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(54) DEVICE TO OPERATE DOWNHOLE EQUIPMENT

VORRICHTUNG ZUM BETREIBEN EINER BOHRLOCHAUSRÜSTUNG

DISPOSITIF D'ACTIONNEMENT POUR ÉQUIPEMENT DE FOND

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**US-A- 2 898 088 US-A- 2 898 088
US-A- 2 964 116 US-A- 2 964 116
US-A- 4 436 164**

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Description

[0001] The present invention relates to a device for providing a pressure pulse for activating fluid pressure activated equipment in a fluid conveying pipe, where a section of the pipe wall includes a number of penetrating bores, and flexible membrane is arranged on the outside of the pipe section, said flexible membrane isolating a first fluid **F1** in the fluid-conveying pipe from a second fluid **F2** in another canal which is in fluidic communication with the equipment, wherein the membrane, on account of its elasticity, conveys pressure changes (pressure pulses) in the fluid **F1** in the pipe to the fluid **F2** in the other canal, as defined in the preamble of the appended claim 1.

[0002] In particular, the invention is concerned with a construction which is capable of supporting operation of down-hole equipment which is hydraulically operated.

Background to the invention

[0003] It has been well known for a long time that, in connection with pressure-pulse activation of mechanical equipment installed down in an oil- or gas-well, there are challenges related to convey these pressure pulses forward to the equipment.

[0004] This is especially pertinent when a pipe which is introduced down into the well is pressurized up to transmit these pressure signals down to the equipment. A problem that is that is often encountered is that, over time, there is formed an accumulation of particles in liquid, which eventually forms a solid mass at a bottom of the pipe, when such particles sink to the bottom. This is especially a problem when plugs are employed in the production pipe which operates in a manner to pump up pressure over the plug from the rig.

[0005] A manner of limiting the problem is to couple the equipment via a hydraulic control line (a conductor) which is disposed outside the existing pipe wherein the plug is mounted. Such a control lines are routed upwards and through the wellhead-installation and further up to the rig, such that it can be subject to pressure directly from the rig, and as a consequence one is still able to operate the equipment despite an accumulation of mud over the plug in the pipe.

[0006] The disadvantage of such a system is that, to a major extent, it renders operation more expensive and establishing a several kilometer long control line (conductor) introduces a risk that it is possible that the pipe which generally, for example, is a thin tube with a dimension 1/4" (6.3 mm) is worn against walls of the well, and it is thereby possible to lose all control of the equipment.

[0007] A known solution is to use an kind of accumulator for introducing clean liquid into the well. Such a solution is described in Norwegian patent application no. 2008 0452. There is described an accumulator which includes a limited volume for supplying the equipment with clean liquid for operating it.

[0008] That which is described in said Norwegian patent application is a piston accumulator which pursuant to the description accumulates pressure during introduction into the well.

5 **[0009]** This system continues to result in a considerable number of problems associated with functionality.

[0010] First and foremost, it is claimed that debris (supply of contamination) are not able to penetrate into the system. But such a claim is incorrect, on account of it being known that a blockage of the canal upstream of the piston, as described, would not be able to convey the pressure pulses which are necessary for the system to function. It is correct that these particles would not be able to contaminate downstream of the piston which is to actuate the cyclic mechanism in the system, which is operable to open depending on a beforehand specified number of pressure pulses. The problem is namely that, by way of liquid communication through the canal upstream for the piston, particles may enter into the chamber and thereby block the piston from moving, such that pressure differences can arise between upstream and downstream of the piston.

[0011] A cyclical-system which is based upon pressure differences would then cease to function.

25 **[0012]** In respect of the state-of-the-art, reference is also made to US patents Nos. US-2,964,116, US-2,898,088 and US-4.436.164.

[0013] In this respect, US-2,964,116 discloses a pressure pulse signalling system in a drill string, wherein a membrane in the form of a sleeve is placed on a perforated pipe section. The membrane transmits pressure pulses from a drilling fluid to a hydraulic fluid in a chamber, surrounding the perforated pipe section, to a conduit, and further to a pressure actuated equipment, as shown in column 4, lines 21-53, column 8, lines 15-20 and on figures 1 a and 2. US-2,898,088 shows a borehole logging system, incorporating a pipe section with a flexible, sleeve shaped membrane, which separates a fluid in the drill pipe from a hydraulic fluid in an outer chamber and in a conduit, the latter being connected to a fluid pressure actuated equipment. Thus, the membrane transmits fluid pressure pulses from the fluid in the drill pipe to the pressure controlled equipment.

45 Object of the invention

[0014] It is a principal object of the invention to provide a new construction which is capable of solving the aforementioned disadvantages and problems.

50

The present invention.

[0015] The device pursuant to the present invention is characterized in that each bore through the pipe section wall defines a central concentric bore, in that each end of the bore forms a conical extension towards the inner wall and the outer wall of the pipe section, respectively.

[0016] The beneficial implementations appear in the

dependent claims 2 to 8.

[0017] An advantage of this solution of having conical extended bores is that each hole is not so easily blocked permanently by slime and particles. A particle in the pipe fluid, which may bind and block the entrance to the bored hole will simply loosen and be pushed back again when the fluid flow is reversed. The particle will then be easier to be loosened by the back flow.

