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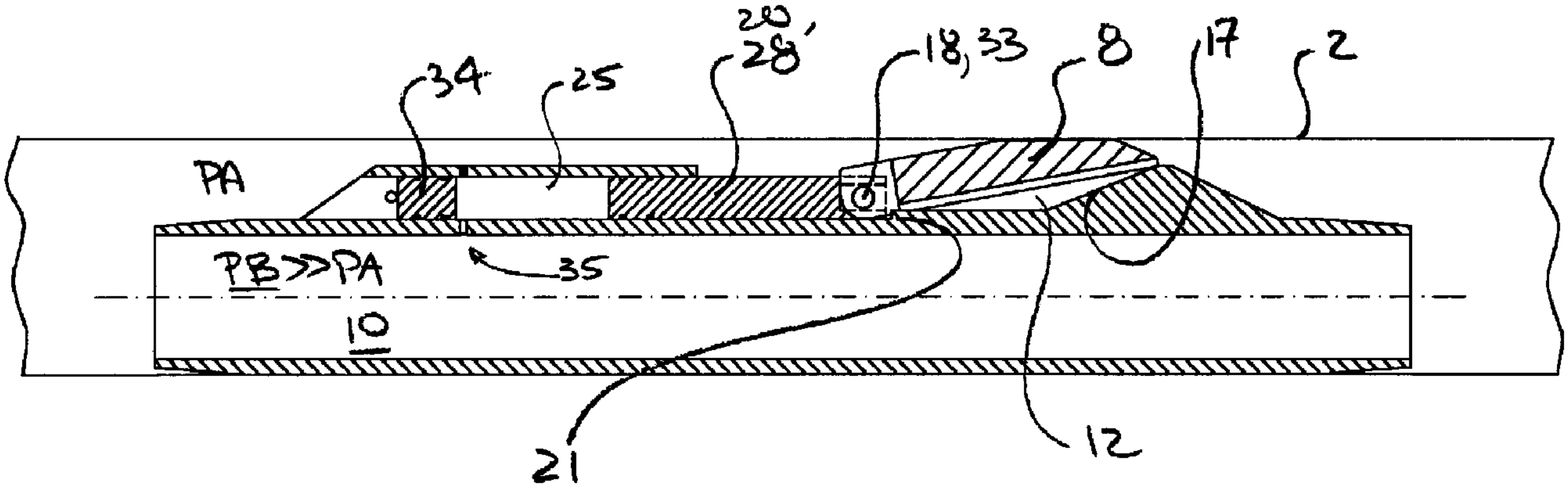
(54) Title: ROTARY PUMP STABILIZER



(57) Abrégé/Abstract:
Apparatus is provided for stabilizing a rotary or progressive cavity pump suspended from production tubing. The stabilizing apparatus is connected to the pump and comprises a tubular body having a contiguous wall, a longitudinal bore contiguous with the production tubing and a sliding dog disposed in a longitudinal pocket formed in the exterior of the tubular body. One or more longitudinal piston bores are formed within the cylindrical wall and each contains a longitudinally movable piston. Each piston extends into the pocket and pivotally connects to the sliding dog. The piston bore is connected to the longitudinal bore. In operation, fluid pressure drives the pistons, actuating the sliding dog and driving the dog radially outwards to brace against the casing, the radial force produced being proportional with the fluid pressure. Under de-pressurized conditions, upward drag on the sliding dog compresses the pistons, retracting the dog, and permits removal of the tool and pump.

"ROTARY PUMP STABILIZER"

ABSTRACT OF THE DISCLOSURE

Apparatus is provided for stabilizing a rotary or progressive cavity pump suspended from production tubing. The stabilizing apparatus is connected to the pump and comprises a tubular body having a contiguous wall, a longitudinal bore contiguous with the production tubing and a sliding dog disposed in a longitudinal pocket formed in the exterior of the tubular body. One or more longitudinal piston bores are formed within the cylindrical wall and each contains a longitudinally movable piston. Each piston extends into the pocket and pivotally connects to the sliding dog. The piston bore is connected to the longitudinal bore. In operation, fluid pressure drives the pistons, actuating the sliding dog and driving the dog radially outwards to brace against the casing, the radial force produced being proportional with the fluid pressure. Under de-pressurized conditions, upward drag on the sliding dog compresses the pistons, retracting the dog, and permits removal of the tool and pump.

