US012385343B1

(12) **United States Patent**
Eriksen et al.

(10) **Patent No.: US 12,385,343 B1**
(45) **Date of Patent: Aug. 12, 2025**

(54) **PLUG BREAKER**

(71) Applicant: **TCO Group AS**, Indre Arna (NO)

(72) Inventors: **Tommy Eriksen**, Voss (NO); **Richard Hagvåg Ringstad**, Indre Arna (NO)

(73) Assignee: **TCO Group AS**, Indre Arna (NO)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days.

(21) Appl. No.: **19/186,848**

(22) Filed: **Apr. 23, 2025**

(30) **Foreign Application Priority Data**

Dec. 13, 2024 (NO) 20241225

(51) **Int. Cl.**
E21B 23/04 (2006.01)

(52) **U.S. Cl.**
CPC ***E21B 23/0413*** (2020.05)

(58) **Field of Classification Search**
CPC .. E21B 2200/06; E21B 23/0413; E21B 23/04; E21B 34/103
See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

11,808,109	B1	11/2023	Conner et al.	
2008/0196903	A1*	8/2008	Wardley	E21B 21/12 166/387
2013/0014941	A1*	1/2013	Tips	E21B 23/0412 166/250.15
2013/0186633	A1*	7/2013	Kitzman	E21B 23/04 166/318
2014/0083713	A1*	3/2014	Budler	E21B 33/14 166/373
2014/0251629	A1*	9/2014	Castro	E21B 34/14 166/318
2015/0129205	A1*	5/2015	Hofman	E21B 34/103 166/250.01

(Continued)

OTHER PUBLICATIONS

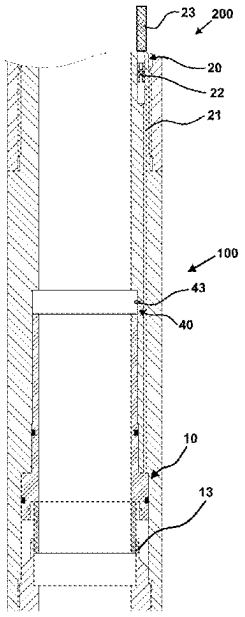
Norwegian Search Report for Serial No. 20241225; issued Apr. 8, 2025.

Primary Examiner — Shane Bomar
(74) *Attorney, Agent, or Firm* — Flener IP & Business Law; Zareefa B. Flener

(57) **ABSTRACT**

A soft open preventer system including: a preventer tubular, a soft open preventer, a channel system, and a downhole tool. The soft open preventer includes a preventer support and a preventer release element. The channel system includes a channel, a channel release, and pressure applier. The downhole tool includes a tool release element. The soft open preventer, the downhole tool, and the channel system is arranged at least partially in the preventer tubular. The soft open preventer is arranged such that the downhole tool will not activate before the soft open preventer activates. The pressure applier is arranged to activate the channel release, the channel release is arranged to allow pressure to increase in the channel, and the channel is in fluid contact with at least a portion of the preventer support. The preventer release element supports the preventer support and is arranged such that when a threshold absolute pressure or pressure differential is applied to the preventer release element, the preventer release element breaks activating the soft open preventer. This allows the preventer support to move. The preventer system is arranged such that activation of the soft open preventer will allow the activation of the downhole tool.

20 Claims, 13 Drawing Sheets



(56) **References Cited**

U.S. PATENT DOCUMENTS

2017/0211351	A1*	7/2017	Graf	E21B 34/066
2018/0171737	A1*	6/2018	Xu	E21B 29/02
2018/0252073	A1*	9/2018	Richards	E21B 47/12
2018/0328144	A1*	11/2018	Arabsky	E21B 23/006
2019/0078408	A1	3/2019	Fripp	
2020/0362668	A1*	11/2020	Fripp	E21B 34/063
2023/0243229	A1*	8/2023	Eriksen	E21B 33/134 166/179
2023/0279736	A1*	9/2023	Eriksen	E21B 17/1078 166/192
2023/0358114	A1*	11/2023	Dyck	E21B 33/13
2023/0400059	A1*	12/2023	Eriksen	F16J 15/022
2024/0279994	A1	8/2024	Decuir et al.	

