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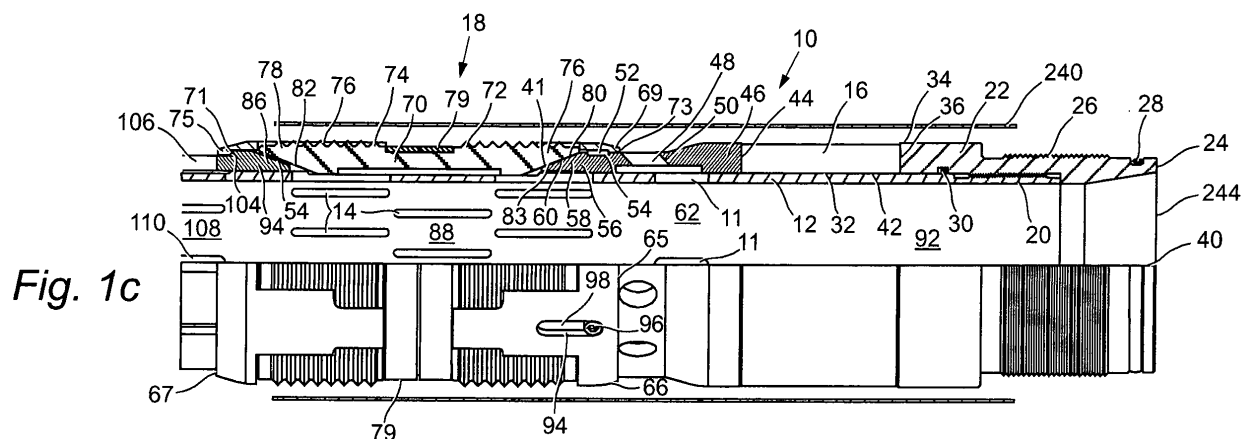
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(54) **Large bore packer**

(57) A retrievable large bore packer (10) for providing an annular seal and an anchor system in a well bore. Ports (14) are provided behind the slips (70) to prevent debris build-up and allow the slips (70) to release. These ports (14), in a thin walled tubing (12), allow the collapse of the tubing behind the slips to aid removal of the packer

if the sealing element (16) does not release. The slip arrangement is mounted entirely above the sealing element (16) to remove the requirement to seal between the slips and the inner bore of the packer. In this way the packer can have a large bore. Further flow paths are provided through the packer above the seal to prevent debris build-up above the sealing element.



Description

[0001] The present invention relates to a packer typically used in the oil and gas industry to provide an annular seal and anchor system in a well bore. More particularly, though not exclusively, the present invention relates to a retrievable packer having a single anchoring arrangement located above the seal for use in a variety of applications in a well bore, including production, testing, fluid injection, and zonal isolation.

[0002] A packer is a common downhole tool used both in the drilling and completion of a well. The characteristic elements in a packer are a sealing element, a holding or setting device and a fluid passageway. Two types of sealing element exist, these being an inflatable element which expands to create a seal by the introduction of fluid to an inner enclosure of the element and an elastomeric element which is solid and expands outwards under vertical compression. The inflatable element is typically found in permanent packers which are designed to remain in the well bore. These permanent packers are generally used to create a seal between the well bore and tubing or casing located therein referred to as open hole. Alternatively they may be used in cased holes where the seal is created in the annulus between the casing and an inner tubing string. Elastomeric seals are more commonly found in production or test packers. Production packers are used in completions to isolate an annulus between the casing or liner and the production tubing. By creating a seal in the annulus production control is achieved and tasks such as testing, fluid injection, and zonal isolation can be accomplished. As the tasks performed by production packers may be temporary, these packers are designed to be run in on wireline, tubing or coiled tubing. They must also be retrievable and in this regard the sealing element must be releasable.

[0003] For retrievable packers, the holding or setting device must anchor the packer to the casing or liner, achieve expansion of the sealing element typically by weight, tension or rotation and be itself releasable so that the entire packer can be retrieved from the well bore. A common system used to anchor the packer is by use of slips. These are longitudinally arranged blocks having teeth on an outer surface for gripping the liner or casing. At each end of each slip, on the under surface, there is arranged a wedge to provide a sliding surface. An expander, typically in the form of a cone, is driven behind the slips to engage the sliding surface. The slips are mechanically connected to the mandrel of the packer and are forced radially outwards therefrom by the expander to grippingly engage the liner or casing. The movement of the expander is generally used to compress the sealing element. The movement of the holding or setting device is generally controlled from a running and setting tool used when the packer is run into the well bore. Similarly a retrieval tool can be used to release the slips from the casing and retract the seal so that the packer can be retrieved.

[0004] Typically available retrievable packers such as the HORNET 10K performance packer from Baker Oil Tools, Houston, USA, and the Versa-Set retrievable packer from Halliburton, Houston, USA, have a dual arrangement of slips located at either side of the sealing element. By oppositely arranging the slips it ensures that the packer is held in both directions. The packers are set by mechanically setting the tool down and rotating the tool by a quarter turn.

[0005] A known disadvantage of these retrievable packers is failure of the slips to release due to a build up of debris behind the slips which prevent the slips retracting to release. Once the sealing element has been expanded and the packer set, the fluid located in the annulus above the sealing element is static. Debris in the fluid settles on the top of the sealing element and this builds up within the annulus and reaches the slips located above the sealing element. In an attempt to overcome this difficulty most manufacturers have slips located under the sealing element which are then protected from the ingress of debris. The retrievable packers detailed above have slips above and below the sealing element. In these arrangements the seal must release in advance of the upper slips so that debris in the upper slip is encouraged to fall out and so aid release. While this assists the upper slips, the lower slips are flooded with debris when the seal is released. This causes problems in releasing the lower slips.

[0006] There are a number of other disadvantages in having a slip located below the seal. It is known that elastomeric seals tend to 'solidify' in use. Therefore when the packer needs to be released, the seal will not contract. The easiest way to deal with this problem is to release the slips and pull the packer from the well bore. As most slips located under seals can only be released once the seal is released, pulling the packer is not an option as the slips will still be grippingly engaging the tubing. In the worst case scenario the entire packer has to be milled out.

[0007] Yet further, in order to mechanically set and release a slip located below a seal, all the connections to achieve this must pass through the inside of the mandrel on which the seal is arranged. Additionally the entire slip arrangement must be pressure sealed as well pressure testing is done against the lower side of the seal. These two requirements produce a complex mechanical arrangement which utilises a significant cross sectional area of the throughbore of the packer. As the bore diameter of the tubing string directly affects the production rate of the well, every millimetre of reduced bore size represents a loss in possible production from the well. A large bore diameter also provides the option of passing other tools through the bore of the packer, if necessary, which may negate the requirement to retrieve the packer between other wellbore interventions.

