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(54) Method of and apparatus for assembling a tool string

(57) A method of and apparatus for assembling a tool string includes a body member (12) and a coupling mechanism (6, 7, 8, 9) on the body member (12). The coupling mechanism (6, 7, 8, 9) releasably secures the body member (12) to an internal profile (3) in the borehole (1). The apparatus also includes a support mechanism (15, 19, 20, 21, 22, 23) on the body member (12). The support mechanism (15, 19, 20, 21, 22, 23) is movable between a support position (50) in which the tool string or a portion (24) of the tool string is supported on the body member (12), and a release position (52) in which the tool string or portion (24) is released from the body member (12).

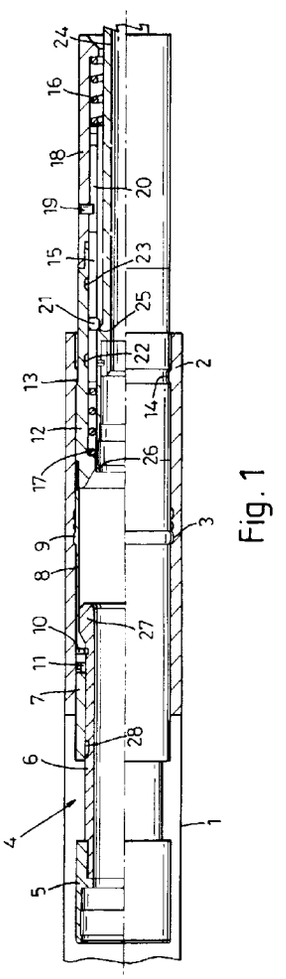

Fig. 1

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Description

The invention relates to a method of and apparatus for assembling a tool string.

Coil tubing is frequently used in boreholes, especially highly deviated boreholes to perform operations within the borehole. It is possible to attach specialised equipment to the end of the coil tubing to perform specific operations in the borehole, such as survey equipment. In general, a number of different tools may be attached to the end of the coil tubing and the attached tools are normally referred to as the "tool string". An advantage of using coil tubing is that because the coil tubing itself is relatively rigid and non-flexible compared with wireline, the coil tubing and attached tool string can be pushed along highly deviated wells, such as horizontal wells. Such operations would generally not be possible with wireline.

However, a disadvantage of coil tubing is that, due to the inflexible nature of the coil tubing and the type of equipment required to insert the coil tubing into a borehole, problems are encountered when trying to insert relatively long tool strings into the borehole due to space limitations. Hence, it may only be possible to use a relatively short tool string with coil tubing.

In accordance with the present invention, a method of assembling a tool string comprises introducing a body member into a borehole and releasably securing the body member to an internal profile in the borehole, supporting a first portion of the tool string to be assembled on the body member to support the said portion in the borehole, introducing a second portion of the tool string into the borehole, coupling the second portion to the first portion to assemble the tool string, and subsequently releasing the assembled tool string from the body member.

In accordance with a second aspect of the present invention, apparatus for assembling a tool string in a borehole comprises a body member, a coupling mechanism on the body member to releasably secure the body member to an internal profile in the borehole, and a support mechanism on the body member, the support mechanism being movable between a support position, in which the tool string or a portion thereof is supported on the body member, and a first release position, in which the tool string or the portion is released from the body member.

The invention has the advantage of permitting a tool string to be assembled within a borehole and is especially, but not solely, useful for assembling tool strings for coil tubing.

Preferably, the internal profile to which the apparatus is releasably secured may take the form of a landing nipple in a tubing string.

Preferably, the body member is tubular with a through bore having a longitudinal axis, which is substantially parallel to the longitudinal axis of the portion of the borehole in which the body member is releasably secured, in use. Typically, the first portion of the tool string is supported within the through bore of the body member and the second portion may enter the through bore to couple to the first portion.

Typically, the support mechanism may include an indexing mechanism to guide the support mechanism between the support position and the first release position. Preferably, the support mechanism is provided with a second release position and typically, the support position is located between the two release positions.

Preferably, the support mechanism may include a first movable member which engages a first shoulder on a tool forming part of the first portion of the tool string when in the support position, and moves out of engagement with the first shoulder when in the first release position. Preferably, the first movable member is biassed to the support position from the first release position.

