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(54) Title: SYSTEM FOR RESEALING BOREHOLE ACCESS

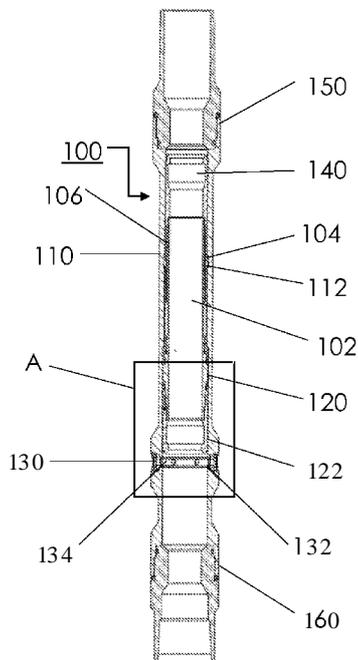


Figure 1

(57) Abstract: A re-closable toe sleeve is disclosed where the toe sleeve has a port allowing fluid access from the interior of the toe sleeve to the exterior of the toe sleeve. A burst disk is placed inside the port to prevent fluid access from the interior of the toe sleeve to the exterior of the toe sleeve. However upon the fluid in the interior of the toe sleeve reaching a predetermined level the burst disk is removed or otherwise modified to allow fluid access through the port. A sliding sleeve is placed within the toe sleeve so that the sliding sleeve can be moved to cover the port thereby preventing fluid access from the interior of the toe sleeve to the exterior of the toe sleeve or the sliding sleeve may be moved to uncover the port thereby allowing fluid access from the interior of the toe sleeve to the exterior the toe sleeve. The sliding sleeve is mechanically moved from the surface and is typically run into the well in the open position such that the port is uncovered by the sliding sleeve.





## SYSTEM FOR RESEALING BOREHOLE ACCESS

### BACKGROUND

**[0001]** In order to produce hydrocarbons, such as oil and gas from a subterranean reservoir, either onshore or offshore, a borehole is drilled through various layers of rock in a formation. A casing may be cemented into the formation along all or part of the borehole to create a wellbore, and a production string is inserted into the wellbore to convey the hydrocarbons to the surface. In other instances, in place of cement, annular packers may be used to seal the casing to the wellbore to prevent the longitudinal flow of fluids along the exterior of the casing. The casing in many instances becomes the production tubular for the wellbore such that the annular packers or the cement isolates each formation zone or portion of a formation zone from one another.

**[0002]** With the casing cemented into the well or the annular packers deployed along the length of the casing, the casing is effectively sealed against allowing any fluids to flow from the formations to the interior of the casing. With the casing effectively sealed against fluid flow, positive fluid downward through the casing is limited at best without access to the exterior of the casing making it difficult if not impossible to pump a ball or a dart through the casing to actuate the toe sleeve.

**[0003]** Therefore access to the exterior of the casing and therethrough to the various formation zones is needed. One means of accessing the exterior of the casing is to utilize a plug and perforate operation where a plug, a setting tool, and a perforating gun sleeve are run into the well on wireline or coil tubing using gravity or a tractor to pull the tool into position. If a sleeve system is used then actuation is limited to mechanical manipulation from the surface such as by the use of coil tubing, slick line, or electric line.

**[0004]** It has been found that it is possible to establish sufficient fluid flow through the casing and into the adjacent formation thereby allowing the subsequent activation of sliding sleeves by dropping balls, plugs, or darts by

use of pressure to establish fluid flow with the exterior the casing where the pressure required to establish fluid flow to the exterior is preset at the surface to correspond to the requirements of the well.

[0005] Once the casing is in place in the wellbore and either cemented or all of the packers actuated fluid access to the exterior is required to facilitate the subsequent activation of sliding sleeves or other tools by dropping balls, plugs, or darts. In order to provide such fluid access to the exterior of the casing a toe sleeve subassembly is installed at the bottom of the casing. The toe sleeve subassembly has at least one port through which fluid may flow thereby establishing fluid flow through the casing and allowing the activation of ball actuated tools.

[0006] The port is provided with a burst disk where the burst disk has to be of sufficient strength to maintain a predetermined pressure during other operations that may be conducted prior to the establishment of fluid flow to the exterior of the casing. In order to operate the burst disk and establish circulation in the wellbore the casing has to be pressurized to some predetermined amount in excess of the pressure required during other operations conducted prior to the establishment of fluid flow to the exterior of the casing. Once the burst disk has burst fluid may then be pumped down through the interior of the casing and into the adjacent formation allowing balls darts or plugs to be pumped down through the casing to actuate other sleeves or tools in the casing above the toe sleeve.

