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(54) Titre : SYSTEME DE VANNE D'UNE CONDUITE DE PUITS A TRAVERS UNE FORMATION CONTENANT DES
HYDROCARBURES ET PROCEDE DE FONCTIONNEMENT
(54) Title: A VALVE SYSTEM OF A WELL PIPE THROUGH AN HYDROCARBON CONTAINING FORMATION AND A
METHOD TO OPERATE SAME

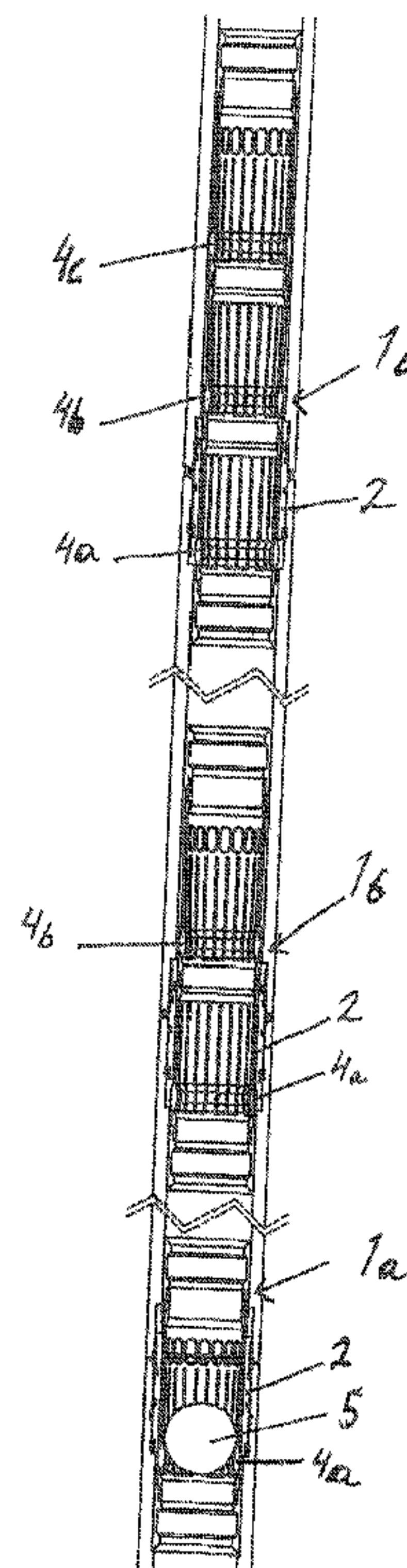


FIG 2

(57) Abrégé/Abstract:

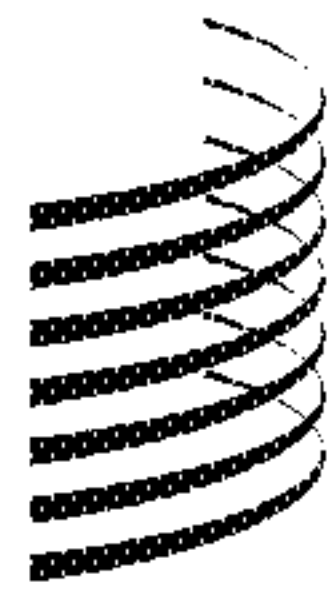
A method is described for the operation of a valve system for a production pipe (1 04) in a well (101) through a hydrocarbon containing formation with one or more valves (1 a, 1 b, 1 c) that comprise one or more seats that are activated selectively by the use

(57) Abrégé(suite)/Abstract(continued):

of a ball (5) of the same size, where the ball is set up to land on one or more ball seats (4a, b, c,...) internally in the valve, where the seat (4a,b,c.) can be activated for landing of a ball (5a) either before driving into a well or by the passing of a previously released ball or other suitable object (5) of an adjusted diameter or shape. The method is characterised in that each applied valve (1 a, 1 b, 1 c) comprises two separated casings 2 and 3, respectively, in the form of an inner casing (3) arranged inside an outer casing (2), where the inner casing (3) can be freely moved axially with regard to the outer casing (2) as the inner casing (3) comprises one or more ball seats (4), the one axially above the other, and which are activated to hold back a ball (5), successively in that the inner casing (3) is moved axially through the outer casing (2). A valve system for the same is also described.

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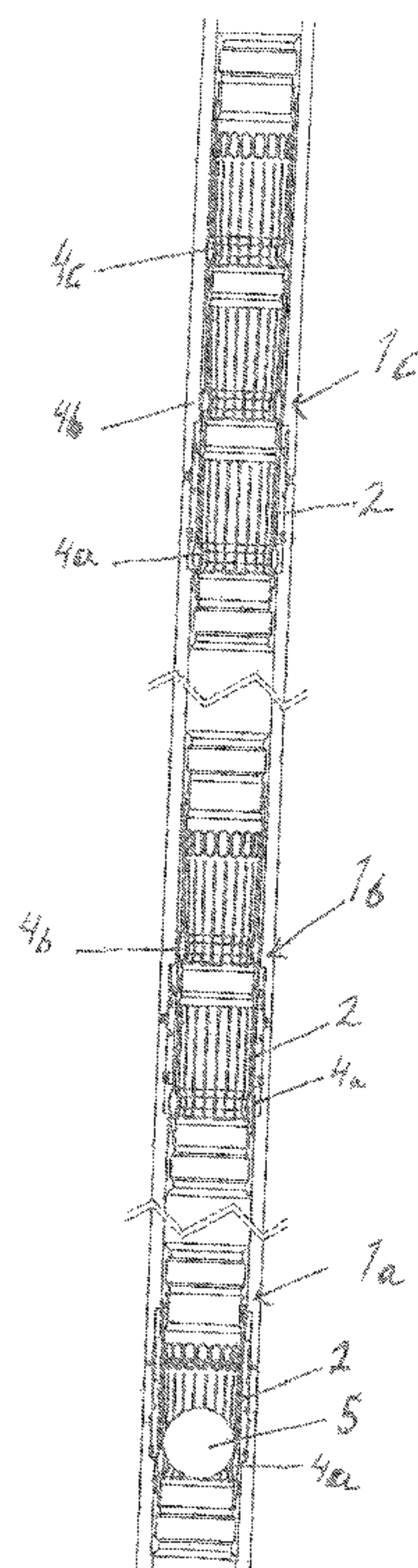
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(54) Title: A VALVE SYSTEM OF A WELL PIPE THROUGH AN HYDROCARBON CONTAINING FORMATION AND A METHOD TO OPERATE SAME



(57) Abstract: A method is described for the operation of a valve system for a production pipe (1 04) in a well (101) through a hydrocarbon containing formation with one or more valves (1 a, 1 b, 1 c) that comprise one or more seats that are activated selectively by the use of a ball (5) of the same size, where the ball is set up to land on one or more ball seats (4a, b, c,...) internally in the valve, where the seat (4a,b,c.) can be activated for landing of a ball (5a) either before driving into a well or by the passing of a previously released ball or other suitable object (5) of an adjusted diameter or shape. The method is characterised in that each applied valve (1 a, 1 b, 1 c) comprises two separated casings 2 and 3, respectively, in the form of an inner casing (3) arranged inside an outer casing (2), where the inner casing (3) can be freely moved axially with regard to the outer casing (2) as the inner casing (3) comprises one or more ball seats (4), the one axially above the other, and which are activated to hold back a ball (5), successively in that the inner casing (3) is moved axially through the outer casing (2). A valve system for the same is also described.

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A VALVE SYSTEM OF A WELL PIPE THROUGH A HYDROCARBON
CONTAINING FORMATION AND A METHOD TO OPERATE SAME.

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The present invention relates to a method for the operation of a valve system as given in the introduction in claim 1, and also the valve system itself as given in the introduction in claim 7. In more detail the invention relates to new features of a downhole ball valve that can be activated.

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The expression "oil well" refers, in general, to wells for extraction of oil and/or gas. "Oil well" comprises a well in connection with exploration of new fields, new production wells that are being tested or which are being equipped for operation, production wells that are operating and wells that are being set up, i.e. that is, that it is being made ready for production. The method and valve construction of the present invention are particularly suited for use in shale gas wells.

15

An oil well is normally comprised of several pipes inside each other down in a borehole, where the outer layer or layers are called casings, and an inner production pipe, and also control lines for carrying signals for the control of the instrumentation in the well. The casing protects the inner production pipe and holds the formations that surround the well in place so that they do not collapse into the well. They also protect against unwanted inflow of fluids from the surrounding formations.

20

At the completion and start-up of shale gas wells and oil wells or other oil and gas wells, it is, in some cases, necessary to carry out a cracking operation. This implies that one pumps a liquid down into the reservoir under high pressure so that the shale or the formation cracks open. One does this to get a large surface down in the formation through the cracks so that the gas or the oil can flow easier in towards the production pipe.

25

30

When such a job is to be carried out, it is important to have good control of the pressure at the different zones in the well. At the same time it is difficult to pump sufficiently large amounts of liquid down into the well to reach the required pressure simply because of the large volume of the whole well.

35

Therefore, it is common to divide the well into zones. Today, this is normally done by applying (leading down) a rubber element that swells up in contact with hydrocarbons or water. These rubber elements are fitted on the outside of the production pipe that is led into the well at the reservoir. Then, the rubber elements
5 swell up against the formation (well wall) and form a seal between the formation and the production pipe. If one then inserts several such seals, one gets the well divided into a number of closed zones between these seals.

To get the well in production, there is, in addition, a valve normally fitted that can be
10 opened and closed between two such rubber elements that will make up a zone, this to give the oil/gas an opening into the production pipe so that it can flow and also to make an opening for the cracking liquid and flow in through this during the cracking job. The division into zones results in that one only needs to pump a smaller amount of liquid down into the well. By using such rubber gaskets between each zone with
15 valves in between, the cracking jobs become simplified and one does not need to pressurise the whole well but only the area between the two gaskets which make up a zone. This is carried out in that the valve or valves are open in a zone between two gaskets, while the rest is closed. In this way one can selectively crack or produce from the well and possibly close for the ingress of water that arises in a different
20 zone by closing the valves.

Another method to form zones is that one pumps cement (concrete) down through the production pipe and up on its outside so that the pipe is fastened to the formation by the cement. This cements is pumped down into the production pipe from the
25 surface and all the cement is forced out of the production pipe and up along its outside in that one lets down a cement arrow on the top of the cement which forces the cement down in front of it when it is forced down into the production pipe by the liquid pressure supplied from above. The production pipe is open at the end and the cement will now flow out through this opening and up into the annular space
30 between the formation and the production pipe. This will leave the production pipe empty of cement internally and cemented securely to the formation.

The production pipe can also have a number of valves that can be opened and the division into zones will now be set up by the cement that seals between each valve,
35 as the area between the production pipe and the formation is filled by the cement.

When one then opens one of the valves, the pressure supplied from the surface will be great enough to crack the cement in the immediate vicinity of the valve that is open but not great enough to crack the cement nearest the other valves. In this way one also gets the well divided into zones.

5

The number of such zones and the number of valves in each zone varies with the well conditions, but it is very common to have many zones from five up to 30 and each zone can readily have up to ten valves.

10 These valves can normally be opened /closed with a wireline intervention tool or they can be opened in that one drops a pellet or a ball down into the tube in the well which then stops in a seat in the valve. The pressure is then increased above the ball and a slide or casing is pushed down to open the valve. Normally this is achieved in that the valve that is placed uppermost in the production pipe has a ball
15 seat with a large diameter and then reducing the diameter of the ball seat successively down the well.

By first letting down a small ball in the pipe, one will then pass through all the upper valves and get the ball landed on the seat in the valve that lies at the bottom of the
20 well which has a seat adjusted to the diameter of the ball.

