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(54) **DRILL STRING ROD**

(57) The present invention relates to a drill string rod (10) for percussion drilling. The drill string rod comprises: **an elongated intermediate section** (11) extending along an axis A; a **first coupling** (12) intended to be connected to a corresponding coupling element on an adjacent drill string, drill bit or percussion tool, said first coupling is arranged at a first end of the intermediated section; and a **second coupling** (13) arranged at a second end of the intermediate section (11), intended to be connected to an corresponding coupling element on an adjacent drill string, drill bit or percussion tool, said second coupling is arranged at a second end of the intermediated section, wherein the drill string rod (10) is made of a metal material and at least an area of the first outer peripheral surface (18) of the first load bearing structure and / or the second outer peripheral surface (23) of the second load bearing structure is covered by a hard layer (30). The invention furthermore relates to a drill string formed by two or more of the drill string rods according to the invention.

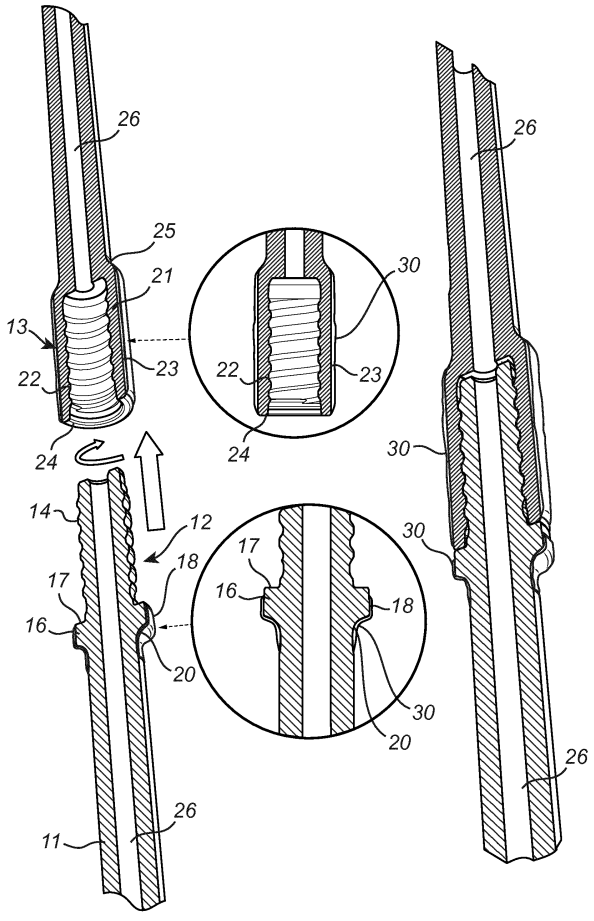

Fig. 3A Fig. 3B

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Description

Field of the invention

[0001] The present invention generally relates to a drill string rod for percussion drilling.

Technical background

[0002] Within the constructional work sector and the mining industry percussion drilling is an established method for drilling long bore holes with an elongated drill string formed by a number of drill string rods. During drilling, a hammering impact from a hydraulically driven piston is acting on the drill string to exert the required force to break the rock and generate the bore hole.

[0003] The length of the drill string is during the drilling increased by adding further drill string rods as the depth of the bore hole increases. In order to provide a flexible system that is convenient for the operator to use, the drill string rods are substantially identical and in one end of the rod provided with a male coupling and in the opposite end a female coupling such that the drill string rods could be connected by fitting the male coupling to the female coupling of the adjacent drill string rod. EP 2 845 992 discloses one embodiment of the described drill string system.

[0004] During percussion drilling, the drill string and the drill string rods are exposed to considerable loads due to the hammering impact from the hydraulically driven piston and the harsh environment in the drilled bore hole. To ensure the desired performance of the drill string it is essential that the drill string rods maintain their ability to withstand the loads generated during drilling and there is a constant need for improved technical solutions that aim to improve the performance of the drill string and extend the life time of the drill string rods.

Summary

[0005] It would be advantageous to achieve a drill string rod that at least is alleviating some of the drawbacks mentioned above. To better address one or more of these concerns a drill string rod as defined in the independent claims is provided. Preferable embodiments are defined in the dependent claims.

