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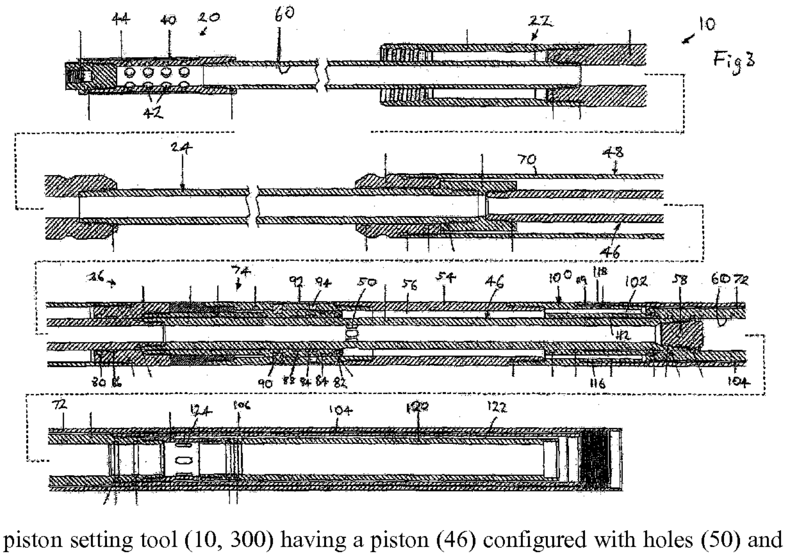

(57) Abstract: A balanced piston setting tool (10, 300) having a piston (46) configured with holes (50) and flow channels (56, 102, 104, 112 and 122) for allowing displacement of well fluid around the piston (46) as it changes modes of operation whereby there is zero displacement of well fluid and no change in the pressure of well fluid in a test zone during packer inflation nor during changes in the mode of operation of the setting tool (10, 300), thereby avoiding damage to the formation or otherwise skewing data concerning the characteristics of the said formation.

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"BALANCED PISTON SETTING TOOL"

FIELD OF THE INVENTION

This invention generally relates to a balanced piston setting tool for use in controlling inflatable packers used in down hole applications in geological formations, such as those containing valuable fluids.

More particularly, the present invention relates to a balanced piston setting tool used to control inflatable packers whose mode of operation is set by lowering hollow drill rods, upon which a single or a pair of inflatable packers are attached, permitting changes in the mode of operation of the tool whilst substantially avoiding displacement of well fluid in a test zone during inflation of the or the pair of packers and during changes in said mode of operation.

In the context of the present invention "balanced" refers to ensuring the pressures across a piston, which controls the mode of operation of the tool, are balanced or equal.

In the context of the present invention "displacement" refers to displacement of well fluid with respect to the well bore. Then "low displacement" refers to minimal displacement of well fluid from the well bore into the surrounding formation as the or the pair of packers is inflated and as the setting tool changes mode of operation.

Conveniently the displacement may be referred to as "zero displacement" and the tool may be referred to as a "zero displacement setting tool". And the displacement of interest is to avoid displacement of well fluid in the vicinity of the test zone. The result of zero displacement is that the pressure of well fluid in the test zone (and hence in the formation surrounding said test zone) remains substantially unchanged during packer inflation and during changes in the mode of operation of the setting tool, thereby avoiding damage to the formation or otherwise skewing data concerning the characteristics of the said formation.

It is to be understood that whilst it is preferred to eliminate both causes of well fluid displacement in the vicinity of the test zone we consider the elimination of either cause to be beneficial. That is, the adoption of either solution to well fluid displacement is considered to be within the teaching of this new art.

TERMINOLOGY

In the fields of well and borehole technology there are a diversity of terminologies used. So as to avoid confusion the following specific terminology is used in the context of the present invention:

- "Annular" is a term used to refer to the space between two generally coaxial hollow bodies. Also, "annular" is taken to mean generally annular and may include a situation where part of an annular space is completely annular and another part of the annular space may not be completely annular.

- "Casing" is a term used to refer to any type of pipe casing or the like, used in oil and gas or water well drilling operations. The term "well casing" is often used when referring to casing.
- "Core barrel" is a term used to refer to a tube used to line an open hole (sometimes referred to as a bore hole).
- "Drill string" is a term used to refer to column or string of metal tubes (referred to as drill pipe) with a drill bit attached to its lowermost end for drilling a hole in a formation.
- "Elastomeric packer element" or "packer element" is a term used to refer to any type of generally tubular expandable element that may be inflated by settable or non-settable slurry, liquid or gas, usually to close off part of an annular cavity.
- "Formation" is a term used to refer to geological strata being drilled typically for valuable fluids such as water, oil or gas of the like.
- "Inflatable packer" is a term used to refer to an entire packer assembly capable of inflation by settable or non-settable slurry, liquid or gas, and includes an elastomeric packer element.
- "Open hole" is a term used to refer to a well hole or borehole that has not been or is yet to be lined with a casing and cementitious material between the casing and the open hole.
- "Open hole annulus" is a term used to refer to the annular space between the casing and the open hole.
- "Rods" is a term used to refer to hollow tubing which inflatable testing and completion tools are mounted for lowering and manipulation within a bore or well.
- "Well fluid" is a term used to refer to any type of slurry, liquid or gas capable of use in inflating an inflatable packer, and includes water, brine, gas (such as nitrogen), resin, gel, cement, drilling mud or the like.

BACKGROUND TO THE INVENTION

In the field of down hole drilling, testing and completion it is known to use drill rods to manipulate a test or completion tool to change its mode of operation within an open hole in a formation. Typically, once the tool is set in place by inflating elastomeric (typically wire reinforced rubber) material packers, the rods are typically rotated to manipulate the tool to open and / or close valve components to change the flow of well fluids through the tool and hence change the tool's mode of operation. The purpose of the process is to subject a test zone to changes in pressure so as to measure the porosity and other characteristics of the formation in the region surrounding the test zone.

There are two common problems caused by using a tool to test the characteristics of the formation surrounding the test zone. The first problem is that in the process of inflating one or more packers well fluid is displaced in the test zone and forced into the formation surrounding the test zone. This displaced well fluid prematurely pressurises the formation around the test zone, which can damage the formation and skew data regarding the characteristics of the formation. Also, changing the mode of operation of the tool by manipulating the rods causes displacement of well fluid in the region of the test zone and again prematurely pressurises the formation around the test zone and skew data regarding the characteristics of the formation.

It is desirable, therefore, to have a testing tool in which the pressure of the well fluid in the vicinity of the test zone remains substantially constant during packer inflation and / or during changes in the mode of operation of the testing tool.

SUMMARY OF THE INVENTION

Therefore, it is an object of the present invention to provide a balanced piston setting tool for down hole use employing one or more inflatable packers, the balanced piston setting tool being operable so as to substantially avoid displacement of well fluid in the vicinity of a test zone during packer inflation and / or during changes in the mode of operation of the setting tool.

In accordance with one aspect of the present invention, there is provided a balanced piston setting tool for down hole use employing at least one inflatable packer, the setting tool including a housing within which is disposed an actuating piston operable in differing modes of operation for allowing variations in the flow of well fluid through the setting tool, wherein the actuating piston has flow channels arranged for fluidic communication with flow channels in the housing, whereby well fluid can flow around the actuating piston as it reciprocates in the housing whilst changing its mode of operation, whereby the well pressure in the vicinity of the test zone remains substantially static during changes in the mode of operation of the setting tool.

