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(54) **Inflow control in a production casing**

(57) The present invention relates to a downhole artificial lifting system (100) for introducing fluid into a production casing (4) from an annulus outside the production casing. The production casing has a casing wall (102) with a wall thickness, and the system comprises the production casing which at a first part (107) is surrounded by an intermediate casing (18) creating the annulus which is downwardly closed, and a fluid delivering means (108) pumping fluid into the annulus. The invention also relates to a tool and a method.

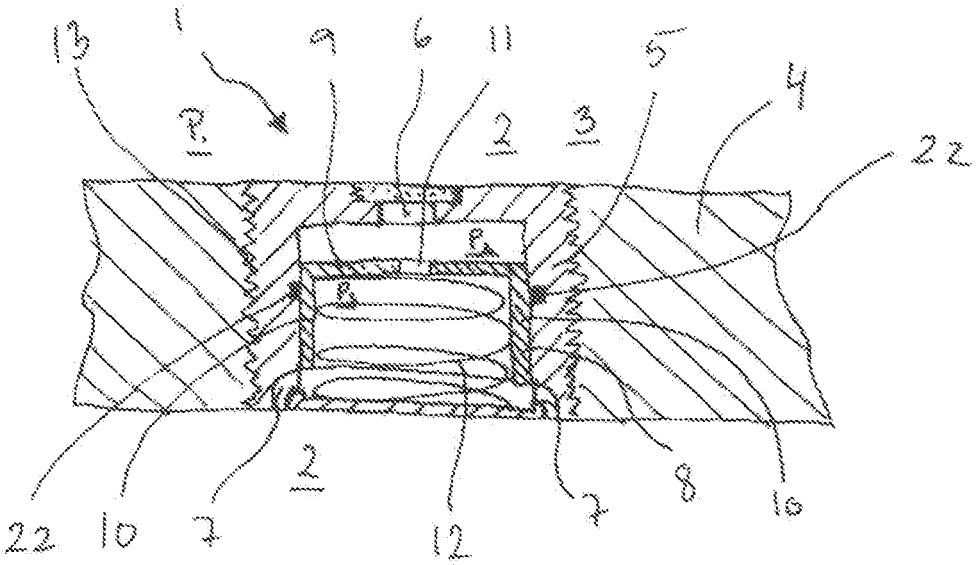

Fig. 1

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Description

Technical field

[0001] The present invention relates to a downhole artificial lifting system for introducing fluid into a production casing from an annulus outside the production casing. The production casing has a casing wall with a wall thickness, and the system comprises the production casing which at a first part is surrounded by an intermediate casing creating the annulus which is downwardly closed, and a fluid delivering means pumping fluid into the annulus. The invention also relates to a tool and a method.

Background

[0002] In an oil or gas production well, there might not be sufficient pressure in the reservoir to lift the production fluids to the surface. In these circumstances, artificial lift may be necessary to lift the produced fluids to the surface. In other circumstances, artificial lift may be used in naturally flowing wells, which do not technically need it, to increase the flow rate to a higher level than the natural rate.

[0003] Artificial lift refers to the use of an artificial means to increase the flow of liquids, such as crude oil or water, from a production well. This is generally done by using a mechanical device inside the well, e.g. a pump or a velocity string, or by decreasing the weight of the hydrostatic column by injecting a fluid, often a gas, into the liquid a certain distance down the well. The latter is often called a gas lift system.

[0004] In a gas lift system, the injected gas aerates the fluid to reduce its density. The formation pressure is thereby able to lift the oil column and force the fluid out of the wellbore. Gas may be injected continuously or intermittently, depending on the producing characteristics of the well and the arrangement of the gas lift equipment.

[0005] Accordingly, it is known to use gas lift systems for artificial lift in production wells. The known gas lift systems may consist of a mandrel, which is a device installed in the tubing string of a well..

[0006] There are two common types of mandrels. In a conventional gas lift mandrel, a gas lift valve is installed as the tubing is placed in the well. Thus, to replace or repair the valve, the tubing string must be pulled up. This is a cumbersome operation. Another known mandrel is the side-pocket mandrel. In a side-pocket mandrel, the valve is installed and removed by means of wireline while the side-pocket mandrel is still in the well. This may eliminate the need to pull up the tubing to repair or replace the valve, however, side-pocket mandrels are complicated systems to operate and are furthermore installed as the tubing is placed in the well. Furthermore, mandrels occupy a lot of space outside the production casing, which complicates other operations performed outside the production casing.

[0007] Furthermore, as mentioned above, the known gas lift system is installed in the tubing, i.e. the casing, however, the known gas lift system is difficult or nearly impossible to retrofit into existing production wells.

Description of the invention

[0008] 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 alternative downhole artificial lifting system with a simple and reliable design.

[0009] It is also an object to provide an alternative downhole artificial lifting system which does not occupy much space inside and outside the production casing.

[0010] Additionally, it is an object to provide an alternative downhole artificial lifting system which may easily be retrieved and replaced.

[0011] Furthermore, it is an object to provide an alternative downhole artificial lifting system which may be retrofitted in existing production casings.

[0012] 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 artificial lifting system for introducing fluid into a production casing from an annulus outside the production casing, the production casing having a casing wall with a wall thickness, the system comprising:

- the production casing which at a first part is surrounded by an intermediate casing creating the annulus which is downwardly closed, and
- a fluid delivering means pumping fluid into the annulus,

  wherein the system further comprises at least one inflow control valve arranged in the first part of the casing wall and having an axial extension which is substantially the same as the wall thickness.

[0013] By having an inflow control valve, a more simple system is obtained which is easy to install, both in an existing casing and at the time of installing the casing in the borehole. Furthermore, it is possible to obtain a solution which does not change the inside or outside diameter of the casing, which makes it easier to perform subsequent operations.

[0014] The fluid may have a density lower than that of crude oil, and the fluid may be gas.

[0015] Furthermore, the system may comprise a plurality of valves arranged in one level.

[0016] In one embodiment, the inflow control valve may be a constant inflow control valve providing a constant inflow of fluid into the production casing.

[0017] In another embodiment, the annulus may be closed by a packer, and a blocking means may be arranged outside the first part, dividing the annulus into a top part and a bottom part, causing the bottom part to be a confined annulus area between the blocking means

and the packer.

[0018] The blocking means may have a flow providing means for allowing fluid to pass the blocking means.

[0019] This flow providing means may be a valve means connectable to the fluid delivering means, allowing the fluid of the fluid delivering means to flow past the top part of the annulus and into the confined annulus area.

[0020] Furthermore, the system may comprise a plurality of blocking means so that a first blocking means creates a confined annulus area between the first blocking means and the packer, and a second blocking means creates a confined annulus area between the first blocking means and the second blocking means.

[0021] Additionally, the valve means may be a one-way valve.

[0022] Furthermore, the first part of the casing wall may have at least one valve outside each confined annulus area, allowing fluid to flow from that confined annulus area into the production casing through the valve.

[0023] The downhole inflow control valve may comprise a housing having an inlet and an outlet; a piston element sliding within the housing and comprising a face and at least one side abutting the housing and extending from the face towards the outlet of the housing, the face facing the inlet and having a piston hole allowing the fluid from the inlet to flow through the piston hole and out through the outlet; and a spring element arranged between the housing and the piston, wherein the side of the piston element is able to, at least partly, close the outlet in order to reduce the inflow of fluid into the casing.

[0024] Moreover, the inflow control valve may comprise a fastening means for fastening the valve to an opening in the casing.

