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(72) Inventors:

- **Rantala, Esa**
34150 Kyrönlahti (FI)
- **Parkkinen, Tapio**
33410 Tampere (FI)
- **Keskilammi, Juha**
CH-8400 Winterthur (CH)
- **Mäki, Jorma**
34140 Mutala (FI)

(71) Applicant: **Sandvik Intellectual Property AB**
811 81 Sandviken (SE)

(54) **Damper unit and drill string system comprising such a damper unit**

(57) A damper unit (1) and a drill string system comprising a DTH hammer and a damper unit. The damper unit comprises at least one first damping element (81,82) for damping of tensional forces along an axial direction of the damper unit and at least one second damping el-

ement (11) for damping of compressive forces along the axial direction, wherein the first damping element (81,82) is separate from the second damping element (11). The stress level exerted on an individual damping element is low and the durability of the damping element is improved.

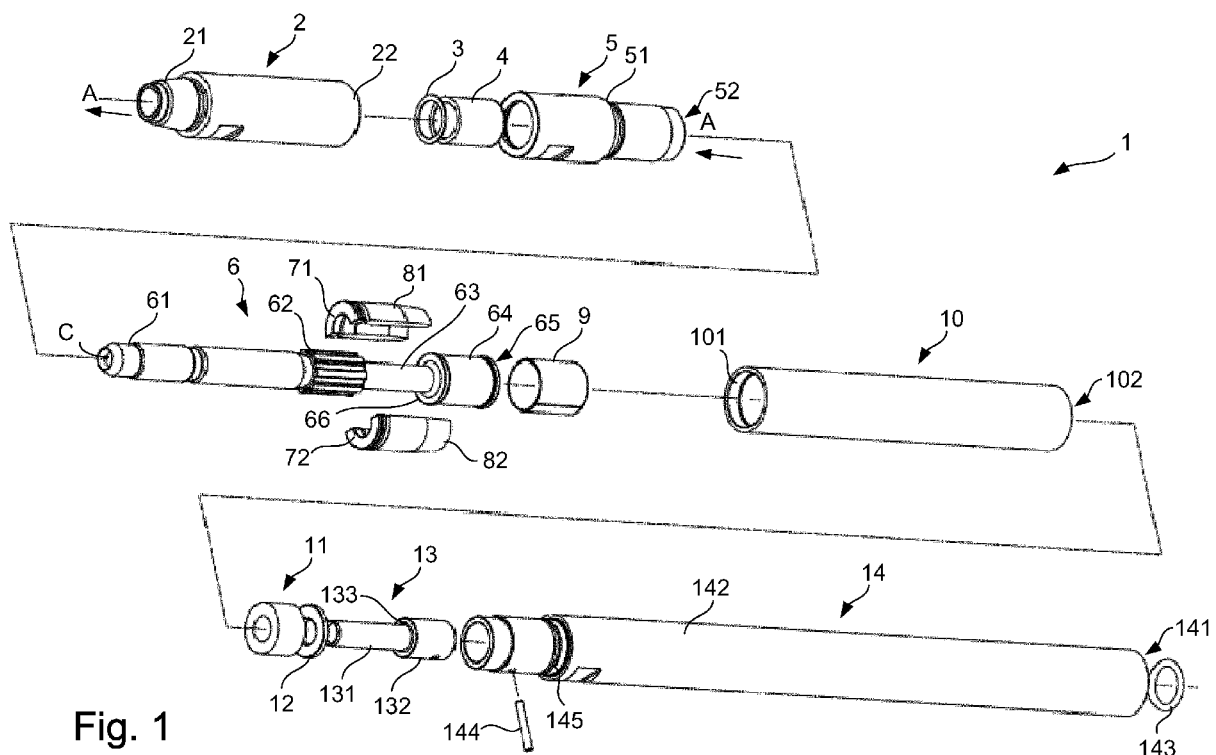


Fig. 1

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Description

Technical Field

[0001] The present disclosure relates to a damper unit and to a drill string system comprising a DTH hammer.

Background

[0002] A down-the-hole (DTH) hammer drill is a bottom-hole drill that combines a hitting action with the turning action of rotary drilling and is used for drilling of deep and narrow holes in medium to extremely hard formations. The drill string may comprise a plurality of drill string sections, formed as tubes with connectors at both ends. The percussion mechanism, the hammer, is located directly behind (normally above) the rotating percussive drill bit and is thereby located in the bore hole. An energy transfer medium, such as highly pressurized air or liquid, is transmitted through the drill string directly to the hammer for driving of the same. The drive section, which rotates and propels the drill string, may be located above ground and feeding of the drill string also takes place outside of the bore hole. Residual medium from the DTH hammer is released in the lower part of the DTH hammer and travels with high speed upwards between the drill string and the wall of the drill hole, transferring drill cuttings from the drill hole to the surface.

[0003] Vibration and shock impulses created during the drilling operation are transmitted to the drive section of the boring device, through the drill string, causing a premature deterioration of the drive section and other parts of the drilling system. This eventually results in failure of the drilling system. In order to reduce the deteriorating effects of the created vibrations and shock impulses, a shock absorbing mechanism, which may be inserted between the drill string and the DTH hammer, is commonly used. Examples of such shock absorbing mechanisms are steel springs, rubber blocks or pneumatic or hydraulic shock absorbers. Pneumatic and hydraulic shock absorbers can, however, be bulky, require additional equipment and systems to properly function and thereby be expensive.

[0004] In SU1754877, an example of a shock absorber is shown. Vertical vibrations are damped by operation of a resilient member, formed by resilient and rigid rings alternately stacked on one another, and by elastic properties of liquid present in shock absorber cavities. The shock absorber further comprises a torque transfer unit comprising grooves filled with balls accommodated in a sealed liquid chamber having an upper and a lower cavity with fittings for filling the chamber with liquid.

[0005] In JP03253689 a shock absorbing mechanism is shown that includes a displacement absorption section for transmission of rotational force to the DTH hammer and for absorbing displacement in an axial direction of the DTH hammer. The shock absorbing mechanism further includes a buffer section that buffers vibrations and

shocks from the DTH hammer. The buffer section may be made up of layers of rubber plates and metal spacers, alternately stacked on each other.

[0006] The resilient rings of the resilient member shown in SU1754877 and the rubber plates of the buffer section shown in JP03253689 appear to be highly stressed, being exerted to alternating tensile and compressive forces during the damping of vibrations and shocks created during the drilling operation. As a consequence, the durability of the shock absorbing mechanisms shown in these documents is expected to be low.