In accordance with one aspect of the present invention, there is provided a balanced piston setting tool for down hole use employing at least one inflatable packer, the setting tool including:

a housing attached upstream of the at least one inflatable packer;

an actuating piston disposed in the housing and reciprocable therein to effect at least one of: inflation of the at least one inflatable packer and changes in the mode of operation of the tool;

attachment means at the upstream end of the housing to enable deployment and retrieval of the tool; and

a venting means situated in the housing, the venting means permitting flow of well fluid from inside the housing to outside the housing upstream of the at least one inflatable packer dependent upon the position of the said actuating piston, the venting means being in fluidic communication with the test zone and permitting flow of well fluid out of the housing during changes in the mode of operation of the setting tool, and permitting flow of well fluid from the test zone to outside said housing during inflation of the at least one inflatable packer;

wherein, during inflation of the at least one inflatable packer and during changes in the mode of operation of the setting tool, well fluid in the vicinity of the test zone remains substantially undisplaced with respect to the well bore.

Typically, there are one or more pairs of inflatable packers arranged in straddle formation creating one or more test zones. Although a single inflatable packer could be used to create a single test zone with the blank end of a well bore.

In the context of the present invention the inflatable packers may be of conventional type as is well known in the art, provided that they be of the multiple set / multiple deployment type.

Throughout the specification, unless the context requires otherwise, the word "comprise" or variations such as "comprises" or "comprising", will be understood to imply the inclusion of a stated integer or group of integers but not the exclusion of any other integer or group of integers. Likewise the word "preferably" or variations such as "preferred", will be understood to imply that a stated integer or group of integers is desirable but not essential to the working of the invention.

BRIEF DESCRIPTION OF THE DRAWINGS

The nature of the invention will be better understood from the following description of a specific embodiment of the balanced piston setting tool of the present invention, given by way of example only, with reference to the accompanying drawings in which:

Figure 1 is a perspective view, seen from above, of a balanced piston setting tool in accordance with the present invention shown in relation to a pair of inflatable packers configured in a straddle arrangement, shown split into 2 segments;

Figure 2 is a part cross-sectional side view of the balanced piston setting tool of Figure 1, shown disposed in a lower end of a core barrel and split into 3 segments;

Figure 3 is a cross-sectional side view of the balanced piston setting tool of Figure 1, shown to a larger scale and split into 4 segments;

Figure 3a is a cross-sectional side view of a part of the tool Figure 3, shown to a still larger scale;

Figures 4a to 4d are part cross-sectional side views of the balanced piston setting tool of Figure 1, shown in 4 modes of operation, being packer inflation, recirculation, shut in and inflow respectively;

Figures 5a to 5c are cross-sectional side views of a bottom cross-over sub of the balanced piston setting tool of Figure 1, wherein Figure 5c is rotated 45 degrees about the longitudinal axis with respect to Figure 5c; and

Figure 6 is a part cross-sectional side view of a lower part of another embodiment of the balanced piston setting tool of Figure 1, shown to a larger scale and split into 3 segments, the embodiment using T-seals and a modified piston.

DETAILED DESCRIPTION OF PREFERRED EMBODIMENTS

In the drawings there is shown a balanced piston setting tool 10 in accordance with the present invention, shown connected to a pair of inflatable packers 12 arranged in a straddle configuration for deployment in a core barrel 14 in a well bore drilled in a formation for testing in the vicinity of a test zone 16.

Particularly as shown in Figures 1 and 2 the balanced piston setting tool 10 includes an inlet filter 20, a top crossover 22, an entry pipe 24, a valve assembly 26 and a bottom crossover 28 (Figures 5a to 5c). For convenience the bottom crossover 28 is shown at the upstream end of the inflatable packers 12. In this regard it is to be noted that the dimensions of the bottom crossover 28 may change to accommodate packers of differing sizes whilst the size of the tool 10 remains substantially unchanged.

The inlet filter 20 typically has a latch 30 attached to it for deployment and retrieval of the tool 10 in the core barrel 14.

The core barrel 14 has a landing ring 32 adjacent its lower end 34 and a lift sub 36 disposed upstream of the landing ring 32 for engaging with tines 38 of the latch 30. The landing ring 32 is modified from conventional landing rings used in core barrels 14 so as to provide a better seal against the tool 10.

Particularly as shown in Figures 3 and 3a the inlet filter 20 has a mesh screen 40 overlying a plurality of holes 42 formed on a housing 44. Typically the screen 40 is made from stainless steel and has holes of around 1 mm bore. Well fluid flows from the outer curved surface of the screen 40 through the holes 42 in the housing 44 and into the top crossover sub 22 through the entry pipe 24 which terminates at a hollow piston 46 and which reciprocates therewith in a tubular case 48.

The piston 46 is elongate and has a series of fluted holes 50 disposed radially spaced apart around its circumference towards a downstream end 52. The tubular case 48 has an extension 54 which defines a cavity 56 around the piston 46. The cavity 56 surrounds the holes 50 during some modes of operation of the tool 10, as described in more detail hereinafter. The piston 46 also has a head 58 closing it off at its downstream end 52. The head 58 is dimensioned to bear against seals disposed within a bore 60 of the tool 10. The bore 60 is generally cylindrical and extends from the entry pipe 24 to the bottom crossover 28.

The function of the tool 10 is controlled by and depends upon the disposition of the piston 46 in the bore 60.

The tubular case 48 includes an upper case 70 and a lower case 72 separated by an emergency deflation sub 74. The emergency deflation sub 74 has wipers 80 and 82 at its opposing ends, disposed to bear against the outer curved surface of the piston 46. The sub 74 also has O-ring seals 84 and PTFE bearings 86 and 88 to centralise the operation of the piston 46 in the bore 60.

The sub 74 also includes shear pins 90, a cover 92 and holes 94. Emergency deflation of the packers 12 is possible be pulling upon the core barrel 14 with sufficient force to shear the pins 90 which allows the piston 46 to move towards the surface of the well bore a short distance sufficient to expose the holes 94 to the cavity 56 and permit the packers 12 to deflate.

The head 58 of the piston 46 protrudes through a displacement sub 100 which connects the emergency deflation sub 74 to the lower case 72. The displacement sub 100 has longitudinal holes 102 communicating from the cavity 56 to an annular passageway 104 defined between the inner curved surface of the lower case 72 and the outer curved surface of an inner case 106 suspended between the displacement sub 100 and the bottom crossover sub 28. Flow of well fluids through the holes 102 and the annular passageway 104 permits inflation of the packers 12 as indicated by arrows 110 in Figure 4a.

Particularly as shown in Figure 3a, the displacement sub 100 also has a plurality of apertures 111, referred to as circulation ports 111, radially disposed to permit flow of well fluids from an annular cavity 112, through a stainless steel mesh filter 114 (with holes of about 1 mm bore) and therethrough an annular cover 116 having further holes 118 in a cover 119 to the well bore outside the tool.

The inner case 106 contains a sleeve 120 connected between the bottom crossover sub 28 and the displacement sub 100 to form another annular passageway 122. The sleeve 120 has fluted holes 124 at its upstream end for permitting communication of well fluids between the bore 60 and the annular passageway 122 in some modes of operation of the tool 10.

The holes 124 are arranged to overly the holes 50 of the piston 46 as shown in Figure 4b. This permits recirculation of well fluids from the surface of the well through the bore 60 of the piston 46 then through the circulation ports 111, the screen 116 and the holes 118 in the cover 119 and back up to the surface of the well via the core barrel 14.

Particularly as shown in Figures 5a to 5c the bottom crossover sub 28 has a body 128 with an external thread disposed to engage with an internal threaded end of the lower case 72. The body 128 also has another external thread disposed to engage with the inflatable packers 12. The body 128 further has coaxial and cylindrical lands for receiving free ends of the inner case 106 and the sleeve 120.

The bottom crossover sub 28 also has a bore 130 which is blanked off at its upstream end 132 and is in communication with the mandrel of the packers 12 at its downstream end 134 and thereby to the test zone 16.