Thus, one can choose the correct valve according to the diameter of the ball. This system creates restrictions in the well as one is dependent on ball seats with a large diameter at the top, which then gets successively smaller and smaller as one goes
25 down the well.

It is the aim of the invention to provide a system where balls of the same diameter can be used to open a number of valves in a well without this creating restrictions in the well, as all the zones can be opened with the large ball that is normally let down
30 last to open the last uppermost zone. This is achieved in that one sets up a construction according to the invention which ensures that the upper valves count the number of balls that pass and first open when the right number of balls has passed.

35 The method with different ball diameters that leads to a restriction being set up in the well is unwanted considering the operations that shall be carried out later in the well. These operations can be, for example, well logging, placing of plugs and closing a

section permanently, or simply that the restrictions in the pipe represent a throttling of the production. For these reasons, the ball seats must be bored out from the pipe with the use of a costly operation with coiled pipes after the cracking job has been carried out so that the production pipe in the well gets a uniform, large, inner
5 diameter without the restrictions which the ball seats represent.

Review of prior art.

Norwegian patent application NO 20100211 describes such a system with several ball sizes for each zone. It is based on two casings for activation, an inner casing
10 that contains a loose ball seat which is fastened in an outer casing with some shear pins. When the ball hits the seat, both casings will move down until a shear pin is broken and the ball is released and moves down to the next valve where the operation is repeated, to continue down the well so that all the zones open. This system can indeed activate several valves by the use of the same ball diameter, but
15 will leave all valves which the ball has passed, activated and open. For that reason one cannot use the system to provide a solution where all the zones in a well can be controlled independently with one ball size. It is not desirable to open all the zones for cracking in one single operation because this will not lead to a good result. This system, like other systems, must use a procedure where one starts with a small ball
20 to open the bottom zone in the well, thereafter continuing to open the next zone with a somewhat larger ball. The system cannot be reused for subsequent operations either, as it is based on a shear pin that allows the inner casing to loosen. This shear pin cannot be replaced down in the well so the system can only be used once.

25 On the other hand, it can be preferred to have several valves in the same zone by using the same ball diameter for the activation, where it would be advantageous to use this solution in that each zone has its own ball diameter, i.e. the smallest at the bottom to increase the diameter upwards in the well.

30 Today, there are two solutions where one can use balls of the same diameter in all the zones.

One of them has an external indexing system which makes the casing rotate, also known as a "jay slot system" as described in the US patent no. 2013/248201. This
35 lets the balls pass until a wanted number of rotations/ indices on the casing has been reached. Typical for such a system is that there is the highest number of rotation points on the upper casings and smallest on the lower.

The problem with this system is that one is dependent on a spring that pushes the casing up again to the starting position after a completed rotation. This is so that the seat for the ball that has gone past shall be activated again. These systems are also expensive and complicated to manufacture and install, it is particularly expensive to cut out the external groove on the casing that shall generate the rotation.

The system is also very sensitive to contaminations and dirt in the well liquid that comes into the groove and in the spring pocket and can lead to it locking completely. It is also difficult to zero the system, if a new cracking job or acid stimulating job shall be carried out, or simply that one just wants to close the zone. The system will also cease to function if it is used in connection with the cemented production pipe or if the spring should break.

Another known system is one that is comprised of several cut grooves in the pipe that the inner casing and the ball seats are indexed by, as shown in the British patent number GB-2.506.265. This system has a cut groove for each position that the casing shall have and leads to a costly and complicated internal rotation to make, for example, 20-50 such internal, exact cut-outs inside the valves. Another disadvantage is that as it is described, all the grooves will be exposed to deposits and coverings that can be lodged in the grooves and hinder the operation of the system.

The casing that carries out the actual activation is here a separate part from the closing/opening casing, and the function is based on that the activation casing being moved a required number of times downwards to finally land on the top of the closing/opening casing. This results in the opening casing being moved down to an open position with the help of the hydraulic pressure that arises above the activation ball. It is important to note here that the activation casings with the ball seats have the same outer diameter as the closing casing, and that they are two separate parts which cannot simply be moved to an open and close position as a unit.

Common to all these solutions is the disadvantage that they are difficult to reset to the starting position after use. Therefore, they must be regarded as system which can be used once only. Other disadvantages are that they require accurate control of the number of balls that are dropped to get the indexing mechanism to go a complete turn or that the ball seat drops out of position in the last activation. The known systems are also exposed to deposits from preceding cementing jobs which

means that they are, in general, not suited for use in wells with a so-called cemented liner. When the production pipe "Liner" is cemented, cement will be pumped past all the valves and parts of the cement will then penetrate into the valves when it passes and harden inside. This will make the operation of the valves impossible after the cementing job has been completed.

As mentioned, there are several systems that use balls of different sizes. When we in this context talk about activating balls, it is implied that it is not limited to round balls, but it can also be activating cementing arrows of different kinds in the industry, or other objects that can be hydraulically pumped down in the well to land on a seat in the valve tool.

The systems that use balls of different sizes will not be relevant in this connection as the aim here is to provide a tool that does not have the disadvantages of several ball sizes as mentioned above.

With regard to prior art, reference is also made to WO 2010/127457, US-2011/030976 and US 2014/151054.

The present invention.

The method according to the present invention is characterised in that each applied valve comprises two separated casings in the form of an inner casing arranged inside an outer casing, where the inner casing can be moved axially freely with regard to the outer casing, as the inner casing comprises one or more ball seats, the one axially above the other, and which are activated to hold back a ball, successively in that the inner casing is displaced axially through the outer casing.

The inner casing preferably pulls along the outer casing to an open position when the ball lands on the last seat in the row in the inner casing so that it opens for a fluid connection between the inside of the pipe and the formation through aligned openings in the inner casing, outer casing and the valve, respectively.

Particularly preferred is that the last seat in the inner casing forms a restriction to prevent the ball being released when it lands on this last seat.

According to a preferred embodiment, the last seat in an inner casing releases the ball after opening of the outer casing that constitutes the valve, for example, so that

several valves are installed in the same using zone, where the bottom valve will then hold back the ball in accordance with requirements and thereby make possible several openings for fluid flow out to and in from the same zone in the formation.

- 5 The well is preferably divided into zones in that the pipe, between each set of valves, comprises gaskets that form a seal between the formation and the pipe. It is particularly preferred that the bottom valve set in the production pipe comprises one single casing with one ball seat and also openings uppermost around the pipe circumference to set up said fluid flow to a first zone, a next valve set comprising two
- 10 casings with respective ball seats, where the uppermost casing comprises openings uppermost around the pipe circumference to set up said fluid flow to a second hydrocarbon-carrying zone, as each further set of valves in the row upward comprises one more casing than an underlying casing, as each uppermost casing comprises said openings uppermost around the pipe circumference to set up said
- 15 fluid flow between the production pipe and respective hydrocarbon-carrying zones.

The valve system according to the invention is characterised in that the valve housing comprises two separated casings in the form of an inner casing arranged inside an outer casing, where the inner casing can be moved freely with regard to

20 the outer casing, as the inner casing comprises one or more ball seats, the one axially upstream of the other and which is activated to hold back a ball, successively in that the inner casing can be moved axially through the outer casing.

Preferred embodiments of the valve system are as given in the dependent claims 8 –

25 24.

In particular, the valve system is applied where it is inserted in a production string, to open a formation for production of hydrocarbons where, between each unit 1 of the valve system, a gasket is arranged that closes the axial fluid flow in the well (outside

30 the production string), as the valve set is set up for successive opening of parts of the formation for production by the pumping-in of fluid via the valve system and which cracks the rock matter in the formation so that it starts to produce hydrocarbons that then can flow into the well and up through the production pipe.

35 Description of the invention.

The present invention provides a solution to the problem of diameter restrictions in oil and gas wells as a consequence of ball activated valves, where the seats for the

balls normally form a restriction, in that several valves in series can be opened with the same ball size at a given point in time. This is carried out by (see figure 3) arranging an outer casing 2 inside the production pipe which covers the outlet opening 14 in the production pipe when the outer casing 2 is in its initial position.

- 5 Openings 29 that are also formed through the wall of the outer casing 2, and which shall later be aligned radially with the openings 14, but which are not aligned in the initial position of the casing 2, and are thereby closed for the fluid flow.

- 10 A new inner casing 3 that is comprised of several ball seats (see the perspective figure 13) of the same diameter is placed inside the outer casing 2. The uppermost ball seats in the inner casing 3 of the valve are not activated when the system is driven into the well, and will have a sufficiently large diameter for the first ball to pass freely, but will stop in the bottom seat 4a that is defined inside the outer casing 2 since the constriction of the casing 2 forces the seat in the inner casing 3 radially
15 inwards and hinders the ball from passing.

- Thus, the first, for example, the bottom ball seat, is activated (i.e. that the seat is forced in and the ball 5 cannot pass) and thus set up to receive the first ball. When the first ball 5 lands in this activated seat, it will, as a consequence of the fluid
20 pressure, displace the inner casing 3 one step downwards so that the next ball seat, in the inner casing that is above the first ball, is activated as the seat enters into the outer casing 2 that has a diameter that is smaller and compresses the seat so that it becomes activated. As the next ball seat becomes activated the first ball is released in that this ball seat comes axially out of the outer casing 2 and down in a larger
25 diameter so that the seat is no longer activated as the increased diameter permits the seat to expand and release the ball.

- The outer casing which seals the passage out to the formation is held in place by the friction or a form of locking device such as split rings, doggers or split fingers in a
30 groove, as this locking device is released by the inner casing when it comes to its last position. Up to this, the inner casing is free to move axially through the outer casing. This prevents a complete opening occurring too early and alignment of the radially directed channels 14 and 29, respectively, in the valve. It is not before the last seat in the inner casing 3 comes down to and moves downward in the outer
35 casing 2 that this is displaced and such that then all openings 14-29-50 are aligned from the outermost to the innermost in the assembly.

Then the first ball continues down the well pipe to the next valve where the same operation is repeated. Only when the correct number of balls has passed and the last seat in the valve is active, i.e. has come into the outer casing, will this open with a simultaneous downward displacement and thereby both the openings 14 and 29 will be aligned. A smaller fraction of liquid will also flow out through the slits 190 that are formed between each finger 192, i.e. before the openings 50 are aligned with 14 and 29. It is only when the three openings 50,14,29 align that one gets a full out/inflow of liquid through the channels 14 and 29. Thus, an efficient counting mechanism is provided where the uppermost zone has, for example, ten ball seats where the first nine are used as a counting function in that the seat 1 activates the seat 2 when the ball 1 passes, seat 3 when ball 2 passes, etc. Then, when seat 10 is activated the valve will be fully open (all openings 50-29-14 are aligned) when the ball 10 is let down into the well. Through this one can provide a system where the bottom valve has one seat that opens when ball 1 is let down, the zone can then be cracked by the pumping of a hydraulic pressure.

For example, as can be seen in figure 4, the first ball has gone through all the preceding sets of inner casings and is placed in the lowest three. This has then led to that all inner casings 3 in each set are moved down one step so that the outer casing 2 now surrounds and activates the next lowest inner casing in each set.

When ball number 2 is let down it will land on the now active seat 2 in the valve 2 from the bottom and up and open this, at the same time the ball will now be held in place by the seat in valve 2 and be prevented from continuing down the well. Ball 2 seals now for flow past the ball and zone 2 which is open above the ball seat can be cracked. This can be carried out without any of the above-lying zones being open and without any liquid flowing down to the zone 1 lying below.