* cited by examiner

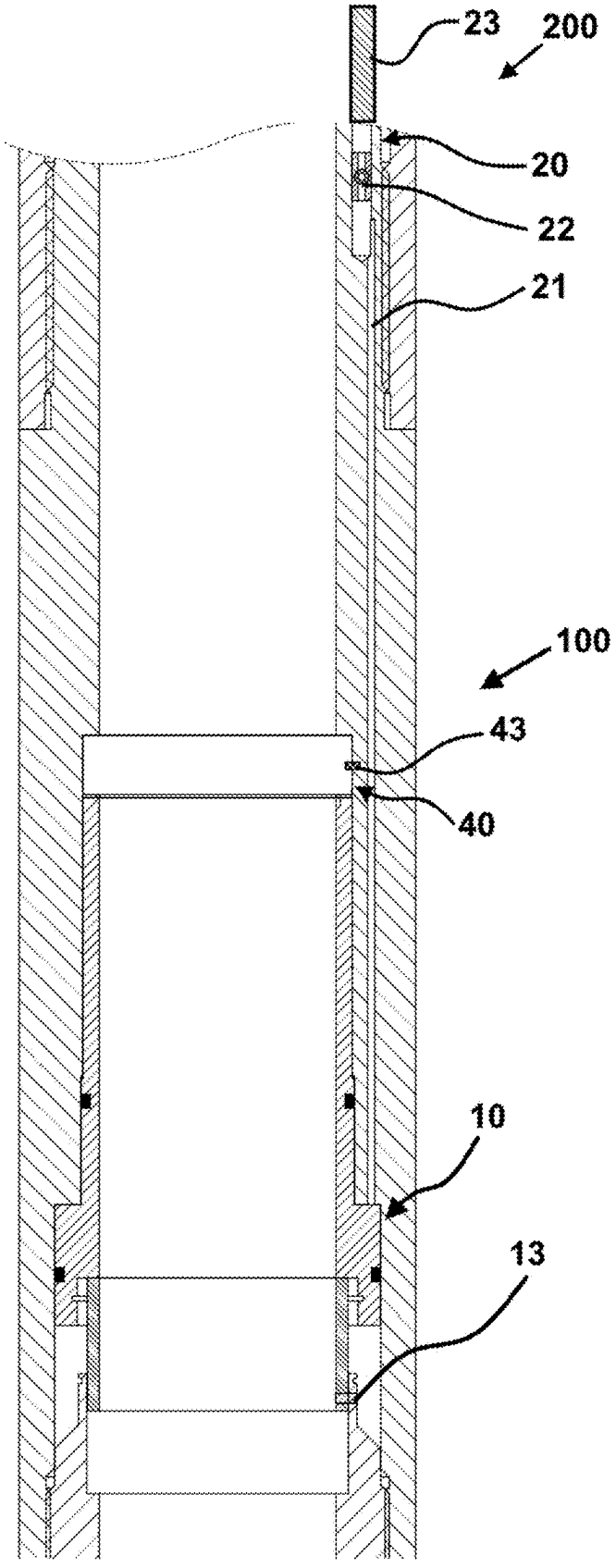


FIG 1A

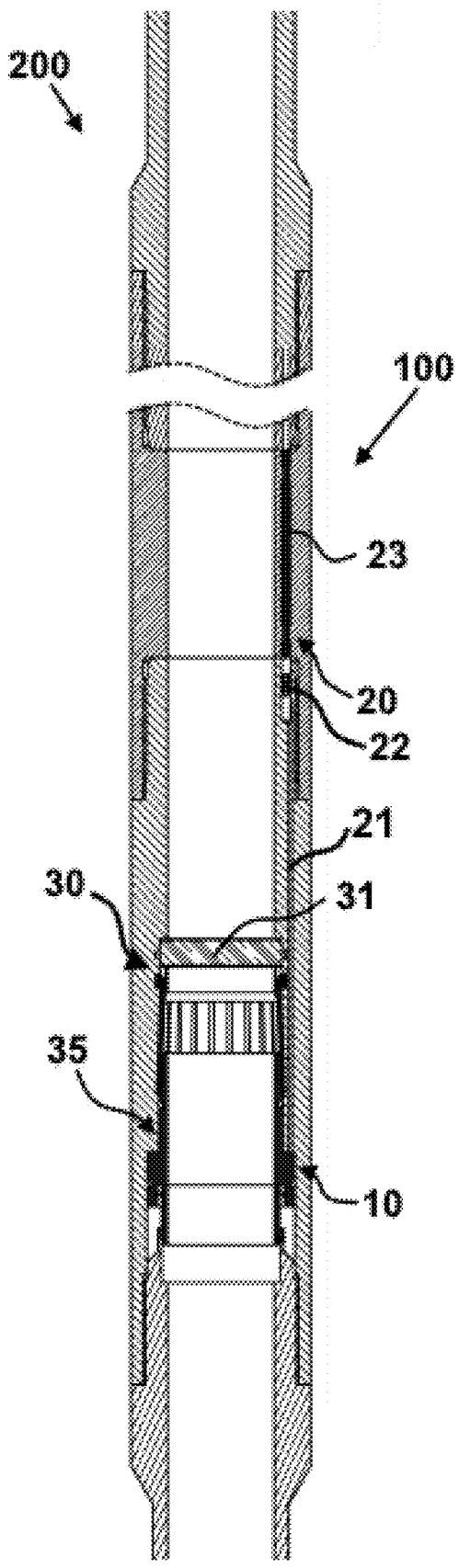


FIG 1B

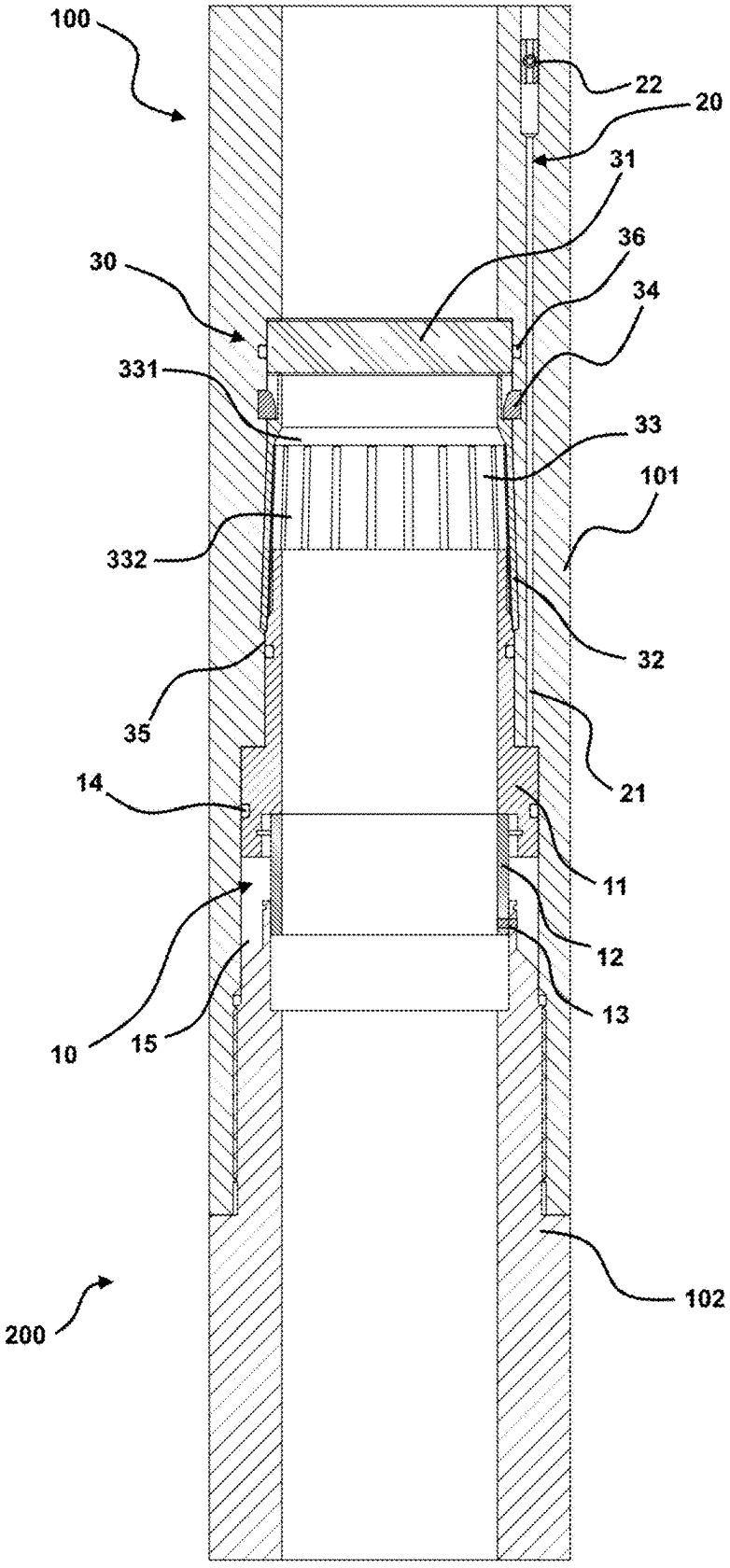

100
22
20
31
36
30
34
331
33
101
332
32
35
21
14
11
12
13
10
15
102
200

FIG 2A

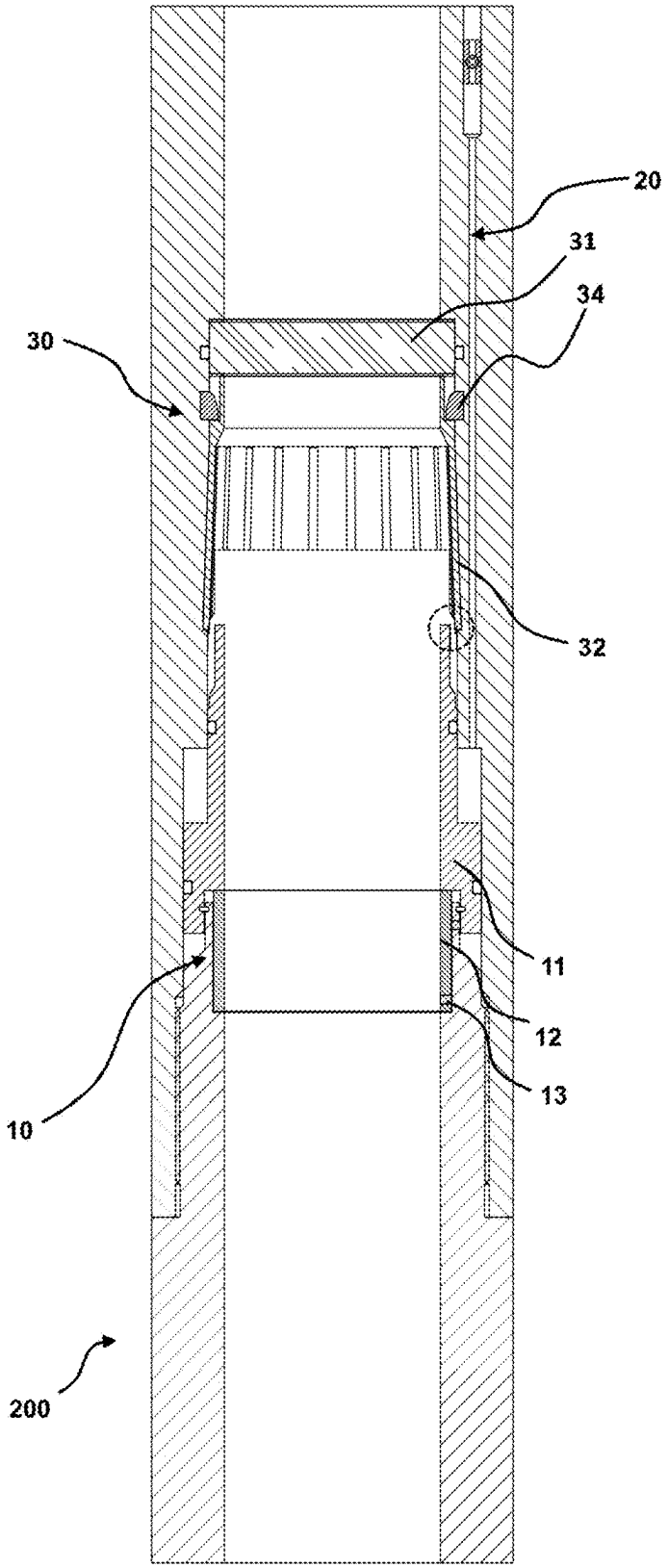


FIG 2B

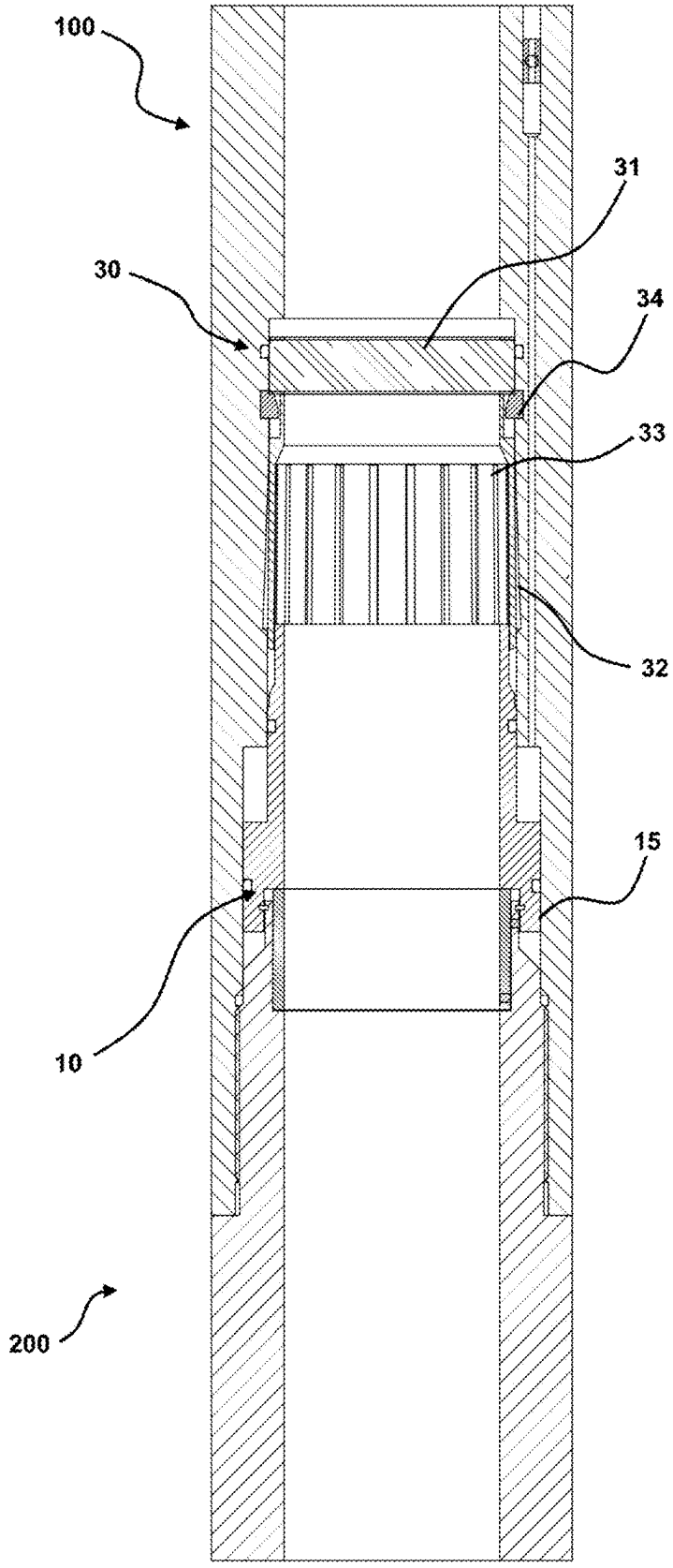


FIG 2C

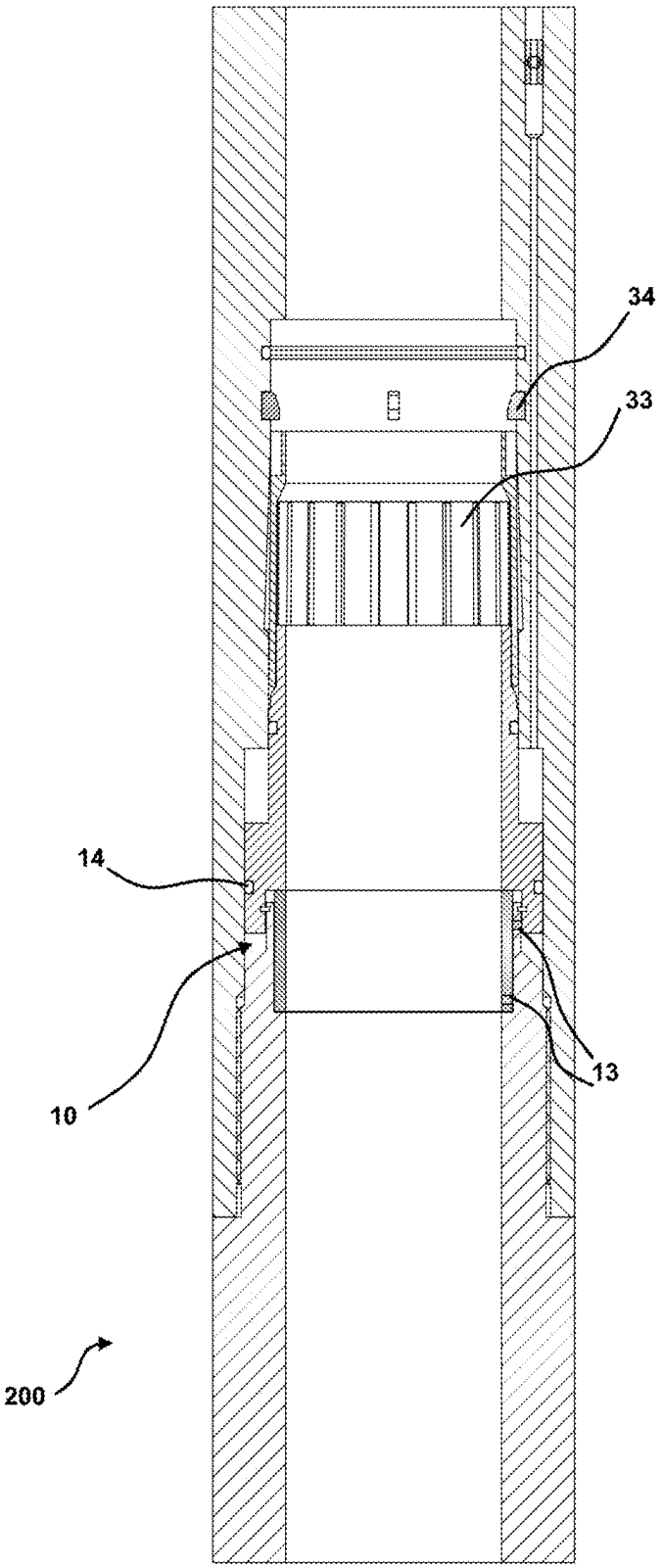


FIG 2D

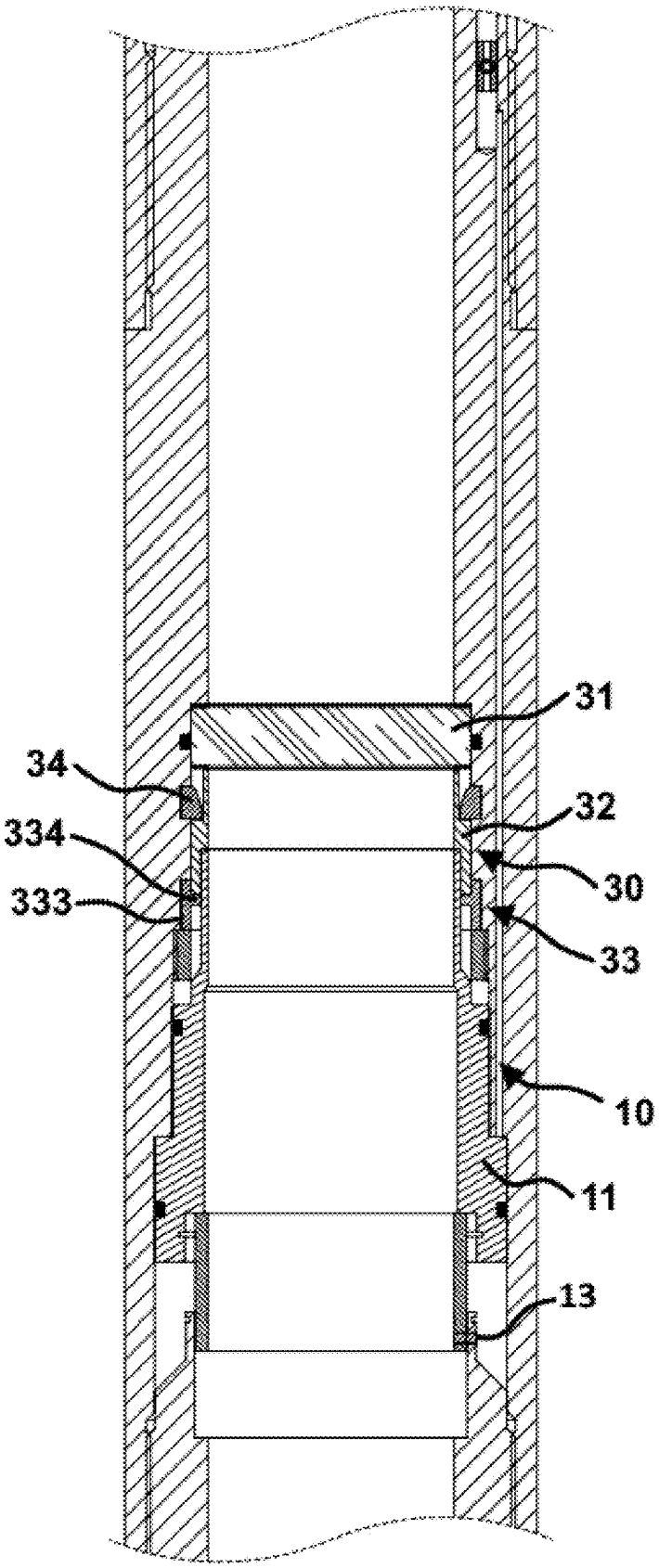


FIG 3

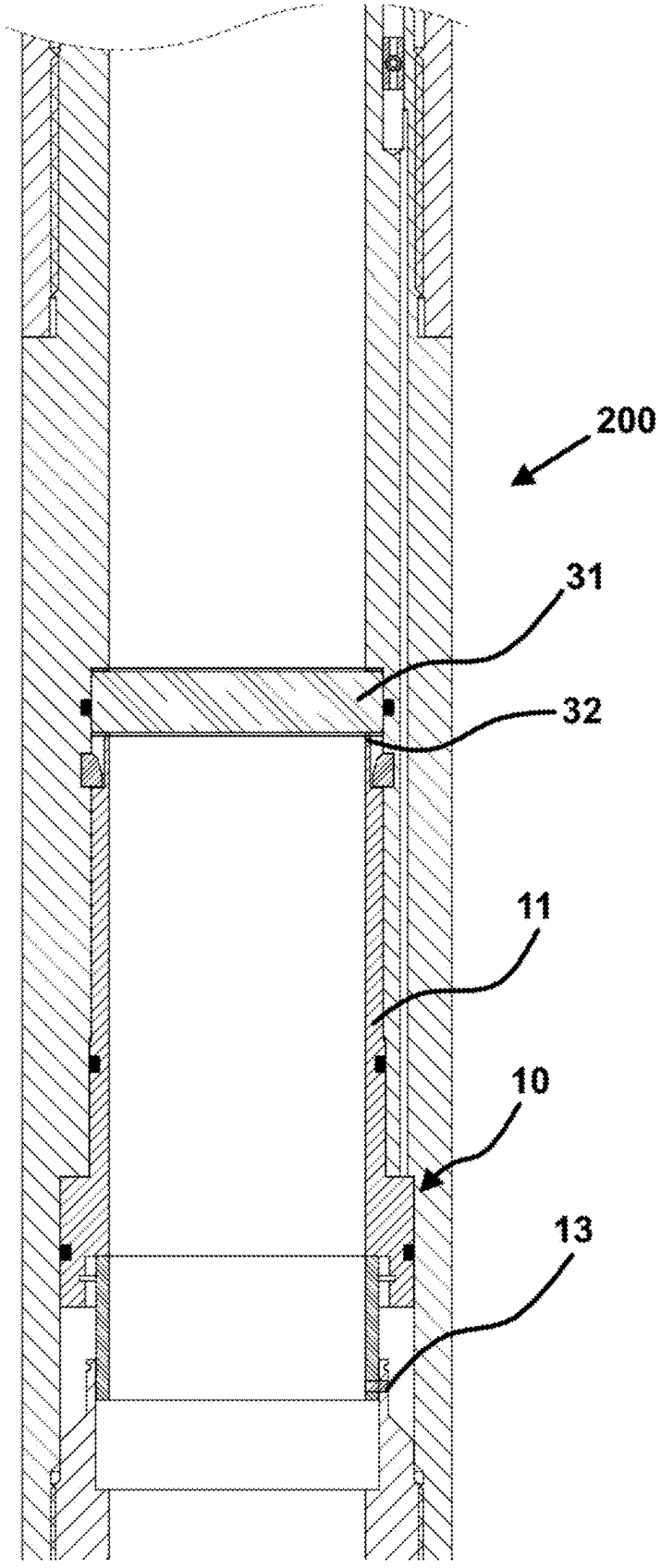


FIG 4

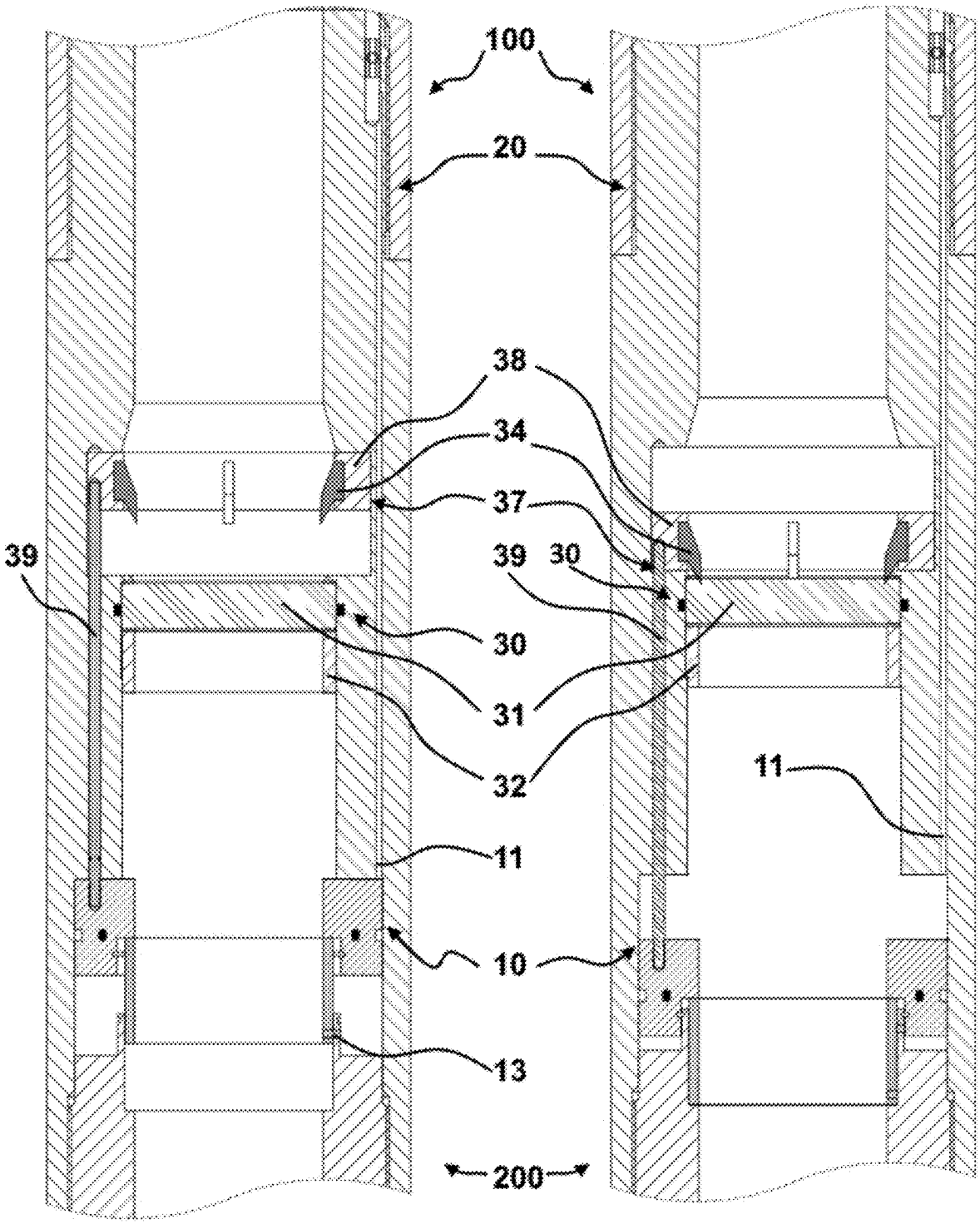


FIG 5A FIG 5B

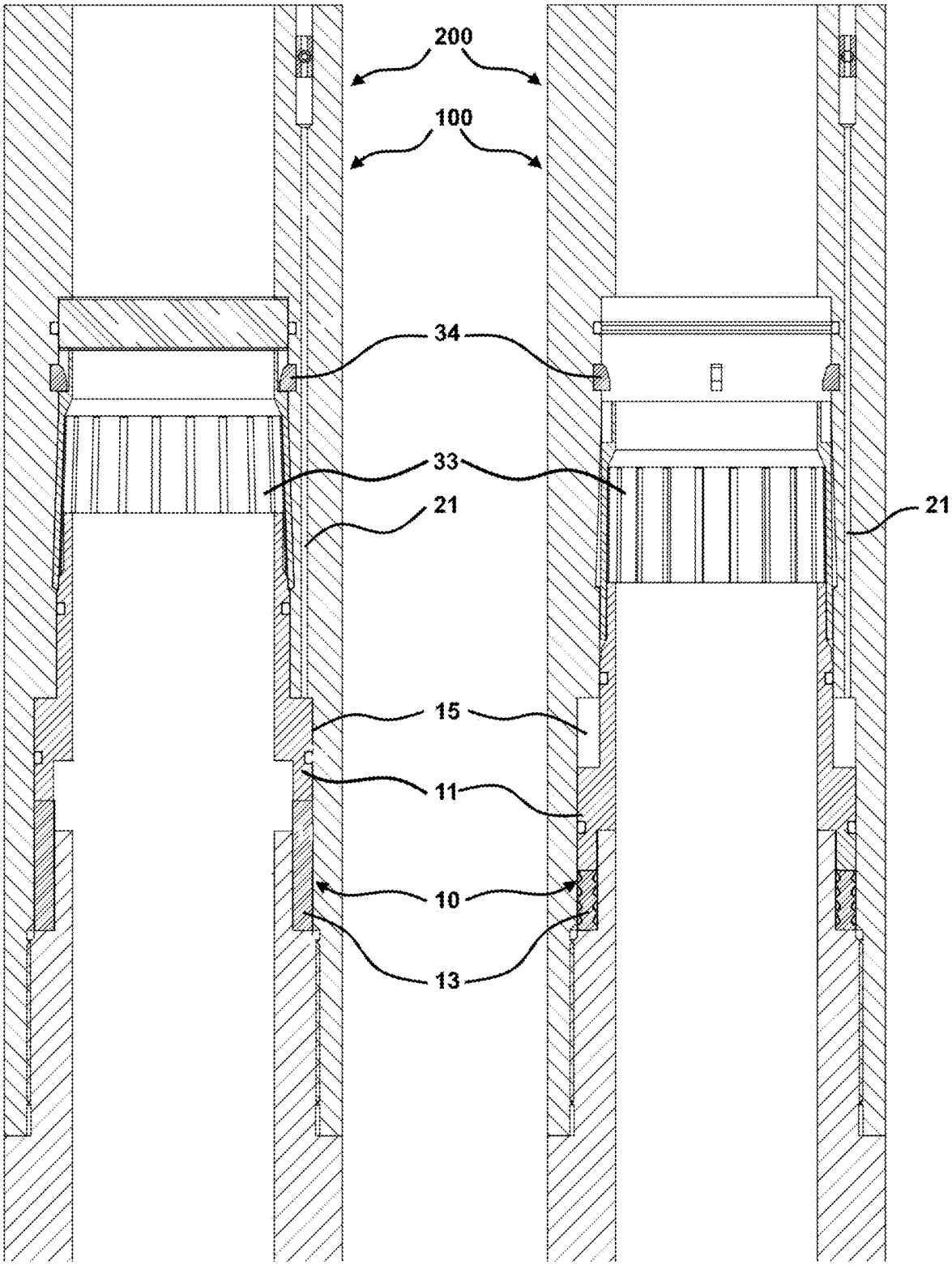


FIG 6A

FIG 6B

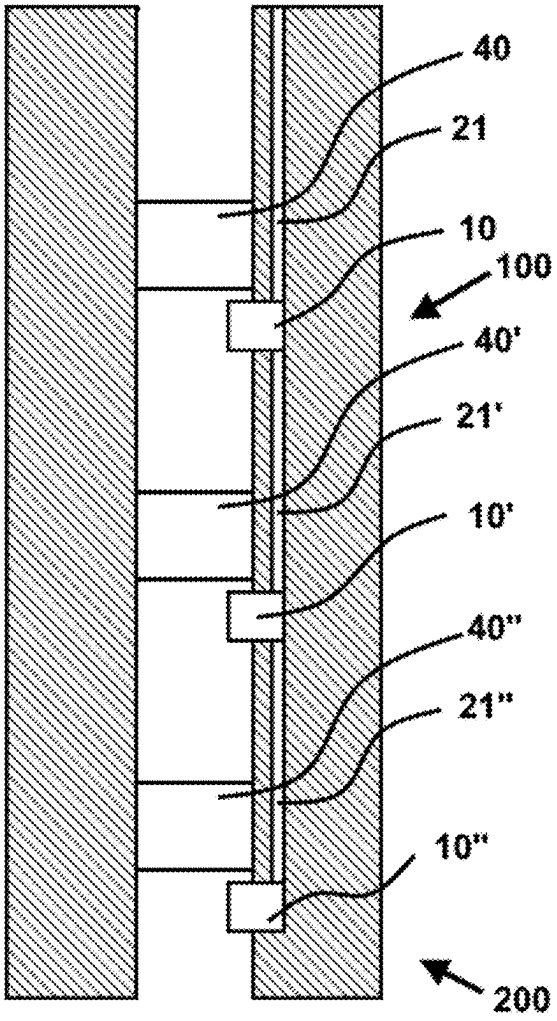


FIG 7A

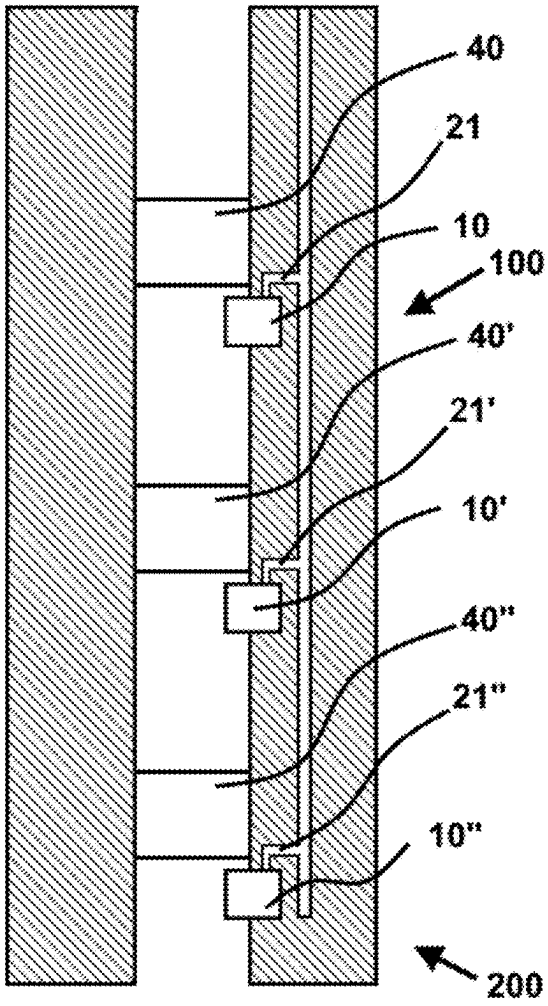


FIG 7B

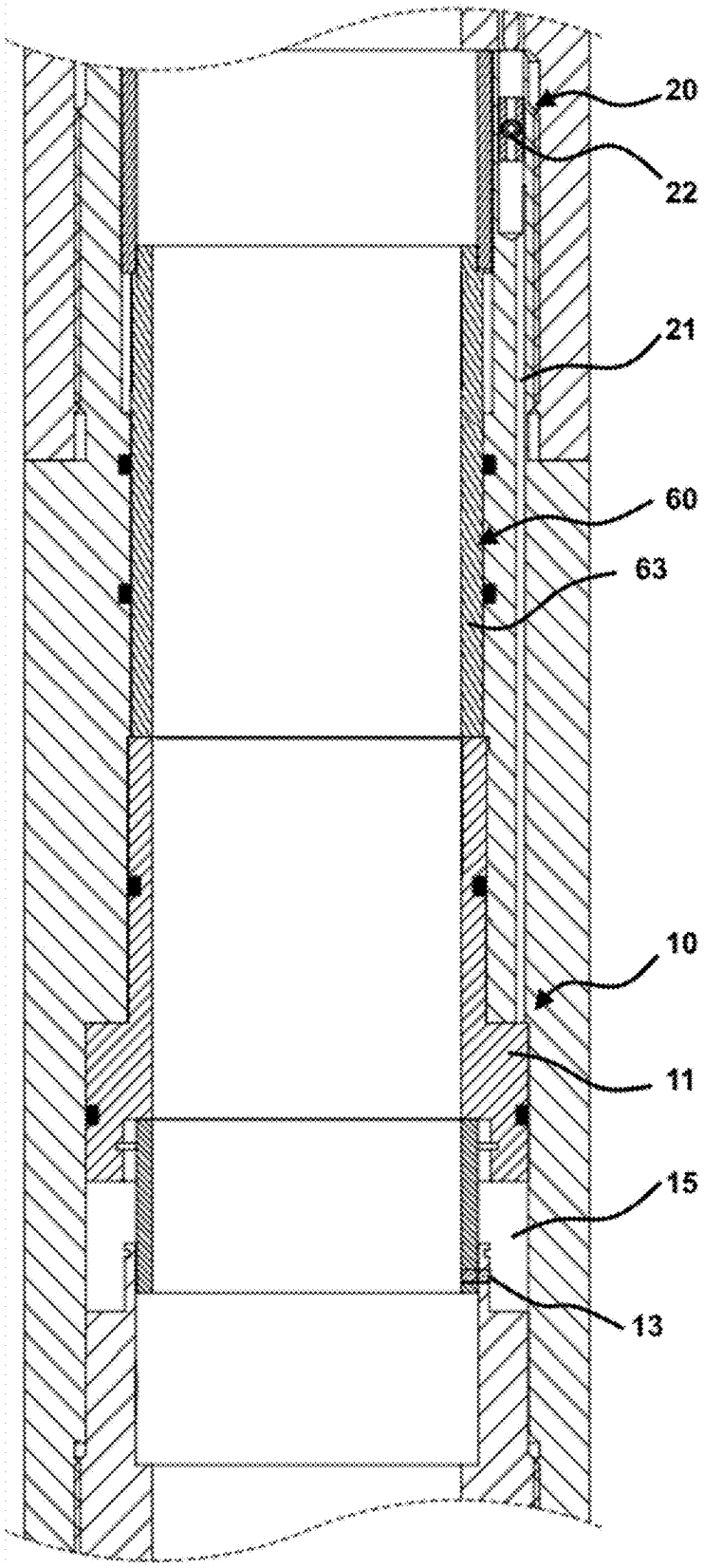


FIG 8

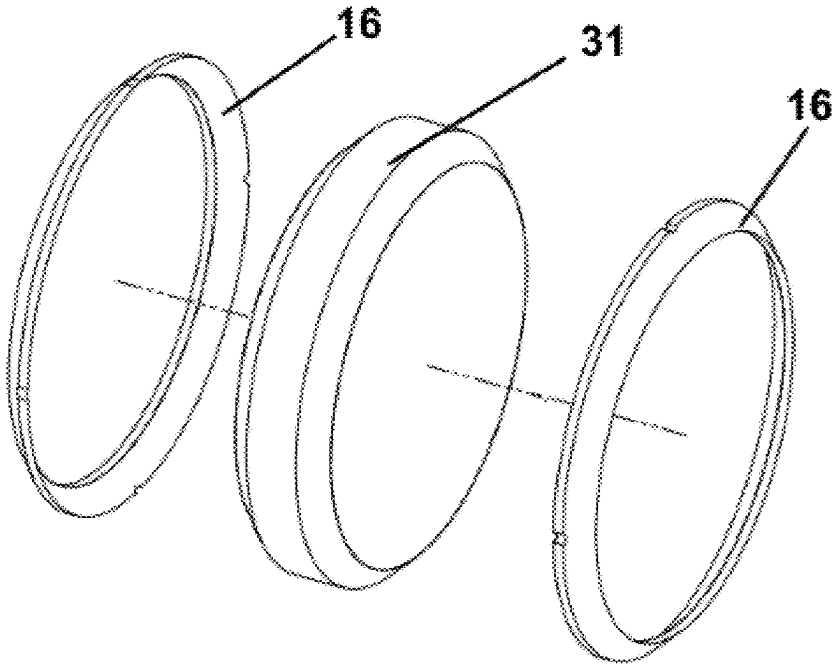


FIG 9

PLUG BREAKER

FIELD OF INVENTION

The invention is in the field of systems to activate a downhole tool, exemplified by the breaking of a frangible plug. More specifically it relates to a channel providing force onto a component that is not dependent on the pressure differential downhole of the tool. Also, it relates to the activation of a sleeve, or the breakage of a frangible plug with breakers located above said plug.

BACKGROUND

Many downhole tools can be activated by applying pressure. This can be easily done by pumping from above and is often preferable to more complicated activation means that require wirelines, ball drops, signals of various kinds like RFID or chemical activation. Many pressure activated systems require a counter that counts pressure cycles, but in its simplest form a single pressure spike, above what would normally occur in the well, can be enough for tool activation. In either case, it is of course important that the tool activates at the correct predetermined pressure.