The upstream end 132 has two (or more) holes 136 in fluidic communication with the bore 60. The holes 136 terminate at their downstream ends in radial holes 138, which are protected from grit by a screen 140 (typically made from 1 mm perforated stainless steel mesh) and covered by an aperture cover 142 with holes 144.

The holes 136 allow well fluid to flow out from the bore 60 as the piston 46 travels into the bore, and thence out of the tool via the holes 138 and 144. The holes 136 also allow well fluid to flow from outside the tool 10 through the holes 144 and 138 and back into the bore 60 as the piston is retracted from the bore 60.

Hence, the flow of well fluid through the holes 136 permits the piston 46 to move and change the mode of operation of the tool 10 and avoids that well fluid from reaching the test zone 16 and hence avoids changes in tool 10 operation from displacing well fluid in the test zone 16.

The bottom crossover 28 also has radially disposed holes 150 located proximate the blanked end 132 and in communication with the bore 130. The holes 150 terminate in the annular passageway 122 to permit well fluid to flow from the bore 130 (and hence from the test zone 16) into the annular passageway 122.

Also, during inflation of the packers 12, from the time the expanding packers 16 touch the well wall until they reach their full inflation pressure, there is a squeeze pressure displacement of well fluid in the test zone 16. The displaced well fluid is permitted to travel up the mandrel of the packers 12 through the bore 130 of the bottom crossover sub 28 out of the holes 150 into the inner annular passageway 122 through the holes 124 back down the bore 60 of the sleeve 120 through the holes 136 in the end 132 of the bottom crossover sub 28 and out of the tool 10 via the holes 138 and 144. This flow avoids the well fluid from prematurely entering into the formation surrounding the test zone 16 and thus protects it and avoids incorrect test results.

As shown in Figure 5c the bottom crossover 28 also has inflation conduits 154 axially displaced from its central axis. Typically, there are four inflation conduits 154, which extend from the annular passageway 104, downstream of the holes 150, through the body 128 to its downstream end 134, for supplying inflation well fluids to the packers 12.

The packers 12, in the exemplary embodiment, include a top packer 200, a bottom packer 202, each with mandrels joined together by a perforation sub 204. The perforation sub 204 is located in the test zone 16 and has axial holes communicating well fluid from the bore of the mandrels to the test zone 16. The perforation sub 204 has longitudinal inflation conduits (not shown) for communicating inflation well fluid from the top packer 200 to the bottom packer 202 – and vice versa for deflation.

The tool 10 has O-rings and D-seals to ensure fluid tight seals between adjacent components as and were required.

In Figure 6 there is shown a setting tool 300 similar to the setting tool 10 and like numerals denote like parts. The setting tool 300 differs from the setting tool 10 primarily in that it uses T-seals 301 to 306 in place of the D-seals. The T-seals 301 to 306 require fitment by threading between sleeves instead of deformation (as used with D-seals). The T-seals 301 to 306 have the advantage that they are not prone to wash-out by fast moving well fluid.

Also, the setting tool 300 differs in that it has a plug 310 located immediately below the holes 50. The purpose of this change is to prevent the lower end of the piston 46 acting as a sump for detritus material entrained in the well fluid - which can otherwise block up the internals of the piston 46. In this embodiment the detritus material can fall out the lower end of the piston 46 at a bypass plug 312 and back up to the bore of the drill rods above the setting toll 300.

USE

Conveniently the setting tool of the present invention can be used for open hole injection testing and open hold drill stem testing. Although, it can also be used in cased hole applications.

Use of the present invention shall now be described in relation to deployment by mineral wireline coring equipment in a core barrel 14, through the drill bit 34. Although it is to be understood that it could be deployed upon hollow rods in an open hole.

Operating Procedure Using Mineral Wireline Coring Deployment

During assembly of the tool 10 onto the packers 12 at a drill rig water is poured in to fill the flow passages and chambers to displace air that may otherwise lead to air locks and prevent the proper operation of the tool. Typically it is not possible to displace all of the air.

In use, the tool 10 and straddle packers 12 are run in the well, upon mineral wireline coring equipment, to the required depth at which it lands upon the landing ring 32 in the core barrel 14. The wireline deployment equipment can then be retrieved and further actuation of the tool 10 conducted by manipulation of the drill rods / core barrel 14.

In a wireline configuration the core barrel 14 is typically devoid of well fluid during deployment of the tool 10.

Typically, a side entry sub is installed at surface, above the well to allow connection to a pump and pressure monitoring system (not shown) as is well known in the art.

Once the tool 10 is in its desired position the core barrel 14 can be filled with well fluid (typically water) and the well fluid pressurised to enter into the tool through the inlet filter 20 to the bore 60.

The tool 10 of the present embodiment has 4 **stages of operation**. The first stage of operation is inflation to inflate the packers 12. The second stage is circulation and shut in during which the packer pressure is maintained without continued fluid pressure from the surface of the well. In the circulation stage well fluid can be recirculated down the core barrel 14 into the tool 10 to flush any remaining air out of the tool 10. The third stage is full shut in. And the fourth stage is injection of well fluid into the test zone 16.

Pressurisation of the tool 10 is not responsible for changes in the position of the piston 46. Change in the mode of operation of the tool 10 is achievable by lowering the core barrel 14 once the packers 12 are inflated.

The first step is to inflate the packers 12 – the **first stage of operation**. This is done by increasing the well fluid pressure which causes flow along the bore 60 through the holes 50 in the piston 46, through the cavity 56, along the outer annular passageway 104, through the inflation conduits 154 and into the top packer 200, between its mandrel and its packer element, through the perforation sub 204 and into the bottom packer 202. Increased flow of well fluid causes the elements of both packers 200 and 202 to begin to inflate.

Preferably, maintain a low flow rate when inflating the packers 12 to prevent over pressurising the packers 12, which can easily happen with an abrupt increase in packer pressure once the packer elements make contact with the borehole. With high flow rates this might cause a pressure spike (which can lead to packer failure) before the operator has a chance to reduce flow rate/pressure.

The packers 12 are typically inflated to between 800 to 1500 psi (5.5 to 10.5 MPa, above static pressure). Being hydraulically inflated, any increase in differential pressure as a result of injection testing also results in an increase in packer pressure. Therefore, straddle packers for the purpose of testing do not need to be inflated higher than 1500 psi above static pressure even if differential pressures up to 5000 psi are expected.

Once the packers 200 and 202 inflate so their elements touch the borehole increased flow of well fluid causes the pressure in the elements of the packers 200 and 202 to increase. This results in the shoulders of the packer elements to expand in a direction along the length of the packers 12 in the vicinity of the test zone 16. This expansion effectively reduces the volume of the test zone and displaces well fluid out of the test zone 16 and forces it into the radial holes in the perforation sub 204 up the bore of the mandrel of the top packer 200 and into the bore 130 of the bottom crossover sub 28. The well fluid then flows through the holes 150 and into the inner annular passageway 122 up to the holes 124 and into the bore 60 of the tool 10.

In this configuration the piston 46 is at the upper limit of its travel, as shown in Figure 4a and hence the head 58 of the piston 46 prevents the well fluid from flowing further out of the borehole. Instead the well fluid is directed back downstream to the bottom crossover sub 28 where it enters the holes 136 and exits the tool 10 via the holes 138 and 144. The well fluid exits the tool 10 above the packers 12.

Hence, the well fluid displaced by the inflation of the packers 200 and 202 in the z-fold (shoulder) region of the packer elements is squeezed out of the tool 10 via the bottom crossover sub 28 instead of being forced into the formation in the vicinity of the test zone 16 – hence overcoming a severe limitation of prior art tools.

Once the packers 12 are fully inflated the well fluid pressure needs to be maintained to keep the packers 12 inflated.