Preferably, the first movable member is a dog which is typically located in a movable sleeve mounted on the body member.

Typically, a second movable member is provided which engages with a second shoulder on the first portion of the tool string when the support mechanism in the support position, and which moves out of engagement with the second shoulder when the support mechanism is in the first release position or the second release position.

Preferably, the support position and the first release position, and the second release position if present, are aligned in a direction which is substantially parallel to the longitudinal axis of the body member.

Preferably, the second release position is used to aid disassembly of the tool string in order to recover the tool string from the borehole.

Examples of a method of and apparatus for assembling a tool string in accordance with the invention will now be described with reference to the accompanying drawings, in which:-

Fig. 1 is a partial cross-section through a first example of apparatus for assembling a tool string in a first position in a landing nipple in a borehole;
Fig. 2 is a partial cross-section through the apparatus of Fig. 1 in a second position;
Fig. 3 is a partial cross-section through the apparatus of Fig. 1 in a third position;
Fig. 4 is a partial cross-section through the apparatus of Fig. 1 in a fourth position;
Fig. 5 is a side view of an indexing slot for use with the apparatus shown in Figs. 1 to 4;
Fig. 6 is partial cross-sectional view through a second example of apparatus for assembling a tool string in a borehole, shown in a running in configuration; and,
Fig. 7 is a side view of an indexing slot for use with apparatus shown in Fig. 6.

Fig. 1 shows a tubing string 1 located within a bore-

hole and a landing nipple 2 located on the tubing string 1. The landing nipple 2 has an internal profile 3.

Apparatus 4 is located in the landing nipple 2. The apparatus 4 comprises a connection sub 5 which is threadedly coupled to a locking slide 6. The locking slide 6 is located within an upper body member 7 which includes a number of sprung fingers 8 (only one shown). Each of the sprung fingers 8 has a head portion 9 which engages with the internal profile 3 of the landing nipple 2. The upper body member 7 also includes a shear pin 10 and a spring loaded shear pin 11. The upper body member 7 is threadedly coupled at its lower end to a lower body member 12 which has a downwardly facing shoulder 13 on its outer surface which engages with a shoulder 14 on the landing nipple 2. The lower body member 12 has a sleeve slide 15 located within it.

Two helical springs 16, 17 are positioned at either end of the slide 15. A bottom sub 18 is attached to the lower end of the lower body member 12 and mounted on the sub 18 is an indexing pin 19 which engages with an indexing slot 20 formed in the slide 15. The indexing slot 20 is continuous around the slide 15. Located within the sleeve 15 is a dog 21. The lower body member 12 also has two recesses 22, 23 into which the dog 21 may move when the sleeve 15 has moved against the biassing action of either of the springs 17, 16 so that the dog 21 coincides with either of the recesses 22, 23. Also shown in Fig. 1 is the top end of a tool 24 which is to form part of a coil tubing tool string, as will be explained below. The upper end of the tool 24 includes a downwardly facing shoulder 25 which engages with the dog 21 when in the position shown in Fig. 1 and a connector profile 26 which takes the form of an enlarged head on the upper end of the tool 24.

In use, the tool 24 is inserted into the apparatus 4 on the surface and the apparatus 4 with the tool 24 extending from it may be inserted into the tubing string 1 via conventional wireline or coil tubing operations. After being inserted into the tubing string 1, the apparatus 4 is lowered until the shoulder 13 on the lower body member 12 hits shoulder 14 on the landing nipple 2. In this position the heads 9 of the sprung fingers 8 will engage the internal profile 3 on the landing nipple 2. The locking slide 6 is retained in the position shown in Fig. 1 during lowering of the assembly into the tubing string 1 by means of the shear pin 10 which locks the locking slide 6 to the upper body member 7.

After the position shown in Fig. 1 is obtained, a downward force, for example by use of a jar mechanism, is applied to the connection sub 5 and locking slide 6 to shear the shear pin 10. This then permits the locking slide 6 to move to the position shown in Fig. 2, in which the connection sub 5 abuts against the top end of the upper member 7 and locking heads 27 of the locking slide 6 abut against the heads 9 of the sprung fingers 8 to prevent the heads 9 becoming disengaged from the internal profile 3. In this position, the sprung shear pin 11 can extend into recess 28 in the locking slide 6 to retain the locking slide 6 in the position shown in Fig. 2.

