 are schematic presentations of the individual sequences which the single-acting tool goes through from its starting position to the hammering position and back to the initial position.

Figure 5 shows a schematic presentation of an embodiment of the mechanical hammering tool according to the invention where the hammering tool is double-acting.

25 Figure 6 shows a detailed section of the release mechanism in the double - acting hammering tool shown in figure 5.

Figure 7.1 shows a schematic presentation of the release strut of the double-acting hammering tool shown in figure 5.

30 Figure 7.2 shows a schematic presentation of the connection housing of the double-acting hammering tool shown in figure 5.

Figure 7.3 shows a schematic presentation of the hammering part of the double acting hammering tool shown in figure 5.

Figures 8.1-8.8 show schematic presentations of the individual sequences that the double-acting hammering tool shown in figure 5 goes through from the initial position to hammering position and back to the initial position.

5 Detailed description of an embodiment

Figure 1 shows a an embodiment of a single-acting hammering tool 20 for use in oil wells. The hammering tool is, at a first section, connected to a cable (not shown) that runs up to a surface installation fitted with, in themselves known, means set up for driving the cable into and out of the bore hole, including positioning of connected equipment and application of a given tension in the cable.

At the other, first end the hammering tool is connected to downhole equipment (not shown). The hammering tool 20 comprises a release strut 1 and a hammering part 10 that is arranged on each side of a hollow cylinder 3 also called connecting housing. A release mechanism, hereinafter called a locking unit 21 is arranged between the release strut 1 and the hammering part 10. (This is shown in detail in Figure 2). The locking unit is arranged in a locked position in Figure 2 as well as Figure 6.

The release strut 1 has the form of an extended trunk comprising a thread 1a arranged on the outside of the cylinder 3 and coupled to the cable (not shown) and a release end 1f that stretches towards the hammering part 10 inside the cylinder 3. Details of the shape of the release strut 1 are shown in Fig. 3.1. The release strut 1 is formed as a cylindrical element comprising parts of different diameters. The thread 1a is, as mentioned previously, arranged on the outside of the cylinder 3. A first intermediate part 1b is arranged inside the cylinder 3, towards the end 1a. A first parapet section 1c forms the connection between the end 1a and the intermediate part 1b. The first parapet section 1c has a diameter that is larger than the parts 1a and 1b, and larger than the opening 3a in the cylinder 3. This means that the end 1a cannot be led into the cylinder 3, but stops at the parapet section 1c. A second parapet section 1d, which in turn is connected to another intermediate part 1e, is arranged at the other end of the

first intermediate part 1b. The second intermediate part 1e has a diameter which is smaller than the parts 1a and 1b. The second intermediate part 1e is also connected to the release end 1f. This release end 1f has a diameter which is larger than the second intermediate part 1e and smaller than the parts 1a and 1b. At the end towards the second intermediate part 1e the release end 1f preferably has a conical shape 1g that runs from the release end 1f diameter to the second intermediate part 1e diameter. It is preferred that the release end 1f has a corresponding conical shape 1g' at the end that stretches towards the hammering part 10. Other shapes suitable for carrying out the invention other than conical are possible embodiments of the invention.

Furthermore, the hammering tool 20 comprises a force spring 2 arranged around the first intermediate part 1b of the release strut 1. The force spring 2 is arranged between the second parapet section 1d on the release strut 1 and a cylinder edge 3d at the inside of a first section of the cylinder 3. A gap between the second parapet section 1d and the internal wall 3f of the cylinder 3 is smaller than the force spring 2 so that this is prevented from passing the parapet section 1d when it is compressed. This means that the parapet section 1d keeps the force spring in the first intermediate part 1b and prevents it from moving towards the second intermediate part 1e when the force spring is compressed.

The force spring 2 is shown separately in figure 3.2. Here, it is formed as a spiral spring of, for example, steel wire or similar materials, the force spring 2 can possibly also be a cup spring or other springs that are appropriate for the implementation of the invention. The force spring could also be other resilient members suitable to set a pre-biased force.

The hammering part 10 shown in figure 3.10 has the form of an extended cylindrical trunk and has a hammering release end 10a lying inside the cylinder 3 against the release strut 1. The hammering release end 10a has the form of a hollow cylinder and envelops the locking unit 21. At the other end towards the well, a hammering end 10c is arranged. The hammering end 10c and the hammering release end 10a could have the same diameter, but this is not a requirement of the invention.