[0007] In many instances over the course of the life of a well it may become necessary to prevent access through many or all of the access points, such as sliding sleeves, to the exterior of the well. In instances where access is provided by sliding sleeves a tool, such as a fishing tool, may be run into the well to close each of the sliding sleeves. However since the toe subassembly is operated by means of a burst disk a bridge plug is required to be run in and an operation separate from the operation to close each of the sliding sleeves. There is a

need to easily close the toe subassembly without running in a separate bridge plug.

#### SUMMARY

[0008] In an embodiment of the invention a valve is provided, operable from the surface, to reseal the toe subassembly. More specifically, the toe subassembly has a housing. The housing has a port where the port allows access from the interior of the housing to the exterior of housing. Within the port is placed the burst disk where the burst disk has a burst rating less than the pressure required during the casing integrity test. An interior sleeve is axially movable within the housing. The set of seals is arranged around the exterior of the interior sleeve so as to seal a portion of the annular space between the exterior of the interior sleeve in the interior of the housing such that when the interior sleeve is in the closed condition the set of seals and the interior sleeve is arranged to prevent fluid access from the interior of the casing to the exterior of the casing. The toe subassembly may be placed in the well as part of an assembly of valves such as sliding sleeves with the toe subassembly at the bottom of the assembly or closest to the bottom of the well. The casing and is run into the wellbore in the open condition where the interior sleeve does not restrict fluid access to the burst disk allowing the burst disk to be compromised upon command.

[0009] When required the interior sleeve may be moved by a fishing tool conveyed into the well on wireline however other means of closing the toe sleeve may be used. The interior sleeve is provided with a profile such that a tool, including the fishing tool, can be run into the well, latch into the profile, and shift the interior sleeve so that fluid access is no longer provided through the port to the exterior of the casing. If so required the profile may be again utilized to shift the sleeve so that the port again provides fluid access to the exterior of the well.

## BRIEF DESCRIPTION OF THE DRAWINGS

**[0010]** Figure 1 depicts a toe subassembly in its run-in condition.

**[0011]** Figure 2 depicts the toe subassembly of Figure 1 in its closed condition.

**[0012]** Figure 3 depicts a close-up of the area of Figure 1 denoted by box A.

**[0013]** Figure 4 depicts a close-up of the area of Figure 2 denoted by box B.

**[0014]** Figure 5 depicts a burst port subassembly that has been ruptured and is open to fluid flow from the interior of the toe subassembly.

**[0015]** Figure 6 depicts a burst port subassembly that has been ruptured and is closed to fluid flow from the interior of the toe subassembly.

## DETAILED DESCRIPTION

**[0016]** The description that follows includes exemplary apparatus, methods, techniques, or instruction sequences that embody techniques of the inventive subject matter. However, it is understood that the described embodiments may be practiced without these specific details.

**[0017]** Figure 1 depicts a toe subassembly 100 in the configuration where it is run into the wellbore. The toe subassembly 100 has a housing 110, an interior sleeve 120, a port 134, a burst port subassembly 130 residing in port 134, a profile 140, an upper end 150, and a lower end 160. Coupled to the interior sleeve 120 is a lock ring 104, which may be a shear pin, a c-ring, or merely a protrusion on the exterior of the interior sleeve 120, resides in recess 106 in the interior surface of the housing 110. The lock ring 104 abuts shoulder 112 in recess 106 to prevent the interior sleeve 120 from inadvertently moving downward. In this run-in configuration the interior sleeve 120 is positioned in the housing 110 such that the lower end 122 of the interior sleeve 120 does not

restrict fluid access from the interior 102 of the toe subassembly 100 to the interior 132 of the burst disk subassembly 130.

**[0018]** By allowing fluid access from the interior 102 of the toe subassembly 100 to the interior 132 of the burst disk subassembly 130 when the fluid reaches a predetermined pressure the burst disk subassembly 130 will yield thereby allowing fluid access from the interior 102 of the toe subassembly 100 through port 134 to the exterior of toe subassembly 100 and typically into an adjacent formation (not shown). In certain instances the burst disk assembly is dissolvable such that the burst disk will degrade or dissolve over time to allow fluid flow through the port 134.

**[0019]** Figure 2 depicts the toe subassembly 100 of Figure 1 in its closed condition with the interior sleeve 120 positioned in the housing 110 such that the interior sleeve 120 prevents fluid access from the interior 102 of the toe subassembly 100 to the interior 132 of the burst port subassembly 130.

**[0020]** Typically the interior sleeve 120 is moved from its running condition as depicted in Figure 1 to its closed condition in response to wellbore conditions such as the well producing excessive water. By utilizing a profile that matches profile 121 towards the lower end 122 of interior sleeve 120, typically on the end of a wireline, coil tubing, or other tubular to latch into profile 140. Force is then applied to interior sleeve 120 to overcome the resistance of lock ring 104 against shoulder 112 in recess 106 to shift the interior sleeve 120 downwards such that the interior sleeve 120 blocks fluid access from the interior 102 to the interior 132 a burst port subassembly 130. As shown in Figure 2 lock ring 104 now resides in recess 108 thereby preventing the upward movement of interior sleeve 120.