The core barrel 14 can then be lowered a distance of around 250 mm so that the holes 50 of the piston 46 overly the circulation ports 111 of the displacement sub 100 so the well fluid can pass out of the tool 10 to displace any air remaining in the tool 10. This initiates the **second stage of operation** as shown in Figure 4b and the pressure in the core barrel 14 can be reduced since well fluid cannot flow out of the packers 12.

During the lowering of the core barrel 14 the well fluid downstream of the head 58 of the piston 46 is pushed through the holes 136 in the end 132 of the bottom crossover sub 28 and out of the tool 10 via the holes 138 and 144. The screen 140 inhibits the flow of particulate material into the tool 10 so as to avoid blockage of flow passages.

The venting of the well fluid through the bottom crossover sub 28 prevents displacement of well fluid into the test zone 16 – again avoiding a problem that plagues prior art tools 10.

The core barrel 14 can then be lowered a further distance of around 125 mm to initiate the **third stage of operation** of the tool 10. Again well fluid is displaced out of the tool 10 via the bottom crossover 28 to avoid damage to the test zone 16.

In the third stage of operation the tool 10 provides a flow path from the work string / core barrel 14 to the formations in the vicinity of the test zone 16. The test zone 16 can be either between two packers 200 and 202 (a so called straddle system as shown in Figure 1) or between a single packer 200 and the bottom-hole section (single packer, so called terminal test). The operator can then begin the Injection phase of the test.

In the third stage the tool 10 is completely shut in. The annulus, work string, inflation pressure and formation pressure are all isolated.

Drill stem testing (DST) can be undertaken during this stage of operation of the tool 10. In a DST – after blowing down a water cushion, the pressure is held in the string and stroked down into this position full shut-in before venting compressed air at surface. This now locks in the water cushion.

When performing a DST test, this is the stage in which the water cushion can be adjusted with compressed air to displace fluid into the annulus. The pressure is then held in the rods until the tool is stroked into the Full Shut-In position (third stage). Once the tool is in the Shut-In position, the air can be vented at surface via a choke manifold or diverter.

The core barrel 14 can be lowered a further distance of around 125 mm to initiate the **fourth stage of operation** of the tool 10. The well fluid displaced by the piston 46 is again vented out of the tool 10 through the bottom crossover 28 to protect the test zone 16.

In the fourth stage of operation the holes 50 of the piston 46 overly the holes 124 in the bore 60 which permits well fluid to flow into inner annular passageway 122, through the holes 150 of the bottom crossover sub 28, through the bore 130, through the top packer mandrel and into the test zone 16 via the radial holes in the perforation sub 204.

The fourth stage allows either injection into, or inflow from the formation, depending on type of test being performed.

As with the other stages of operation the test zone 16 is protected from the displacement of well fluids by the piston 46 by venting through the bottom crossover sub 28 and into the core barrel 14.

Once the tests are complete the core barrel 14 is raised up a distance of around 500 mm to return the tool 10 back to default position (the first stage of operation) and to allow deflation of the packers 12. Typically 15 to 20 minutes or more are required to allow full deflation of the packers 12.

Retrieval of the tool 10 can be effected by reintroducing the wireline coring equipment into the core barrel 14 and lowering onto the lift sub 36, latching thereto and then pulling the tool 10 towards to surface of the well.

If the packers 12 fail to deflate emergency deflation can be activated by pulling up into the first stage and then build up the pressure in the tubes / rods and the packer to 1000 psi or more (this will depend on how much friction the packer has against the borehole – If the packer 12 is slipping against the borehole, then top the pressure up making sure not to exceed maximum allowable pressure for the given diameter. Maintain the pressure in the tubing and take up 4.4T (9700lb) of over pull. This causes the shear pins 90 to shear and the packers 12 will deflate via the holes 94 in the emergency deflation sub 74 down-hole and not through the tubing. Then static level differential between the work string and the annulus will start to equalise.

One benefit when running the tool 10 in mineral wireline coring configuration, is that once the tool 10 has been stroked back into the deflation position (the first stage), the latch head can be unlatched which will allow the tool 10 to deflate down hole. This occurs once the test seal has unseated from the landing ring 32. So in this case rod and annulus differential is not so important.

The tool of the present invention has a circulating sub, but can only be actuated when the packers are inflated. It is recommended therefore that a wireline actuated (multi cycle) or drop ball actuated (single cycle) displacement/circulating sub be fitted above the tool to displace string volume during tripping operations.

Operating Procedure Using Tubing Deployment

Alternatively the tool 10 can deployed using tubing, such as hollow tubing is an open bore or in a cased well. The tool 10 is attached to the end of the tubing and lowered into the bore or well.

In this arrangement priming of the tool 10 and packers 12 is the same is for wireline and the tool 10 is still operated through 4 stages.

The tool 10 is run in to its required depth and the packers 12 inflated in accordance with the above described procedure except that the well fluid is poured into the tubing and pressure applied to the tubing to increase pressure of the well fluid.

Operation of the tool 10 in all other respects is the same as for wireline deployment.

ADVANTAGES

The tool 10, 300 of the present invention has the advantage that well fluids displaced during inflation of packers and during changes in mode of operation of the tool 10, 300 are vented out of the tool 10, 300 and away from the test zone 16. Hence, preparation of the tool 10, 300 for testing of the formation in the vicinity of the test zone 16 avoids disturbance of the formation by avoiding inflow of well fluid into the formation until testing is ready to be undertaken. This avoids damaging the formation and / or skewing the results of subsequent tests.

A principal objective of the tool 10, 300 is to facilitate testing conducted over extended periods. Also, to address the concern of getting the pipe stuck in an unstable hole during such tests, the second stage has a bypass feature to allow circulation during shut-in.

MODIFICATIONS

It will be readily apparent to persons skilled in the relevant arts that various modifications and improvements may be made to the foregoing embodiments, in addition to those already described, without departing from the basic inventive concepts of the present invention. For example, the tool 10 of the present invention could be operated in 3 or 4 stage modes of operation without changing the benefits it offers in relation to avoiding displacement of well fluid in the test zone 16. This could be achieved by omitting the circulation ports 111 from the displacement sub 100.

CLAIMS:

1. A balanced piston setting tool for down hole use employing at least one inflatable packer, the setting tool including a housing within which is disposed an actuating piston operable in differing modes of operation for allowing variations in the flow of well fluid through the setting tool, wherein the actuating piston has flow channels arranged for fluidic communication with flow channels in the housing, whereby well fluid can flow around the actuating piston as it reciprocates in the housing whilst changing its mode of operation, whereby the well pressure in the vicinity of the test zone remains substantially static during changes in the mode of operation of the setting tool.

2. A balanced piston setting tool for down hole use employing at least one inflatable packer, the setting tool including:

   a housing attached upstream of the at least one inflatable packer;

   an actuating piston disposed in the housing and reciprocable therein to permit effect at least one of: inflation of the at least one inflatable packer and changes in the mode of operation of the tool;

   attachment means at the upstream end of the housing to permit enable deployment and retrieval of the tool; and

   a venting means situated in the housing, the venting means permitting flow of well fluid from inside the housing to outside the housing upstream of the at least one inflatable packer dependent upon the position of the said actuating piston, the venting means being in fluidic communication with the test zone and permitting flow of well fluid out of the housing during changes in the mode of operation of the setting tool, and permitting flow of well fluid from the test zone to outside said housing during inflation of the at least one inflatable packer;

   wherein, during inflation of the at least one inflatable packer and during changes in the mode of operation of the setting tool, well fluid in the vicinity of the test zone remains substantially undisplaced with respect to the well bore.

3. A balanced piston setting tool according to Claim 2, in which there is at least one pair of inflatable packers arranged in a straddle configuration.