A cylindrical intermediate piece 10b is arranged between the ends 10a and 10c. This intermediate piece 10b has a smaller diameter than the end pieces 10a, 10c and is adapted to correspond with the diameter of the opening 3b in the first section of the cylinder 3. Slits 10d are also arranged in the hammering release end 10a. These are arranged diametrically opposite each other and are adapted correspond with the shape of the locking bodies 4 that are described in more detail below.

In addition, there is a groove 10e is arranged on the inside of the hammering release end 10a. This groove 10e is adjusted to blocking devices 8 that are described in further detail below. The hammering release end 10a has a larger diameter than the intermediate piece 10b so that there is a hammering edge 10f in the transition between these.

The cylinder 3 or connecting housing is shown in detail in Fig. 3.3. It is formed as a cylindrical housing with an opening 3a in the second section of the cylinder towards the cable end. The opening corresponds with the diameter of the first intermediate part 1b of the release strut 1 so that the release strut can move in the longitudinal direction. The first section of the cylinder 3 facing an opening 3b towards the downhole tool is adjusted or corresponds with the diameter of the intermediate piece 10b of the hammering part 10. The cylinder 3 in the figure 3.3 is shown with conical ends that stretch from an outer diameter of the cylinder 3 to the opening diameter of the openings 3a and 3b but other shapes are possible. There is a through-running hollow space 3f in the cylinder between the opening 3a and the opening 3b. This hollow space has a larger diameter than the openings 3a and 3b. Therefore, there are cylinder edges 3d, 3e on the short side of the hollow space 3f on both sides of the openings 3a and 3b. The cylinder edge 3e in the cylinder 3 is set up to meet or strike the hammering edge 10f of the hammering part 10 in the hammering position of the tool. A Groove 3c is arranged inside the cylinder 3. This is arranged in the same horizontal plane as the slits 10d of the hammering part in the initial position of the hammering tool 20 so that the groove 3c and the slits 10d are align and are corresponding in the initial position of the hammering tool 20.

The locking unit 21 is arranged on the inside of the hammering part 10. The locking unit 21 is shown schematically in figure 2, while the individual parts are shown separately in figures 3.4-3.8.

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At least one locking body 4 is arranged in the openings 10d. This is shown in detail in figure 3.4. The placing of the locking body or bodies in the hammering tool 20 are shown in figures 1 and 2. The locking body or bodies 4 that are shown in the figures comprise a 7-edged block with a groove side 4a that lies against the groove 3c on the inside of the cylinder 3 in the initial position of the hammering tool 20, two parallel sides 4c lie against the surfaces in the slits 10d in the hammering part 10. The side 4a and the sides 4c are connected by tilted sides that run at an angle between the sides. The sides 4a and 4b lie against the groove 3c in the cylinder 3 in the initial position of the hammering tool 20.

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The locking body 4, have on the inside of the hammering part 10, surfaces 4d that run downwards at an angle and form a point 4e. In a single- acting hammering tool (Figures 1-4.6) the surface 4d facing the locking unit 21 lies against a tilted surface 5a in the locking unit 21 in the initial position, while in a double-acting hammering tool both the surfaces 4d lie against two opposite surfaces 5a in the locking unit 21 and 21' on each side of the locking body or bodies 4 (This will be described further in figures 5-8.8). The locking body 4 can also have other shapes that are appropriate for the implementation of the invention. For instance locking body 4 could be an 5-edge block without the sides 4b or one tilted surface 4d facing the surface 5a of the locking unit 21.

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There are in the Figure 2 shown two locking bodies arranged at opposite sides in the cylinder 3. This is e possible embodiment of the invention. There could also be arranged only one locking body 4 or more than two locking bodies 4 in the cylinder, this is possible embodiments of the invention.

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Figure 3.5 shows a cylindrical ball housing 5. This is arranged on the inside of the hammering part 10. The outside of the ball housing 5 lies against the inside of the hammering release end 10a. A tilted ball housing end 5a lies against the locking body or bodies 4 and is adjusted to the tilt of the side surface 4d of the

locking body 4. A release spring 9 (shown in Figure 2 and 9) is pre-stressed against the ball housing 5 so that the tilted surface 5a lies against the tilted surface 4d of the respective locking body and forces the locking body radially through the respective slit 10 of the hammering part 10 towards the respective groove 3c in the cylinder 3. This prevents axial displacement between the cylinder 3 and the hammering part 10 in the initial position of the hammering tool 20.