[0018] One of the advantages of the present invention, as defined, is that a piston which moves axial in a longitudinal direction will be limited in area which can be affected, whereas a bellows which moves radially is capable of providing an enormous area which can be affected. This area is limited only by the length of the bellow.

Description of the figures.

[0019] The present invention will now be described in more detail with reference to the accompanying diagrams.

Figure 1 is an illustration of a pipe which is installed within a borehole in, for example, a hydrocarbon-bearing formation, wherein the inventive device is employed.

Figures 2 and 3 are illustrations of the details of the inventive construction **10** in two positions, in that it is disposed a distance upstream in respect of down-hole equipment **20** which is to be operated hydraulically pursuant to the present invention.

Figure 3B is an illustration of an elongate cross-section of a hole which is arranged in a radial direction through the pipe wall.

Figures 4 and 5 are illustrations of an enlarged portion of Figures 2 and Figure 3, and illustrates the hydraulic canal **30** through the pipe wall and which couples the pressure pulse device **10** with the equipment **20**.

[0020] The Figures provide illustrations of a pipe **12** which is deployed in a borehole **14** in a formation **16**. Described as a non-limiting example, a pipe section **18** is installed at a lowest portion of the pipe **12** with a seat accommodating a plug **22**. The plug **22** is used, for example, initially for testing and checking that the interior of the pipe is sufficient non-leaky under pressure, and will function as intended during production of hydrocarbons from the formation **16**.

[0021] As a consequence of the upwardly-facing surface of the plug **23** being susceptible to collecting large deposits **25** of contamination comprising solid particles such as slime, the device **10** is positioned a distance up over the plug **20**, and the plug **20** and device **10** are mutually coupled via a canal **30** which extends axially along and through the wall of the pipe between these two re-

gions.

[0022] The device includes a perforated pipe section **27** which is installed into the pipe **12**. A hollow volume or chamber **26** is defined between the outer wall **21** of the section and the inner wall of the pipe **12**.

[0023] Surrounding the pipe section **25** is threaded a sleeve-shaped elastic bellows or membrane **24**, and uppermost at **31** and lowermost at **33** is attached in the solid material of the pipe section **25**. The bellows **24** can subsequently bulge out from a position where it lies bonded onto the pipe section's outer wall **21** and to an extent it bulges out and lies against the inner wall **13**. Outside the bellows **24** is a ring-shaped chamber **26** coupled with a drilled canal **30** which extends through the pipe wall downwardly to the release mechanism (not especially shown here) which is used to explode the plug away.

[0024] The bellow's position or bulging will be dependent upon a difference in a pressure **P1** within the pipe **12** and a pressure **P2** in the chamber or the canal **30** outside the membrane **24**. Figure 2 illustrates the situation where the pressure **P1** is higher than the pressure **P2** (**P1 > P2**) such that the membrane bulges out.

[0025] Figure 3 is an illustration of a situation wherein the pressure **P2** is higher or equal to the pressure **P1** and the membrane lies in a wavy manner against the outer wall **21**.

[0026] A release mechanism which removes the plug is adapted such that it counts a number of pulses, wherein the pulses are generated by increasing and decreasing the fluid pressure **P1**, and wherein the plug is exploded away at a predetermined number of pulses.

[0027] In the chamber radially outside the bellows, there is filled a clean liquid which is present in connection with an outside lying pipe or the internally bored canal **30** which again is present in connection with, for example, a pressure-pulse sensitive valve.

[0028] The pressure-sensitive valve can be set, or be set up, either to read the signals electronically with help of a pressure transmitter, or it can be a purely mechanical system which reads pressure pulses for opening the valve at a predetermined number of pressure pulses.

[0029] When the valve opens, the clean liquid flows past the valve and operates the equipment which is hydraulically operated. The technology can be used to operate down-borehole equipment which is hydraulically operated, and requires clean liquid for operating correctly. Examples of such equipment can be detonation systems for removable (disappearing) plugs, sliding sleeves, hydraulically operated ball valves and hydraulically-operated flapper valves. These are only some few examples of equipment with which this new technological solution can be utilized. The hydraulically operated system can for example be a layer-divided plug **22** fabricated from glass. In whatever manner it is removed or smashed is not specifically shown in the Figures. The pressure-pulse controlled apparatus can include a device **39** which is operable to count the number of pulses, and when it has counted a correct number, the mechanism is acti-

vated and releases an explosive mechanism. This can, for example, mean that an axially-disposed piston **38** in the pipe wall is pushed downwardly with large force and slides a horizontally-orientated smashing piston in a radial direction and into the plug **22** which thereby can be smashed. The plug can be fabricated from ceramics materials which can be smashed or from glass which is adapted for this purpose.

[0030] By utilizing a bellows instead of a piston, it is also possible to bore a large number of holes radially through the wall around the periphery of the protective collar which supports the bellow and maintains the clean liquid in place. An elongate cross-section of these bored out holes **50** in a radial direction through the pipe wall **26**, is shown in cross-section in Figure 3B. On both sides thereof (from each end thereof), there is bored out a hole through the wall. The central portion of the hole through the wall beneficially has a form of a bored out region **56** with circular cross-section, whereas each end of the circular bore continue with a gradually increasing cross-section diameter towards the wall surfaces, namely showing a conical form. The bored out region is of course widest out towards the wall surfaces, namely the form of holes **52** to **54** shown in the diagrams are such that that the outermost form respectively cone-shaped form or conically formed holes, or substantially of trumpet-form. These bores can have other cross-sections than circular. An advantage with this form of hole is that each hole is not so easily blocked permanently by slime and particles.