Meant by ball is any object that is dropped down into the well, and it can be a ball or a pellet of different, optionally varying materials, alternatively it can be an arrow that is especially designed for the purpose or another type of object that can be pumped down in the well with the help of a liquid pressure.

The present invention also provides a solution to the problem of resetting the valves to their initial position in a secure way so that they can be used for subsequent maintenance cracking jobs. This is carried out in that at each end of the inner casing 1 that contains the seats a standardise profile for such operations that one can

connect up is arranged. Such connecting up can be made in many ways but a common method will be the use of coiled pipes. One can then either force all valves open by driving in coiled pipes or one can force them to close.

- 5 This can be carried out in that one hooks on to the profile, either at the bottom or at the top of the inner cylinder, and pulls or pushes this to its final stop where the coupling is released. When the casing is pulled back to its initial position, the outer casing will be pulled along up to the closed position. Similarly, the outer casing will follow to the lower position if the resetting tool that fits in the profile is pressed down
10 and thereby the inner casing that brings with it the outer casing to an open position.

- It is implied that one can also use other standard profiles for such resetting tools, and that it may be sufficient with one profile at one end of the tool. It is also important to note here that the system is not dependent on shear pins that are considered to be a
15 one-time use only solution. The system can, of course, be made with shear pins as a replacement for the preferred solution with split rings, but then one will get a one-time use only system which is not the preferred solution, but which can be acceptable in some cases.

- 20 The present invention also solves the problem of pumping a cement/concrete mixture past the valves as all the hollow spaces and surfaces in the valve are filled/covered with an appropriate lubricant /grease that contains a sugar level high enough to prevent hardening of the cement that is pumped past the valve. The sugar mixed with the lubricant will hinder the cement from hardening in the area where the
25 lubricant is, but will not prevent hardening of the cement/concrete that passes the lubricant. The present invention solves at least one of the given problems.

- The present invention provides a device according to the characteristic part of the subsequent independent claims. Alternative and advantageous embodiments are
30 given in the dependent claims.

Description of the figures.

A detailed, non-limiting description of possible embodiments of the invention is given in the following, with reference to the enclosed figures, where:

35

Figure 1a shows a borehole 100 for a well that runs down through an oil/gas-carrying formation 102 and where a production string 104 runs down in the well. It can be

seen that the well runs vertically at first, thereafter to be turned in the horizontal direction. The figure shows an example, where nine valve units 1 are installed in the well so that it is possible to pump fluid in sections into the formation 100 to make it ready for production of oil/gas.

5 Figure 1b shows an enlarged section of the horizontal part of the well and shows that gaskets 10 are placed around the pipe 104 between each valve unit 1 so that it is possible to isolate the sections from which it will be sprayed out to crack open the formations. In this case, three such zones are set up and three valve units are arranged in accordance with the invention.

10

Figure 2 shows a model of a well with several valves 1a, 1b and 1c installed.

Figure 2 shows a section of a preferred embodiment of a valve device 1a, 1b and 1c according to the present invention with a varying number of ball seats. The valve
15 device 1a has one seat 4a, the valve device 1b has two seats 4a and 4b, the valve device 1c has three seats 4a, 4b, 4c, as all three valve systems comprise an outer casing 2 that surrounds an inner casing 3. The valve 1a is shown after the first ball 5 has been dropped down in the well pipe and shows that the valve device 1a is on its way to be opened with the ball 5 placed on the seat 4a.

20

Figure 3 shows section details of valve 1a from figure 2 with a first ball 5 lying on the seat 4a. Here, the following details are also shown: An outer casing 2, a first casing 19 which, together with several units, will constitute an inner casing 3, a split ring 6, split rings 8, locking groove for split rings 11 and 12, gaskets 17 and 18, an opening
25 channel 14 in the wall of the valve 1a, an opening channel 29 through the wall of the outer casing 2 and also the reset uppermost profile 20. The openings around the circumference of the inner casing 3 are shown by 50.

Figure 4 shows, in section, details of fig. 2 after two balls have been dropped down
30 in the well. Shown here is that zone number 2, marked by the number 23 in the well 15, is ready for cracking by the pumping in of fluid under pressure, as the ball 5b (number two) lies on the seat 4b in the valve 1b, and the outer casing 2 is moved axially to an open position from the inside to the outside of valve 1b for flow through the channels 29/14, first through the slits 190 between each finger 192 (figure 13) in
35 the inner casing and thereafter through the openings 50 and further out through 29 and 14. We can also see that the well 15 is divided into zones by the gaskets 21.

Zone 22 is cracked completely with cracks 25 with the help of fluid pressure. We also see that the ball 1 (5a) lies on the seat in the valve 1a.

Figure 5 shows section details of ball number two 5b on seat 4b in an embodiment, where the ball 5b is held back in valve 1b after the outer casing 2 is displaced so that the channels/openings 29/14 are aligned and the liquid can flow out outside the pipe.

Figure 6 shows a section of valve 1c with the third ball 5c on the seat 4c that is actively displaced to this position by ball number to 5b (see figure 5) that has previously gone past. Ball 5c is now ready to open the channel 29/14 in that it displaces the outer casing 2 axially (downwards). We can see a (schematic) threaded connection 16 at each end of the valve unit 1c for coupling. Such connections can be found on all the valves 1 for the purpose of fastening them to the production pipe 26.

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Figure 7 shows a section of the valve unit 1c where the inner casing 3 and the outer casing 2 are mutually moved to an open position by setting up a fluid pressure above the ball 5c. The ball is stuck as a consequence of the fingers 4a (194 in figure 13) being forced inwards by the restriction that is formed by the outer casing 2, and all the channels 50,29 and 14 are aligned for through-flow of fluid. Thus, it is the last seat construction in the casing 1 that pushes the outer casing 2 along axially (downwards) so that the channels are aligned.

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Figure 8 shows a section of the valve unit 1c when the first ball 5a passes through this and lands on the seat 4a. The arrows 27 show the direction the ball moves from the top to the bottom. The number 16 shows the threaded connection in the valve construction 1c for securing (as an insert) to the production pipe 26.

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Figure 9 shows a longitudinal section of valve 1c with ball number to – 5b on the seat 4b.

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Figure 10 shows a section of valve 1c with ball number three - 5c- on the seat 4c.

Figure 11 shows a section of valve 1c with ball number three – 5c- on the seat now in an open position and channel 14 open and aligned with channel 29 and 50, respectively, and also the restriction 9 for the split ring 6. The ball 5c is held back in the restricted channel and fluid can be pumped out through the channels 50,29,14.

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Figure 12 shows a longitudinal section of valve 1c that allows the ball number three 5c through after opening of the valve.

Figure 13 shows a 3D isometric perspective drawing of an assembled inner casing 3 that in this case encompasses three ball seat sections 19a + 19a + 19b, and also upper and lower sections 20 and 21, respectively, for the coupling together.

Detailed description of preferred embodiments of the invention.

The bottom of the two similar seat sections 19a has a ball seat 4, i.e. as the first (lowest) unit. Number 4b shown is the second seat in the row and the third unit is number 4c, etc. The uppermost unit 4c/19b in this example has openings 50 in the wall around the whole of the pipe circumference and these are set up to align/correspond with the channel 14 in the valve pipe 1 and the holes 29 in the outer casing 2 to offer a full and free opening in the open position for the pumping out of liquid/fluid. The number 28 shows parts of the casing unit that are not split longitudinally so that several casing sections 19, together with end profiles 20, can be screwed together to form the inner casing 3.

In more detail, figure 13 shows an example of a multi-divided inner casing 3 comprising lower and upper coupling parts 20 between which a number of ball seat sections 19a and an upper section 19b are inserted, for example, by screw connections. Each of the sections 19 comprises a pipe end where, cut out in the ring-formed wall, is a number of axially formed U-shaped slits 190 which each define a flap – finger – 4/192 that can be bent outwards or inwards. At the bottom, each flap comprises a thickening of the wall, a protrusion or a bead 194 that normally extends outside the outer side of the casing 3. Two such separated sections 19a are shown in figure 13, plus a third section 19b which, in addition to flaps 192, comprises a number of through-running holes/cut outs 50 through the wall of the casing 19b around its circumference. In a ring-formed recess around the outer circumference at the upper part of the casing 3, a split ring is placed set up to be compressed in that it hits a restriction 9 (figure 11) in the inner side of the valve 1 when it is being pushed down.

The casing 19 is fitted inside the inserted valve casing 1, where the lowest section then lies mounted inside the surrounding outer casing 2. During said pushing down, the casing 3 is released for further axial travel, independent of the casing 2. This release preferably takes place after the casing 2 is moved to an open position in the valve casing 1.

When the casing 3 is moved inside the outer casing 2 the radial, inwardly facing restrictions in the casing 2 will press against each of the beads 194 so that the flaps 192 are pressed radially inwards and thereby form a stopper seat for the balls/pellets 5 that are moved axially inside the casing 3.

Furthermore, when the outer casing 2 is pushed downwards and the openings 29 and 14 are aligned and form a radial flow channel, fluid/liquid can flow out through the slits.

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In the preferred version the invention solves the problem of different ball sizes and the reduction of the diameter of the production pipe in that all ball seats have the same diameter and, at the same time, can be activated in a wanted sequence, typically from the bottom upwards.

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In the present invention the object/pellet/ball 5 that is dropped or is pumped down the well will freely be able to move past all the seats in a valve 1 except those that are in an engagement with the outer casing 2 that forms a restriction which forces the fingers 4 inwards and thereby prevents the ball 5 from continuing downwards.

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When the first activating object (ball) 5 is dropped down in the well, it will hit the lowest seat in the inner casing 3 that is in active position through the restriction that is set up by the narrower, inner opening of the outer casing 2.

Then when one drops a first ball or another activation object 5 down in the well, in a valve with three seats, it will first hit the seat 4c uppermost in the upper valve 1c. The seat 4c is now not activated (squeezed together) by the outer casing 2 and will let the ball 5 through and go past. The same is the case for the subsequent seat 4b in this first valve 1c (see figure 8). The ball rushes past the seats 4c and 4b till it hits the lowest seat 4a which is now in an active engagement (squeezed together by) with the outer casing 2 and through this is activated. When the ball hits the activated seat 4a which is activated in the outer casing 2, it will pull the inner casing 3 downwards because of the pressure from above.

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When the activated seat 4a and the ball 5 on the seat have moved to the end on the outer casing 2, the ball 5 will be released again (the restriction ends), as the seat 4a on which it lies is no longer active - the fingers are forced outwards -when it comes out of the outer casing 2. At the same time, the axial movement of the casing 3

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caused by the first passing ball 5 will activate the seat 4b which has now gone into an engagement in the outer casing 2.

When ball 5 number two is released it will again move the inner casing 3 axially downwards and release the ball 5 so that it can continue its travel down the well to the below-lying zone. The valve 1c in the preferred embodiment has now counted two balls 5 without being activated / opened (without the channels 29,14 being aligned). Then when the ball 5 number three is dropped into the well it will land on the now activated seat 4c in the valve 1c and again move the inner casing 3 axially downwards because of the fluid pressure that builds up behind the ball 5.

During the last move, the inner casing 3 hits a split ring 6 fitted on the casing 3 (see, for example, figure 3) at the top of the outer casing 2 and the pressure builds up behind the ball 5 such that the friction acting on the outer casing 2 by the split rings 8 is overcome, the split rings 8 lie in the grooves 11 and 12. When the friction generated by the split rings 8 is overcome, the outer casing 2 and the inner casing 3 move together axially/downward with the help of the pressure that builds up behind the ball 5 that lies on the seat 4c. The axial movement of the outer casing 2 ensures that the channels 29 and 14 are aligned and open for fluid connection out through the valve 1c so that pressure communication with the well 15 lying outside is achieved through the now open channels 29/14. The now open channels 14 were previously closed with the help of the gaskets 17 and 18 and also the outer casing 2.