Between the ball housing ends 5a, an opening 5d is arranged that is larger than the second intermediate part 1e and the release end 1f on the release strut 1. This allow the second intermediate part 1e and the release end 1f of the release part to move in the longitudinal direction within the ball housing 5.

At least one through-going ball opening 5c are also arranged in the ball housing 5. The figure 2 shows two openings but just one or more than two openings are also possible. The at least one through going ball opening 5c is adjusted to at least one blocking device, for example, at least one spherical or ball shaped blocking member 8. A possible shape of the member is shown in figure 3.8.

In addition, a stopping edge 5b is arranged inside the ball housing 5. The stopping edge 5b is arranged perpendicularly to the surface of the ball housing 5, on the inside of the ball housing 5.

The ball housing 5 has a hollow, through-going opening 5d in the centre of the ball housing 5 in the longitudinal direction and is set up to surround parts of the release strut 1.

The at least one blocking member 8 from figure 3.8 is arranged in the ball openings 5c and lie against the groove 10e on the inside of the hammering release end 10a of the hammering part 10 in the initial position of the hammering tool 20. On the opposite side, the balls 5 lie against a ball wedge 7. There are shown two balls arranged in the ball openings 5c in figure 2. One ball situated in each of the ball openings 5c. Possible embodiments of the invention is only one spherical shaped ball or more than two.

Figure 3.7 shows the ball wedge 7 in detail. The ball wedge 7 is formed as a cylinder and arranged on the inside of the ball housing 5 and is in contact with the ball housing 5. The ball wedge 7 has a sloping end 7a adjusted to the shape

of the ball housing 5 and lie against the inside of the ball housing 5. The ball wedge 7 has a longitudinal opening 7b axially through the ball wedge 7. The second intermediate part 1e and the release end 1f of the release strut 1 is adapted to be movable through the opening 7b of the ball wedge and is surrounded by this. Furthermore, the ball wedge 7 has a recessed section 7c with a diameter that is less than the diameter of the rest of the ball wedge 7. The recessed section 7c is arranged near the middle of the ball wedge 7. The transition between the recessed section 7c and the ball wedge 7 has a vertical surface 7g in the one part 7d that faces the release strut 1 and a conical transition 7c to the opposite part 7e. The ball housing 5 and the ball wedge 7 are set up for axial movement with respect to each other until the stopping edge 5b meets the surface 7d of the ball wedge 7 or the sloping end 7d is in contact with the inside of the ball housing when depending on with the direction the wedge is moved. . This is explained in more detail in the figures 4.1-4.6.

Grooves 7f are arranged on the inside of the first part 7d of the ball wedge. The grooves 7f are adapted to receive a fastening mechanism 6 , which is, for example, a friction ring . The friction ring 6 is adapted to surround the part 1e or 1f of the release strut 1, dependent on which position the tool is in.

A possible embodiment of the fastening mechanism 6 is shown in detail in figure 3.6. The friction ring 6 has a slit 6a across the ring, with ring ends 6b and 6c on each side of the slit 6a. With this, the ring 6 becomes more flexible and can thereby increase the diameter of the ring in that the ring ends 6a, 6b are forced away from each other so that the release end 1f shall be able to be surrounded by the ring 6. Other shapes of the fastening mechanism are also possible.

The release spring 9 shown in figure 3.9 is arranged against the hammering release end 10a, between the ball wedge 7 and the intermediate piece 10b of the hammering part 10. It could be formed as a spiral spring and is shown in more detail in figure 3.9. The release spring 9 is arranged on the underside of the locking unit 21 to hold the locking bodies 4 in position in the locking groove 3c. The release spring also covers other resilient member other than a spiral spring

can also be used to obtain the required pre-stressing of the locking unit 21 against the locking bodies 4 and are embodiments of the invention.

Figure 4.1-Figure 4.6 show the individual sequences the hammering tool 20 goes through to perform a stroke to for instance to loosen a downhole tool from the hammering tool 20 according to the invention.