[0031] The risk that the holes with such a form can be blocked by debris and solid particles and slime can be reduced by the holes being bored out such that they are concentric in both directions. This form of hole through the wall having an expanding cross section of the bore, towards the outer wall, resulting in there being achieved an effect, wherein there will always be fluid/liquid streaming both ways as a result of particles bound in the conical hole which is opened up with largest diameter at an opposite side to that which is influenced by pressure with a result that the particles become loosened when pressure is applied from the side that has smallest hole. A particle **60** in the pipe fluid, which may bind and block the entrance to the bored hole **56**, when the fluid **F1** streams in a direction of the arrow **P2**, will simply loosen and be pushed back again when the fluid pressure **P2** exceeds the fluid pressure **P1** and the fluid **F2** streams back. The particle **60** will then be easier to be loosened by the back streaming.

[0032] Moreover, with reference to Figures 2 and 3, there are provided a breaking plate (or several), brushing disks which are arranged to break or burst when, for example, 10 Bar pressure difference between the pressure in the clean fluid behind the flexible material and the liquid in the well pipe arising, further ensuring against there arising a pressure difference between the two liquids. The flexible membrane will also always bring about that identical pressures arise on both sides and return to its original form after a pressure excursion.

[0033] Through the wall of the pipe **27**, namely above the perforated wall portion, there are bored out one (or more) holes **160** which forms a fluid connection between the ring-shaped chamber **26** outside the bellows and an inner of the pipe denotes by **F1/P1** (Figures 2 and 3). In the hole, there is installed a metal plate for providing a bursting disk **162**, wherein this plate is attached via an anchoring denoted by **58**, such as screw or the similar on the diagrams.

[0034] The burst disk **162** is adapted for creating fluidic communication in an event that an excessive pressure is developed on the back side (**P2**) of the bellows, namely when the pressure is not the same as the pressure **P1** within the pipe (tubing).

[0035] The bore for the break disk can, as a point of reference, be placed anywhere, as long as it stands positioned such that it separates fluid between the tubing and back side of the bellows and creates a communication path between them when it bursts.

[0036] The burst disk **162** will also provide an eventual operation of the equipment which is to be controlled by later re-filling with liquid when the clean liquid behind the membrane is consumed, wherein the membrane is pre set towards the walls in its respective housing, so that a pressure difference arises between the well pipe (**P1**) and the back side (**P2**) of the membrane, whereafter the burst disk will break and liquid from the well will thereafter pour into the system.

[0037] There are thus many advantages in comparison to known state-of-the-art which has a limited volume surfaces which can be influenced with associated risk that holes of the system become blocked in operation.

Claims

1. A device for providing a pressure pulse for activating fluid pressure activated equipment in a fluid conveying pipe (**12**), where a section (**27**) of the pipe wall includes a number of penetrating bores, and flexible membrane (**24**) is arranged on the outside of the pipe section (**27**), said flexible membrane (**24**) isolating a first fluid (**F1**) in the fluid-conveying pipe from a second fluid (**F2**) in another canal (**30**) which is in fluidic communication with the equipment, wherein the membrane (**24**), on account of its elasticity, conveys pressure changes in the fluid (**F1**) in the pipe (**12**) to the fluid (**F2**) in the other canal (**30**), characterized in that each bore (**50**) through the pipe section wall (**27**) defines a central concentric bore (**56**), in that each end of the bore (**56**) forms a conical extension towards the inner wall (**121**) and the outer wall (**21**) of the pipe section (**27**), respectively.
2. A device as claimed in claim 1, characterized in that each bore (**50**) extension has a cone shaped form, or substantially of trumpet-form.

3. A device as claimed in any of claims 1 to 2, **characterized in that** the membrane is a sleeve formed bellows (24) that is threaded onto the outside of the pipe section (27) and arranged in a chamber-forming (26) seat in the pipe section (27), wherein the wall of the pipe section (27) comprises said number of penetrating bores (50) holes for providing a fluid communication from the fluid (F1) at a first pressure (P1) in the pipe (12) radially outwardly towards the membrane located outside of the pipe section wall. 5
4. A device as claimed in any of the preceding claims, **characterized in that** the membrane (24) is a sleeve-formed bellows, and the chamber is formed from a ring formed region surrounding the pipe section periphery. 10
5. A device as claimed in any of the preceding claims, **characterized in that** the flexible membrane provides a similar pressure on both sides of the membrane, which for example will contract, expand and contract itself back to its original form after an application of pressure. 15
6. A device as claimed in any of the preceding claims, **characterized in that** a burst-disk (162) is arranged in a bored hole/canal through the wall of the pipe (12/27) for defining a removable dividing plate between the first (F1) region in the fluid-conveying pipe having a first pressure (P1) and the second fluid (F2) region in the other canal having a second pressure (P2). 20
7. A device as claimed in any of the preceding claims, **characterized in that** the burst-disk (62) is operable to break when a given pressure difference between the first and second fluid regions (F1) and (F2) arises, for example there arises a pressure difference of 10 Bar between the two regions, for ensuring the system against further pressure differences between the two liquids. 25
8. A device as claimed in any one of the preceding claims, **characterized in that** the burst-disk (62) is located in a bore hole through the wall at the top of the pipe section (27) where the bellows are mounted, for providing communication in an event that there arises a too high second pressure (P2) in the second fluid (F2) on the backside (P2) of the bellows and which is not similar to the first pressure (P1) in the first fluid (F1) within the pipe (12). 30