Summary

[0007] It is a general object of the present disclosure to provide an improved shock absorbing mechanism. One particular object is to provide a durable shock absorbing mechanism that is subjected to low stress levels.

[0008] The invention is defined by the appended independent claims. Embodiments are set forth in the dependent claims, in the attached drawings and in the following description.

[0009] According to a first aspect, there is provided a damper unit for a drill string, comprising at least one first damping element for damping of tensional forces along an axial direction of the damper unit, at least one second damping element for damping of compressive forces along the axial direction, wherein the first damping element is separate from the second damping element.

[0010] The term "separate" indicates that the first and second damping elements are arranged to operate independently of each other. For example, they may be formed of separate pieces of material, such that they may be positioned in a spaced apart manner.

[0011] By a damping element is here meant a component which is integrated with the damper unit and enclosed therein. Fluid, such as water or air, in one way or another communicating with fluid in the environment on the inside/outside of the damper unit does not constitute a damping element or part of a damping element.

[0012] Because the first and second damping elements are separate and used for damping of different forces, tensile and compressive forces imparted on the damper unit respectively, the damping elements are not subjected to alternating tension and compression. Thereby, the wear on an individual damping element is less than if the damping element would have been subjected to alternating compression and tension. Hence, the durability of the damping element is improved. Furthermore, the damping elements are not subjected to any shear stresses. Further, since the damping elements are separate it is also possible to individually adapt the damping elements for the relevant compressive/tensile forces exerted on the damper unit. Hence, at least one of the first and second damping elements may be arranged to operate substantially only in a compression mode.

[0013] This means that a damping element which operates in substantially a compression mode is not sub-

jected to any external tensional forces. Since compression strength often is greater than the tensile strength of a material, a damper element only being exerted to compressive forces results in less wear on the damping element than if damper elements that are exerted to tension only or to both compression and tension. Hence, the durability of the damping elements is extended.

[0014] In one embodiment, at least one of the first and second damping elements may be compressed by rigid components of the damper unit.

[0015] This means that the damping elements not are compressed by fluid (liquid or gas).

[0016] At least one of the first and second damping elements may be made of a damper material such as a rubber or rubber-like material, e.g. polyurethane.

[0017] Examples of rubber and rubber-like materials that may be used as a damper material is natural rubber, synthetic rubber, PU, TPE or foamed materials.

[0018] In an alternative embodiment at least one of the first and second damping elements may comprise a metal spring.

[0019] At least one of the first and second damping elements may be arranged in a damper space, which is defined by respective axially extreme ends of the first and second damping element, wherein the damping space is substantially free from other components.

[0020] This means that the damping space may not contain for example two damper elements with a non-damping element placed in between. Neither is there any liquid or gas within this damper space. Hence, the damper space contains only the damper element, which, in the axial direction, may be in the form of a single, one-piece damper element. Such a damper element may, as illustrated in Fig. 1, have one or more longitudinal slits, allowing for mounting of the damper element.

[0021] In one embodiment, the first and second damping elements may be made of different damper materials.

[0022] The damper material of at least one of the first and the second damping elements may in one embodiment be substantially homogenous.

[0023] The first and second damping elements may further present different lengths in an axial and/or radial direction.

[0024] The damper unit may in one embodiment comprise at least one central channel, extending axially between the axially upper end and the axially lower end, and being adapted for conducting pressurised fluid, such as gas or liquid.

[0025] The terms "upper" and "lower" indicate the positioning of the parts when drilling a vertical hole downwardly, and thus the lower end may be understood as the distal end as seen from a drive section, such as a drilling machine, and the upper end may be understood as the proximal end.

[0026] The central channel may, when the damper unit is in a maximum compressed state, have a substantially constant inner diameter along at least 75% of its axial length, at least 85% of its axial length or at least 95% of

its axial length.

[0027] When subjected to tensile or compressive forces, a closable/expandable circumferential gap in the wall of the central channel, defining a length of stroke of the damper unit, is expanded or closed in the axial direction. When in a maximum compressed state the gap may be substantially closed.

[0028] A smallest inner diameter of the central channel may be about 15 to 25 mm and a largest inner diameter of the central channel may be about 40 to 50 mm.

[0029] The damper unit may have, when the damper unit is in a maximum compressed state, a substantially constant outer diameter along at least 75% of its axial length, at least 85% of its axial length, at least 95% of its axial length or at least 99% of its axial length.

[0030] When subjected to tensile or compressive forces, a closable/expandable circumferential gap in the outer wall of the damper unit, defining a length of stroke of the damper unit, is expanded or closed in the axial direction. When in a maximum compressed state the gap may be substantially closed.

[0031] A smallest outer diameter of the damper unit may be about 70 mm to 80 mm and a largest outer diameter may be about 95 mm to 110 mm.

[0032] According to a second aspect there is provided a drill string system, comprising a DTH hammer and a damper unit arranged above the DTH hammer.

[0033] In one embodiment of the drill string system, the DTH hammer is water driven.

Brief description of the drawings

[0034]

Fig. 1 is an exploded view of a part of a drill string system being provided with an embodiment of a damper unit.

Figs 2-12 are half sectional views of different embodiments of a damper unit.

Fig. 13 is a schematic diagram of a drill string system.

Description of embodiments

[0035] Throughout the following description, structure having the same function will retain the same reference numerals.

[0036] In Fig. 1 an exploded view of a damper unit 1 for a drill string system is shown. The arrows A in the figures point in a direction from an axially upper end to an axially lower end of the damper unit. The axially lower end of the drill damper unit 1 may, when used in a DTH hammer 100 drill system, through a lower connector, be connected to the axially upper end of the percussion mechanism of the DTH hammer 100 (Fig. 13). The axially upper end of the drill damper unit 1 may be connected to a damper unit, such as drill tube 110. The lower connector may alternatively be connected to an axial upper end of another damper unit 110 or to an axially upper

end of a drill string system part. The rotating percussive drill bit (not shown) may be located directly below the hammer in the axial direction, and hence both the drill bit and the hammer are located in the bore hole during the drilling operation.

[0037] A drive section 120 of the drilling system, which rotates and propels the drill string 100, 1, 110, may be located above ground 0. Feeding of the drill string, adding more drill string system parts 110 to each other in the axial direction also takes place outside of the bore hole.