**[0021]** Figure 3 depicts a close-up of the area of Figure 1 denoted by box A. In Figure 3 the burst disk subassemblies 130 and the lower end 122 of interior sleeve 120 along with its sealing system are more easily described. The interior sleeve 120 is in its run-in position such that the lower end 122 of interior sleeve 120 do not block fluid access to ports 134 and thus to the interior 132 of burst

disk subassemblies 130. The interior sleeve 120 has a first seal 142 and a second seal 144 that are longitudinally offset from each other and are retained in place about the exterior of interior sleeve 120. The first seal 142 and the second seal 144 reside in recess 108 and each form a seal between the interior sleeve 120 and the housing 110.

**[0022]** Figure 4 depicts a close-up of the area of Figure 2 denoted by box B. The interior sleeve 120 is in its closed position such that interior sleeve 120 blocks fluid access to ports 134. While typically the burst disk pressure has been exceeded such that the burst disk subassemblies are open Figure 4 depicts the toe subassembly 100 with the interior sleeve 120 and its closed position thereby preventing fluid access to the interior 132 of burst disk subassembly 130. With the interior sleeve 120 in its closed position seals 140 and 144 are in a spaced apart relation sufficient to straddle port 134 thereby sealing the interior 102 of the toe subassembly 100 against fluid access to port 134.

**[0023]** Figure 5 depicts a burst port subassembly 130 that has been attached to housing 110 in port 134 by threads 135. While threads are shown, welding, press fit, or any other means of attachment may be used. The interior sleeve 120 is in its run-in position and is not shown in figure 5. Fluid pressure has been increased such that inner disk 145 has been ruptured and exterior pressure protection cap 137 has been forced off of its seat in the direction as indicated by arrow 143 such that fluid, as depicted by arrows 139 and 141, may flow from the interior 102 of toe subassembly 130 through port 134 and at least to the exterior of toe subassembly 130.

**[0024]** Figure 6 depicts a burst port subassembly 130 attached to housing 110 in port 134 by threads 135. The interior sleeve 120 is in its closed position. Seals 142 and 144 form a fluid tight seal between interior sleeve 120 and housing 110 thereby preventing fluid access from the interior 102 of toe subassembly 100 through port 134 and the now open burst disk subassembly 130 to the exterior of toe subassembly 100.

[0025] While the embodiments are described with reference to various implementations and exploitations, it will be understood that these embodiments are illustrative and that the scope of the inventive subject matter is not limited to them. Many variations, modifications, additions and improvements are possible.

[0026] Plural instances may be provided for components, operations or structures described herein as a single instance. In general, structures and functionality presented as separate components in the exemplary configurations may be implemented as a combined structure or component. Similarly, structures and functionality presented as a single component may be implemented as separate components. These and other variations, modifications, additions, and improvements may fall within the scope of the inventive subject matter.

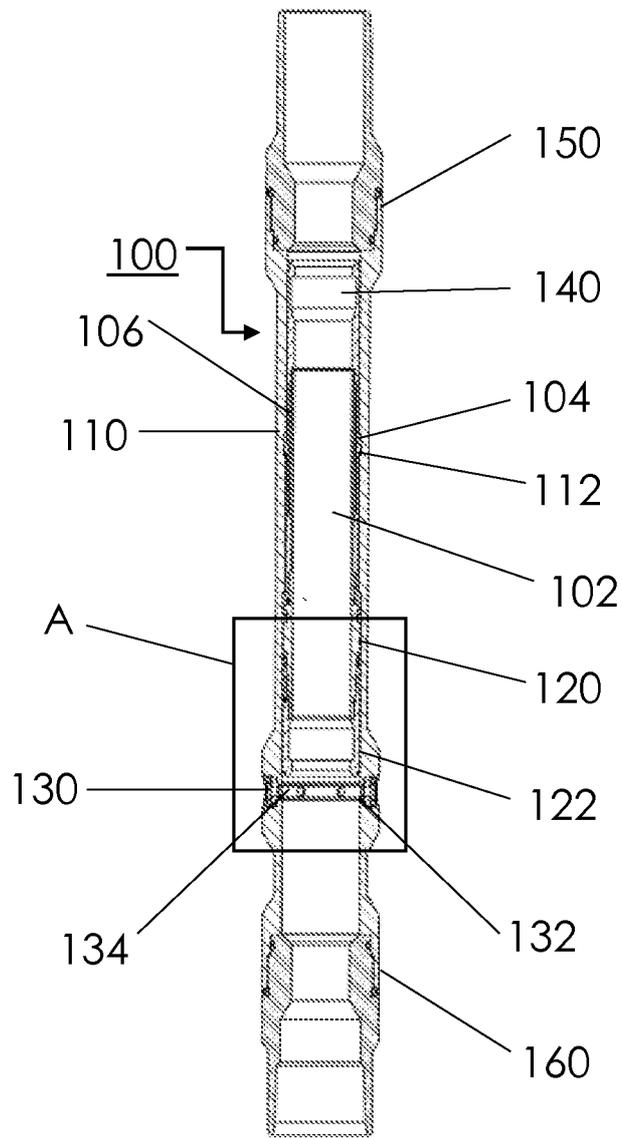
What is claimed is:

1. A valve for use in stimulation of a formation comprising:  
a cylindrical housing having at least one port extending radially through the wall of the housing;  
an interior sleeve disposed coaxially within the housing and axially movable between an open position, wherein the interior sleeve does not cover the port, and a closed position, wherein the interior sleeve covers the port;  
a burst disk mounted in the port and, in an initial state, blocking fluid flow through the port; and  
an interior sleeve returning unit to move the interior sleeve between the open position and the closed position.
2. The valve according to claim 1, wherein in the initial state the interior sliding sleeve does not cover the port.
3. The valve according to claim 1, wherein in the initial state the interior sliding sleeve covers the port.
4. The valve according to claim 1, wherein the burst disk is configured to rupture at a predetermined pressure difference between an interior of the housing and an exterior of the housing.
5. The valve according to claim 1, wherein the burst disk is configured to rupture at a predetermined pressure difference between an interior of the housing and an atmospheric chamber.
6. The valve according to claim 1, wherein the burst disk is configured to dissolve when exposed to a dissolving fluid.
7. The valve according to claim 1 wherein the burst disk is slot shaped.

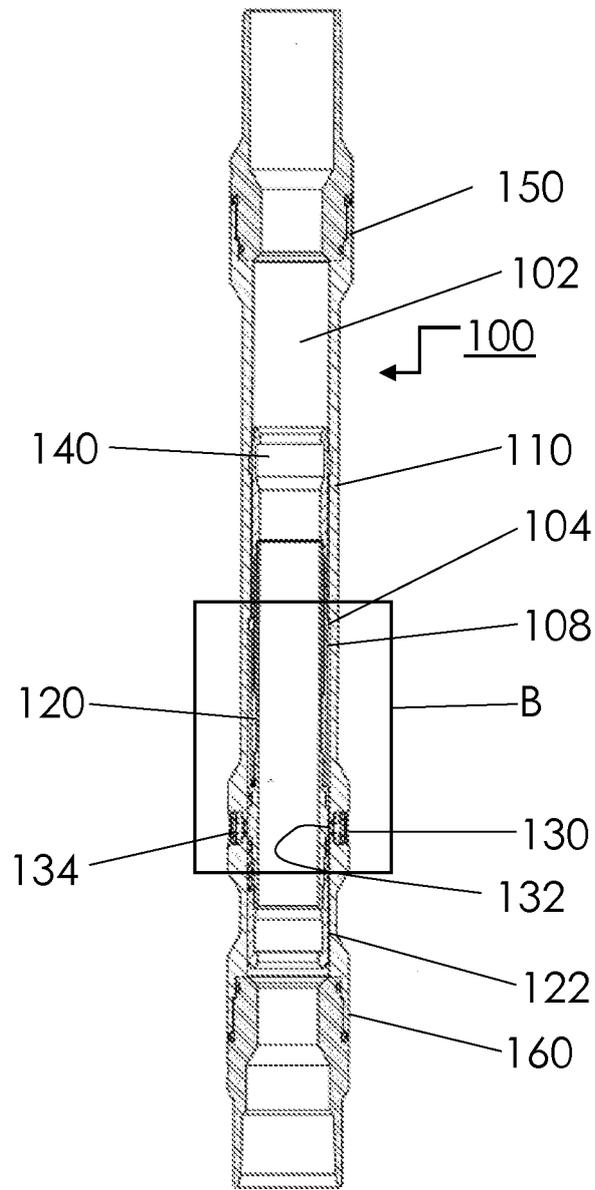
8. The valve according to claim 1, wherein the interior sleeve includes a latch profile.
9. The valve according to claim 1, wherein the interior sleeve includes a ball seat.
10. The valve according to claim 1, wherein the interior sleeve returning unit has a profile matching the profile of the interior sleeve.
11. The valve according to claim 1, further comprising a sliding sleeve valve above the valve.
12. The valve according to claim 1, further comprising a sliding sleeve valve below the valve.
13. A method for stimulating a formation, comprising:
  - installing a sliding sleeve in a tubular string;
  - installing a valve in the tubular string below the sliding sleeve, wherein the valve has a port, a burst disk, and an interior sleeve, further wherein the interior sleeve is movable between an open position where the interior sleeve does not cover the port and a closed position where the sliding sleeve covers the port;
  - running the tubular string into a well with the interior sleeve in the open position;
  - increasing the fluid pressure in the interior of the valve;
  - rupturing the burst disk; and
  - flowing through the port.
14. The method of claim 13, wherein in the open position the interior sleeve does not cover the port.