[0008] A large bore packer has been described in US 3,776,307. In order to achieve the large internal bore, the packer is a length of deformable liner into which is set grippers and sealing rings on the outer surface thereof.

A setting tool running the entire length of the packer is used and the tool includes both explosive charges and wedges to deform the liner so that the grippers engage the casing wall and the seals are crushed against it. The setting tool is then removed leaving a deformed liner with a seal against the casing at an upper end and an anchor at the lower end. While this creates a large bore packer, the packer is obviously not retrievable due to the deformities made in the liner.

[0009] It is an object of the present invention to provide a retrievable downhole packer with a relatively large bore.

[0010] It is an object of at least one embodiment of the present invention to provide a retrievable downhole packer where all the slips are located above the sealing element.

[0011] It is a further object of the present invention to provide a retrievable downhole packer which obviates or mitigates at least some of the disadvantages of the prior art retrievable downhole packers.

[0012] According to a first aspect of the present invention there is provided a retrievable downhole packer for use in tubing in a well bore, said packer comprising:

mandrel means having a first inlet and a first outlet for connection in a workstring to thereby provide a first fluid flow path through the packer;
a sealing element on said mandrel means for releasably, sealingly engaging said tubing;
slip means on said mandrel means for releasably, grippingly engaging said tubing; and
wherein said mandrel means includes a plurality of ports and wherein at least one port is arranged at the slip means to provide a second fluid flow path from the slip means to the first fluid flow path at the slip means.

[0013] In this way, the slip can be arranged above the seal so that the bore size can be increased while providing a fluid flow path at the slip which prevents the build-up of debris behind the slip.

[0014] Preferably, the sealing element is arranged at a lower end of the packer. In this arrangement the surface against which pressure testing is achieved is positioned at an end of the packer so that fewer pressure seals are required in the packer. Advantageously therefore, the slip means is located above the sealing element. In this way there is a single slip means arranged downstream of the sealing element.

[0015] Preferably the packer further comprises an actuating mechanism, the actuating mechanism being arranged above the slip means and comprising a plurality of sleeves, wherein at least two sleeves are interconnected by a ratchet means. In this way the ratchet may be used to lock the packer in a desired position.

[0016] Preferably the actuating mechanism is adapted to provide a first position where the slip means and the sealing element are in a retracted position; a second position where the slip means and the sealing element are

in an extended position; and a third position, independent of the first and second positions, wherein the slip means and the sealing element are returned to the retracted position.

[0017] Preferably in the first position and third position there are provided a plurality of flow paths from the tubing to the first flow path through the packer. Advantageously in the second position there are provided a plurality of flow paths from the tubing to the first flow path through the packer.

Preferably the sealing element comprises an elastomeric ring. More preferably the sealing element is arranged between two opposing surfaces which move relatively towards each other to compress the sealing element.

[0018] More preferably the actuating mechanism is operated by a longitudinal force applied to the mechanism. This force is linear as compared to rotational to provide a simple mechanism for actuation.

[0019] Preferably the packer includes first attachment means for engagement with a setting tool, wherein the packer is set by longitudinal movement of a first lifting sleeve in the packer. When set the actuation mechanism may be in the second position. More preferably the setting tool may be combined with a running tool.

[0020] Preferably also the packer includes second attachment means for engagement with a retrieval tool, wherein the packer is adjusted to a retrieval position by longitudinal movement of a second lifting sleeve in the packer. When in the retrieval position, the actuation mechanism may be in the third position.

[0021] Preferably the slip means comprises oppositely arranged upper and lower wedge means with at least one slip located there between wherein at least one of the wedges is adapted to move under an end of the slip to force to slip to an extended position.

[0022] An embodiment of the present invention will now be described, by way of example only, with reference to the accompanying figures, of which:

Figures 1a to 1c illustrate a retrievable downhole packer according to an embodiment of the present invention in the running position;

Figures 2a to 2c illustrate the retrievable downhole packer of Figure 1 in the set position; and

Figures 3a to 3c illustrate the retrievable downhole packer of Figure 1 in the retrieval position.

[0023] Reference is initially made to Figures 1a-c of the drawings which illustrates a downhole retrievable packer, generally indicated by reference numeral 10, according to an embodiment of the present invention. Packer 10 includes a first mandrel 12 being a cylindrical section of tubing incorporating a plurality of ports, generally indicated by reference numeral 14, a sealing element 16 and a slip arrangement 18.

[0024] Beginning at Figure 1c there is a stop 22 at-

tached to a lower end 20 of the first mandrel 12. The stop 22 has, at a distal end 24, a pin section 26 for the attachment of other tools such as an injection valve. An o-ring 28 is arranged below the threaded portion of the pin section 26 to ensure that there is a seal between the packer 10 and anything mounted below for the purposes of allowing pressure testing to be achieved against the sealing element 16. Stop 22 is threadably engaged to the first mandrel 12 and a further o-ring 30 so as to ensure all connections at the lower side 32 of the sealing element 16 are sealed. An upper end 34 of stop 22 comprises a compression surface 36 which is perpendicular to the longitudinal axis 40 of the packer 10. The inner diameter 32 of the sealing element 16 is arranged against the surface 36.

[0025] Sealing element 16 is an elastomeric ring which, in an embodiment, is made of Viton® though could be made of any like material which will expand under compression. The ring is of a cylindrical section extending along a portion of and around the outer surface 42 of the first mandrel 12. The sealing element 16 is bounded at its upper end 44 by a sliding sleeve 46. Movement of the sliding sleeve 46 downwards will compress the sealing element 16 against the surface 36 thereby causing it to expand resiliently outwardly from the first mandrel 12, beyond the radial extent of the stop 22 and the sliding sleeve 46. The sealing element 16 cannot expand inwards as it is bounded by the outer surface 42 of the first mandrel 12. The portion of the first mandrel 12 located behind the sealing element 16 is complete with no ports located therein. The surface 42 at the sealing element 16 is smooth to ensure a seal is maintained between the sealing element 16 and the first mandrel 12.