Patentansprüche

1. Vorrichtung zum Bereitstellen eines Druckpulses zum Aktivieren von fluiddruckaktivierter Ausrüstung in einem fluidfördernden Rohr (12), wobei ein Be-

reich (27) der Rohrwand eine Anzahl von Durchgangsbohrungen umfasst und eine flexible Membran (24) auf der Außenseite des Rohrbereichs (27) angeordnet ist,

wobei die flexible Membran (24) ein erstes Fluid (F1) in dem fluidfördernden Rohr abgrenzt von einem zweiten Fluid (F2) in einem weiteren Kanal (30), welcher in fluidischer Verbindung mit der Ausrüstung ist, wobei die Membran (24) durch ihre Elastizität Druckänderungen in dem Fluid (F1) in dem Rohr (12) zu dem Fluid (F2) in dem weiteren Kanal (30) befördert, **dadurch gekennzeichnet, dass** jede Bohrung (50) durch die Rohrbereichswand (27) eine mittige konzentrische Bohrung (56) definiert, wobei jedes Ende der Bohrung (56) jeweils eine kegelförmig Aufweitung in Richtung der inneren Wand (121) und der äußeren Wand (21) des Rohrbereichs (27) dargestellt.

2. Vorrichtung wie beansprucht in Anspruch 1, **dadurch gekennzeichnet, dass** jede Bohrungs- (50) aufweitung eine kegelförmige Form oder im Wesentlichen eine Trichterform aufweist.
3. Vorrichtung wie beansprucht in einem der Ansprüche 1 bis 2, **dadurch gekennzeichnet, dass** die Membran ein hülsenförmiger Balg (24) ist, welcher auf die Außenseite des Rohrbereichs (27) aufgezogen ist und in einer kammerbildenden (26) Passung in dem Rohrbereich (27) angeordnet ist, wobei die Wand des Rohrbereichs (27) die Anzahl von eindringenden Bohrungs- (50) löchern umfasst zum Bereitstellen einer fluidischen Verbindung von dem Fluid (F1) mit einem ersten Druck (P1) in dem Rohr (12) nach radial Außen zu der Membran, welche außerhalb der Rohrbereichswand angeordnet ist.
4. Vorrichtung wie beansprucht in einem der vorangehenden Ansprüche, **dadurch gekennzeichnet, dass** die Membran (24) ein hülsenförmiger Balg ist, und die Kammer von einem ring-bildenden Bereich gebildet ist, welche die Rohrbereichsumgebung umgibt.
5. Vorrichtung wie beansprucht in einem der vorangehenden Ansprüche, **dadurch gekennzeichnet, dass** die flexible Membran einen ähnlichen Druck auf beiden Seiten der Membran bereitstellt, welche nach einer Anwendung von Druck zum Beispiel sich zusammenzieht, sich ausdehnt, und sich zu ihrer anfänglichen Form wieder zusammenzieht.
6. Vorrichtung wie beansprucht in einem der vorangehenden Ansprüche, **dadurch gekennzeichnet, dass** eine Bruchscheibe (162) in einem gebohrten Loch/Kanal durch die Wand des Rohres (12/27) an-

geordnet ist, um eine entfernbare, teilende Platte zwischen dem ersten (F1) Bereich des fluidfördernden Rohres mit einem ersten Druck (P1) und einem zweiten Fluid- (F2) Bereich in dem weiteren Kanal mit einem zweiten Druck (P2) zu definieren.

7. Vorrichtung wie beansprucht in einem der vorangehenden Ansprüche, **dadurch gekennzeichnet, dass** die Bruchscheibe (62) einsetzbar ist, um bei einem bestimmten Druckunterschied zwischen dem ersten und dem zweiten Fluidbereich (F1) und (F2) zu brechen, zum Beispiel dann, wenn ein Druckunterschied von 10 bar zwischen den zwei Bereichen aufkommt, um das System gegen größere Druckunterschiede zwischen den zwei Fluiden zu sichern.
8. Vorrichtung wie beansprucht in einem der vorangehenden Ansprüche, **dadurch gekennzeichnet, dass** die Bruchscheibe (62) in einem Bohrloch durch die Wand am Oberteil des Rohrbereichs (27) angeordnet ist, wo der Balg angebracht ist, um eine Verbindung bereitzustellen, für den Fall, dass ein zu hoher zweiter Druck (P2) in dem zweiten Fluid (F2) auf der Rückseite (P2) des Balges aufkommt, und welcher nicht ähnlich zu dem ersten Druck (P1) in dem ersten Fluid (F1) innerhalb des Rohres (12) ist.