[0006] The drill string rod for percussion drilling according to the invention comprises:

an elongated intermediate section extending along an axis A,

a first coupling intended to be connected to a corresponding coupling element on an adjacent drill string, drill bit or percussion tool, said first coupling is arranged at a first end of the intermediated section and comprises a first load bearing structure having an extension in radial direction exceeding the extension of the intermediate section such that a first support surface intended to bear against a corresponding support surface on the adjacent drill string, drill bit or percussion tool is formed on the side of the first load bearing structure facing away from the intermediate section, said first load bearing structure has a first outer peripheral surface and a first tapered transition section extending between the first outer peripheral surface of the first load bearing structure and the intermediate section; and

a second coupling arranged at a second end of the intermediate section, intended to be connected to a corresponding coupling element on an adjacent drill string, drill bit or percussion tool, said second coupling is arranged at a second end of the intermediated section and comprises a second load bearing structure having an extension in radial direction substantially the same as the extension in radial direction of the first load bearing structure, said second load bearing structure has a second outer peripheral surface and a second support surface intended to bear against a corresponding support surface on the adjacent drill string, drill bit or percussion tool, said second coupling furthermore comprising a second tapered transition section extending between the second outer peripheral surface of the load bearing structure and the intermediate section,

wherein the drill string rod is made of a metal material and at least an area of the first outer peripheral surface of the first load bearing structure and / or the second outer peripheral surface of the second load bearing structure is covered by a hard layer.

[0007] The drill string rod according to the invention ensures that the drill string rod will work as intended for an increased period of time than known drill strings. The hard layer, i.e. a layer of material that is harder and more resistant to wear than the material of the drill string rod, could be applied on surface areas of the drill string rod where the loads during drilling are high to prevent that the strength of the load bearing structures is affected by wear which eventually will affect the load bearing capacity of the drill string rod. The possibility to apply the hard layer on selected areas makes it possible to optimize the design of the drill string rod for maximum performance. By applying the hard layer, the original and desired outer diameter is not worn down as is the case with known drill string rods. A specifically defined diameter is important in order to achieve drilling efficiency by appropriate stress wave transition throughout the drill string. Furthermore, the overall life time of the drill string rod is increased in comparison to drill strings used today.

[0008] In one embodiment of the drill string rod, the hard layer is a layer of material that is harder and more resistant to wear than the material of the drill string rod. The layer has a thickness in a direction perpendicular to the first outer peripheral surface and / or the second outer peripheral surface within the range of 0.1 - 5 mm. The defined layer thickness range provide an effective pro-

tection to surface areas of the drill string rod where the loads during drilling are high and there is risk of wear.

[0009] In one embodiment of the drill string rod, the first and second outer peripheral surfaces are substantially parallel to axis A. This configuration provides a smooth peripheral shape that is substantially parallel to the wide walls of the bore hole.

[0010] In one embodiment of the drill string rod, the first and / or the second tapered transition section are covered by the hard layer. This embodiment is favorable since it has turned out that these parts of the drill string rod are exposed to considerable wear during use.

[0011] In one embodiment of the drill string rod, the area covered by the hard layer extend around the entire periphery of the drill string rod around axis A. It is favorable to extend the layer of material that is harder and more resistant to wear around the entire periphery of the drill string rod to protect the entire circumference of the drill bit rod.

[0012] In one embodiment of the drill string rod, a part of the first and / or second outer peripheral surface along axis A is covered by the hard layer and said part of the first and or second outer periphery is arranged adjacent to the respective first or second tapered transition section and the remaining part of the first or second outer peripheral surface is uncovered such that it has a smaller radius than the covered part of the first and or second outer periphery. This embodiment is favorable since the applied layer, extending further from the longitudinal axis A than the first and second outer periphery of the load bearing structures, will protect the first and second support surfaces on the respective load bearing structure from damage during drilling, handling and transportation of the drill string rods since the first and second outer periphery and the first and second support surface are at least partly protected from contact with the ground, surrounding structures and the inside of the bore hole.

[0013] In one embodiment of the drill string rod, the hard layer is a layer of material including an iron-based alloy, a cobalt-based alloy, a nickel-based alloy, a refractory metal, a cemented carbide, a metal matrix composite and/or a chromium carbide alloy. These different alternative materials provide a protective layer that is able to withstand wear and increase the intervals between replacement of the drill string rod.