In a preferred embodiment the split ring 6 is compressed in that it hits a restriction 9 (figure 11) in the inside of the valve 1. This will again release the casing 3 for further axial travel, independent of casing 2. This release preferably takes place after the casing 2 has moved to an open position in the valve 1.

When the casing 3 is released for further travel downward, it will release the ball 5 again to be able to operate one or more valves further down the well, preferably with the same number of seats 4. When the ball then hits the last valve 1 in the well with the same number of seats 4, it will now be held back again either in that the restriction 9 is removed and through this the compressing function this has on the split ring 6, or in that, for example, another physical form for the end stopper is inserted that prevents the split ring 6 from being compressed. Both these solutions will hinder the last valve 1 and let the ball 5 drop further down the well if they are placed correctly.

A third solution is that the inner casing 3 gets a separate end stopper that prevents it from wandering so far axially that it brings the seat out of the outer casing 2. This can be in the form of a simple end stopper that cannot be compressed, but only pulls along the outer casing open.

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This will also leave the last valve in this zone open with the ball on the seat which will thereby make up a seal so that it will be possible to pressurise the well above the ball.

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Between the ball 5 and the seat 4 there will always be some leakage, but this is marginal in comparison to the leakage if the ball had not been on the seat and has been shown to be of no significance. The point is not to provide any 100% leakproof connection between ball 5 and seat 4 but to set up a sufficiently large flow restriction which makes it possible to build up fluid pressure above the ball 5.

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It is implied that ball 5 number one (5a) opened the bottom valve 1a and that the subsequent next ball 5 opened the second bottom valve 1b.

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It is also implied that the valves 1a, 1b and 1c could have any number of ball seats such as 4a, 4b and 4c to become activated after a correct number of balls has been dropped down into the well. Typically, there could be up to twenty zones in a well and then the uppermost valve 1 could readily have twenty such ball seats 4 to be able to let nineteen balls 5 past before activation.

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Another preferred embodiment is to use five different ball sizes to get a maximum of five seats 4 in each valve. This can be made due to production considerations. Then, one would be able to get twenty zones in a well with relatively small restrictions compared with using twenty different ball sizes.

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In a preferred embodiment the ball seats are formed through a partial split of a casing 19. A number of casings 19 is put together to the casing 3 and the number of sections decides how many seats there are in the valve and through this how many balls 5 that can pass before activation. The use of such split casings is a well-known solution to generate a radial, diametrical movement on a casing. Other known

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methods for this can also be used such as lugs that are activated when the inner casing 3 glides into the outer casing 2 or a split ring such as ring 6. Or other forms

for embodiments where the seats in the casing 3 will be inactive when they are not compressed inside the casing 2.

Another preferred embodiment is that the seats 4, before entering into the casing 2, are in an activated state but have no radial support from the outer casing 3 lying outside or from the body of the valve 1 itself so that they can expand freely and let the ball 5 past. When the seats 4 then move inside the casing 2, this will make up the radial support for the seats 4 and through this activate these so that the ball will push/move the casing 3 axially to the point where the inner casing 3 with the ball seats 4 comes out again of the outer casing 2. In this way it will be possible to achieve an identical function of the invention without compressing the seats when they enter the casing 2 lying outside. It must also be understood that for such a solution, alternatives to seat 4 that are made up by the split fingers in the casing 19 that together form the inner casing 3, could possibly be used, such as split rings, dogger pins or other solutions where the outer casing 2 constitutes a radial support for the seats 4 and through this prevents the ball 5 from passing.

According to a preferred embodiment of the invention, there will be most ball seats 4a, 4b, 4c etc., in the upper valve and least on the bottom valve. For example, the upper valve can have ten seats and the lower one seat, the second bottom two, etc. Then one will be able to let a ball 5 go through all the valves and land on the bottom valve 1a. When it lands on the bottom valve 1a, it will immediately move axially as it rests on a split ring 6 that constitutes the end stopper for the inner casing 3 relative to the outer casing 2.

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According to a preferred embodiment of the invention, all internal hollow spaces are filled with a viscous lubricant, such as a petroleum based grease, a heavy paraffin wax or a natural grease that contains sufficient amounts of sugar which will prevent the cement that may penetrate into the hollow spaces from starting to harden. This lubricant can also include beeswax, or pure honey that will also prevent that the cement (the concrete) is hardened, at the same time as it provides a lubricating effect. The point is that this lubrication contains a type of chemicals, such as sugars, or something else that prevents hardening of the cement. The hardening of the cement can also be stopped by mixing into other known chemicals in this area; such chemicals are regarded to be incorporated into the invention and are not described further herein.

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In its simplest form the valve can be comprised of a casing 2 fitted inside a production pipe, this casing is set up to seal for outflow or inflow through openings in the valve pipe 1 in its first position. In its second position the casing 2 permits free flow of liquid or gas, either from the valve pipe 1 out into the formation or from the formation and into the valve pipe. Inside this casing 2 an inner casing 3 is placed as described, that has one or more ball seats that have the same diameter in the preferred embodiment. This inner casing is free to move axially in the outer casing between two end stoppers that will prevent the inner casing 3 from sliding out of the outer casing 2.

One can also imagine solutions where the ball seats in the inner casing 3 have several diameters to further increase the flexibility of the valve.

In cases where one of the casings is stuck or one shall return the valve to its initial position, the inner casing can also have built-in profiles for well tools so that it can be displaced axially also with the use of typical coiled pipes or wireline tools or other well intervention tools that are used.

The main aim of the counting mechanism is to open the valve at the correct point in time, but it can, of course, also be used to activate other well equipment via the same time-providing or counting function. The following examples can be mentioned, amongst others: activation of well perforation cannons, activation of other types of well inflow valves, injection valve for chemicals, gas-lift valves and so-called sliding sleeves.

The valve casing 1 can preferably be produced in any material suitable for installation in a well, and typical examples can be mentioned, amongst others, some used steel types such as ASI 4140, 420 mod 13%Cr, super duplex or high grade steel such as Inconel 718 without and the material types of valve 1 to these. One can also imagine that ceramic materials and other composite materials can be used.

The material types for the other parts of the valve can typically be the same as for valve 1, but for the inner casing one will preferably choose a flexible material that can also be a steel spring that makes movements possible for the seats in the casing 3.

While the invention is described with reference to a preferred embodiment, it shall be understood that a number of modifications can be carried out without going beyond the extent of the enclosed claims.

P A T E N T C L A I M S .

1. Method for the operation of a valve system for a production pipe (104) in a well (101) through a hydrocarbon containing formation with one or more valves (1a,1b,1c) that comprise one or more seats that are activated selectively by the use of a ball (5) of the same size, where the ball is set up to land on one or more ball seats (4a,b,c,...) internally in the valve, where the seats (4a,b,c,...) can be activated for the landing of a ball (5a) either before driving into a well or in the passing of a previously released ball or other suitable object (5) of an adjusted diameter or shape, characterised in that each applied valve (1a,1b,1c) comprises two separated casings (2 and 3, respectively) in the form of an inner casing (3) arranged inside an outer casing (2), where the inner casing (3) can be freely moved axially with regard to the outer casing (2) as the inner casing (3) comprises one or more ball seats (4), the one axially above the other, and which are activated to retain a ball (5), successively in that the inner casing (3) is moved axially through the outer casing (2).
2. Method according to claim 1, characterised in that the inner casing (3) drags with it the outer casing (2) to an open position when the ball (5) lands on the last seat (4a) in the row in the inner casing (3) so that it opens for fluid connection between the inside of the pipe (104) and the formation (100) through aligned openings (50,29,14) in the inner casing (3), the outer casing (2) and the valve (1a), respectively.
3. Method according to claims 1-2, characterised in that the last seat (4c, fig 13) in the inner casing (3) forms a restriction so that the ball (5) is not set free when it lands on this last seat (4a).
4. Method according to one of the preceding claims, characterised in that the last seat (4c) in an inner casing (3) sets the ball (5) free after an opening of the outer casing (2) that makes up the valve, for example, so that several valves (1) are installed in the same using zone where the bottom valve (1) will then hold back the ball (5) in accordance with claim 3, and through this sets up several openings for fluid flow out to and in from the same zone in the formation (100).
5. Method according to one of the preceding claims 1, characterised in that the well (100) is divided into zones in that the pipe (104), between each set of valves

(1a,1b,1c), comprises gaskets (110) that form a seal between the formation and the pipe (104).

6. Method according to one of the preceding claims, characterised in that the
5 bottom valve set (1a) in the production pipe (104) comprises one single casing with a ball seat (4a) and also openings (50) uppermost around the pipe circumference to set up said flow of fluid to a first zone, a second valve set (1b) comprising two casings with respective ball seats (4a,4b) where the uppermost casing comprises openings (50) uppermost around the pipe circumference to set up said fluid flow to a
10 second hydrocarbon-carrying zone, as each further valve set (1) in the row upwards comprises one casing more than an underlying casing, as each uppermost casing comprises said openings (50) uppermost around the pipe circumference to set up said fluid flow between the pipe and the respective hydrocarbon-carrying zones.
- 15 7. Valve system for application in a production pipe (104) in a well (101) through a hydrocarbon-carrying formation and which can be activated selectively by the use of pellets or balls of a single size, where the ball is set up to land on one or more ball seats inside the valve, where the seats (4) can be activated for landing of a ball (5) either before driving into a well or in the passing of a previously dropped ball or other
20 adapted object (5) with an adjusted diameter or form, characterised in that the valve housing (1) comprises two separated casings (2 and 3, respectively) in the form of an inner casing (3) arranged inside an outer casing (2), where the inner casing (3) can be moved freely with regard to the outer casing (2), as the inner casing (3) comprises one or more ball seats (4), the one axially above the other, and that are
25 activated by retaining a ball (5), successively in that the inner casing (3) can be moved axially through the outer casing (2).
8. Valve system according to claim 7, characterised in that the last seat (4c, fig 13) of the inner casing (3) forms a restriction so that the ball (5) is not released when
30 it lands in this last seat (4a).
9. Valve system according to one of the claims 7-8, characterised in that the last seat (4c) in the inner casing (3) can release the ball (5) after the opening of the outer casing (2) that makes up the valve, for example, such that several valves (1) are
35 installed in the same using zone where the bottom valve (1) will then hold back the ball (5) in accordance with claim 3 and through this make possible several openings for the flow of fluid out to and in from the same zone.

10. Valve system according to one of the preceding claims 7-9, characterised in
that the first ball seats (4) in the inner casing (3) lets the ball (5) pass the valve (1)
 and axially downwards to a next valve (1) in a row when the inner casing (3) in its
 activated (constricted) seat (4) comes out of engagement with the outer casing (2)
 5 and into the now increased internal diameter (ID) of the valve (1).

11. Valve system according to one of the preceding claims 7-10, characterised in
that the first ball seats (4) displace/move, with the help of the pressure behind an
 activation object, the inner casing (3) axially down a position for each activation
 10 object/ball (5) which, by fluid pressure from above, is pumped down into the well,
 thereby to activate a last seat (4c – fig. 13) to finally open the valve (1) by an axial
 displacement of the outer casing (2) in parallel with the inner casing (3).

12. Valve system according to one of the preceding claims 7-11, characterised in
 15 that the inner casing (3) comprises one or more end pieces/end profiles (20) for
 connection of a resetting tool.

