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(71) Applicant: **Welltec A/S**
3450 Allerød (DK)

(72) Inventors:
- **Hallundbæk, Jørgen**
  3230 Græsted (DK)
- **Larsen, Stig Sejr**
  2730 Herlev (DK)

(74) Representative: **Hoffmann Dragsted A/S**
Rådhuspladsen 16
1550 Copenhagen V (DK)

(54) **Downhole power system**

(57) The present invention relates to a downhole power system (1) comprising a tubing string (2) comprising a pressurised fluid (3), a turbine (4) for converting energy from the pressurised fluid into rotation of a shaft (5), a generator (8) or a tool (6, 6a) powered by the turbine, wherein a constant flow downhole assembly (7) is arranged between the tubing string and the turbine for providing a substantially constant flow of the pressurised fluid to the turbine. The present invention also relates to a constant flow downhole assembly and to a method for proving a substantially constant flow of fluid into a turbine of the downhole power system.

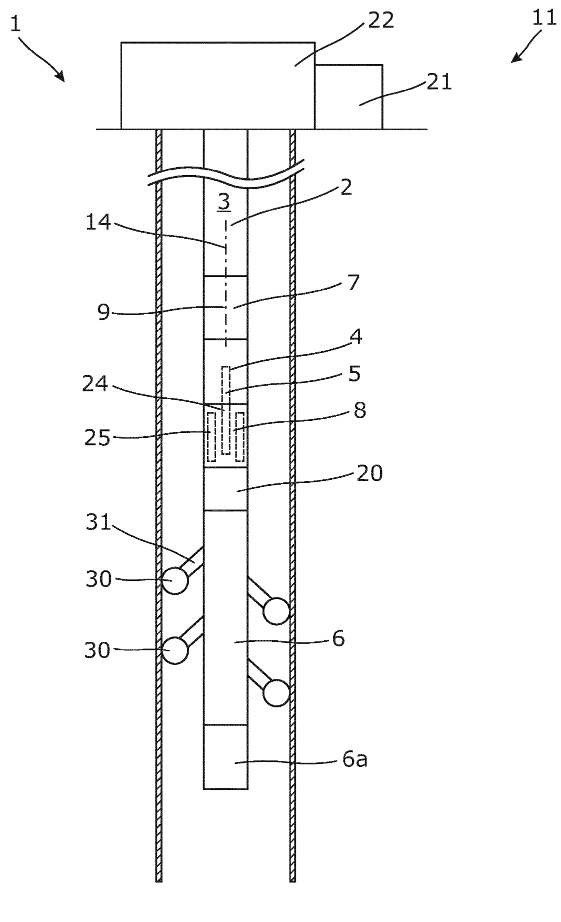

Fig. 1

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Description

Field of the invention

[0001] The present invention relates to a downhole power system, a constant flow downhole assembly and a related method for providing fluid into a turbine of the downhole power system.

Background art

[0002] Fluid fed down coiled tubing is used for driving a variety of tools or drilling bits. When driving a tool, a wireline is not always suitable or capable of providing adequate power for powering the tool, and thus the pressurised fluid fed down the tubing is used. The tubing may be connected to a turbine for converting the energy from the pressurised fluid into a mechanical energy; however, tests have shown that the turbines are very quickly destroyed. Thus, in order for such coiled tubing system to be reusable, substantial repair work often has to be performed.

Summary of the invention

[0003] It is an object of the present invention to wholly or partly overcome the above disadvantages and drawbacks of the prior art. More specifically, it is an object to provide an improved downhole system in which pressurised fluid fed down a tubing is used for powering a tool downhole consuming a substantial amount of power while being reusable operation after operation, hence eliminating the need to perform substantially repair work.

[0004] 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 power system comprising:

- a tubing string comprising a pressurised fluid,
- a turbine for converting energy from the pressurised fluid into rotation of a shaft,
- a tool powered by the turbine,

wherein a constant flow downhole assembly is arranged between the tubing string and the turbine for providing a substantially constant flow of the pressurised fluid to the turbine.

[0005] The downhole power system as described above may further comprise a generator arranged between the turbine and the tool, the generator comprising a rotor and a stator and the rotor being connected with the shaft.

[0006] In one embodiment, a gearing unit may be arranged between the shaft and the rotor.

[0007] Also, the constant flow downhole assembly may have an assembly axis and may comprise a body comprising a main bore having a bore inlet and at least one bore outlet, a hollow piston having a piston inlet and a piston outlet, said hollow piston being arranged in the main bore, and a spring arranged in the main bore, said spring being compressed upon movement of the piston in a first direction.

[0008] Moreover, the bore inlet may be in fluid communication with the piston inlet.

[0009] Further, the piston may have a piston end wall surrounding the piston inlet, the piston inlet being opposite the bore inlet.

[0010] In addition, the piston inlet may be smaller than the bore inlet so as to force the piston to move in the first direction.

[0011] In an embodiment, the piston may have a piston wall adapted to partly cover the bore outlet when the piston moves in the first direction for reducing the flow of fluid into the bore outlet.

[0012] The piston wall may uncover the bore outlet when the piston moves in a second direction opposite the first direction for increasing the flow of fluid into the bore outlet.

[0013] Additionally, the piston outlet may be arranged in the piston wall.

[0014] Also, the piston outlet may be elongated and extend along the assembly axis.

[0015] Furthermore, the piston may have a plurality of piston outlets arranged circumferentially around the piston wall.

[0016] Moreover, the bore outlet may be arranged radially in relation to the assembly axis.

[0017] In an embodiment, the main bore may comprise a plurality of bore outlets.

[0018] The bore outlets may be arranged circumferentially around the main bore.

[0019] In addition, the piston may have a first end opposite a second end having the piston outlet, and the spring may abut the first end of the piston.

[0020] Further, the spring may be arranged partly within the piston and may abut a piston end wall in which the piston inlet is arranged.

[0021] Also, the main bore may comprise first openings arranged upstream of the piston to allow pressurised fluid to flow in a bypass channel out through second openings and into apertures arranged in the piston wall.

[0022] Changeable flow restrictors may be arranged in the first openings.

[0023] Moreover, the constant flow downhole assembly may comprise a sleeve covering the flow restrictors.

[0024] In an embodiment, the sleeve may form part of the bypass channel.

[0025] Additionally, the sleeve may be displaceable or disconnectable for changing the flow restrictors.

[0026] The main bore may be closed in an end opposite the inlet by an end wall, and the spring may be arranged between the end wall and the piston.

[0027] Furthermore, the constant flow downhole assembly may be a self-regulating valve.

[0028] Also, the constant flow downhole assembly may be adapted to regulate a flow of fluid in the range of 0.5-5 barrels/min.

[0029] Further, the spring may be adapted to absorb a pressure of up to 700 bar (10,000 PSI).

[0030] Moreover, the flow restrictors may be nozzles.

[0031] In addition, the tool may be a driving unit, such as a downhole tractor.

[0032] The tool may be a sensor tool, a stroker tool, a key tool, a cutting tool, a neutron tool, a laser diagnostic tool, a laser cutting tool, a casing collar locator, an acoustic tool, a pulse-generating tool, a milling tool, a setting tool, or a similar tool.