During this operation the tool 24 is supported in the apparatus 4 by means of the locking dog 21 which abuts against shoulder 25 on the tool 24.

After the apparatus 4 has been locked into the landing nipple 2, the wireline or coil tubing used to run the apparatus 4 into the landing nipple is disconnected from the connection sub 5 and retrieved to the surface.

The coil tubing to which the tool string is to be attached is prepared and the desired upper portion of the tool string is attached to the lower end of the coil tubing and inserted into the tubing string 1 in a conventional manner. The upper portion of the tool string is then lowered on the end of the coil tubing until a connection sub 29 on the lower end of the upper portion of the tool string contacts the top end of the tool 24. The connection sub 29 includes a lower mandrel 30 which engages with the central bore of the tool 24. The outer shape of the mandrel 30 is preferably non-circular and the central bore of tool 24 is also non-circular to prevent the mandrel 30 rotating with respect to the tool 24. Threadedly attached to the lower mandrel 30 is a central body member 31 and threadedly coupled to the other end of the central body member 31 is an upper sub 32. Slidably located on the outside of the central body member 31 is a sleeve 33 to which is attached a number of sprung fingers 34 with engagement heads 35. The coil tubing and the connection sub 29 is lowered until it reaches the position shown in Fig. 3. In this position, the heads 26 and 35 abut against each other and further downward movement of the connection sub 29 causes the fingers 34 and sleeve 33 to remain stationary with respect to the landing nipple 2, as the head 26 pushes the sprung fingers 34 and sleeve 33 against the action of the spring 36 as the lower mandrel 30 moves further into the tool 24 and the connection sub 32 and central body member 31 move downwards. This downward movement of the central body member 31 while the fingers 34 remain stationary with respect to the landing nipple 2 permits the heads 35 on the fingers 34 to enter recess 37 in the central body member 31. The heads 35 when in this position then ride underneath the head 26 and move to the position shown in Fig. 4 in which the connection sub 29, and therefore the upper portion of the tool string attached to the lower end of the coil tubing, is coupled to the tool 24 by means of the heads 26, 35.

The configuration of the indexing slot 20 is shown schematically in Fig. 5. In the positions shown in Figs. 1 to 4, the indexing pin 19 is at position 50. Prior to inserting the tool 24 into the apparatus 4 and the weight of tool 24 being supported by dog 21, the pin is in an unloaded equilibrium position 49. When the weight of the tool 24 is applied to dog 21, pin 19 moves along the slot 20 in the slide 15 to position 50. After the position shown in Fig. 4 is reached an upward force is applied to the coil tubing so that the head 35 pulls against the head 26. This removes weight from the dog 21 and permits the slide 15 to return to its equilibrium position which

moves the indexing pin 19 along slot 20 to the position 51 shown in Fig. 5.

Setting down weight on the coil tubing then forces the tool 24 downwards against the dog 21 which moves the indexing pin 19 along slot 20 to position 52. In this position the dog 21 is adjacent recess 23, and force exerted downwardly by the shoulder 25 on the dog 21 causes the dog 21 to enter the recess 23 thereby permitting the tool string to pass down through the apparatus 4 into the tubing string below the nipple 2. After the tool string has cleared the body member 4, the spring 16 pushes the slide 15 back towards its equilibrium position and pin 19 moves to position 53.

The operator may then carry out the desired operations in the borehole using the assembled tool string.

In order to retrieve the tool string from the borehole the coil tubing is reeled in until the head 26 contacts the lower side of the dog 21. Further upward movement of the tool string then causes the head 26 to push the dog 21 and slide 15 upwards and pin 19 moves further up slot 20 to position 54. In this position the dog 21 moves into recess 22 thereby permitting the head 26 to pass the dog 21. The dog 21 moves out of the recess 22 and the slide 15 returns to its equilibrium position when the shoulder 25 has cleared the dog 21 in an upwards direction. This corresponds to pin 19 moving along slot 20 to return to position 49. Setting weight down on the coil tubing string then causes the shoulder 25 to engage with the shoulder 21 and move to the position shown in Figs. 1 to 4 in which the shoulder 21 supports the weight of the tool string. In this position, the pin 19 has moved to position 50.