[0014] In one embodiment of the drill string rod, a passage for a flushing media extend coaxially to axis A within the drill string rod. This configuration makes it possible to lead a stream of flushing media through the drill string rod to a flushing media outlet in the drill bit to remove residue material from the bore hole and improve the drilling performance.

[0015] In one embodiment of the drill string rod, the intermediate section has a circular or hexagonal cross-sectional shape transverse to axis A. The circular or hexagonal cross-sectional shape ensures a drill string rod with the desired characteristics.

[0016] In one embodiment of the drill string rod, the first and second tapered transition sections have a circular cross-sectional shape transverse to axis A, and a curved, straight or stepwise reduced radius along axis A. These different configurations provide a drill string rod that is able to withstand the loads during use since the axial loads exerting during use are transferred via the load bearing structures to the intermediate section.

[0017] In one embodiment of the drill string rod, the first and second support surface are arranged in a plane substantially transverse to axis A. This embodiment of the drill string rod can withstand high axial loads during drilling.

[0018] In one embodiment of the drill string rod, the first coupling is a male coupling comprising a spigot portion extending substantially coaxial to axis A from the first contact surface of the first load bearing structure, and the second coupling is a female coupling comprising a sleeve shaped element extending coaxially to axis A and said sleeve shaped element is ended by said second contact surface. This embodiment of the drill string rod is favourable since two or more drill string rods could easily be connected to form an extended drill string without the need for additional coupling elements or connectors.

[0019] The invention furthermore relates to a drill string comprising two, or more, of the drill string rods according to the definitions above fitted together by the first and second couplings such that the first and second contact surface on adjacent drill string rods are in contact with each other.

Brief description of the drawings

[0020] The invention will be better understood through the following illustrative and non-limiting detailed description of preferred embodiments, with reference to the appended drawings, on which:

Figure 1 is a perspective view of a drill string rod and enlarged male and female couplings.

Figure 2 illustrates a perspective view of two drill string rods connected to form a drill string.

Figure 3A and 3B illustrates cross-sectional views along axis A of the male and female coupling of the drill string rod before and after fitting to an adjacent drill string rod.

[0021] All figures are schematic, not necessarily to scale, and generally only illustrating parts which are necessary to elucidate the invention, wherein other parts may be omitted or merely suggested.

Detailed description of embodiments

[0022] In figure 1 a perspective view of a drill string rod 10 according to the invention is illustrated.

[0023] The drill string rod 10 comprises an elongated intermediate section 11 extending along an axis A and a

first coupling 12 arranged at one end of the intermediate section and a second coupling 13 arranged at the opposite end of the intermediate section. The first and second coupling make it possible to connect the drill string rod to a not illustrated drill bit, a not illustrated percussion drilling tool, i.e. percussion drilling machinery, arranged to provide the required power during drilling or further drill string rods to extend the drill string as the depth of the bore hole increases. The drill bit is configured to act on the rock and form the bore hole and could be adapted to the specific type of rock.

[0024] The first coupling 12 comprises a first load bearing structure and the second coupling 13 comprises a second load bearing structure, which both are designed to withstand the loads exerted during drilling and transfer the loads between the drill bit, drill string rod or rods and the percussion drilling machinery. The first and second coupling could be embodied in different ways as long as load bearing capacities are ensured.

[0025] The first load bearing structure has an extension in radial direction exceeding the extension of the intermediate section 11 such that a first support surface 17 intended to bear against a corresponding support surface on the adjacent drill string rod, drill bit or percussion tool is formed on the side of the first load bearing structure facing away from the intermediate section. The first load bearing structure furthermore has a first outer peripheral surface 18 substantially parallel to axis A and a first tapered transition section 20 extending between the first outer peripheral surface 18 of the first load bearing structure and the intermediate section 11 to form a smooth transition between the load bearing structure and the intermediate section. The second load bearing structure has the same essential parts as the first load bearing structure and has an extension in radial direction substantially the same as the extension in radial direction of the first load bearing structure. The second load bearing structure has a second outer peripheral surface 23 substantially parallel to axis A and a second support surface 24 intended to bear against a corresponding support surface on the adjacent drill string rod, drill bit or percussion tool. The second coupling 13 furthermore comprising a second tapered transition section 25 extending between the second outer peripheral surface 23 of the second load bearing structure 21 and the intermediate section 11. The first and second support surfaces are arranged in a plane transverse to axis A.