"ROTARY PUMP STABILIZER"

FIELD OF THE INVENTION

The invention relates to a dynamic pressure-responsive tool used for the stabilization tools suspended from production tubing, said tools being subject to undesirable lateral movement, more particularly tools subject to vibration in operation such as progressive cavity pumps.

BACKGROUND OF THE INVENTION

Apparatus are known for stabilizing various well tools which are suspended at the bottom of a production tubing string. An example of a tool which would benefit from stabilization is a rotary or progressive cavity pump ("PC pump"). A PC pump is located within an oil well, positioned at the bottom end of a production tubing string which extends down the casing of the well. The pump pressurizes well fluids and drives them up the bore of the production tubing string to the surface. The pump comprises a pump stator coupled to the production tubing string, and a rotor which is both suspended and rotationally driven by a sucker rod string extending through the production tubing string bore. The stator is held from reactive rotation by a tool anchored against the casing. Usually this anti-reactive, or no-turn tool is located at the base of the stator. Typically a no-turn tool applies serrated slips to grip against the casing.

The rotor is a helical element which rotates within a corresponding helical passage in the stator. Characteristically, the rotor does not rotate concentrically within the stator but instead scribes a circular or elliptical path. This causes vibration and oscillation of the sucker rod, the pump's stator and the tubing attached thereto.

The greater the pump flow, the greater is the vibration. This can lead to loosening of the slips and functional failure of the no-turn tool. Other problems include fatigue failure of the connection of the stator to the tubing or nearby tubing-to-tubing connections.

In the prior art, bow springs have typically been used to centralize and stabilize the stator and the supporting tubing. By design, the bow springs are radially flexible, in part to permit installation and removal through casing. Unfortunately, the spring's flexibility permits cyclic movement, resulting in fatigue and eventual failure of the springs.

Unitary tubing string centralizers generally position the tool in a concentric or central position in the well. While these centralizers may provide a positioning function, they are not effective as a tool-stabilizing means. The known centralizers are passive devices and do not actively contact the casing.

More sophisticated apparatus are known which more positively secure and position tools within a well. For example, in U.S. Patent 2,490,350 to Grable, a centralizer is provided using mechanical linkages which lock radially outwardly to engage the casing. Each of a plurality of two-bar linkages is held tight to the outside of the tubing string with a retaining bolt. A longitudinal spring and longitudinal ratchet are arranged external to the tubing for pre-loading of one link with the potential to jack-knife the linkage outwardly, except for the restraining action of the retaining bolt. A radial plunger extends through the tubing wall to contact the linkage. The plunger has limited stroke. When the tubing string bore is pressurized, the plunger urges the linkage sufficiently outwardly to break the retaining bolt, permitting the spring to drive the linkage radially outwardly. The driven link engages the ratchet, ensuring the linkage movement is uni-directional.

In U.S. Patent 4,960,173 to Cognevich, a tubular housing is also disclosed having mechanical linkages which are held tight to the housing during installation. The linkages are irreversibly deployed upon melting of a fusible link at downhole conditions. An annular compression spring actuates a telescoping sleeve which deploys a four-bar linkage and forcibly holds the linkage against the casing wall. Rollers on the ends of two of the linkages contact the casing wall for aiding in limited longitudinal movement of the tubular housing once the linkages are deployed. Gradual radial adjustment of the linkage is permitted by a fluid bleed to permit the telescoping sleeve to slowly retract during this movement. If the bleed fails and additional radial movement is continues, a pin will shear, fully releasing the telescoping sleeve and linkage from the compression spring.

In summary, both Grable and Cognevitch disclose apparatus which:

- rely upon compression spring force alone to drive and hold the linkages radially outwardly;
- do not deploy or extend the linkage until after installation on the casing;
- result in an irreversible deployment; and

- in the case of Grable, do not permit movement or removal without damage to the linkage, and in the case of Cognevitch, limited movement is permitted but if the linkage cannot accept the movement required, a jarring action will shear a pin and irreversibly separate the compression spring from the linkage.

Therefore, for well tools which require secure stabilization within the casing, there is a demonstrated need for a device which is capable of providing a stabilizing force which is greater than that provided by spring force alone, yet is still capable of being moved within or removed from the casing without irreversible damage to the apparatus.

SUMMARY OF THE INVENTION

Stabilizing apparatus is provided for securely stabilizing downhole tools suspended from a production tubing string containing fluid under varying pressure. Such a tool is associated with or is the source of lateral movement within the casing.