At this point in the operation, fluid is pumped into the coil tubing at a high enough pressure to open ports 38 in the central body member 31 which permit fluid to enter the fluid cavity 39. The pressure of the fluid entering the fluid cavity 39 causes the fingers 34 and slide 33 to move against the action of spring 36 so that the head 35 of fingers 34 enter recess 37 in the central body member 31 at which point the upper portion of the tool string and connector 29 may be removed from the upper end of the lower portion of tool 24. After the upper portion of the tool string has been removed from the upper end of tool 24, the tool 24 is supported by locking dog 21 on the apparatus 4.

After the coil tubing and upper portion of the tool string is removed from the tubing string coil tubing may then be rerun into the hole or wireline run into the hole to engage the connector sub 5. Upward jarring on the connector sub 5 then shears pin 11 and further upward movement exerted on the connection sub 5 moves the locking slide 6 and heads 27 to the position shown in Fig. 1. This permits the sprung fingers 8 to deflect inwards, on further upward force, so that the apparatus 4 and tool 24 may be removed from the nipple and retrieved up the tubing string and out of the borehole. When the tool 24 is removed from the apparatus 4, the slide 15 reverts to its equilibrium position and pin 19 moves to position 51.

Fig. 6 is a partial cross-sectional view through a second example of apparatus 60 for assembling a tool string in a landing nipple in a bore hole. The apparatus 60 comprises a deployment tool 61 which is connected to a running tool 62 for running the deployment tool and setting the deployment tool in a nipple in a borehole. Also shown in Fig. 6 is the top end of a tool 71 which is to form part of a coil tubing tool string, as explained below. The deployment tool 61 is substantially the same as the apparatus 4 described above in Figs. 1 to 5. The main difference between the deployment tool 61 and the apparatus 4 is that the deployment tool 61 includes a pair of dogs 63, 64 on a slide 65 which slides within a lower body member 66 which has three locking dog recesses 67, 68, 69. In addition, an indexing slot 70 (see Fig. 7) in slide 65 has a different configuration to the indexing slot 20. The parts of the deployment tool 61 which are the same as the apparatus 4, have been given the same reference numerals.

The upper end of the tool 71 has two shoulders 72, 73 which are supported by dogs 63, 64, respectively.

An advantage of the deployment tool 61 is that by providing two support dogs 63, 64 and a modified indexing slot 70, additional security is provided to help prevent tool 71 falling into the bore hole in the event that the upper end of the tool 71 is not properly engaged with an upper tool prior to tool 71 being released from engagement with the dogs 63, 64.

In use, the apparatus 60 and the deployment tool 61 are used in a similar manner to the apparatus 4. The tool 71 is inserted into the deployment tool 61 on the surface and the deployment tool 61 with the tool 71 is inserted into the tubing string via the running tool 62 using conventional wireline or coil tubing. The deployment tool 61 is set in a landing nipple in the same manner as for the apparatus 4 described above.

However, with the deployment tool 61, the pin 19 is initially in position 75 in slot 70 (see Fig. 7) and moves to position 76 when the weight of the tool 71 is supported by the dogs 63, 64. After the second tool has been run into the hole and engaged with the upper end of tool 71, an overpull is applied to the coil tubing to ensure that tools 71 and the second tool are properly connected. During the overpull, the pin 19 moves to the position 77. After the overpull has been applied and there is confirmation that the tools are connected together, weight is set down on the tool 71 to move the pin 19 to the position 78 in slot 70. A further pull upwards on the coil tubing removes the weight of tool 71 from the dogs 63, 64 and permits the pin 19 to move to position 79 in the slot 70. Setting weight down on tool 71 then moves pin 19 to position 80 in which the locking dogs 63, 64 may enter the recesses 69, 68, respectively. This releases the tool 71 from engagement with the deployment tool 61 and permits the tool string to be run into the hole below the nipple to which the deployment tool 61 is secured. During retrieval of the tool string, the operation is the same

as that described above for the apparatus 4 and position 81 in the slot 70 corresponds to position 54 in the indexing slot 20 for the apparatus 4.