[0026] Sliding sleeve 46 is ported, having eight cylindrical apertures 48 equidistantly spaced around the outer surface 50. Any number of apertures 48 may be selected and they may be of any size or dimensions. The apertures may also be directed to lie at an angle with respect to the axis 40 to assist in the passage of fluid therethrough. Located on the outer surface 50 is a c-ring 52 mounted in a circumferential recess 54 and sitting proud of the recess. The upper end 56 of the sliding sleeve 46 comprises a wedge 58 which presents a downwardly angled ramp 60 radially outwardly from the axis 40 in the form of a frusto-conical annular surface 41.

[0027] In the first mandrel 12 adjacent to the apertures 48 are a first array 62 of ports 14. This array 62 is a circumferential band of slotted ports 14, there number being selected to match the number of apertures 48 on the sliding sleeve 46, if desired. While the sliding sleeve 46 may move longitudinally with respect to the first mandrel 12, the first array 62 of ports 14 will always be accessible to the apertures 48.

[0028] Arranged above the sliding sleeve 46 but engageable therewith is a slip assembly 18. Assembly 18 comprises a cylindrical barrel 66 in which are arranged suitably shaped apertures through which the slips 70 can extend radially outwardly from to engage a casing or tub-

ing. Each end 65,67 of the barrel includes an overhang portion 69,71 having a lip 73,75 on an underside thereof which, at the upper end of the sleeve 46, engages the c-ring 52.

[0029] The slips 70 each comprise an arcuate substantially rectangular-shaped member 72 having a raised side portion 74, at each end of the slip 70, having a plurality of teeth 76 thereon. Between the raised portions 74, located centrally to the slip 70 is a slip retaining means 79. The slip retaining means 79 comprises two c-clips which are arranged to interlock circumferentially together but operate independently. By wrapping around the slips 70, the c-clips bias the slips 70 inwardly towards the first mandrel 12. The upper end 78 and lower end 80 of each slip 70 are formed having frusto-conical arcuate surfaces 82,83 respectively, which are complimentary to and slidably engage the frusto-conical annular surface 41 of lower wedge 58 and a frusto-conical annular surface 84 of an upper wedge 86, respectively. When engaged, the slips 70 are forced outwards against the c-clips, forcing them to expand.

[0030] In the first mandrel 12, adjacent to the slips 70, is a second array 88 of ports 14. This array 88 comprises three annular bands of elongate slotted ports 14. The ports in each band are offset with respect to the ports in a neighbouring band to provide a large flow area through the first mandrel 12 behind the slips 70. This flow path allows debris to escape from the area formed between the reverse side 76 of each slip 70, the wedges 58,86 and the outer surface 42. This flow path is open at all times during operation of the packer 10 even as the first mandrel 12 moves relative to the slip barrel 66. The slip barrel 66 has limited longitudinal travel by virtue of a pin and slot arrangement 94. A pin 96 is arranged on the sliding sleeve 46, which located in an elongate slot 98 on the barrel 66, thereby limiting the travel of the barrel 66 and sliding sleeve 46 relative to each other while also positively engaging them together.

[0031] As the slips 70 are arranged above the sealing element 16, a seal is not required to be maintained between an outer surface 90 of the slips 70 and the inner bore 92 of the packer 10. In this way, a single mandrel 12, is located at the slips 70 and behind the sealing element 16. This allows a maximised bore 92 diameter so that production and /or injection flow rates through the packer are not restricted and a minimal pressure drop is experienced through the bore 92.

[0032] Reference is now made to Figure 1b which illustrates a thin walled actuating mechanism, generally indicated by reference 100, for operating the slips 70 and sealing element 16. At the lower end 102 of the mechanism 100 is a second sliding sleeve 94 which co acts with the slip barrel 66 by virtue of the frusto-conical surface 82 at the upper end 78 of the slip 70 slidably engaging the frusto-conical annular surface 84 of the upper wedge 86 on the sleeve 94. Behind the wedge 86 is an overhang 104 for engagement with the lip 75 of the barrel 66. By this engagement the second sleeve 94 can lift the over-

hang 104 in order to effect release of the slips 70 for radial expansion.

[0033] Sliding sleeve 94 is also ported, having eight elongate slots 106 equidistantly spaced around the outer surface 108. Any number of apertures 106 may be selected and they may be of any size or dimensions. In the first mandrel 12 adjacent to the slots 106 are a third array 108 of apertures 110. This array 108 is a circumferential band of slotted ports 110, there number being selected to match the number of slots 106 on the sliding sleeve 94. This provides a flow path between the outside 90 of the packer 10 at the sleeve 94 and the bore 92 to aid run-in of the packer 10.

[0034] Threadably engaged to an upper end 112 of the sleeve 94 is an outer sleeve 114. Outer sleeve 114 and sliding sleeve 94 together provide an upward facing abutment surface 116 at a lower end 118 of the sleeve 114. The outer sleeve 114 also includes eight elongate slots 120 spaced equidistantly around and through the cylindrical body of the sleeve 114. At an upper end 122 of the sleeve 114 there is located a circular port 124 through which a shear screw 126 can be inserted. Threadably engaged to an underside 128 of the outer sleeve 114 there is a middle sleeve 130.

[0035] Middle sleeve 130 abuts the upward facing abutment surface 116 at a lower end 132 and extends beyond the upper end 122 of the outer sleeve 114. The extension provided allows for a further band of elongate slots 134 to be arranged through the middle sleeve 130. At an upper end 136 of the sleeve 130, the underside 138 of the sleeve 130 includes a surface 140 which threaded to a mating threaded outer surface 141 on each of six bridging blocks 142 located underneath the sleeve 130. These bridging blocks 142 each have a serrated outer surface 141 to interlock with the surface 140. In the middle of the sleeve 130 there are arranged eight recesses 144 shaped to receive a headed locating pin 146 and holding it firmly in place by virtue of the outer sleeve 114 covering the head of each pin 146.

[0036] The middle sleeve 130 also includes a circular port 148 matching the circular port 124 so that the shear screw 126 can be inserted through both ports 124,148 simultaneously. Additionally, directly under the slots 120 of the outer sleeve 114 there are located an equal number of slots 150. In this way the sleeves 114 and 130 are effectively a single sleeve as they move together by virtue of their threaded engagement. The dual sleeve arrangement allows the pins 146 to be effectively trapped within the sleeve arrangement.

[0037] For similar constructional reasons the first mandrel 12 is threadably engaged to a second mandrel 152. A lower end 156 of the second mandrel 152 overlays the upper end 154 of the first mandrel at the point of threaded engagement with the lower end 156 providing an abutment surface 158 to meet the upward facing abutment surface 116. The second mandrel then comprises a cylindrical body having a larger bore diameter than the first mandrel towards the upper end 160 of the packer 10.