The pressure increase often needs to be not too gradual. This is because mechanical activation by pressure usually is a result of some part being moved, and if the pressure is applied too slowly this might not happen. For example, if a frangible plug blocking a pipe is to be removed by driving a breaker object into said plug, the breaker needs to contact the plug at speed, or the plug might not break at the pressure it was designed to do so.

If a pressure activated tool fails to be activated at the preset intended pressure due to a too slow pressure increase, the well operator will have to crank up the pressure, and subject the well to more pressure than was intended or desired. This could have detrimental effects on the well or activate other tools to be activated at a higher pressure. For the mentioned frangible plug this slow breaking of the plug is what one could name a "soft open", rather than a normal opening where the plug is opened quickly as a breaker makes contact with the plug at considerable speed.

Frangible plugs are plugs that are brittle and are usually made of materials such as glass or ceramics. Unlike most materials, such materials are not corroded by the chemical well environment, nor do they change properties noteworthy with pressure and temperature. They are also very strong, so they can hold very high pressures without breaking outright. But due to their frangible nature, when subjected to point forces, such as can be provided by a knife edge or round surface (herein referred to as a breaker), they will shatter and break into small pieces and leave the pipe open. When the plug is frangible the resulting pieces will usually be small enough not to interrupt well operations, and if they are not a debris catcher can be used. Such frangible plugs are used for a variety of purposes where temporarily plugging of a well pipe (casing or liner) is desired, such as during completion or flotation.