[0025] This fastening means may comprise a thread or a plurality of projecting parts for projecting into a groove in a hole in a wall of the casing, such as a bayonet lock.

[0026] Furthermore, the inflow control valve may comprise a unique identifier, such as a chemical or radioactive tracer.

[0027] Additionally, the inflow control valve may comprise a gas detection means, a water detection means or a density detection means which is able to close the valve if the density is lower or higher than a predetermined density.

[0028] This gas or water density detection means may comprise closing means for closing the outlet or the inlet.

[0029] In one embodiment, the valves may be controllable from above the well.

[0030] In another embodiment, the valves may be remotely controllable from above the well.

[0031] The gas may flow directly into the production casing through the valve.

[0032] In an embodiment of the invention, the inflow control valve may have a height and a diameter, and the height is substantially equal to the wall thickness of the casing. In another embodiment of the invention, the inflow control valve may be connected directly or indirectly to the delivering means.

[0033] By directly is meant by means of a tubing or the like flow transpotable means, and by indirectly is meant that the valve is in fluid communication with the delivering means, e.g. through of the annulus.

[0034] The delivering means may be submerged into the intermediate casing on the outside of the production casing.

[0035] Furthermore, the delivering means may have a tubing part for connection with the valve.

[0036] The inflow control valve may comprise a connection means for connection with the tubing part of the delivering means.

[0037] In one embodiment, the system may further comprise a tool for placing a valve in a casing, the tool comprising a milling means for creating an opening in the casing wall.

[0038] The tool may further comprise a means for creating a fastening recess or threads in the opening or an insertion means for inserting a valve into the opening.

[0039] In another embodiment, the system may comprise a tool for placing a valve in a casing, the tool comprising a milling means for creating an opening in the casing wall, a means for creating a fastening recess or threads in the opening, and an insertion means for inserting a valve into the opening.

[0040] Furthermore, the system may comprise a tool for retrieving a valve in a casing wall, the tool comprising a key means for inserting into a recess in the valve and for unthreading the valve, or for releasing the fastening means of the valve in order to retrieve the valve.

[0041] This invention also relates to a method for fitting a downhole inflow control valve into an existing production casing downhole, the casing having a casing wall, the method comprising the steps of introducing a tool into the casing and lowering the tool to a predetermined position, providing an opening in the casing wall, inserting the downhole inflow control valve into the opening, and fastening the downhole inflow control valve to the casing wall.

[0042] The opening may be provided with fastening means, such as a thread, enabling the fastening of the valve to the casing wall to be carried out by screwing the valve into the casing wall, or the opening is provided with fastening means, such as a mechanical locking means, which is adapted to correspond with corresponding locking means on the valve.

[0043] The invention furthermore relates to a method for replacing a downhole inflow control valve in a production casing downhole, the casing having a casing wall, the method comprising the steps of introducing a tool into the casing and lowering the tool to the valve to be replaced, unfastening the valve from the casing wall, retrieving the valve from the casing and thereby exposing an opening in the casing wall, inserting a new valve into the opening, and fastening the new valve to the casing wall.

[0044] Additionally, the invention relates to a method

for providing artificial lift in a well downhole using at least one inflow control valve in a production casing downhole, the production casing being enclosed by an intermediate casing creating an annulus, the method comprising the steps of connecting a fluid delivering means with the annulus, pumping fluid into the annulus by means of the fluid delivering device, wherein the fluid has a density lower than that of crude oil or is gas, opening the inflow control valve being connected to the annulus, allowing the fluid to enter through the inflow control valve into the production casing, whereby the fluid in the production casing starts to flow, or flows faster.

[0045] Finally, the invention relates to a method for detecting during production a position of a specific downhole inflow control valve among a plurality of inflow control valves arranged spaced apart in a casing wall of a casing downhole, wherein each valve comprises a unique identifier, the method comprising the steps of analysing a fluid for the purpose of locating the existence of unique identifiers, comparing the analysis of the fluid with the unique identifier of each valve, and determining the specific valve based on the comparison.

Brief description of the drawings

[0046] 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 downhole artificial lifting system according to the invention when creating an opening in the casing,

Fig. 2 shows another embodiment of the system when inserting an inflow control valve,

Fig. 3 shows yet another embodiment of the system with the inflow control valve inserted,

Fig. 4 shows a cross-sectional view of the inflow control valve,

Fig. 5 shows another embodiment of the inflow control valve,

Fig. 6 shows yet another embodiment of the inflow control valve,

Fig. 7 shows yet another embodiment of the inflow control valve, and

Fig. 8 shows another embodiment of the system when performing artificial lift in a well.

[0047] All these 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

[0048] The invention relates to a downhole artificial lifting system 100 for introducing fluid into a production casing 4 from an annulus outside the production casing. The production casing 4 has a casing wall 102 with a wall thickness t. The downhole system 100 comprises the production casing 4 which at a first part 107 is surrounded by an intermediate casing creating the annulus which is downwardly closed, and a fluid delivering means 108 pumping fluid into the annulus. The system 100 further comprises at least one inflow control valve 1 arranged in the first part 107 of the casing wall 102, and having an axial extension which is substantially the same as the wall thickness t.

[0049] By having an inflow control valve 1, the thickness of the casing does not increase, which makes other operations easier. Furthermore, the complicated prior art solution of having a valve incorporated in a surrounding mandrel is no longer the only solution. In addition, such an inflow control valve makes it possible to easily mount the system into an existing well, and the valve is easily replaced later on if necessary.

[0050] As shown in the system of Fig. 1, the casing 4 is a production casing enclosed by a surrounding intermediate casing 18, and the fluid which is pumped down into the intermediate casing 18 and into the valves of the production casing is gas. Packers 19 are arranged between the production casing 4 and the intermediate casing 18.

[0051] Fig. 1 shows a downhole artificial lifting system 100 according to the invention when creating an opening 103 in the casing 4 in order to insert an inflow control valve 1. A downhole tool 101 comprising a milling means 106 is inserted into the first part 107 of the production casing 4. The tool 101 comprises a downhole tractor which controls and moves the milling means 106 into position and maintains the milling means in position while creating the opening 103 in the well. The milling means 106 may also be held into place by an anchor section which is submerged into the well without using a downhole tractor.

[0052] In order to be able to fasten the valve 1 in the opening, the milling means 106 may comprise means for creating a recess in the opening 103, enabling the projecting fastening means 13 of the valve 1 to unfold in this recess and thus be fastened. In another embodiment, the tool 101 comprises a means for creating a thread in the opening 103, allowing the valve to be mounted by screwing it into the opening.

[0053] When the opening 103 has been created, the tool 101 is moved so that the insertion means 104 is positioned outside the opening, enabling mounting of the valve 1 in the opening as shown in Fig. 2.

[0054] Fig. 3 shows yet another embodiment of the

system where the inflow control valve 1 has been inserted, and the tool is being retracted from the well. The well is now ready for performing artificial lift by pumping gas down into the annulus between the intermediate casing 18 and the production casing 4. The gas enters the production casing 4 through the inflow control valves 1, and the gas is thus pumped into the fluid in the form of bubbles, and the weight of the hydrostatic column in the first part 107 of the well decreases. In this way, the flow of the well fluid is initiated, or the well fluid already flowing is accelerated.

[0055] By having an inflow control valve 1, the inflow of lifting fluid is controlled to obtain an optimal mix with the well fluid, and thereby an optimal artificial lift of the well, .