[0038] An energy transfer medium such as highly pressurized air or liquid (e.g. water) may be transmitted from a pump located above ground through a central channel C in the drill string to the hammer for driving of the same. The central channel C extends axially between the axially upper and axially lower ends of the damper unit and the drill string system parts. Residual medium from the DTH hammer is released in the lower part of the DTH hammer and travels with high speed upwards between the drill string and the wall of the drill hole, transferring drill cuttings from the drill hole to the surface.

[0039] The damper unit 1 is provided with a dampening function, which dampens vibrations and shocks created during the drilling operation. This dampening function reduces deteriorating effects on various parts of the drill string system.

[0040] The damper unit 1 comprises first and second damping elements 81, 82; 11, in Fig. 1 shown as annular shapes. The first damping element 81, 82 is arranged for damping of tensile forces exerted on the damper unit 1 and the second damping element 11 is arranged for damping of compressive forces. The pushing force from the highly pressurized medium conducted within the central channel C of the damper unit towards the DTH hammer can be higher or lower than the feed force of the drill system. This means that the total force inside the damper unit 1 may be tension or compression. Therefore damping effect in both axial directions is advantageous. The damping also works when pushing/pulling the drill string into/out of the drill hole.

[0041] Referring initially to Figs 1 and 10, there is disclosed an exploded view of a drill string damper unit 1, and a half sectional view, respectively, of the same conceptual damper design.

[0042] The arrow A points in the downward direction. The unit 1 comprises a lower connector sleeve 2 having a lower connector portion 21, which here forms a male connector and an inner thread 22 for connection to an outer threaded portion 61 of a main shaft 6. The main shaft 6 further comprises an outwardly splined portion 62 for interaction with a corresponding inwardly splined portion 52 of a guide sleeve 5, to enable axial movement between the main shaft 6 and the guide sleeve 5, while preventing rotational movement between the main shaft 6 and the guide sleeve 5.

[0043] The guide sleeve 5, is, in its turn, via an outer thread 51 connected to an inner thread 101 of an outer sleeve 10.

[0044] The main shaft 6 further provides a first damper core 63 and a first shoulder 66 for interaction with a tension damper 81, 82.

[0045] The tension damper 81, 82 may be formed of one or more pieces, and may, as illustrated in Fig. 1, be axially divided for facilitating mounting of the tension damper 81, 82. A ring 71, 72 (e.g. a metal ring) may provide a second shoulder 711 for interaction with the tension damper 81, 82. The other axial side of the ring 71, 72 may rest on a shoulder formed by the guide sleeve 5. The tension damper element does not have to be constituted by two separate parts. A one-piece tension damper element can be feasible. Such element can be made circumferentially expandable for mounting, or non-expandable for mounting in versions according to Figs. 4, 5 and 12.

[0046] The shoulder 66 may be formed by an axially extended portion 64 of the main sleeve 6, so as to also provide a third shoulder 65 for interaction with a compression damper 11. The compression damper 11 may be formed of a single piece of material. However, it is understood that the compression damper may be formed of more pieces, which may, as with the tension damper 81, 82, be axially divided for facilitating mounting of the compression damper 11.

[0047] A secondary shaft 13 may be arranged to provide a damper core 131 for the compression damper 11. The secondary shaft may have a portion 132 with larger diameter, adapted for providing a connection to an upper connector sleeve 14. The connection to the connector sleeve 14 may be achieved by a pin 144 type connection. The portion 132 having larger diameter may provide a fourth shoulder 133 for interaction with the compression damper 11. A ring 12 may be provided in order to enlarge or otherwise improve the shoulder's 133 contact surface with the compression damper 11.

[0048] The connector sleeve 14 may provide an upper connector 141, which here has the form of a female connector, where a sealing ring 143 may be provided for sealing the channel C formed inside the unit 1. The connector sleeve may further be connected to the outer sleeve 10 by a threaded connection involving outer threads 145 on the connector sleeve 14 and inner threads 102 on the outer sleeve 10.

[0049] The upper connector sleeve 14 may present an axially extended portion 142, adapted for providing the unit 1 with a length corresponding to other components of the drill string system, thus facilitating its handling.

[0050] Further components, such as circlips 3 and bearings 4, 9 may be provided, if desired.

[0051] In operation, the damper unit 1 will function as follows.

[0052] When subjected to an axial compression force, a lower fixed link will be provided by the lower connector sleeve 2, and the main shaft 6. An upper fixed link will be provided by the upper connector sleeve 14 and the secondary shaft 13. Thus, the compression damper 11 will be subjected to a compression force between the

shoulders 65 and 133, and the inner gap G_i and the outer gap G_o will close.

[0053] When subjected to an axial tension force, a lower fixed link will be provided by the lower connector sleeve 2 and the main shaft 6. An upper fixed link will be provided by the upper connector sleeve 14 and the guide sleeve 5. Thus, the tension damper 81, 82 will be subjected to a compression force between the shoulders 66 and 711, and the inner gap G_i and the outer gap G_o will open.

[0054] The splined portions 52, 62 will allow axial movement between the lower link and the upper link, while preventing relative rotational movement, thus allowing the drill torque to be properly transferred.

[0055] Fig. 2 illustrates an alternative embodiment of the damper unit 1. Here, the lower connector sleeve 2 is formed in one piece with the main shaft. Moreover, the lower connector portion 21 is a female connector and the upper connector portion 141 is a male connector.

[0056] An intermediate sleeve 15 may be provided radially between the tension damper 81, 82 and the outer sleeve 10. An axial extension sleeve 16 may be provided between the shoulder forming portion 64 and the compression damper 11. The intermediate sleeve 15 and the axial extension sleeve 16 may be slidable relative to all of their radially juxtaposed components.

[0057] When subjecting the unit 1 of Fig. 2 to a compressive force, a lower fixed link will be formed by the lower connector sleeve 2, and the axial extension sleeve 16, which provides a surface 65 contacting the compression damper 11. An upper fixed link will be provided by the upper connector sleeve 14, which provides the other surface 133. The smaller one of the inner gap G_i and the outer gap G_o will define a maximum length of stroke.

[0058] When subjecting the unit of Fig. 2 to a tensile force, a lower fixed link will be provided solely by the connector sleeve 2 (which is integrated with the main shaft). An upper fixed link will be provided by the upper connector sleeve 14, the outer sleeve 10, the guide sleeve 5 and the steel ring 71.