[0033] In an embodiment, the tubing string may be a coiled tubing.

[0034] Also, the tubing string may be a casing.

[0035] A packer may be arranged surrounding the constant flow downhole assembly for isolating the casing in a first casing part and a second casing part, the first casing part comprising pressurised fluid for driving the turbine.

[0036] Moreover, the constant flow downhole assembly may have a first end and a second end, the first end being adapted to be connected with the tubing string, and the second end being adapted to be connected with the turbine.

[0037] The first end may have a male connection adapted to be connected with a female connection of the tubing string, and the second end may have a female connection adapted to be connected with a male connection of the turbine.

[0038] The present invention also relates to a constant flow downhole assembly for controlling a substantially constant flow rate in the downhole power system as described above, and having an assembly axis, the constant flow downhole assembly comprising:

- a body comprising a main bore having a bore inlet and at least one bore outlet,
- a hollow piston having a piston inlet and a piston outlet, and being arranged in the main bore, and
- a spring arranged in the main bore, said spring being compressed upon movement of the piston in a first direction.

[0039] In the constant flow downhole assembly as described above, the piston inlet may be smaller than the bore inlet so as to force the piston to move in the first direction.

[0040] Furthermore, the present invention relates to a method for proving a substantially constant flow of fluid into a turbine of the downhole power system as described above, comprising the steps of:

- pressurising a fluid in a tubing string,
- entering the pressurised fluid into the main bore of the constant flow downhole assembly,
- letting the pressurised fluid flow past the hollow piston and into the turbine until the fluid flow exceeds a predetermined level,
- moving a piston by the pressurised fluid pressing on a top of the piston, and
- reducing a flow area of the bore outlet by the piston moving in a first direction until the fluid flow is substantially equal to the predetermined level.

[0041] The method for providing a substantially constant flow of fluid into a turbine of the downhole power system as described above may further comprise the steps of:

- letting the pressurised fluid flow past the hollow piston and into the turbine until the fluid flow is below the predetermined level,
- pressing onto the piston end wall in a second direction opposite the first direction by means of the spring, and
- increasing the flow area of the bore outlet by movement of the piston until the fluid flow is substantially equal to the predetermined level.

<u>Brief description of the drawings</u>

[0042] 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 power system according to the invention,

Fig. 2 shows a cross-sectional view of a constant flow downhole assembly,

Fig. 3 shows a cross-sectional view of one embodiment of the constant flow downhole assembly,

Fig. 4 shows a cross-sectional view of another embodiment of the constant flow downhole assembly,

Fig. 5 shows a cross-sectional view of yet another embodiment of the constant flow downhole assembly,

Fig. 6 shows another embodiment of the downhole power system according to the invention,

Fig. 7a shows a diagram of a first test, and

Fig. 7b shows a diagram of a second test.

[0043] All the figures are highly schematic and not necessarily to scale, and they show only those parts which are necessary in order to elucidate the invention, other parts being omitted or merely suggested.

Detailed description of the invention

[0044] Fig. 1 shows a downhole power system 1 having a tubing string 2 comprising a pressurised fluid 3 for driving a turbine 4 for converting the energy from the pressurised fluid into rotation of a shaft 5. The shaft is illustrated by dotted lines. The downhole power system 1 further comprises a tool 6 powered by the turbine indirectly through the shaft 5. A constant flow downhole assembly 7 is arranged between the tubing string 2 and the turbine 4 for providing a substantially constant flow of the pressurised fluid to the turbine. When pumping fluid down a tubing string, the pressure of the fluid varies significantly due to the fact that it is difficult to maintain a constant pressure output of the pump during a downhole operation since the pump is often manually operated over a long period of time. Turbines have a design which is sensitive to variations in the flow rates and thus to variations in the rotational speed of the shaft. Tests have shown that if the pressure is controlled, the turbine is capable of running over a long period without being damaged. By controlling the pressure by means of the constant flow downhole assembly 7, the flow rate will not fluctuate more than 10% above or below a predetermined flow rate level, regardless of the pressure of the fluid entering the constant flow downhole assembly. The turbine is therefore not damaged when driven by pressurised fluid fed down the tubing string and can easily be used for powering a tool operation again and again, without substantial repair work being necessary. By having the constant flow downhole assembly, the flow rate can be kept substantially constant and the turbine can be designed to have a smaller safety margin, and thus the turbine will be able to run more efficiently.

[0045] Since the downhole power system is not dependent of a range of a wireline for powering a tool, the downhole power system is able to perform operations requiring more power than a wireline can deliver, also in a remote part of the well 11. The tubing string may be coiled tubing or drill pipe.

[0046] The downhole power system further comprises a generator 8 arranged between the turbine and the tool. The generator comprises a rotor 24 and a stator 25, and the rotor is connected with the shaft 5. When the shaft rotates the rotor, the generator is able to produce electrical power to the tool, and a wireline is hence no longer required for powering an electrical motor 20 driving the tool 6. In a downhole power system in which the tool can be operated by a rotational shaft, the generator can be dispensed with. In Fig. 1, the tool is a driving unit 6 propelling itself and a sensor tool 6a forward in the well 11.

[0047] The flow of fluid for ensuring optimal operation of the turbine is provided by the constant flow downhole assembly 1 connected with the tubing string so that a tubing string axis 14 is coincident with an assembly axis 9, as shown in Fig. 1. Fig. 2 shows a cross-sectional view of the constant flow downhole assembly which comprises a body 15 having a main bore 16 with a bore inlet 17 and at least one bore outlet 18. The constant flow downhole assembly 7 comprises a hollow piston 19 having a piston inlet 32 and a piston outlet 33. The hollow piston 19 is arranged in the main bore 16 and a spring 34 is arranged in the main bore 16 and partly within the hollow piston, said spring being compressed upon movement of the piston in a first direction 35. The piston is thus open in a first end 36, and in a second opposite end the piston has a piston end wall 39 in which the piston inlet is arranged. The main bore 16 has an open end at the bore inlet 17 and a closed end 38 in an end of the main bore opposite to that of the bore inlet. The spring is compressible between the piston end wall 39 and the closed end 38 upon movement of the piston in the first direction when the pressurised fluid presses on the piston end wall from the bore inlet 17. Thus, the piston inlet is smaller than the bore inlet so as to force the piston to move in the first direction. When the piston is moved in the first direction, the first end is positioned so that a piston wall 40 covers the bore outlet and thus reduces the flow of fluid through the bore outlets 18 and into the turbine (not shown). When the pressure decreases again, the spring forces the piston to move in a second direction opposite the first direction in order to balance the force on the piston and provide an equilibrium, and the piston end wall 39 is moved accordingly so that the piston wall 40 uncovers the bore outlet and the flow of fluid into the bore outlets 18, and thus the flow is kept constant.

[0048] The piston in Fig. 2 is allowed to move back and forth in the main bore 16, and in order to ensure that the compressed spring does not bulge and jam inside the constant flow downhole assembly 7, the closed end 38 has a projection 41 extending into the main bore 16, creating an annular bore part in which the movement of the spring is controlled. The body 15 of the constant flow downhole assembly 7 has a body outlet 42 provided with a thread 43 for connection with the turbine. Outlet channels 44 are provided in the body 15 fluidly connecting the bore outlets 18 with the body outlet 42 and thus with the turbine when connected with the constant flow downhole assembly 7. In the end of the body opposite the bore outlet 42, the body is provided with threads 43 for connection with the tubing string.