The novel apparatus utilizes fluid pressure to actively and forcefully stabilize the tool. No springs are required for its actuation or release. Further, when the fluid pressure diminishes, such as when no fluid is being produced, the apparatus may be readily repositioned, repeatably installed or removed without irreversible alteration of the apparatus or peripheral damage. The apparatus is dynamically responsive so as to provide greater stabilizing force at higher fluid pressures, for instance, in the case of a PC pump tool, when the pump is pumping more vigorously.

In a broad aspect of the invention, stabilizing apparatus is connected to a well tool, such as a PC pump, suspended from the bottom of a production tubing. The apparatus comprises a tubular body having an enclosing wall and a longitudinal bore contiguous with that of the production tubing string. A sliding dog is recessed within the tubular body. The sliding dog is attached pivotally to one or more pistons, housed and moveable within piston bores formed in the cylindrical wall of the tubular body. When actuated longitudinally, the pistons drive the sliding dog upward to contact and be driven up a ramp so as move radially so as to contact and brace against the casing. The piston's bore is connected to the longitudinal bore so that it is pressurized dynamically with fluid. As the fluid pressure actuates the sliding dog radially outwards, the radial force is proportional with the fluid pressure.

BRIEF DESCRIPTION OF THE DRAWINGS

Figure 1 is cross-sectional view of the lower end of a well casing with the stator of a PC pump suspended from production tubing and anchored to the casing, the pump having a stabilizer of the present invention connected thereabove for stabilizing the pump and tubing within the casing;

Figure 2 is a partially exploded perspective view of an embodiment of the stabilizer. A portion of the stabilizer is cut-away to illustrate the sliding dog;

Figure 3 is a cross-section side view of the stabilizer of Fig. 2, showing the sliding dog in the non-actuated position; and

Figure 4 is a cross-sectional side view of the stabilizer of Fig. 2 showing the sliding dog in the actuated position.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

Having reference to Fig. 1, a stabilizer 1 is located within the bore of the casing 2 of a completed oil well 3. The stabilizer 1 is connected to a downhole well tool such as a rotary pump. Shown in this embodiment, the stabilizer 1 is connected co-axially and in-line to the stator 4 of a progressive cavity pump ("PC pump") 5. The PC pump is located within the well casing 2. The PC pump is suspended from a production tubing string (not shown) by connection through the stabilizer 1. In operation, the PC pump 5 pressurizes well fluids and directs them up the bore of the production tubing string to the surface.

In the context of a PC pump, its stator 4 is secured against reactive torque rotation in the casing 2. While not shown, it is understood that the stator 4 is secured using a no-turn tool usually positioned at the lower end of the PC pump. The rotor of the PC pump 5, which is not shown would be typically suspended and rotationally driven from a sucker rod, also not shown.

Referring also to Fig. 2, the stabilizer 1 comprises a tubular body 7, a sliding dog 8 and fluid-pressure actuating means 9. The tubular body 7 has a longitudinal bore 10 extending therethrough for passing pressurized well fluids pumped from the PC pump 5, through bore 10 and up the production tubing string to the surface. The longitudinal bore 10 through the body 7 forms a contiguous wall annular wall 11 for separating the bore 10 from the casing 2. In Figs. 2 – 4 the bore 10 is eccentric within the tubular body 7 for providing a thickened wall portion 11b in which the pocket 12 is formed.

The sliding dog 8 is radially extendible to engage the casing 2 (Figs. 1 and 4). Fluid pressure PB in the bore 10, being greater that the pressure PA existing outside the stabilier 1, forcibly actuates and braces the sliding dog against the casing 2 and substantially arrest oscillatory movement of the PC pump stator 4. The bracing of the dog 8 against the casing 2 thereby jams the tubular body 7 against the opposing side of the well casing 2.

In greater detail and having reference to Figs. 2, 3, and 4, the stabilizer 1 comprises the tubular body 7 having a sliding dog 8. As shown in Fig. 3 and 4, the sliding dog 8 is operable between a retracted position (Fig. 3) within the body 7 and a radially extended position (Figs. 1,4) for engaging the casing 2.

A single, longitudinally extending pocket 12 is formed in cylindrical wall 11, extending radially inwardly or recessed from the outer surface 13 of the body 7. The pocket 12 has a first and second end 14,15. The first, downhole end 14 has a radial, closed face and the second uphole surface end 15 is sloped. The pocket has a floor 16. An inclined ramp 17 is formed at the pocket's second end 15, rising from the floor 16 up to the outer surface 13 of the body 7. One or more longitudinally extending stops 21 are formed on the pocket's floor 16 preceding the ramp 17. Grooves 22 are formed in the base of the sliding dog 8 and size correspondingly for enabling sliding passage over the stops 21.