4. A balanced piston setting tool according to Claim 3, in which the actuating piston has flow channels arranged for fluidic communication with flow channels in the housing, wherein well fluid can flow around the actuating piston as it reciprocates in the housing whilst changing its mode of operation, whereby the well pressure in the vicinity of the

test zone remains static during changes in mode of operation of the setting tool.

5. A balanced piston setting tool according to Claim 3, in which the actuating piston has flow channels arranged for fluidic communication with flow channels in the housing, wherein well fluid can flow around the actuating piston as it reciprocates in the housing whilst changing its mode of operation, whereby the well pressure in the vicinity of the test zone remains static during inflation and deflation of said at least one inflatable packer.

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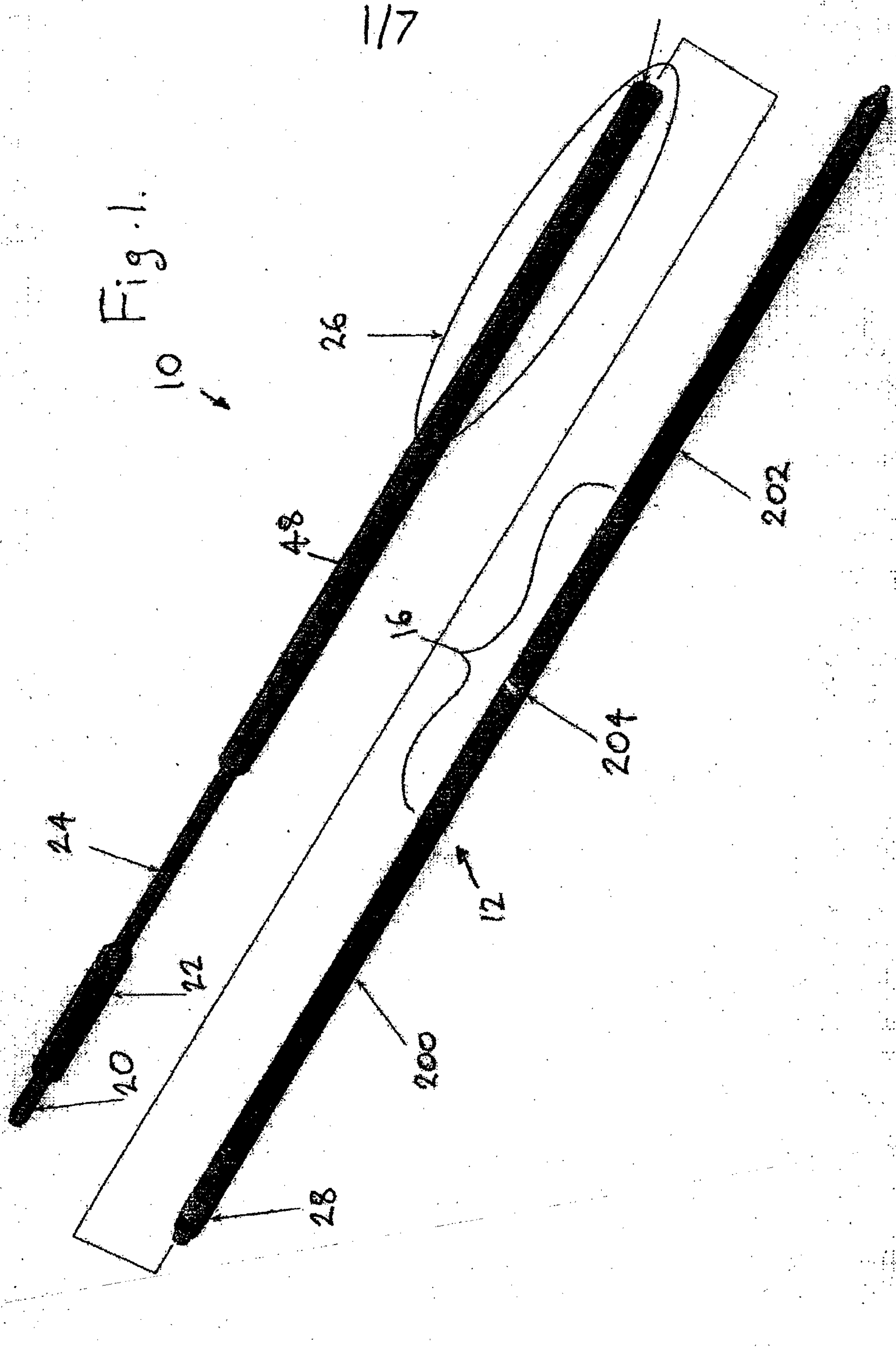

Fig. 1.

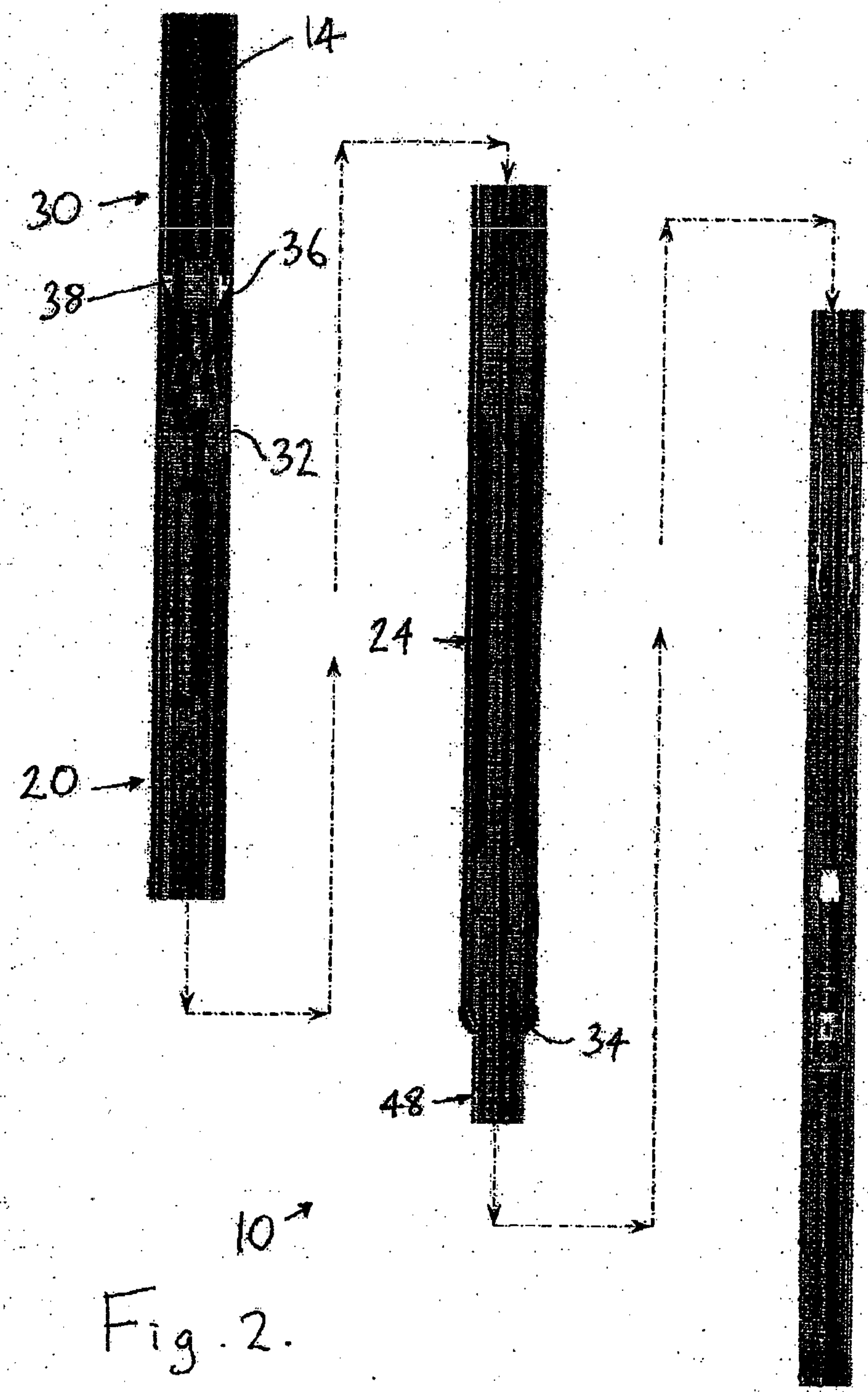

Fig. 2.