[0049] Due to the design of the constant flow downhole assembly with a piston having a large opening in the piston end wall, through which the fluid can flow, and large cross-sectional areas of the fluid channels, the assembly can function in a downhole environment where the fluid is often "dirty" and contains elements or substances. Furthermore, by having a hollow piston, the constant flow downhole assembly can be designed as an elongated assembly having a substantially small diameter, and the constant flow downhole assembly is thus capable of fitting into a tool string in a downhole well.

[0050] The constant flow downhole assembly is a self-regulating valve and provides a substantially constant flow of fluid independent of the variations in the pressure in the tubing string. By varying the size of the piston inlet and/or the stiffness of the spring, the constant flow downhole assembly 7 can be designed to deliver from 80 litres/min. (0,5 barrels/min) to 800 litres/min. (5 barrels/min) at a pressure varying from 10 (145 PSI) to 700 bar (10,000 PSI), preferably from 140 bar (2,000 PSI) to 700 bar (10,000 PSI), and more preferably from 275 bar (4,000 PSI) to 700 bar (10,000 PSI).

[0051] In Fig. 3, the main bore has a plurality of bore outlets arranged radially in relation to the assembly axis 9 along the circumference of the main bore. Channels 44 fluidly connect the bore outlets with the turbine when the turbine is connected with the constant flow downhole assembly 7 so that the flow of fluid is transferred to the turbine in the circumference of the constant flow downhole assembly. Furthermore, the main bore comprises first openings 45 arranged upstream of the piston to allow pressurised fluid to flow in a bypass channel 46 out through second openings 47 and into apertures 48 arranged in the piston wall 40. Fluid is thus led from the main bore both through the piston inlet and through the bypass channels 46 when the pumping of fluid down the tubing string is started, thus pressurising the fluid. Thus, in the initial phase, more fluid is let into the bore outlets 18 so that the flow rate is rapidly increased to the intended constant flow rate. Subsequently, the fluid presses onto the piston end wall 39 because the piston inlet 32 is smaller than the bore inlet 17, and the piston wall 40 begins to close or cover the second openings 47, and less fluid is consequently allowed to pass and the main part of the fluid is let through the piston inlet.

[0052] The piston outlets 33 are, in Fig. 4, arranged in the piston wall 40. The outlets are arranged circumferentially around the piston wall 40. When the piston moves in the first direction 35, the piston outlets 33 are only partly overlapping the bore outlet 18, and thus the flow area is decreased. However, the piston wall never covers the bore outlet entirely. Thus, the valve never closes completely. The flow rate when the flow area has been descreased is substantially equal to the flow rate before the flow area was decreased. The piston outlets 33 have an elongated shape and extend along the assembly axis 9. As shown, the shape of the outlets varies so that at one end the outlet is wider than at the other end of the elongated piston outlets. By varying the width of the outlets along the elongation of the outlet, the flow may be kept more constant than with outlets having widths of equal size. Furthermore, the constant flow downhole assembly 7 comprises a retaining ring 50 arranged in a groove 51 in the body so that the piston is prevented from sliding out of the bore inlet 17. The spring abuts an end face 52 of the piston facing the closed end of the main bore 16 and is thus compressed between the end face 52 of the piston 19 and the closed end 38 of the main bore 16. By arranging the spring to abut the end face of the piston, the spring does not extend inside the hollow piston and thus does not restrict the flow of fluid from the piston inlet 32 to the bore outlet 18. As the spring is compressed, the windings of the piston are forced closer together and may thus function as a restriction if the spring is arranged partly inside the hollow piston.

[0053] In Fig. 5, the constant flow downhole assembly 7 comprises changeable flow restrictors 53 arranged in the first openings 45. The flow of fluid into the bypass channel 46 is thus restricted, and by changing the changeable flow restrictors 53, the flow rate provided by the constant flow downhole assembly 7 may easily be varied. The constant flow downhole assembly further comprises a sleeve 56 covering the flow restrictors. The sleeve is slidably arranged so that the flow restrictors can easily be replaced. The sleeve forms part of the bypass channels 46 and O-rings 57 are provided to seal off the bypass channels 46. As shown, the flow restrictions may be nozzles 55 arranged in the first openings.

[0054] Fig. 7a shows a diagram displaying the flow rate of a first flow test which has been made on the constant flow downhole assembly in which no nozzles or restrictions were arranged in the first openings, and thus no means has been provided in the opening to restrict the flow into the bypass channel. Fig. 7b shows a diagram displaying the flow rate of a second flow test which has been made on the constant flow downhole assembly in which nozzles were arranged in the first openings, and thus the flow into the bypass channel was restricted. As can be seen, the flow rate in the first test is increased more quickly than in the second test in which the nozzles were used. Thus, by having nozzles the flow rate increases less rapidly as the pressure in the casing string increases. By having nozzles the tendency of the piston to rattle or slap back and forth between the piston end wall and the closed end of the main bore is furthermore decreased. Thus, the flow delivered to the turbine is more constant and this further increases the lifetime of the turbine. In addition, the first and second tests show that by using the constant flow downhole assembly of the present invention, the flow rate is kept substantially constant regardless of the pressure of the fluid. In the first and the second tests of Figs. 7a and 7b, the flow rate, after the initial section of building up the flow rate to around 320 litres/min, was kept at 320 litres/min $\pm 2\%$.

[0055] In Fig. 6, the downhole power system comprises a pump 21 at the top of the well 22 for pressurising the tubing string 2. In Fig. 1, the tubing string is a drill pipe or coiled tubing, and in Fig. 6 the casing is used as the tubing string so that no extra tubing is inserted in the well. A packer is arranged surrounding the constant flow downhole assembly 7 for isolating the casing in a first casing part 61 and a second casing part 62, the first casing part comprising pressurised fluid for driving the turbine. The pressurised fluid enters the constant flow downhole assembly 7, ensuring that a substantially constant pressure is delivered to the turbine 4 driving a shaft connected with the rotor in the generator 8. In between the turbine and the generator, a gearing unit 10 is arranged between the shaft and the rotor so that the rotor rotates at a higher rotational rate than the turbine 4 and the shaft. The generator powers the electrical motor 20 and a sensor tool 6a. The electrical motor controls the movement of a lateral locator 6, arranged in front of the sensor tool, when the lateral locator has located the lateral and the tool is to move into the lateral. The tool may be a tool demanding more power than normal tools such as cutting tools, neutron tools, laser diagnostic tools, laser cutting tools, etc. The tool may also be a casing collar locator, an acoustic tool, a pulse-generating tool, a stroker tool, a key tool, a milling tool, a setting tool or a similar tool.