13. Valve system according to one of the preceding claims 7-12, characterised in
that the outer casing (2) in the valve (1) is physically locked to the valve via at least
 20 one split ring (8) up to the inner casing (3) being moved to a position where a last
 seat (4c – fig. 13) is activated and is then released for opening in that the friction in
 the, at least, one split ring (8) is overcome by the pressure that builds up behind the
 ball (5), and through this overcomes the friction that is made up by the locking.

14. Valve system according to one of the preceding claims 7-13, characterised in
 25 that the outer casing (2) can be prevented from moving by the use of locking bodies,
 for example, a shear ring, shear pin and split fingers, said locking body immobilises
 the outer casing in a position for fluid flow by said movement of the inner casing (3).

15. Valve system according to one of the preceding claims 7-14, characterised in
that the locking body of the outer casing (2) is held locked via a pressure supplied by
 the inner casing (3), in that the pressure from the adapted inner casing (3) influences
 one or more pegs that are forced through the outer casing (2) by the inner casing (3)
 and out into a cut groove in the wall of the valve (1), when the inner casing (3)
 30 reaches its activation position, this has a smaller diameter in an area that makes it
 possible for the pegs to collapse inwards and release the outer casing (2) for
 movement so that the openings (14,29) are aligned for fluid flow.

16. Valve system according to one of the preceding claims 7-15, characterised in that the inner casing (3) comprises ball seats (4) for the placing of balls (5) of different diameters to further increase the flexibility of the system.

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17. Valve system according to one of the preceding claims 7-16, characterised in that the outer casing (2) is held in place by, for example, a split casing that exerts a friction out against the outer wall of the valve.

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18. Valve system according to one of the preceding claims 7-17, characterised in that all inner hollow spaces and all exposed surfaces are filled with a lubricant that contains a chemical that prevents hardening of cement, such as, for example, sugar.

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19. Valve system according to one of the preceding claims 7-18, characterised in that the outer casing (2) is fitted with internal cut-outs that will make expansion of the ball seats (4) possible to release the ball before the ball seat is out of the outer casing (2).

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20. Valve system according to one of the preceding claims 7-19, characterised in that the valve (1) encompasses a further number of ball seats than the described 4a, 4b, 4c, to permit even more valves and be operated by one ball (5) size.

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21. Valve system according to one of the preceding claims 7-20, characterised in that the valve (1) comprises a ball seat as that described (4a- figure 2) to permit even greater flexibility.

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22. Valve system according to one of the preceding claims 7-21, characterised in that the inner casing (3) or the outer casing (2) is formed with, for example, one or more split rings for increased friction inner casing (3) or outer casing (2), or by other known constructions for increased friction, such as a coarser surface on the material, another material than on the other parts, a covering of another material, grooves in the material, C-clip rings, shear rings or shear pins for the purpose of preventing unintended movement of the outer casing (2).

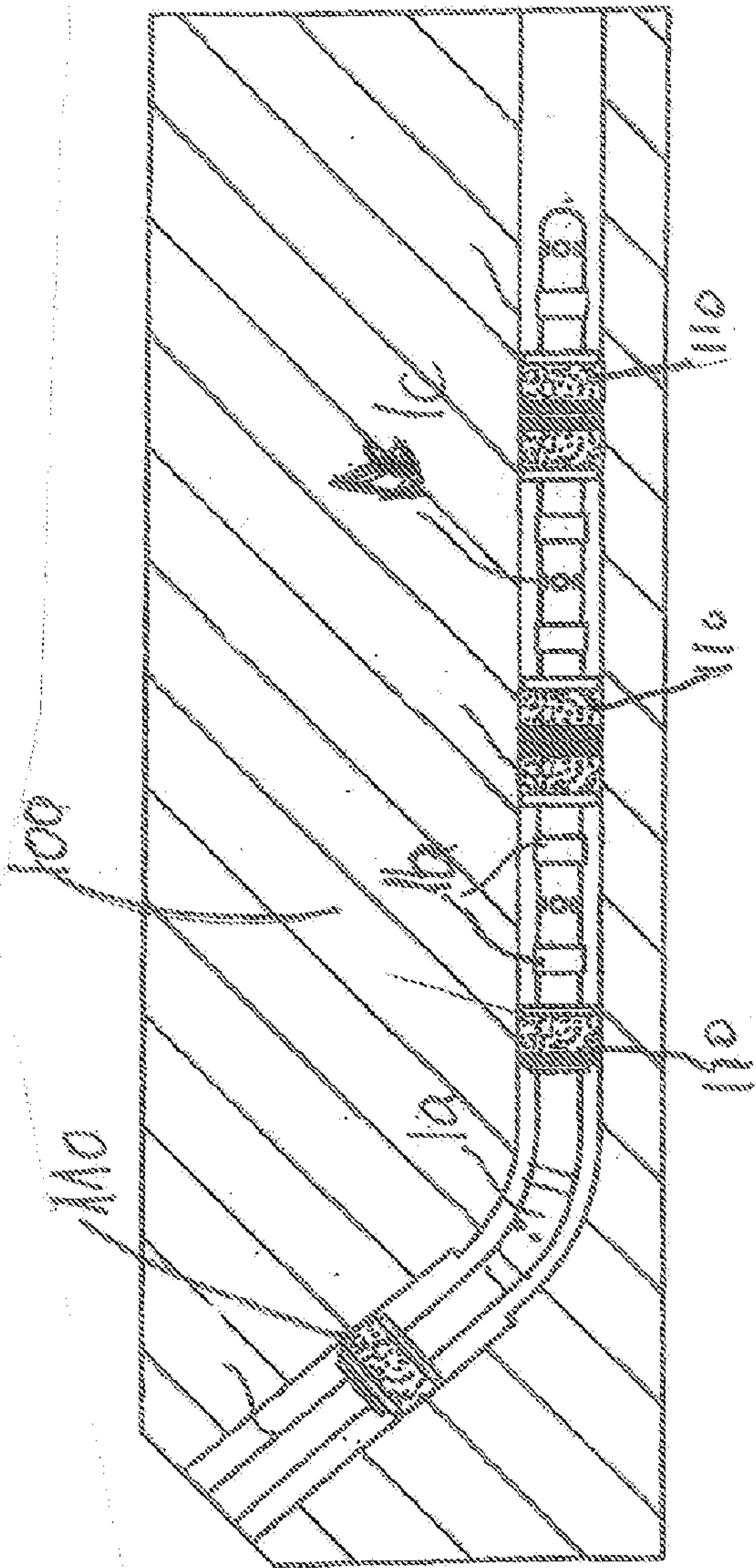
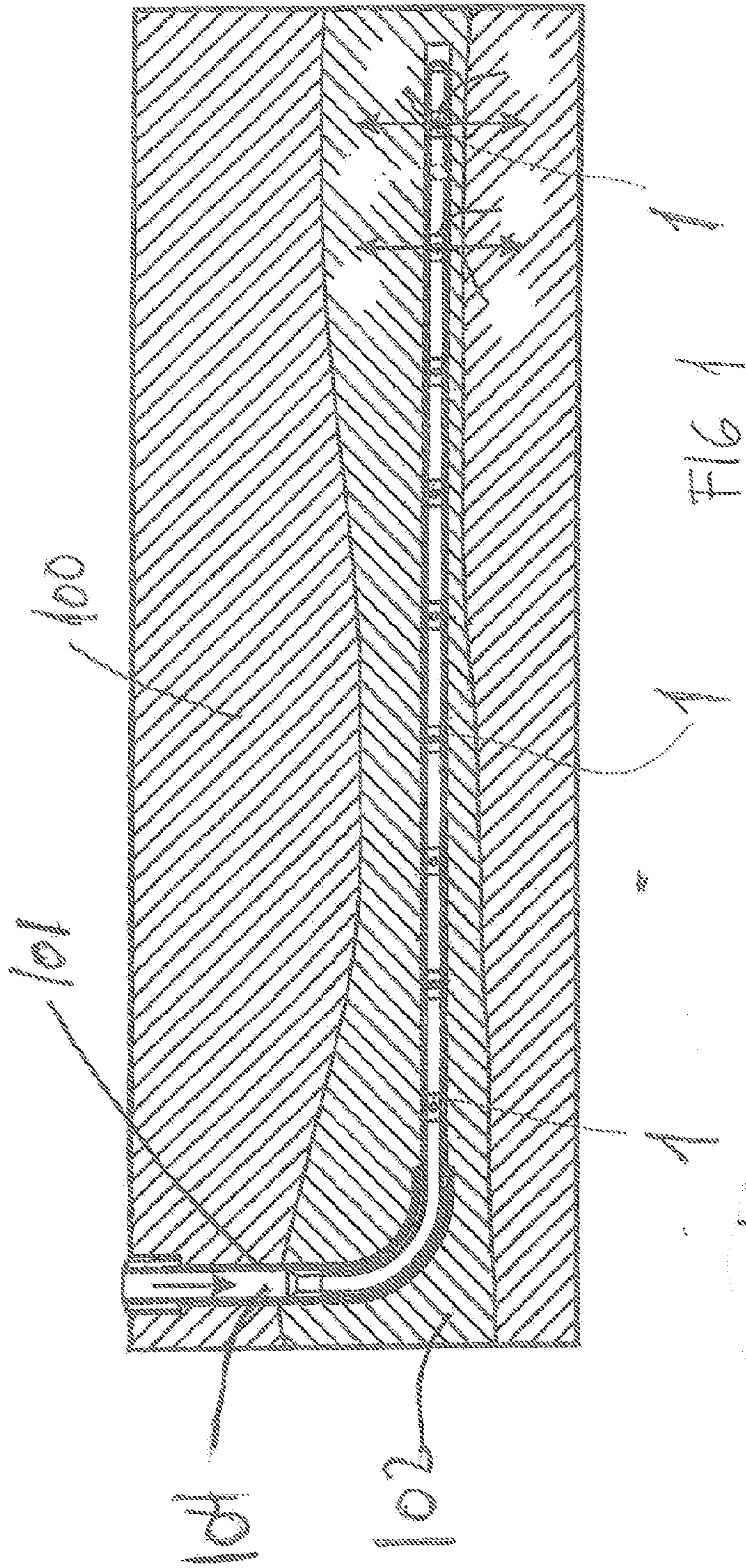
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23. Valve system according to one of the preceding claims 7-22, characterised in that the valve (1) comprises ball seats that are set up to first open the valve and then to close it if further balls (5) are let down into the pipe/well (1/3).

24. Valve system according to claim 7, characterised in that a bottom valve set (1a) in the production pipe (104) comprises a single casing with one ball seat (4a) and also openings (50) uppermost around the pipe circumference to set up said fluid
5 flow to a first zone, a second valve set (1b) comprises two casings with respective ball seats (4a,4b) where the top casing comprises openings (50) uppermost around the pipe circumference to set up said fluid flow to a second hydrocarbon-carrying zone, as each further valve set (1) in the row upwards comprises one casing more than in an underlying valve set, as each uppermost casing comprises said openings
10 (50) uppermost around the pipe circumference to set up said fluid flow between the pipe and respective hydrocarbon-carrying zones.