Figure 4.1

The hammering tool 20 is, in its initial position, placed down in a well (not shown). The release strut 1 is connected to a cable or a wire that runs up to the surface (not shown). The hammering part 10 is coupled to the downhole equipment that stretches down into the borehole. These parts are not shown in any of the figures. In this position the force spring 2 is in a initial, free position, i.e. the spring 2 is not compressed. The friction ring 6 surrounds a section of the second intermediate part 1e on the release strut 1. The release strut 1 is in this position not coupled to the locking unit and is movable in relation to the locking unit 21 and the hammering part 10.

In this position the at least one locking body 4 engage with the hammering part 10 and the cylinder 3 as previously described so that these cannot be displaced axially with respect to each other.

The locking unit 21 is in a fixed mode where it is pre-stressed against the at least one locking body 4. In this position the locking unit 21 is not displaced with respect to the hammering part 10.

Figure 4.2

The hammering tool 20 is supplied with an axial force (arrow) in that the cable or wire line is tightened. The force spring 2 inside the cylinder 3 will be gradually compressed in that the release strut 1 is pulled upwards. Kinetic energy will then be stored in the hammering tool 20.

The release strut 1 is pulled upwards until the release end 1f meets the friction ring 6. The friction ring 6 forces itself outwards and the release strut 1 moves further upwards through the cylinder 3. The release strut 1 has arrived in this position inside the "release window".

In the figure 4.2 the hammering tool 20 is shown in a state where the release strut 1 is in its outermost stretching position and the desired pre-stressing force in the force spring 2 has been reached in that the second stopper or parapet section 1d of the release strut 1 and the cylinder edge 3d in the cylinder 3 compresses the force spring 2 together. It will also be possible to choose other stretch positions to obtain other pre-stressing forces in the force spring 2.

Figure 4.3

The pre-stressing force will thereafter diminish somewhat, i.e. the release strut 1 will be pulled downwards towards the well. The friction ring 6 that is arranged in the ball wedge 7 surrounds a section of the releasing end 1f of the release strut 1 coupling the friction ring 6 and the release strut 1 together through friction forces. There will be more friction force between the friction ring 6 and the releasing end 1f of the release strut 1 than the axial force from the release spring 9 causing both the release strut 1 and the locking unit 21 to move downward. When the release strut 1 is moved towards the well, this leads to a movement of the ball wedge 7 downwards in the same direction and distance as the release strut 1 towards the well until the ball wedge 7 stops in that the surface 7g in the ball wedge 7 meets the edge 5b in the ball housing 5. In this position the recessed section 7c in the ball wedge 7 is in line or contact with the at least one blocking element 8, shown as spherical shaped ball 8 in the figures. In the figures there are shown two spherical shaped balls in opposite ball openings 5 in the ball housing 5. The spherical shaped balls 8 lies in the groove 10e in the hammering part 10 and will move out of this groove 10e towards the recessed sections 7c and the wedge 7 and the ball housing 5 is locked together in the axial direction so that the whole of the locking unit 21 is pushed downwards.

The locking unit 21 is in a released mode in this position in that it can be displaced axially with respect to the hammering part 10.

Figure 4.4

After the ball housing 5 and the ball wedge 7 have been coupled together the inclining ball housing end 5a of the ball housing 5 will be pushed downwards and release the locking bodies 4 because a further movement of the release

strut 1 downwards. The locking bodies 4 will be pulled out of the locking grooves 3c when the pressure from the locking unit against the locking bodies 4 are released. The locking bodies 4 will be retracted into the cylinder 3 so that the hammering part 10 is released from the cylinder 3 and these parts can be displaced axially with respect to each other. The pre-stressed force spring 2 will accelerate the cylinder 3 upwards until the internal lower edge 3e lies or strike against the hammering part 10f. The cylinder 3 makes a sudden stop and this leads to a blow in the tool. This position is called the hammering position of the tool.

Figure 4.5

The stretch force diminishes and the hammering tool is supplied with an axial force (arrow) that will push the release end 1f of the release strut 1 back through the friction ring 6 so that the friction ring 6 surrounds a section of the second intermediate part 1e of the release strut 1. This force is greater than the friction force between the friction ring 6 and the release end 1f.

At the same time the locking bodies 4 are led back into the locking groove 3c in the cylinder 3 in that the groove 3c and the slits 10d of the hammering part 10 are brought back to the initial position where they lie level with each other in the same horizontal plane.