[0026] In the embodiment of the drill string rod 10 illustrated in figures 1 to 3 the first coupling 12 is embodied as a male coupling and the second coupling 13 as a female coupling.

[0027] The male and female configuration of the first and second coupling make it possible to connect two or more substantially identical drill string rods to a drill string 100 with the desired length by connecting the male coupling of one drill string to the female coupling of the adjacent drill string rod. During drilling, further drill string rods 10 are connected to extend the length of the drill string 100 as the depth of the bore hole increases.

[0028] The intermediate section 10 could be embodied in different ways with for example a circular, rectangular, pentagonal or hexagonal cross-sectional shape as long as the required strength is ensured. The intermediate section is either solid or comprising a passage 26 extending in the center of the intermediate section through the drill string rod to allow a flow of flushing media through the drill string to the drill bit arranged at the forward end of the drill string to remove particles and gravel cut off from the rock during drilling. The flushing media is for example air, water or a mixture of air and water.

[0029] The illustrated male coupling 12 comprises a male spigot portion 14 extending co-axially to the intermediate section along axis A from the first support surface 17. In the illustrated embodiment, the male spigot portion 14 has substantially the same radius as the intermediate section 11, but dimensions could be changed to adapt the spigot portion and intermediate section to different needs. The male spigot portion 14 comprises an external thread 15 extending along the entire length of the spigot portion along axis A.

[0030] Between the male spigot portion 14 and the intermediate section 11 the first load bearing structure 16 is arranged. In the embodied male coupling the load bearing structure 16 is designed as a flange extending in substantially radial direction from axis and has an extension in radial direction exceeding the extension of the intermediate section and the male spigot portion such that the first support surface 17 is formed on the side of the flange that is facing the spigot portion. The support surface 17 is arranged substantially transverse to axis A and has a uniform shape around the male spigot portion. The first outer peripheral surface 18 extends around and along the flange and is arranged substantially parallel to axis A. The first outer peripheral surface could however also be angled in relation to axis A and the length of the load bearing structure, i.e. the flange, along axis A adapted to the specific needs for the drill bit rod. Between the first outer peripheral surface 18 and the intermediate section 11 the first tapered transition section 20 is arranged. The first tapered transition section 20 is intended to form a smooth connection between the peripheral surface 28 of the flange 16 and the intermediate section 11 to transfer the loads though the drill string rod and has a circular cross-sectional shape transverse to axis A. The narrowing transition could be embodied in different ways and examples of different embodiment could be a curved section, a straight angled section or a section with stepwise reduced radius along axis A.

[0031] In the opposite end the second coupling 13 is arranged. The second coupling is embodied as a female coupling permanently fitted to the intermediate section 11. The female coupling 13 has a shape and dimension corresponding to the dimensions of the male coupling, i.e. the male spigot portion 14 and the support surface 17 to make it possible to connect identical drill string rods 10 to each other to form the drill string 100. The female

coupling 13 comprises a sleeve shaped element 21 extending co-axially to the intermediate section. The sleeve shaped element 21 has internal threads 22 corresponding to the external threads on the male spigot portion. The outside surface of the sleeve shaped element constitutes the second outer peripheral surface 23 extending substantially parallel to axis A. The sleeve shaped element 21 has an internal radius corresponding to the radius of the male spigot portion and an external radius corresponding to the radius of the flange 16. The sleeve shaped element 21 is ended by the substantially flat second support surface 24 extending in a plane transverse to axis A. The axial length of the male spigot portion and the sleeve shaped element is selected such that when two or more drill string rods are fitted together, the second support surface 24 should be in contact with first support surface 17 of the adjacent drill string rod such that the axial forces during drilling is transferred from one drill string rod to the other via the load bearing structures, i.e. the sleeve shaped element 21, the second support surface 24 and the first support surface 17 on the first load bearing structure 16 instead of via the threads. The second outer peripheral surface 21, i.e. the sleeve shaped element, has a radius substantially identical to the radius of the flange 16 such that the contact area between the contact surface and the support surface is as large as possible.

