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(54) **A downhole stimulation system and a drop device**

(57) The present invention relates to a downhole system (100) for installation in a borehole (36) for creating a cased well (2). The downhole system comprises a plurality of casing sections (101) mounted to form a casing string (102), and a plurality of sleeves (3), each sleeve comprising a sliding sleeve part (103) and a tubular part (104) mounted as part of the casing string comprising at least one opening (32), the sliding sleeve part (103) being movable from a first position in which the sliding sleeve part closes the opening (32) to a second position in which the fluid is allowed to flow through the opening (32). Each sleeve (3) comprises a sleeve activation means adapted to move the sliding sleeve part (103) from the second position to the first position.

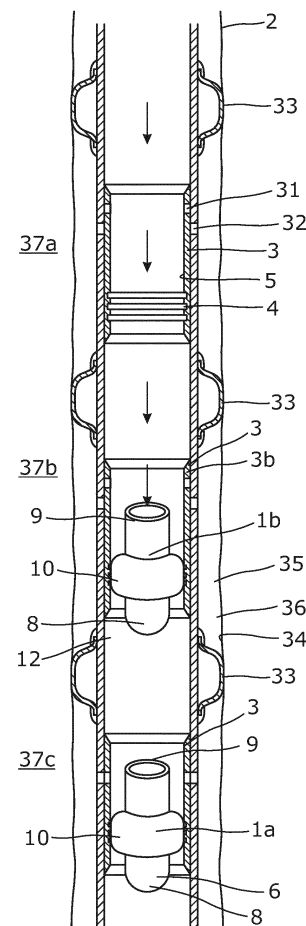


Fig. 4

Description

Field of the invention

[0001] The present invention relates to a downhole system for installation in a borehole for creating a cased well. Furthermore, the invention relates to a drop device for immersing into a well and to a stimulation method.

Background art

[0002] When stimulating production zones, a first ball is dropped into the well, flowing with the fluid until it reaches a ball seat which it cannot pass, causing the ball to seat in the ball seat of a first sleeve. A continuous pumping of fluid into the well then results in a pressure on the ball moving the sleeve from a closed position to an open position. As the sleeve opens, the fluid enters the formation surrounding the well, and the stimulation process can begin. A second production zone is stimulated by dropping a second ball which is larger than the first ball, which flows in the fluid until it reaches a ball seat in another sleeve positioned closer to the top of the well than the first sleeve. The second ball seats in the ball seat of the second sleeve, the sleeve is forced open, and the stimulation process of the second production zone can begin. In this way, multiple balls can be dropped to stimulate multiple sections of the well.

[0003] When the stimulation of the production zones has ended, an operation tool is submerged into the well to retrieve the ball being seated in the sleeve closest to the surface, e.g. by drilling a hole in the ball. The first operation tool is then withdrawn from the well again, and the operation tool is, in a second run, submerged into the well to retrieve the next ball. The retrieval process is continued until all the balls have been retrieved and oil production can be initiated by opening all the sleeves again.

[0004] Using this ball dropping process is inexpensive, but it is also very time-consuming since the balls have to be retrieved one by one. Furthermore, retrieving a round ball rolling in a ball seat can be very difficult, and the retrieval process may therefore fail.

Summary of the invention

[0005] It is an object of the present invention to wholly or partly overcome the above disadvantages and drawbacks of the prior art. More specifically, it is an object to provide an improved way of stimulating several production zones in a faster and more reliable way than with prior art solutions.

[0006] The above objects, together with numerous other objects, advantages, and features, which will become evident from the below description, are accomplished by a solution in accordance with the present invention by a downhole system for installation in a borehole for creating a cased well, comprising:

- a plurality of casing sections mounted to form a casing string,
- a plurality of sleeves, each sleeve comprising a sliding sleeve part and a tubular part mounted as part of the casing string comprising at least one opening, the sliding sleeve part being movable from a first position in which the sliding sleeve part closes the opening to a second position in which the fluid is allowed to flow through the opening,

wherein each sleeve comprises a sleeve activation means adapted to move the sliding sleeve part from the second position to the first position.

[0007] In one embodiment, the sleeve activation means may be a spring.

[0008] The spring may be arranged in a recess in the tubular part.

[0009] Furthermore, the spring may be a coiled spring, a disc spring or a similar spring.

[0010] In another embodiment, the sleeve activation means may comprise at least one piston sliding in a groove in the tubular part, the piston being fasten with or being part of the sliding part, and the piston comprising a gas within the groove when the sliding sleeve part moves from the first position to the second position.

[0011] The piston may be annular.

[0012] Furthermore, the groove may function as a piston housing.

[0013] Moreover, the groove may be annular.

[0014] In addition, the activation means may comprise at least one electromagnet powered by a battery, the electromagnet and the battery being arranged in the tubular part and the electromagnet attracting or repelling the sliding sleeve part.

[0015] Also, the sliding sleeve part may comprise a magnet arranged opposite the electromagnet.

[0016] Further, the tubular part may comprise a plurality of electromagnets.

[0017] Additionally, the plurality of electromagnets may be arranged in at least one row and are activated successively to move the sliding sleeve part.

[0018] The downhole system described above may further comprise annular barriers arranged on an outer face of the casing on opposite sides of the opening, the annular barriers being expanded to abut an inner face of the borehole and dividing an annulus between the casing string and the borehole into production zones, and the downhole system may further comprise a drop device as described below.

[0019] The present invention furthermore relates to a drop device for immersing into a well having a casing with an inner face and at least one sleeve having a profile and an inner face, the drop device comprising:

- a body having a width,
- a leading end, and
- a trailing end,

wherein the body further comprises:

- a sealing element arranged between the leading end and the trailing end, moving from a first position in which fluid is allowed to pass the device and a second position in which the sealing element abuts the inner face of the casing and seals a first zone in the well from a second zone in the well.

[0020] By sealing the first zone from the second zone, acid can be pumped down and into the formation and not pass the drop device further down the well. In this way, the acid is not wasted as the rest of the well is sealed off by the sealing element.

[0021] The drop device described above may further comprise a second part connected with the body by means of a connecting element.

[0022] In an embodiment, the second part may comprise projectable keys for engaging the profile of the sleeve and opening the sleeve as the body of the drop device is forced to move in relation to the casing when the sealing element abuts the inner face of the casing and the first zone of the casing is pressurised, whereby the fluid pressurises against the sealing element.

[0023] Furthermore, the second part may comprise two or more projectable elements, such as slips, dogs, claws, keys or anchors, for landing on a restriction in the casing.

[0024] When the keys engage the profile of the sleeve and fasten the drop device in the longitudinal extension of the casing, the second part pulls in the body and activates the sealing element to move from the first position to the second position. Subsequently, the first zone of the casing is pressurised from the top of the well above the second part, and the fluid pressurises the sealing element, forcing the body with the sealing element to move further away from the top of the casing, pulling in the second part to move along with the body.

[0025] Furthermore, the connecting element may be a chain or a shaft.

[0026] By having a chain, the second part is able to pull in the body when the keys engage the sleeve, and in a similar manner, the body is able to pull in the second part to force the sleeve open. Furthermore, when the stimulation operation has ended, and the drop device has thus opened a plurality of sleeves successively, the drop device just drops to the bottom of the well, and then the chain folds, enabling the second part to drop down onto the body. The use of a chain rather than a shaft enables the drop device to fold and take up less space in the bottom of the well. Since the drop device is able to fold, it does not need to be retracted immediately after the stimulation job has ended, but may be retracted at the earliest convenience.

[0027] Moreover, the sealing element may be a cup seal having a circumferential flange connected in an angle with a base part of the cup seal.

[0028] Also, the flange may abut the inner face of the

casing when the casing is pressurised in that the fluid forces the flange radially outwards towards the inner face of the casing, thus forcing it to abut the casing.

[0029] Thus, the drop device may further comprise projectable keys for engaging the profile of the sleeve and opening the sleeve as the drop device is forced downwards when the sealing element abuts the inner face of the sleeve.

[0030] In an embodiment, the projectable keys may be projectable radially from the body.

[0031] In another embodiment, the body or the second part may further comprise a detection unit for detecting the sleeve.

[0032] Furthermore, the detection unit may comprise a tag identification means for detecting an identification tag, such as a radio frequency identification (RFID) tag, arranged in connection with the sleeve.

[0033] The drop device described above may further comprise a key activation unit for activating the keys to project.

[0034] Additionally, the detection unit may comprise a casing profiling means, such as a magnetic casing profiling means detecting the magnetic changes in the casing when passing a sleeve or other casing components.

[0035] In an embodiment, the width of the body with the sealing element in the first position may be less than an inner diameter of the sleeve.

[0036] Also, the body may comprise an activation means for activating the sealing element to move from the first to the second position or from the second to the first position.

[0037] In addition, the activation means may be a pump.

[0038] Moreover, the activation means may be an electrical motor.

[0039] The drop device may further comprise an electrical motor for driving the pump.

[0040] Moreover, the drop device may comprise a battery for powering the activation means.

[0041] Additionally, the drop device may comprise a turbine for recharging the battery as the device immerses down the well.

[0042] In addition, the drop device may comprise a generator driven by the turbine.

[0043] Furthermore, the drop device may comprise a timer adapted to activate the sealing element to move from the second position back to the first position after a predetermined time interval.

[0044] In an embodiment, the timer may be activated when the sealing element has moved from the first position to the second position.

[0045] In addition, the timer may be activated when the keys are retracted.

[0046] In another embodiment, the drop device may further comprise an activation sensor adapted to activate the sealing element to move from the second position back to the first position when a condition in the well changes.

[0047] Furthermore, the sensor may comprise a pressure sensor adapted to activate the sealing element to move from the second position back to the first position when a pressure in the well changes.

[0048] Also, the pressure sensor may activate the sealing element to move when the pressure decreases after being above a certain pressure, e.g. when the acid stimulation has ended.

[0049] During the acid stimulation, the pressure in the well follows a certain pattern such as a pattern starting with an initial zone pressure, then reaching an increased stimulation pressure followed by a decreased pressure. This pressure pattern is detected by the pressure sensor in the drop device. In most acid stimulation jobs, the pressure increases, then decreases and again drops to a decreased pressure almost equal to the initial zone pressure.

[0050] The drop device may further comprise a flow meter adapted to activate the sealing element to move from the second position back to the first position when a flow in the well changes.

[0051] Further, the drop device may comprise a connection means arranged at the trailing edge.

[0052] Hereby, the drop device is adapted to connect itself with a second drop device. When the first drop device deactivates its sealing element and drops further down the well, the second drop device dumping into the first drop device is connected with the first drop device at the bottom of the well.

[0053] Moreover, the drop device may comprise a connection means arranged at the leading edge, adapted to connect the drop device with a second drop device.

[0054] In an embodiment, the drop device may be autonomous.

[0055] By autonomous is meant that the drop device operates without wireline, coiled tubing or drill pipe.

[0056] In another embodiment, a wireline may be connected to the drop device.

[0057] Furthermore, the sealing element may be inflatable.

[0058] Additionally, the sealing element may be an elastomeric compressible element.

[0059] The drop device may further comprise a detection sensor for detecting a condition of the well and/or the sleeve.

[0060] Moreover, the detection sensor may be a pressure sensor, a temperature sensor and/or a scanning sensor.

[0061] By having a sensor, the drop device is able to detect if the sleeve has been opened sufficiently for the acid or fracturing fluid to perform an acceptable stimulation job and thus measure the stimulations efficiency. The sensor can subsequently confirm that the sleeve is closed again before the drop device deactivates the sealing element and moves further down the well. The sensor can also measure the pressure in the well during the operation and the pressure difference across the seal initiated by the expanded or inflated sealing element. Fur-

thermore, the sensor can measure the temperature to detect if a water or gas break-through occurs during or after the stimulation. The temperature decreases if the gas content of the fluid entering the well increases after the stimulation process. The temperature increases if the water content of the fluid entering the well after the stimulation process increases.

[0062] In an embodiment, the drop device may further comprise a communication unit for loading information from a reservoir sensor.

[0063] Moreover, the drop device may further comprise a self-propelling means, such as a turbine or a propeller.

[0064] The present invention furthermore relates to a downhole system comprising a well having a plurality of sleeves and the drop device described above, wherein the sleeves each have an identification tag, such as an RFID tag.

[0065] Furthermore, the well may comprise a casing and a reservoir sensor 46, and the drop device may comprise a communication unit for loading information from the reservoir sensor.

[0066] The present invention furthermore relates to a stimulation method comprising the steps of:

- entering a drop device described above into a well for stimulation of a first production zone,
- detecting a sleeve in the well,
- activating the projectable keys to project to engage the profile of the sleeve,
- activating the sealing element to move from a first position in which fluid is allowed to pass the body to a second position in which the sealing element abuts the inner face of the casing and seals a first zone in the well from a second zone in the well,
- pressurising the well filled with fluid, forcing the body to move away from the sleeve,
- pulling the second part with the projected keys by means of the body and moving the sleeve from a closed position to an open position,
- letting the fluid out through the open sleeve and into a formation surrounding the well,
- releasing the body by activating the projectable keys to move from a projected position to a retracted position,
- activating the sealing element to move from the second position back to the first position, and
- letting the drop device immerse further into the well.

[0067] In an embodiment, the method may further comprise the step of closing the sleeve.

[0068] Moreover, the well may be divided into production zones and comprise a plurality of production sleeves adapted to open in order to start production of fluid through the production sleeve.