The locking bodies 4 are held in place by the locking unit 21 in that the inclining face 5a on the end of the ball housing 5 lies against the opposite inclining face 4d of the locking bodies 4. The locking unit 21 is forced against the locking bodies 4 with the help of the release spring 9.

Figure 4.6 shows the hammering tool back in the initial position and is corresponding to Figure 4.1

The hammering tool that is described above is preferably single-acting for a wireline. Using the hammering tool as double-acting for a coil tubing, snubbing or well tractor also lies within the invention.

A double -acting hammering tool 30 is shown in figures 5 and 6.

In this embodiment, the shape of the locking unit from fig. 2 is arranged as upper and lower locking units 21,21'. These form a double-acting locking unit 31 in a hammering part 1000. The locking units 21,21' are arranged the wrong way around ie inverted with respect to each other, one on each side of the locking bodies 4.

Parts of the hammering tool 30 that have a different form than the single-acting hammering tool 20 are shown in more detail in figures 7.1-7.3.

A release strut 100 for a double-acting hammering tool 30 is shown in Fig. 7.1.

This has a similar form and parts as the release strut 1 for the single-acting release strut 1, but the release strut 100 has, in addition, a third intermediate part 100e and a second release end 100f. These are corresponding to the second intermediate part 1e and the release end 1f. The third intermediate part 100e is coupled between the intermediate part 1d and the second release end 100f. In addition, the release strut 100 has a guiding part 100h that is connected between the first parapet section 1c and the first intermediate part 1b. The guiding part 100h has a larger diameter than the intermediate part 1b so that there is an edge 100i between the parts 100h and 1b. The other parts are similar as described as the single-acting hammering tool 20.

A cylinder 300 of the double-acting hammering tool 30 is shown in fig. 7.2. It also has a similar shape as the cylinder 3 of the single-acting hammering tool 20 with parts that are described in more detail in connection to this. The cylinder 300 has a reduced portion 300g of the inner diameter in the cylinder 300. This reduced portion 300g has a diameter and placing that corresponds to the second parapet section 1d of the release strut 100 so that this section is allowed to move through the reduced portion. It has also an outer surface 300h that makes up the hammering surface at downwards hammering. The reduced portion 300g and the cylinder edge 3d defines the boundaries for the force spring 2 in the axial direction.

A hammering part 1000 of the double-acting hammering tool is shown in Fig. 7.3. The new, modified parts on this hammering part 1000 are arranged at the end that faces the release strut 100 and comprises a release end 1000a and a

groove 1000e. These have the same form as the hammering release end 10a and the locking groove 10e, but are arranged inverted with respect to the slits 10d. The hammering part 1000 also has a hammering surface 1000f that is formed by the difference in diameter between the intermediate piece 10b and the hammering end 10c.

In an upward or first directional blow or stroke, the inner edge 3e in the cylinder 3 meets the hammering edge 10f of the hammering part 10 such as in a single-acting blow, while in a downward or second directional blow or stroke, the outer surface 300h of the cylinder 3 meets the hammering surface 1000f in the hammering part 1000.

The sequences of the double-acting hammering tool are shown in the figures 8.1-8.8.

Upwards or first directional blow/stroke:

The individual locking units 21 and 21' of the double-acting hammering tool 31 have the same parts and work in the same way as the locking unit 21 of the single-acting hammering tool 20, apart from that the release strut 100 must be pulled up a distance that is sufficient for both the upper and lower locking units 21' and 21 to be released to release the locking bodies 4. The upper locking unit 21' is defined as the locking unit that is nearest the second section of the cylinder 300 or the cable side of the well when the hammering tool 30 is placed in the well. The lower locking unit 21 is defined as the locking unit that is placed nearest the first section of the cylinder 300 or the downhole equipment in the well when the hammering tool 30 is placed in the well.

Fig. 8.1 shows the double-acting hammering tool 30 in its initial position. Then the upper and lower locking units 21 and 21' lie against the locking bodies 4 on both sides of these.