From the lower end 156 there is a fourth array 162 of wide elongate slots 164 arranged circumferentially around the second mandrel 152. Due to the length of the slots 164, supports 165 are located across each slot 164 which create two adjacent slots 167,169 moving together. The upper slots 167 are so sized to allow the bridging blocks 142 to slide within the slots 167.

[0038] Within the lower slots 169 are arranged segments 171. There may be six segments 171 in an equal or greater number of slots 169. Each segment 171 includes a pair of circular ports 166,168. The first port 166 is threaded to receive the shear screw 126 while the second port 168 is sized so that the locating pin 146 can pass through. Such engagement with the locating pin 146 means that the segment 171 remains in fixed relationship to the middle 130 and outer 114 sleeves. The mandrel 152 can move relative to the segment 171 and thus the sleeves 130,114 via the travel in the lower slot 171.

[0039] On a portion 170 of the upper surface 172 of the second mandrel there is arranged a series of notches to form a ratchet 174 as is known in the art. This is best seen with the aid of Figure 1 a. Further along the upper surface 172 at the upper end 176 of the mandrel 152 there is arranged a screw thread 178 which threadably engages with a matching screw thread on an inner surface 180 of a first lifting sleeve 182. This engagement leaves a portion 184 of the second mandrel extending inwardly from the inner surface 180 of the lifting sleeve 182. An oppositely arranged protrusion 186 on the inner surface 180 provides a cylindrical pocket 188 there between. At the upper end 190 of the lifting sleeve 182 there is arranged a fishing neck 192 for engagement with a setting and /or retrieval tool as is known in the art. On the outer surface 194 of the sleeve 182 there is provided a recess 196 into which a portion of a second shear screw 198 may be located.

[0040] The uppermost end 160 of the packer 10 is formed from the upper end 200 of a top sleeve 202. Top sleeve 202 runs on the outer surface 90 of the packer 10 to the middle sleeve 130. The diameter of the sleeve 202 then reduces to lie beneath the middle sleeve 130. The top sleeve 202 includes six threaded ports 204 arranged circumferentially and equidistantly around the sleeve 202. The threaded ports hold the second shear screws 198 with the ends thereof initially located in the recesses 196 in the first lifting sleeve 182. A ratchet block 206 is resiliently held by matching serrations to the underside of the top sleeve 202 and thereby locates the block 206 against the ratchet 174. At the lower end 208 of the top sleeve 202, the sleeve includes sized apertures 210 which allow the bridging blocks 142 to move radially through the sleeve 202.

[0041] Holding the bridging block 142 in place from the bore 92 is a second lifting sleeve 212 which is located entirely within the bore 92. Lifting sleeve 212 has a retaining role. At its lower end 214 there are six recesses 216 located equidistantly around the outer surface 218.

The recess 216 is sized to hold a lower portion of the shear screw 126, with the upper portion of the shear screw 126 being threadably retained in the second mandrel 152. Adjacent each recess 216 in a longitudinal arrangement is a slot 218. The slot is elongate and sized to receive the locating pin 146 and thereby dictate the limited relative movement allowed between the middle sleeve 30 and the second lifting sleeve 212.

[0042] A fifth array 220 of ports 222 is provided in the sleeve 212 arranged as six elongate slots. By virtue of the locating pins 146 these ports 222 are always aligned with the slots 134 on the middle sleeve 30 and with slots 164 of the second mandrel 152 during running in. The outer surface 218 of the sleeve 212 provides a stepped profile 224 at the upper edge 230 of the ports 222 which co-acts with a matching stepped profile 226 on the inner surface 228 of the bridging blocks 142. At an upper end of the second lifting sleeve 212 there is located a fishing neck 230 on which a retrieval tool may engage as is known in the art. Behind the fishing neck 230 there is located a c-ring 234, which initially sits in a cylindrical recess 236 behind the fishing neck 230 and is kept in place via the location of the inner surface 238 of the second mandrel 152.

[0043] When assembled, the packer has a large inner bore 92 diameter as the diameter of all the sleeves is no smaller than the diameter of the first mandrel 12. Additionally all the inner surfaces of the sleeves lining the inner bore 92 are made smooth so as to minimise turbulence through the packer 10 and the associated effect on the injection/production flow rates.

[0044] In an embodiment of the packer 10, the packer has a maximum outer diameter of 114.55 mm and a minimum inner diameter of 66.68 mm over an overall length of 1991 mm. In this embodiment the sealing element has a size of 5 ½ " 17 to 26 ppf and a maximum differential pressure across the seal of 5,000 psi (344.74 bar).

[0045] In use, the packer 10 is assembled in the configuration illustrated in Figures 1a-c. In this position, the sealing element 16 is retracted and lies entirely within the outer diameter of the packer 10 at the stop 22. Similarly the slips 70 are also retracted into the assembly 18. The overhangs 69,71 lie over the teeth 76 by virtue of the first lip 73 being retained on the lower side of the c-ring 52 and the upper lip 75 co-operating with the overhang 104 of the second sliding sleeve 94. Shear screws 126,198 are located through the ports to retain the sleeves 130,114, 212 in fixed relationship with each other and the segment 171. In this regard ratchet block 206 is located at an upper end of the ratchet 174. The bridging blocks 142 are located on the stepped profiles 224 of the second lifting sleeve 212 and are locked against the middle sleeve 130 by mutual engagement at the threaded surfaces 140,141. The locating pins 146, 96 are aligned at the upper ends of the slots 218, 98 in the second lifting sleeve 212 and barrel 66, respectively.

[0046] In this arrangement the packer 10 is fully extended to reveal the multiple flow paths which exist from

the bore 92 to the outer surface 90 of the packer 10. Between the sealing element 16 and the slip assembly 18, apertures 48 are exposed and provide a flow path through the packer 10 by virtue of the first array 62 of ports 11 located below. Similarly slots 106 on the second sliding sleeve 94 are exposed and aligned with the third array 108 of slotted ports 110 in the first mandrel 12 to provide a fluid flow path through the packer 10. Yet further, elongate slots 120 on the outer sleeve 114, which are aligned with slots 150 on the middle sleeve 130, are located above the fourth array 162 of wide elongate slots 164 of the second mandrel 152 providing a further fluid passageway between the bore 92 and the outer surface 90. Still further is the alignment of slots 134 of the middle sleeve 130, slots 164 of the second mandrel 152 and slots 222 in the second lifting sleeve 212, to provide a further fluid flow path between the bore 92 and the outer surface 90 of the packer 10.