In addition, both the apparatus 4 and the deployment tool 61 may be used for multiple connections of coil tubing tools. In the case of the apparatus 4, a shoulder 25 is provided on the upper end of each tool to be connected. Hence, after the lower tool 24 has passed through the dog 21, the dog 21 is free to return to the equilibrium position. The weight of the tool above applied to the dog 21 through the shoulder 25 on the tool above will then cause the pin 19 to move to position 50 and further tool or tools may be connected to the tool now supported by the dogs 21. In the case of the apparatus 60, support shoulders 72, 73 are provided on the upper end of each connecting tool. Hence, after the lower tool 71 has passed through the dogs 63, 64, the dogs 63, 64 will be free to return to the equilibrium position and the next support shoulders on the tool above the tool 71 engage with the dogs 63, 64. This causes the pin 19 to move to position 76 via equilibrium position 75. In this manner the deployment tool 61 can be used to connect a number of coil tubing tools together.

The invention has the advantage of permitting relatively long tool strings which could not normally be used with coil tubing, to be used with coil tubing by assembling the tool string within the borehole.

Modifications and improvements may be made without departing from the scope of the invention.

Claims

1. Apparatus for assembling a tool string in a borehole (1) comprising a body member (12), a coupling mechanism (6, 7, 8, 9) on the body member (12) to releasably secure the body member (12) to an internal profile (3) in the borehole (1), and a support mechanism (15, 19, 20, 21, 22, 23) on the body member (12), the support mechanism (15, 19, 20, 21, 22, 23) being movable between a support position, in which the tool string or a portion (24) thereof is supported on the body member (12), and a first release position, in which the tool string or portion is released from the body member (12).

2. Apparatus according to claim 1, wherein the support mechanism (15, 19, 20, 21, 22, 23) includes an indexing mechanism (19, 20) to guide the support mechanism between the support position and the first release position.

3. Apparatus according claim 1 or claim 2, wherein the support mechanism (15, 19, 20, 21, 22, 23) includes a first movable member (21) which engages a first shoulder (25) on a tool (24) forming part of the tool string when the support mechanism is in the support position, and which moves out of engagement with the shoulder (25) when the support mechanism is in the first release position.

4. Apparatus according to claim 3, the apparatus further comprising a biassing device (16, 17) to bias the support mechanism (15, 19, 20, 21, 22, 23) to the support position from the first release position.

5. Apparatus according to claim 3 or claim 4, wherein a second movable member (64) is provided which engages a second shoulder (73) on the tool (71) forming part of the tool string when the support mechanism is in the support position, and which moves out of engagement with the second shoulder (73) when the support mechanism is in the release position.

6. Apparatus according to any of the preceding claims, wherein the support mechanism is movable between the support position and a second release position.

7. Apparatus according to claim 6, wherein the second release position permits the tool string to pass through the support mechanism prior to supporting the tool string for disassembly of the tool string.

8. Apparatus according to claim 6 or claim 7, wherein the support position is located between the first and the second release positions.

9. Apparatus according to any of the preceding claims, wherein the tool string is a coiled tubing tool string.

10. A method of assembling a tool string comprising introducing a body member (12) into a borehole (1) and releasably securing the body member (12) to an internal profile (3) in the borehole (1), supporting a first portion (24) of the tool string to be assembled on the body member (12) to support the said portion (24) in the borehole (1), introducing a second portion (32) of the tool string into the borehole (1), coupling the second portion (32) to the first portion (24) to assemble the tool string, and subsequently releasing the assembled tool string from the body member (12).

11. A method according to claim 10, the method further comprising pulling upwardly on the tool string after the second portion (32) has been coupled to the first portion (24) and releasing the upward pull before subsequently releasing the assembled tool string from the body member (12).