[0056] As can be seen in Figs. 1-3, the annulus is closed by a packer 110 dividing the production casing 4 in a first 107 and a second part, causing the first part of the production casing to be situated above the packer. To ensure that the annulus above the packer 110 is not filled with lifting fluid, such as gas, a blocking means 109 is arranged outside the first part 107 of the production casing 4, dividing the annulus into a top part 113 and a bottom part 114, causing the bottom part to be a confined annulus area 115 between the blocking means 109 and the packer 110. In order to perform artificial lifting of the well, only the smaller confined annulus area 115 has to be filled with lifting fluid. Therefore, the blocking means 109 has a flow providing means 112 for allowing fluid to pass the blocking means, and a tubing is connected between a gas delivery means 108 and the flow providing means 112 in order to fill the confined annulus area 115.

[0057] In Fig. 8, one of the inflow control valves 1 is connected to a tubing, and gas is thereby provided directly from the gas delivery means 108 into the valve, and the blocking means 109 is no longer necessary, but may be used to hold the tubing in place.

[0058] The system 100, 115 comprises a plurality of blocking means so that a first blocking means creates a confined annulus area between the first blocking means and the packer 110, and a second blocking means creates a confined annulus area between the first blocking means and the second blocking means. When having several confined areas, the first part 107 of the casing wall 102 has at least one valve 1 outside each confined annulus area 115, enabling fluid to flow from that confined annulus area into the production casing 4 through the valve.

[0059] The system 100 may comprise a plurality of inflow control valves 1 situated in the same level spaced apart along the diameter of the casing 4. In another embodiment, the valves 1 are arranged spaced apart along the longitudinal extension of the casing 4.

[0060] The inflow control valve 1 of the system 100 may be the valve described below in connection with Figs. 4-7, or it may have other designs and configurations as long as it is able to control the inflow of fluid, and as long as it has an extension which is substantially the same as the wall thickness t of the production casing 4.

[0061] The downhole artificial lifting system 100 may comprise a screen 20 causing the fluid to flow through the screen before entering the inflow control valve 1. In this way, the fluid is slowed down, and large solid elements are prevented from entering the valve. On the inside of the production casing 4 outside the outlets 7, the system 100 may have a sleeve which is able to close off the outlet 7 of the valve 1.

[0062] The inflow control valve 1 of the system 100 may also comprise a chamber filled with a unique identifier.

[0063] Furthermore, the system 100 may comprise a control means for controlling the closing of each valve 1 from the surface. The system 100 may also comprise a tool 101 which is inserted into the casing 4 in order to close the outlets 7 of the valves 1.

[0064] Moreover, the system 100 may comprise a means for replacing a valve 1. In this embodiment, it comprises a tool 101 for retrieving the valve 1 in a production casing wall 102, which tool comprises a key means 105 for inserting into a recess in the valve and for unthreading the valve, or for releasing the fastening means 13 of the valve in order to retrieve the valve. In order to release the fastening means 13, the key means 105 has to retract a sleeve retracting the projecting fastening means, which has unfolded in the recess, back into the valve, and the valve can then be retracted from the opening in the casing wall 102. Furthermore, the system 100 comprises an insertion means 104 for inserting a valve 1 into the opening 103.

[0065] Accordingly, when replacing a downhole inflow control valve 1 in a production casing 4 downhole, the casing having a casing wall 102, a tool 101 is introduced into the production casing and lowered to the valve to be replaced. The valve 1 is subsequently unfastened from the production casing wall 102 and retrieved from the casing 4, causing an opening in the casing wall to be exposed. Subsequently, a new valve 1 is inserted in the opening 103 and fastened to the production casing wall 102.

[0066] By well fluid present in the well before performing a gas lift is meant any type of fluid which may be present in oil wells, such as oil, oil mud, crude oil, water etc. By oil is meant any type of oil composition, such as crude oil, an oil-containing fluid etc. Oil and water fluids may therefore all comprise other elements or substances than oil and/or water, respectively. The fluid may also be a combination of gas, oil, water and small solids in the fluid.

[0067] By fluid for performing the gas lift operation by forcing this fluid into the production casing gas is meant any type of gas composition or fluid having a density lower than that of crude oil.

[0068] By a casing 4 is meant all types of pipes, tubings, tubulars etc. used downhole in relation to oil or natural gas production.

[0069] The downhole inflow control valve 1 comprises

a housing 5 having an inlet 6 and an outlet 7. As can be seen in Fig. 4, the housing 5 is arranged in the casing wall 102 by means of a threaded connection 13 and has substantially the same extension as the wall thickness t of the production casing 4.

[0070] Inside the housing 5, a piston element 8 is arranged, which slides back and forth to narrow the outlet hole of the housing 5. The piston element 8 comprises a face 9 facing the inlet 6 of the housing 5. The piston element 8 further comprises a side 10 abutting the inside of the housing 5 and extending from the face 9 towards the outlet 7 of the housing 5. The face 9 has a piston hole 11 allowing the fluid from the inlet 6 to flow through the piston hole 11 and out through the outlet 7 of the housing 5. The valve 1 further comprises a spring element 12 arranged between the housing 5 and the piston 8, wherein the side 10 of the piston element 8 is able to, at least partly, close the outlet 7 in order to reduce the inflow of fluid into the casing 4 and thus reduce the flow rate of the fluid.

[0071] By having a piston element 8 moving inside the valve housing 5, a self-actuated valve 1 with a very simple design which is able to control the inflow of fluid is obtained. This simple design makes the valve easier to manufacture, and furthermore, it may cause fewer parts to fail when the valve 1 is inserted downhole. When inserting the inflow control valve 1 downhole, the valve must be easy to mount, which is not the case when holes of the valve have to be aligned with existing holes. The inflow control valve 1 is easily installed in an existing production casing 4 by milling a hole in the casing with a threaded connection 13, and the valve can then be installed without any further alignments.

[0072] The housing 5 has a first 14, a second 15 and a third 16 wall, and the second wall 15 is arranged between the first 14 and the third wall 16, ensuring that the first 14 and the second wall 15 do not abut one another. The inlet 6 is arranged in the first wall 14 of the housing 5, and the outlet 7 is arranged in the abutting second wall 15. The spring element 12 is arranged within the piston 8 and presses against the face 9 of the piston 8 from the outlet 7 towards the inlet 6.

[0073] In Fig. 4, the housing is shaped like a hollow cylinder, and the piston 8 is shaped like a hollow cylinder without a bottom. The face 9 of the piston 8 is thus circular, and the side 10 of the piston 8 is a circumferential side extending from the face 9 towards the third wall 16 of the housing 5 and the outlet 7. In another embodiment, the housing 5 may have a square cross-section, meaning that the housing 5 has four second walls 15 between the first 14 and the third wall 16.

[0074] In Fig. 7, the side 10 of the piston 8 is also a circumferential side which has two openings arranged outside and in alignment with the outlet 7 of the housing 5, enabling the fluid to flow out of the housing 5 and into the production casing 4. If the outlet 7 is to be narrowed, the side 10 of the piston 8 is displaced away from the inlet 6 in the housing 5. This embodiment has the advantage that if the pressure in the annulus drops because the inlet 6 is blocked by e.g. debris, or if the filter or screen is blocked, the spring element 12 forces the piston 8 towards the inlet 6, whereby the outlet 7 is closed.

[0075] On the outside of the side 10 of the piston 8, between the opening and the end farthest away from the piston face 9, the side 10 of the piston 8 is arranged with a barb or a projection which enters the outlet 7, causing the piston 8 to be unable to move downwards again. The barb or projection is maintained inside the wall of the piston side 10, and when possible, it swings outwards towards the outlet opening. In this way, the inflow control valve 1 is permanently closed, which makes it possible to arrange a new valve elsewhere in the casing wall 102, or to replace the valve. If the valve was not locked, and the feature blocking the flow passage over time was removed, the valve would begin to let fluid flow into the production casing 4 again. This is not a desirable situation as it makes optimal management of the production impossible.