With the packer 10 in the assembled position illustrated in Figures 1a-c, this is considered the running position. Any tool may be located on the pin section 26 at the lower end 24 and typically, this would be a flow control tool such as the applicants, Red Spider High Lift Injection Valve or other intervention equipment such as the applicant's eRED or hRED devices.

[0047] The packer 10 is run in on wireline, electric line or coiled tubing using a standard running tool (not shown) as is known in the art. The packer is run to the required depth inside a casing 240. An annulus 242 exists between the packer 10 and the casing 240. During run in fluid can enter an inlet 244 at a lower end 24 of the packer, travel through the bore 92 to exit at an outlet 246, while also being able to travel out of the bore 92 into the annulus 242 by virtue of the multiple flow paths described above.

[0048] When in position, the packer is set using the running tool. Engagement is made with the fishing neck 192 of the first lifting sleeve 182 as is known in the art and by holding of the fishing neck 192 and pushing down on the top sleeve 202, the first lifting sleeve is moved upwards, relative to the top sleeve 202 and the second lifting sleeve 212. This movement is achieved by shearing the screw 198 between the two sleeves. The screw parts are retained in the packer as the upper end remains screwed in the port 204 while the lower end is locked in the recess 196 which is now held closed by virtue of the inner surface 239 of the top sleeve 212. In shearing the screw 198, the ratchet 174 moves under the ratchet block 206 due to the upward movement of the mandrel's 12, 152 up the inside of the bore which thereby collapse the packer 10 and reduce its overall length. The bridging blocks 142 remain stationary as the stepped profiles 224,226 engage effectively holding the second lifting sleeve 212 and the middle sleeve 130 in position. Similarly pin 146 holds these sleeves and segment together and by screwthreads, the outer sleeve 114 and second sliding sleeve 94 are also held stationary.

[0049] The slots 167,169 in the mandrel 152 allow the mandrel's 12,152 to pass the bridging blocks 142 and

the pin 146 and shear screw 126. As the mandrel's 12,152 are raised the stop 22 is also raised as the packer reduces in length. A compression force is thus applied to the lower side 32 of the sealing element 16 which causes the element to be compressed and expand radially outwards to provide a seal on the casing 240.

[0050] At the same time, the wedges 58,86 are driven towards the slips 70 and by engagement of the frusto-conical surfaces 82,84 and 41,83 respectively, the slip is forced radially outwardly for the teeth 76 to engage the casing 240. As this occurs, the overhangs 69,71 at each end of the barrel 66 pass over the sliding sleeves, and at least partially cover the ports 48,106. The slips 70 are prevented from travelling too far from the assembly 18, by virtue of the pin 96 travelling the limited length of the slot 98 in arrangement 94. When the pin 96 reaches the lower end of the slot 98, movement of the ratchet block 206 further along the ratchet 174 will pull the stop 22 against the lower side 32 of the sealing element to ensure the seal is achieved against the casing. On releasing the running tool, the ratchet 174 maintains the mandrel's 12,152 in fixed relationship to the other sleeves and locks the packer in this setting. This configuration is illustrated in Figures 2a-c.

[0051] In this configuration fluid flow at positions above the sealing element 16 are maintained to allow the clearing of debris from above the sealing element 116. More particularly, the second array 88 of ports 14 lie behind the slips. These provide a direct fluid flow path around the slips 70 to prevent the ingress of debris around the slip assembly 18.

[0052] When it is desired to remove the packer 10 from the casing 240 a pulling tool (not shown) is run into the upper end 160 of the packer 10. A modified GS-type pulling tool would be appropriate as a pulling tool. The running tool engages with the fishing neck 230 of the second lifting sleeve 212 and with enough force to shear the screw 126, the second lifting sleeve 212 moves independently upwards relative to the second mandrel 152. The second lifting sleeve 212 is raised until an upper surface 244 abuts the ledge 186 on the first lifting sleeve 182, whose position is fixed by being threaded to the second mandrel 152.

[0053] In this position, the c-ring 234 now lies at the recess 236 and will expand into the available space. This forms a connection between the lifting sleeves 182,212 and effectively locks the packer 10 in the retrieval position. During the travel of the second lifting sleeve 212, the bridging blocks 142 separate from the sleeve 212 as they are held in position by the top sleeve 202 which does not move. Accordingly, the ports 222 in the sleeve 212 move under the bridging blocks 142. This movement provides a space under the blocks 142 which they fall into. The blocks 142 are T-shaped to prevent them falling through the ports 222 and are therefore retained within the sleeve 212 so that they do not come free or enter the bore 92.

[0054] Movement of the second lifting sleeve 212 also

moves the segment 171 and sleeves 130,114 by virtue of the locating pin 146 holding them together. When the bridging blocks 142 meet the support 165, the sleeves 130,114,212, continue to move as the segment 171 passes through the slot 169 in the mandrel 152. This travel initially stops when the surface 118 of the mandrel 152 abuts the surface 116 at the outer sleeve 114. Pressure on lifting the sleeve 212 against the now fixed segment 171, is sufficient to shear the screw 126. With the shearing of the screw 126, a lower portion of the screw is positively retained in a recess 216 in the sleeve 212. The sleeve 212 can now move relative to the segment 171 and sleeves 130,114 as the locating pin moves along the slot 218 in the sleeve 212.

[0055] These movements in the actuating mechanism 100, translate to the slips 70, by the pulling of the second sliding sleeve 94 upwards as it is threaded to the outer sleeve 114. Pulling allows the slips 70 to retract by virtue of the c-clips 79 until the overhang 71 on the lip 75 at the barrel 66 engages the overhang 104 on the sleeve 94. The barrel 66 is then shifted upwards, with the slot 98 moving past the pin 96, so that it locates at the lower end of the slot 98 again. The overhang 69 of lip 73 engages with the c-ring 52 and pulls the first sliding sleeve 46 upwards. This upwards movement releases the compression on the sealing element so that it may retract and release from the casing 240. The stop 22 remains stationary so that the outer surface 42 of the first mandrel 12 behind the sealing element increases.

[0056] The movements to obtain a retrieval configuration re-open all the flow paths from the annulus 242 to the bore 92 while maintaining the passage of fluid through the ports 14 of the second array 88. This flow of fluid prevents the slips 70 from failing to retract through the ingress of debris. Additionally, as the slips 70 are released prior to the sealing element 16, if the sealing element has solidified and fails to retract all the pulling force can be applied directly to the sealing element 16 to aid recovery.