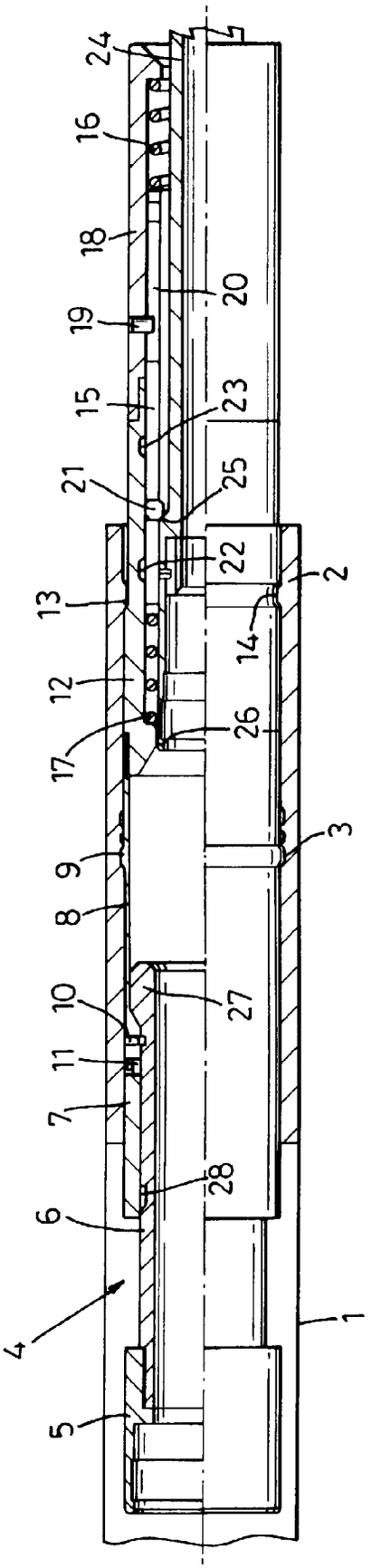
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Fig. 1

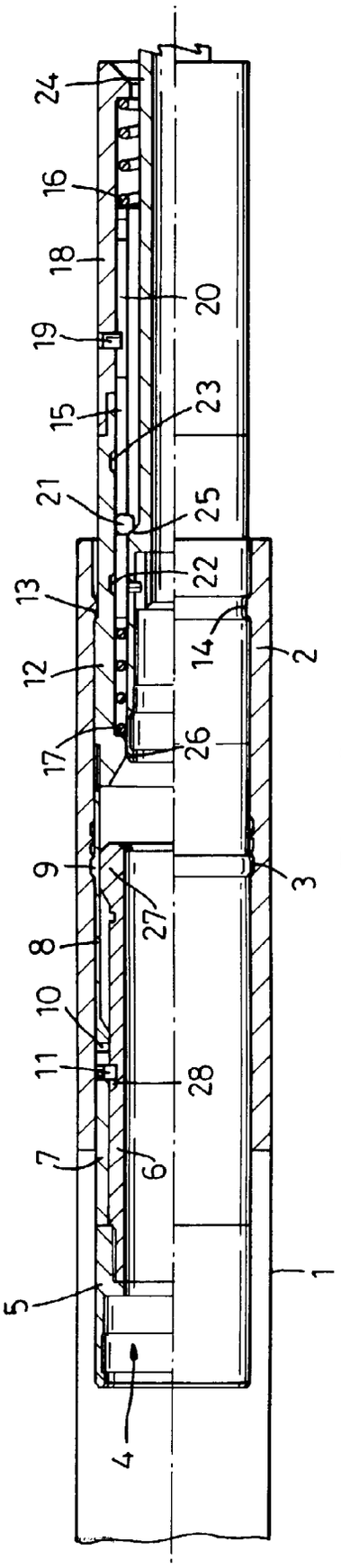
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Fig. 2

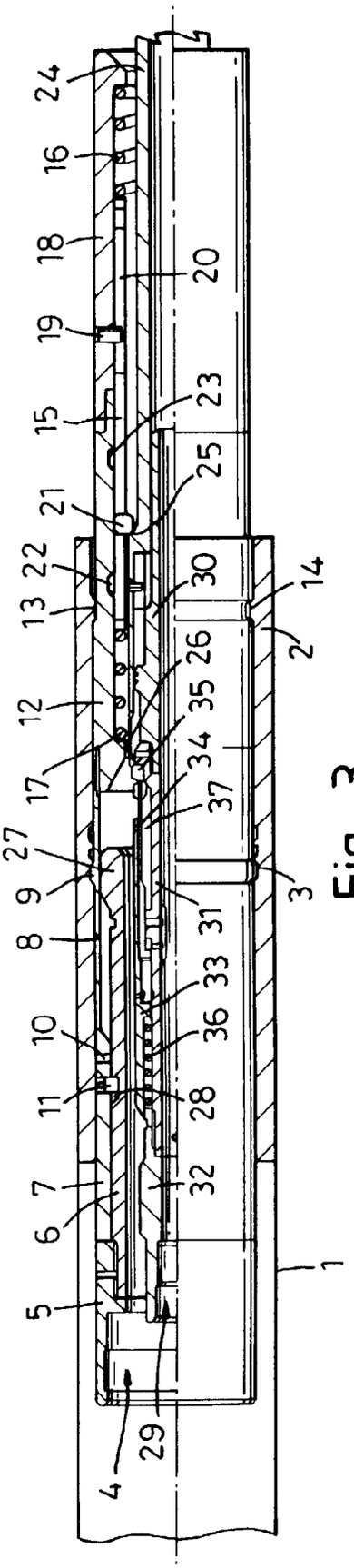
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Fig. 3