For a simple frangible plug system, either the plug or breaker is able to move into the other but is prevented from doing so by something holding it in place; a tool release element. This something is typically a shear element such as a shear ring or shear pins that shear off when enough pressure is applied. If there is not sufficient pressure, or said pressure is increased too slowly, the shear element will shear but there might not be enough force for the breaker to impact the plug hard enough to break. This can also happen if the shear element is mistuned, or the tuning miscalculated, or if the well conditions are very different from what was expected, such as more viscous fluids or debris making it harder for parts to move, or if there is a surge of pressure from below the plug or a fluctuation in the pressure applied from above. It is possible that the pressure differential across the plug causes the plug or breaker to release but does not have sufficient force to break the plug. Regardless of the specific reasons for the "soft opening", the results are that the frangible plug and breaker are slowly brought in contact and then just rest in contact, no breaking occurs. Then it has become much harder to break the plug, as it or the breaker now cannot build up speed and slam into one another as there is no moving distance to build up said speed over. Therefore, more pressure than was intended or desired must then be applied to break and open the plug, or it may not be possible to apply enough energy to break the plug.

The same kind of soft open problems as the soft opening of frangible plugs apply to other well tools that are to be activated by pressure. For example, sleeves that are to be moved by pressure can get stuck when moved only partially, and then need more pressure to be moved fully into their desired end position. Such a sleeve could have many uses, such as opening and closing passages leading fluids through the pipe wall, for example bypassing a plug, or the sleeve itself could act as a breaker for a plug, or engage another tool to activate it. Usually well tools activated by pressure are sold as an enclosed product, ready to be attached in line with the work string.