[0057] Additionally if, for any reason, the slips 70 fail to come away from the casing 240, a retrieval tool can be used to pull the entire packer 10 from the well bore. Advantageously, mandrel 12 is a thin-walled construction and this, together with the large array 88 of ports 14 behind the slips 70, will allow the mandrel 12 to collapse. Such a collapse of the mandrel 12 behind the slips 70 will pull the slips from the casing wall 240 and so assist in retrieval. While the description has used the terms 'upper' and 'lower', these are meant as purely relative and the packer could be equally run on tubing in a deviated well bore.

[0058] The principal advantage of the present invention is that it provides a retrievable downhole packer with a relatively large bore as the sealing element is located below the slips and only a single mandrel is required to pass behind the slips and does not require to be pressure sealed at the slips. Saving on the number of mandrels/sleeves in the bore and their thickness provides a packer

with a bore which is larger than current packers of comparable outer diameters. A larger bore means a reduced pressure drop through the packer and an increased flow rate. The single slip assembly and sealing element also provides a packer which has a reduced length in comparison to current packers and this provides the same benefits as for the increased bore diameter.

[0059] A further advantage of the present invention is that it provides a retrievable downhole packer with a simpler mechanical construction as there are only two connections below the sealing element which need to be pressure sealed. No pressure sealing is required around the slip assembly or the actuating mechanism. Further as there is a top end release and retrieve mechanism, latching and retrieval is easier using standard running/setting and retrieval tools.

[0060] A yet further advantage of the present invention is that it provides a retrievable downhole packer which is not prone to failure through the ingress of debris into the slips. In the present invention the slips are located above the sealing element so that they are protected from debris fall out when the sealing element is released. Additionally ports behind the slips and through the packer maintain fluid movement to prevent debris settling at the slips.

[0061] A still further advantage of the present invention is that it provides a retrievable downhole packer in which the packer and slips return to their original state after retrieval. Additionally on retrieval, all the outer moving parts are locked in position so that the packer cannot be reset if it hangs on any obstacles while being pulled out-of-hole.

[0062] It will be apparent to those skilled in the art that various modifications may be made to the invention herein described without departing from the scope thereof. For example, the ports and apertures may be of different sizes and shapes. Overhangs may be present to cover the edges of the sealing element to prevent it releasing entirely from the packer. The choice of shearing mechanisms may be varied.

Claims

1. A retrievable downhole packer for use in tubing in a well bore, said packer comprising:

mandrel means having a first inlet and a first outlet for connection in a workstring to thereby provide a first fluid flow path through the packer; a sealing element on said mandrel means for releasably, sealingly engaging said tubing; slip means on said mandrel means for releasably, grippingly engaging said tubing; and wherein said mandrel means includes a plurality of ports and wherein at least one port is arranged at the slip means to provide a second fluid flow path from the slip means to the first fluid flow

path at the slip means.

2. A retrievable downhole packer according to claim 1 wherein the sealing element is arranged at a lower end of the packer.
3. A retrievable downhole packer according to claim 1 or claim 2 wherein the slip means is located entirely above the sealing element.
4. A retrievable downhole packer according to any preceding claim wherein the packer further comprises an actuating mechanism which is adapted to provide a first position where the slip means and the sealing element are in a retracted position; a second position where the slip means and the sealing element are in an extended position; and a third position, wherein the slip means and the sealing element are returned to the retracted position, and wherein in the first position and third position there are provided a plurality of flow paths from the tubing to the first flow path through the packer.
5. A retrievable downhole packer according to any one of claims 1 to 3 wherein the packer further comprises an actuating mechanism which is adapted to provide a first position where the slip means and the sealing element are in a retracted position; a second position where the slip means and the sealing element are in an extended position; and a third position, wherein the slip means and the sealing element are returned to the retracted position and wherein in the second position there are provided a plurality of flow paths from the tubing to the first flow path through the packer.
6. A retrievable downhole packer according to any one of claims 1 to 3 wherein the packer further comprises an actuating mechanism which is adapted to provide a first position where the slip means and the sealing element are in a retracted position; a second position where the slip means and the sealing element are in an extended position; and a third position, independent of the first and second positions, wherein the slip means and the sealing element are returned to the retracted position.
7. A retrievable downhole packer according to any one of claims 4 to 6 wherein the actuating mechanism is arranged above the slip means and comprises a plurality of sleeves, wherein at least two sleeves are interconnected by a ratchet means.
8. A retrievable downhole packer according to any preceding claim wherein the sealing element comprises an elastomeric ring.
9. A retrievable downhole packer according to claim 8

wherein the sealing element is arranged between two opposing surfaces which move relatively towards each other to compress the sealing element.

10. A retrievable downhole packer according to any one of claims 4 to 9 wherein the actuating mechanism is operated by a longitudinal force applied to the mechanism. 5
11. A retrievable downhole packer according to any preceding claim wherein the packer includes first attachment means for engagement with a setting tool, wherein the packer is set by longitudinal movement of a first lifting sleeve in the packer. 10
12. A retrievable downhole packer according to claim 11 wherein, when set the actuation mechanism is in the second position. 15
13. A retrievable downhole packer according to claim 11 or claim 12 wherein setting tool is combined with a running tool. 20
14. A retrievable downhole packer according to any preceding claim wherein the packer includes second attachment means for engagement with a retrieval tool, wherein the packer is adjusted to a retrieval position by longitudinal movement of a second lifting sleeve in the packer. 25
15. A retrievable downhole packer according to claim 14 wherein, when in the retrieval position, the actuation mechanism is in the third position. 30
16. A retrievable downhole packer according to any preceding claim wherein the slip means comprises oppositely arranged upper and lower wedge means with at least one slip located there between wherein at least one of the wedges is adapted to move under an end of the slip to force the slip to an extended position. 35 40