[0059] As shown in Fig. 1, the upper connector sleeve 14 may be extended in the axial direction, so that the damper unit is given the same length as other components of the drill string. This may facilitate its handling in the drilling equipment.

[0060] Fig. 3 illustrates another alternative embodiment of a damper unit 1. The embodiment of Fig. 3 differs from that of Fig. 2 in that the intermediate sleeve 15 has a greater axial extension and in that the extension sleeve 16 has a smaller radial extension, such that it extends between, and contacts, the ring 71 and the upper connector sleeve 14. The intermediate sleeve 15 may be slidable relative to all of its radially juxtaposed components. Hence, in this embodiment, the intermediate sleeve 15 will enclose both dampers 81, 82; 11.

[0061] When subjecting the unit of Fig. 3 to a compressive force, a lower fixed link will be provided by the connector sleeve 2 and the extension sleeve 16. The upper fixed link will be provided by the upper connector sleeve

14. When the compression takes place, the intermediate sleeve 15 will contact the steel ring 71, 72 and thus the tension damper 81, 82 will be entirely relieved of load.

[0062] When subjecting the unit of Fig. 3 to a tensile force, the lower fixed link will be provided by the connector sleeve 2. The upper fixed link will be provided by the upper connector sleeve 14, the outer sleeve 10, the guide sleeve 5 and the steel ring 71, 72.

[0063] The radially outer surface of the extension sleeve 16 may be in sliding contact with the radially inner surface of the intermediate sleeve 15.

[0064] Fig. 4 illustrates yet another alternative embodiment, wherein the connector sleeve 2 and the main shaft 6 are formed as two separate parts, which are joined together as described with respect to Figs 1 and 10. Hence, an external thread 61 of the main shaft is connected to an internal thread 22 of the lower connector sleeve 2. Moreover, the outwardly facing splines 62 are formed in the connector sleeve 2, and not in the main shaft 6. Moreover, the intermediate sleeve 15 has been abolished and the extension sleeve 16 is designed as described with respect to Fig. 2.

[0065] When subjecting the unit of Fig. 4 to a compressive force, a lower fixed link will be provided by the connector sleeve 2, the main shaft 6 and the extension sleeve 16. The upper fixed link will be provided by the upper connector sleeve 14.

[0066] When subjecting the unit of Fig. 4 to a tensile force, the lower fixed link will be provided by the connector sleeve 2 and the main shaft 6. The upper fixed link will be provided by the upper connector sleeve 14, the outer sleeve 10, the guide sleeve 5 and the steel ring 71, 72.

[0067] Fig. 5 illustrates yet another alternative embodiment, which is very similar to that of Fig. 4. However, in the embodiment of Fig. 5, the main shaft, including the damper core 63 is formed in one piece with the lower connector sleeve 2. The axially extended portion forming the compression shoulder 65 is formed as a separate piece, which is connected to the damper core 63 by a threaded connection.

[0068] Under compression and tension, the embodiment of Fig. 5 operates in the same manner as that of Fig. 4.

[0069] Fig. 6 illustrates another alternative embodiment, which is very similar to that of Fig. 10, but where the connection between the lower connector sleeve 2 and the main shaft 6 is provided by an external thread 22 of the connector sleeve 2 and an internal thread 61 of the main shaft 6. The splines 62 are formed in one piece with the main shaft 6.

[0070] Under compression and tension, the embodiment of Fig. 6 operates in the same manner as that of Figs 4 and 5.

[0071] Fig. 7 illustrates yet another alternative embodiment, which is identical to that of Fig. 6, only the "polarity" of the connector elements 21, 141 has been reversed. Thus, in Fig. 7, the lower connector element 21 is a male

connector and the upper connector element 141 is a female connector.

[0072] Fig. 8 illustrates yet another alternative embodiment. This embodiment resembles the one in Fig. 7, however the lower connector sleeve 2, and the main shaft are formed in one piece. Moreover, the outer gap Go is situated at the connector 21 and in practice, the gap Go will occur between the damper unit 1 and the component (not shown) to which it is connected via the lower connector sleeve 2.

[0073] When subjecting the unit 1 of Fig. 8 to a compressive force, a lower fixed link will be formed by the lower connector sleeve 2 and the axial extension sleeve 16, which provides a surface 65 contacting the compression damper 11. An upper fixed link will be provided by the upper connector sleeve 14, which provides the other surface 133. The smaller one of the inner gap Gi and the outer gap Go will define a maximum length of stroke.

[0074] When subjecting the unit of Fig. 8 to a tensile force, a lower fixed link will be provided solely by the connector sleeve 2. An upper fixed link will be provided by the upper connector sleeve 14, the outer sleeve 10, the guide sleeve 5 and the steel ring 71.

[0075] Fig. 9 illustrates yet another alternative embodiment. Here, the lower connector sleeve 2 and the main shaft 6 are separate components, which are interconnected by a threaded connection between outer threads 61 of the main shaft 6 and inner threads 22 of the lower connector sleeve 2. This part of the main shaft 6 is designed very similar to that of Figs 1 and 10.

[0076] Fig. 10 has been extensively discussed above.

[0077] Fig. 11 illustrates yet another embodiment of a unit 1, which basically corresponds to the one illustrated in Fig. 10, but which differs in that the main shaft 6 comprises a further axial extension 67 providing the damper core for the compression damper 11. The extension 67 may extend so far as to provide a sliding contact with the upper connector sleeve 14, such that the inner gap Gi will be provided at the upper connector sleeve 14.

[0078] In this embodiment only the lower connector sleeve 2, the main shaft 6 and the upper connector sleeve 14 define the wall of the central channel C.

[0079] Fig. 12 illustrates yet another alternative embodiment. Here, the main shaft 6 forms a damper core (at 63 and 131, respectively) for both dampers 81, 82; 11. The main shaft is connected to the lower connector sleeve 2 via a threaded connection at 22, 61.

[0080] The upper connector sleeve 14 is connected to the outer sleeve 10 via a threaded connection at 102, 145. There is slidable contact between the main shaft 6 and the upper connector sleeve 14.

[0081] The outer sleeve 10 is connected to the guide sleeve 5 at 51, 101. There is also sliding contact between the guide sleeve 5 and the main shaft 6.

[0082] A tension damper 81 is provided for being compressed between a surface 53 of the guide sleeve 5 and a surface 751 of a ring 75.

[0083] A compression damper 11 is provided to be

compressed between a surface 761 of a second ring 76 and a surface 146 of the connector sleeve 14.