The present invention provides a solution to the soft opening problem described above in the form of a soft open preventer system. The operating principle of the preventer is to allow the pressure from the well to come through a valve when the valve opens. The opening of the valve is triggered by something, such as manually, by an electric signal conveyed by wireline, a pressure activated electric signal, or a mechanical counter. A pressure activated electric signal or so-called e-trigger is when a specific pressure pattern is recognized and leads to a mechanical part being moved. A mechanical counter has an indexing system that moves/counts pressure pulses of a certain strength and then, after a predetermined number of cycles, leads to a mechanical part being moved. There are many ways of opening the valve, the important thing is that until this happens, the pressure from the well cannot be transmitted through the valve. This then allows the tool to be activated to experience the pressure the valve transmits, so that it can activate. In the example of a frangible plug to be broken by a breaker, the tool release element is then after the valve opening, and only then, allowed to experience the well pressure, and the frangible plug can be broken. So while the opening of the valve is necessary to allow the tool release element to experience the well pressure, the tool release element itself determines when the frangible plug is opened depending on what pressure it is tuned to. Therefore, it is possible to use two different shear elements for opening a frangible plug, tuned differently, so that one of said shear elements is tuned to pend the valve at a set pressure, while another shear element is set to break the plug at a different pressure. Thus, the soft open preventer acts as a guarantee that the frangible plug opening occurs when the differential pressure is above the desired limit such that the plug will break.

Usually, a frangible plug is operated as a single cycle barrier ("pump open") and uses a shear device that opens the very first time the differential pressure reaches a limit. However, with a soft open preventer it is possible to operate the plug system in as a multicycle barrier. A multicycle

barrier is one in which the pressure can be repeatedly increased greater than the limit of that would open a single cycle barrier. A multicycle valve can be operated several times to the full rated maximum pressure, and then opened at a lower applied pressure or pressure differential.

Advantages of the Present Invention

Some of the advantages of some or all of the examples disclosed include:

- Reduces the chance of the plug not being broken if there is enough pressure differential across the plug to cause it to enter a breaking activation, but insufficient force to break it.
- Allows a frangible plug to be broken not based upon a differential pressure across the plug.
- Allows the pressure to be increased past the pressure differential or absolute pressure sufficient to break the plug, without trigging the mechanism that results in the plug being broken.
- Allows for multiple kinds of release elements to be used.
- Allows for a pressure differential across the soft open preventer (not across the plug) and not an absolute pressure to activate a tool.
- Allows the plug soft open tubular system to be operated in a multicycle.
- Allows for an alternative way to activate a downhole tool.
- Allows for an unmoving frangible plug to be broken.
- Other advantages are derivable from the disclosure.

SHORT SUMMARY OF THE INVENTION

In some aspects, the techniques described herein relate to a soft open preventer system including: a preventer tubular, a soft open preventer, a channel system, a downhole tool, where the soft open preventer includes: a preventer support, and a preventer release element, and the channel system includes a: a channel, a channel release, and pressure applier; and the downhole tool includes: a tool release element; wherein: the soft open preventer, the downhole tool, and the channel system is arranged at least partially in the preventer tubular; and the soft open preventer is arranged such that the downhole tool will not activate before the soft open preventer activates; the pressure applier is arranged to activate the channel release, the channel release is arranged to allow pressure to increase in the channel; the channel is in fluid contact with at least a portion of the preventer support, and the preventer release element supports the preventer support; wherein: the preventer release element is arranged such that when a threshold absolute pressure or pressure differential is applied to the preventer release element, the preventer release element breaks activating the soft open preventer, allowing the preventer support to move; and preventer system is arranged such that activation of the soft open preventer will allow the activation of the downhole tool.

In some aspects, the techniques described herein relate to the soft open preventer system, wherein the downhole tool further includes a tool release element, wherein the downhole tool activates when the tool release element breaks.

In some aspects, the techniques described herein relate to the soft open preventer system, wherein the preventer release element and the tool release element is a single element.

In some aspects, the techniques described herein relate to the soft open preventer system, wherein the soft open preventer further includes a preventer sleeve that supports the preventer support.

In some aspects, the techniques described herein relate to the soft open preventer system, wherein the pressure applier is a counter.

In some aspects, the techniques described herein relate to the soft open preventer system, wherein the pressure applier is an electronic trigger.

In some aspects, the techniques described herein relate to the soft open preventer system, wherein the channel is arranged in the preventer tubular.

In some aspects, the techniques described herein relate to the soft open preventer system, wherein the preventer release element is a shear element.

In some aspects, the techniques described herein relate to the soft open preventer system, wherein the preventer release element is a tension element.

In some aspects, the techniques described herein relate to the soft open preventer system, wherein the preventer release element is a tensile element.

In some aspects, the techniques described herein relate to the soft open preventer system, wherein the preventer release element is a crumple element.

In some aspects, the techniques described herein relate to the soft open preventer system, wherein the tool release element is a shear element

In some aspects, the techniques described herein relate to the soft open preventer system, wherein the tool release element is a tension element.

In some aspects, the techniques described herein relate to the soft open preventer system, wherein the tool release element is a tensile element.

In some aspects, the techniques described herein relate to the soft open preventer system, wherein the preventer support and/or preventer sleeve is an axially movable sleeve.

In some aspects, the techniques described herein relate to the soft open preventer system, wherein the preventer support and preventer sleeve are a single element.

In some aspects, the techniques described herein relate to the soft open preventer system, wherein the preventer release element is arranged between the preventer sleeve or in the preventer support, and an element that is stationary with respect to the preventer tubular.

In some aspects, the techniques described herein relate to the soft open preventer system, wherein the preventer support is arranged to prevent the tool release element from breaking.

In some aspects, the techniques described herein relate to the soft open preventer system, wherein the downhole tool activates simultaneously with when the soft open preventer activates.

In some aspects, the techniques described herein relate to the soft open preventer system, wherein the preventer release element breaks simultaneously or shortly after the tool release element.

In some aspects, the techniques described herein relate to the soft open preventer system, wherein the downhole tool is a plug assembly, wherein the plug assembly includes: a plug that blocks fluid flow through the preventer tubular when the plug is intact; and a seat that supports the plug, wherein the plug assembly is configured to break the plug after the plug assembly activates.

In some aspects, the techniques described herein relate to the soft open preventer system, wherein the plug assembly further includes a breaker assembly, wherein the breaker assembly includes a breaker object, wherein the breaker object is arranged to break the plug on contact, preferably by axial movement between the plug and the breaker object.

In some aspects, the techniques described herein relate to the soft open preventer system, wherein the plug assembly wherein: the tool release element is a plug release element; wherein the plug release element is arranged bring the breaker object in contact with the plug when the plug release element breaks.

In some aspects, the techniques described herein relate to the soft open preventer system, wherein the plug assembly is arranged such that the seat moves axially when the plug release element breaks.

In some aspects, the techniques described herein relate to the soft open preventer system, wherein the preventer support supports the seat.

In some aspects, the techniques described herein relate to the soft open preventer system, wherein the seat and the preventer support is a single element.

In some aspects, the techniques described herein relate to the soft open preventer system, wherein the plug release element is the preventer release element.

In some aspects, the techniques described herein relate to the soft open preventer system, wherein: the plug release element includes a shear ring body and a shear ring lip, and the shear ring lip supports the seat; wherein the preventer support supports the shear ring lip.

In some aspects, the techniques described herein relate to the soft open preventer system, wherein the downhole tool includes a sleeve and wherein In some aspects, the techniques described herein relate to the soft open preventer system is arranged such that activation of the sleeve activates the downhole tool.

In some aspects, the techniques described herein relate to the soft open preventer system, wherein the plug assembly further includes a breaker assembly wherein the breaker assembly includes: the breaker object, and a breaker support; wherein the breaker object is supported by the breaker support, the breaker support is supported by the preventer support; and wherein: the breaker support supports the breaker object, and wherein the activation of the soft open preventer allows the breaker assembly to activate.

In some aspects, the techniques described herein relate to the soft open preventer system, wherein the preventer support and the breaker support are a single piece.

In some aspects, the techniques described herein relate to the soft open preventer system, wherein the plug is stationary.

In some aspects, the techniques described herein relate to the soft open preventer system, wherein In some aspects, the techniques described herein relate to the soft open preventer system further includes a: a second downhole tool, a second channel, and a second soft open preventer; wherein In some aspects, the techniques described herein relate to the soft open preventer system is arranged such that: the second channel is in fluid connection with the channel after the first soft open preventer activates, and the channel second channel is in fluid connection with the second soft open preventer.

In some aspects, the techniques described herein relate to the soft open preventer system, wherein In some aspects, the techniques described herein relate to the soft open preventer system further includes a: a second downhole tool, a second channel, and a second soft open preventer; wherein In some aspects, the techniques described herein relate to the soft open preventer system is arranged such that: the second channel is in fluid connection with the channel before the first soft open preventer activates, and the channel second channel is in fluid connection with the second soft open preventer.

In some aspects, the techniques described herein relate to the soft open preventer system, wherein the second downhole tool is a plug assembly.

BRIEF DESCRIPTION OF THE FIGURES

The above and further features of the invention are set forth with particularity in the appended claims and advantages thereof will become clearer from consideration of the following detailed description. Embodiments of the present invention will now be described, by way of example only, with reference to the following diagrams wherein:

FIG. **1**A discloses a cross-sectional side view of a soft open preventer system with a general downhole tool.

FIG. **1**B discloses a cross-sectional side view of a soft open preventer system where the downhole tool is a plug assembly.

FIG. **2**A discloses a closeup cross sectional view of an example of a soft open preventer system in the first position.

FIG. **2**B discloses a closeup cross sectional view of an example of a soft open preventer system in the second position.

FIG. **2**C discloses a closeup cross sectional view of an example of a soft open preventer system in the third position.

FIG. **2**D discloses a closeup cross sectional view of an example of a soft open preventer system in the fourth position.

FIG. **3** discloses a cross-sectional view of a second example of a soft open preventer system with a different plug assembly.

FIG. **4** discloses a cross-sectional view of a third example of a soft open preventer system with a different seat.

FIGS. **5**A and **5**B disclose a cross-sectional view of a fourth example of a soft open preventer system with a different breaker object.

FIG. **6** discloses a cross-sectional view of a fifth example of a soft open preventer system with a crumple element.

FIG. **7**A-B discloses a cross-sectional view of a seventh and eight examples of a soft open preventer system with multiple channel systems in different configurations.

FIG. **8** discloses a cross-sectional view of a ninth example of a soft open preventer system with a sleeve.

FIG. **9** discloses a perspective view of an alternative shape of a plug with sealing elements.

REFERENCE NUMBERS AND CORRESPONDING ELEMENTS

10 Soft Open Preventer **10**
11 Preventer support **11**
12 Preventer sleeve **12**
13 Preventer release element **13**
14 Sleeve Snap Ring **14**
15 Preventer Gap **15**
16 Bearing Ring **16**
20 Channel System **20**
21 Channel **21**
22 Channel Release **22**
23 Pressure Applier **23**
30 Plug Assembly **30**
31 Plug **31**
32 Seat **32**
33 Plug Release Element **33**
331 Plug Release Body **331**
332 Plug Release Fingers **332**
333 Shear Ring Body **333**

334 Shear Ring Lip **334**
34 Breaker Object **34**
35 Housing **35**
36 Sealing Elements **36**
37 Breaker Assembly **37**
38 Breaker Support **38**
39 Breaker Body **39**
40 Downhole Tool **40**
43 Tool Release Element **43**
60 Sleeve **60**
63 Sleeve Release Element **63**
100 Preventor Tubular **100**
101 Upstream tubular **101**
102 Downstream tubular **102**
200 Soft open preventer system **200**

DETAILED DESCRIPTION OF THE INVENTION

Reference will now be made in detail to the present embodiments of the invention, examples of which are illustrated in the accompanying drawings. Alternative embodiments will also be presented. The drawings are intended to be read in conjunction with both the summary, the detailed description, and any preferred and/or particular embodiments, specifically discussed or otherwise disclosed. This invention may, however, be embodied in many different forms and should not be construed as limited to the embodiments set forth herein. These embodiments are provided by way of illustration only. Several further embodiments, or combinations of the presented embodiments, will be within the scope of one skilled in the art.

The present invention is a soft open preventer system that is arranged in a housing in the tubular. While this will function with a general downhole tool, most of the specific disclosure will be on plug assemblies and downhole tools that include a sleeve.

The following describes a plug assembly and a soft open preventer that activates with a pressure differential between the pressure uphole on the plug and the pressure downhole on the plug. The soft open preventer and plug assembly do not need to activate at the same pressure differential.

In the first position, the plug rests on a seat, is intact, and prevents fluid flow through the tubular. The seat is supported by a soft open preventer. A fluid channel is arranged to apply pressure to the soft open preventer. Both the soft open preventer and plug assembly are stationary.