[0056] In order to provide a substantially constant flow of fluid into a turbine of the downhole power system, the downhole power system is entered into the well, and the tubing string is pressurised so that the pressurised fluid enters the main bore of the constant flow downhole assembly. The pressurised fluid flows past the hollow piston of the constant flow downhole assembly and into the turbine until the fluid flow exceeds a predetermined level. Then the piston is moved by the pressurised fluid pressing on the piston end wall, reducing a flow area of the bore outlet by the movement of the piston until the fluid flow is substantially equal to the predetermined level. Then the spring presses on the piston end wall and the flow area of the bore outlet is increased by the movement of the piston until the fluid flow is substantially equal to the predetermined level. Hereby, the constant flow downhole assembly ensures that a substantially constant flow is delivered to the turbine due to the balancing between the spring and the dynamic pressure of the flow to obtain a state of equilibrium.

[0057] A stroker tool is a tool providing an axial force. The stroker tool comprises an electrical motor for driving a pump. The pump pumps fluid into a piston housing to move a piston acting therein. The piston is arranged on the stroker shaft. The pump may pump fluid into the piston housing on one side and simultaneously suck fluid out on the other side of the piston.

[0058] By fluid or well fluid is meant any kind of fluid that may be present in oil or gas wells downhole, such as natural gas, oil, oil mud, crude oil, water, etc. By gas is meant any kind of gas composition present in a well, completion, or open hole, and by oil is meant any kind of oil composition, such as crude oil, an oil-containing fluid, etc. Gas, oil, and water fluids may thus all comprise other elements or substances than gas, oil, and/or water, respectively.

[0059] By a casing is meant any kind of pipe, tubing, tubular, liner, string etc. used downhole in relation to oil or natural gas production.

[0060] The driving unit may be a downhole tractor which may have projectable arms 31 having wheels 30 as shown in Fig. 1, wherein the wheels contact the inner surface of the casing for propelling the tractor and the tool forward in the casing. A downhole tractor is any kind of driving tool capable of pushing or pulling tools in a well downhole, such as a Well Tractor®.

[0061] Although the invention has been described in the above in connection with preferred embodiments of the invention, it will be evident for a person skilled in the art that several modifications are conceivable without departing from the invention as defined by the following claims.

Claims

1. A downhole power system (1) comprising:

- a tubing string (2) comprising a pressurised fluid (3),
- a turbine (4) for converting energy from the pressurised fluid into rotation of a shaft (5),
- a tool (6, 6a) powered by the turbine,

wherein a constant flow downhole assembly (7) is arranged between the tubing string and the turbine for providing a substantially constant flow of the pressurised fluid to the turbine.

2. A downhole power system according to claim 1, further comprising a generator (8) arranged between the turbine and the tool, the generator comprising a rotor (24) and a stator (25) and the rotor being connected with the shaft.

3. A downhole power system according to any of the preceding claims, wherein the constant flow downhole assembly has an assembly axis (9) and comprises:

- a body (15) comprising a main bore (16) having a bore inlet (17) and at least one bore outlet (18),
- a hollow piston (19) having a piston inlet (32) and a piston outlet (33), said hollow piston being arranged in the main bore, and
- a spring (34) arranged in the main bore, said spring being compressed upon movement of the piston in a first direction (35).

4. A downhole power system according to claim 3, wherein the bore inlet is in fluid communication with the piston inlet.

5. A downhole power system according to claim 3 or 4, wherein the piston inlet is smaller than the bore inlet so as to force the piston to move in the first direction.

6. A downhole power system according to any of the claims 3-5, wherein the piston has a piston wall (40) adapted to partly cover the bore outlet when the piston moves in the first direction for reducing the flow of fluid into the bore outlet.

7. A downhole power system according to any of the claims 3-6, wherein the piston outlet is elongated and extends along the assembly axis.

8. A downhole power system according to any of the claims 3-7, wherein the main bore comprises first openings (45) arranged upstream of the piston to allow pressurised fluid to flow in a bypass channel (46) out through second openings (47) and into apertures (48) arranged in the piston wall.

9. A downhole power system according to claim 8, wherein changeable flow restrictors (53) are arranged in the first openings.

10. A downhole power system according to any of the claims 3-10, wherein the flow restrictors are nozzles (55).

11. A downhole power system according to any of the preceding claims, wherein the tool is a driving unit (6), such as a downhole tractor.

12. A downhole power system according to any of the preceding claims, wherein the tubing string is a coiled tubing.

13. A constant flow downhole assembly for controlling a substantially constant flow rate in the downhole power system according to any of the preceding claims, and having an assembly axis, the constant flow downhole assembly comprising:

- a body comprising a main bore having a bore inlet and at least one bore outlet (18),
- a hollow piston (19) having a piston inlet and a piston outlet, and being arranged in the main bore, and
- a spring arranged in the main bore, said spring being compressed upon movement of the piston in a first direction.

14. A constant flow downhole assembly according to claim 13, wherein the piston inlet is smaller than the bore inlet so as to force the piston to move in the first direction.

15. A method for providing a substantially constant flow of fluid into a turbine of the downhole power system according to any of the claims 1-12, comprising the steps of:

- pressurising a fluid (3) in a tubing string,
- entering the pressurised fluid into the main bore of the constant flow downhole assembly,
- letting the pressurised fluid flow past the hollow piston and into the turbine until the fluid flow exceeds a predetermined level,
- moving a piston by the pressurised fluid pressing on a top of the piston, and
- reducing a flow area of the bore outlet by the piston moving in a first direction until the fluid flow is substantially equal to the predetermined level.