[0084] The rings 75, 76 may be slidable both relative the main shaft 6 and relative the outer sleeve 10.

[0085] Splines 62, 103 formed in the main shaft 6 and the outer sleeve 10, respectively are arranged to interact to prevent relative rotating motion between the main shaft 6 and the outer sleeve 10.

[0086] When subjecting the unit 1 of Fig. 12 to a compressive force, a lower fixed link will be formed by the lower connector sleeve 2, the main shaft 6 (via its shoulder that engages the second ring 76) and the second ring 76. An upper fixed link will be provided by the upper connector sleeve 14, which provides the other surface 146.

[0087] When subjecting the unit 1 of Fig. 12 to a tensile force, a lower fixed link will be provided by the lower connector sleeve 2, the main shaft 6 (via its shoulder which engages the first ring 75) and the first ring 75. An upper fixed link will be provided by the upper connector sleeve 14, the outer sleeve 10 and the guide sleeve 5.

[0088] By individually varying the characteristics of the first and second damping elements 81, 82; 11 it is possible to adapt the damping for the relevant compressive/tensile forces exerted on the damper unit 1. This can for example be done by varying the axial/radial thickness of a damping element 81, 82; 11. A radially thinner damping element 81, 82; 11 may result in a stiffer damping and a thicker damping element in a softer damping. In addition, by varying the damper material of the damping elements 81, 82; 11 it is also possible to adapt the damping characteristics of the damping elements 81, 82; 11 to the relevant forces.

[0089] Further, the length of the stroke is easily adaptable for the relevant forces exerted on the damper unit 1. For example in the embodiment of the damper unit 1 shown in Fig. 10, by providing a longer axially extended portion 64, the closable/expandable axial gap Go formed in the radially outer wall of the damper unit 1 between the radially outer surface of the lower connector sleeve 2 and the radially outer surface of guide sleeve 5 will be wider, and hence the stroke longer.

[0090] The threaded connections used to interconnect some of the parts of the damper unit 1 may be replaced with other types of detachable connections, such as snap connections, pin connections or bayonet-type connections.

[0091] The upper and lower connectors of the damper unit 1 may be adapted for any drill string connector system. Hence, they may include conical threads, straight threads, bayonet-type connections, snap connections or pin connections.

[0092] As shown in the different embodiments, a damper unit 1 may include several parts that are interconnected mechanically or include more or less one-piece parts. Depending on the manufacturing process, cost of material, assembly considerations, ease of replacement in the damper unit etc. there are different advantages associated with having many different parts

on one hand and one-piece parts on the other.

Claims

1. A damper unit (1) for a drill string, comprising:

at least one first damping element (81, 82) for damping of tensional forces along an axial direction of said damper unit,
at least one second damping element (11) for damping of compressive forces along said axial direction,

characterized in that

said first damping element (81, 82) is separate from said second damping element (11).

2. The damper unit (1) according to claim 1, wherein at least one of said first and second damping elements (81, 82; 11) is arranged to operate substantially in a compression mode.

3. The damper unit (1) according to any one of the preceding claims, wherein at least one of said first and second damping elements (81, 82; 11) is compressed by rigid components (2, 6, 14, 16, 71) of said damper unit (1).

4. The damper unit (1) according to any one of the preceding claims, wherein at least one of the first and second damping elements (81, 82; 11) is made of a damper material, such as a rubber or rubber-like material, e.g. polyurethane.

5. The damper unit (1) according to any one of the preceding claims, at least one of the first and second damping elements (81, 82; 11) comprises a metal spring.

6. The damper unit (1) according to any one of the preceding claims, wherein at least one of said first and said second damping elements (81, 82; 11) is arranged in a damper space, which is defined by respective axially extreme ends of said damping element (81, 82; 11), wherein said damping space is substantially free from other components.

7. The damper unit (1) according to any one of the preceding claims, wherein said first and second damping elements (81, 82; 11) are made of different damper materials.

8. The damper unit (1) according to any one of the preceding claims, wherein the damper material of at least one of said first and said second damping elements (81, 82; 11) is substantially homogenous.

9. The damper unit (1) according to any one of the pre-

ceding claims, wherein said first and second damping elements (81, 82; 11) present different lengths in an axial and/or radial direction.

10. The damper unit (1) according to any one of the preceding claims, further comprising at least one central channel (C), extending axially between an axially upper end and an axially lower end of the component, and being adapted for conducting pressurised fluid, such as gas or liquid.

11. The damper unit (1) according to claim 10, wherein said central channel (C), when said damper unit (1) is in a maximum compressed state, has a substantially constant inner diameter along at least 75% of its axial length, at least 85% of its axial length or at least 95% of its axial length.

12. The damper unit (1) according to claim 12, wherein a smallest inner diameter of said central channel (C) is about 15 to 25 mm and a largest inner diameter of said central channel is about 40 to 50 mm.

13. The damper unit (1) according to any one of the preceding claims, wherein the damper unit (1), when said damper unit (1) is in a maximum compressed state, has a substantially constant outer diameter along at least 75% of its axial length, at least 85% of its axial length, at least 95% of its axial length or at least 99% of its axial length.

14. The damper unit (1) according to claim 13, wherein a smallest outer diameter of said damper unit (1) is about 70 mm to 80 mm and a largest outer diameter is about 95 mm to 110 mm.

15. A drill string system, comprising:

a DTH hammer

a damper unit (1) according to any one of the preceding claims, arranged above said DTH hammer.