In the second position, a pressure applier opens the channel release and allows the uphole pressure to reach the soft open preventer. A threshold pressure differential in the fluid channel is applied such that at least a portion of the soft open preventer moves in an axial direction. In the third position, after a threshold differential pressure is applied to the plug, the plug assembly activates, a portion of the plug assembly moves, and brings the plug into contact with the breaker object. In the fourth position, the plug is broken, and fluid flow is restored through the preventer system.

Note that the invention can be arranged such that it is the pressure from downhole that triggers the breaking of the plug, but it is more common with pressure from uphole being used for that purpose.

Direction terms such as up, down, left, right, above, below, etc. are being used in reference to the orientation of the elements in the figures. In no way is this intended as limiting. It is possible to run the soft open preventer, the channel system, or the plug assembly independently in an opposite manner as described. For example, the triggering can be determined by the pressure from the downhole side.

Reference is made to FIG. **1**A. FIG. **1**A discloses a cross-sectional side view of a soft open preventer system **200** in the first position for a general downhole tool **40**.

The soft open preventer system **200** comprises a preventer tubular **100**, a, soft open preventer **10**, channel system **20**, and a downhole tool **40**. The soft open preventer **10** prevents the downhole tool **40** from activating prematurely. Usually, the soft open preventer **10** does this by preventing one or more elements of the downhole tool **40** from moving.

The channel system **20** comprises a channel **21**, a channel release **22**, and a pressure applier **23**. The channel release **22** in almost all of the figures is a release valve. However, this specific channel release **22** is not the only one that would be acceptable. Other examples include other kinds of valves and burst disks. The important factor of channel release **22** is that it stops the fluid pressure connection between the pressure through the preventer tubular **100** and the channel **21** and can be opened (thus the channel system **20** activates) by the pressure applier **23**. It is the function of the channel release **22** to activate when it is time for the soft open preventer **10** to experience pressure from uphole. In the disclosed figures, channel **21** is arranged in the preventer tubular **100**. Other options are possible.

The pressure applier **23** shown in the figures is a counter. However, this is a specific type of pressure applier. The function of the pressure applier **23** is to activate the channel system **20** by triggering the channel release **22** such that pressure from uphole is applied to the soft open preventer **10**. Examples of other suitable means are mechanical or pulse counters, electronic triggers, release valves, acoustic signals, and pressure sensors. In the case of counters, at a certain count (normally specified by the number of pressure cycles) the channel release **22** opens and exposes channel **21** to pressure from the uphole side of the plug. In the case of electric triggers, they are usually triggered by following a "pressure key" of specific pressures or pressure pulses and durations. In the case of a pressure sensor, channel release **22** will usually be configured to open once a threshold absolute pressure has been applied.

Eventually, pressure applier **23** will open the channel release **22** and the pressure from uphole will be enough so that the preventer release element **13** breaks. It is possible for the pressure applier **23** and the channel release **22** to be one element that fulfills both roles. Please note that both the preventer release element **13** or the plug release element **33** can be configured to work by absolute pressure instead of differential pressure.

When the threshold differential pressure (or absolute pressure) across the soft open preventer **10** is high enough through the channel system **20**, the soft open preventer **10** will move. The activation of the soft open preventer **10** will then allow the downhole tool **40** to activate. This activation can occur simultaneously with the activation of the soft open preventer **10**, or at a later time.

The tool release element **43** is shown in FIG. **1**A as arranged between the housing in the preventer tubular **100** and a downhole tool **40**. However, this is a general schematic of a downhole tool **40** and a tool release element **43**. The tool release element **43** is arranged somewhere in the downhole tool **40**. It breaks and the downhole tool **40** activates after the soft open preventer **10** activates. The exact location of the tool release element **43** could be different for different downhole tools **40**.

Later examples will include where the downhole tool is a plug assembly **30** or a sleeve **60**. In these cases, the tool

release element **43** is either a plug release element **33** or a sleeve release element **63**. If these elements are not present, then the release elements **43**,**33**,**63** can be considered to be the preventer release element **13**.

Reference is made to FIG. **1**B. FIG. **1**B discloses a cross-sectional side view of a soft open preventer system **200** in the first position where the downhole tool **40** is a plug assembly **30**. The function and operating principles of channel system **20** and soft open preventer **10** is the same as for FIG. **1**A for a general downhole tool.

The function of the plug assembly is to break a plug **31** that is providing a temporary barrier to fluid flow through the preventer tubular **100**.

The soft open preventer **10**, channel system **20**, and plug assembly **30** are arranged in the housing **35**. The housing is the portion of the soft open preventer system **200** (usually the preventer tubular **100**) that has been shaped to accommodate the soft open preventer **10**, channel system **20**, and plug assembly **30**. Other elements and assemblies can also be accommodated in the housing **35**. It is possible for the housing **35** to be arranged in an element between the preventer tubular **100** and some or all of the other elements in the soft open preventer system **200**.

It is common with a plug assembly **30** that operates purely on the pressure differential experienced across plug **31**. However, it is possible that the plug assembly moves from the first position (plug intact as in FIG. **2**A) without sufficient force to break the plug **31**. This is referred to as a soft release. The soft open preventer **10** is designed such that it is not the pressure differential across the plug that causes the plug assembly **30** to release the plug **31**, rather it is the fluid threshold differential pressure through channel system **20** applying pressure on the soft open preventer **10**. When the threshold differential pressure across the soft open preventer **10** is high enough through channel system **20**, the soft open preventer **10** will move. This in turn will ensure that when plug **31** experiences enough threshold differential pressure plug **31** breaks and reopen flow through the soft open preventer system **200** (shown in FIG. **2**D).

The soft open preventer **10** prevents the plug assembly **30** from activating with the absolute uphole pressure or pressure differential. The soft open preventer **10** allows the plug assembly **30** to experience a pressure greater than that required to activate the plug assembly **30** and break the plug **31**. It this way, the soft open preventer system **200** can be cycled through multiple pressure values before the plug assembly **30** activates. This is sometimes referred to as a multicycle plug assembly **30** (as opposed to a single cycle plug assembly **30** where once the threshold differential pressure is reached, it activates). When it is time to break the plug **31**, the pressure applier **23** opens the channel release **22** and allows pressure in the channel system **20** to activate the soft open preventer **10**. Then the plug assembly **30** is allowed to activate.

Depending on the exact configuration, it can be easier to set the threshold differential pressure of the preventer release element **13** rather than simply increasing the threshold differential pressure of the plug release element **33**.

Note that soft open preventer **10** does not need to be located below plug assembly **30** or the plug **31**.

Reference is made to FIGS. **2**A-**2**D that disclose first to fourth position of the soft open preventer system **200**.

Reference is made to FIG. **2**A. FIG. **2**A discloses a close-up cross-sectional view of the soft open preventer system **200** in a first position. The uphole side is on the top of the figure and the downhole side is on the bottom of the figure. As above, the soft open preventer system **200** comprises a preventer tubular **100**, in which a soft open preventer **10**, channel system **20**, and plug assembly **30** is arranged in a housing **35** of the preventer tubular **100**. The soft open preventer **10** supports the plug assembly **30**. Fluid in the channel system **20** applies pressure to the soft open preventer **10**.

The preventer tubular **100** is comprised of the upstream tubular **101** and the downstream tubular **102**. As mentioned previously, the housing **35** can be a separate element and/or a portion of the preventer tubular **100**.

The soft open preventer **10** comprises a preventer support **11**, preventer sleeve **12**, preventer release element **13**, and sleeve snap ring **14**. Pressure on the soft open preventer **10** is applied to the preventer support **11** through a channel system **20**. The channel system **20** comprises a channel **21**.

In the example shown in the figure it also includes a channel release **22**. The channel release **22** blocks the pressure from the pressure uphole from reaching the channel **21**.

The preventer support **11** is supported by the preventer sleeve **12**. The preventer sleeve **12** is connected by a preventer release element **13** to the downstream tubular **102**. When the preventer release element **13** breaks, the soft open preventer **10** moves. In the figure then preventer support **11** moves into the preventer gap **15**. The preventer gap **15** is dimensioned such that the gap is deep enough such that the soft open preventer **10** moves far enough such that the plug **31** makes the contact with the breaker object **34** and breaks.

When the pressure through channel **21** is above the threshold differential pressure of the preventer release element **13** (arranged between the preventer sleeve **12** and the preventer tubular **100**), it actives the soft open preventer **10**. This allows the soft open preventer **10** to move such that the plug **31** of the plug assembly **30** can move. In the example shown, the preventer release element **13** is arranged between the downstream tubular **102** and the preventer sleeve **12**. When the preventer release element **13** breaks, the preventer sleeve **12** moves causing the preventer support **11** to move. This in turn will cause seat **32** to move. A sleeve snap ring **14** locks the soft open preventer **10** in place such that it will not move upwards. In this example, it is arranged on the preventer support **11**.

By the phrase "the preventer release element **13** or the plug release element **33** breaks", it is referring to the behavior that results in the release elements changing shape allowing the parts to move. Examples of this "breaking" of a release element are when the shear ring breaks or shears into at least two pieces, a tension type of release element collapses or expand, a tensile element stretching until breaking, a sleeve overcoming the friction that is holding an element in place, or a compression element crumpling. Both the preventer release element **13** and the plug release element **33** can be of the types of release elements **13**,**33** mentioned above.

Note that the preventer release element **13** can be arranged along the preventer support **11** or preventer sleeve **12**, or part of the preventer support **11** or preventer sleeve **12** itself. It is possible for the preventer sleeve **12** (or any other element designed as a "sleeve") to not form a ring. For example, it could be half or quarter sleeve.

The role of the pressure applier **23** is to operate independent of the pressure differential across the plug. The soft open preventer **10** acts as a guarantee that the opening occurs when the differential pressure across the plug **31** is above the desired limit to break the plug.

The plug assembly **30** comprises a plug **31**, seat **32**, plug release element **33**, breaker and a breaker object **34**. The

plug assembly **30** is arranged in a housing **35**, and sealing elements **36** are shown to prevent fluid from traveling around the plug **31**. These elements **36** do not always seal entirely, depending on the application. The plug **31** is supported by the seat **32**. A plug release element **33** is arranged such that when threshold pressure differential is applied, it collapses or breaks. The plug **31** is the able to move in an axial direction towards the breaker object **34** until it makes contact with the plug **31** (as shown in FIG. **2**C). Seat **32** is supported by soft open preventer **10**, in this case the preventer support **11**. When the preventer release element **13** breaks due to pressure in the channel system **20**, it ensures that there is enough differential pressure so that when the plug release element **33** collapses, the plug **31** will break on the breaker object **34**.

The sealing element **36** is shown as being parallel to the preventer tubular **100**, however this is an example. Other examples include sealing between a chamfered angle on the plug and the preventer tubular **100**. Another example is between a sloped portion in the housing **35** and the plug **21**.

The purpose of the breaker object **34** is to simply break whatever it contacts, in this case a plug **31**. The breaker object **34** does not need to break the plug **31** on contact, but by the time it reaches the final position. For a plug **31** there are many known types of breakers including: knives, explosives, crushers, studs, spikes, balls, and so on. These are well known in the art.

The breaker object **34** is shown as being located in the housing **35**, however the location can be in different places. The important role of the breaker object **34** is that it breaks the plug **31** in the fourth position, but it doesn't need to shatter the plug **31** on contact, but between the third and fourth position. Normally the breaking will occur very quickly after the plug **31** impacts the breaker object **34**. The location of the breaker object **34** is not important, but the breaker object **34** should be moving toward the plug **31** with respect to the plug **31**. Most of the figures show that the breaker object **34** is stationary, but FIGS. **5**A-B shows the breaker object **34** moving. If the plug **31** was also moving, it would be possible for the breaker object **34** to still make contact depending on relative speeds between the plug **31** and breaker object **34**.

The example of a plug release element **33** that is disclosed in FIG. **2**A-**2**D is one that uses tension. The plug release element **33** comprises a plug release body **331** with plug release fingers **332** extending from it. The plug release fingers **332** are biased outwards and prevent the seat **32** from moving toward the breaker object **34**. Once the preventer release element **13** of the soft open preventer **10** breaks due to pressure in channel system **20**, the preventer support **11** moves downwards. It is then the plug release element **33** that prevents the plug assembly **30** from entering the second position.

Note that in this example, the preventer support **11** prevents the plug **31** from moving because there is no space for it to move inwards. This region has been outlined with a dotted circle in FIG. **2**B.

FIG. **2**B discloses the same view as FIG. **2**A, but the soft open preventer system **200** is in the second position. In the second position, the pressure from the channel system **20** is high enough to overcome the preventer release element **13** in the soft open preventer **10** and the soft open preventer **10** has moved. In this specific example, the movement of the preventer support **11** allows the possibility that the seat **32** will move. This region has been outlined with a dotted circle. One skilled in the art would be able to arrange the soft open preventer **10** and the plug assembly **30** such that it would not be possible for the plug **31** to break before the soft open preventer **10** has moved.