A pivot point 18 pivotally connects the sliding dog 8 to a linear actuating member 20.

Having reference to Fig. 3, before actuation, in the non-pressurized, rest position shown in Fig. 3, the sliding dog 8 resides within the pocket 12.

As shown in Figs. 1 and 4, when the bore 10 is pressurized for actuation (PB>>PA), the actuating member 20 is advanced longitudinally along pocket 12 for driving the sliding dog 8 against ramp 17. The ramp 17 deflects the dog 8 radially outward as it pivots relative to the actuating member 20. Eventually, as the actuating member 20 extends, the sliding dog 8 radially contacts and braces against the casing 2.

If the casing 2 is damaged or too large for the stabilizer 1 used, the dog 8 may not engage the casing and risk over extension of the actuating member 20. In such cases, the stops 21 block the actuation member from further extension.

The actuation of the sliding dog 8 is performed with pressure-actuating means 9. The actuating member 20 is an arrangement of one or more pistons and piston bores. More particularly, longitudinally-extending piston bores 25 are formed within the cylindrical wall 11.

Each piston bore 25 has a first end 26 opening into the pocket's first end 14. The piston bore 25 is blocked at its second end 27. A piston 28 is disposed in each piston bore 25 and is longitudinally movable between the bore's first and second ends 26, 27. The stops 21 in the pocket 12 act to arrest the pistons' outward movement.

A double O-ring seal 29 is fitted to the pressure end 30 of the piston 28. The piston 28 extends from the first end 26 of the piston bore 25 and into the pocket. The pocket end of the piston 28 is fitted with a pivot point 32 for connection with the dog's pivot point 18 using pin 33. The pin 33 may be designed to shear at emergency retrieval forces, far above that experienced during service.

The second end of the piston bore 27 is closed with cylindrical plugs 34. Each plug is fitted with double O-ring seals 35 for forming a pressure chamber 36 within the piston bore 25, located between the plug 34 and the pressure end of the piston 28. The pressure chamber 36 communicates with the longitudinal bore 10 through ports 35 drilled through cylindrical wall 11.

Preferably the tubular body 7 is cast in one piece. The pocket is recessed into wall 11, such as being cast in place or formed through a process such as milling. The piston bores 25 are drilled into the cylindrical wall of the stabilizer from the downhole end of the stabilizer through to the first end 14 of the pocket 12. Ports 35 are drilled through the cylindrical wall 11 and into the longitudinal bore 10. The unused portion of ports 35, extending from the wall's outer surface 13 into the piston bore 25 is subsequently sealed off, retaining the port between the piston bore 25 and the longitudinal bore 10. The pistons 28 are placed into their bores 25 with the double O-ring seal 29 slightly uphole of ports 35. The plugs 34 block the piston bore 25 from the annulus between the well casing 2 and the stabilizer 1. The plugs 34 form the pressure chambers and are held in place with a stop pin 37.

The pressure actuating means 9 is provided as dynamic means which makes the stabilizing capability stronger as the fluid pressure PB in the longitudinal bore 10 increases.

The pressure actuating means 9 comprises the piston 28, the piston bore 25, and the port 35 between the piston and longitudinal bores 25,10. As shown in Fig. 3, when the PC pump operates, the resulting fluid pressure PB within the longitudinal bore 10 is raised above the pressure PA outside the stabilizer 1, the differential pressure (PB-PA) causing the piston 28 to advance towards the first end 26, actuating the sliding dog 8.

The greater is the fluid pressure PB in the bore 10, the greater is the differential pressure (PB-PA), the greater is the force applied to the pistons 28 and the greater is the force applied by the sliding dog against the casing 2. Serendipitously, as the PC pump works harder and results in greater vibration, the bore pressure PB also increases and the sliding dog 8 provides even greater stabilizing force.

In an example case where each piston 28 and piston bore 25 are 1 inch in diameter, differential fluid pressures (PB-PA) of 2000 psi(g) result in actuating forces of 1500 pounds, and radial forces of 7500 pounds being applied against the casing wall.