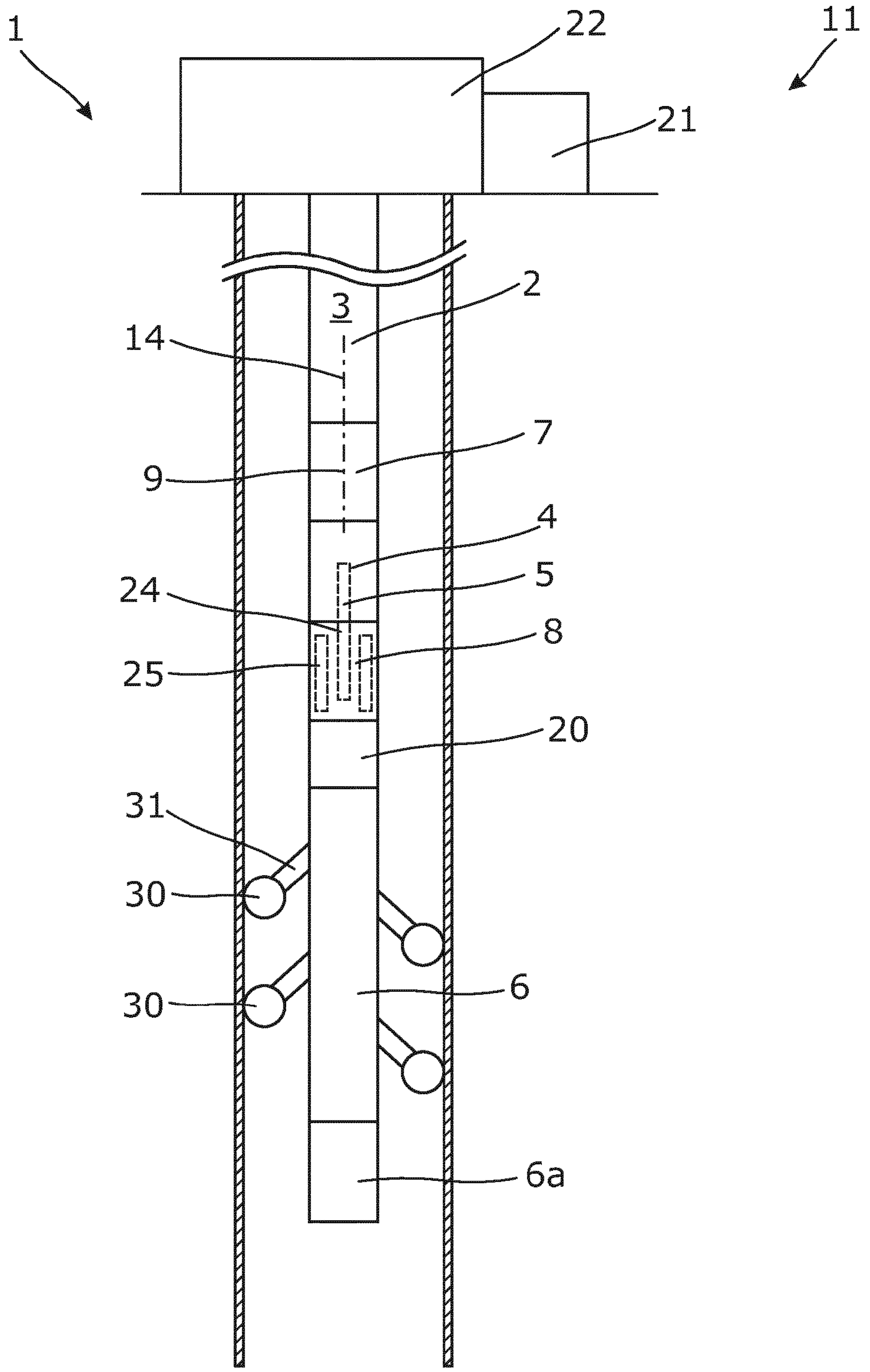

Fig. 1

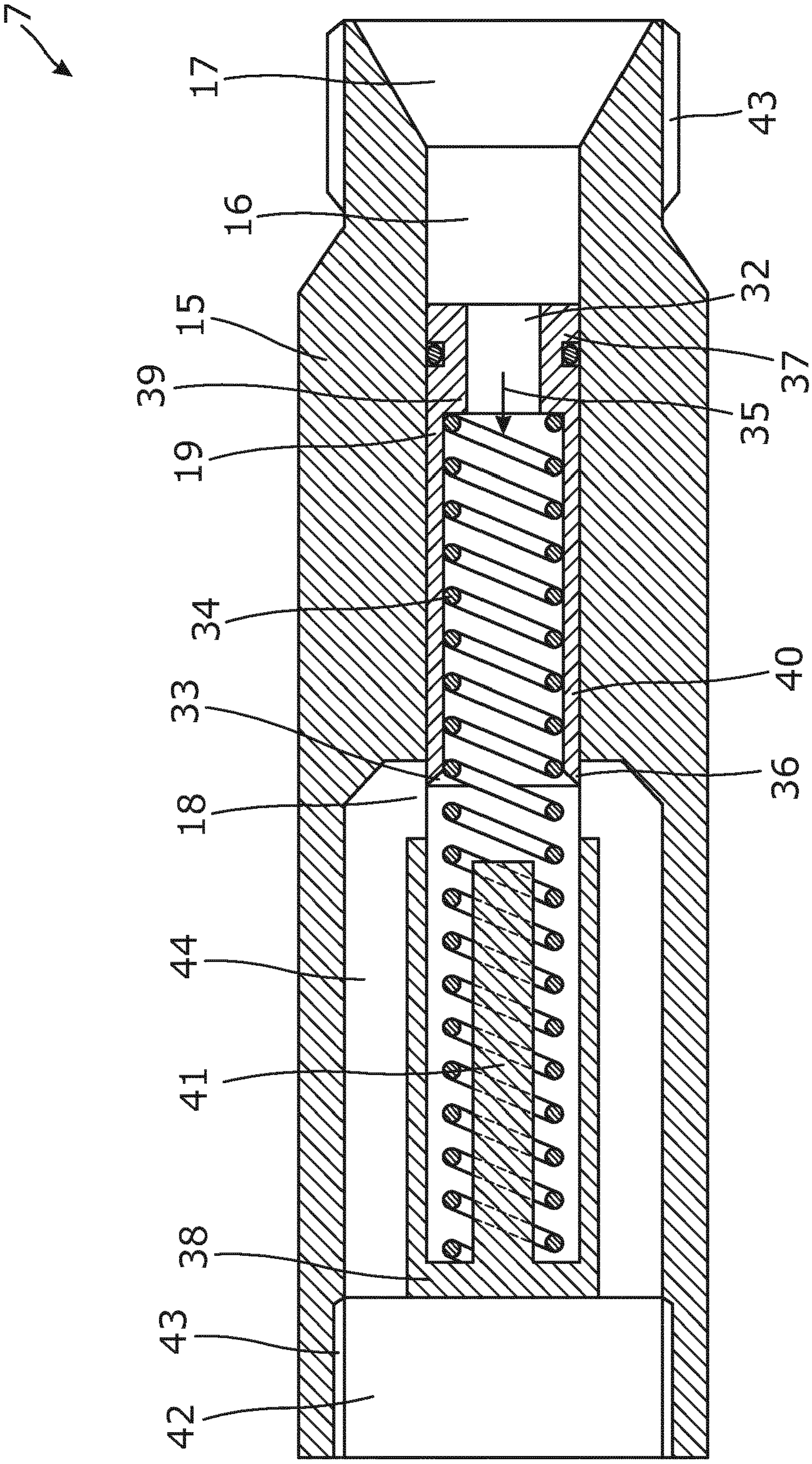

Fig. 2

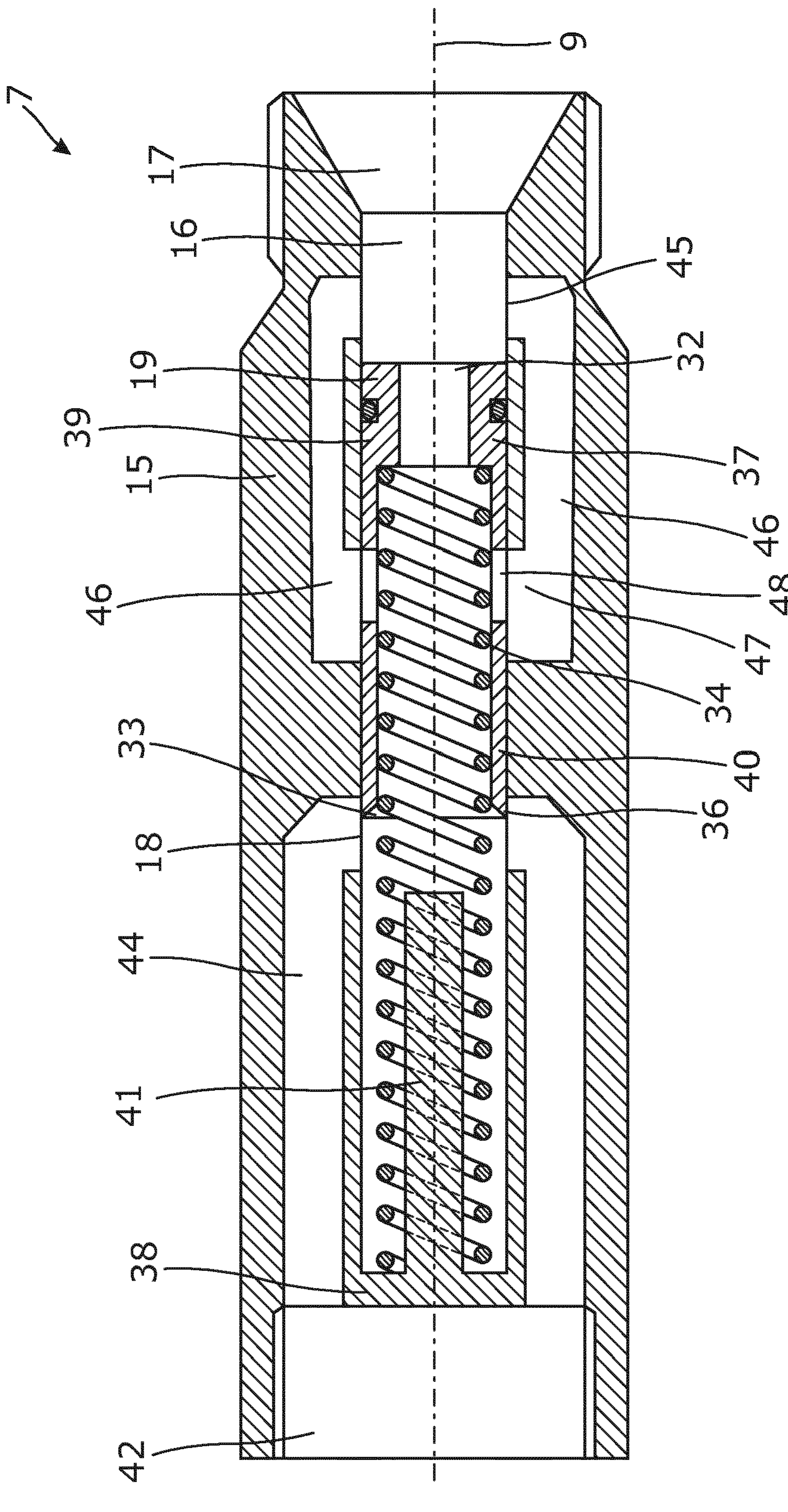

Fig. 3

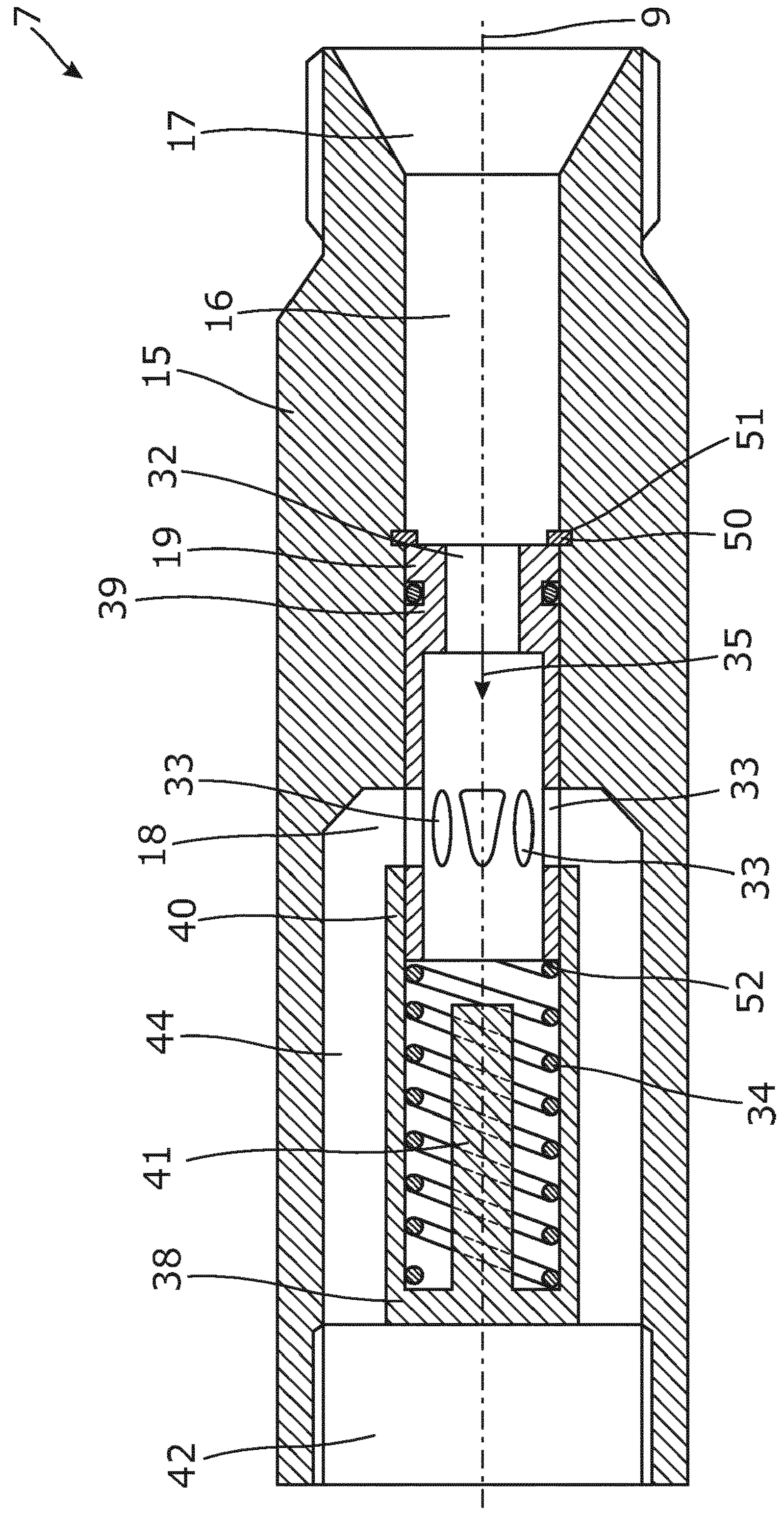

Fig. 4

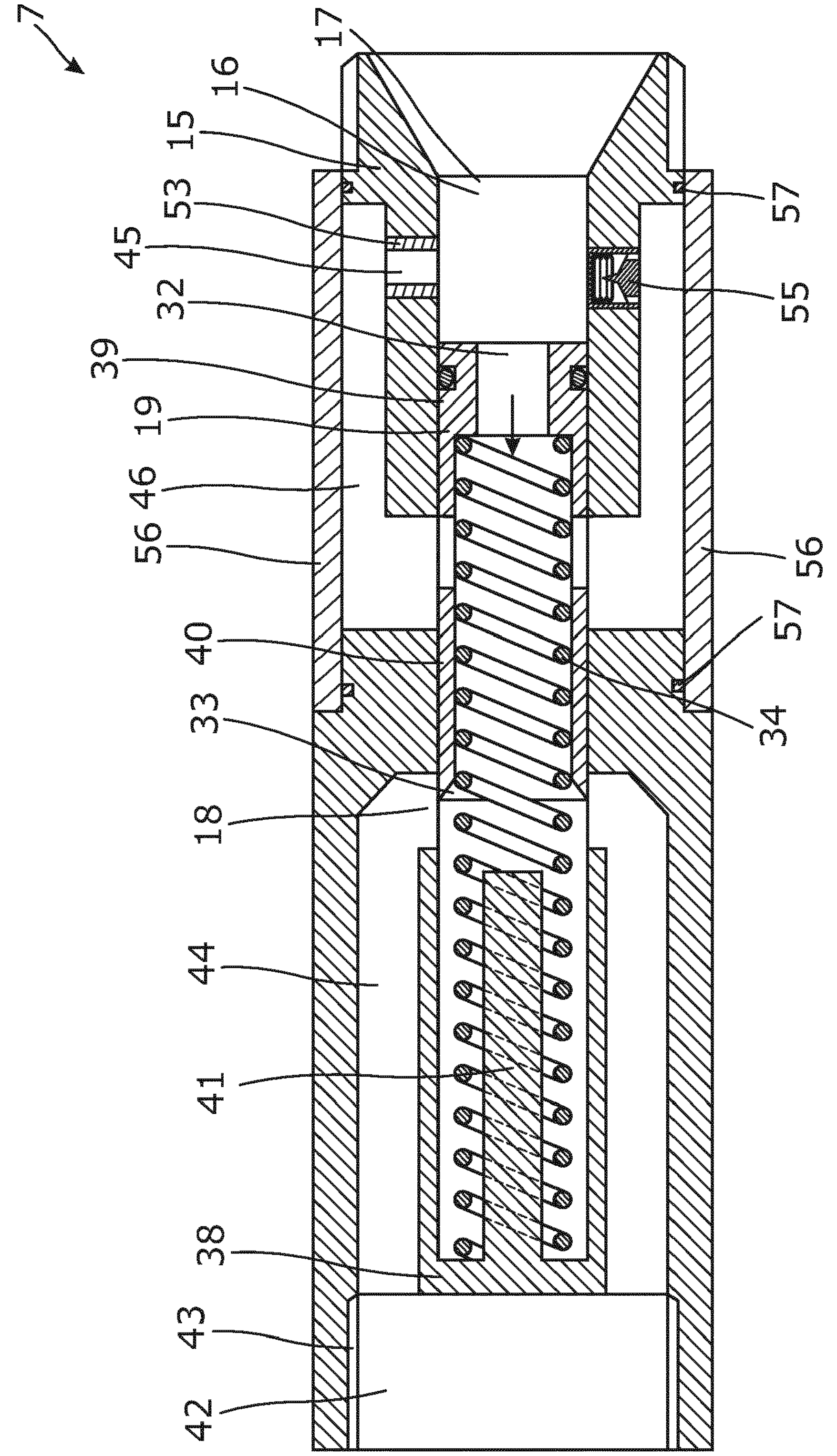

Fig. 5

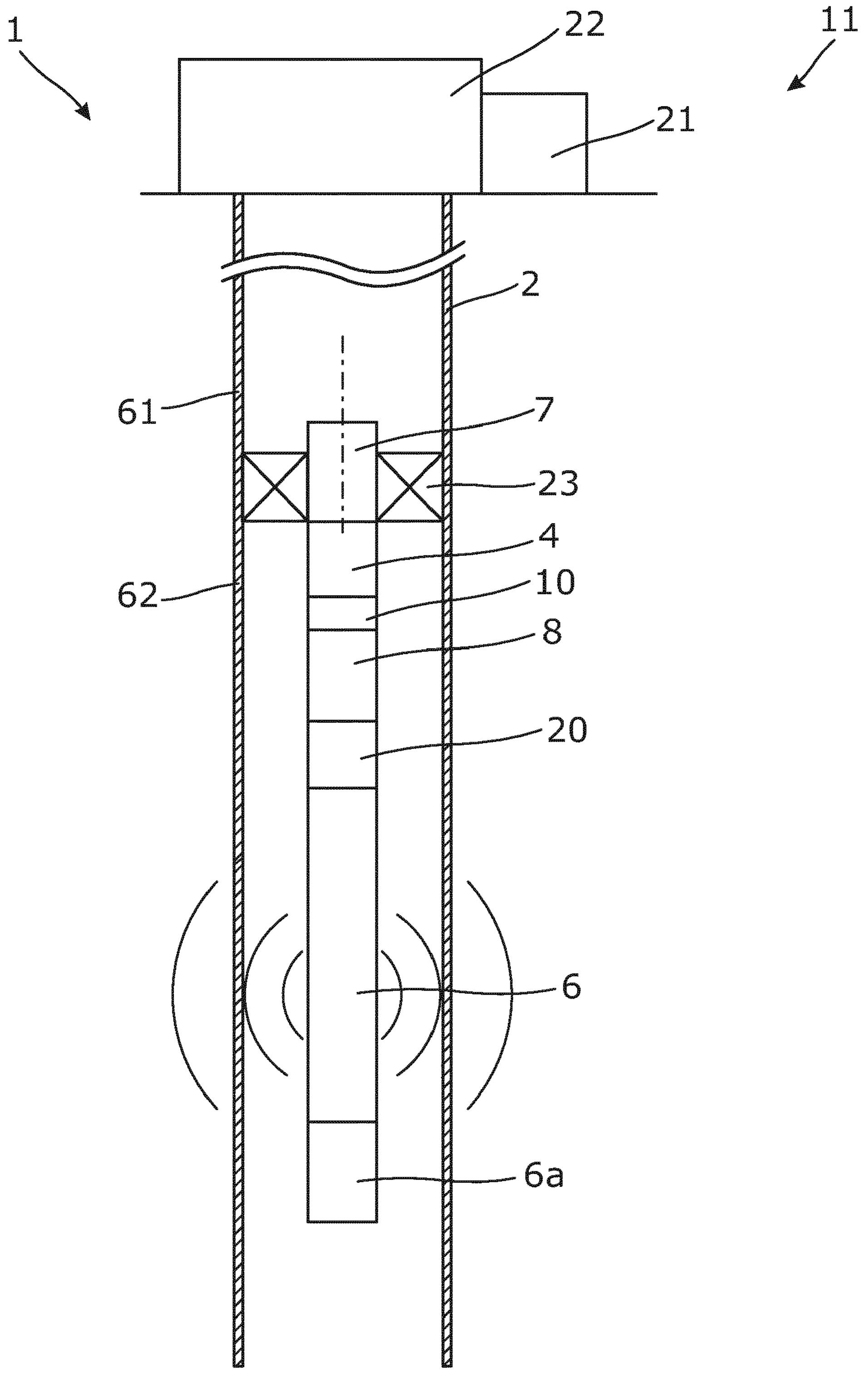

Fig. 6

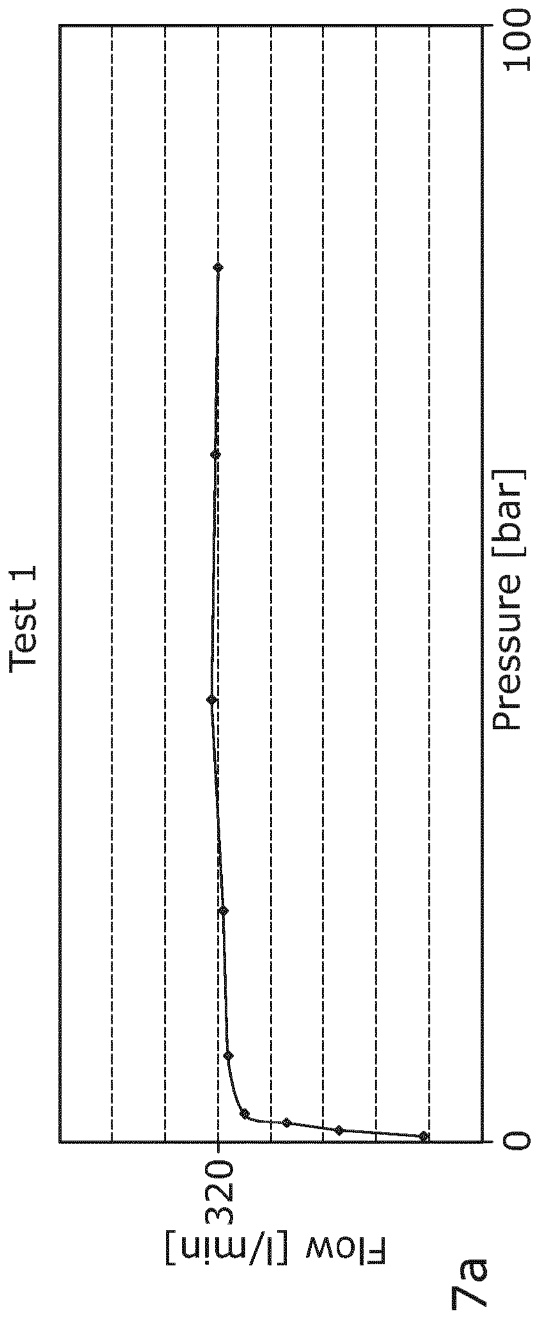
Test 1
Flow [l/min]
320
0
100
Pressure [bar]

Fig. 7a

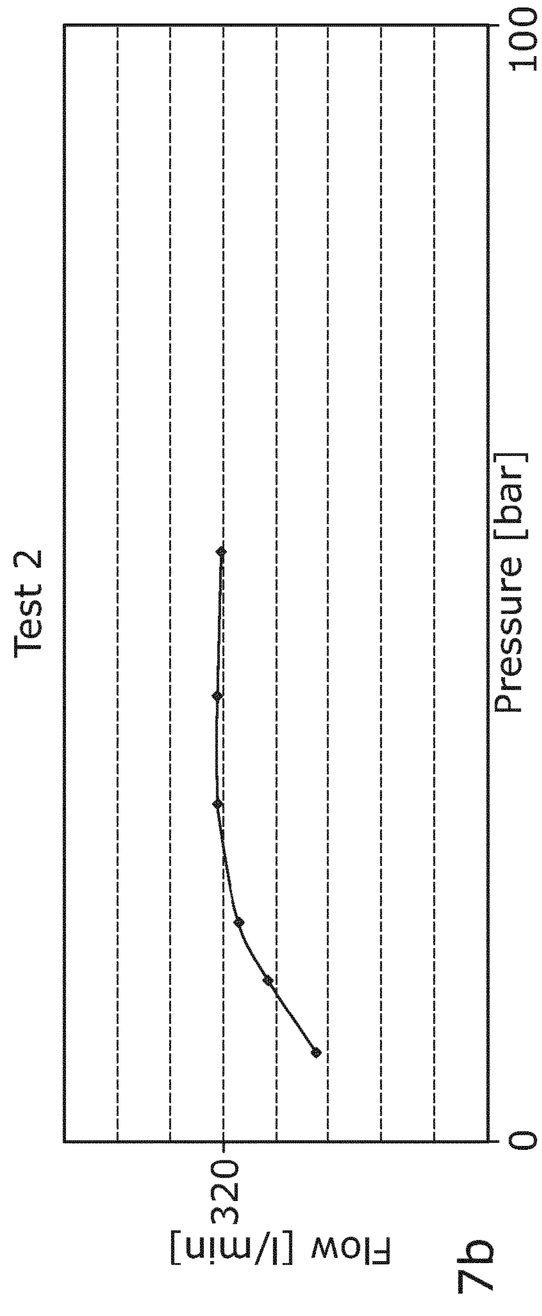
Test 2
Flow [l/min]
320
0
100
Pressure [bar]

Fig. 7b

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European Patent Office
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EUROPEAN SEARCH REPORT