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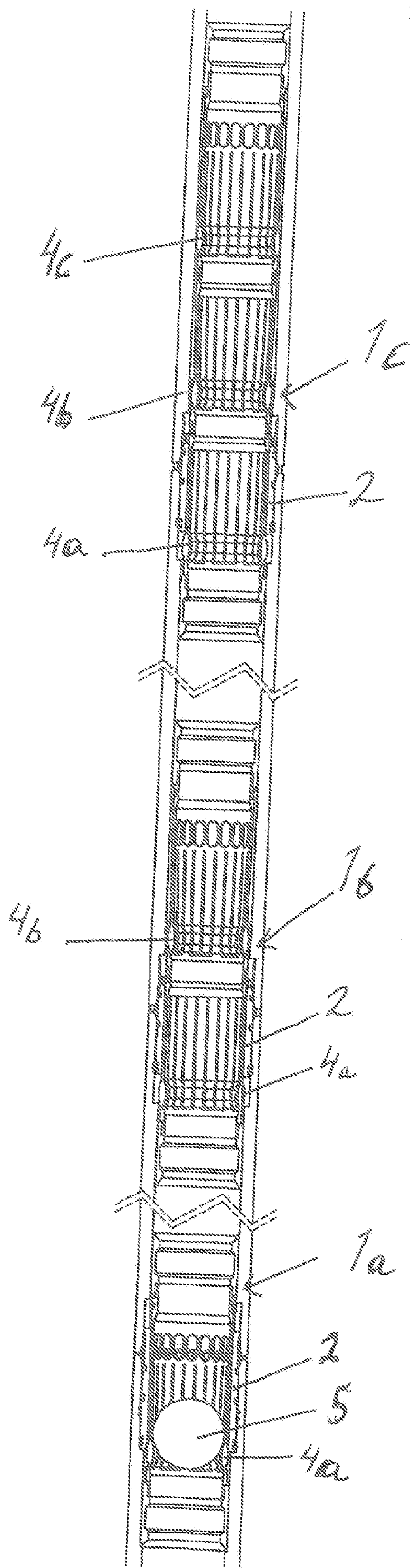
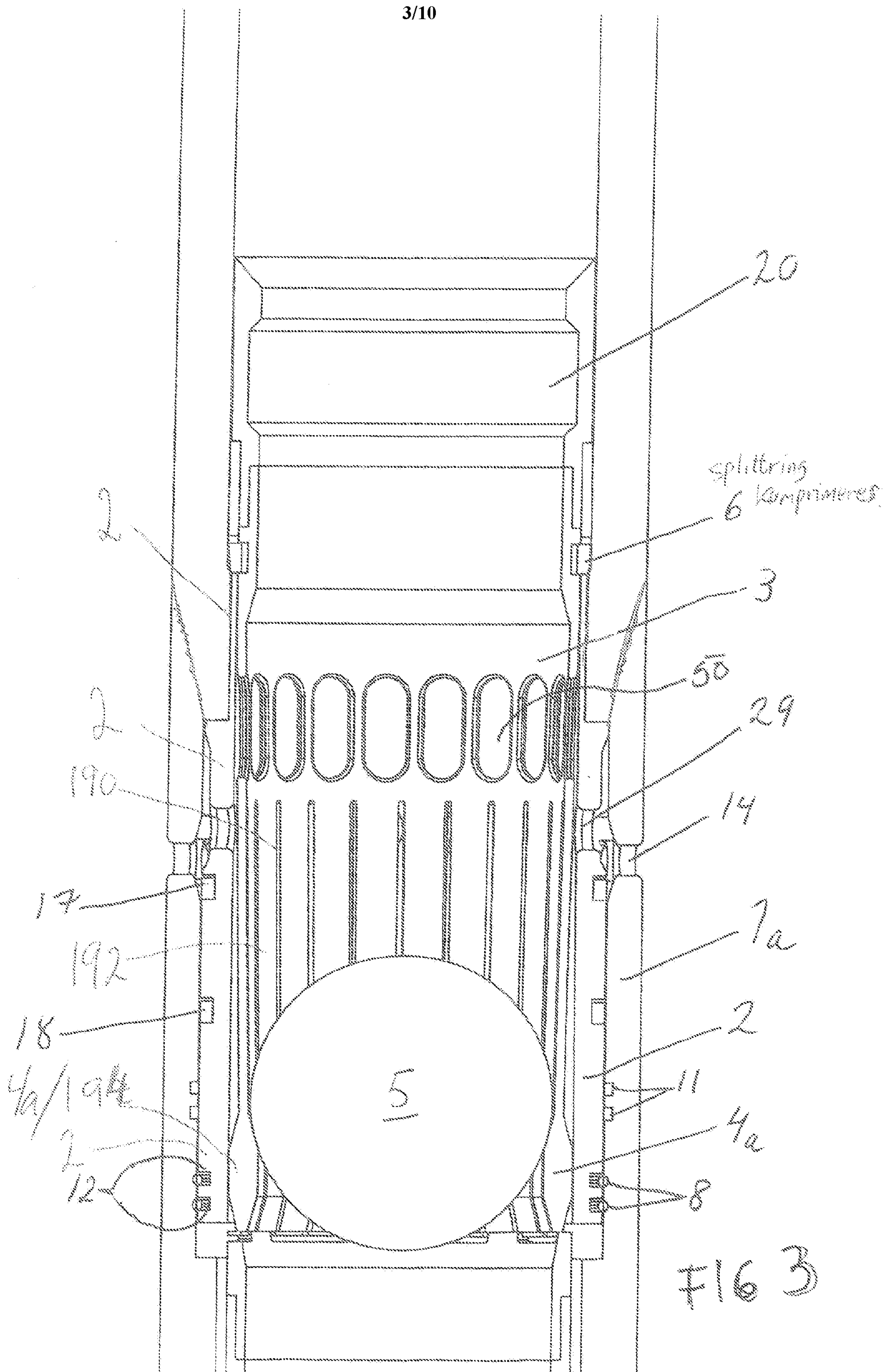
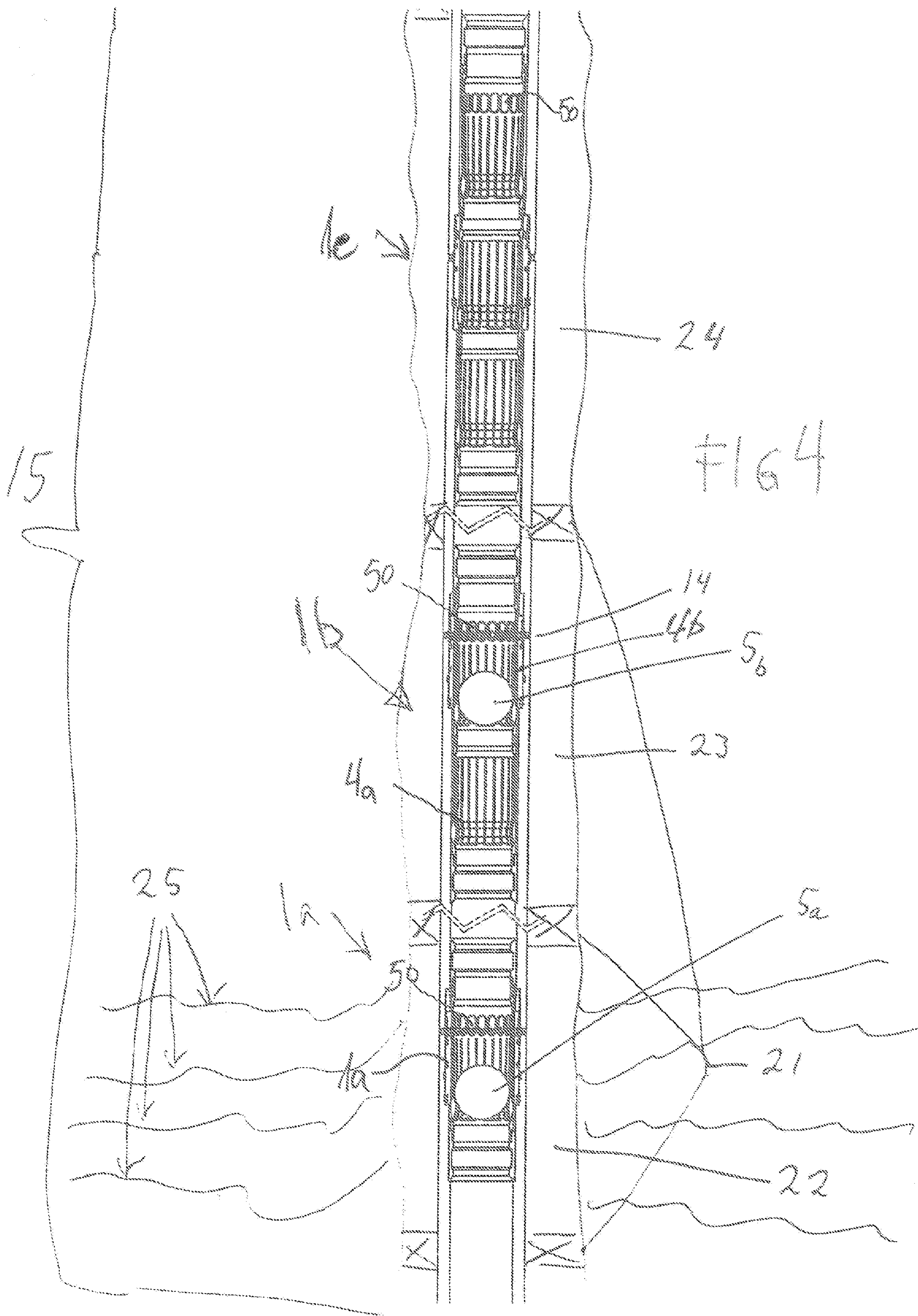
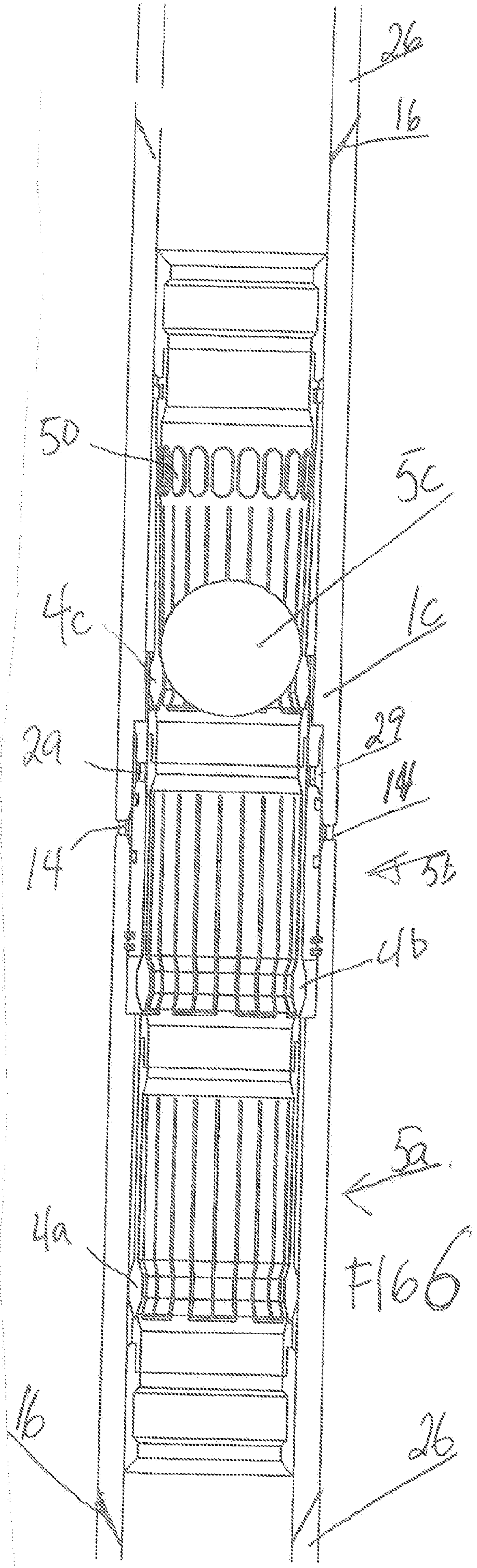
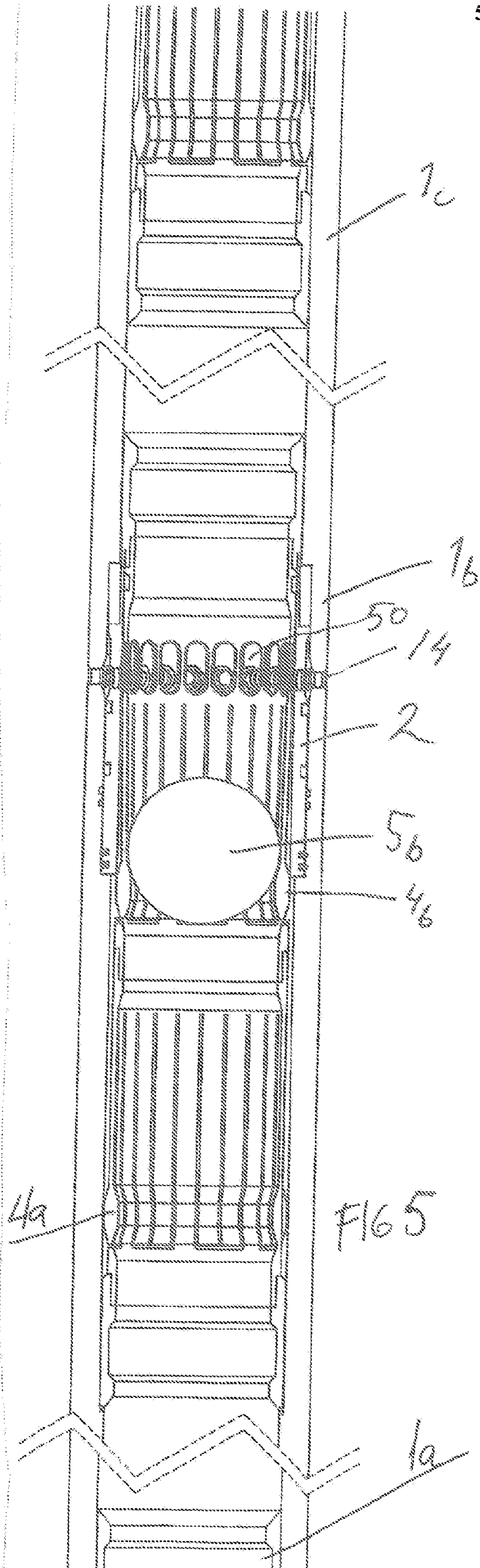
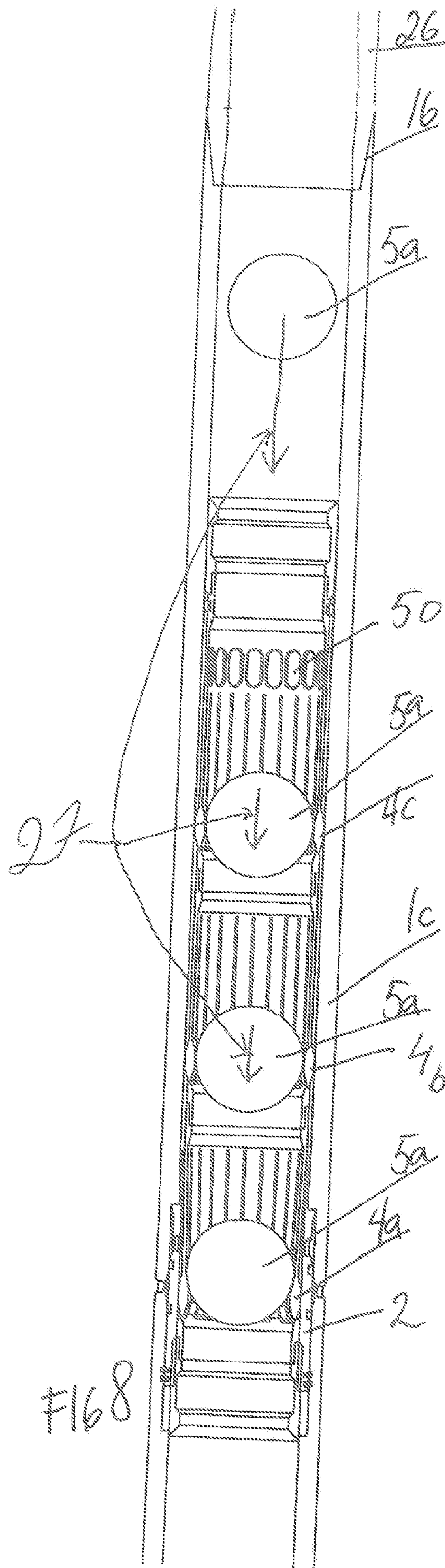
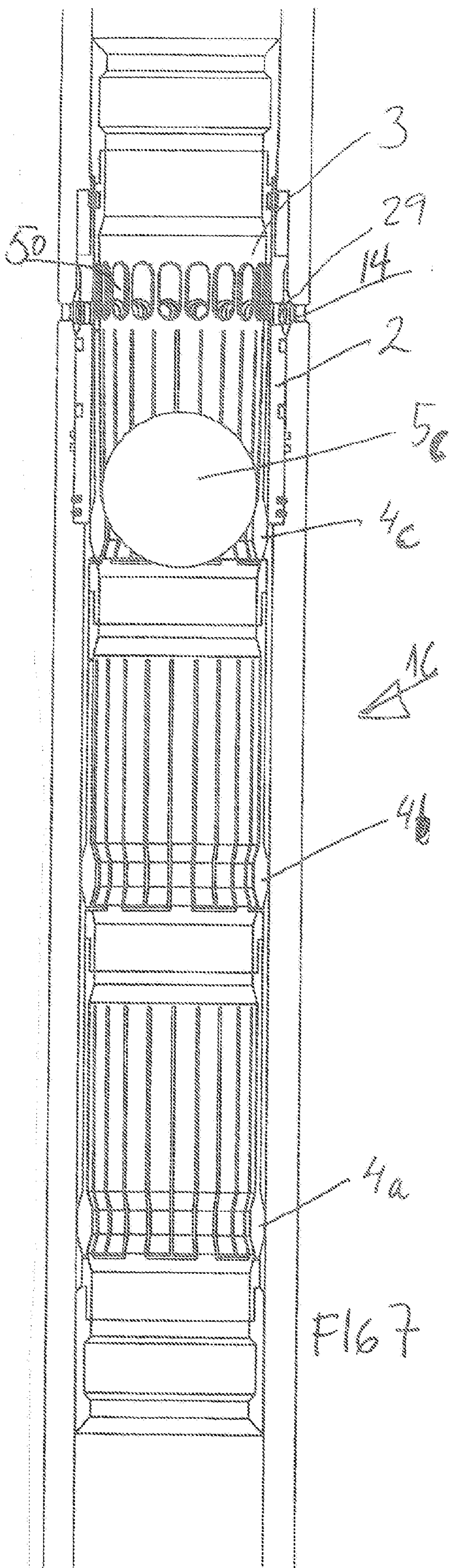