[0076] The fluid in the annulus has a first pressure, the fluid after passing the inlet 6 has a second pressure, the fluid after passing the piston opening has a third pressure, and the fluid after passing the outlet 7 has a fourth pressure. When the second pressure is greater than the third pressure and a spring force of the spring element 12, the piston 8 is pushed by the second pressure to, at least partly, close the outlet 7. In this way, the valve is able to control the inflow of fluid into the production casing 4.

[0077] As can be seen in Figs. 4-7, the housing 5 comprises a cavity in which the piston 8 slides. The piston 8 divides the housing 5 into two parts, a first cavity part and a second cavity part which still remain one cavity.

[0078] The fluid in the annulus has a first pressure P_1, the fluid in the first cavity part after passing the inlet 6 has a second pressure P_2, the fluid after passing the piston opening in the second cavity part has a third pressure P_3, and the fluid after passing the outlet 7 has a fourth pressure P_4. When the second pressure is greater than the third pressure and a spring force F of the spring element, the piston 8 is pushed by the second pressure to, at least partly, close the outlet 7.

[0079] In Fig. 4, the inflow control valve 1 comprises two outlets 7. In another embodiment, it may comprise more outlets 7.

[0080] In Figs. 4-6, the spring element 12 is shown as a helical spring. In Fig. 7, the spring element 12 is a disk spring of discs in layers. The spring element 12 may be any kind of suitable spring means, such as a leaf spring or a rubber element.

[0081] In Fig. 4, the inflow control valve 1 is fastened to the production casing 4 by means of threads, but it may also have other fastening means 13, such as a plurality of projecting parts for extending into a groove in the casing wall 102. The fastening means 13 may in this way be a bayonet lock. In Fig. 5, the valve has fastening means 13 in the form of projections functioning as barbs when released into the groove in the casing wall 102.

The inflow control valve 1 may also have the shape of a tapering cone fitting into a cone-shaped opening in the casing wall 102. In order to fasten the valve when inserted into the production casing 4, the valve is provided with fastening means 13 in the form of arms 13 which are spring-loaded and released when the tip of the valve enters the outside of the casing 4 as shown in Fig. 7. In this way, the inflow control valve 1 is easily insertable into existing wells from within the well.

[0082] The piston element 8 slides inside the housing 5, and in order to force the fluid to penetrate only through the piston hole 11, sealing means 22 may be arranged between the piston side 10 and the second wall 15 of the housing 5. The sealing means 22 may be fastened in a circumferential groove in the piston 8 as shown in Fig. 4, or in a circumferential groove in the housing wall as shown in Fig. 5. The sealing means 22 may be an O-ring or any other suitable sealing means 22.

[0083] The inflow control valve 1 may comprise a filter 17 preventing solid elements in the fluid from entering the valve through the inlet 6. The filter 17 is thus arranged in an opening in the housing 5 where it is connected to the housing 5 by means of a threaded connection 13. As shown in Fig. 5, a screen 20 may be positioned on the outside of the production casing 4, causing the fluid to enter through the screen 20 before entering the inlet 6.

[0084] In Fig. 5, the piston element 8 has a bottom face fastened to the face 1 by means of bars, pins or the like elongated elements, and the spring element 12 is arranged between the bottom face and the housing 5. The piston element 8 may also be a hollow cylinder or another hollow element having e.g. a square cross-section as shown in Fig. 7. The spring element 12 may be arranged between the third wall 16 of the housing 5 and the bottom of the piston element 21. On the outside of the piston 8, the side 10 may also be barbed or provided with a projection to inhibit a spring force, causing the projection to enter the outlet 7 and thereby closing it.

[0085] The inflow control valve 1 comprises a water detection means which closes the valve when the fluid flowing in from the annulus contains too much water. The valve 1 may also comprise a density detection means which detects changes in the density of the fluid, enabling the valve to be closed if the density is lower or higher than a predetermined density.

[0086] The valve 1 comprises closing means enabling it to close itself when the fluid reaches a too high water content, or the density has changed too much. The valve 1 may also be closed via central control at the surface or by a tool 101 inserted into the production casing 4. By being able to monitor the water content and close the valve when the limit is reached, it becomes much easier to maintain a high quality production.

[0087] If the piston element 8 is a hollow element as shown in Fig. 7 and is provided with barbs or projections on the outside, the closing procedure may be performed by drilling a hole in the bottom of the inflow control valve 1 and subsequently pushing up the piston 8 until the projections unfold in the outlets 7 and thereby close the valve 1.

[0088] The closing means of the detection means may comprise a swellable material arranged in the inlet 6 or in another opening through which the fluid flows, causing the swellable material to swell when the fluid contains too much water.

[0089] The detection means may also comprise a dissolvable material comprising a unique identifier which is released when the material dissolves. The dissolvable material may be a plastic material containing the identifier.

[0090] The water detection means or the density detection means may comprise a unique identifier, such as a chemical or radioactive tracer, which is released when a predetermined limit is reached. In another embodiment, the filter 17 comprises and/or is coated with the unique identifier. In yet another embodiment, the valve comprises a chamber filled with the unique identifier. In this way, each valve can release a unique identifier identifying that specific valve in order to detect which valve needs to be closed to control and optimise production.

[0091] The unique identifier may be a hydrophilic identifier which is released when the fluid contains water. The chamber filled with the unique identifier can be opened by means of the water detection means.

[0092] In order to detect any identifiers sent by one or several valves 1, the system 100 may comprise means for analysing the fluid for the purpose of locating the existence of unique identifiers.

[0093] Thus, if it is necessary during production to detect the position of a specific inflow control valve 1 among a plurality of inflow control valves arranged spaced apart in a production casing wall 102 downhole in which each valve has a chamber filled with a unique identifier, an analysis of a fluid is performed for the purpose of locating the existence of unique identifiers. Subsequently, the fluid analysis is compared with the unique identifier of each valve, and this comparison forms the basis of a determination of the specific valve.

[0094] In the event that the tools are not submergible all the way into the casing 4, a downhole tractor 25 can be used to push the tools all the way into position in the well. A downhole tractor is any type of driving tool capable of pushing or pulling tools in a well, such as a Well Tractor®.

[0095] 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. Downhole artificial lifting system (100) for introducing fluid into a production casing (4) from an annulus

outside the production casing, the production casing having a casing wall (102) with a wall thickness (t), the system comprising:

- the production casing which at a first part (107) is surrounded by an intermediate casing (18) creating the annulus which is downwardly closed, and
- a fluid delivering means (108) pumping fluid into the annulus,

wherein the system further comprises at least one inflow control valve (1) arranged in the first part of the casing wall and having an axial extension which is substantially the same as the wall thickness.

2. Downhole artificial lifting system according to claim 1, wherein the fluid has a density lower than that of crude oil.

3. Downhole artificial lifting system according to claim 1 or 2, wherein the fluid is gas.

4. Downhole artificial lifting system according to any of the preceding claims, wherein the system comprises a plurality of valves.

5. Downhole artificial lifting system according to claim 4, wherein the valves are all arranged in one level.

6. Downhole artificial lifting system according to any of the preceding claims, wherein the inflow control valve is a constant inflow control valve providing a constant inflow of fluid into the production casing.