In figure 8.2 tension force is supplied and the release strut 100 is pulled upwards/outwards in the cylinder 300 until the release end engage with the friction ring 6 in the lower locking unit 21. The release end 1f will surround the friction ring 6 in the lower locking unit 21, but without this mechanism being

released as it is locked against any movement in this direction. When the release end 1f gradually reaches the upper locking unit 21' and engage with the friction ring 6' in upper locking unit 21' it will be pulled up together with the release strut 100 via the friction ring 6' that surrounds the lowermost release end 1f. The upper locking unit 21' will thus be released from the locking bodies 4.

In figure 8.3 the supplied tension force by the release strut 100 will diminish somewhat and the compressed force spring 2 will push on the second parapet section 1d on the release strut 100 so that it moves somewhat in the opposite direction and the lowest release end 1f and the coupling to the friction ring 6 will move the lowest locking unit 21 away from the locking bodies 4. The force that holds the locking bodies in the groove 3c in the cylinder is removed.

The upper locking unit 21' will also move downwards towards the locking bodies 4 in this operation, in parallel with the lower locking units 21, but still have so much distance from the locking bodies 4 that it will not come back into engagement with the locking bodies 4 again before the lower locking units 21 are released from the locking bodies 4. The locking bodies 4 are now free and are pulled out of the grooves 3c.

In figure 8.4 the force spring 2 will accelerate the cylinder 300 until the internal lower edge 3e lies against the hammering release end 10f resulting in an upwards blow.

Downwards or second directional blow/stroke:

Figure 8.5 shows the double-acting hammering tool 30 in its initial position. Then the upper and lower locking units 21, 21' lie against the locking bodies 4 on both sides of the locking bodies and forcing the locking bodies in the groove 3c of the cylinder.

In figure 8.6 a pressure force is supplied and the release strut 100 is pushed down/inwards through the cylinder 300. The release end 100f will, at first, surround the friction ring 6' in the upper locking unit 21', but without this locking

unit 21' being released as it is locked against movement in this direction. When the release strut 100 gradually reaches the lower locking unit 21, it will be released and be pulled down together with the release strut 100 via the friction ring 6 that surrounds the uppermost release end 100f. The lower locking unit 21 is thereafter released from the locking bodies 4.

In figure 8.7 supplied pressure force from the release strut 100 will diminish somewhat and the compressed force spring 2 will push on the surface 100i on the release strut 100 so that this goes back somewhat, and the uppermost release end 100f will drag along the friction ring 6' that releases the upper locking unit 21' from the locking bodies 4. The lower locking unit 21 will also move up/outwards towards the locking bodies 4 in this operation, in parallel with the upper locking units 21', but still have so much distance from the locking bodies 4 that they will not come back into engagement with the locking bodies 4 again before the upper locking units 21' are released from the locking bodies 4. The locking bodies 4 are now free and are led out of the locking groove 3c.

In figure 8.8 the force spring 2 will accelerate the cylinder 300 until the external lower surface 300h lies against the edge 1000f resulting in a downwards blow. The double acting release spring having a release spring arranged within the hammering release part below the locking unit 21 and above the locking unit 21'.

By release of the locking unit 21 and 21' it is referred to the sequences described in relation to the single-acting hammer tool with the ball housing, ball wedge, ball, friction ring etc.

It is to be understood that the mode of operation of the hammering tool depends on the relation between the force spring 2, the release spring 9 and the friction force between the release end 1f of the release strut 1 and the friction ring 6.

The mechanism within the locking unit 21 and 21' is in this embodiment All position references such as upwards, downwards, upper and lower are defined according to a normal placing of the hammering tool in the well.

The arrangement of a hammering tool according to the invention will be able to include any features that are described or illustrated herein, in any operative combination; any such operative combination will be an embodiment of the arrangement for the hammering tool that is according to the invention. The
5 method of the invention will be able to encompass any feature or step that has been described herein or that has been illustrated, in any combination, where any such combination will be an embodiment of the method according to the invention.

Meant by functionally coupled is that the parts do not need to be coupled
10 directly, but can be coupled via other parts the coupling could also be a friction coupling.

CLAIMS

1.