FIG. **2**C discloses the same view as FIG. **2**A and FIG. **2**B, but the soft open preventer system **200** is in the third position. In the third position, the soft open preventer **10** has moved and a threshold pressure differential is applied to the plug such that the plug release element **33** has collapsed or broken. The seat **32** of the plug assembly **30** has moved until the plug **31** is in contact with the breaker object **34**. In many cases the third position occurs simultaneously with, or shortly after, the second position. An advantage of this is that the plug can break at the lowest pressure needed to ensure that there is enough force, such that the plug will break. Between the first position and the third position, both the soft open preventer **10** has moved, and the plug release element **33** has changed its state due to a pressure differential across the plug **31**, so that the plug **31** moves.

By simultaneously it is meant that the breaking of the preventer release element **13** and the breaking of the plug release element **33** occurs when the pressure reaches the threshold needed for the preventer release element **13**. It is possible that there is a delay in the actual moving of the soft open preventer **10** and movement of the plug assembly **30**. As mentioned previously soft open preventer **10** and the downhole tool **40** can be activated simultaneously.

FIG. **2**D discloses the same view as FIGS. **2**A-**2**C, but the soft open preventer system **200** is in the fourth position. In the fourth position, the soft open preventer **10** has moved as the preventer release element **13** has broken and the plug release element **33** has collapsed. The final result of this is that the plug **31** is broken on the breaker object **34** and fluid flow has been restored through the soft open preventer system **200**. The snap ring **14** locks the soft open preventer **10** in place so that it is not possible for move back toward the uphole side.

The preventer support **11** and preventer sleeve **12** of the soft open preventer **10** can be made of a single piece. This will be considered the preventer support **11**. Note that the snap ring **14** is an optional element. Also, the preventer release element **13** is shown as a shear pin, but can be a shear screw, shear ring, or other shear element. These are examples of sleeve release elements **13** that operate by a force transverse to the body of the element that causes a shearing. Also note that it can be an element that is arranged to break due to tensile force being applied between a fixed and a movable element. This is an example of a preventer release element **13** that breaks due to a force on the element by stretching. The preventer release element **13** can also be an element that crumples due to forces that compress the element, usually in the axial direction (but radially is possible). Another example of a preventer release element **13** is a spring requires a certain threshold force to compress.

The preventer support **11** can be made of multiple pieces. For example, there could be a piece that took pressure applied through channel **21** and transmitted that to the preventer release element **13**, and a second portion that prevents the plug assembly **30** from activating. This can be generalized to the preventer support **11** from allowing the downhole tool **40** to activate (discussed later in FIGS. **8**A-**10**). There can be intermediate pieces of the preventer support **11** as well to serve other functions or to connect the other portions together.

The preventer release element **13** does not have to be between the preventer sleeve **12** and the downstream tubular **102**. It can be arranged between any portion of the soft open preventer **10** and the preventer tubular **100**, or between the soft open preventer **10** and something that is stationary with

respect to the preventer tubular **100**. It is also possible for the preventer release element **13** to be between the soft open preventer **10** and the plug release element **33**. One advantage of this is to reduce the number of elements needed in the soft open preventer system **200**.

While the figures show that the plug assembly **30** includes a plug **31** release element **33**, this plug release element **33** is optional. It is possible for the channel system **20** to support the plug **31** by acting as a seat **32** or supporting the seat **32**. Additionally, the breaker object **34** can be arranged above the seat **32** such that the breaker object **34** strikes a plug **31** that is not moving with respect to the plug **31**. Normally, this will be because the plug **31** is stationary with respect to the housing. Note that the breaker object **34** can be a separate element that is moved when the soft open preventer **10** moves, or part of the soft open preventer **10** itself. FIG. **2**B describes the case where the preventer release element **13** and plug release element **33** are set at different pressure differential thresholds. If the preventer release element **13** is set at the same pressure differential threshold as the plug release element **33**, the plug **31** will break as soon as the preventer release element **13** breaks. However, it may be desirable for the plug release element **33** to be set so that the breaking of the plug **31** will be ensured, but not occur at a higher than needed to release the preventer support **11**.

The channel **21** is arranged in the walls of the preventer tubular **100**. However, it made be made by a separate element that is attached a location stationary with respect to housing, to form a channel **21**. Another option would be a separate element that has a channel **21** entirely contained within it. Additionally, a channel **21** can be arranged in the annulus. Any combination of the channel **21** being made up of individual sections of the aforementioned ways to form a channel **21** is possible.

The tension type plug release element **33** of the FIGS. **2**A-**2**C and **6**A-**6**B is not the only option for a plug release element **33**, as mentioned previously. Rather the plug release fingers **332** tensioned outwards, it could also be tensioned inwards. A shear type plug release element is also possible. Another example is an electronic trigger.

The figures show the preventer release element **13** between the preventer sleeve **12** and the preventer tubular **100** (in the housing **35** in this case). Another stationary element with respect to the preventer tubular **100** would also function. However, the preventer release element **13** can be placed between the preventer support **11** and a stationary element (or directly into the housing **35** or preventer tubular **100**).

While the figures show that there is only a preventer release element **13**, it is possible to have more than one. Additionally, it is possible to have multiple different types of preventer release element **13** in the same soft open preventer **10**.

Reference is made to FIG. **3**. FIG. **3** discloses another example of the soft open preventer **10** in the first position. The plug assembly **30** is different than that in FIG. **2**A-**2**D. As before, the plug **31** is supported by the seat **32**. A breaker object **34** is arranged to break the plug **31** upon contact.

Unlike in the previous example, seat **32** rests on the plug release element **33**. In this case the plug release element **33** is a shear ring, rather than a tension element. When the threshold differential pressure across the shear ring, the shear ring breaks into two or more pieces and releases the seat **32**. This results in the plug **31** and seat **32** moving axially, the plug **31** impacting the breaker object **34**, and the plug **31** breaking.

This shear ring kind of plug release element **33** has two pieces. The first is that which remains stationary and does not receive the load from seat **32**, the shear ring body **333**. The second is the part that receives the load from the seat **32** and is the shear ring lip **334**. This is the same for other kinds of shearing based plug release elements **33** including shear pins.

As usual, the soft open preventer **10** prevents the plug **31** from breaking early by preventing it from moving. In the specific example shown in the figure, it is arranged to prevent seat **32** from moving. Another way would be for preventer support **11** to support the shear ring lip **334**.

Reference is made to FIG. **4**. FIG. **4** discloses another example of a soft open preventer system **200** with a plug assembly. As discussed previously, it is possible for the preventer release element **13** and the plug release element **33** (not shown) to be arranged such that when the threshold differential pressure in channel **21** is reached, the preventer release element **13** breaks and the soft open preventer **10** moves.

In this example, the plug assembly **30** does not have a plug release element **33** and the movement of the plug **31** is entirely dependent on the preventer release element **13** breaking. The soft open preventer **10** (in the example specifically the preventer support **11**) is seat **32** on which the plug **31** rests. When the preventer release element **13** breaks, the soft open preventer **10** moves and brings the breaker object **34** into contact with the plug **31**.

This shows that the plug release element **33** is an optional element and only preventer release element **13** is needed. In this case, it can be thought that the combination of a plug release element **33** and the preventer release element **13**, is simply the preventer release element **13**.

Reference is made to FIGS. **5**A and **5**B. FIGS. **5**A and **5**B disclose another example of a soft open preventer system **200**. In this example, the plug **31** does not move with respect to the preventer tubular **100**. The plug assembly **30** also lacks a plug release element **33**. One of the most common ways to break a plug **31** is to use an explosive.

In FIG. **5**A, the soft open preventer system **200** is the initial position where the plug **31** is not broken and the preventer release element **13** has not broken. This example discloses an application of the soft open preventer **10** to break a plug **31** that is stationary. The plug **31** rests on the seat **32**. The seat **32** is stationary with respect to the plug **31** in each operational position of the soft open preventer system **200** (determined by movement of the plug assembly **30** and soft open preventer **10**).

In FIG. **5**B, the pressure in the channel system **20** is above a threshold differential pressure, and the soft open preventer **10** moves. Specifically, FIG. **5**B shows the movement from the initial position to where the breaker object **34** impacts the plug **31**. After the soft open preventer **10** activates, the breaker object **34** moves and breaks the plug **31**.

In the example shown, a breaker assembly **37** comprises at breaker object **34**, a breaker support **38**, and a breaker body **39**. The breaker assembly **37** is arranged to move (activate) when the soft open preventer **10** activates. In this specific example the breaker body **39** rests upon the preventer support **11**, the breaker support **38** is supported by the breaker body **39**. The breaker support **38** contains the breaker object **34**. When the soft open preventer **10** activates, the preventer support **11** moves causing the breaker body **39** to move. Thus, the breaker support **38** and breaker object **34** move as well. To ease installation, the breaker support **38**, could be made of a plurality of segments.

In the configuration where the plug **31** is stationary, the seat **32** means an element that remains fixed with respect to the preventer tubular **100**. This can be as simple as a portion of the preventer tubular **100** that protrudes so that the plug **31** can rest upon it. The seat **32** can also be a separate element as shown in FIGS. **5**A and **5**B.

It is possible for the breaker object **34** to be part of the preventer support **11** itself. By breaker support **38** it is meant what the breaker object **34** is mounted to or in. This does not only hold true for this example, but all of those that contain a breaker object **34**.

Note that in this configuration there is no third position as the plug assembly **30** does not contain a plug release element **33**. However, it would be possible to have a release element on the breaker assembly **37**. For example, this release element could be placed on the breaker body **39**.

The plug **31** is usually stationary. However, in this example, breaking could also happen if both the plug **31** and breaker assembly **37** move. In this case, the breaker object **34** would move faster than the plug **31**.

Note that the breaker body **39** could be part of the breaker support **38** and/or part of the soft open preventer **10**. The breaker body **39** can have more shapes than that of a rod. Other examples could include sleeves, half sleeves, or other things that keep the breaker object **34** moving uninterrupted until it impacts the plug **31**.

Reference is made to FIGS. **6**A and **6**B. FIG. **6** discloses another example of a soft open preventer system **200**. In the previous figures, the preventer release element **13** was a shear element (pin, screw, ring, etc) between the preventer sleeve **12** and a stationary element with respect to the preventer tubular **100** (in this case the downstream tubular **102**). In this example, the preventer release element **13** is a crumple element. There is no preventer sleeve **12** and the preventer support **11** is supported by the preventer release element **13**. Pressure in channel system **20** causes the preventer release element **13** to compress or break. Once the preventer release element **13** compresses, the preventer support **11** is free to move downwards, the plug **31** is free to move and impacts the breaker object **34**.

FIG. **6**A discloses the soft open preventer system **200** in the initial state (first position), where the both the preventer release element **13** and plug release element **33** are unbroken, the soft open preventer **10** doesn't move and the plug **31** is not broken.

FIG. **6**B discloses the soft open preventer system **200** in the final state (fourth position) where both the preventer release element **13** and plug release element **33** have broken, the plug **31** has been in contact with the breaker object, and the plug is broken.

FIGS. **6**A and **6**B disclose that the preventer release element **13** is arranged in the preventer gap **15**. An alternative is to arrange release element **13** outside of the preventer gap **15**, which is shown filled in FIG. **6**A and not filled in FIG. **6**B as the preventer release element **13** crumples. Another possibility is that the preventer release element **13** is a portion of the preventer support **11** or preventer sleeve **12**, as mentioned previously the preventer support **11** and preventer sleeve **12** can be a single element in the soft open preventer **10**.

While the figures show that the preventer release element **13** is below the preventer support **11**, the preventer release element **13** does not experience the pressure in the channel **21** directly. The preventer support **11** can also be placed so that the fluid pressure of the channel system **20** is directly on the preventer release element **13** and not on the preventer support **11** as in the figures.

Reference is made to FIGS. **7**A and **7**B. FIGS. **7**A and **7**B disclose another example of a soft open preventer system **200**. These are both examples of how a soft open preventer **10** can be used to activate multiple downhole tools **40**,**40'**, **40"** at different pressures. Each discloses three tools that, each with their own soft open preventer **10**,**10'**,**10"** is in fluid contact with a channel **21**. It is possible to use a soft open preventer **10** for more than just activating a single tool.