[0069] In an embodiment, the production sleeve may comprise a screen for filtering the fluid entering through the production sleeve.

[0070] The downhole system described above may further comprise annular barriers surrounding the casing and be expandable to divide the well into production zones.

[0071] Furthermore, the present invention relates to a stimulation method comprising the steps of:

- entering a drop device described above into a well for stimulation of a first production zone,
- detecting a sleeve in the well,
- activating the sealing element to move from a first position in which flow is allowed to pass the device and a second position in which the sealing element abuts the inner face of the sleeve and seals a first zone in the well from a second zone in the well,
- pressurising the well filled with fluid, forcing the drop device to move the sleeve from a closed position to an open position,
- letting the fluid out through the open sleeve and into a formation surrounding the well,
- activating the sealing element to move from the second position back to the first position, and
- letting the drop device immerse further into the well.

[0072] The stimulation method may further comprise the step of projecting projectable keys and engaging the profile of the sleeve for opening the sleeve as the drop device is forced downwards when the sealing element abuts the inner face of the sleeve.

[0073] Moreover, the stimulation method may comprise the steps of detecting a second sleeve and activating the sealing element to move from the first position to the second position, providing a seal at another position further down the well for stimulation of a second production zone; pressurising the well and opening the second sleeve; letting the fluid out through the second sleeve; activating the sealing element to move from the second position back to the first position; and letting the drop device immerse further into the well.

[0074] In addition, the stimulation method may comprise the steps of entering a second drop device into a well when a predetermined amount of time has passed after a pressure decrease during stimulation of the first production zone using the previous drop device; detecting a second sleeve and activating the sealing element to move from the first position to the second position, providing a seal at another position further down the well for stimulating a second production zone; pressurising the well and opening the second sleeve; letting the fluid out through the second sleeve into the second production zone; activating the sealing element to move from the second position back to the first position; and letting the second drop device immerse further into the well.

[0075] Moreover, the stimulation method may comprise the steps of abutting the previous drop device with the second drop device, and connecting the two drop devices to each other.

[0076] Also, the stimulation method may comprise the

steps of entering a fishing tool into the well; connecting the fishing tool to the drop device; and retracting the tool and the drop device from the well.

[0077] In an embodiment, several drop devices may be connected before the fishing tool connects to the drop device arranged closest to the top of the well.

Brief description of the drawings

[0078] The invention and its many advantages will be described in more detail below with reference to the accompanying schematic drawings, which for the purpose of illustration show some non-limiting embodiments and in which

Fig. 1 shows a drop device immersing in a cased well having sleeves to be opened by the drop device,

Fig. 2 shows the drop device of Fig. 1 in its first and inflated position opposite the sleeve to be opened,

Fig. 3 shows the drop device of Fig. 1 in which the sleeve has been forced open,

Fig. 4 shows a second drop device in its first and inflated position opposite a second sleeve to be opened,

Fig. 5 shows the second drop device of Fig. 4 in which the second sleeve has been forced open,

Fig. 6 shows another embodiment of the drop device in its inflated position and opposite a sleeve to be opened,

Fig. 7 shows the drop device of Fig. 6 in which the sleeve has been forced open,

Fig. 8 shows the drop device of Fig. 6 in which the drop device has been deflated and immersed further into the casing to be positioned opposite a second sleeve, at which position the drop device is inflated and the second sleeve is forced open,

Fig. 9 shows another embodiment of the drop device comprising projectable keys matching a profile in the sleeve to engage the sleeve to force the sleeve open,

Fig. 10 shows yet another embodiment of the drop device,

Fig. 11 shows the downhole system having several drop devices being connected at the end of the well,

Fig. 12 shows one embodiment of the drop device able to propel itself upwards in the well to open the production sleeves,

Fig. 13 shows a downhole system comprising a drop device having a second part,

Fig. 14 shows a cross-sectional view of a self-closing sleeve according to the invention,

Fig. 15 shows another embodiment of a self-closing sleeve,

Fig. 16 shows yet another embodiment of a self-closing sleeve,

Fig. 17 shows another embodiment of the drop device having a cup seal arranged on a shaft,

Fig. 18 shows another embodiment of the drop device, landing on a restriction in the sleeve, and

Fig. 19 shows yet another embodiment of the drop device, landing on a restriction in the sleeve.

[0079] All the figures are highly schematic and not necessarily to scale, and they show only those parts which are necessary in order to elucidate the invention, other parts being omitted or merely suggested.

Detailed description of the invention

[0080] Fig. 13 shows a downhole system 100 for installation in a borehole 34 for creating a cased well 2. The downhole system comprises a plurality of casing sections 101 mounted to form a casing string 102, and further comprises a sleeve 3 being a self-closing sleeve. The sleeve 3 comprises a sliding sleeve part 103 and a tubular part 104 mounted as part of the casing string by means of threaded connections 120. The tubular part comprises at least one opening 32 for allowing access to the borehole 35 so as to inject fluid into the borehole to stimulate the production zone by fracking or acid stimulation. After stimulating the well, the hydrocarbon-containing fluid is allowed to flow from the formation 122 into the casing string.

[0081] In order to provide or hinder access through the opening, the sliding sleeve part is movable between a first position in which the sliding sleeve part covers and thus closes the opening 32 and a second position in which the sliding sleeve part no longer covers the opening 32, thereby allowing fluid to flow through the opening between the annulus 36 and the inside of the casing string. The sleeve comprises a sleeve activation means 105 adapted to move the sliding sleeve part from the second position to the first position and thus close the sleeve after being moved to an open position.

[0082] In Fig. 13, the sleeve has been forced open by a drop device 1. The drop device comprises projectable keys 13 engaging a profile 4 in the sleeve, and after fluid has forced the drop device downwards away from a top of the well opening the sleeve, a stimulation job is initiated

by injecting fluid into the annulus 36. Subsequently, the keys are retracted and the sleeve activation means of the sleeve moves the sleeve from the second position to the first position to close the sleeve.

[0083] In Figs. 13 and 14, the sleeve activation means 105 is a coiled spring arranged in a recess 106 in the tubular part 104. When the drop device forces the sliding sleeve part from the first position to the second position, the spring is compressed as well. After a subsequent release of the sliding sleeve part 103, the compressed spring moves back to its uncompressed state and moves the sliding sleeve part from second position to the first position.

[0084] In Figs. 13 and 14, the sleeve is shown in its open and second position in which the coiled spring is compressed and the sleeve is retracted. In another embodiment, the spring may be a disc spring or a similar suitable spring.

[0085] As shown in Fig. 15, the sleeve activation means 105 comprises at least one piston 108 sliding in a groove 109 in the tubular part. The piston is an annular piston and is part of the sliding part. The piston compresses a gas enclosed within the groove by the piston when the sliding sleeve part moves from the first position to the second position. Thus, the groove functions as a piston housing, and the groove is annular and its shape corresponds to the shape of the annular piston.

[0086] Furthermore, the activation means in Fig. 16 comprises an electromagnet 105a powered by a battery 105b. The electromagnet and the battery are arranged in the recess 106 of the tubular part opposite the opening so that when the electromagnet is activated, it repels the sliding sleeve part and moves it from the second position to the first position, thereby closing the opening. When the drop device moves the sliding sleeve part from the first position to the second position, the sliding sleeve part 103 moves past a contact being in communication with the battery, and the battery activates the electromagnet, e.g. after a predetermined time period, by means of a timer to repel the sliding sleeve part upon release of the keys in the drop device.

[0087] In another embodiment, the sliding sleeve part may comprise a permanent magnet arranged opposite the electromagnet. The tubular part may also comprise several electromagnets arranged along the recess in the longitudinal extension of the sleeve. When the plurality of electromagnets is arranged in a row and the electromagnets are activated successively, they are able to move the sliding sleeve part according to the principle of an electromotor.

[0088] As can be seen in Fig. 13, the downhole system further comprises annular barriers 33. The barriers are arranged on an outer face of the casing on opposite sides of the opening 32 of the tubular part of the sleeve. The annular barriers comprise an expandable sleeve 121 which is expanded to abut an inner face 34 of the borehole 35 and divide an annulus 36 between the casing string and the borehole into production zones 37a, 37b. The

downhole system further comprises the drop device 1 for forcing the sleeves 3 open.

[0089] Fig. 1 shows a drop device 1 immersing in a well 2 having a casing 30 with several sleeves 3. The sleeves have a profile 4 on their inner face 5 for a device to engage the sleeve and open the sleeve so that fluid in the casing can enter the formation surrounding the casing. The sleeves are opened one by one to flush or stimulate the well, e.g. by "fracking the formation", i.e. pumping fluid out through openings 31 in the sleeve and openings 32 in the casing and thus creating fractures in the formation and providing access to hydrocarbon reservoirs in the formation. The well may also be stimulated by pumping acid in through the openings in the casing and the sleeve and dissolving the formation, thereby providing access to the hydrocarbons in the formation. To open a sleeve, the drop device is dropped into the fluid at the top of the well, and the drop device is pumped or falls down the well until it reaches the sleeve which is to be opened. When reaching the sleeve, as shown in Fig. 2, a sealing element 10 surrounding a body 6 of the drop device, arranged between a leading end 8 and a trailing end 9 of the body is moved from a first position to a second projected position in which the sealing element abuts the inner face of the sleeve. The projected sealing element thus seals a first zone 11 in the well from a second zone 12 in the well. Subsequently, the fluid pressure in the well is increased so that the drop device is pumped further down the well, opening the sleeve, as shown in Fig. 3.

[0090] By having a sealing element 10 sealing the first zone above the drop device from the second zone below the drop device, acid is prevented from passing the drop device and entering further down the well. This causes all acid to enter the formation and stimulate the intended production zone opposite the recently opened sleeve, and no acid is wasted on filling up the lower part of the well.

[0091] In addition, the drop device may be used to flush the well on the outside of the casing and thus remove all the drilling mud, etc. When flushing the well, the sleeve furthest away from the top of the well is opened by the drop device, and the fluid is pumped down the inner bore of the casing and back up on the outside of the casing. After the flushing process has ended, the stimulation process can begin, reusing the drop device and sending a second drop device down the well.

[0092] Furthermore, due to the drop device, the casing bore is substantially a monobore compared to prior art drop ball solutions with ball seats decreasing the inner diameter of the bore. When completing a well, it is desirable to have the widest inner diameter possible because this makes it much easier to gain access in later operations. Furthermore, it broadens the variety of tools or strings applicable as these operations are not limited to tools or strings which are able to pass the narrow ball seats.

[0093] While immersing into the well, the drop device projects the sealing element 10 to slow down and abut

the inner face of the sleeve. The drop device comprises a detection unit 14 for detecting the sleeve. The detection unit may comprise a tag identification means 15, as shown in Fig. 9, for detecting an identification tag 16, such as an RFID tag, arranged in connection with the sleeve. The identification tag 16 may also be arranged in the casing at a predetermined distance from the sleeve. In another embodiment, the detection unit comprises a casing profiling means 44, as shown in Fig. 1, such as a magnetic casing profiling means detecting magnetic changes in the casing when passing a sleeve or other casing components.

[0094] In order to pass a sleeve, the width 7 of the body, as shown in Fig. 1, including the sealing element in the first position, must be less than an inner diameter 45 of the sleeve. When projected, such as expanded or inflated, the width of the body, including the sealing element in the second position, is substantially equal to the inner diameter of the sleeve.

[0095] In the downhole system 100 shown in Fig. 1, the casing further comprises annular barriers 33 arranged on an outer face of the casing, expanded to abut the inner face 34 of the borehole 35 and dividing the annulus 36 between the casing and the borehole into production zones 37a, 37b, 37c. In Fig. 3, a third production zone 37c, i.e. the production zone furthest away from the top of the well, is stimulated.

[0096] In Fig. 4, a second drop device 1b is dropped into the well while the first drop device 1, 1a is still positioned opposite the sleeve in the third production zone 37c. The second drop device immerses until it reaches a second sleeve 3b arranged above the third production zone 37c opposite the second production zone 37b. The sealing element 10 of the second drop device is projected to abut and engage the second sleeve, and the drop device is pumped further down the well, opening the second sleeve, as shown in Fig. 5, and fluid is thus allowed to enter into the formation to stimulate the production of hydrocarbons.

[0097] Once the sealing element 10 of the second drop device 1b engages the inner face of the second sleeve, the second zone 12 below the second drop device 1b is isolated and the pressure in the second zone 12 below the second drop device decreases. The first drop device then retracts its sealing element 10 and drops further down the well, as illustrated in Fig. 5. Even though the openings 31 of the sleeve and the openings 32 of the casing are still aligned, enabling the third production zone open to flow, the fluid pumped down the casing to stimulate the second production zone 37b does not enter the third production zone, as the sealing element 10 of the second drop device 1b hinders fluid from passing this second drop device. Thus, all stimulation fluid is let into the production zone to be stimulated and is not partly wasted on another production zone or on filling up the rest of the well.

[0098] In Figs. 6-8, the drop device is used for opening successive sleeves, and thus, one drop device is used

for stimulating several production zones. When reusing the drop device for stimulating several zones, the drop device starts opening a sleeve in the production zone closest to the top of the well and proceeds with the sleeve further down the well until all the production zones have been stimulated. Thus, one drop device is used for performing the stimulation of several or all production zones. In Fig. 6, the drop device flows down the well, and when reaching a position opposite the first sleeve 3a, the sealing element 10 is moved from its retracted position to its projected position. By pumping fluid further down the well, the openings in the sleeve and the casing are aligned, and the sleeve is opened, as shown in Fig. 7. Fluid for stimulating the well is then pumped into the formation, stimulating the first production zone 37a. When the stimulation process of the first production zone has ended, the sealing element is retracted and moved further down the well until the drop device reaches the next sleeve, as shown in Fig. 8.