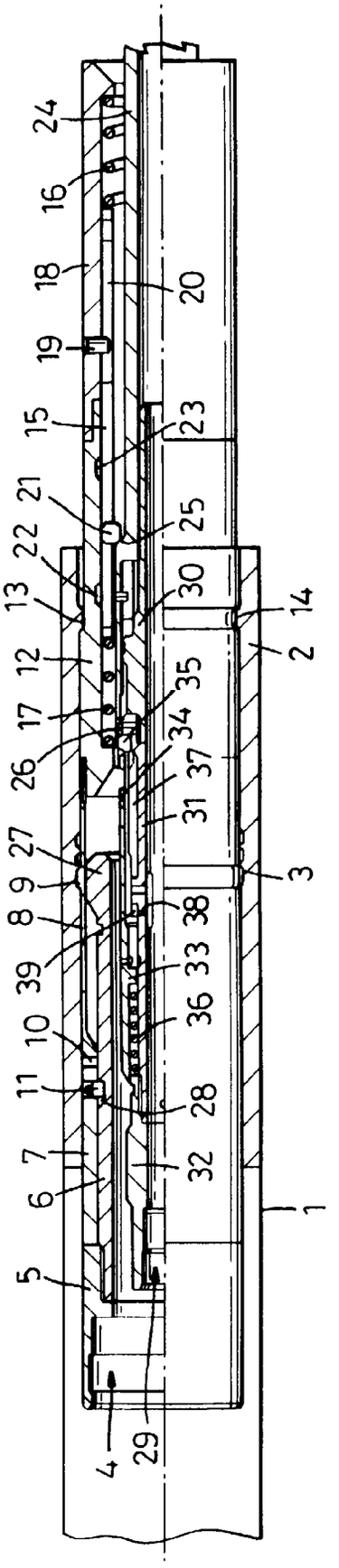
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Fig. 4