[0032] The second coupling furthermore comprises the second tapered transition section 25 extending between the second outer peripheral surface 23 of the load bearing structure 21 and the intermediate section 11. The second tapered transition section 25 has the same characteristics as the first tapered transition section 20, i.e. a circular cross-sectional shape transverse to axis A and a curved, straight or stepwise reduced radius along axis A.

[0033] The drill string rod 10 is made of a metal material and either made in different pieces permanently fitted together or made in one piece of material. To ensure that the drills string rod is able to work as intended for a long period of time the surface of the essential parts of the drill string rod is covered by a hard layer 30. The hard layer is a layer of material that is harder and more resistant to wear than the metal material of the drill string rod 10.

[0034] The hard layer 30 could be applied on different areas of the drill string rod to reduce wear and ensure enough strength in the load bearing structures of the drill string rod for an extended period of time. The hard layer is preferably applied on at least an area of the first outer peripheral surface 18 of the first load bearing structure 16 and / or the second outer peripheral surface 23 of the second load bearing structure 21 since these areas of the drill string rod are essential to ensure that the drill string rod is able to withstand the axial loads on the support surface and the contact surface.

[0035] The applied hard layer 30 has a thickness in a direction perpendicular to the covered surface within the range of 0.1 - 5 mm. The layer thickness is either constant over the entire covered area or adapted such that a thicker layer is applied where the risk for wear is higher. The layer is either applied on the surface of the drill string rod, i.e. the surface of the first and second coupling or within a recess formed in the surface of the first and / or second coupling.

[0036] Different further areas of the drill string rod could be covered by the hard layer. But in order to reach the desired effect at least an area of the first outer peripheral surface of the first load bearing structure and / or the second outer peripheral surface of the second load bearing structure is covered by the hard layer.

[0037] To further increase the protective effect, the first and second tapered transition section could be covered by the hard layer.

[0038] Since the drill string rod is rotating during use, the area covered by the hard layer preferably extends around the entire periphery of the drill string rod around axis A.

[0039] In figure 3A and 3B the illustrated embodiment of the first coupling 12, a part of the first outer peripheral surface arranged adjacent to the first tapered transition section 20 is covered by the hard layer 30. The remaining part of the first outer peripheral surface is uncovered and has a smaller radius.

[0040] Figure 3A and 3B furthermore illustrates an example of a second coupling 13 where a part of the second outer peripheral surface of the load bearing structure arranged adjacent to the second tapered transition section is covered by the hard layer 30. The remaining part of the outer periphery is uncovered and has a smaller radius.

[0041] The hard layer is a layer of a material that is harder and more resistant to wear and could be of different types of materials. Examples of materials are a material including an iron-based alloy, a cobalt-based alloy, a nickel-based alloy, a refractory metal, a cemented carbide, a metal matrix composite and/or a chromium carbide alloy with the desired characteristics. Further materials are possible as well.

[0042] The technique of applying a layer of material that is harder and more resistant to wear is often referred to as "hard facing". Hard facing is a metal working process where a harder or tougher material is applied to a base metal. The applied material is often welded to the base material to ensure that the applied material is adhered to the base material. An alternative method involves the use of powder metal alloys that are welded to the surface of the product that needs the protective hard layer.

[0043] While the invention has been illustrated and described in detail in the drawings and foregoing description, such illustration and description are to be considered illustrative or exemplary and not restrictive; the invention is not limited to the disclosed embodiments. The skilled person understands that many modifications, variations and alterations are conceivable within the scope as defined in the appended claims. For example, the drill string

rod could be embodied with two male couplings or two female couplings such that the two different embodiments of drill string rods are alternated to form an elongated drill string.

[0044] Alternatively, only one drill string rod is enough to drill the intended bore hole and a configuration with male couplings or female couplings in both ends are appropriate to connect the intended drill bit in one end and the percussion tool in the other.

[0045] Additionally, variations to the disclosed embodiments can be understood and effected by those skilled in the art in practicing the claimed invention, from a study of the drawings, the disclosure, and the appended claims. In the claims, the word "comprising" does not exclude other elements or steps, and the indefinite article "a" or "an" does not exclude a plurality. The mere fact that certain measures are recited in mutually different dependent claims does not indicate that a combination of these measures cannot be used to advantage. Any reference signs in the claims should not be construed as limiting the scope of the claims.