[0099] In order to be able to retract the sealing element after the stimulation process has ended, the drop device comprises an activation process sensor 21, shown in Fig. 10, adapted to activate the sealing element to move from the second position back to the first position when a condition in the well changes. The activation sensor 21 may comprise a pressure sensor 24 adapted to activate the sealing element to move from the second position back to the first position when a pressure in the well changes. During the stimulation job, the pressure decreases in a predetermined pattern, and the pressure sensor thus activates the sealing element to retract when the pressure is measured to have followed the predetermined pattern, e.g. when the pressure decreases after being above a certain pressure.

[0100] During acid stimulation, the pressure in the well follows a certain pattern which is measured by the pressure sensor, the pattern beginning with an initial zone pressure, followed by an increased stimulation pressure which is again followed by a decreased pressure. In most acid stimulation jobs, the pressure decreases, then increases and again drops to a decreased pressure almost equal to the initial zone pressure. "Fracking jobs" follow another pressure pattern which is pre-programmed in the sensor.

[0101] In another embodiment, the activation sensor 21 comprises a flow meter adapted to activate the sealing element to move from the second position back to the first position when a flow in the well changes. By measuring the flow in the first zone above the sealing element, the flow of fluid pumped out through the sleeve can be detected so that when the stimulation job has ended, the flow meter detects the change and the sealing element is then retracted.

[0102] The drop device may also comprise a timer 19, as shown in Fig. 10, adapted to activate the sealing element to move from the second position back to the first position after a predetermined time interval. A stimulation job is pre-set to last a certain amount of time, and the

timer is thus set to activate retraction of the sealing element according to the maximum duration of the stimulation job. In another embodiment, the timer is reset or activated when the sealing element has moved from the first position to the second position. The timer may further be reset or activated when the pressure sensor or flow meter has detected that the pressure of the flow is below a predetermined value. If the stimulation job is not finalised but only interrupted and subsequently recommenced, the timer is reset again, and the timer ensures that the retraction of the sealing element is not initiated until the stimulation job has ended.

[0103] In Fig. 8, the sealing element is projected once again when being opposite the second sleeve which is opposite the second production zone 37b, and the sleeve is then opened, and the stimulation can begin. The first sleeve closes when it is no longer retained by the drop device in its open position. The sleeve comprises a retraction spring or a similar retraction solution. When the stimulation job has ended, the drop device continues to the next sleeve until all the intended production zones have been stimulated. After the last stimulation operation, the drop device moves to the end or bottom of the well and is retracted by a fishing tool at the earliest convenience. The retraction of the drop device is not particularly urgent since the drop device does not hinder production or other operations in the well. In order to connect to a fishing tool or a similar operational tool, the drop device comprises a connection means 26 at the trailing end 9, as shown in Fig. 10.

[0104] As shown in Fig. 9, the drop device comprises projectable keys 13 for engaging the profile of the sleeve for opening the sleeve as the drop device is forced downwards when the sealing element abuts the inner face of the sleeve. Thus, the projectable keys engage the profile in the sleeve, and the sealing element provides the seal dividing the well into the first and second zone. As can be seen in Fig. 10, the projectable keys are projectable radially from the body. The keys may also be provided on pivotably connected arms or similar key solutions.

[0105] The drop device comprises an activation means 17 for activating the sealing element to move to a different position, both from the first position to the second position and back to the first position again.

[0106] The sealing element may be inflatable by means of fluid being pumped into the element through fluid channels 40 by the activation means 17 in the form of a pump 50, as shown in Fig. 10. The sealing element may also be an elastomeric compressible element compressed from one side along the axial extension of the device, resulting in the sealing element bulging outwards to be pressed against the inner face of the sleeve. The axial movement used for compressing the sealing element to project outwards from the body of the drop device is provided by a motor and by a piston driven by a pump. The pump is driven by an electrical motor 20 or directly by the fluid in the casing. The activation means or the motor is powered by a battery 18, resulting in an auton-

omous drop device, or through a wireline.

[0107] The activation means 17 in the form of the pump 50 is also used for projecting the keys by means of fluid channels 41, as shown in Fig. 10, pressing the keys radially outwards and compressing a spring 42 so that the keys are automatically retracted if the pump fails. The keys have a key profile 43 matching the profile of the sleeve.

[0108] As shown in Fig. 10, the drop device further comprises a turbine 22 for recharging the battery as the device immerses down the well or for powering the motor. The drop device further comprises a generator 23 driven by the turbine for recharging the battery or powering the motor.

[0109] In Fig. 10, the drop device further comprises a connection means 26 arranged at the leading edge, adapted to connect the drop device with a second drop device 1b, as shown in Fig. 11, and arranged to connect the second drop device 1b with a third drop device 1c, and the third drop device with a fourth drop device 1d. Hereby, the drop device is adapted to connect itself with another drop device. When the first drop device deactivates its sealing element and drops further down the well, the second drop device dumping into the first drop device is connected with the first drop device at the bottom of the well. The sealing elements of the drop device need not be inflated, but if they are inflated, the connection of the drop devices is more successful.

[0110] The drop device further comprises a detection sensor 27, as shown in Fig. 10, for detecting a condition of the well and/or the sleeve. The detection sensor may be a pressure sensor, a temperature sensor and/or a scanning sensor. The drop device is thus able to detect if the sleeve has been opened sufficiently for the acid or fracturing fluid to perform an acceptable stimulation job, and it is thus able to measure the stimulations efficiency. The detection sensor can also confirm whether or not the sleeve is closed again before the drop device deactivates the sealing element. The detection sensor can also measure the pressure in the well during the operation to ensure that the stimulation fluid does not enter a leak instead of the recently opened sleeve. Furthermore, the pressure difference across the seal initiated by the expanded or inflated sealing element can be detected, and a proper seal can thus be proven. Moreover, the detection sensor can measure the temperature to detect if a water or gas break-through has occurred as a result of the stimulation process. If the gas content of the fluid entering the well after the stimulation process increases, the temperature will most likely decrease, and if the water content of the fluid entering the well after the stimulation process increases, the temperature will most likely increase.

[0111] The downhole system 100 comprises the well having a plurality of sleeves and one or more drop devices, as described above. The sleeves each have a passive identification tag 16, as shown in Fig. 9, which tag is detectable by the drop device so as to identify one sleeve from another sleeve. By having passive tags, such

as RFID tags, the sleeves do not need to have a battery or a similar power means which may lose power over time.

[0112] In Fig. 12, the completion has several sleeves 3 within one production zone 37. One sleeve has openings 31 which, in the same way as above, are aligned with openings 32 in the casing, enabling the passage of fluid directly into the annulus.

[0113] The other sleeve is a production sleeve 38 in which a screen 39 surrounds the sleeve so that fluid from the reservoir flows in through the screen 39, past the opening 32 in the casing and in through the openings 31 in the slidable sleeve of the production sleeve 38. The screen thus filtrates the elements, such as scales, prop-pants, or fragments of sandstone, limestone, etc., from the fluid when the fluid passes through the screen. The drop device is used for opening the sleeves to stimulate the production zones, and subsequently, the drop device propels itself upwards to open the production sleeves. When having opened all the production sleeves, the drop device flows upwards with the fluid and ends at the top of the well.

[0114] In order to propel itself upwards, the drop device comprising the aforementioned turbine drives the turbine in the opposite direction and thereby ejects fluid to force itself to the top of the well.

[0115] As shown in Fig. 12, the downhole system 100 further comprises a reservoir sensor 46 for sensing the conditions of the well, the formation and the reservoir fluid, and/or for sensing parameters, such as temperature, pressure, etc. When the drop device passes the reservoir sensor 46, a communication unit 47 of the drop device communicates with the reservoir sensor 46 and loads the information of the reservoir condition from the reservoir sensor 46. The information from the reservoir sensor 46 is then downloaded from the communication unit 47 in the drop device when the drop device returns to surface.

[0116] Thus, any of the aforementioned drop devices may comprise a communication unit 47 capable of communicating with the reservoir sensor 46 arranged in connection with the casing. The reservoir sensor 46 may be any kind of sensor, such as an electromagnetic sensor, a pressure sensor or a temperature sensor, and may have a communication means for communicating with the communication unit 47 of the drop device. The communication unit 47 of the drop device may comprise an activation means for temporarily activating the reservoir sensor to load the reservoir information from the sensor.

[0117] The invention further relates to a stimulation method by which the drop device 1 enters the well 2 for stimulation of a first production zone, as shown in Fig. 1. The sleeve is then detected, and the sealing element is activated to press against the inner face of the sleeve, separating a first zone in the well from a second zone in the well, as shown in Fig. 2 or 6. The well is pressurised forcing the drop device to move the sleeve from a closed position to an open position, and the fluid is let out through

the sleeve, initiating the stimulation process, as shown in Fig. 3 or 7. After the stimulation of this production zone has ended, the sealing element is activated to move from the second position back to the first position, and the drop device immerses further into the well, as shown in Fig. 5 or 11.

[0118] In Fig. 8, a second sleeve is detected and the sealing element is activated to press against the inner face of the second sleeve, providing a seal at another position further down the well for stimulation of a second production zone. The well is then again pressurised, opening the second sleeve, and fluid is let out through the second sleeve to stimulate the second production zone. Subsequently, the sealing element is retracted and the drop device immerses further into the well.

[0119] In Fig. 13, the drop device 1 immerses into the well 2. The drop device comprises a body 6 and a second part 110, and the body and the second part are connected by means of a connecting element 111, such as a chain. The second part comprises projectable keys 13 for engaging a profile 4 of the sleeve 3. The body is thus arranged further down the well in relation to the second part comprising the keys. The second part engages the profile after having detected that the sleeve 3 is opened by means of a detection unit 14. The body comprises a sealing element 10 which is activated when the keys engage the profile and stops the movement of the drop device so that the chain pulls in the body. Due to the second part comprising keys and not a sealing element, the fluid is allowed to pass the second part but not the body when the sealing element is inflated or expanded. When the sealing element has been activated and abuts the inner face of the casing further down the well, the sleeve is opened as the body of the drop device is forced to move in relation to the casing when the first zone of the casing is pressurised, whereby the fluid pressurises against the sealing element.

[0120] As can be seen, the body of the drop device is arranged further down the well below the adjacent annular barrier 33. When expanding the annular barriers 33, the casing is pressurised so that pressurised fluid enters the apertures 112 of the annular barriers. Thus, when pressurising the casing once more to force the sleeve open, the fluid is also allowed to flow into the annular barriers 33 on opposite sides of the sleeve. The pressure inside the annular barriers is thus the same as the pressure in the part of the annulus enclosed by the annular barriers, which minimises the risk of the annular barriers collapsing.

[0121] If the sealing element 10 was arranged between the second part and the adjacent second annular barrier, the fluid would be prevented from flowing into the second annular barrier and would only be allowed to flow into the first annular barrier closer to the top of the well. In that case, the pressure in the stimulated production zone would be higher than the pressure in the second annular barrier, and the second annular barrier would experience a force pressing against the expandable sleeve, which

would entail a risk of the second annular barrier collapsing. By inflating or expanding the sealing element further down the well on the other side of the annular barrier, the pressure is equalised across the expandable sleeve, also in the second annular barrier, substantially diminishing the risk of the second annular barrier collapsing.

[0122] In order to detect when the projectable keys are to project and engage the profile in the sleeve to be opened, the second part further comprises a detection unit 14 which is able to detect the sleeve. The sleeve comprises an identification tag which is detectable by the detection unit.

[0123] The second part further comprises a key activation unit 113 for activating the keys to project and engage the profiles of the sleeve. The key activation unit comprises a hydraulic cylinder powered by an electric motor. When the keys are retracted, the electric motor rotates in an inverted direction or a spring is arranged which is compressed upon projection of the keys and is thus able to retract the keys when the motor stops powering the cylinder.

[0124] The body of the drop device comprises an activation means 17 for activating the sealing element 10 to move from the first to the second position or from the second to the first position. In order to activate the sealing element to expand at the right time, the drop device further comprises an activation sensor 21 adapted to activate the sealing element to move from the second position back to the first position when a condition in the well changes. The activation sensor 21 is adapted to detect a pulling force in the chain, and upon detecting this pulling force, the sealing element is activated to expand or inflate to abut the inner face of the casing.

[0125] In Figs. 13-16, the connection element 111 is a chain, and in Fig. 17, the connection element 111 is a shaft. The drop device 1 of Fig. 17 further comprises a sealing element 10 being a cup seal. The cup seal has a circumferential flange 118 connected in an angle α with a base part of the cup seal. The flange 118 is adapted to abut the inner face of the casing when the casing is pressurised in that the fluid forces the flange radially outwards towards the inner face of the casing and increases the angle α , and the flange thereby abuts the casing.

[0126] Fig. 18 shows another embodiment of the sleeve 3 in which the sliding sleeve part 103 has a projecting flange providing a restriction of the well. As the drop device 1 flows along with the fluid and detects the sleeve 3 to be opened, the drop device expands the sealing element 10 and lands on the restriction. Then, the pressure is further increased and the fluid pressurises the sealing element and thus moves the drop device downwards, thereby opening the sleeve, as shown in Fig. 18.