15. The method of claim 14, further comprising moving the interior sleeve to the closed position.
16. The method of claim 13, wherein in the initial state the interior sliding sleeve does not cover the port.
17. The method of claim 13, wherein in the initial state the interior sliding sleeve covers the port.
18. The method of claim 17, further comprising moving the interior sleeve to the closed position.
19. The method of claim 13, wherein the burst disk is configured to rupture at a predetermined pressure difference between an interior of the housing and an exterior of housing.
20. The method of claim 13, wherein the burst disk is configured to rupture at a predetermined pressure difference between an interior of the housing and an atmospheric chamber.
21. The method of claim 13, wherein the burst disk is configured to dissolve when exposed to a dissolving fluid.
22. The method of claim 13, wherein the burst disk is slot shaped.
23. The method of claim 13, wherein the interior sleeve includes a latch profile.
24. The method of claim 13, wherein the interior sleeve includes a ball seat.
25. The method of claim 13, wherein the interior sleeve returning unit has a profile matching the profile of the interior sleeve.

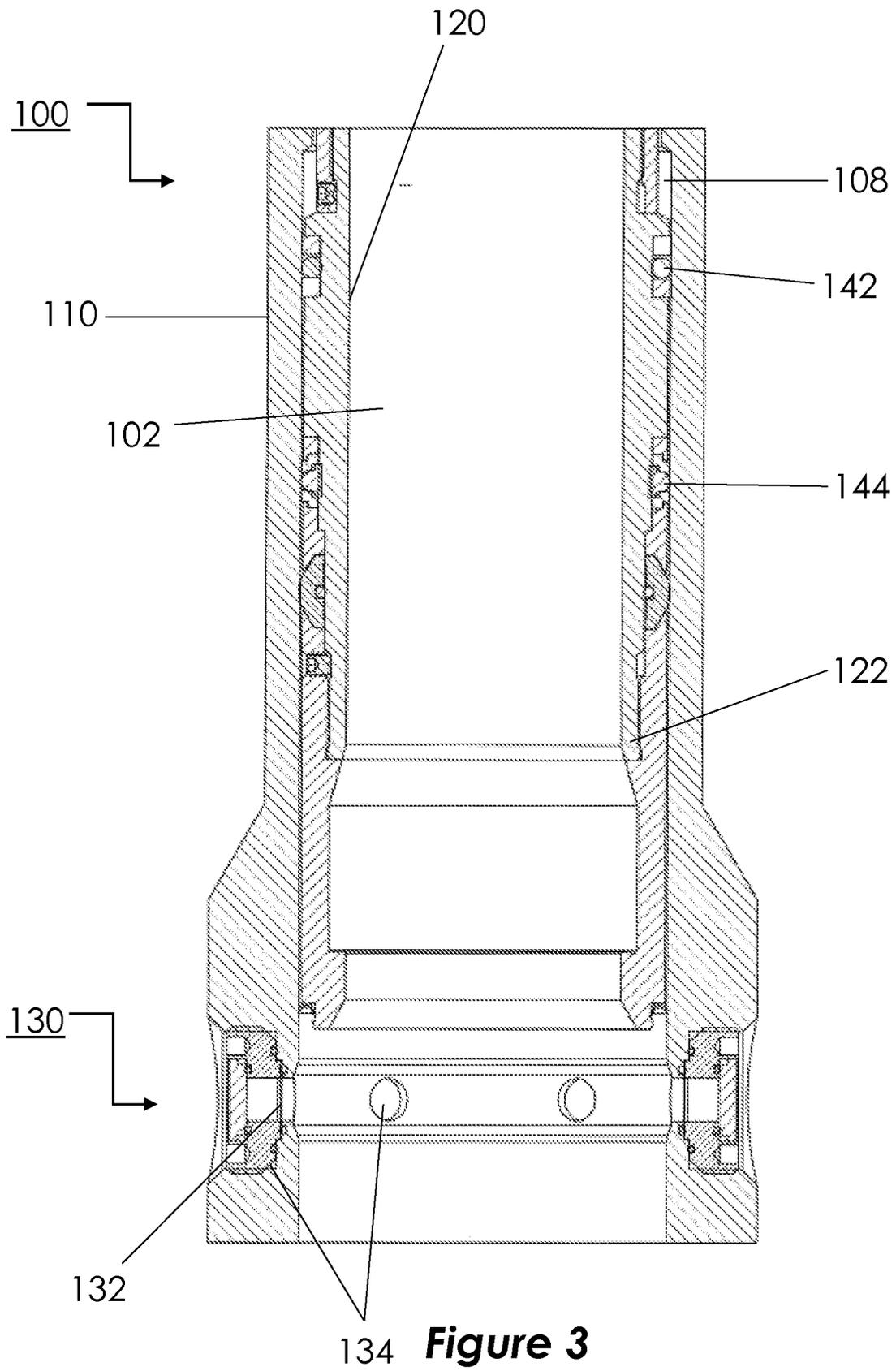
26. The method of claim 13, further comprising a sliding sleeve valve above the valve.
27. The method of claim 13, further comprising a sliding sleeve valve below the valve.
28. The method of claim 13, wherein at least two valves are installed in the tubular string.