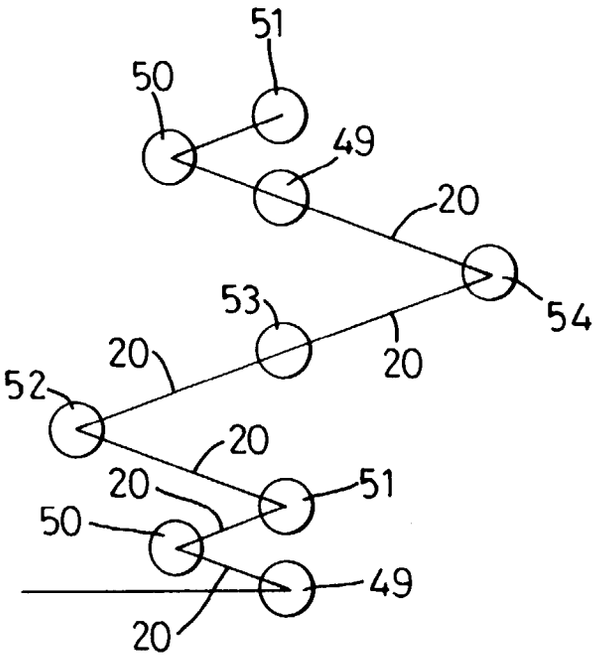

Fig. 5

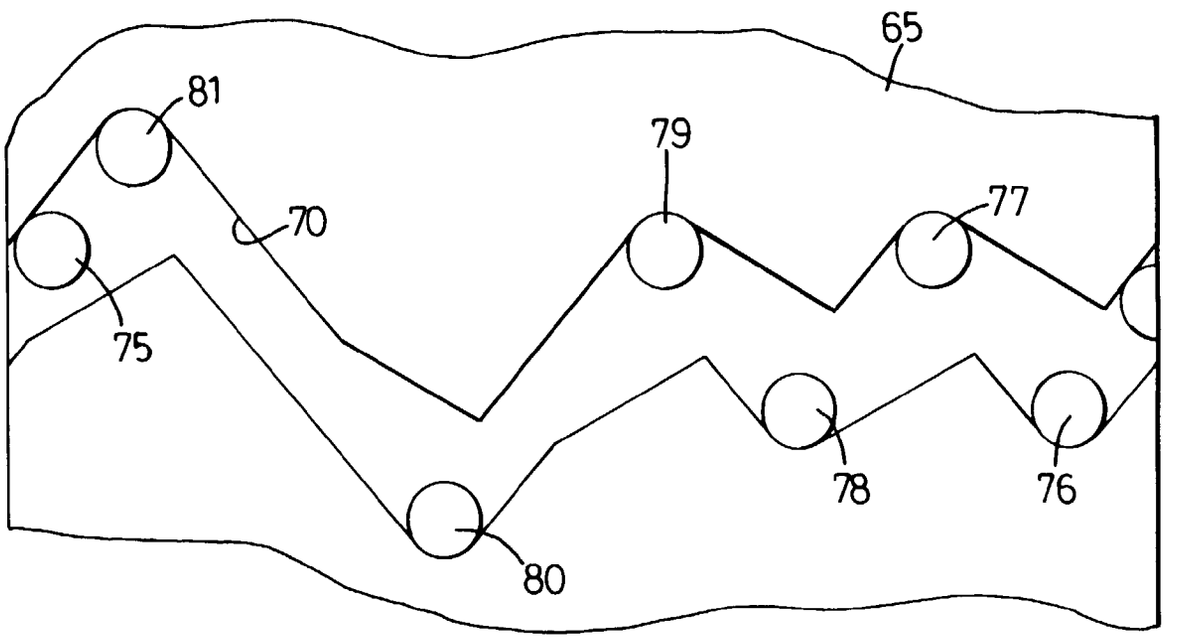

Fig. 7

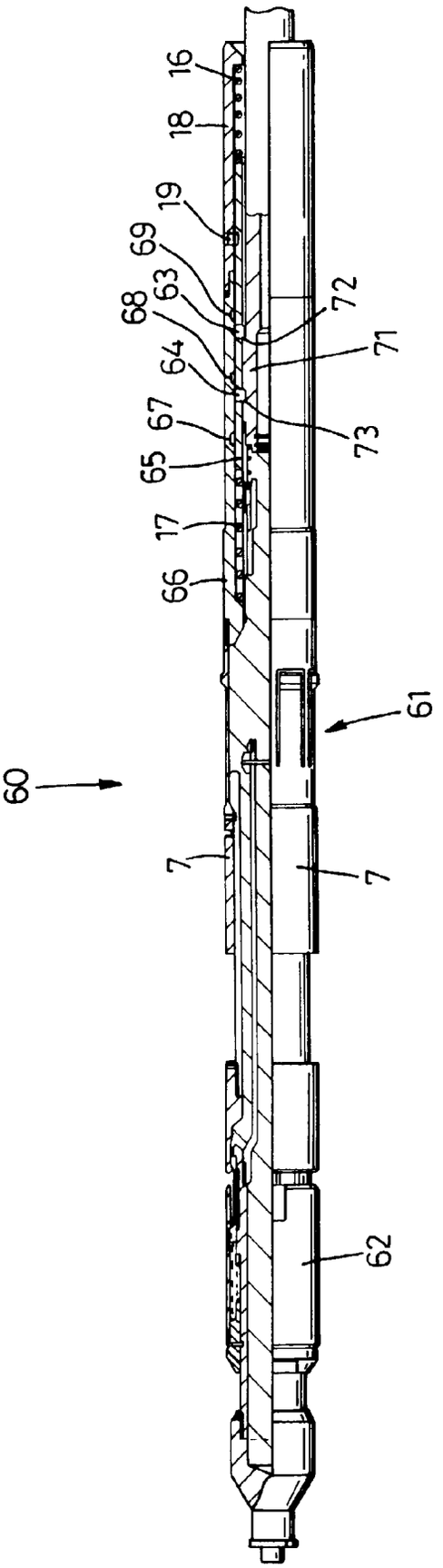

Fig. 6