[0127] In Fig. 19, the drop device comprises a second part 110 comprising two or more projectable elements 130, such as slips, dogs, claws, keys or anchors, which are projected to land on the projectable flange of the sleeve when encountering the sleeve to be opened. The

body 6 and the second part 110 are connected by means of a connecting element 111, such as a chain or a shaft, and when the projectable elements are projected, the activation means 17 of the body activates the sealing element 10 to expand and seal against the casing. As the casing is further pressurised, the fluid pressurises the sealing element and moves the body and thus the second part downwards, thereby opening the sleeve.

The well may be horizontal or vertical. The "up" and "down" used above refer to horizontal as well as vertical wells, "up" being movements towards the top of the well and "down" being movements towards the end of the well.

[0128] The stimulation method may further comprise a step of entering a second drop device into a well when a predetermined amount of time has passed from a pressure decrease during stimulation of the first production zone using the previous drop device. A second sleeve is detected by the second drop device, and the sealing element is activated and moved downwards, opening the second sleeve to let fluid out through the openings 31 in the sleeve and the openings 32 in the casing. After the stimulation has ended, the second drop device immerses further into the well. The second drop device may then abut and connect to a previous drop device. A third and fourth drop device may in the same way connect to the first and second drop devices after they have performed a job or in the event that a job fails. If a drop device fails, it drops to the bottom and connects to another drop device, and a new drop device replacing the failing drop device is dropped into the well.

[0129] When all stimulation jobs have been performed successfully, a fishing tool or a similar operational tool can enter the well and fish all drop devices in one run. The fishing tool just needs to connect to the drop device positioned closest to the top of the well to fish all the drop devices.

[0130] By fluid or well fluid is meant any kind of fluid that may be present in oil or gas wells downhole, such as natural gas, oil, oil mud, crude oil, water, etc. By gas is meant any kind of gas composition present in a well, completion, or open hole, and by oil is meant any kind of oil composition, such as crude oil, an oil-containing fluid, etc. Gas, oil, and water fluids may thus all comprise other elements or substances than gas, oil, and/or water, respectively.

[0131] By a casing is meant any kind of pipe, tubing, tubular, liner, string etc. used downhole in relation to oil or natural gas production.

[0132] In the event that the fishing tool or a similar operational tool is not submergible all the way into the casing, a downhole tractor can be used to push the tool all the way into position in the well. The downhole tractor may have projectable arms having wheels, wherein the wheels contact the inner surface of the casing for propelling the tractor and the tool forward in the casing. A downhole tractor is any kind of driving tool capable of pushing or pulling tools in a well downhole, such as a Well Tractor®.

[0133] Although the invention has been described in the above in connection with preferred embodiments of the invention, it will be evident for a person skilled in the art that several modifications are conceivable without departing from the invention as defined by the following claims.

Claims

1. A downhole system (100) for installation in a borehole (36) for creating a cased well (2), comprising:
 - a plurality of casing sections (101) mounted to form a casing string (102), and
 - a plurality of sleeves (3), each sleeve comprising a sliding sleeve part (103) and a tubular part (104) mounted as part of the casing string comprising at least one opening (32), the sliding sleeve part being movable from a first position in which the sliding sleeve part closes the opening to a second position in which the fluid is allowed to flow through the opening,
 wherein each sleeve comprises a sleeve activation means (105) adapted to move the sliding sleeve part from the second position to the first position.
2. A downhole system according to claim 1, wherein the sleeve activation means is a spring.
3. A downhole system according to claim 2, wherein the spring is arranged in a recess (106) in the tubular part.
4. A downhole system according to claim 3, wherein the spring is a coiled spring, a disc spring or a similar spring.
5. A downhole system according to claim 1, wherein the sleeve activation means comprises at least one piston (108) sliding in a groove (109) in the tubular part, the piston being fasten with or being part of the sliding part, and the piston comprising a gas within the groove when the sliding sleeve part moves from the first position to the second position.
6. A downhole system according to claim 1, wherein the activation means comprises at least one electromagnet (105a) powered by a battery (105b), the electromagnet and the battery being arranged in the tubular part and the electromagnet attracting or repelling the sliding sleeve part.
7. A downhole system according to claim 6, wherein the sliding sleeve part comprises a magnet arranged opposite the electromagnet.

8. A downhole system according to any of the preceding claims, further comprising annular barriers (33) arranged on an outer face of the casing on opposite sides of the opening, the annular barriers being expanded to abut an inner face (34) of the borehole (35) and dividing an annulus (36) between the casing string and the borehole into production zones (37, 37a, 37b, 37c), and the downhole system further comprising a drop device according to any of claims 9-15.
9. A drop device (1) for immersing into a well (2) having a casing (30) with an inner face and at least one sleeve (3) having a profile (4) and an inner face (5), the drop device comprising:
- a body (6) having a width (7),
 - a leading end (8), and
 - a trailing end (9),
- wherein the body further comprises:
- a sealing element (10) arranged between the leading end and the trailing end, moving from a first position in which fluid is allowed to pass the device and a second position in which the sealing element abuts the inner face of the casing and seals a first zone (11) in the well from a second zone (12) in the well.
10. A drop device according to claim 9, further comprising a second part (110) connected with the body by means of a connecting element (111).
11. A drop device according to claim 10, wherein the second part comprises projectable keys (13) for engaging the profile of the sleeve and opening the sleeve as the body of the drop device is forced to move in relation to the casing when the sealing element abuts the inner face of the casing and the first zone of the casing is pressurised, whereby the fluid pressurises against the sealing element.
12. A drop device according to any of claims 9-11, wherein the sealing element is a cup seal having a circumferential flange (118) connected in an angle (α) with a base part (119) of the cup seal.
13. A drop device according to any of claims 9-12, wherein the body further comprises a detection unit (14) for detecting the sleeve.
14. A drop device according to any of claims 9-13, further comprising a key activation unit (113) for activating the keys to project.
15. A drop device according to any of the preceding claims, further comprising an activation means (17)

for activating the sealing element to move from the first to the second position or from the second to the first position.

16. A stimulation method comprising the steps of:

- entering a drop device (1) according to any of claims 11-15 into a well (2) for stimulation of a first production zone,
- detecting a sleeve (3) in the well,
- activating the projectable keys to project to engage the profile of the sleeve,
- activating the sealing element to move from a first position in which fluid is allowed to pass the body to a second position in which the sealing element abuts the inner face of the casing and seals a first zone in the well from a second zone in the well,
- pressurising the well filled with fluid, forcing the body to move away from the sleeve,
- pulling the second part with the projected keys by means of the body and moving the sleeve from a closed position to an open position,
- letting the fluid out through the open sleeve and into a formation surrounding the well,
- releasing the body by activating the projectable keys to move from a projected position to a retracted position,
- activating the sealing element to move from the second position back to the first position, and
- letting the drop device immerse further into the well.