Claims

1. Drill string rod (10) for percussion drilling, said drill string rod comprising:

   an elongated intermediate section (11) extending along an axis A,
   a first coupling (12) intended to be connected to a corresponding coupling element on an adjacent drill string, drill bit or percussion tool, said first coupling is arranged at a first end of the intermediated section and comprises a first load bearing structure (16) having an extension in radial direction exceeding the extension of the intermediate section (11) such that a first support surface (17) intended to bear against a corresponding support surface on the adjacent drill string, drill bit or percussion tool is formed on the side of the first load bearing structure (16) facing away from the intermediate section (11), said first load bearing structure (16) has a first outer peripheral surface (18) and a first tapered transition section (20) extending between the first outer peripheral surface (18) of the first load bearing structure (16) and the intermediate section (11); and
   a second coupling (13) arranged at a second end of the intermediate section (11), intended to be connected to a corresponding coupling element on an adjacent drill string, drill bit or percussion tool, said second coupling is arranged at a second end of the intermediated section (11) and comprises a second load bearing structure (21) having an extension in radial direction substantially the same as the extension in radial direction of the first load bearing structure (16), said second load bearing structure (21) has a second outer peripheral surface (23) and a second support surface (24) intended to bear against a corresponding support surface on the adjacent drill string, drill bit or percussion tool, said second coupling (13) furthermore comprising a second tapered transition section (25) extending between the second outer peripheral surface (23) of the load bearing structure (21) and the intermediate section (11),
   wherein the drill string rod (10) is made of a metal material and at least an area of the first outer peripheral surface (18) of the first load bearing structure (16) and / or the second outer peripheral surface (23) of the second load bearing structure (21) is covered by a hard layer (30).

2. Drill string rod (10) according to claim 1, wherein the hard layer (30) is a layer of material that is harder and more resistant to wear than the material of the drill string rod, said layer has a thickness in a direction perpendicular to the first outer peripheral surface (18) and / or the second outer peripheral surface (23) within the range of 0.1 - 5 mm.

3. Drill string rod (10) according to claim 1 or 2, wherein the first (18) and second (23) outer peripheral surfaces are substantially parallel to axis A.

4. Drill string rod (10) according to anyone of the previous claims, wherein the first (20) and / or the second (25) tapered transition section are covered by the hard layer (30).

5. Drill string rod (10) according to anyone of the previous claims, wherein the area covered by the hard layer (30) extend around the entire periphery of the drill string rod around axis A.

6. Drill string rod (10) according to anyone of the previous claims, wherein a part of the first and / or second outer peripheral surface (18, 23) along axis A is covered by the hard layer (30) and said part of the first and or second outer periphery is arranged adjacent to the respective first or second tapered transition section (20, 25) and the remaining part of the first or second outer peripheral surface (18, 23) is uncovered such that it has a smaller radius than the covered part of the first and or second outer periphery (18, 23) .

7. Drill string rod (10) according to anyone of the previous claims, wherein the hard layer (30) is a layer of material including an iron-based alloy, a cobalt-based alloy, a nickel-based alloy, a refractory metal, a cemented carbide, a metal matrix composite and/or a chromium carbide alloy.

8. Drill string rod (10) according to anyone of the previous claims, wherein a passage (26) for a flushing media extends coaxially to axis A within the drill string rod (10).

9. Drill string rod (10) according to anyone of the previous claims, wherein the intermediate section (11) has a circular or hexagonal cross-sectional shape transverse to axis A.

10. Drill string rod (10) according to anyone of the previous claims, wherein the first (20) and second (25) tapered transition section have a circular cross-sectional shape transverse to axis A, and a curved, straight or stepwise reduced radius along axis A.

11. Drill string rod (10) according to anyone of the previous claims, wherein the first (17) and second (24) support surface are arranged in a plane substantially transverse to axis A.

12. Drill string rod (10) according to anyone of the previous claims, wherein the first coupling (12) is a male coupling comprising a spigot portion (14) extending substantially coaxial to axis A from the first contact surface (17) of the first load bearing structure (16), and the second coupling (13) is a female coupling comprising a sleeve shaped element (22) extending coaxially to axis A and said sleeve shaped element is ended by said second contact surface (24).