FIG. **7**A discloses a simple schematic of three soft open preventers **10**,**10'**,**10"** all connected to individual channels **21**,**21'**,**21"** in a sequential manner. After the first soft open preventer **10** moves due to pressure from the first channel **21** (exposing the first downhole tool **40** to pressure), it exposes the second soft open preventer **10'** to pressure through the second channel **21'**. After the second soft open preventer **10'** moves (and exposes the second downhole tool **40'** to pressure), it exposes the third soft open preventer **10"** to the pressure from third channel **21"** (and triggers the third downhole tool **40"**). In this way, the tools can be triggered in a sequential manner.

FIG. **7**B discloses three soft open preventers **10**,**10'**,**10"** that are connected in a parallel manner. Each of the soft open preventers **10**,**10'**,**10"** have their own channel **21**,**21'**,**21"**. In this way the soft open preventer **10**,**10'**,**10"** can be operated independently giving the possibility of, for example, the first second soft open preventer **10'** being triggered before the first soft open preventer **10**.

Note that as previously discussed, the downhole tool **40** does not have to trigger at the same time as the soft open preventer **10** does. The soft open preventer **10** simply prevents the premature triggering of the downhole tool **40** due to pressure.

A combination of the linear and parallel configurations is possible. For example, the first soft open preventer **10** and the third soft open preventer **10"** could be in parallel, with the second soft open preventer **10'** being in series with the first soft open preventer **10**. It is also possible to have more than one downhole tool **40**, that doesn't not need a channel **21** at all. For example, if a plug **31** in a plug assembly **30** breaks, this could expose another downhole tool **40'** to enough pressure that it will trigger, even without an individual soft open preventer **10** for it. In other words, two downhole tools **40** can be on the same soft open preventer **10**.

Both the linear and parallel configurations (shown in FIGS. **7**A and **7**B) of the soft open preventer **10**,**10'**,**10"** can be arranged such that the same pressure can make two or more of the downhole tool **40**,**40'**,**40"** activate. Note that if one of the three downhole tools **40**,**40'**,**40"** does not activate in this case, even when it was supposed to be at the same pressure for activation, pressure through one of the fluid channels **21**,**21'**,**21"** can be increased until it does.

Normally the downhole tool **40** has a tool release element **43**. This can be the same type of release element as was described earlier for preventer release element **13** and plug release element **33**.

One example of a downhole tool **40** discussed in detail previously, is a plug assembly **30**. This is to prevent the plug assembly **30** from breaking the plug **31** when there is not enough force to break it. Other examples of a downhole tool **40** is a sleeve, such as a sleeve with a bypass channel.

Note that the preventer release element **13** type of one soft open preventer **10** may be different as for another soft open preventer **10'**. In other words, in the first soft open preventer **10** it could be a shear pin and in the second soft open preventer **10'** it could be a tensile element.

Reference is made to FIG. **8**. FIG. **8** discloses the use of the soft open preventer **10** to actuate a sleeve **60**.

It is possible for the sleeve **60** to comprise a sleeve release element **63** if the purpose of the soft open preventer **10** is simply to ensure that the sleeve **60** (or any other downhole tool **40**) does not activate early. However, in the example shown, there is no sleeve release element **63**, only a preventer release element **13**). It can be considered that the sleeve release element **63** is the preventer release element **13**.

Upon activation of the channel release **22**, pressure in the channel **21** will eventually cause the soft open preventer **10** to activate. This causes the preventer support **11** to move into the preventer gap **15**. This movement into the preventer gap **15** allows for the sleeve **60** to move.

The preventer gap **15** will often be a sealed chamber, but this is not a requirement.

Several downhole tools **40** include a sleeve **60** of some kind within them. It would be possible to modify a soft open preventer **10** in the soft open preventer system **200** such that activation of the soft open preventer **10** activates the sleeve **60**, which causes the downhole tool **40** to activate.

Reference is made to FIG. **9**. FIG. **9** discloses a perspective view of an alternative shape of a plug **31**. All of the plugs shown have had a square cross section and O-rings sealing on the side. However, this does not have to be the case and FIG. **9** present an alternative shape of plug. In this case, the plug has been chamfered on both the top and bottom. In this case, there are bearing rings **16** on the angled sides.

Without the bearing ring **16**, it is possible for the plug to break prematurely on the hard metal components that hold the plug in position. Sealing of the plug can be done with an O-ring (and other sealing elements) around its circumference, as in the previous figures. An alternative is to use bearing rings **16** that seal. Note that it is possible to use a single bearing ring **16** that seals.

Also, note that it is possible for only the top or bottom of the plug **31** to be chamfered. It is not required that there are two bearing rings. It is also possible to have a bearing ring that is not angled. It is possible to combine a sealing bearing ring **16** with an O-ring. The O-ring is usually located around the circumference, but it can be along the edge of the chamfered plug.

In a more general description of the different positional states of the soft open preventer system **200**, is given as:

In first position of the soft open preventer system **200** (as shown for a plug assembly **30** in FIG. **2**A):
- The soft open preventer **10** is in its first position (not moving)
- The downhole tool **40** (in this case a plug assembly **30**) is in its second position (not moving)

In second position of the soft open preventer system **200** (as shown for a plug assembly **30** in FIG. **2**B):
- The soft open preventer **10** has activated (in this case the preventer release element **13** breaks) and moves from its first position (stationary) through an intermediate position and stops in the second position.
- The downhole tool **40** is still in its second position.

In third position of the soft open preventer system **200** (as shown for a plug assembly **30** in FIG. **2**C):
- The soft open preventer **10** is in its second position (stationary)
- The downhole tool **40** has activated and moves into an intermediate position between the first position (stationary) and the third position (in which the downhole tool **40** has finished activating).

In fourth position of the soft open preventer system **200** (as shown for a plug assembly **30** in FIG. **2**D)
- The soft open preventer **10** is in its second position
- The downhole tool **40** has finished activating (moving from its first position, through its second position) and is at rest.

However, that is not the only application of the soft open preventer **10**. Another application is using the activation of a soft open preventer **10** to activate a downhole tool **40** by at a certain threshold differential pressure or absolute pressure being applied. Many downhole tools **40** include sleeves that are moved when the downhole tool **40** activates after or with the activation of the soft open preventer **10**.

In most of the previous examples, both the soft open preventer **10** and plug assembly **30** operate on a differential pressure. Configurations using release elements or a crumple element were triggered on absolute pressure (shown in FIGS. **6**A and **6**B). One skilled in the art would easily be able to modify the soft open preventer **10** and the downhole tool **40** to operate at a threshold absolute pressure instead of a threshold differential pressure. This usually means configuring the preventer release element **13** and tool release element **43** such that it breaks at a threshold absolute pressure.

Note that the preventer release element **13**, plug release element **33**, tool release element **43**, and sleeve release element **63** can all be made using (independently) the previously discussed types of release elements **13**,**33**,**43**,**63**.

Another use of the soft open preventer **10** is in a tool that can be activated in two steps. For example a downhole tool **40** that is activated in two steps. For example a safety feature that something cannot happen before a certain pressure has been applied.

Note that the term "activation" means that the tool moves from one state to another, be it any of the examples of downhole tools **40** (examples include a plug assembly **30** and a sleeve **60**) or the soft open preventer **10**. These activations do not have to occur at the same time. Additionally, if a downhole tool's **40** tool release element **43** is referred to as the same as the preventer release element **13**, it means that the tool release element **43** does not exist and only the preventer release element **13** is responsible for the activation of the soft open preventer **10** and downhole tool **40**.

As has been shown in this disclosure, the soft open preventer **10** can be used for more than preventing the opening of a tool early. In the case where the preventer release element **13** and the tool release element **43** are the same, the soft open preventer **10** becomes a way to activate the downhole tool **40** when the possibility of soft opening itself is not a problem.

The invention claimed is:

1. A soft open preventer system (**200**) comprising:
- a preventer tubular (**100**),
- a soft open preventer (**10**),
- a channel system (**20**),
- a downhole tool (**40**),
- the soft open preventer (**10**) comprises:
  - a preventer support (**11**), and
  - a preventer release element (**13**),
- the channel system (**20**) comprises:
  - a channel (**21**),
  - a channel release (**22**), and
  - pressure applier (**23**);

the downhole tool (**40**) comprises:

a tool release element (**43**);

wherein:

the soft open preventer (**10**), the downhole tool (**40**), and the channel system (**20**) is arranged at least partially in the preventer tubular (**100**); and

the soft open preventer (**10**) is arranged such that the downhole tool (**40**) will not activate before the soft open preventer (**10**) activates;

the pressure applier (**23**) is arranged to activate the channel release (**22**), the channel release (**22**) is arranged to allow pressure to increase in the channel (**21**);

the channel (**21**) is in fluid contact with at least a portion of the preventer support (**11**), and

the preventer release element (**13**) supports the preventer support (**11**);

wherein:

the preventer release element (**13**) is arranged such that when a threshold absolute pressure or pressure differential is applied to the preventer release element (**13**), the preventer release element (**13**) breaks activating the soft open preventer (**10**), allowing the preventer support (**11**) to move; and

the soft open preventer system (**200**) is arranged such that activation of the soft open preventer (**10**) will allow the activation of the downhole tool (**40**).

2. The soft open preventer system (**200**) according to claim **1**, wherein the downhole tool (**40**) further comprises a tool release element (**43**), wherein the downhole tool (**40**) activates when the tool release element (**43**) breaks.

3. The soft open preventer system (**200**) according to claim **2**, wherein the preventer release element (**13**) and the tool release element (**43**) is a single element.

4. The soft open preventer system (**200**) according to claim **1**, wherein the soft open preventer (**10**) further comprises a preventer sleeve (**12**) that supports the preventer support (**11**).

5. The soft open preventer system (**200**) according to claim **1**, wherein the pressure applier (**23**) is a counter or an electronic trigger.

6. The soft open preventer system (**200**) according to claim **1**, wherein the preventer release element (**13**) or the tool release element (**43**) is a shear element, a tension element, a tensile element, or a crumple element.

7. The soft open preventer system (**200**) according to claim **4**, wherein the preventer support (**11**) and the preventer sleeve (**12**) are a single element.

8. The soft open preventer system (**200**) according to claim **1**, wherein the downhole tool (**40**) is a plug assembly (**30**), wherein the plug assembly (**30**) comprises:

a plug (**31**) that blocks fluid flow through the preventer tubular (**100**) when the plug (**31**) is intact; and

a seat (**32**) that supports the plug (**31**),

a breaker object (**34**) arranged to break the plug (**31**).

9. The soft open preventer system (**200**) according to claim **8**, further comprising a sealing bearing ring (**16**) in contact with the plug (**31**).

10. The soft open preventer system (**200**) according to claim **8**, wherein

the tool release element (**43**) is a plug release element (**33**) arranged to bring the breaker object (**34**) in contact with the plug (**31**) when the plug release element (**33**) breaks.

11. The soft open preventer system (**200**) according to claim **8**, wherein the preventer support (**11**) supports the seat (**32**), preferably where the seat (**32**) and the preventer support (**11**) is a single element.

12. The soft open preventer system (**200**) according to claim **8**, wherein a plug release element (**33**) is the preventer release element (**13**).

13. The soft open preventer system (**200**) according to claim **8**, wherein the plug assembly (**30**) further comprises a breaker body (**39**) arranged to support the breaker object (**34**), and wherein the breaker body (**39**) is supported by the soft open preventer (**10**), preferably the plug (**31**) is stationary.

14. The soft open preventer system (**200**) according to claim **1**, wherein the downhole tool (**40**) comprises a sleeve (**60**) and wherein the soft open preventer system (**200**) is arranged such that activation of the sleeve (**60**) activates the downhole tool (**40**).

15. The soft open preventer system (**200**) according to claim **9**, wherein a plug release element (**33**) is the preventer release element (**13**).

16. The soft open preventer system (**200**) according to claim **10**, wherein the plug release element (**33**) is the preventer release element (**13**).

17. The soft open preventer system (**200**) according to claim **9**, wherein the preventer support (**11**) supports the seat (**32**), preferably where the seat (**32**) and the preventer support (**11**) is a single element.

18. The soft open preventer system (**200**) according to claim **10**, wherein the preventer support (**11**) supports the seat (**32**), preferably where the seat (**32**) and the preventer support (**11**) is a single element.

19. The soft open preventer system (**200**) according to claim **2**, wherein the soft open preventer (**10**) further comprises a preventer sleeve (**12**) that supports the preventer support (**11**).

20. The soft open preventer system (**200**) according to claim **1**, wherein the soft open preventer system (**200**) further comprises:

a second downhole tool (**40'**),

a second channel (**21'**), and

a second soft open preventer (**10'**);

wherein the soft open preventer system (**200**) is arranged such that:

the second channel (**21'**) is in fluid connection with the channel (**21**) after or before the first soft open preventer (**10**) activates, and the channel second channel (**21'**) is in fluid connection with the second soft open preventer (**10'**).

* * * * *