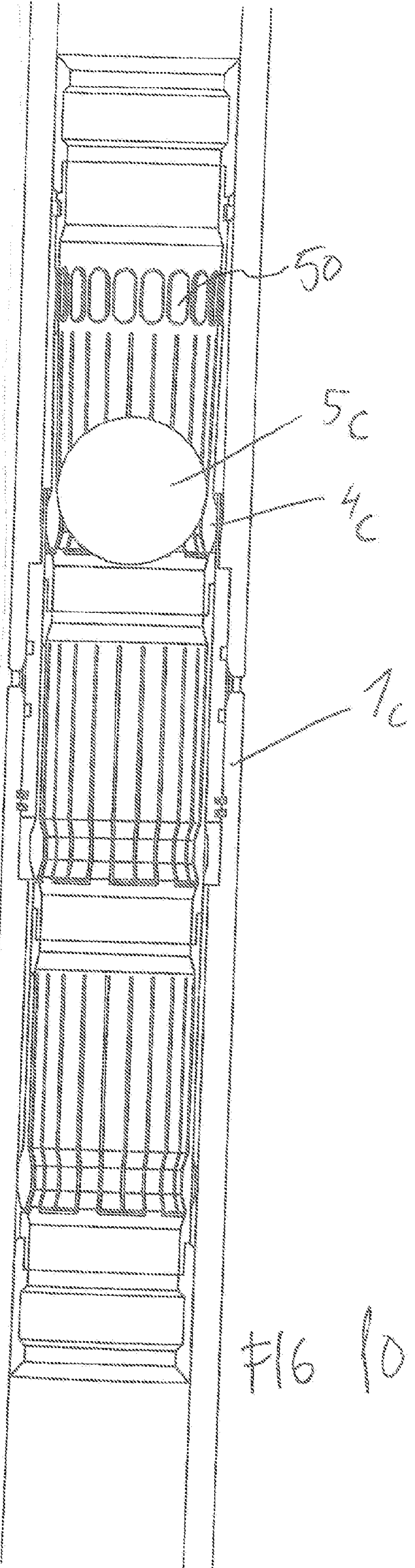
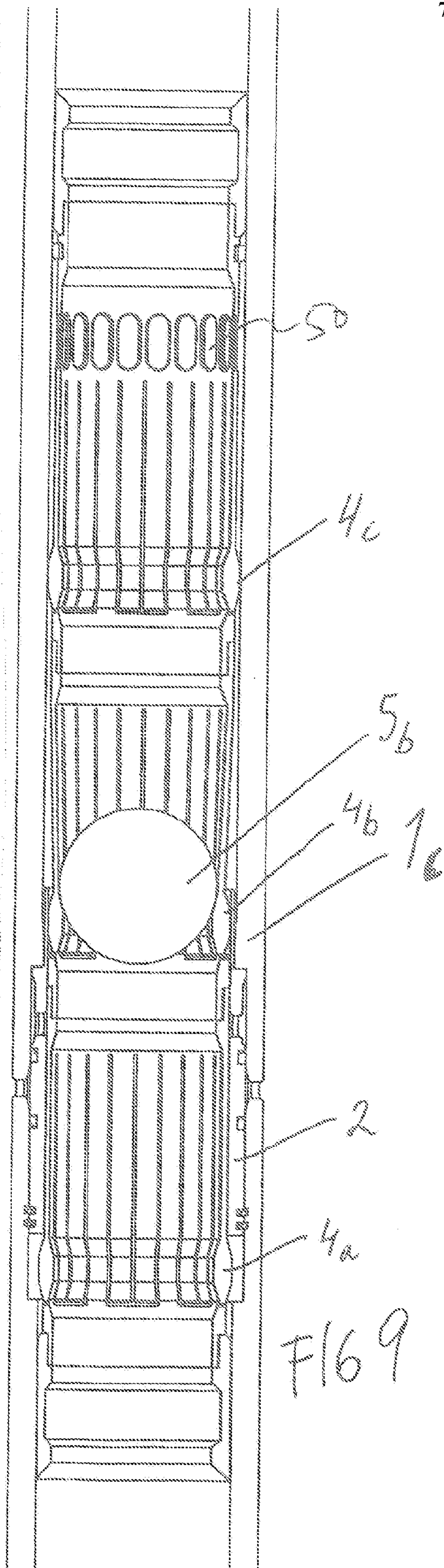
FIG 2