Application Number
EP 12 19 6526

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 4 396 071 A (STEPHENS KELLY D) 2 August 1983 (1983-08-02) * column 7, line 43 - column 8, line 8; figures 2, 4 *	1-5,13	INV. E21B41/00 E21B4/02
X	GB 2 453 867 A (WEATHERFORD ENERGY SERVICES GMBH [DE]) 22 April 2009 (2009-04-22) * page 6, line 6 - line 13 *	1	
X	US 2005/173157 A1 (RAVENSBERGEN JOHN E [CA] ET AL RAVENSBERGEN JOHN EDWARD [CA] ET AL) 11 August 2005 (2005-08-11) * paragraph [0090] - paragraph [0091] *	1	
A	GB 2 467 046 A (WEATHERFORD ENERGY SERVICES GM [DE] WEATHERFORD ENERGY SERVICES GMBH [) 21 July 2010 (2010-07-21) * the whole document *	1	
			TECHNICAL FIELDS SEARCHED (IPC)
			E21B

The present search report has been drawn up for all claims

1

Place of search	Date of completion of the search	Examiner
Munich	16 May 2013	Ott, Stéphane

CATEGORY OF CITED DOCUMENTS

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ANNEX TO THE EUROPEAN SEARCH REPORT ON EUROPEAN PATENT APPLICATION NO. EP 12 19 6526

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The members are as contained in the European Patent Office EDP file on
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16-05-2013

Patent document cited in search report		Publication date	Patent family member(s)		Publication date
US 4396071	A	02-08-1983	CA	1175413 A1	02-10-1984
			EP	0069530 A2	12-01-1983
			JP	S5817992 A	02-02-1983
			NO	822340 A	07-01-1983
			US	4396071 A	02-08-1983
GB 2453867	A	22-04-2009	NONE		
US 2005173157	A1	11-08-2005	CA	2492354 A1	05-08-2005
			GB	2411186 A	24-08-2005
			US	2005173157 A1	11-08-2005
GB 2467046	A	21-07-2010	CA	2688928 A1	16-07-2010
			DE	102009005330 A1	22-07-2010
			GB	2467046 A	21-07-2010
			US	2010183430 A1	22-07-2010

EPO FORM P0459

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