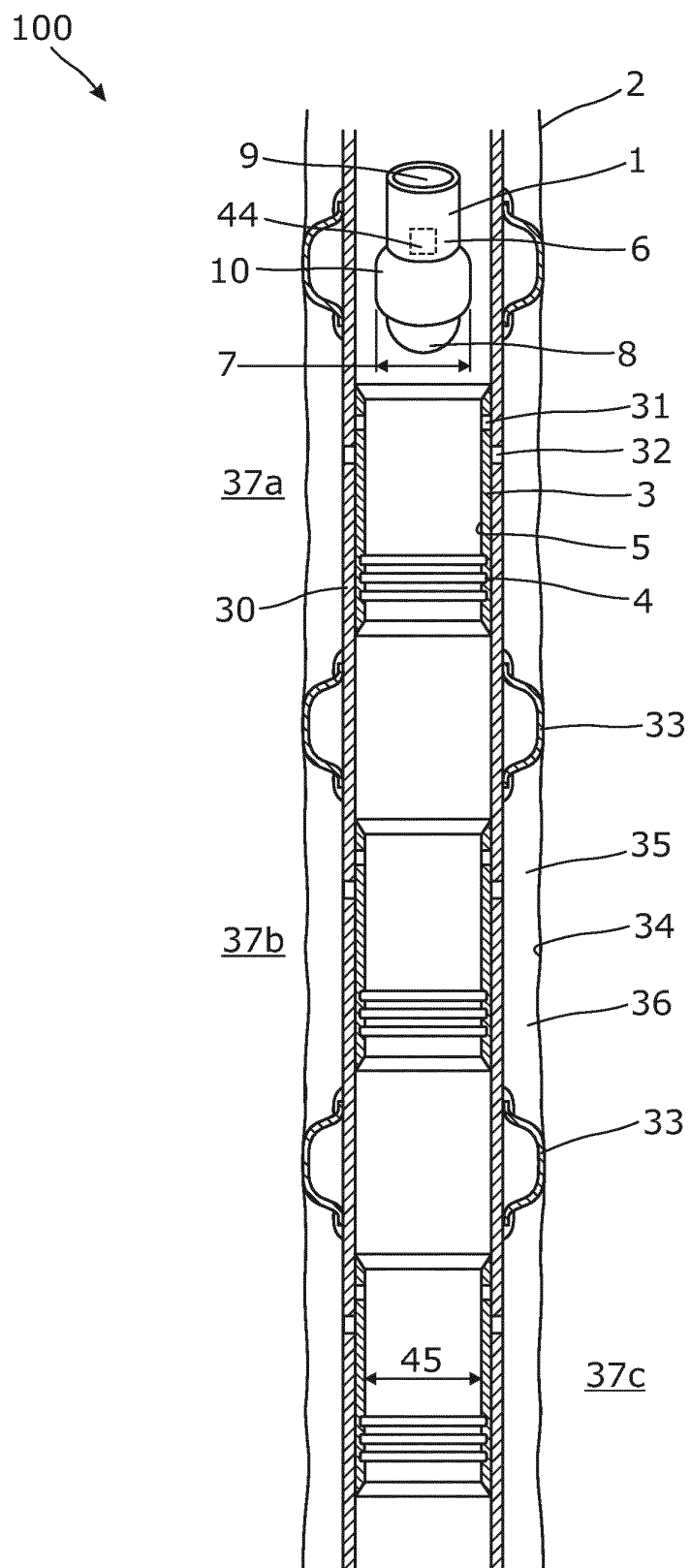


Fig. 1

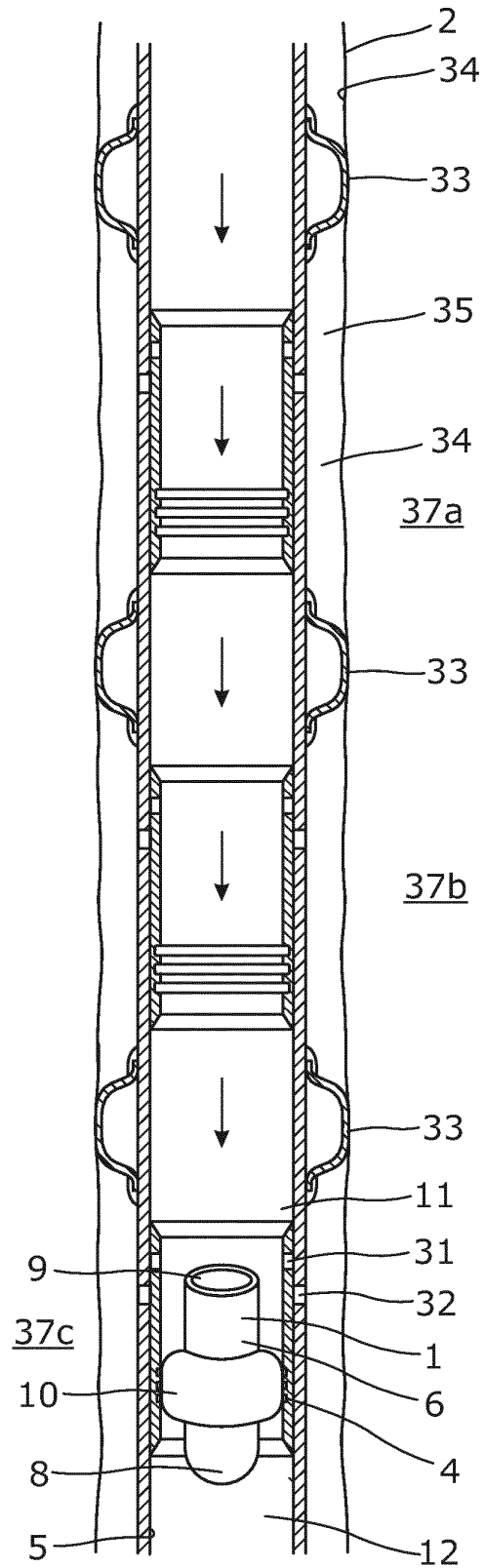


Fig. 2

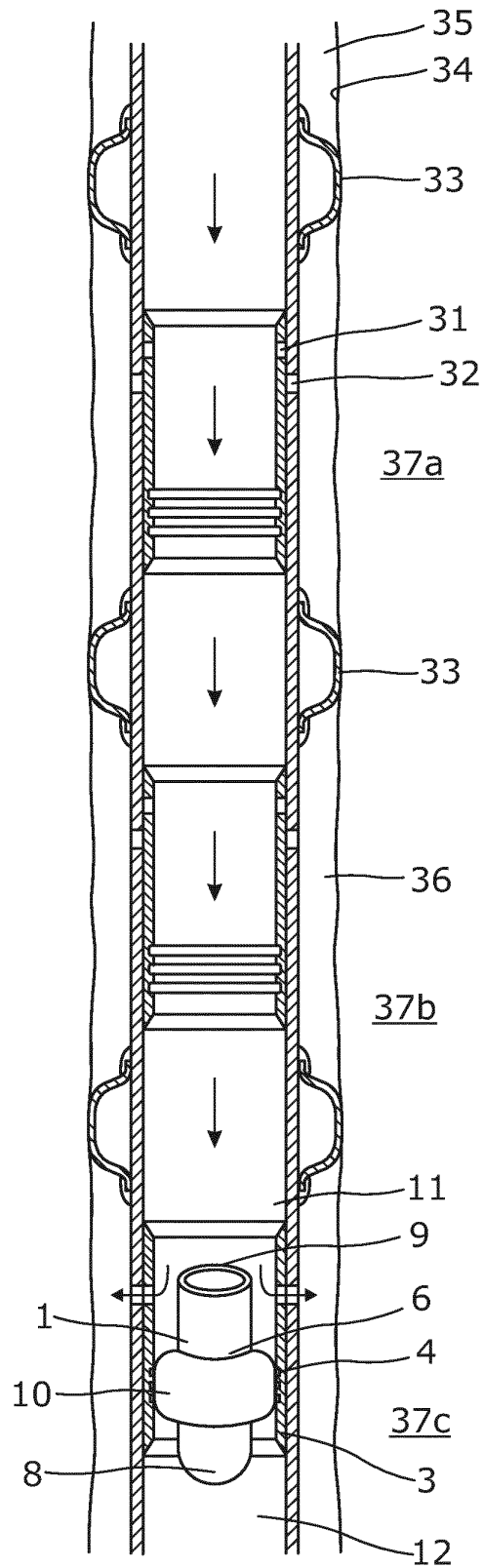


Fig. 3

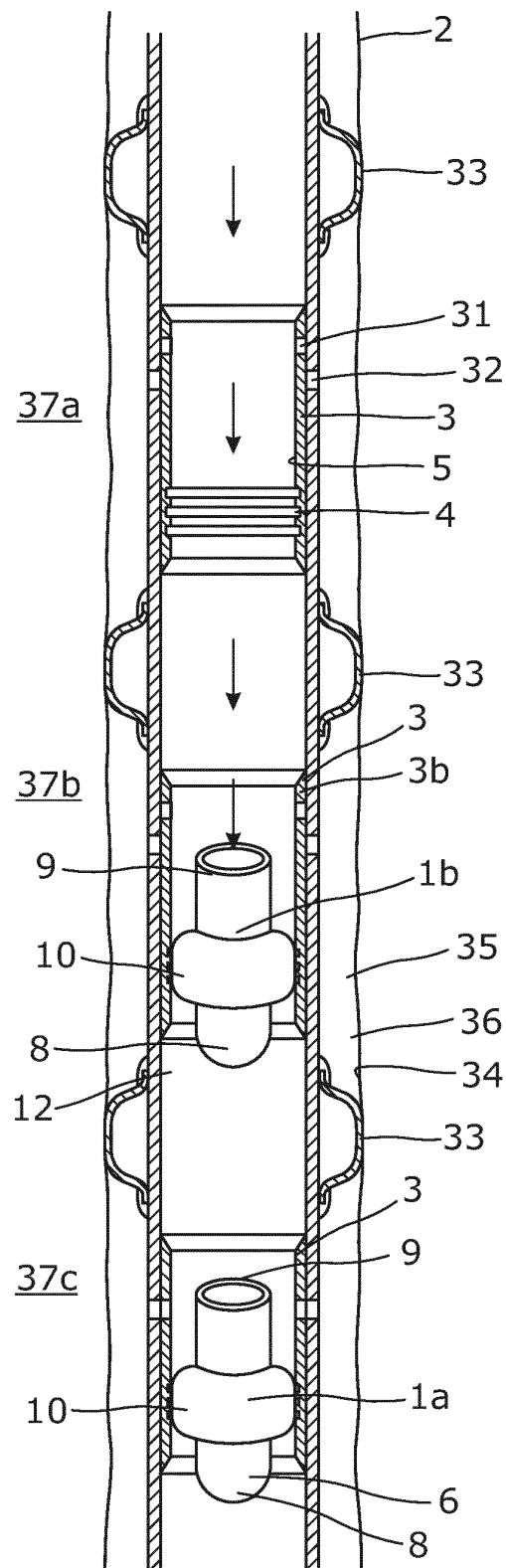


Fig. 4

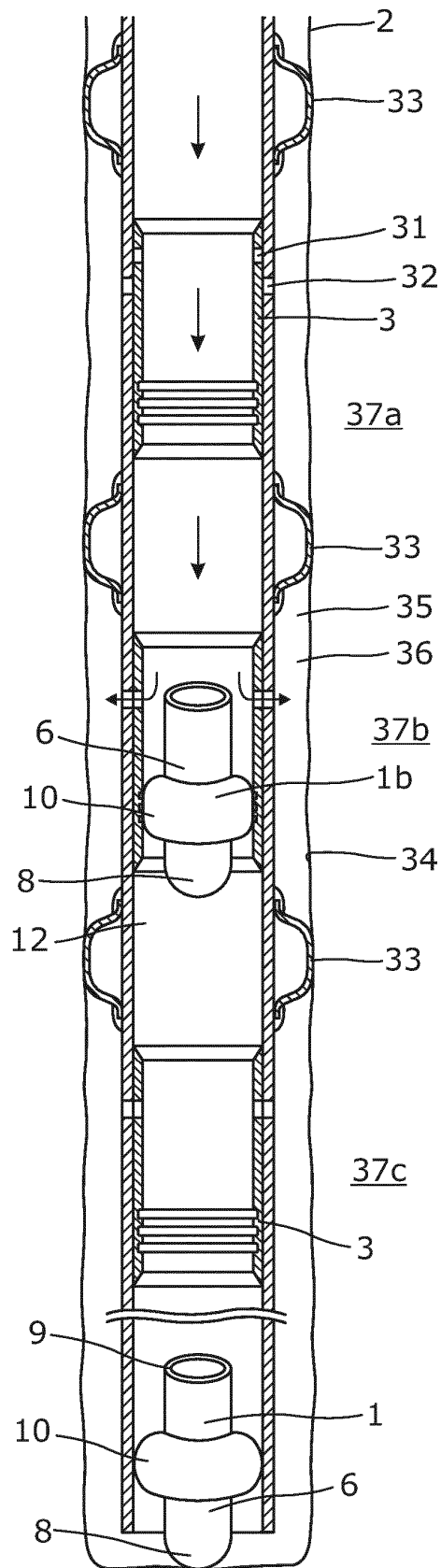


Fig. 5

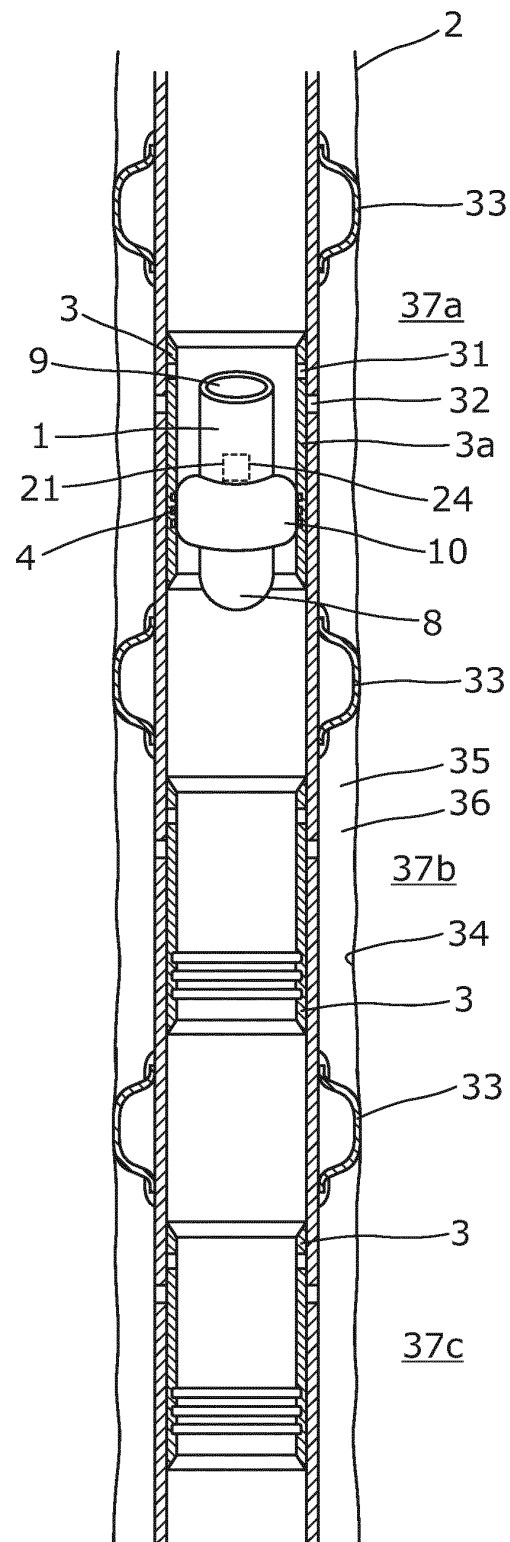


Fig. 6

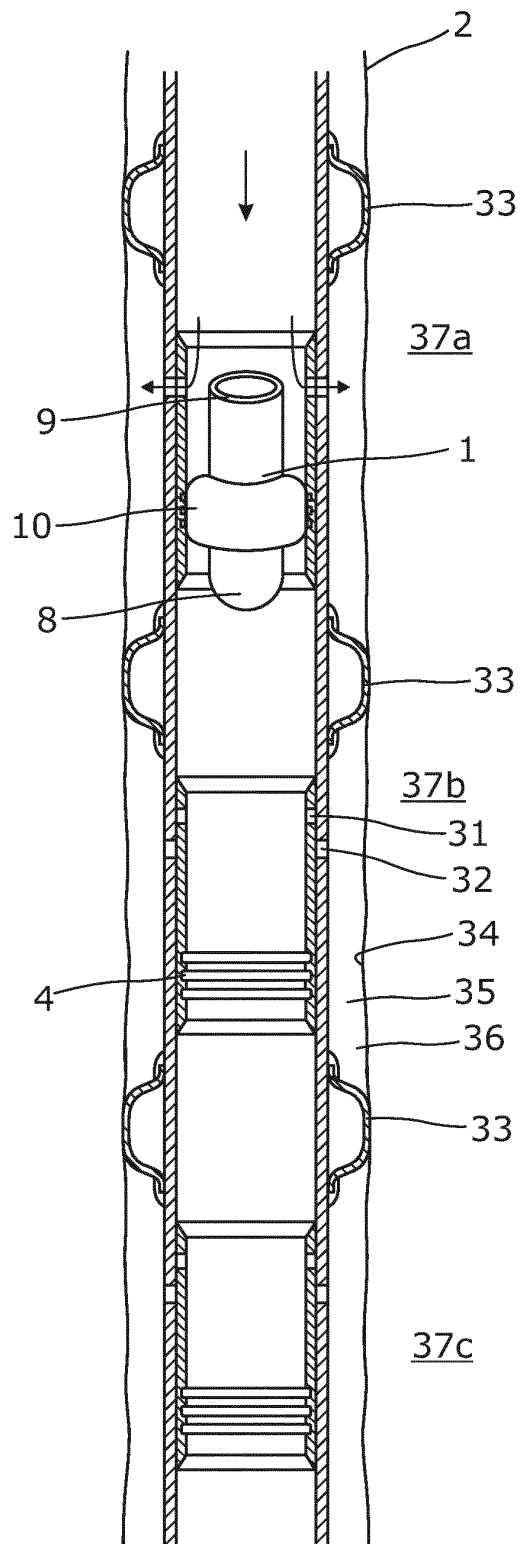


Fig. 7

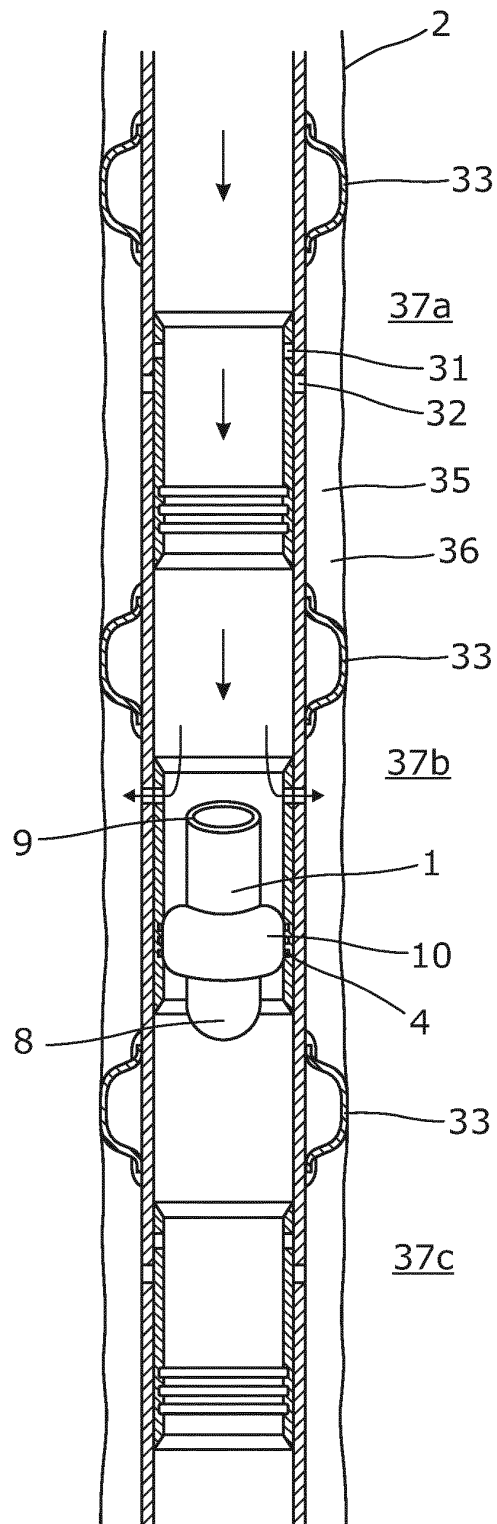


Fig. 8

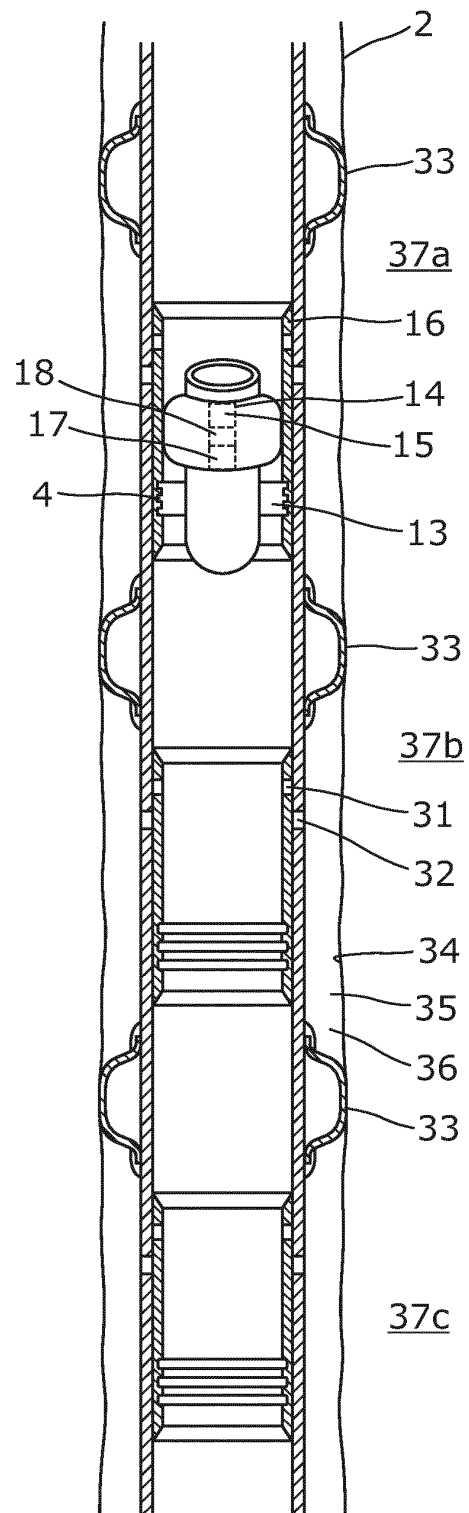


Fig. 9

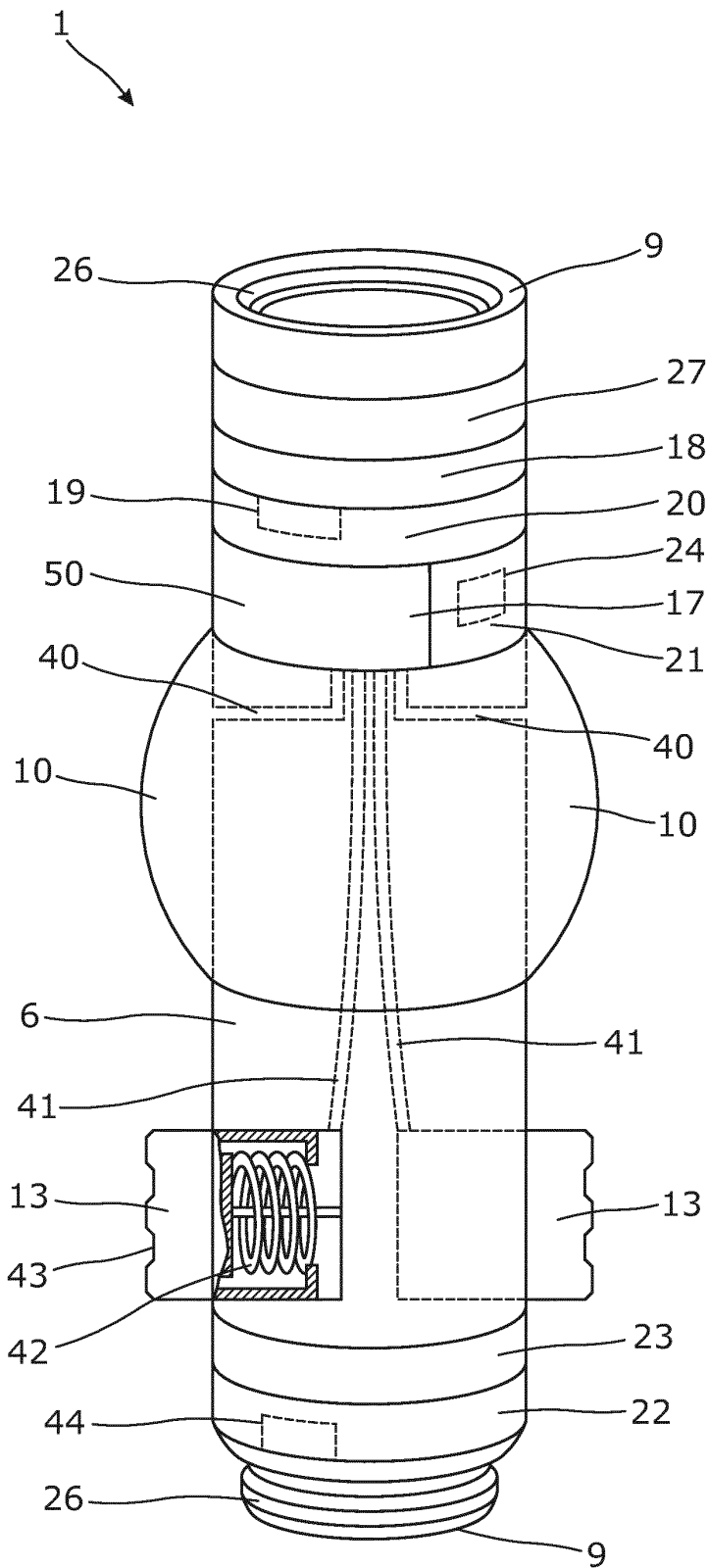


Fig. 10

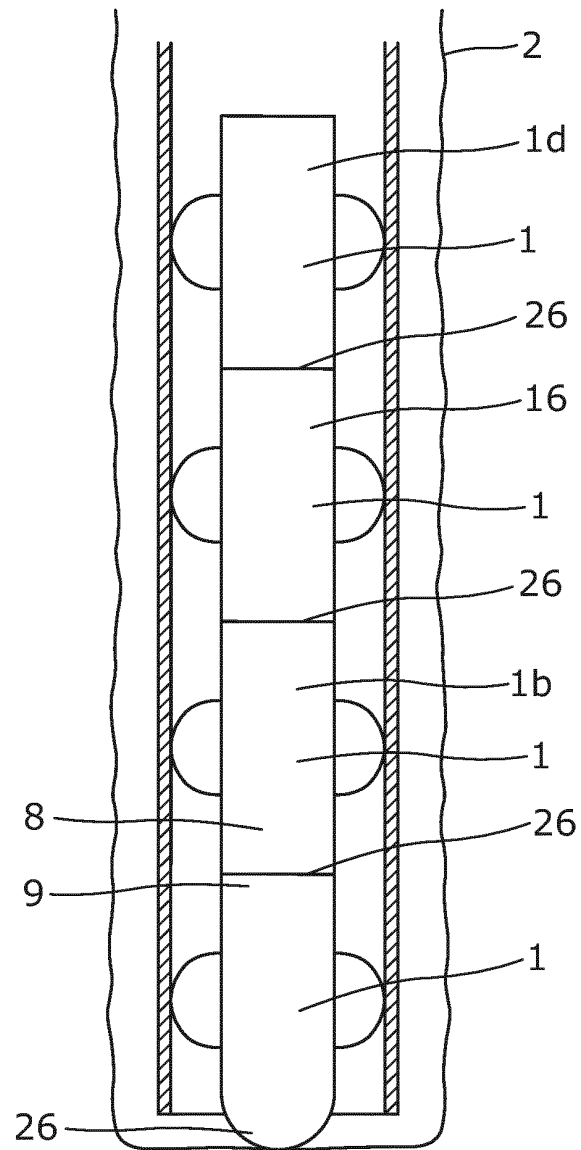


Fig. 11

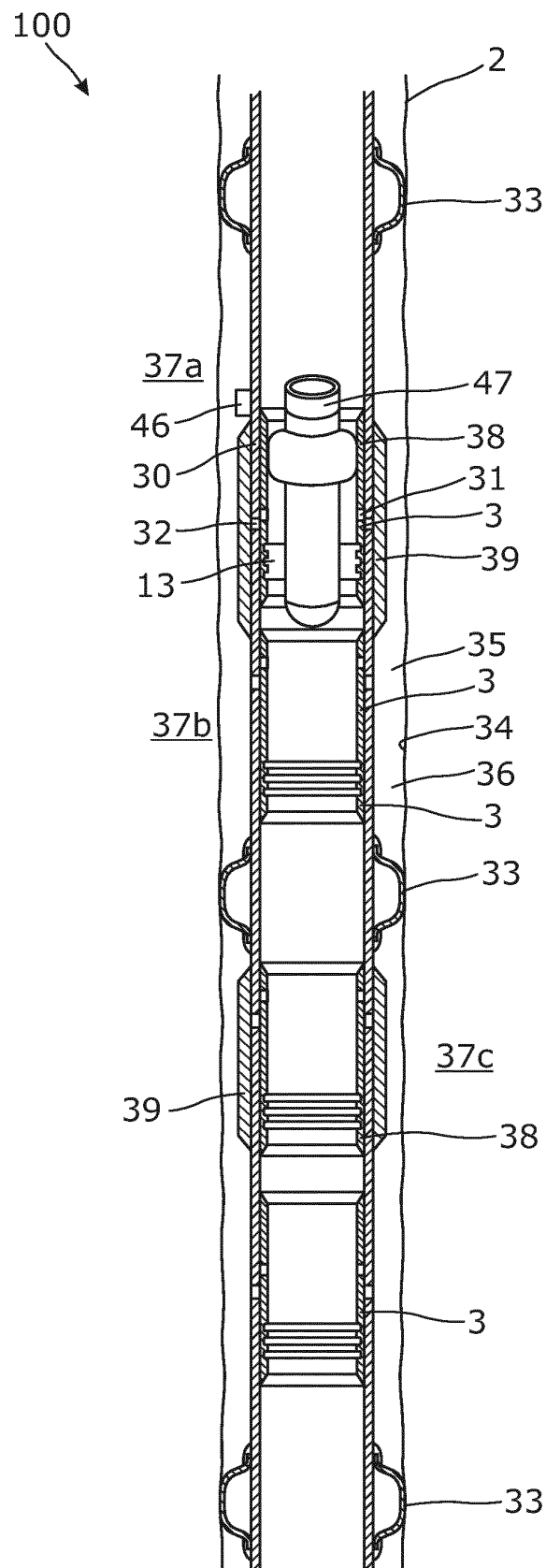


Fig. 12

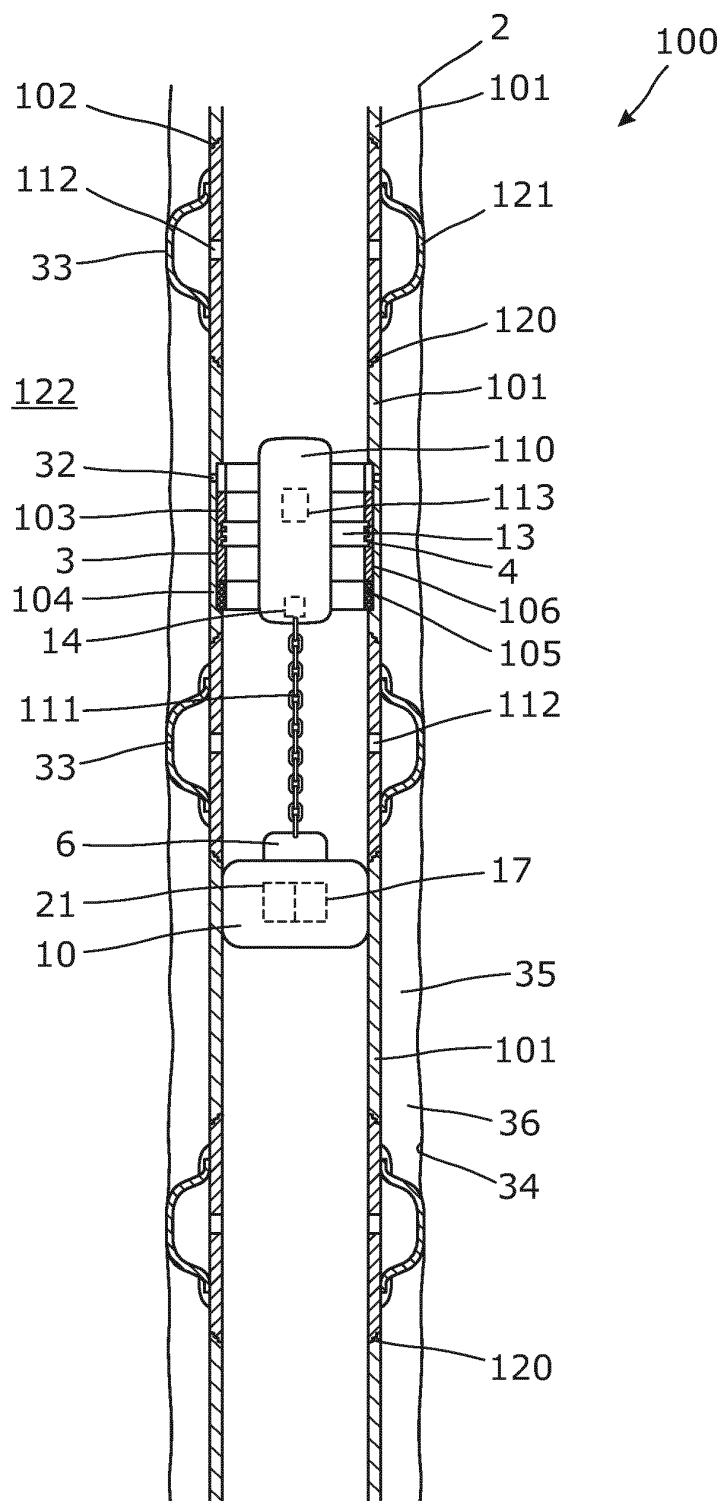


Fig. 13

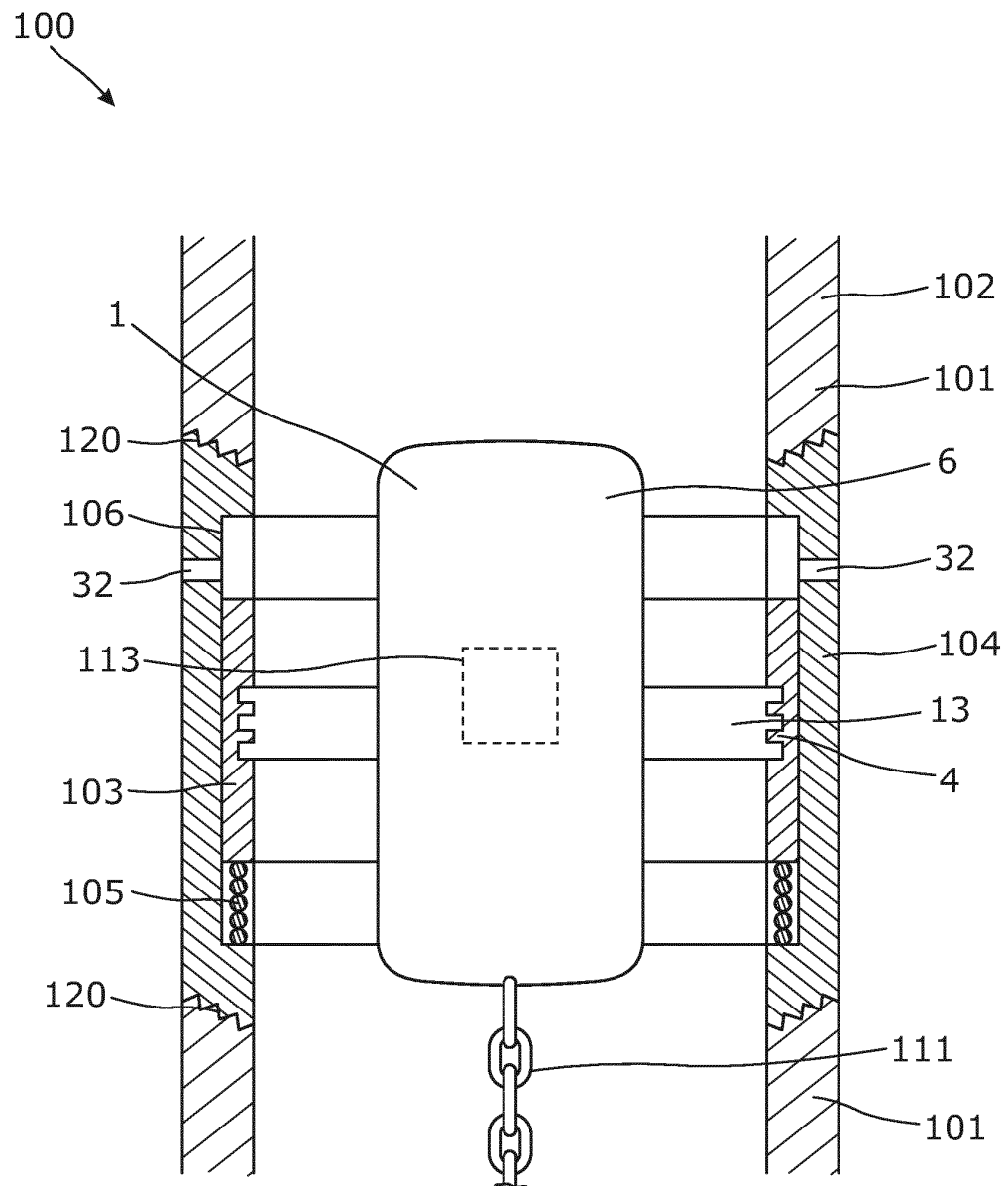


Fig. 14

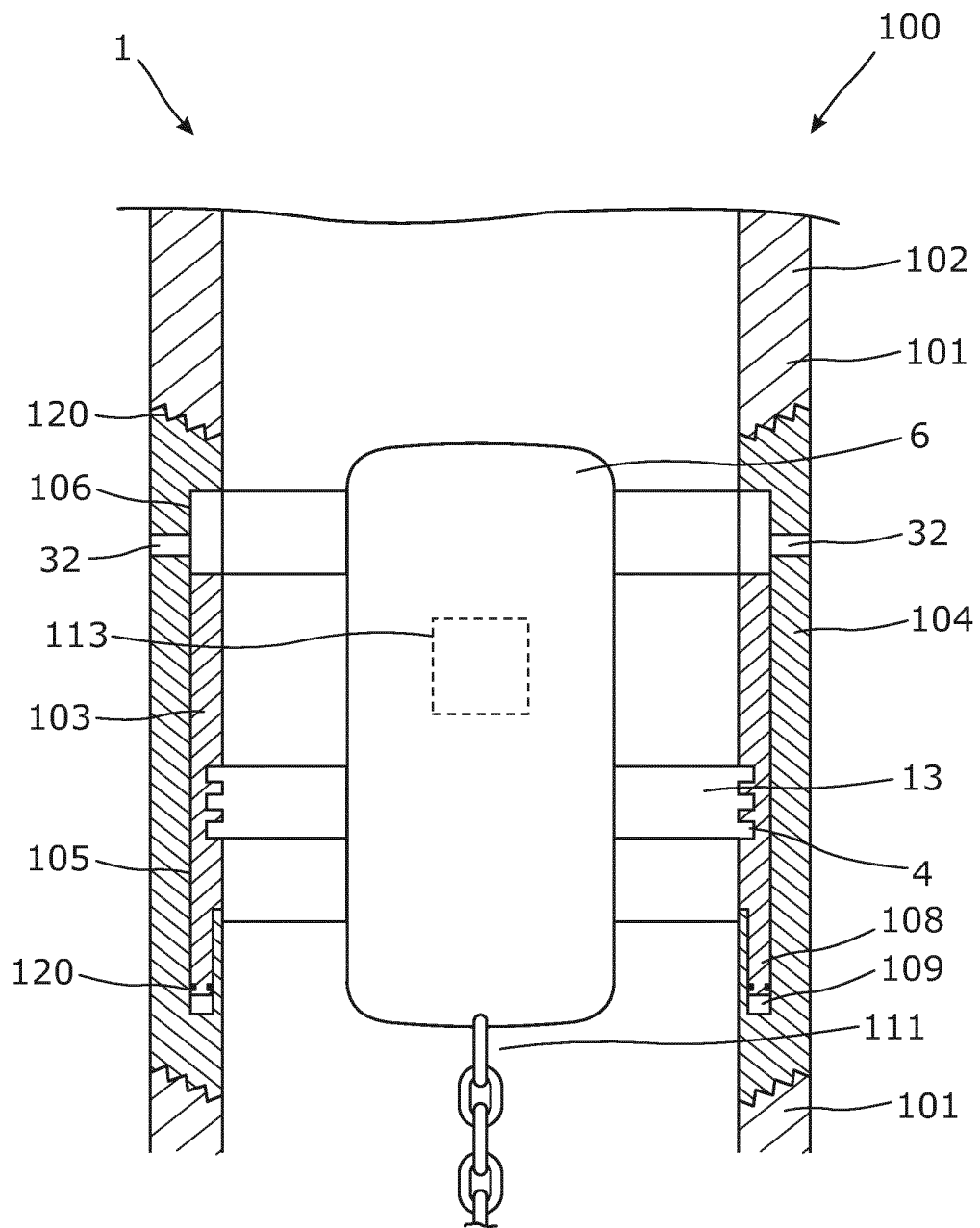


Fig. 15

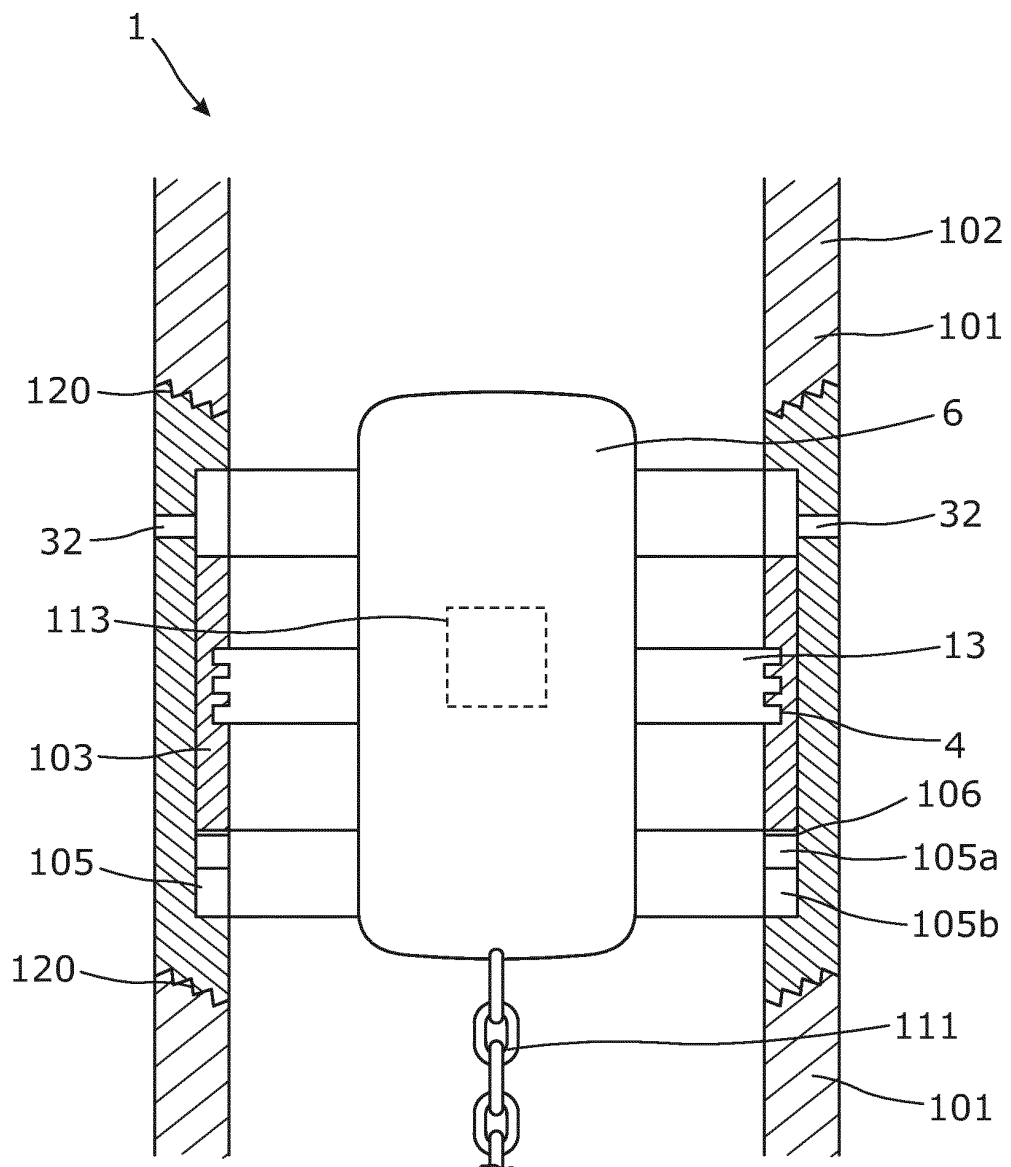


Fig. 16

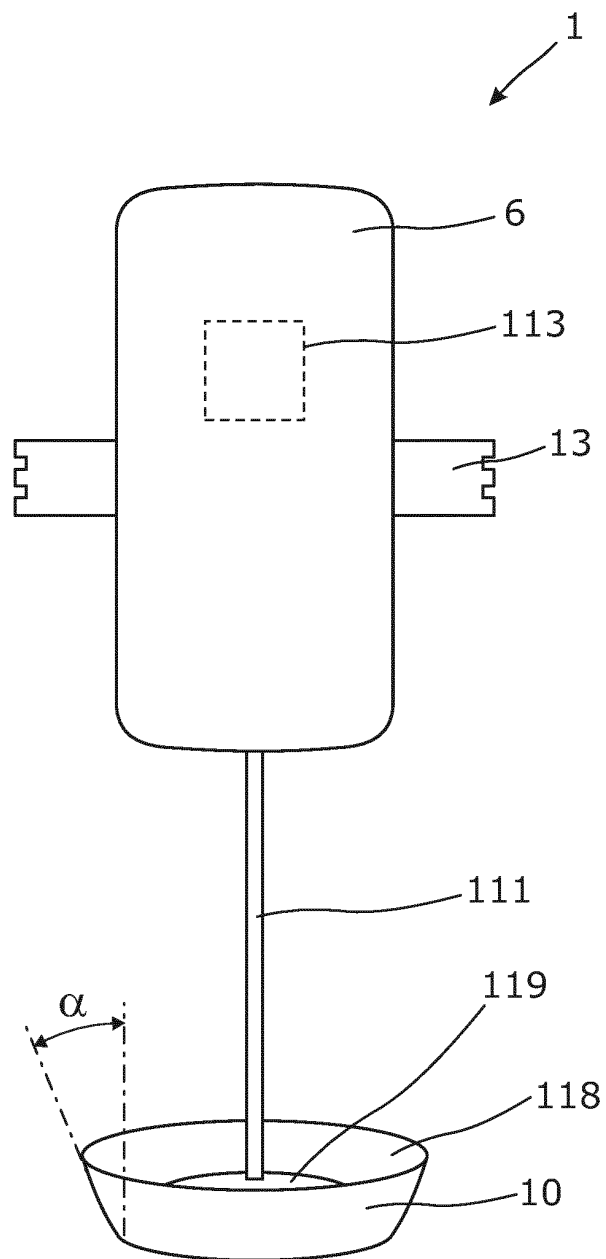


Fig. 17

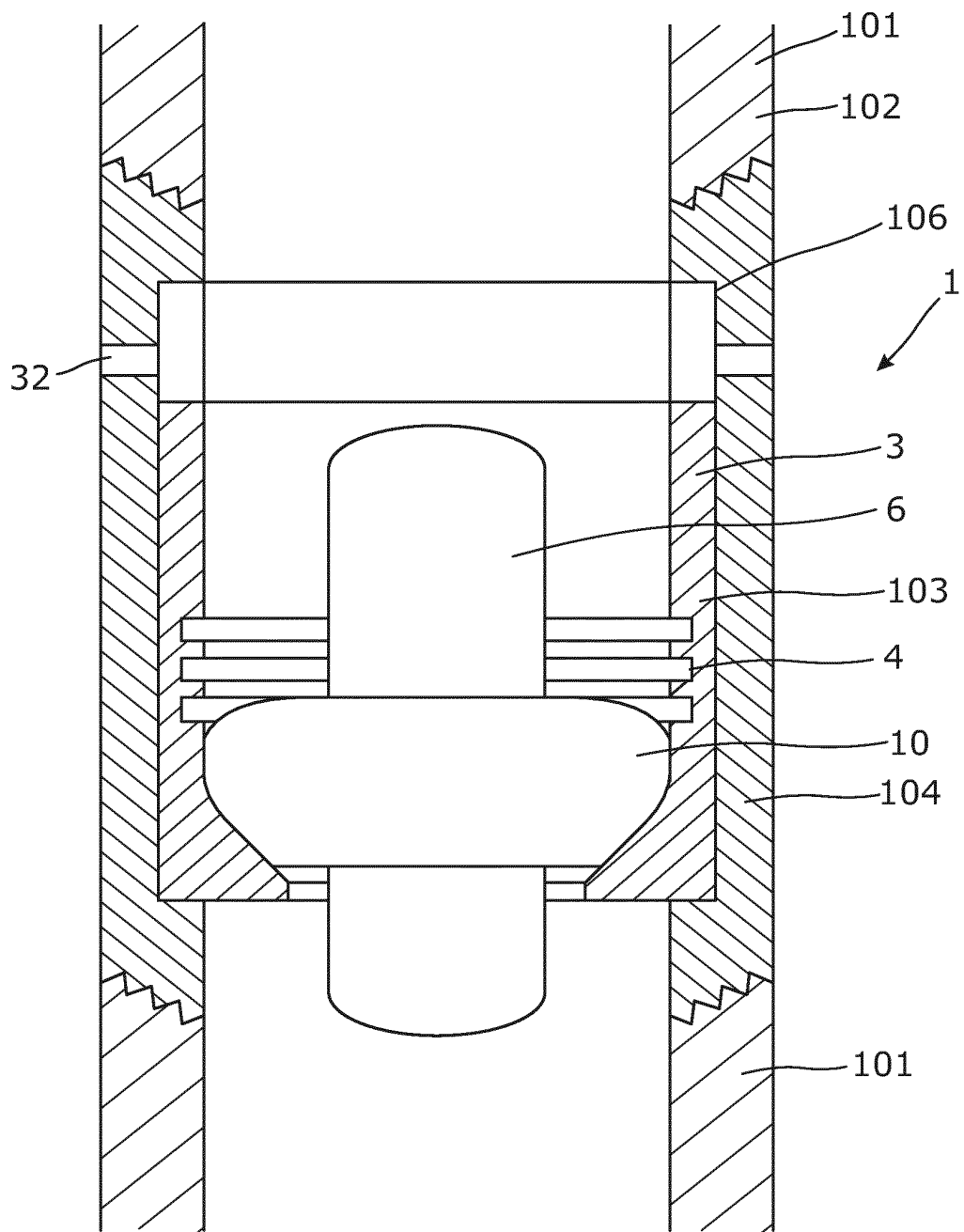


Fig. 18

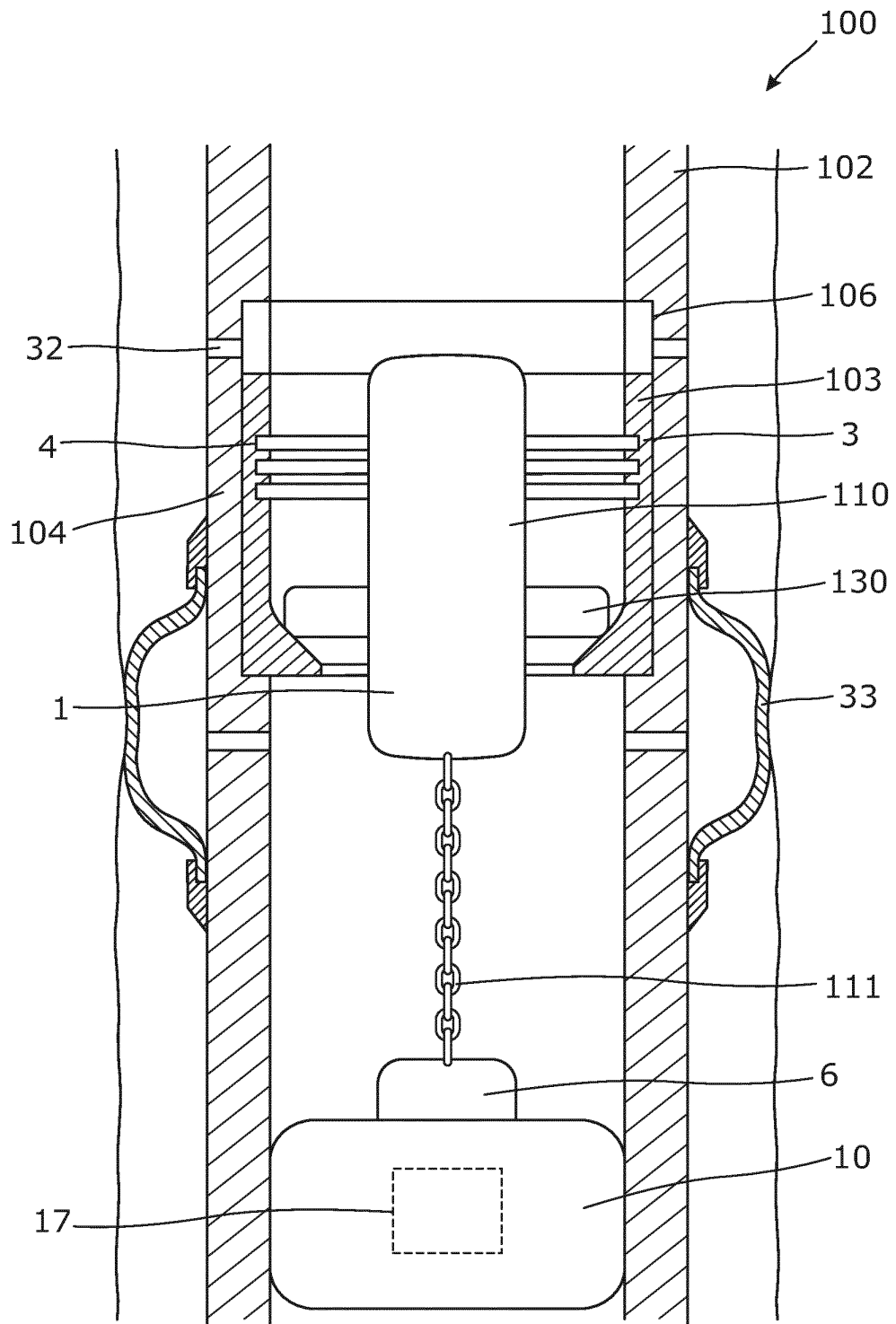


Fig. 19



EUROPEAN SEARCH REPORT

 Application Number
EP 12 19 0842

DOCUMENTS CONSIDERED TO BE RELEVANT			
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
X	US 2012/261127 A1 (ZHOU SHAOHUA [SA]) 18 October 2012 (2012-10-18)	1-5	INV. E21B33/127 E21B34/14 E21B43/14
Y	* abstract *	6-8	