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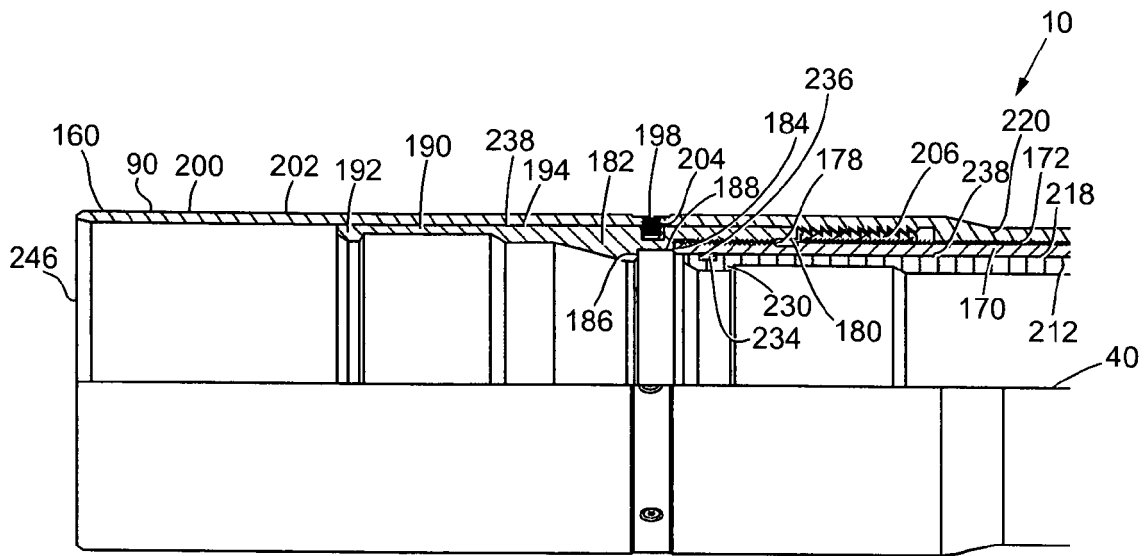