16. A drill string system according to claim 15, wherein said DTH hammer is water driven.

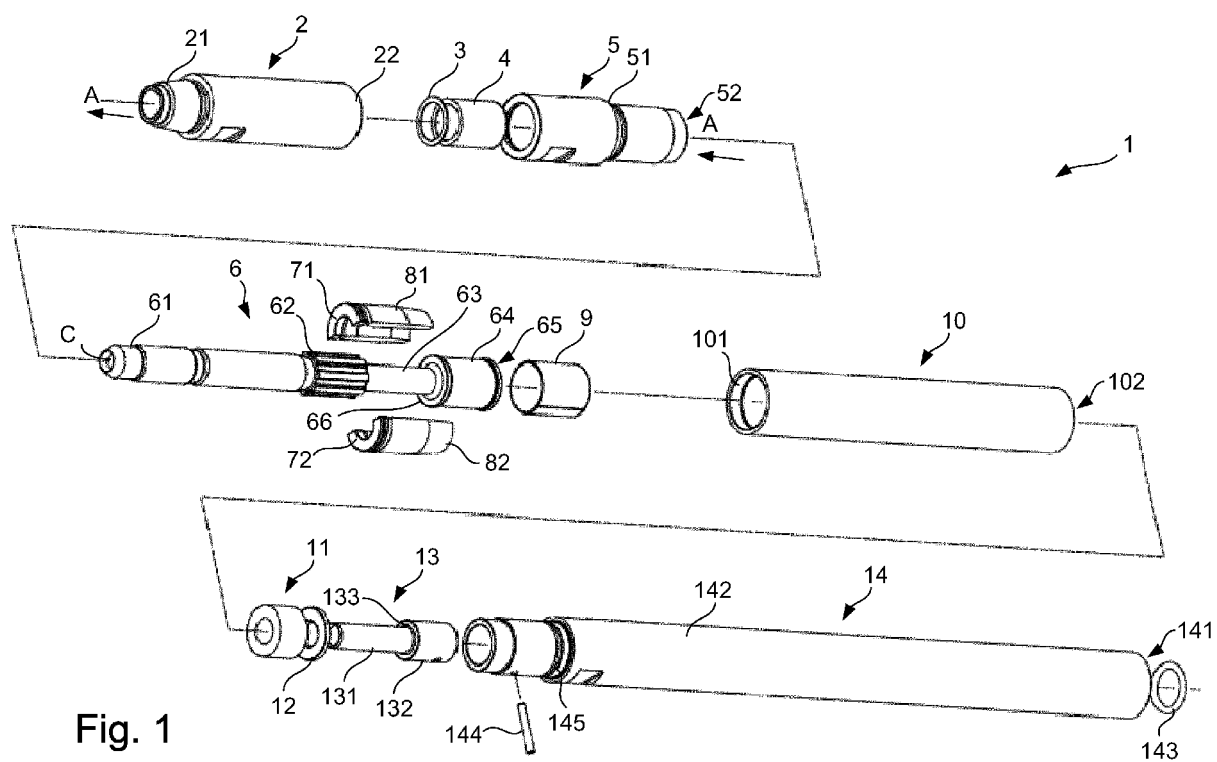


Fig. 1

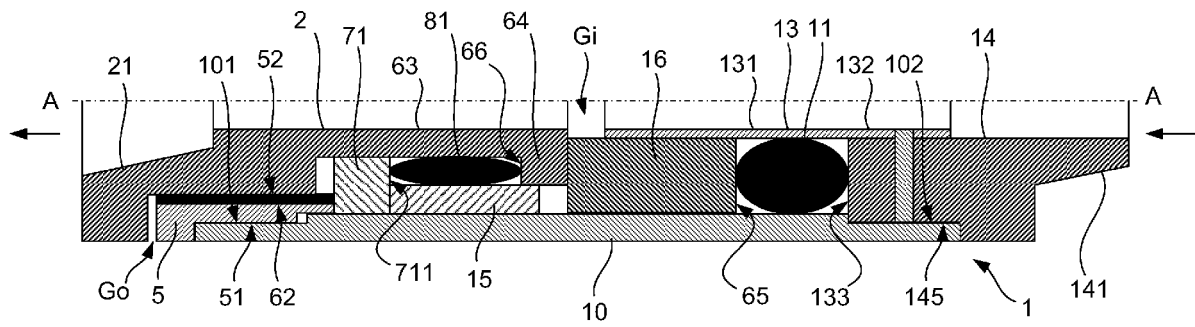


Fig. 2

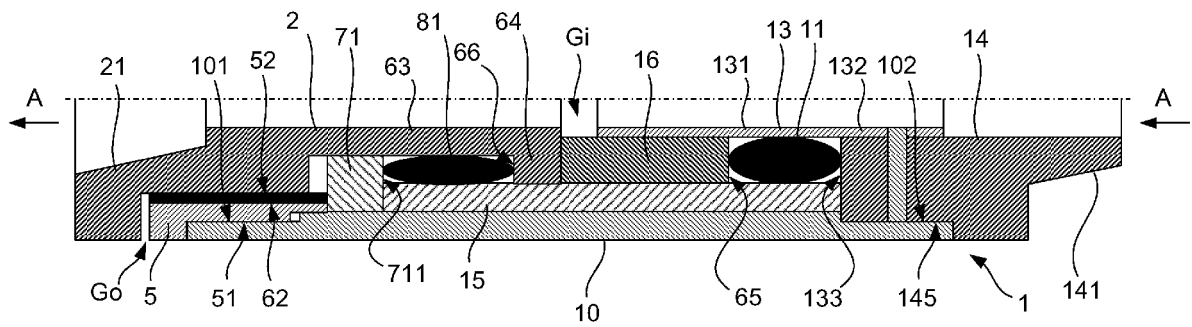


Fig. 3

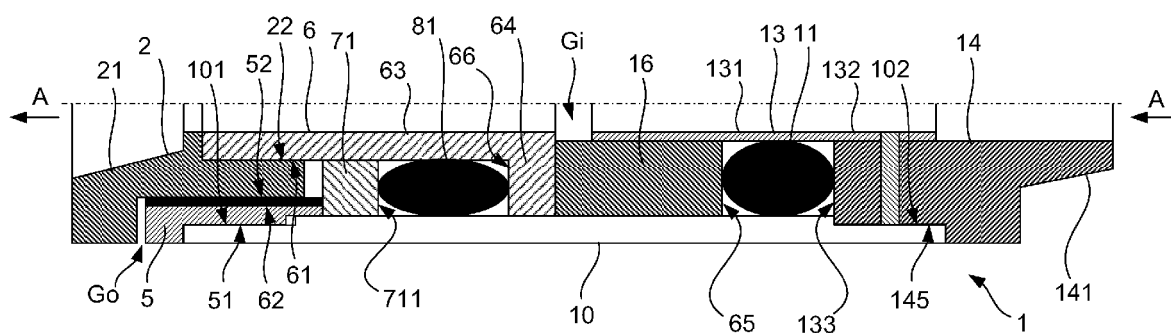


Fig. 4

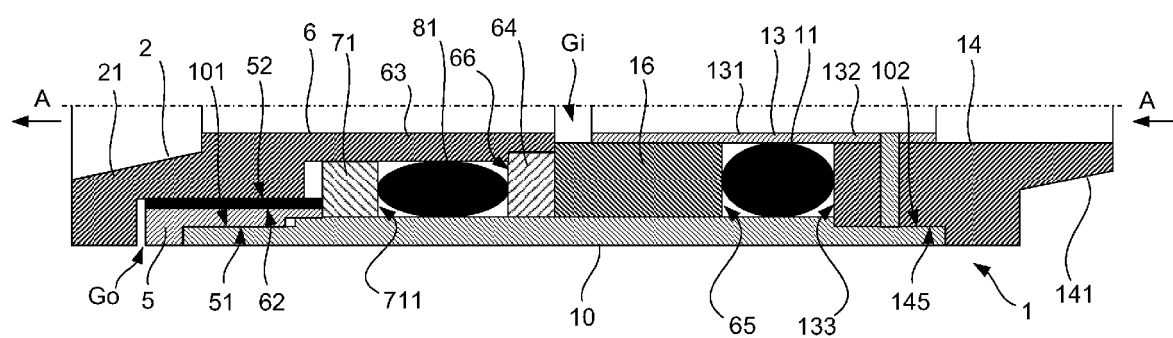


Fig. 5

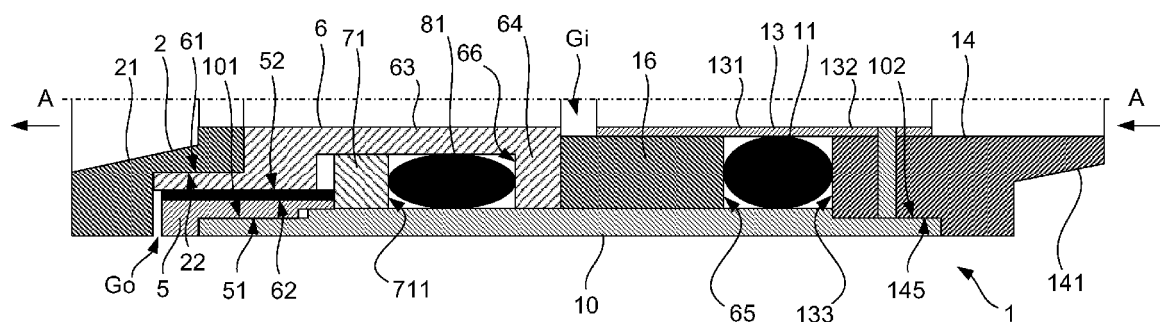


Fig. 6

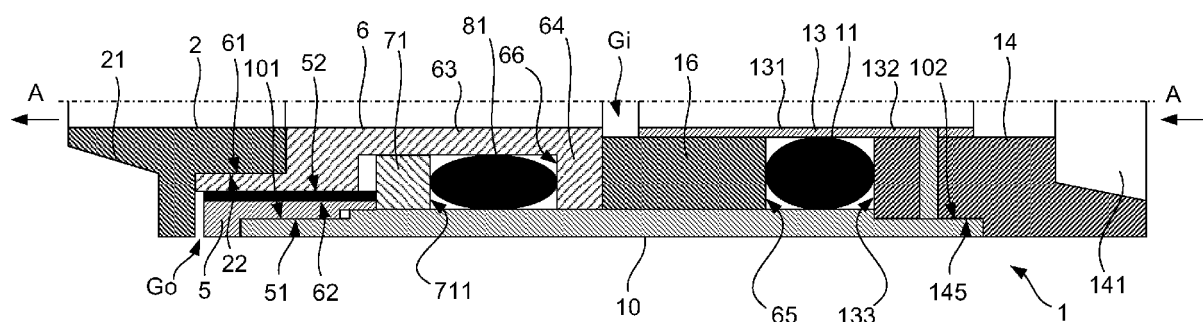