7. Downhole artificial lifting system according to any of the preceding claims, wherein the annulus is closed by a packer (110), and wherein a blocking means (109) is arranged outside the first part, dividing the annulus into a top part (113) and a bottom part (114), causing the bottom part to be a confined annulus area (115) between the blocking means and the packer.

8. Downhole artificial lifting system according to claim 7, wherein the blocking means has a flow providing means (112) for allowing fluid to pass the blocking means.

9. Downhole artificial lifting system according to claim 7 or 8, wherein the system comprises a plurality of blocking means to ensure that a first blocking means creates a confined annulus area between the first blocking means and the packer, and a second blocking means creates a confined annulus area between the first and previous blocking means and the second blocking means.

10. Downhole artificial lifting system according to claim 8 or 9, wherein the first part of the casing wall has at least one valve outside each confined annulus area, allowing fluid to flow from that confined annulus area into the production casing through the valve.

11. Downhole artificial lifting system according to any of the preceding claims, wherein the downhole inflow control valve (1) comprises:

- a housing (5) having an inlet (6) and an outlet (7),
- a piston element (8) sliding within the housing and comprising a face (9) and at least one side (10) abutting the housing and extending from the face towards the outlet of the housing, the face facing the inlet and having a piston hole (11) allowing the fluid from the inlet to flow through the piston hole and out through the outlet, and
- a spring element (12) arranged between the housing and the piston,

wherein the side of the piston element is able to, at least partly, close the outlet in order to reduce the inflow of fluid into the casing.

12. Downhole artificial lifting system according to any of claims 7-9, wherein the system comprises a tool (101) for placing a valve in a casing, the tool comprising:

- a milling means (106) for creating an opening in the casing wall (102),
- a means for creating a fastening recess or threads in the opening (103), and
- an insertion means (104) for inserting a valve into the opening.

13. Method for fitting a downhole inflow control valve into an existing production casing downhole, the casing having a casing wall, the method comprising the steps of:

- introducing a tool into the casing and lowering the tool to a predetermined position,
- providing an opening in the casing wall,
- inserting the downhole inflow control valve into the opening, and
- fastening the downhole inflow control valve to the casing wall.

14. Method for replacing a downhole inflow control valve in a production casing downhole, the casing having a casing wall, the method comprising the steps of:

- introducing a tool into the casing and lowering the tool to the valve to be replaced,
- unfastening the valve from the casing wall,

- retrieving the valve from the casing and thereby exposing an opening in the casing wall,
- inserting a new valve into the opening, and
- fastening the new valve to the casing wall.

15. Method for providing artificial lift in a well downhole using at least one inflow control valve in a production casing downhole, the production casing being enclosed by an intermediate casing creating an annulus, the method comprising the steps of:

- connecting a fluid delivering means with the annulus,
- pumping fluid into the annulus by means of the fluid delivering device,
wherein the fluid has a density lower than that of crude oil or is gas,
- opening the inflow control valve being connected to the annulus, allowing the fluid to enter through the inflow control valve into the production casing, whereby the fluid in the production casing starts to flow, or flows faster.