A cable-operated hammering tool (20) for downhole operations, comprising an extended cylinder (3) with an axially through-going internal opening in the cylinder (3),
a hammering part (10) arranged in a lower section of the cylinder (3), said hammering part (10) is fitted with a detachable coupling for connection with a downhole equipment,
a release strut (1) arranged in the upper section of the cylinder (3), said release strut (1) is connected to a surface installation via a cable,
said hammering part (10) is detachably fastened to the cylinder (3) with the help of, at least, one locking body (4) **characterised in that**
the cable operated hammering tool (20) further comprises a force spring (2) that is in contact with the release strut (1) and set up for the pre-stressing of said release strut (1) by movement in a first direction, that said release strut (1) can be displaced relative said hammering part (10) and set up for release of the hammering part (10) from the cylinder (3) by movement of the release strut (1) in an opposite, second direction opposite to the first direction.

2.

A cable-operated hammering tool according to claim 1, wherein the cylinder (3) is fitted with a cylinder edge (3e), and is set up to hit against the hammering edge (10f) at the release of the, at least, one locking body (4).

3.

A cable-operated hammering tool according to claim 2, wherein the pre-stressing of the hammering tool (20) by the release strut (1) is infinitely variable and set up to impart variable blows between the cylinder edge (3e) and the hammering edge (10f).

4.

A cable-operated hammering tool according to one of the claims 1-3, **wherein** the

locking bodies (4) are held in detachable engagement by a release mechanism (21) and a release spring (9).

5.

A cable-operated hammering tool according to claim 4, **wherein** the release mechanism (21) and the release spring are arranged between the release strut (1) and the hammering part (10).

6.

A cable-operated hammering tool according to claims 4 or 5, **wherein** the release mechanism (21) has a released mode where it can be displaced axially relative the hammering part (10) and a fixed mode where it is in a fixed position relative the hammering part (10), said release mechanism (21) comprises a ball housing (5) arranged adjoining the inside of the hammering part (10) and a ball wedge (7) arranged on the inside of the ball housing (5), a blocking element (8) arranged between the ball housing (5) and the ball wedge (7) is arranged to fasten the ball housing (5) and the ball wedge (7) together in the released mode of the release mechanism.

7.

A cable-operated hammering tool according to claim 1, **wherein** the blocking element is a ball (8).

8.

A cable-operated hammering tool according to claim 4, **wherein** a fastening mechanism (6) is arranged between the ball wedge (7) and the release strut (1) and is set up to lead the release strut (1) in the opposite direction.

9.

A cable-operated hammering tool according to claim 4, **wherein** the fastening mechanism (6) is a friction ring (6).

10.

A cable-operated hammering tool according to claim 1, **wherein** the hammering force of the hammering tool is defined by supplying pulling power in the cable.

11.

Method for the operation of a hammering tool for downhole operations, comprising, an extended cylinder (3) with an axially through-going internal opening in the cylinder (3), where said cylinder (3) is fitted with an internal cylinder edge (3e), a hammering part (10) arranged in a lower section of the cylinder (3) and fitted with a detachable coupling for the connection with downhole equipment, said hammering part (10) is fitted with a hammering edge (10f), a release strut (1) arranged in the upper section of the cylinder (3) is connected to a cable that is connected to a surface installation, cylinder (3) and hammering part (10) are initially coupled together by the locking body (4) that is pre-stressed with the help of, at least, one release mechanism (21):

characterised in that the method comprises the following steps: a) the release strut is led some distance in a first axial direction to a force spring (2) arranged between the cylinder (3) and the release strut (1), which is compressed to a predetermined pre-stressing force,

b) the release strut (1) is led a smaller distance in the axially opposite direction and the release mechanism (21) is led a distance from the locking bodies so that the pre-stressing diminishes,

c) the locking bodies (4) are released from the cylinder housing (3),

d) the pre-stressing force in the force spring (2) leads the cylinder (3) a distance in the first axial direction,

e) the lower edge (3e, 300h) in the cylinder (3) meets the hammering edge (10f, 1000f) in the hammering part (10) resulting in a blow by the tool,

f) the release strut (1) is pulled back by the force spring (2) and the, at least, one release mechanism (21) is pulled towards the locking bodies (4), the locking bodies (4) are led back in engagement with the initial position of the cylinder (3).

12.

The method to operate a hammering tool according to claim 11, **wherein** the release strut in step a) is pulled upwards will the lower edge 3e meet the hammering edge 10f in an upwards blow.

13.

The method to operate a hammering tool according to claim 11, **wherein** the steps a) – f) are repeated in that the release strut in a) is led alternately in the opposite direction in a double action hammering operation.