When it is necessary to move or remove the downhole tool or stabilizer 1 from the casing 2, the pressure is reduced in the longitudinal bore 10. In the case of a PC pump 5, pumping is stopped and the pressure differential between the bore and the casing annulus falls (PB substantially equals PA). The actuating means 9 goes slack and the force of the sliding dog 8 against the casing 2 drops, releasing the dog and enabling movement of the stabilizer 1. When the stabilizer is being removed from the casing, upward movement drags the dog against the casing, forcing the dog 8 back into the pocket 12 (Fig. 4), forcing the pistons 28 back in their bores 25, and ensuring a snag-free profile or line for ease of removal.

THE EMBODIMENTS OF THE INVENTION IN WHICH AN EXCLUSIVE PROPERTY OR PRIVILEGE IS CLAIMED ARE DEFINED AS FOLLOWS:

1. Apparatus for stabilizing a well tool within a subterranean casing, the well tool being suspended from a production tubing string having a bore and pressurized well fluid therein comprising:

a body having a tubular wall and a longitudinal bore extending therethrough which is in communication with the fluid in the production tubing and being connected to the well tool;

one or more recessed pockets formed in the wall and having an uphole end formed with a radially outwards extending ramp;

a radially extendable sliding dog disposed within each pocket;

one or more piston bores formed longitudinally within the wall, each piston bore having a first downhole end in fluid communication with the longitudinal bore and a second end open to the one or more pockets;

a piston longitudinally movable within each piston bore and having an uphole end which extends into the pocket and which is pivotally connected to the sliding dog so that fluid pressure within the longitudinal bore pressurizes each piston bore and causes each piston to advance uphole, driving the sliding dog longitudinally to and radially outwardly along the ramp to contact the casing, the sliding dog bracing against the ramp for bracing against the casing and stabilizing the well tool, the force of contact being proportional to the fluid pressure in the longitudinal bore.

2. The apparatus as cited in claim 1 wherein the well tool being stabilized is a fluid pump which pressurizes fluid within the longitudinal bore.

3. The apparatus as cited in claim 2 wherein the pump is a rotary pump.

4. The apparatus as cited in claim 2 wherein the pump is a progressive cavity pump.

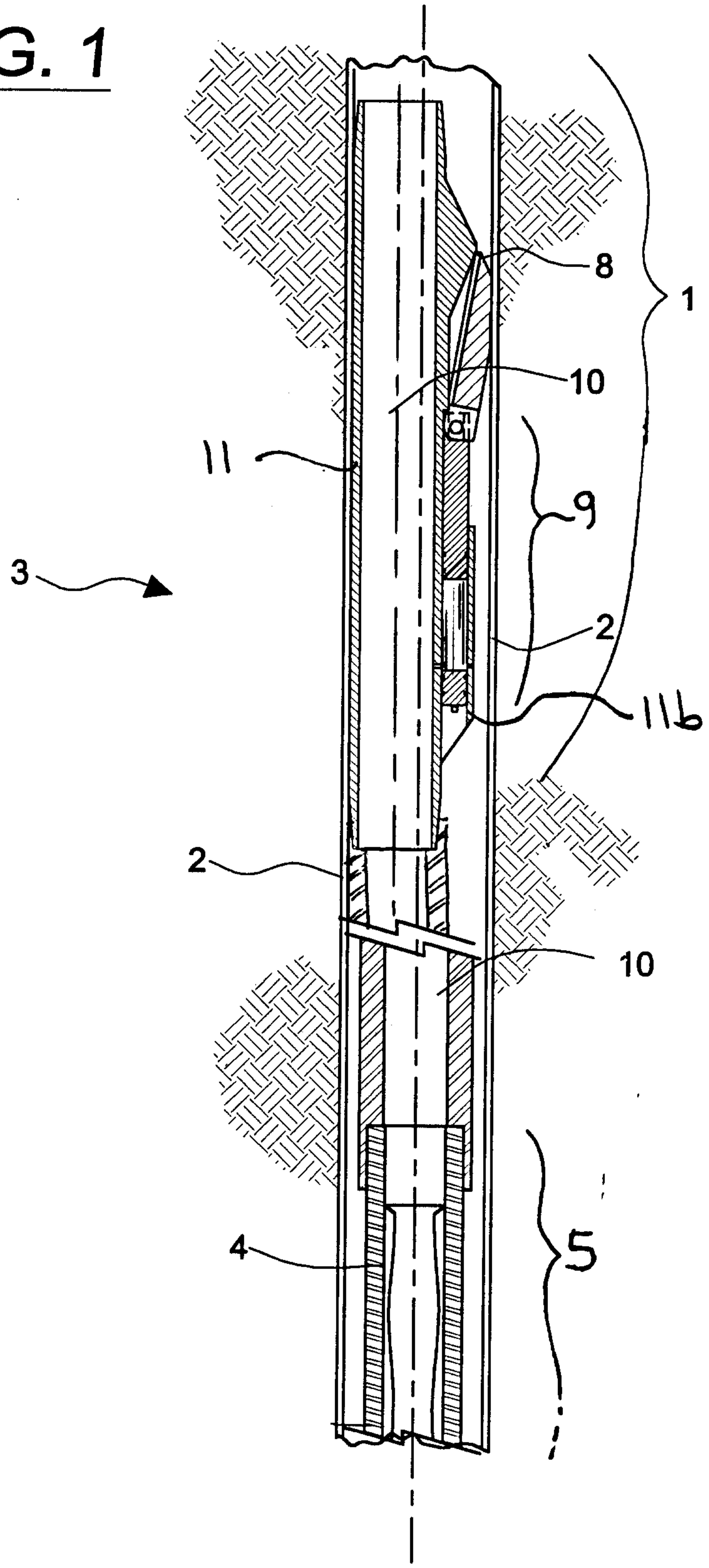
5. The apparatus as cited in claim 2 wherein there is one pocket and when the sliding dog bears against the casing the body bears against the casing opposing the pocket.