16. Tool according to claim 12.

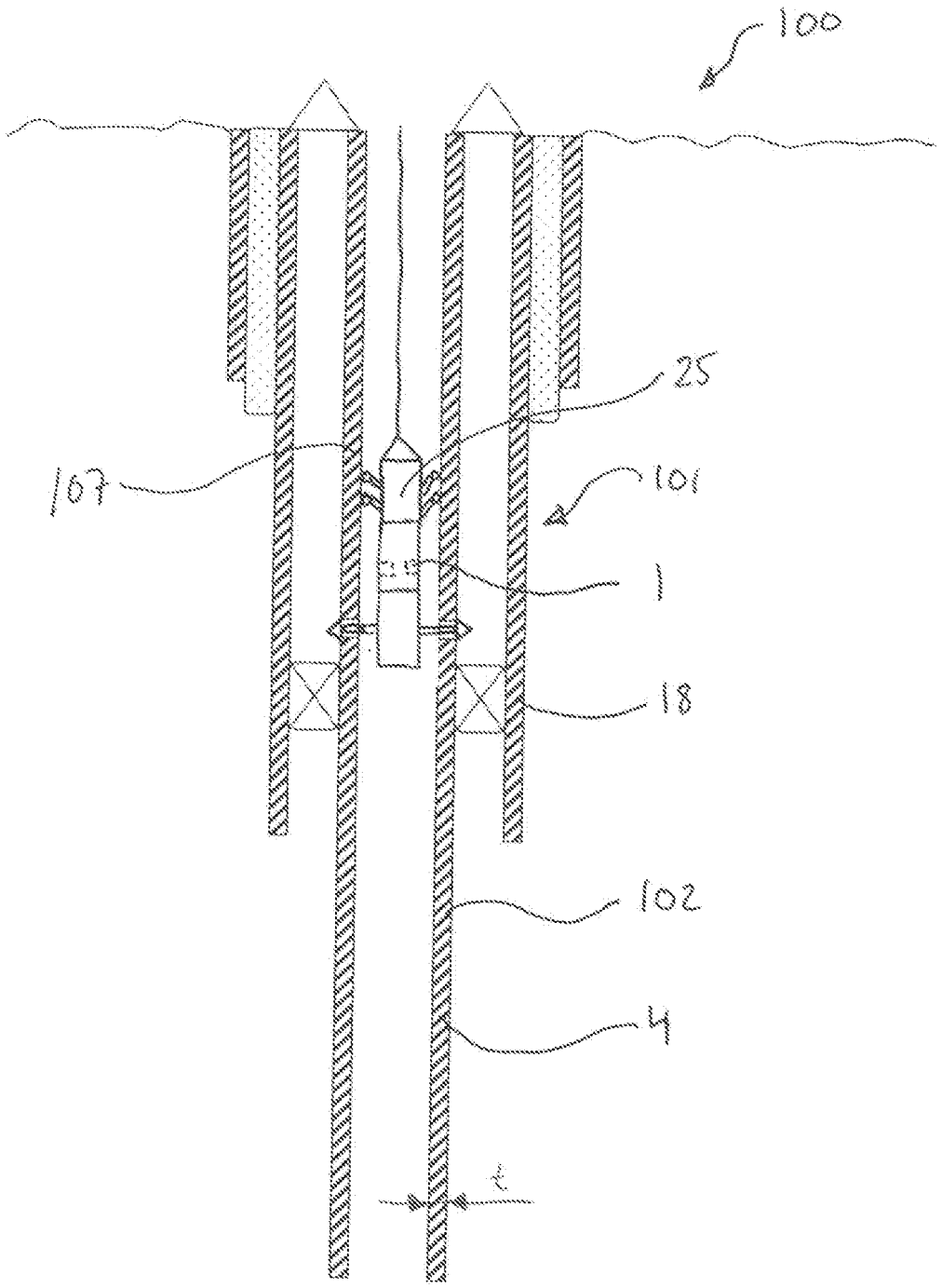

Fig. 1

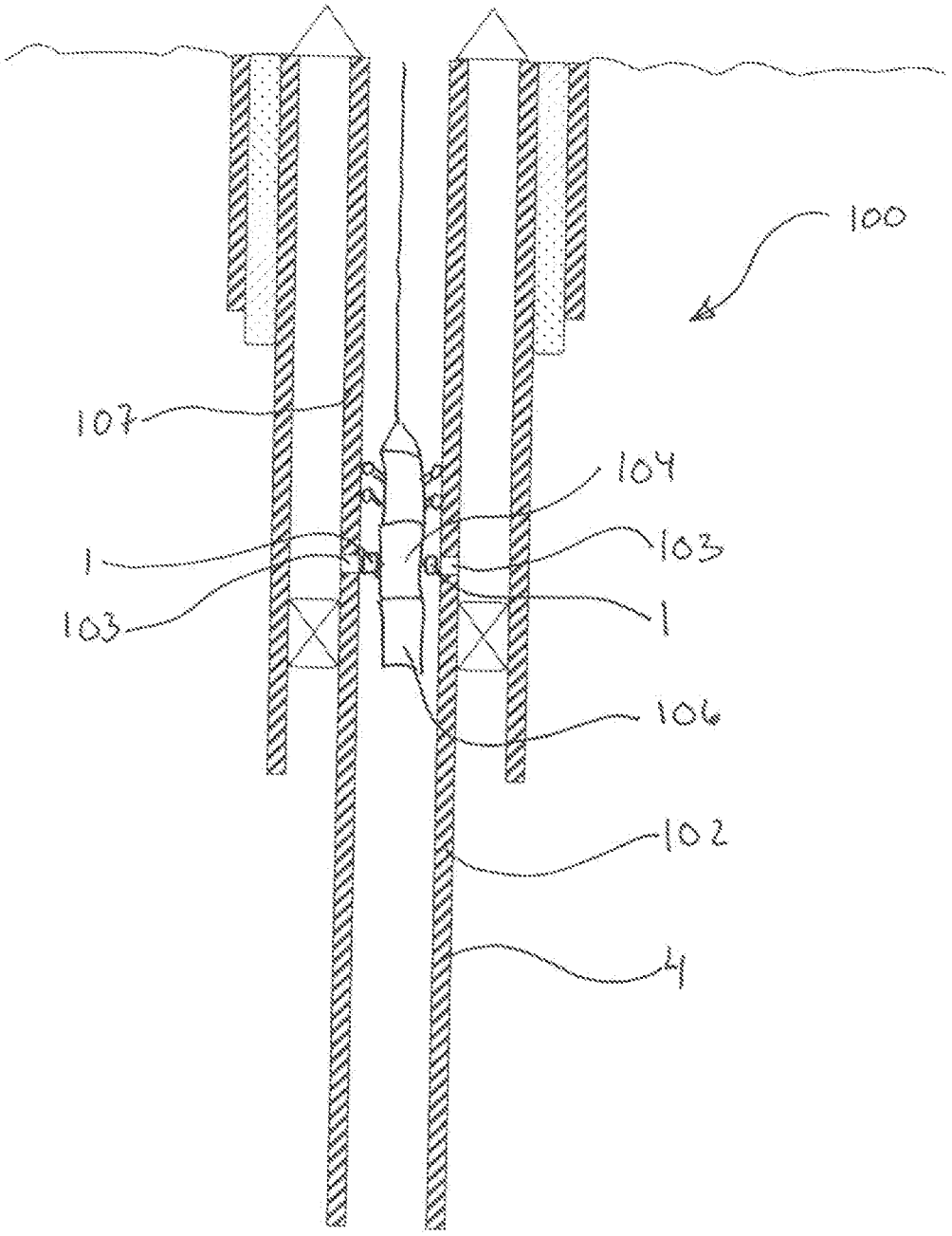

Fig. 2

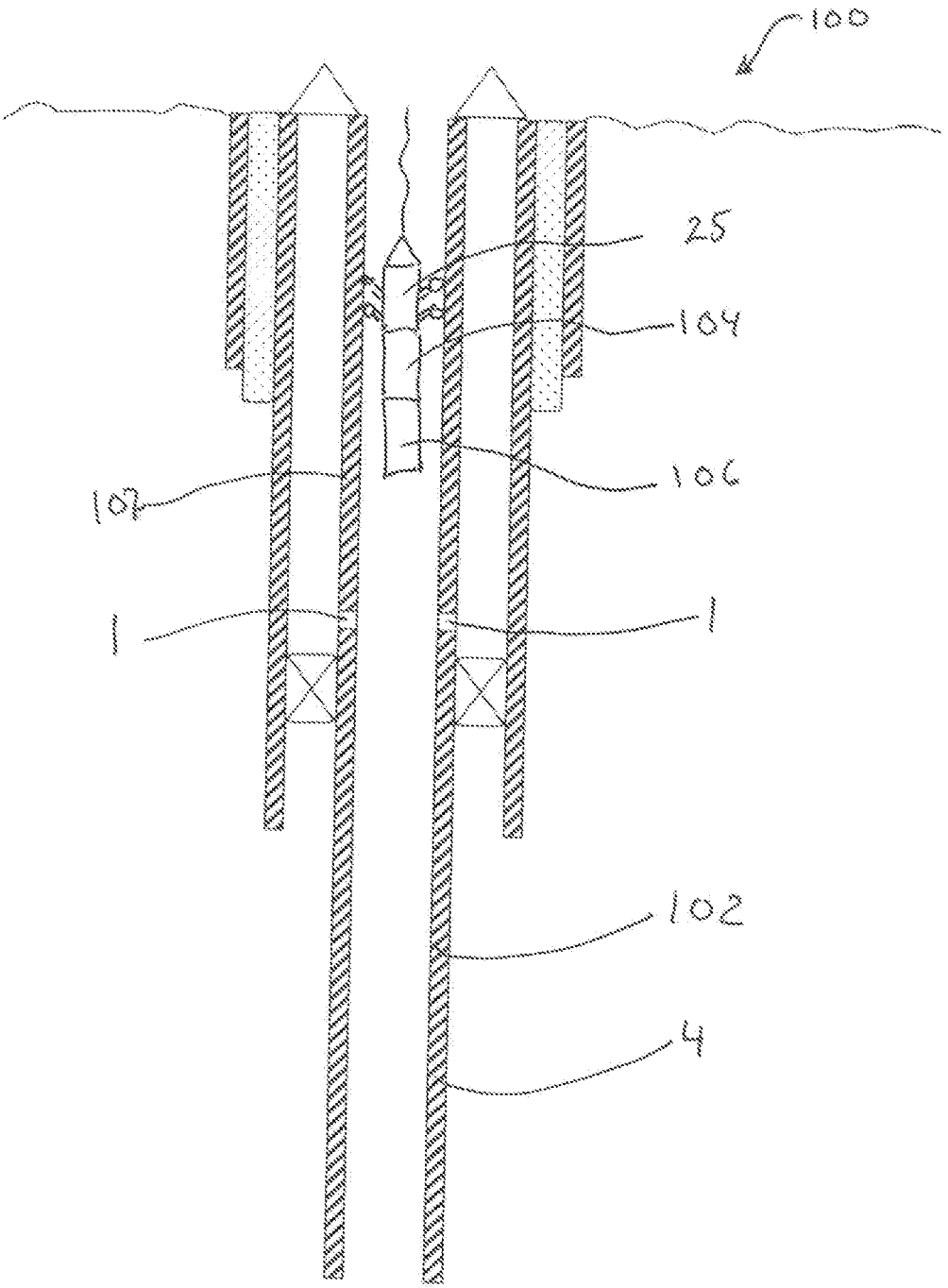

Fig. 3