Fig. 1a

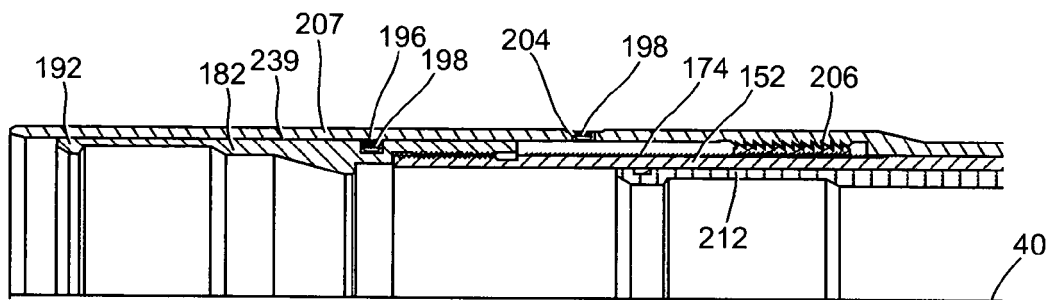


Fig. 2a

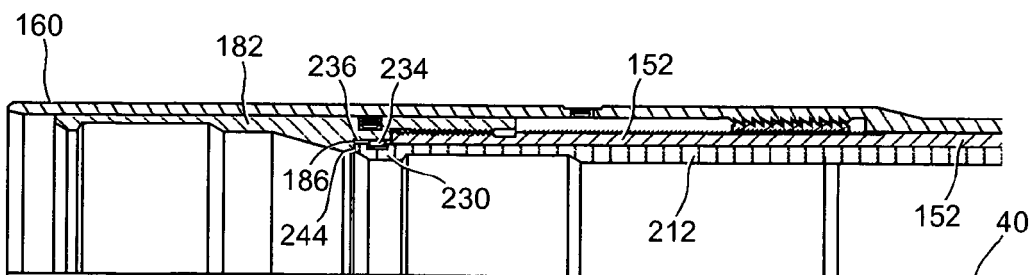


Fig. 3a

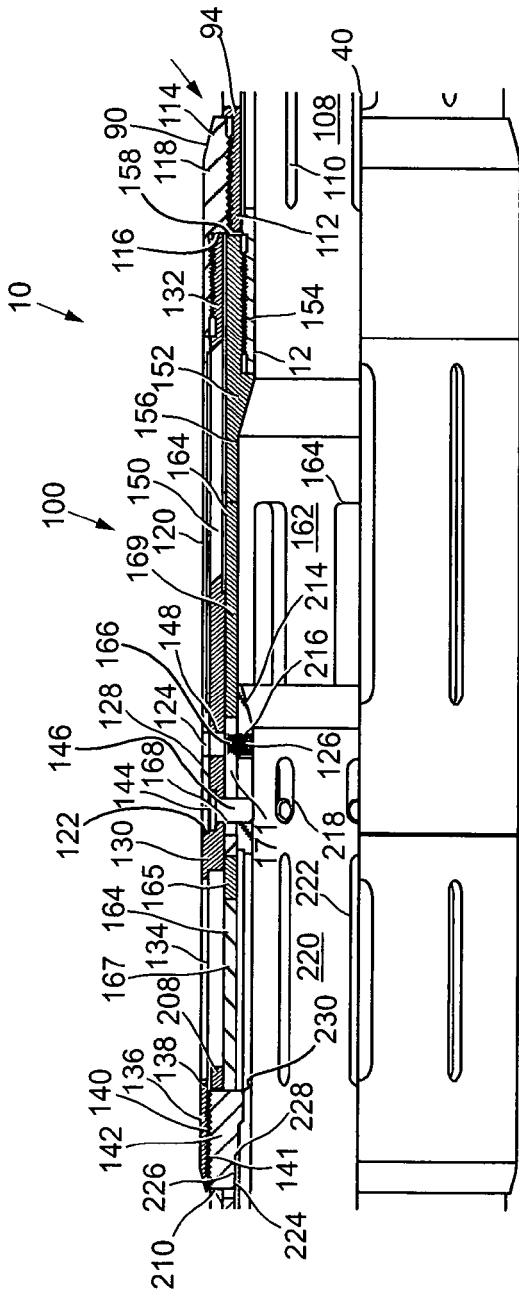


Fig. 1b

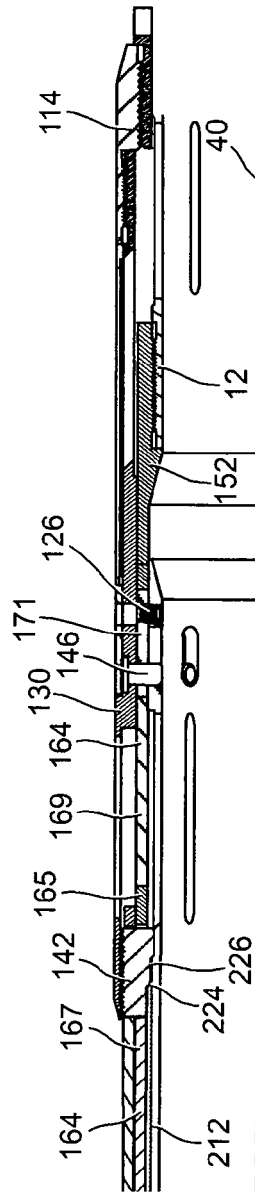


Fig. 2b

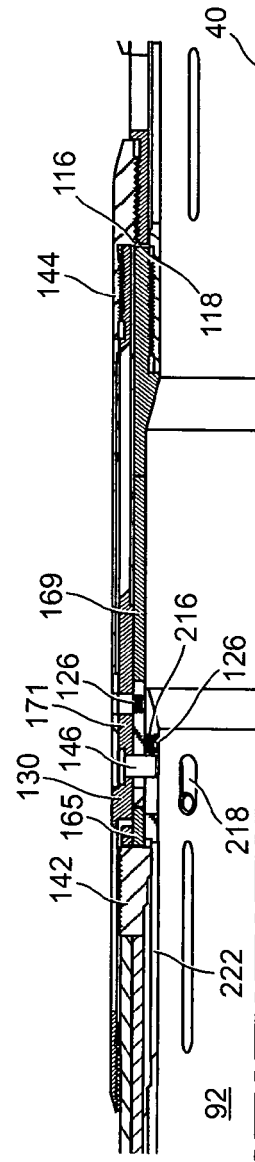


Fig. 3b

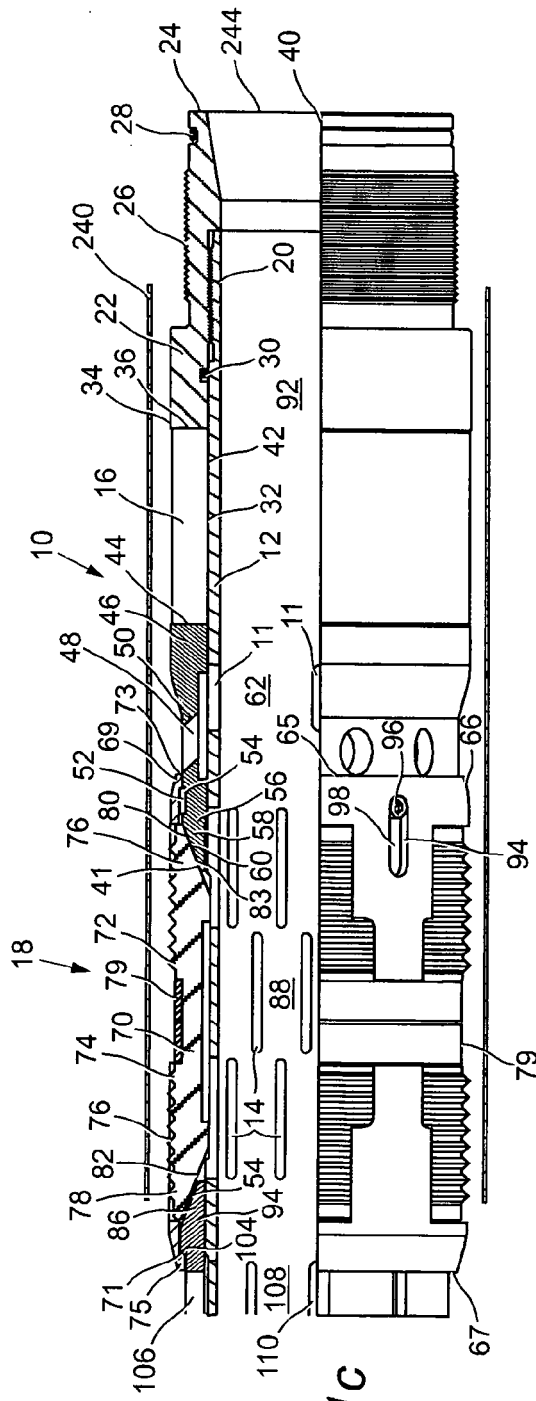


Fig. 1c

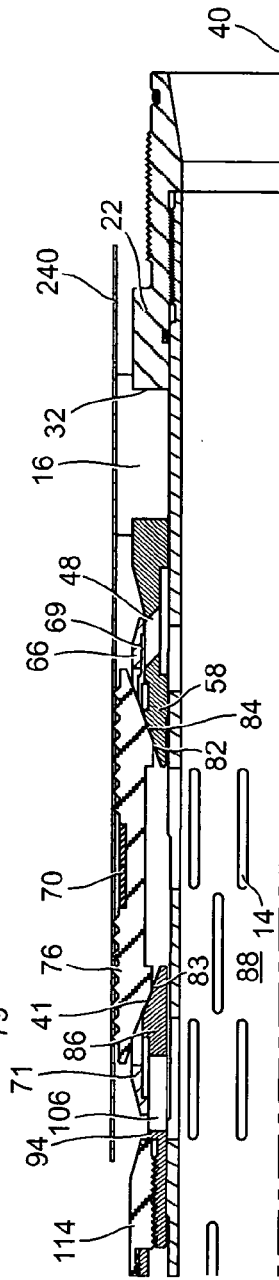


Fig. 2c

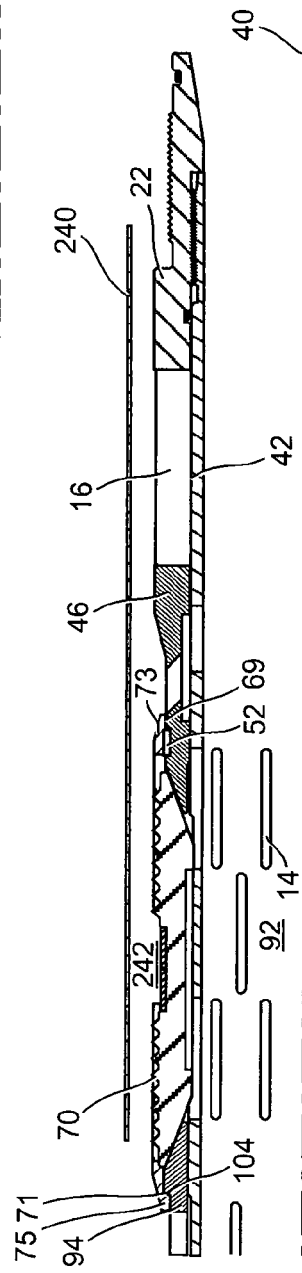


Fig. 3c

REFERENCES CITED IN THE DESCRIPTION

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