6. The apparatus as cited in claim 5 wherein there are two piston bores and pistons disposed and longitudinally movable for each pocket.

7. The apparatus as cited in claim 6 wherein each piston is sealed within its piston bore using O-rings positioned therebetween.

8. The apparatus as cited in claim 7 wherein each pocket has a stop formed therein for preventing overadvancement of the piston from its bore, the sliding dog having corresponding grooves on its underside for passing slidably over the stop of the pocket.

FIG. 1



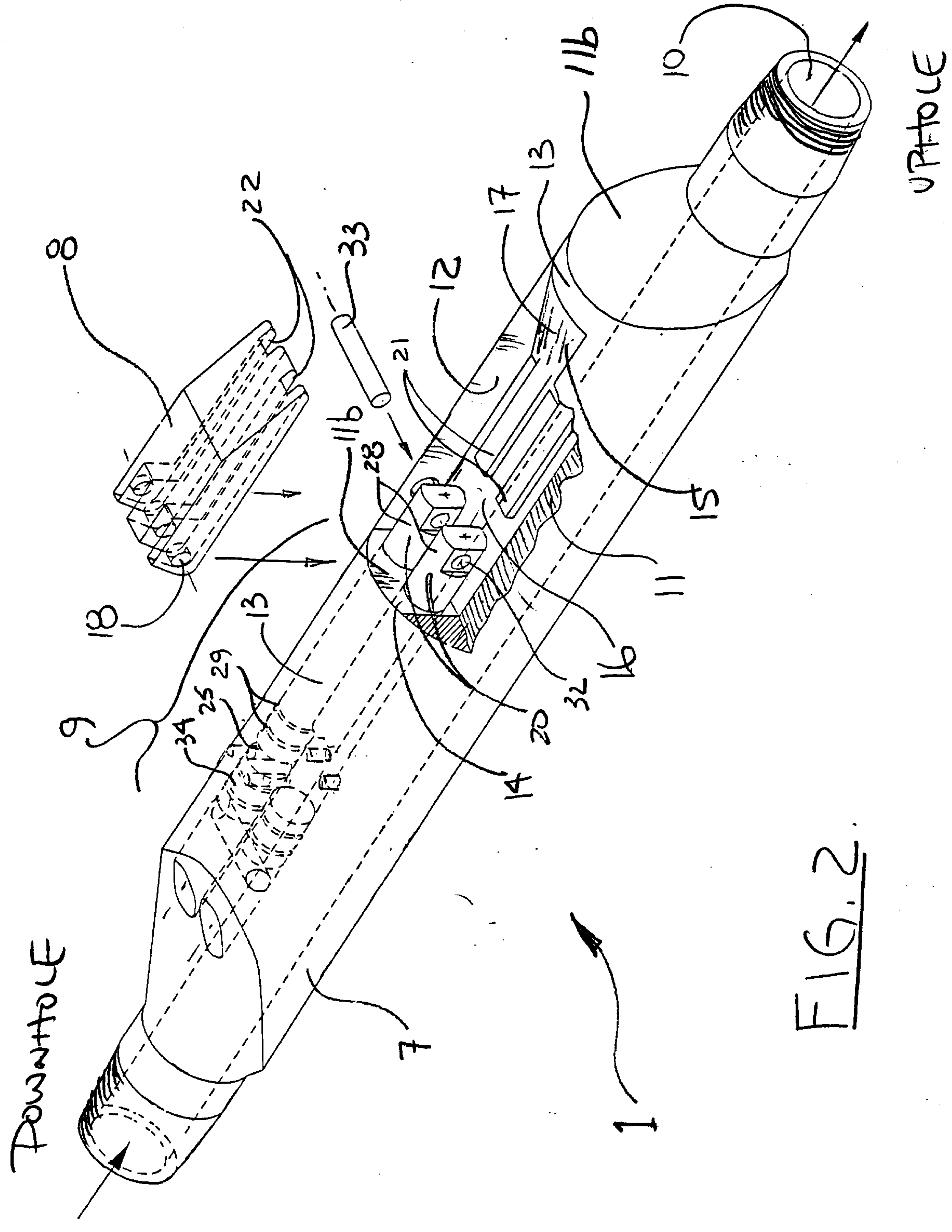


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FIG. 2.

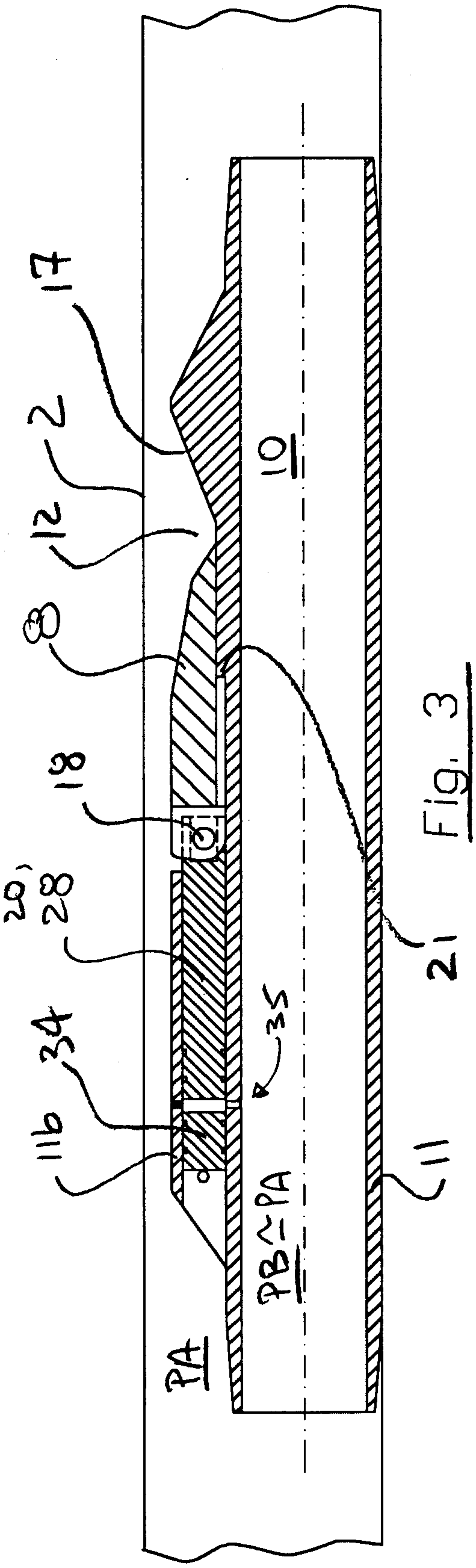
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Fig. 3