Revendications

1. Dispositif permettant de fournir une impulsion de pression permettant d'activer un équipement activé par une pression de fluide dans un tuyau de transmission de fluide (12), où une section (27) de la paroi de tuyau comporte une pluralité d'alésages pénétrants, et une membrane flexible (24) est agencée sur l'extérieur de la section de tuyau (27), ladite membrane flexible (24) isolant un premier fluide (F1) dans le tuyau de transmission de fluide d'un deuxième fluide (F2) dans un autre canal (30) qui est en communication fluidique avec l'équipement, dans lequel la membrane (24), du fait de son élasticité, transmet les variations de pression dans le fluide (F1) dans le tuyau (12) jusqu'au fluide (F2) dans l'autre canal (30), **caractérisé en ce que** chaque alésage (50) à travers la paroi de section de tuyau (27) définit un alésage concentrique central (56), **en ce que** chaque extrémité de l'alésage (56) forme une extension conique dans la direction de la paroi interne (121) et la paroi externe (21) de la section de tuyau (27), respectivement.
2. Dispositif selon la revendication 1, **caractérisé en ce que** chaque extension d'alésage (50) a la forme d'un cône, ou sensiblement la forme d'une trompette.
3. Dispositif selon l'une quelconque des revendications 1 à 2, **caractérisé en ce que** la membrane est un soufflet en forme de manchon (24) qui est fileté sur l'extérieur de la section de tuyau (27) et agencé dans une assise formant une chambre (26) dans la section de tuyau (27), dans lequel la paroi de la section de tuyau (27) comprend ladite pluralité de trous alésés pénétrants (50) permettant de fournir une communication fluidique à partir du fluide (F1) à une première pression (P1) dans le tuyau (12) radialement vers l'extérieur en direction de la membrane située à l'extérieur de la paroi de section de tuyau.
4. Dispositif selon l'une quelconque des revendications précédentes, **caractérisé en ce que** la membrane (24) est un soufflet en forme de manchon, et la chambre est formée à partir d'une région en forme d'anneau entourant la périphérie de section de tuyau.
5. Dispositif selon l'une quelconque des revendications précédentes, **caractérisé en ce que** la membrane flexible fournit une pression similaire sur les deux côtés de la membrane, qui par exemple va se contracter, se dilater et se contracter elle-même et revenir à sa forme d'origine après une application de pression.
6. Dispositif selon l'une quelconque des revendications précédentes, **caractérisé en ce qu'**un diaphragme d'éclatement (162) est agencé dans un trou/canal alésé à travers la paroi du tuyau (12/27) permettant de définir une plaque de division amovible entre la première région (F1) dans le tuyau de transmission de fluide ayant une première pression (P1) et la deuxième région de fluide (F2) dans l'autre canal ayant une deuxième pression (P2).
7. Dispositif selon l'une quelconque des revendications précédentes, **caractérisé en ce que** le diaphragme d'éclatement (62) est exploitable pour se rompre lorsqu'une différence de pression donnée entre les première et deuxième régions de fluide (F1) et (F2) se produit, par exemple une différence de pression de 10 bar se produit entre les deux régions, pour prémunir le système contre d'autres différences de pression entre les deux liquides.
8. Dispositif selon l'une quelconque des revendications précédentes, **caractérisé en ce que** le diaphragme d'éclatement (62) est positionné dans un trou alésé à travers la paroi en haut de la section de tuyau (27) où les soufflets sont montés, pour fournir une communication dans une éventualité où une deuxième pression (P2) trop élevée dans le deuxième fluide (F2) se produit sur le côté arrière (P2) des soufflets et qui n'est pas similaire à la première pression (P1) dans le premier fluide (F1) à l'intérieur du tuyau (12).