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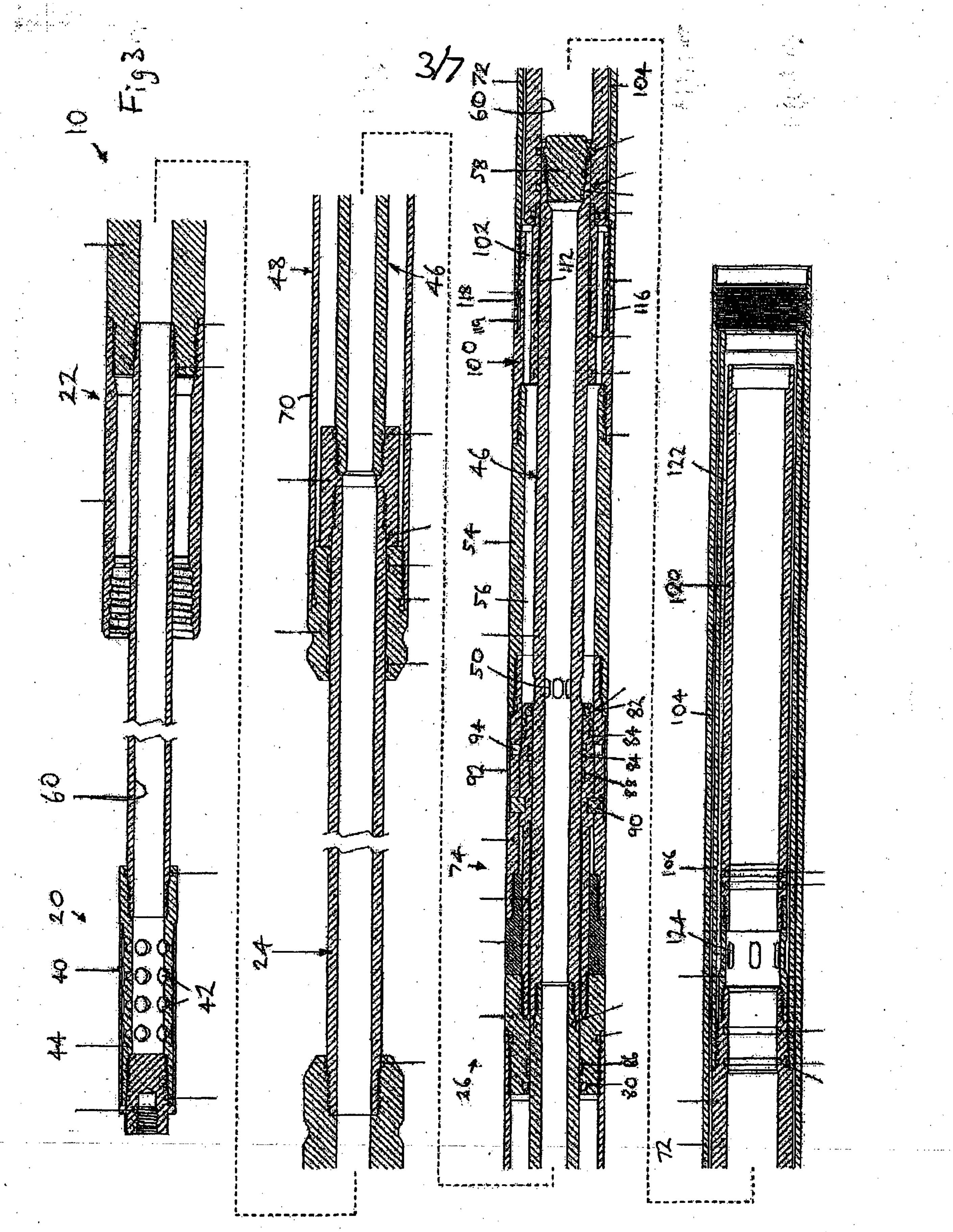
Fig 3
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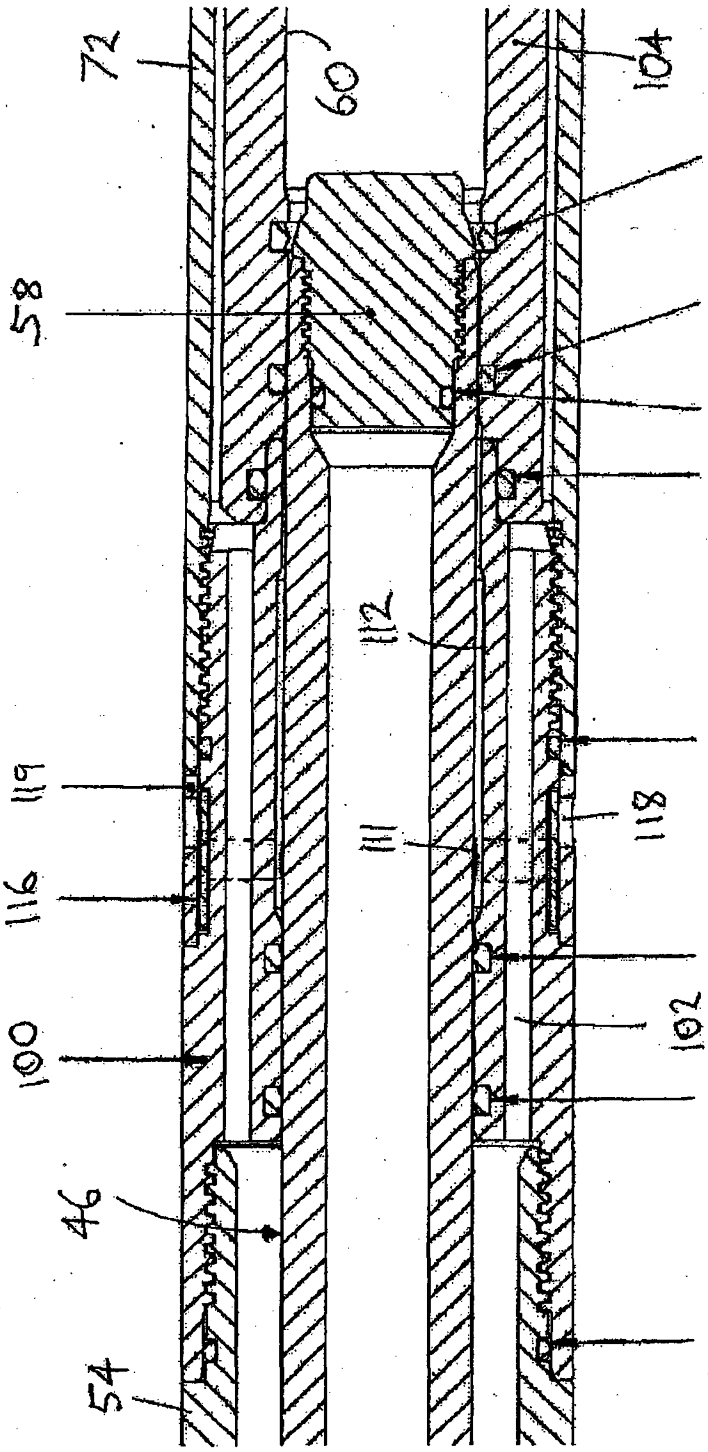
Fig 3a