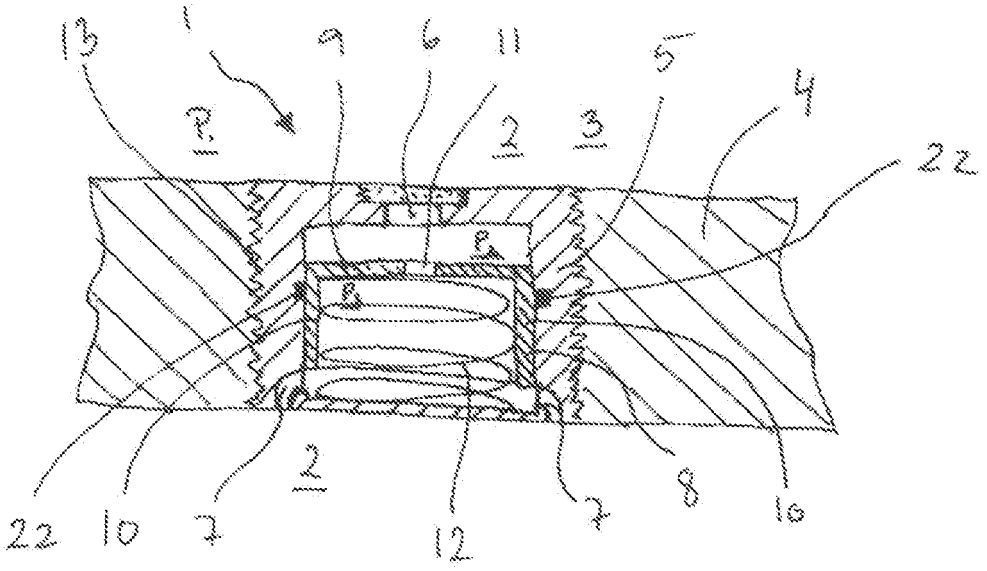
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Fig. 4

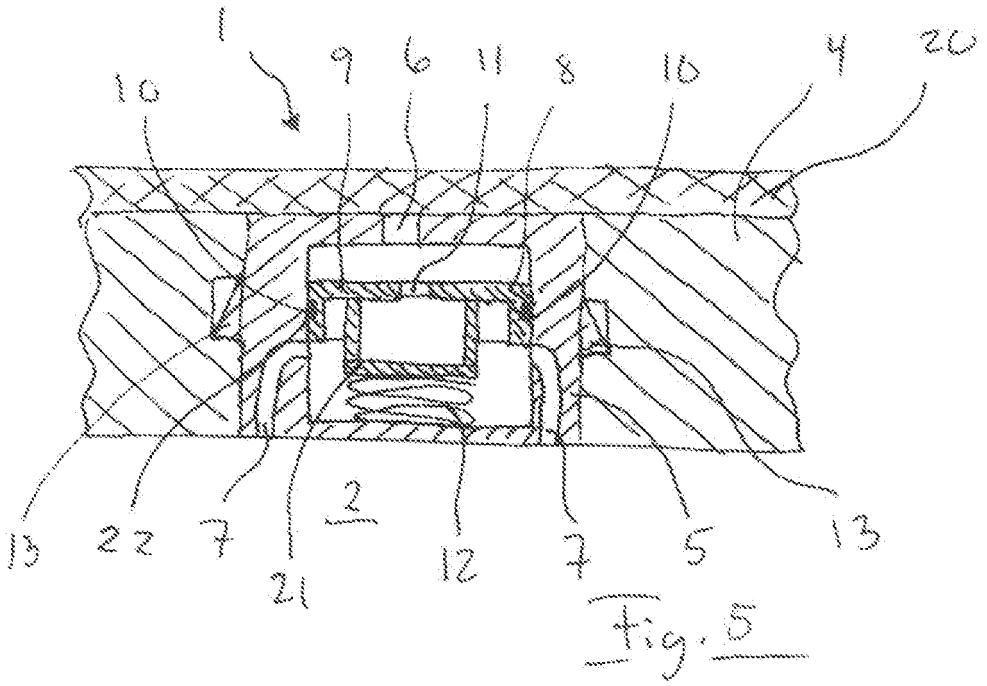
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Fig. 5