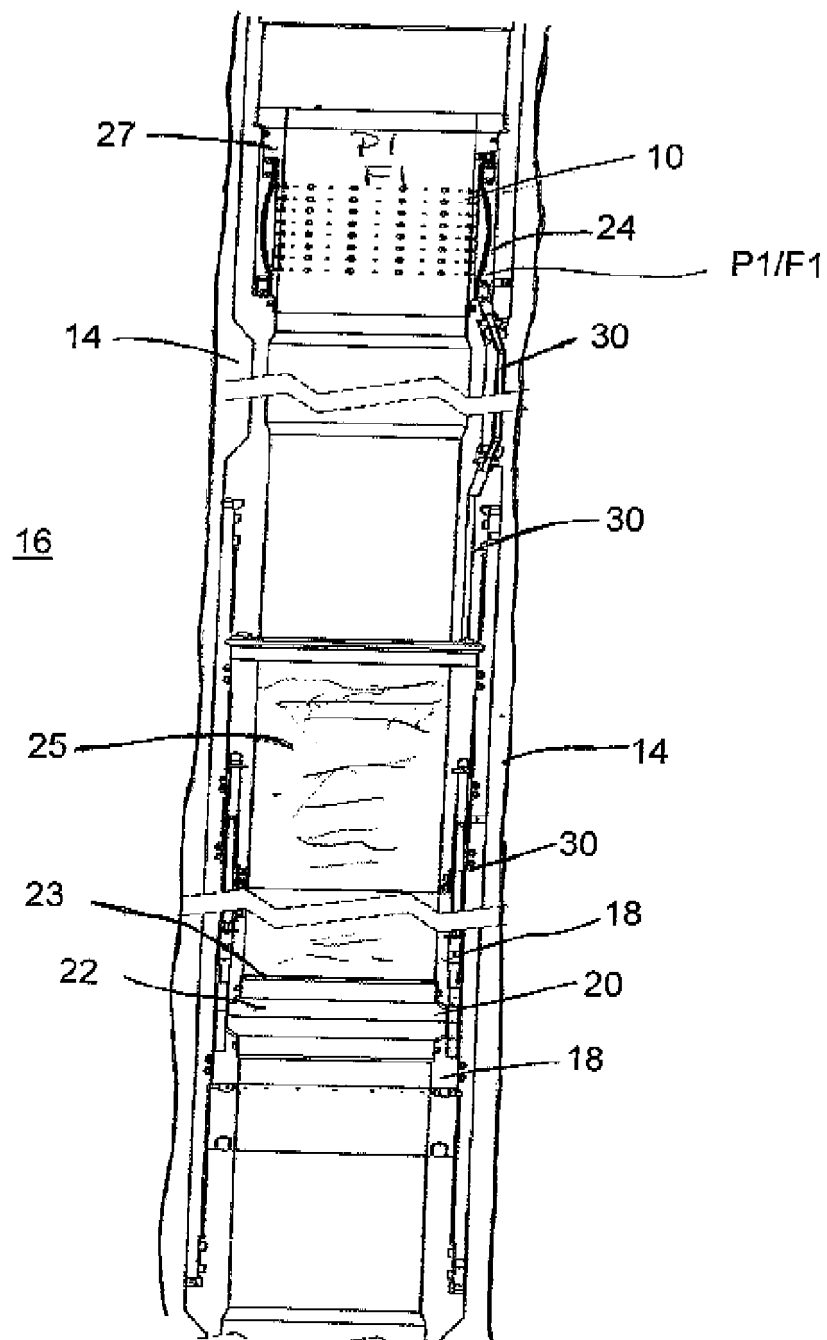


FIG. 1

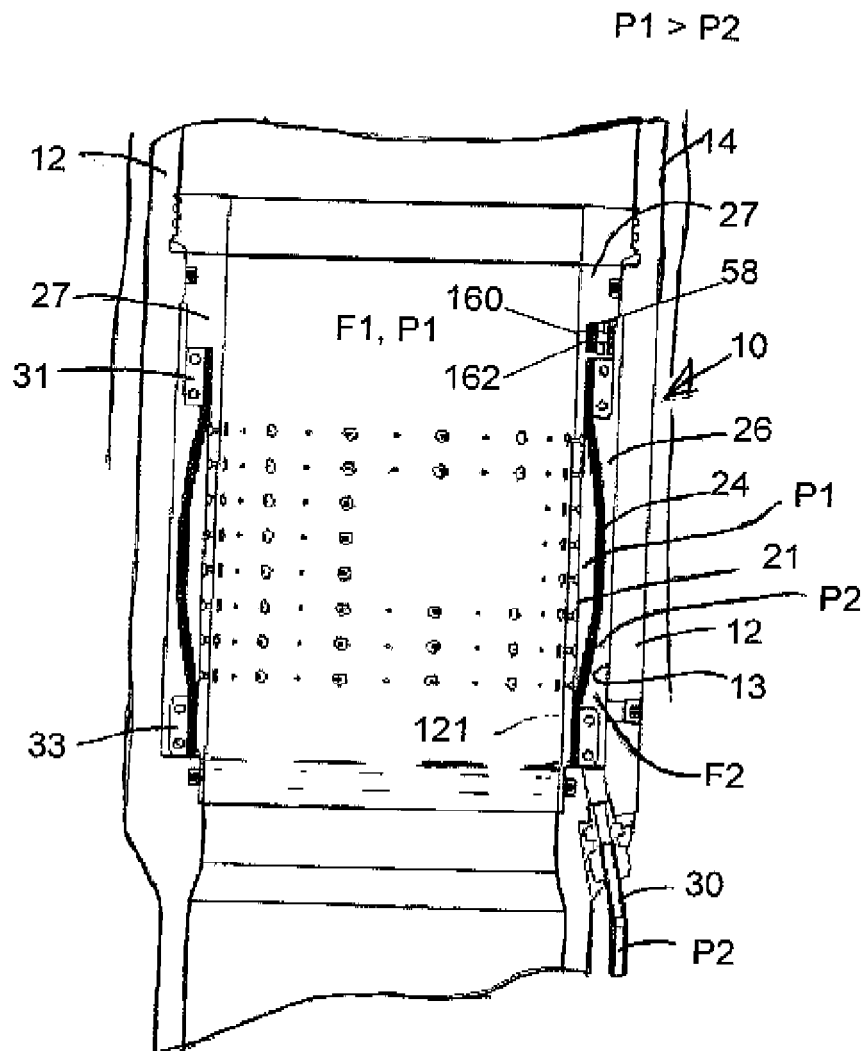


FIG. 2

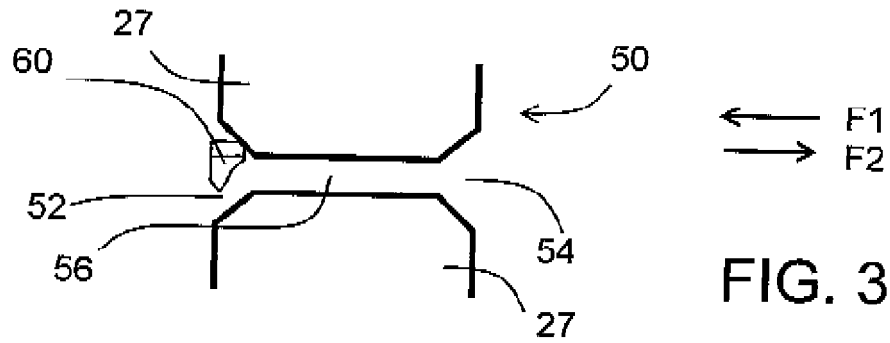