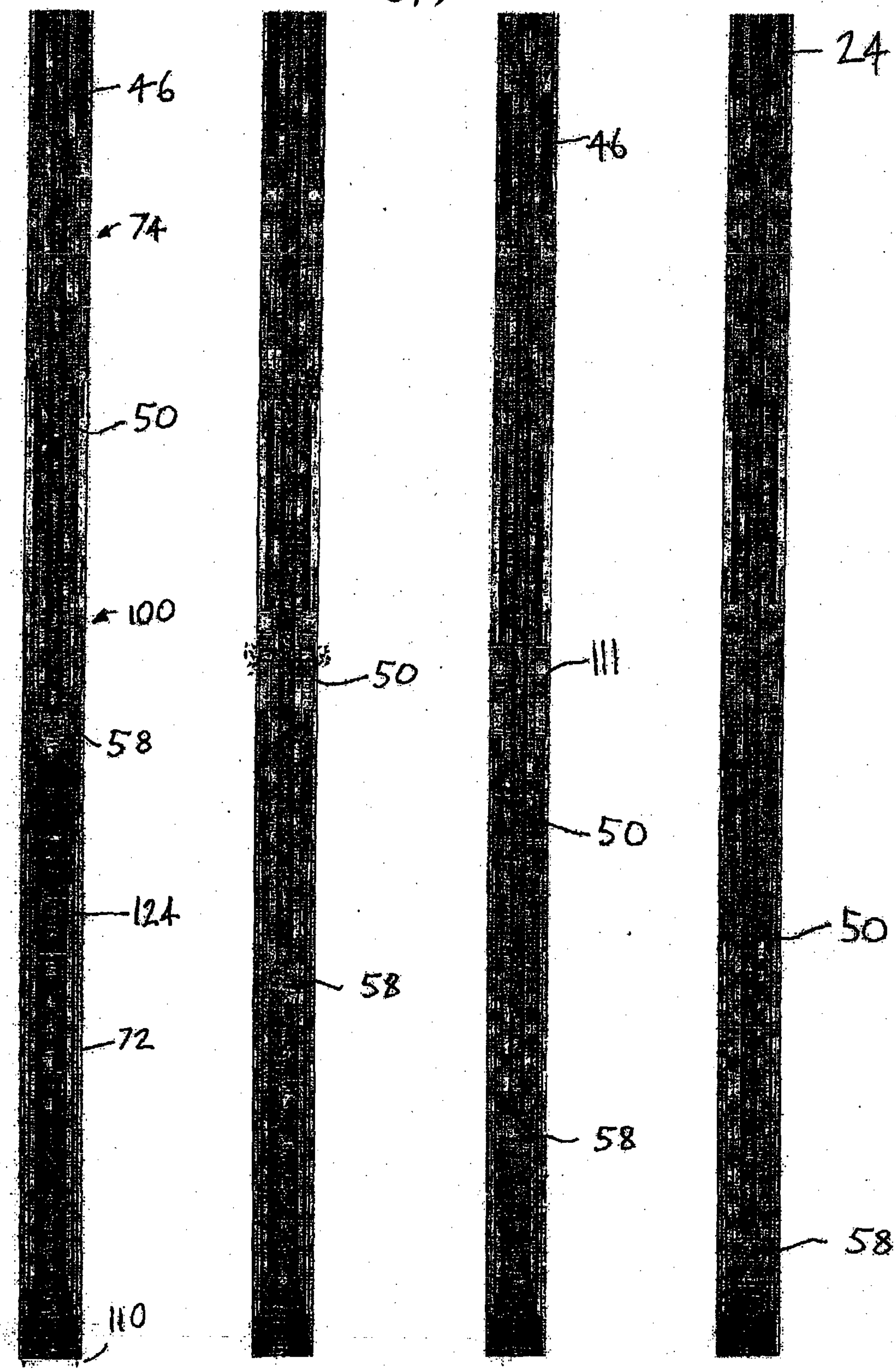
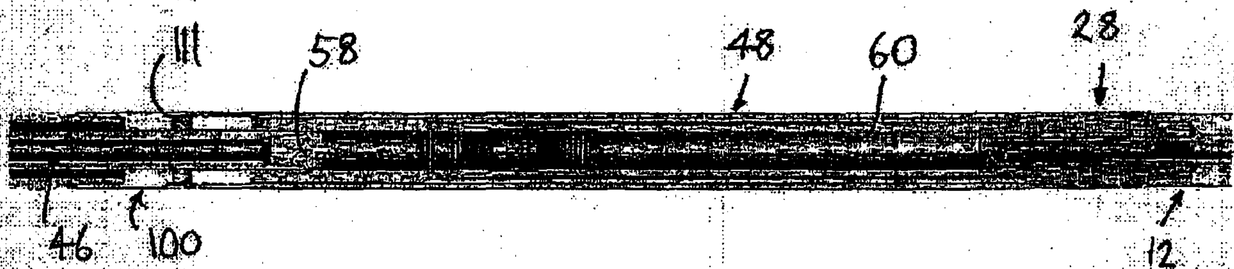


Fig4a Fig4b Fig4c Fig4d

Fig. 5a



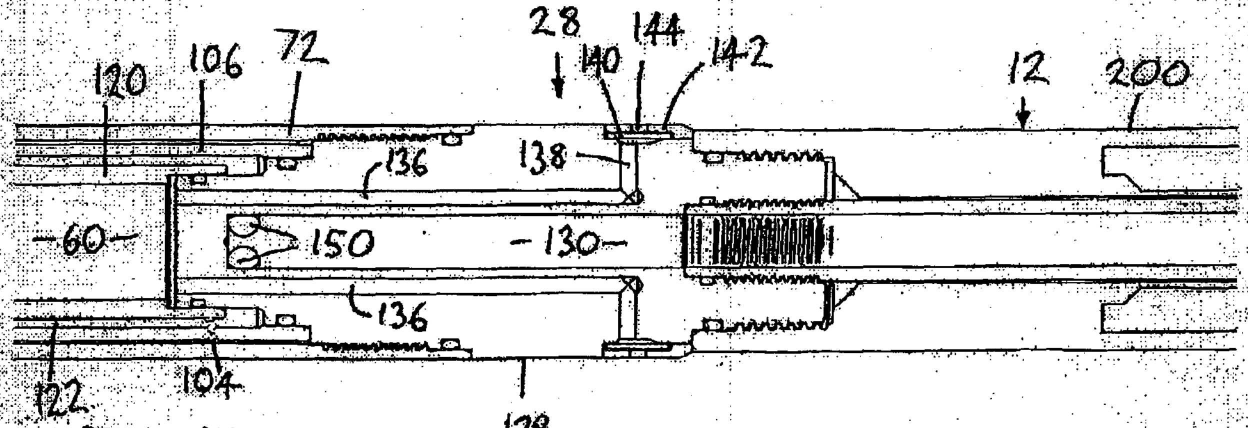


Fig. 5b.