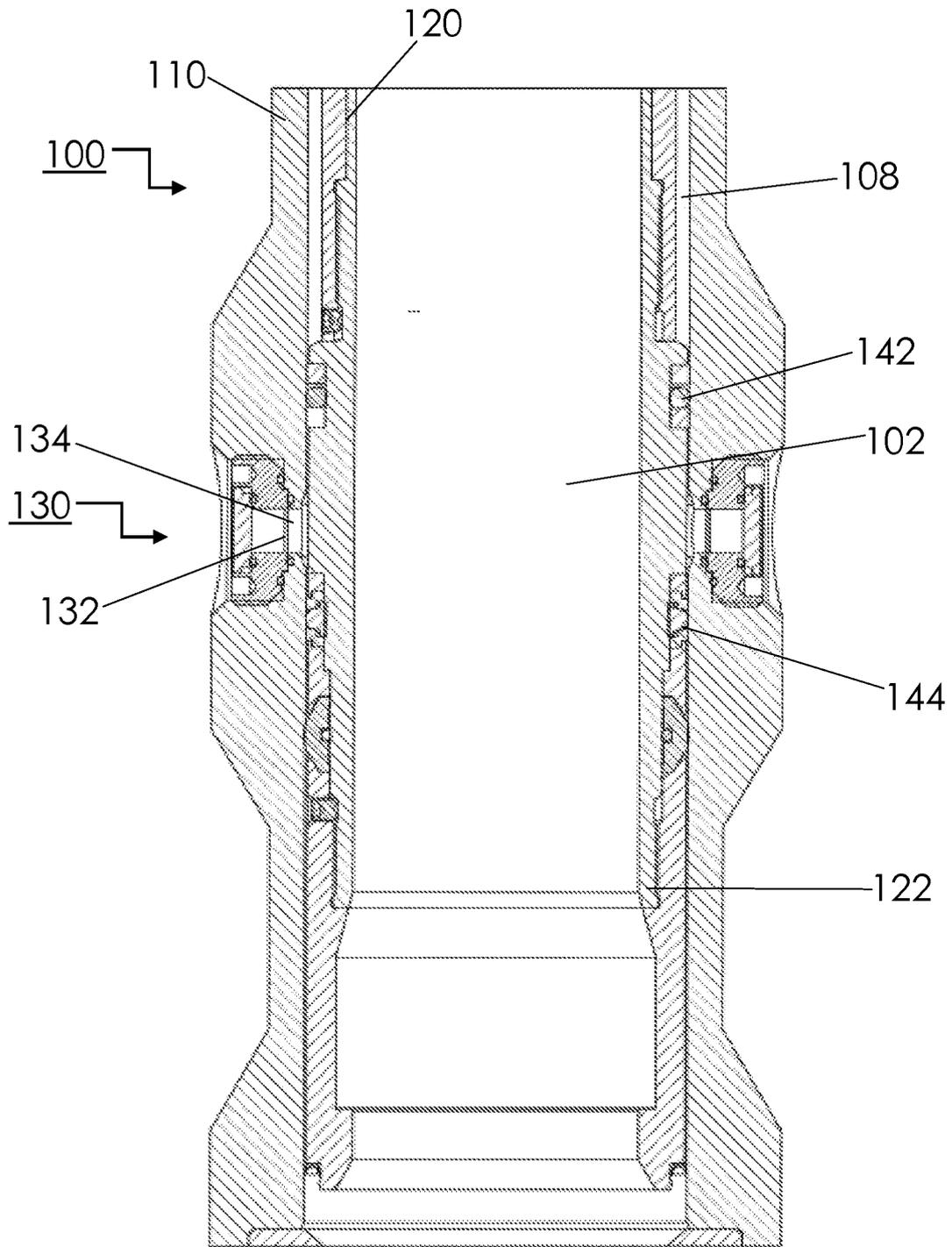


**Figure 1**

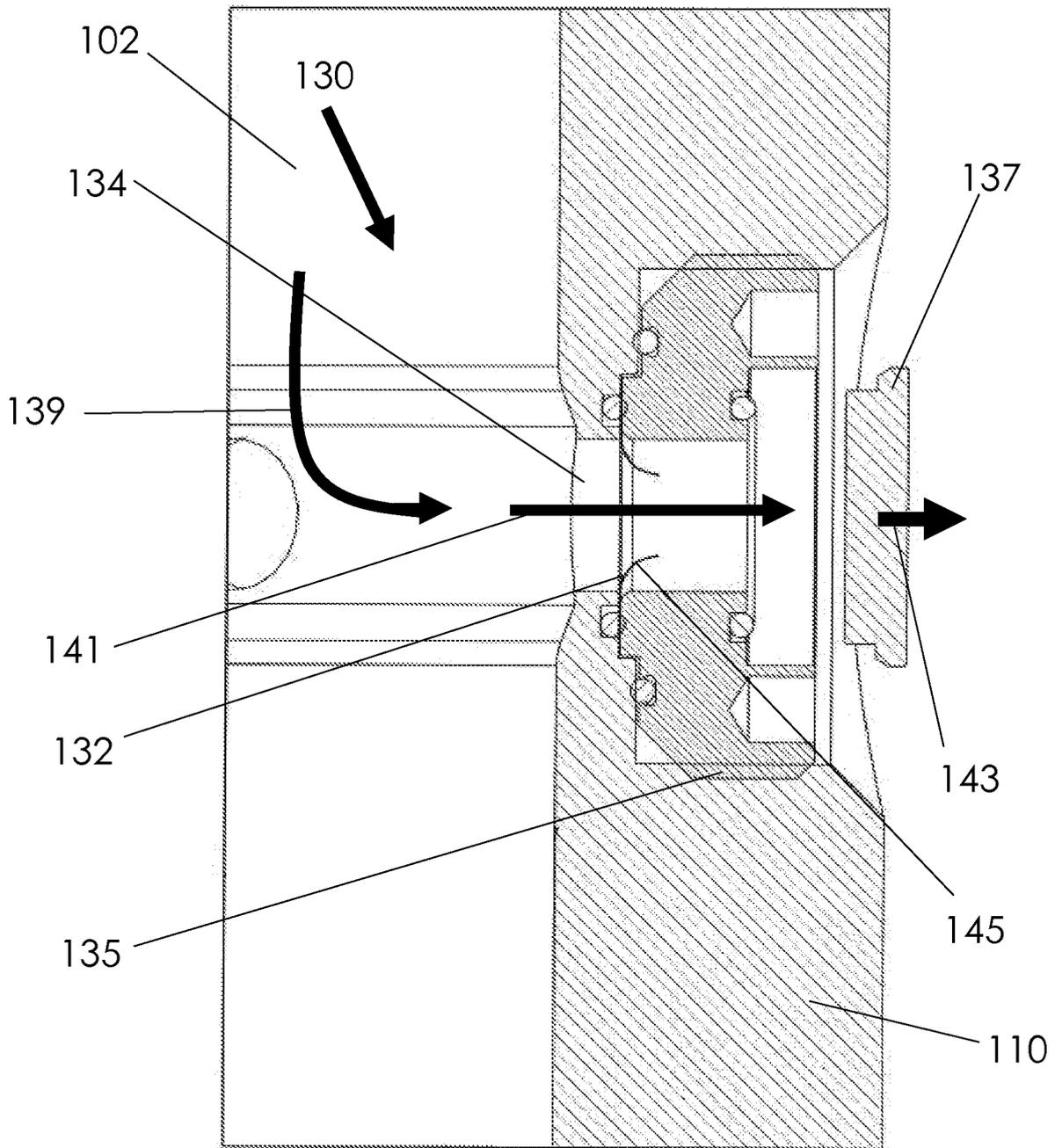


**Figure 2**

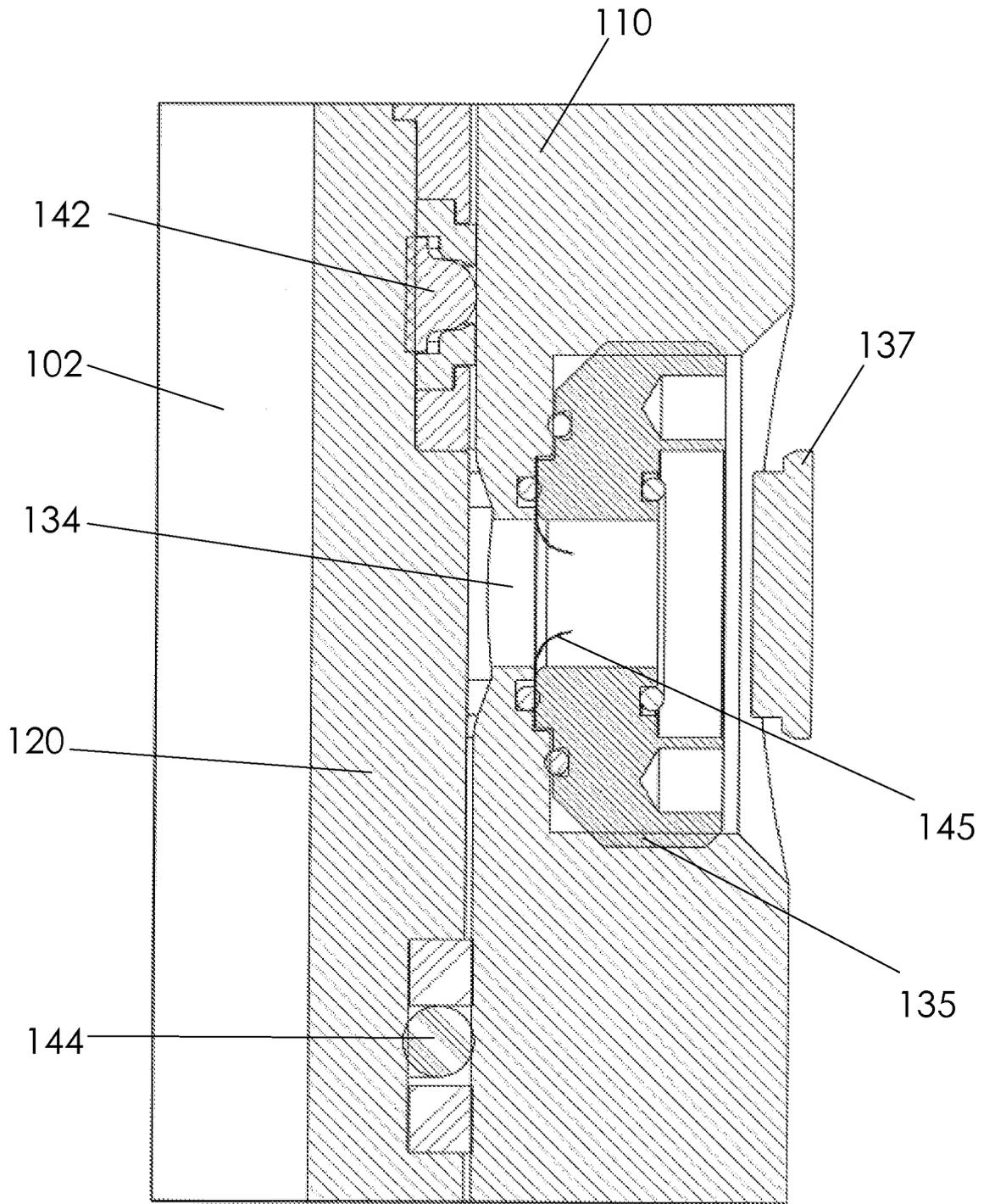




**Figure 4**



**Figure 5**



**Figure 6**

## INTERNATIONAL SEARCH REPORT

International application No.

**PCT/CA2016/050409**

A. CLASSIFICATION OF SUBJECT MATTER  
 IPC: *E21B 34/06* (2006.01) , *E21B 34/10* (2006.01) , *E21B 43/12* (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)  
 IPC: E21B 34/06, E21B 34/10, E21B 43/12

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

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

Questel Orbit (FAMPAT)

Keywords (burst or rupture), (disk or disc), (sleeve or insert), shift+ tool,(reclose+ or re-close+),seat

## C. DOCUMENTS CONSIDERED TO BE RELEVANT

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Further documents are listed in the continuation of Box C.

See patent family annex.

* "A" "E" "L" "O" "P"	Special categories of cited documents: document defining the general state of the art which is not considered to be of particular relevance earlier application or patent but published on or after the international filing date document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified) document referring to an oral disclosure, use, exhibition or other means document published prior to the international filing date but later than the priority date claimed	"I" "X" "Y" "&"	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 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 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
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Date of the actual completion of the international search  
06 June 2016 (06-06-2016)

Date of mailing of the international search report  
15 June 2016 (15-06-2016)

Name and mailing address of the ISA/CA  
 Canadian Intellectual Property Office  
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 50 Victoria Street  
 Gatineau, Quebec K1A 0C9  
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**PCT/CA2016/050409**

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Information on patent family members

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