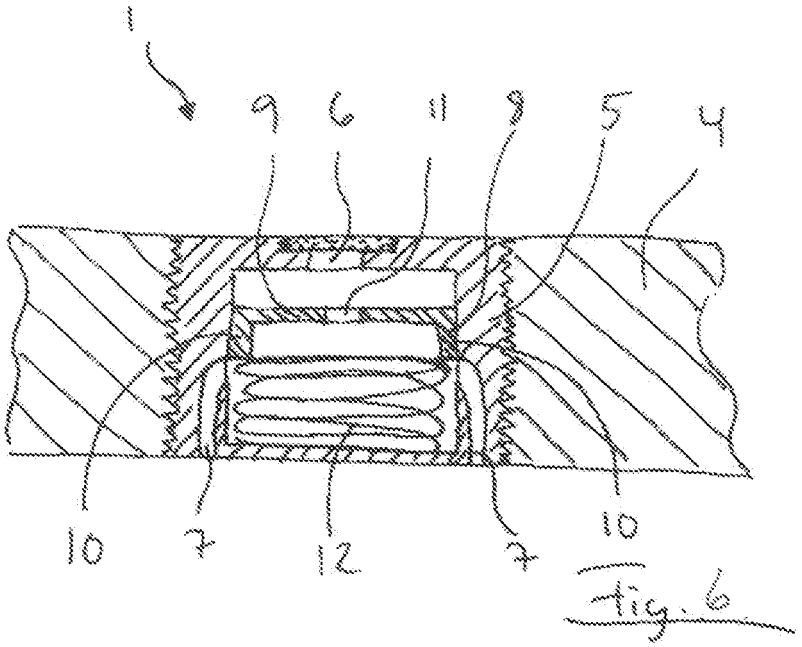

Fig. 6

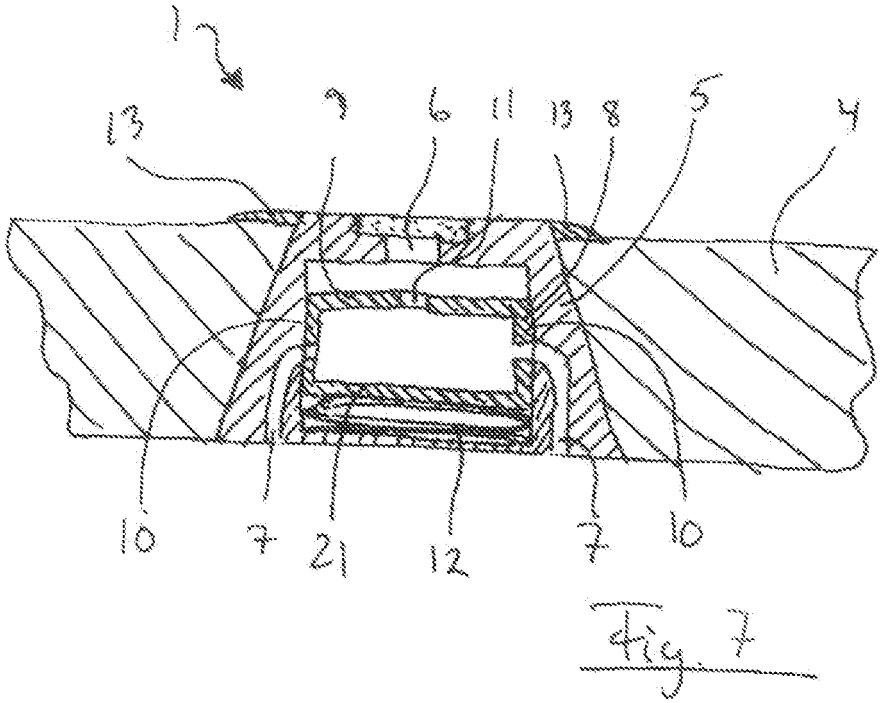

Fig 7

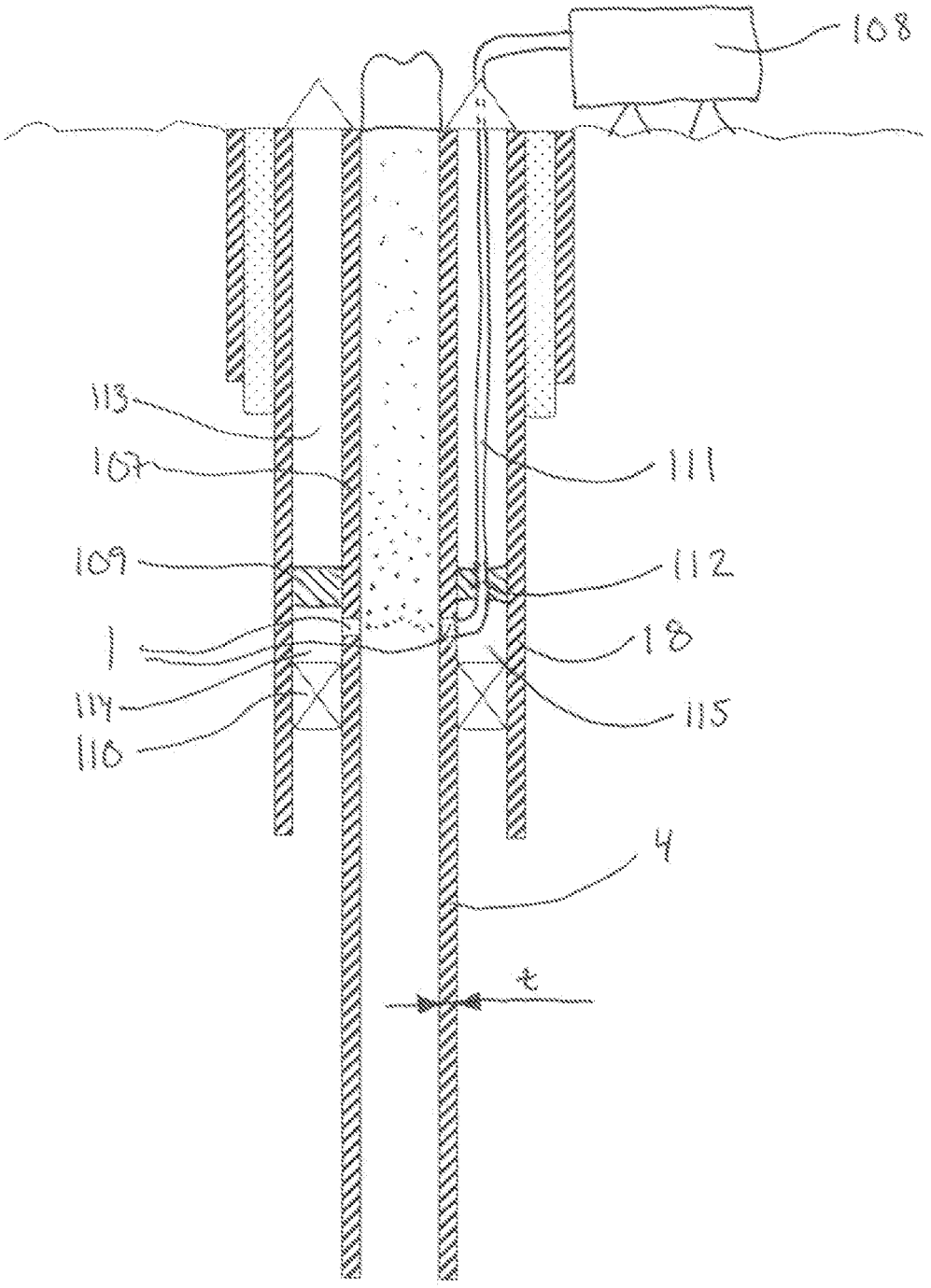

Fig. 8

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EUROPEAN SEARCH REPORT

Application Number
EP 09 18 0568

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 3 342 202 A (MCMURRY EVERETT D ET AL) 19 September 1967 (1967-09-19) * column 1, lines 24-26, 31-36; figures 1-6 * * column 2, lines 58-60, 64-68 * * column 3, lines 45-57, 63-66 * * column 4, lines 1-4 *	1-4,15	INV. E21B43/12
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A	US 2 307 016 A (ALEXANDER BOYNTON) 5 January 1943 (1943-01-05) * figures 1, 3, 5 *	1-6,15	
A	WO 00/75484 A1 (SCHLUMBERGER TECHNOLOGY CORP [US]) 14 December 2000 (2000-12-14) * figure 4 *	1-6,15	TECHNICAL FIELDS SEARCHED (IPC)
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A	US 3 077 894 A (CUMMINGS LESLIE L) 19 February 1963 (1963-02-19) * figures 1, 4 *	1-6,15	

~~The present search report has been drawn up for all claims~~

Place of search	Date of completion of the search	Examiner
Munich	7 May 2010	Georgescu, Mihnea

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

1

EPO FORM 1503 03.82 (P04C01)

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European Patent Office
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Application Number
EP 09 18 0568

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:

"see additional sheet(s)"

☐ 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).

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LACK OF UNITY OF INVENTION
SHEET B

Application Number
EP 09 18 0568

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: 1-6, 15

Artificial lifting system for introducing fluid into a production casing having a casing wall with a wall thickness, the system comprising the production casing with a first part surrounded by an intermediate casing creating an annulus which is dowardly closed a fluid delivery means pumping fluid into the annulus, the system further comprising at least one inflow control valve arranged in the first part of the casing wall and having an axial extension which is substantially the same as the wall thickness.

1.1. claims: 1-5, 15

Claim 1, wherein (potential special technical feature of claim 5) the valves are all arranged in one level.

1.2. claim: 6

Claim 1, wherein (potential special technical feature of claim 6) the inflow control valve is a constant inflow control valve providing a constant inflow of fluid into the production casing.

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2. claims: 7-10, 12, 16

Claim 1, wherein (potential special technical feature of claim 7) the annulus is closed by a packer and divided by a further blocking means into a top and bottom parts.

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3. claim: 11

Claim 1, wherein (potential special technical feature of claim 11) the inflow control valve having housing, inlet, outlet, a piston sliding in the housing and having a face with a hole through fluid can flow from the inlet towards the outlet, and a spring element between the housing and the piston, the side of the piston partially closing the outlet to reduce the inflow.

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4. claim: 13

Method for fitting a downhole inflow control valve into an existing production casing downhole, by lowering a tool into the casing to a predetermined position, providing an opening in the casing wall, inserting the control valve into the opening and fastening the control valve to the casing.

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LACK OF UNITY OF INVENTION
SHEET B

Application Number
EP 09 18 0568

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:

5. claim: 14

Method for replacing a downhole inflow valve in a production casing downhole by lowering a tool to the valve to be replaced, unfastening and retrieving the valve, inserting and fastening a new valve to the casing wall.

Please note that all inventions mentioned under item 1, although not necessarily linked by a common inventive concept, could be searched without effort justifying an additional fee.

ANNEX TO THE EUROPEAN SEARCH REPORT ON EUROPEAN PATENT APPLICATION NO. EP 09 18 0568

This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report. The members are as contained in the European Patent Office EDP file on
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07-05-2010

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For more details about this annex : see Official Journal of the European Patent Office, No. 12/82