Y	----- US 2007/289734 A1 (MCDONALD WILLIAM J [US] ET AL) 20 December 2007 (2007-12-20) * abstract *	6,7	
X	----- US 2011/284232 A1 (HUANG TIANPING [US]) 24 November 2011 (2011-11-24) * paragraphs [0023] - [0025] *	1-4	
A	----- US 2005/230107 A1 (MCDANIEL BILLY W [US] ET AL) 20 October 2005 (2005-10-20) * abstract *	1-7	TECHNICAL FIELDS SEARCHED (IPC) E21B
X	----- US 2006/124310 A1 (LOPEZ DE CARDENAS JORGE [US] ET AL) 15 June 2006 (2006-06-15) * abstract *	9-16	
Y	* abstract *	8	
Y	----- US 2005/011678 A1 (AKINLADE MONSURU OLATUNJI [NL] ET AL) 20 January 2005 (2005-01-20) * figure 4 *	8	
A	----- US 2011/284240 A1 (CHEN KUO-CHIANG [US] ET AL) 24 November 2011 (2011-11-24) * paragraphs [0041], [0042], [0056], [0057] *	8-16	
A	----- US 2012/085538 A1 (GUERRERO JULIO C [US] ET AL) 12 April 2012 (2012-04-12) * paragraphs [0030] - [0032], [0051] *	8-16	
A	----- US 2011/240301 A1 (ROBISON CLARK E [US] ET AL) 6 October 2011 (2011-10-06) * paragraphs [0044] - [0046], [0057], [0063] - [0066], [0069], [0070] *	8-16	
The present search report has been drawn up for all claims			
Place of search The Hague		Date of completion of the search 16 July 2013	Examiner Garrido Garcia, M
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 03.82 (P04C01)