Fig. 7

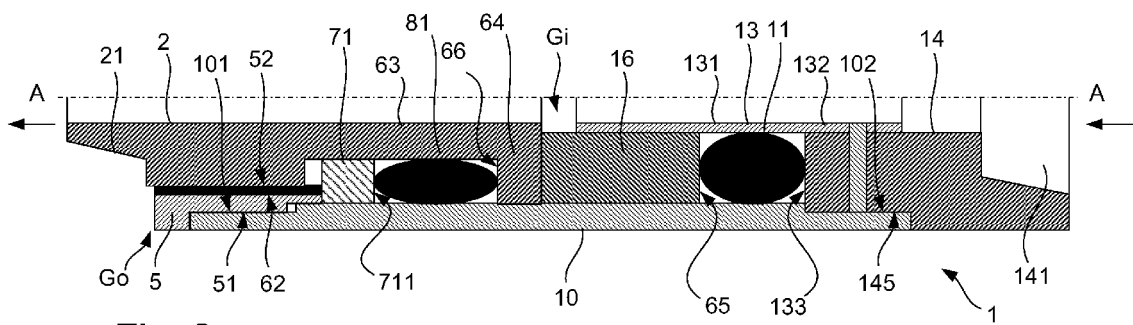


Fig. 8

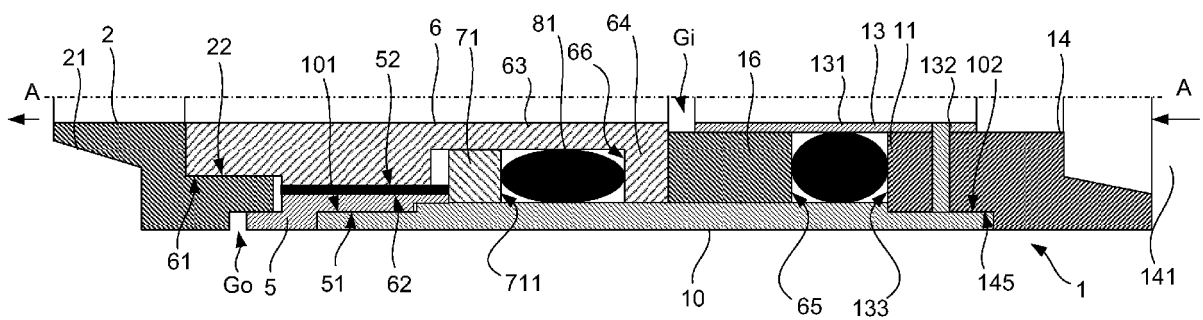


Fig. 9

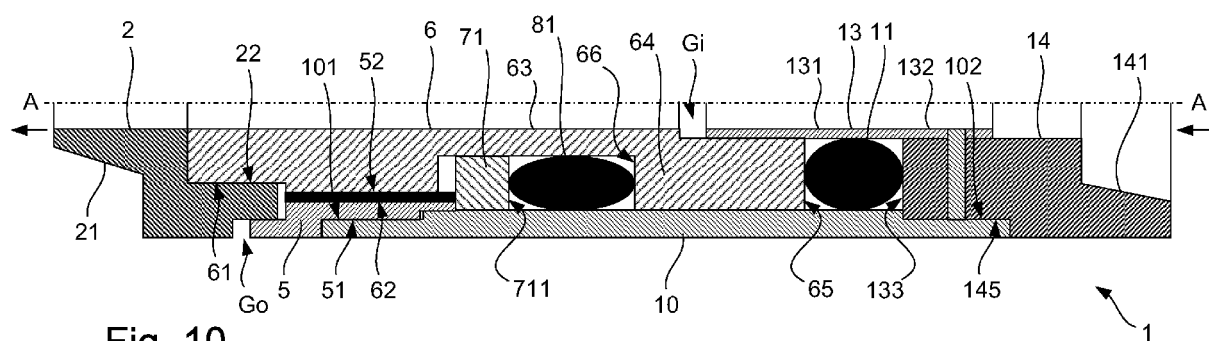


Fig. 10

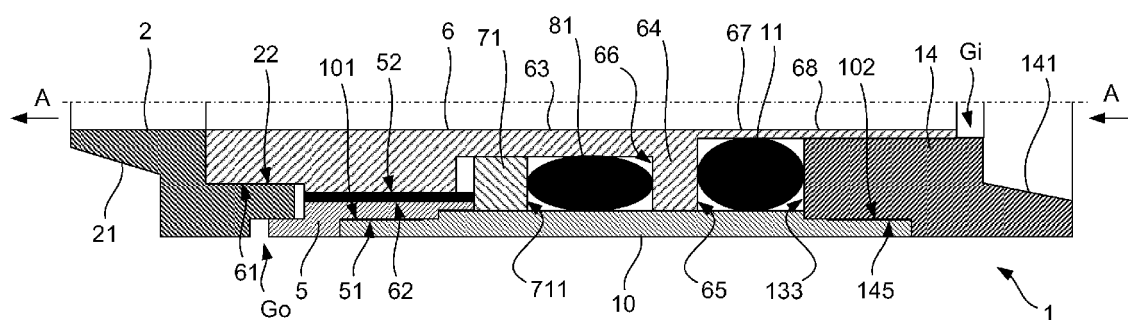


Fig. 11

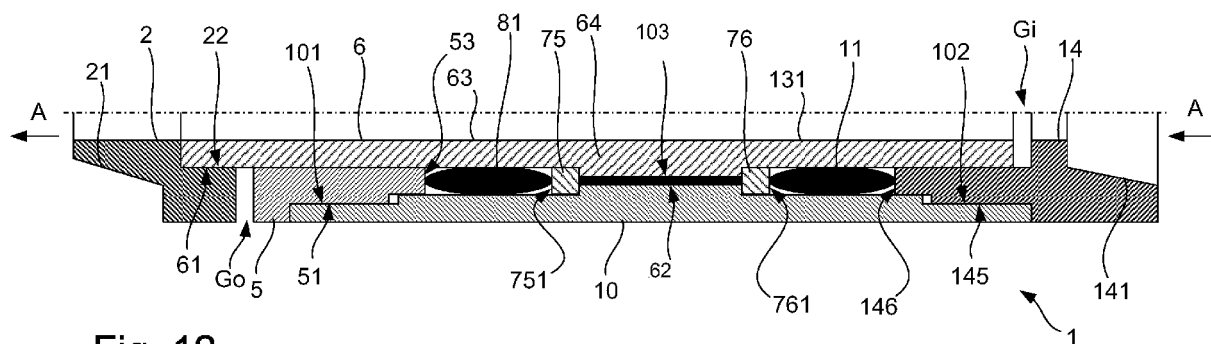


Fig. 12

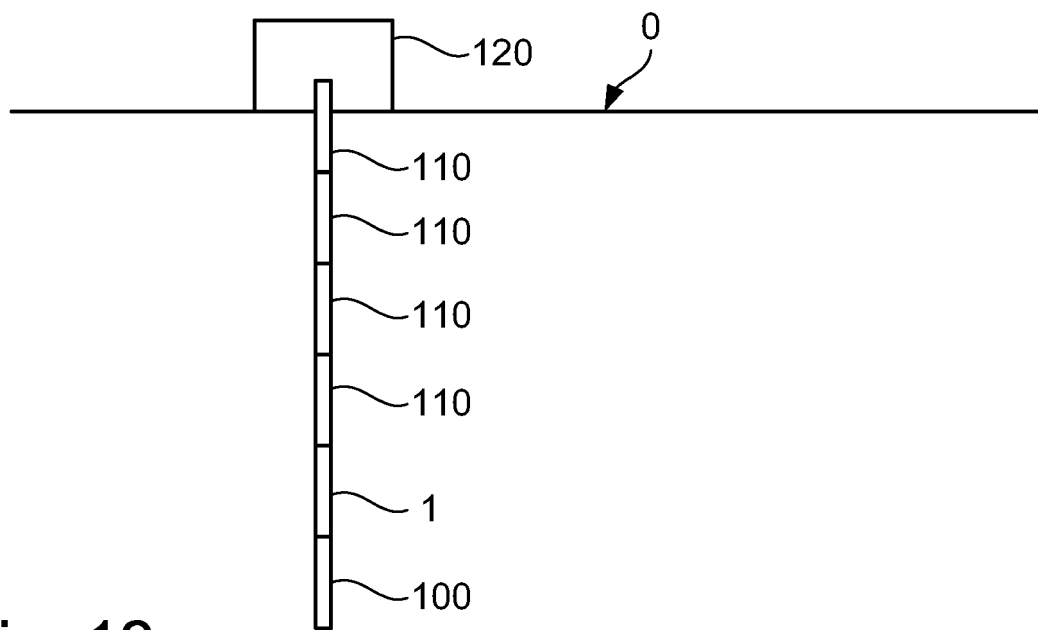


Fig. 13



EUROPEAN SEARCH REPORT

Application Number
EP 11 18 3892

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Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
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Place of search The Hague		Date of completion of the search 9 March 2012	Examiner Dantinne, Patrick
CATEGORY OF CITED DOCUMENTS X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons & : member of the same patent family, corresponding document			

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