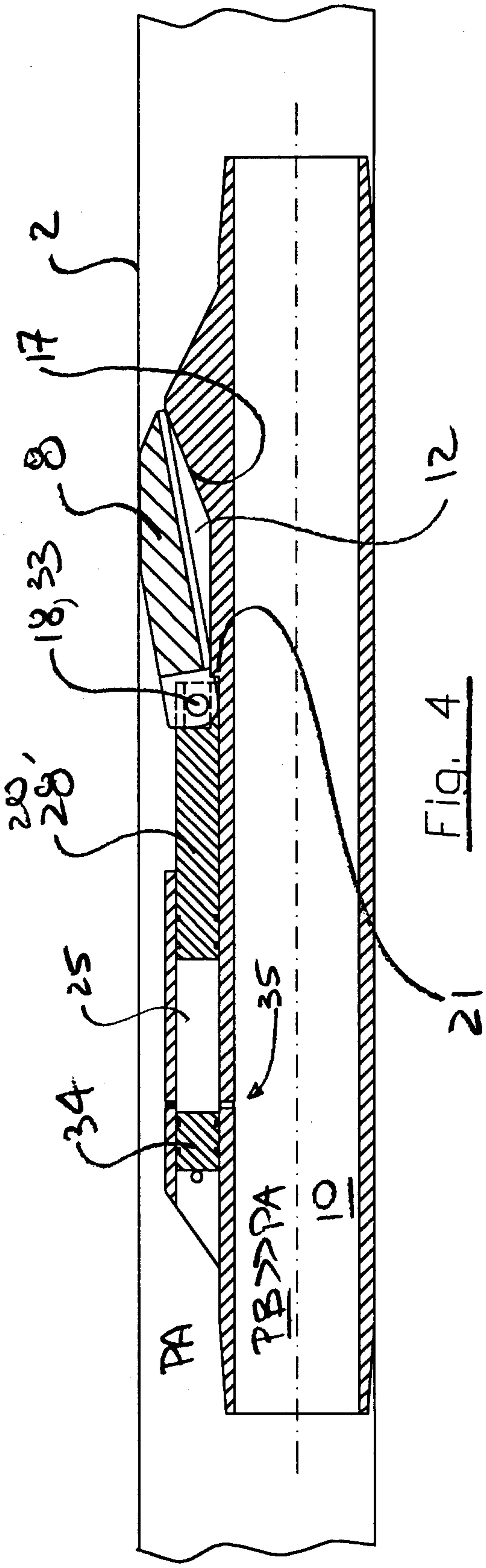
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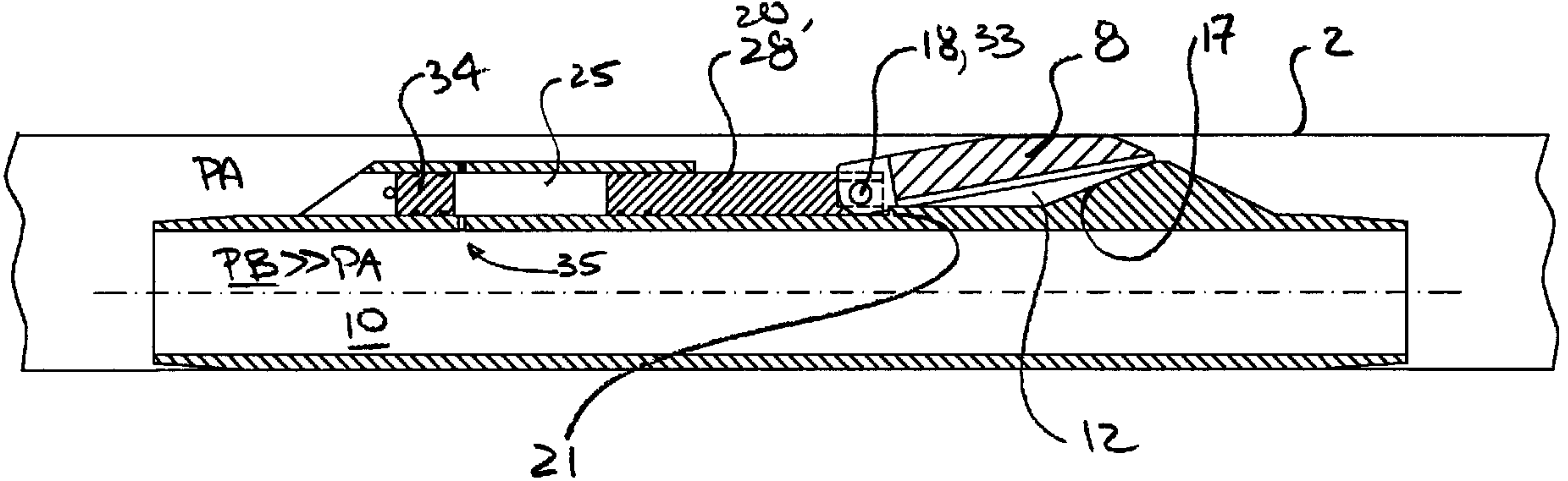
Fig. 4



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