Application Number

EP 12 19 0842

CLAIMS INCURRING FEES

The present European patent application comprised at the time of filing claims for which payment was due.

☐ Only part of the claims have been paid within the prescribed time limit. The present European search report has been drawn up for those claims for which no payment was due and for those claims for which claims fees have been paid, namely claim(s):

☐ No claims fees have been paid within the prescribed time limit. The present European search report has been drawn up for those claims for which no payment was due.

LACK OF UNITY OF INVENTION

The Search Division considers that the present European patent application does not comply with the requirements of unity of invention and relates to several inventions or groups of inventions, namely:

see sheet B

☒ All further search fees have been paid within the fixed time limit. The present European search report has been drawn up for all claims.

☐ As all searchable claims could be searched without effort justifying an additional fee, the Search Division did not invite payment of any additional fee.

☐ Only part of the further search fees have been paid within the fixed time limit. The present European search report has been drawn up for those parts of the European patent application which relate to the inventions in respect of which search fees have been paid, namely claims:

☐ None of the further search fees have been paid within the fixed time limit. The present European search report has been drawn up for those parts of the European patent application which relate to the invention first mentioned in the claims, namely claims:

☐ The present supplementary European search report has been drawn up for those parts of the European patent application which relate to the invention first mentioned in the claims (Rule 164 (1) EPC).



**LACK OF UNITY OF INVENTION
SHEET B**

Application Number

EP 12 19 0842

The Search Division considers that the present European patent application does not comply with the requirements of unity of invention and relates to several inventions or groups of inventions, namely:

1. claims: 1-7

Sliding sleeve

2. claims: 8-16

Drop plug

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

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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
The European Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

16-07-2013

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