FIG. 3B

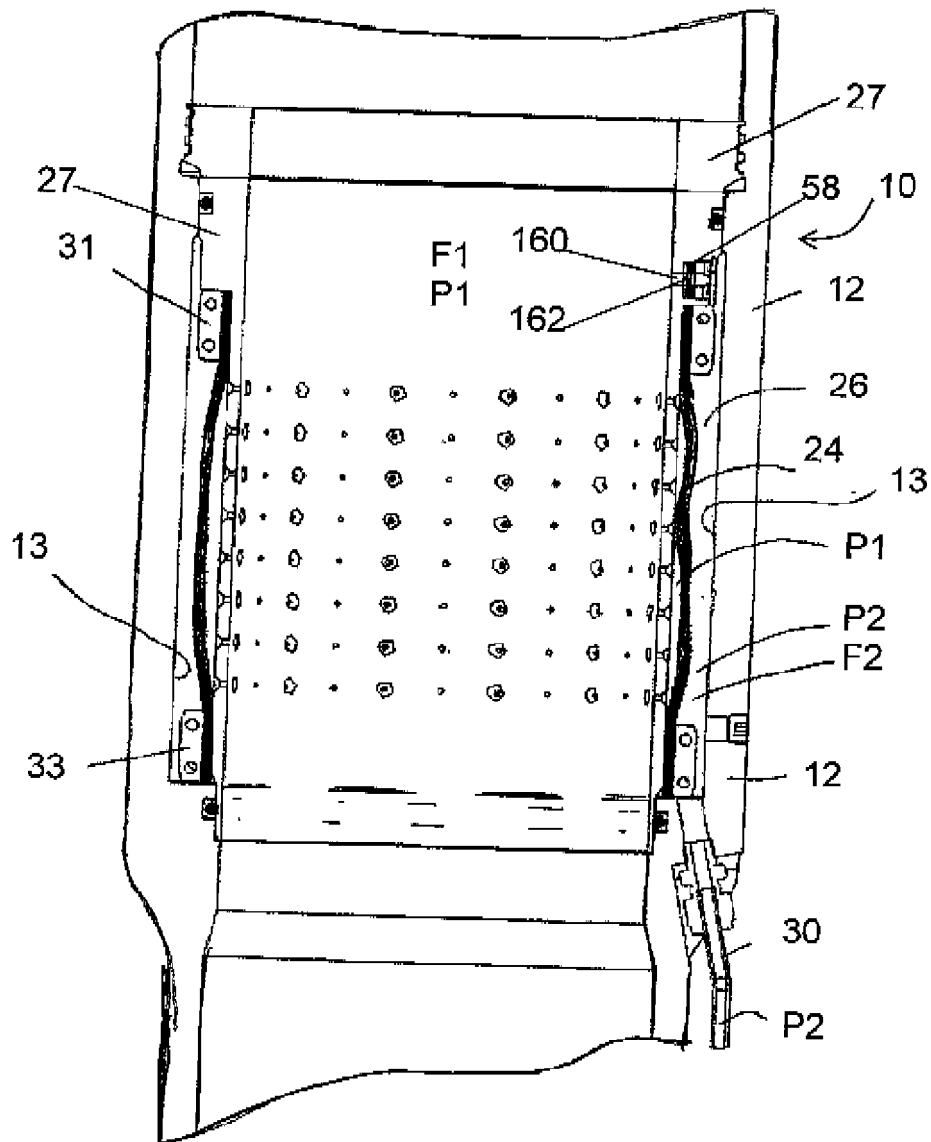


FIG. 3

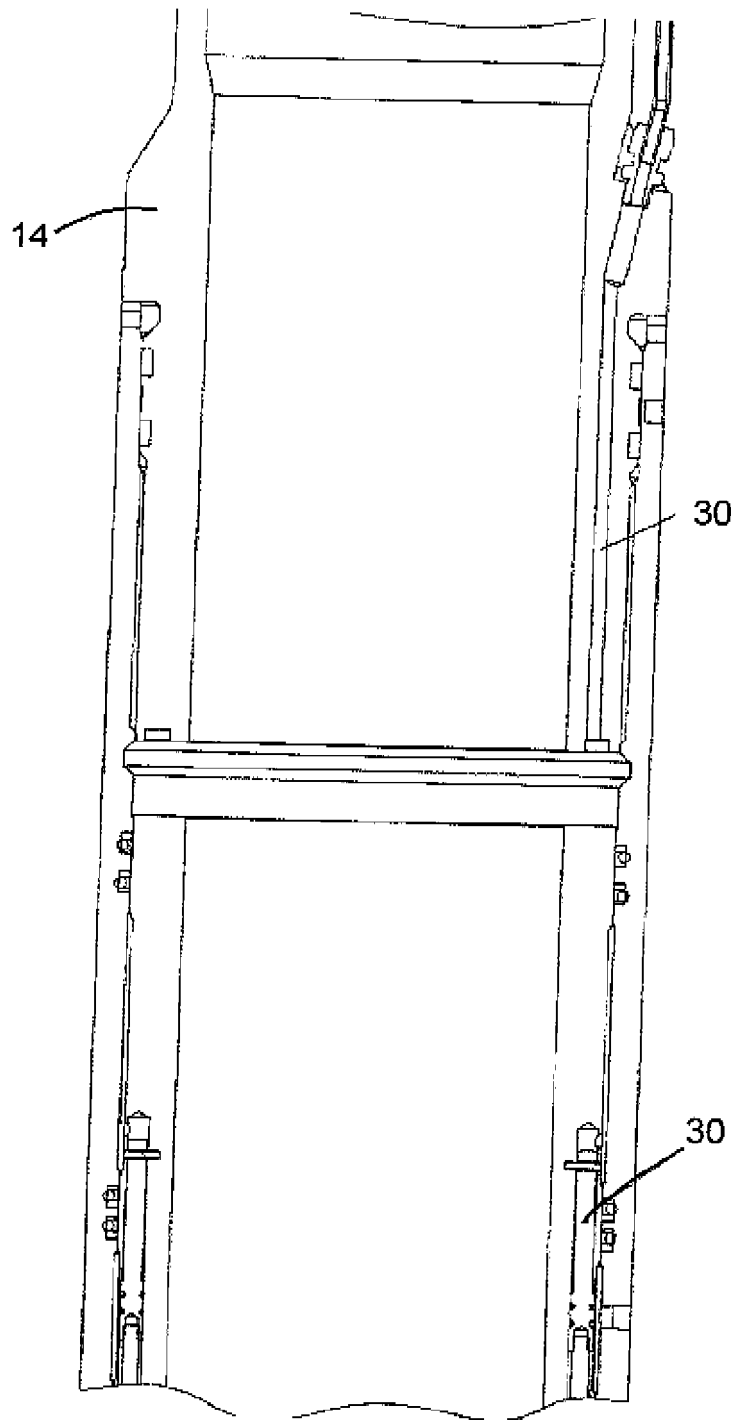


FIG. 4