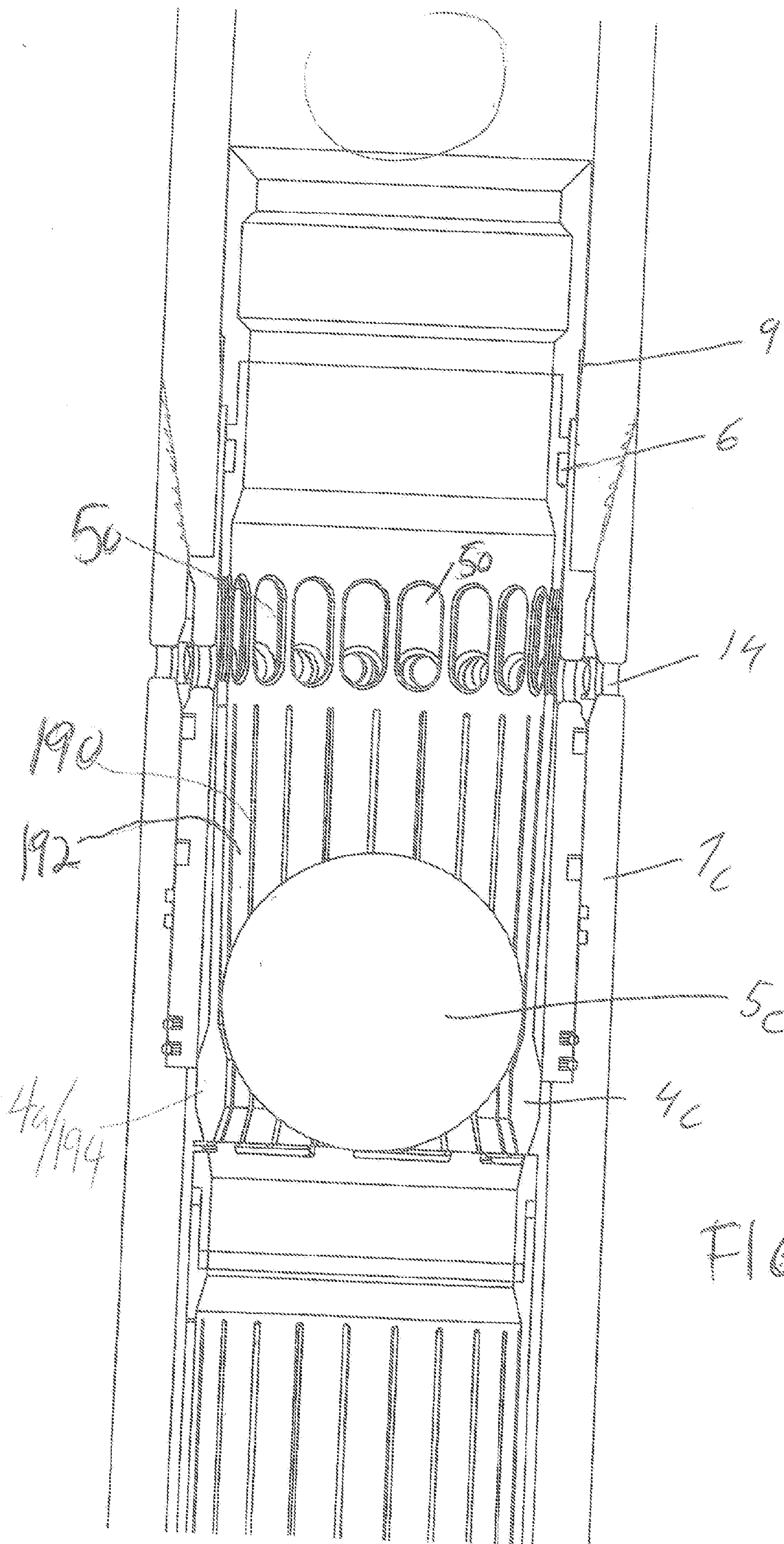


FIG 11

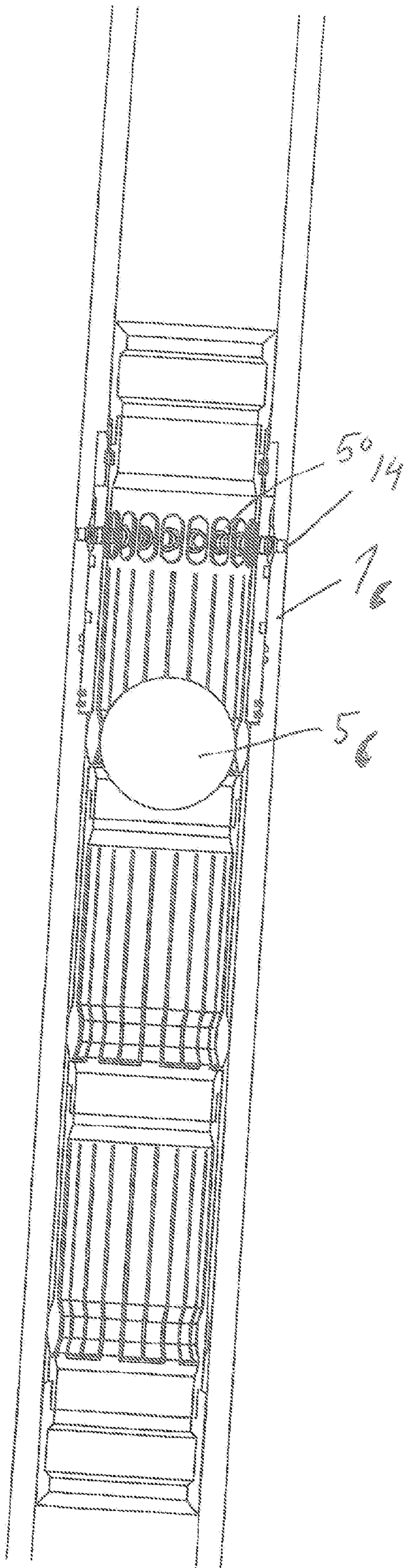
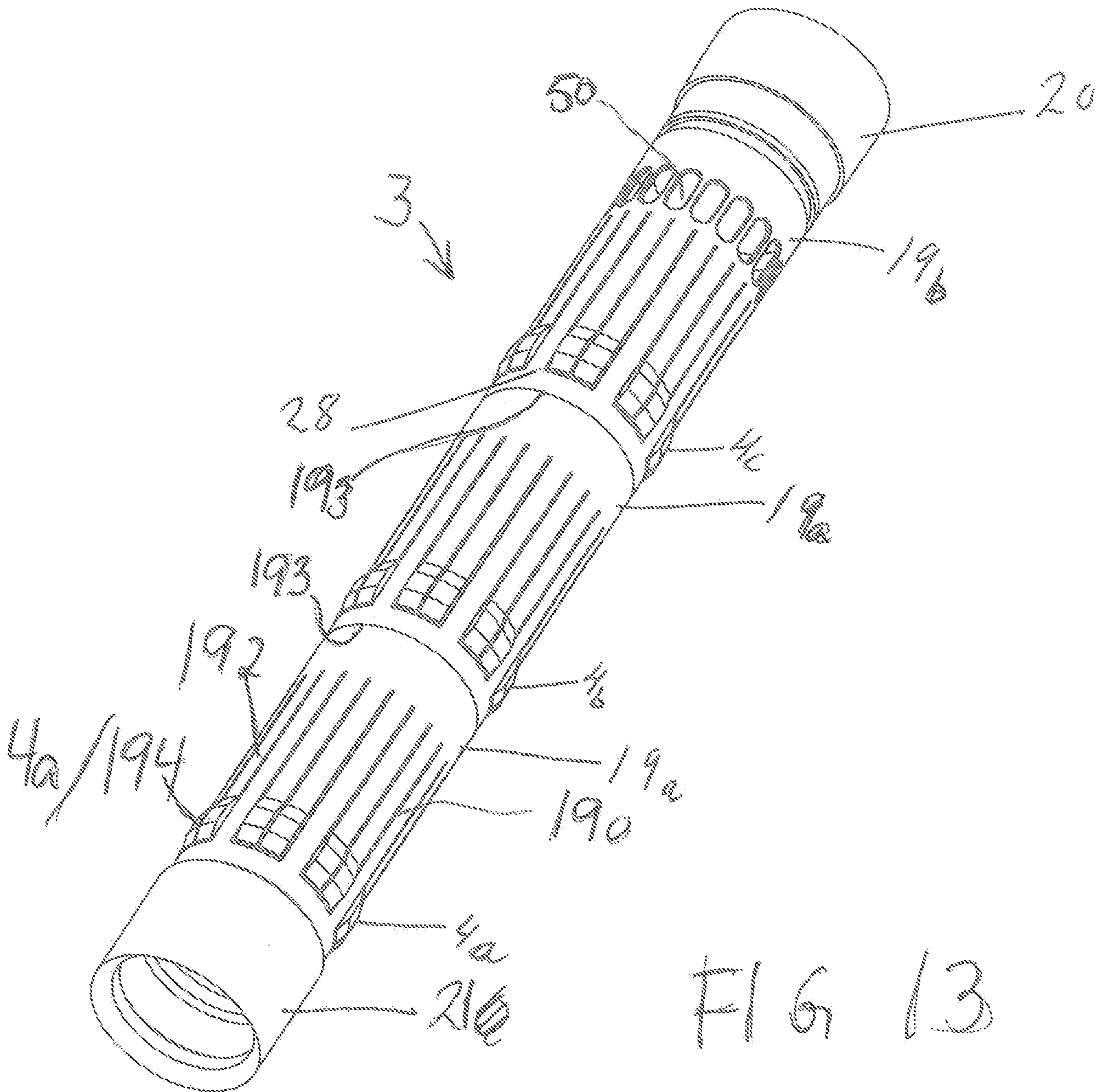
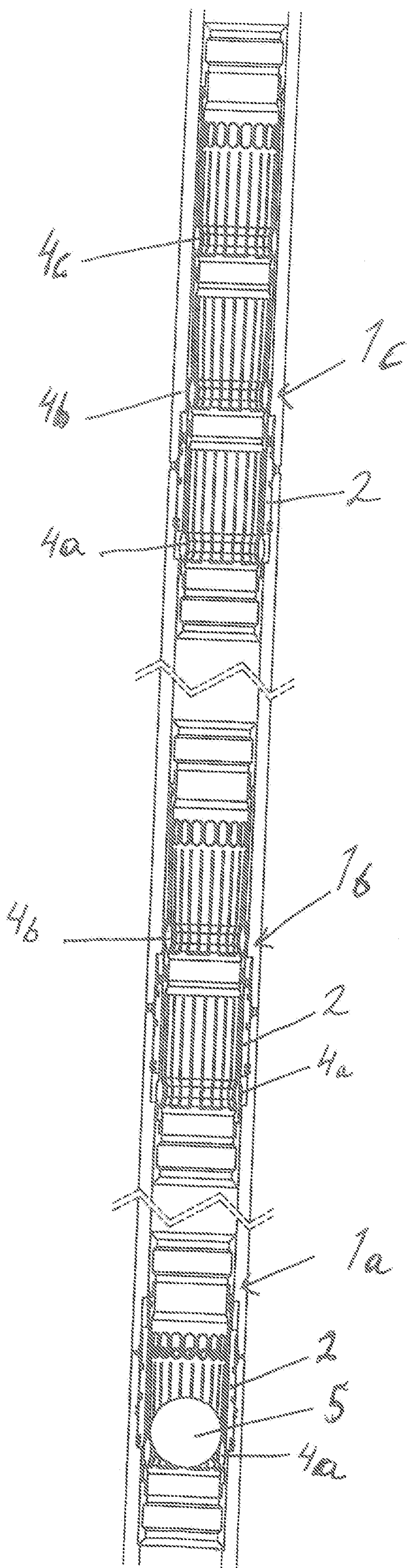


FIG 12





F16 2