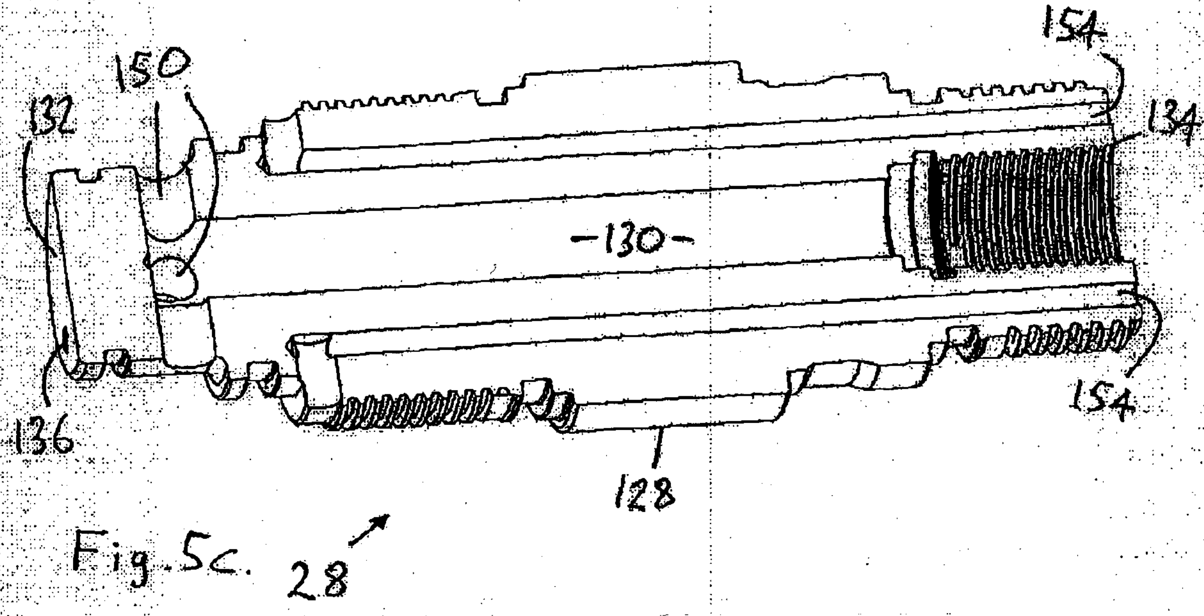


Fig. 5c.

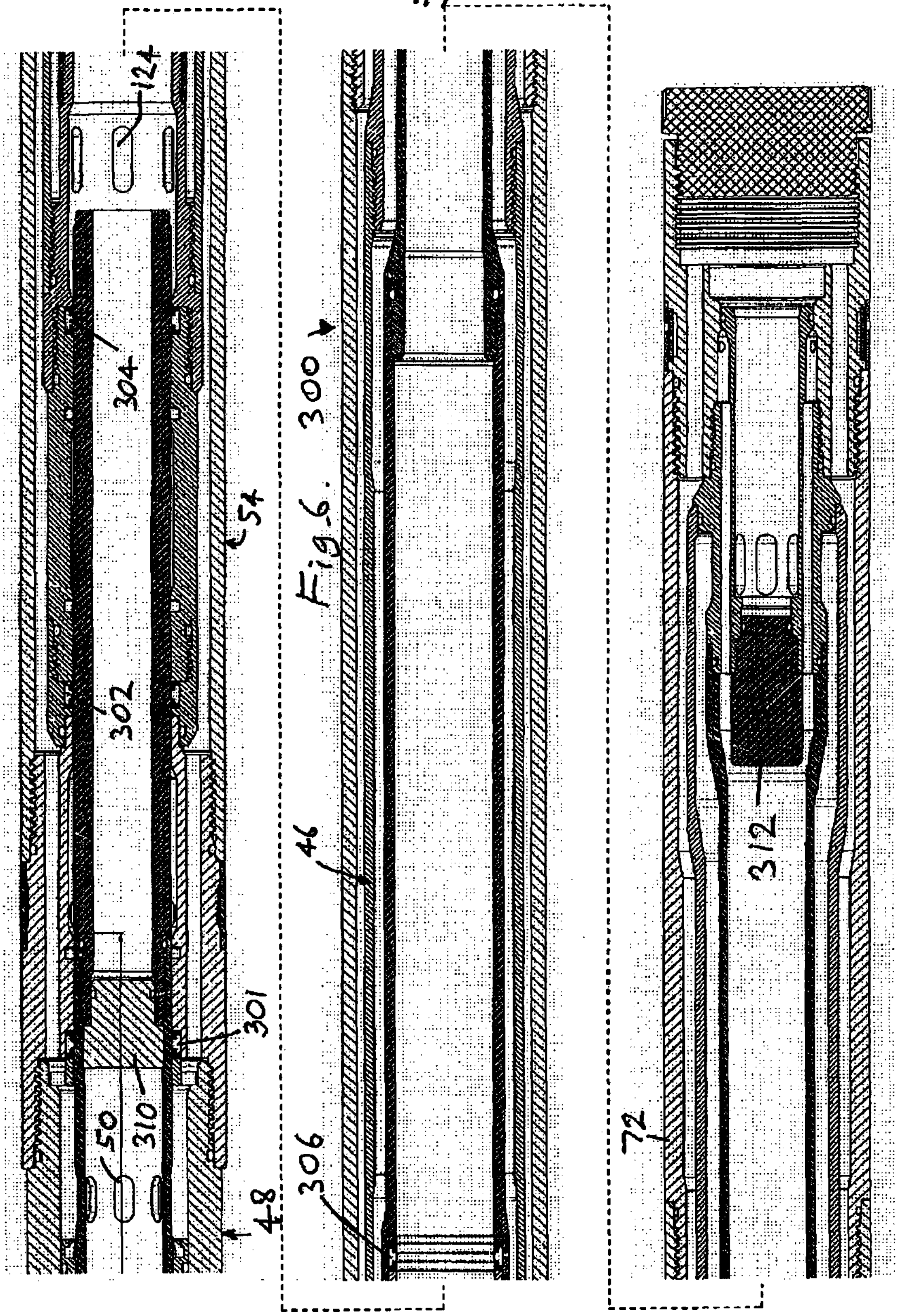


Fig.6.

INTERNATIONAL SEARCH REPORT

International application No.
PCT/AU2012/000534

A. CLASSIFICATION OF SUBJECT MATTER

E21B 23/06 (2006.01) E21B 33/124 (2006.01)

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

WPI, EPODOC: IPC & ECLA E21B23/06 & Keywords (packer, inflate, pressure, piston, low, balanced, equal, test, straddle, static) and like terms

ESPACENET: Keyword only (test, pressure, packer, inflate, inflatable) and like terms

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
	Documents are listed in the continuation of Box C	

[X] Further documents are listed in the continuation of Box C   [X] See patent family annex

* Special categories of cited documents:

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier application or patent but published on or after the international filing date

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"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
20 August 2012	24 August 2012

Name and mailing address of the ISA/AU	**Authorized officer**
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INTERNATIONAL SEARCH REPORT	International application No.
C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT	PCT/AU2012/000534

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 4424860 A (MCGILL) 10 January 1984 Figures 1 - 2C; Column 1 Lines 14 - 29, Column 3 Line 51 - Column 4 Line 5, Column 4 Line 50 - Column 5 Line 60	1-5
A	US 4898236 A (SASK) 06 February 1990 Column 1 Line 10 - Column 2 Line 29	

INTERNATIONAL SEARCH REPORT Information on patent family members	International application No. **PCT/AU2012/000534**

This Annex lists known patent family members relating to the patent documents cited in the above-mentioned international search report. The Australian Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

Patent Document/s Cited in Search Report		Patent Family Member/s	
Publication Number	**Publication Date**	**Publication Number**	**Publication Date**
US 4424860 A	10 Jan 1984	CA 1184113 A1	19 Mar 1985
		EP 0067096 A2	15 Dec 1982
		EP 0067096 B1	31 Aug 1988
		ES 8305876 A1	16 Jul 1983
		MX 157504 A	28 Nov 1988
		US 4424860 A	10 Jan 1984
US 4898236 A	06 Feb 1990	CA 1249772 A1	07 Feb 1989
		US 4898236 A	06 Feb 1990

End of Annex

Due to data integration issues this family listing may not include 10 digit Australian applications filed since May 2001.