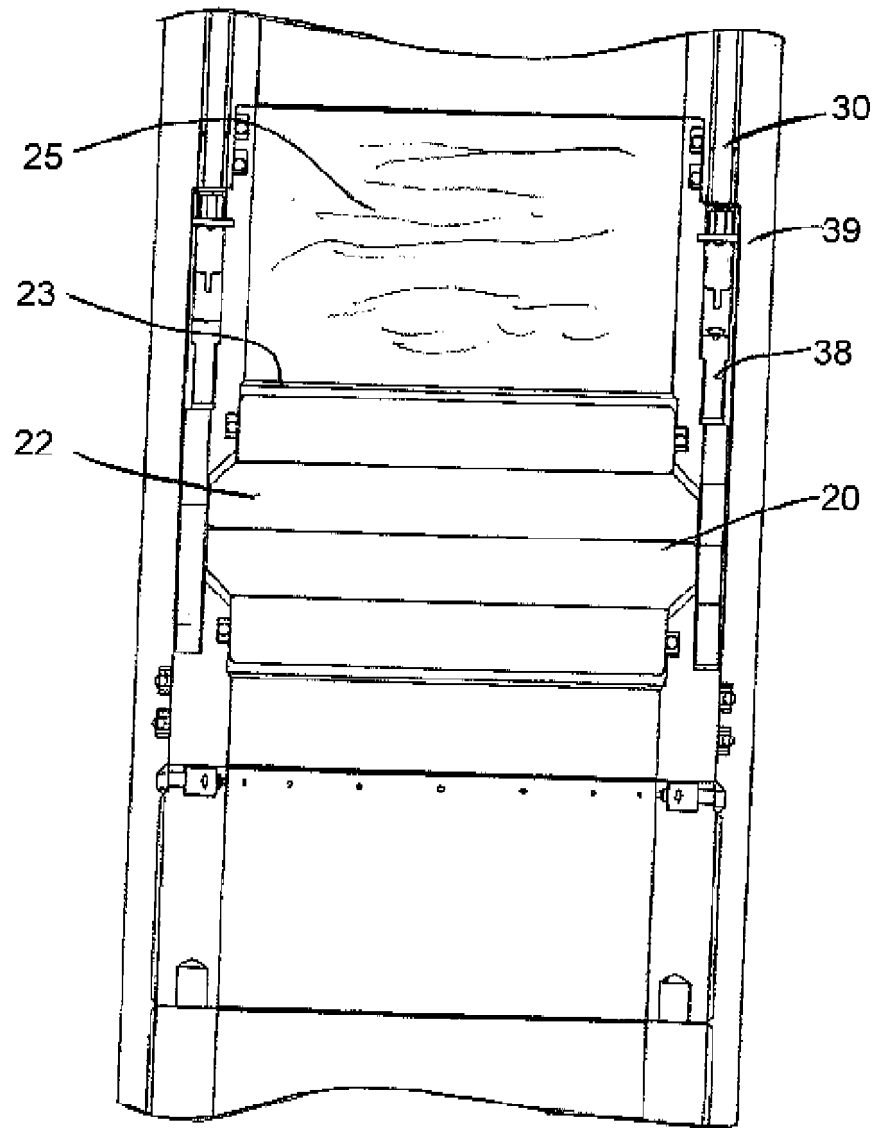


FIG. 5

REFERENCES CITED IN THE DESCRIPTION

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