13. Drill string (100) comprising two, or more, of the drill string rods (10) according to claim 1 fitted together by the first and second couplings (12, 13) such that the first and second contact surface (24) on adjacent drill string rods (10) are in contact with each other.

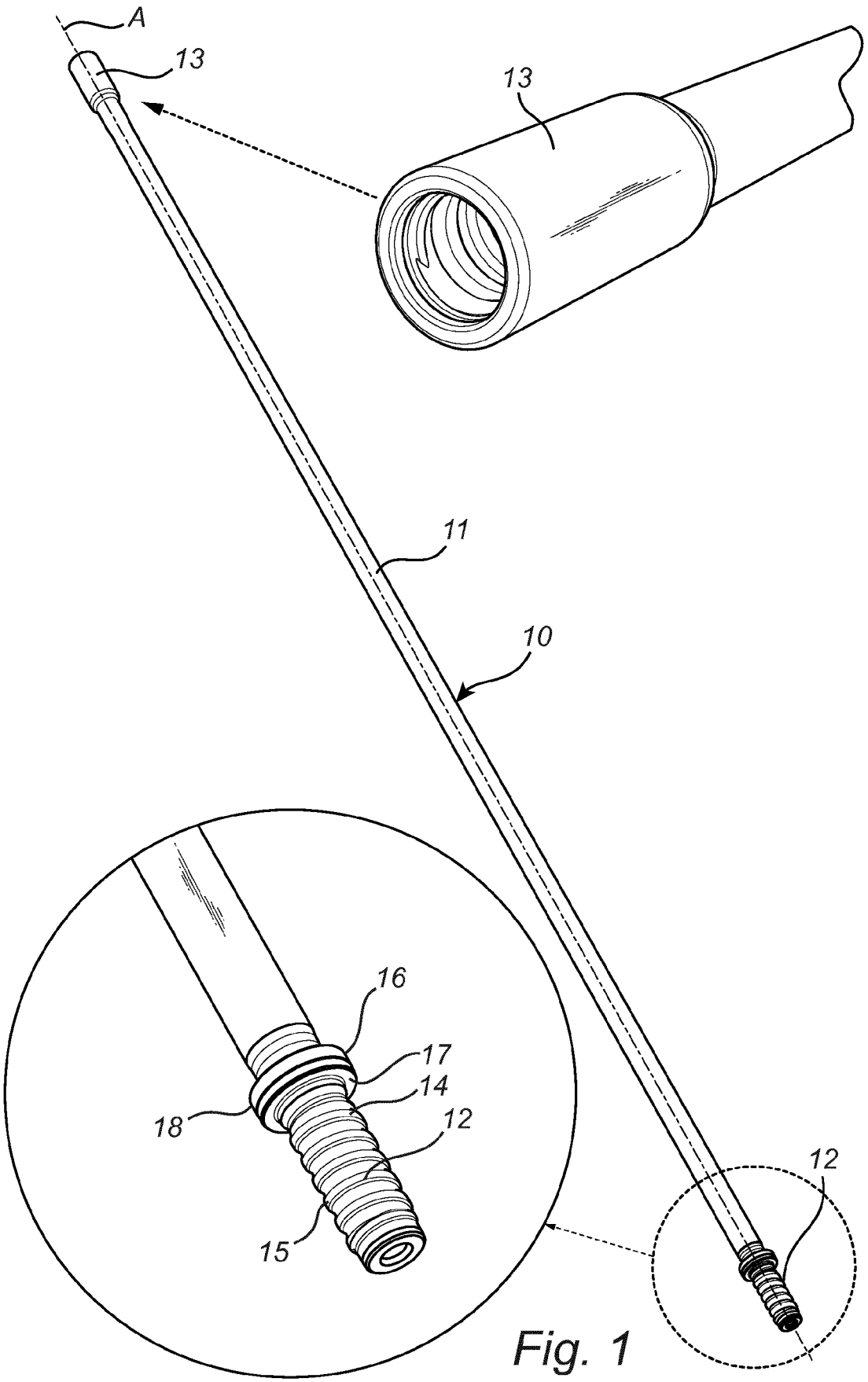

Fig. 1

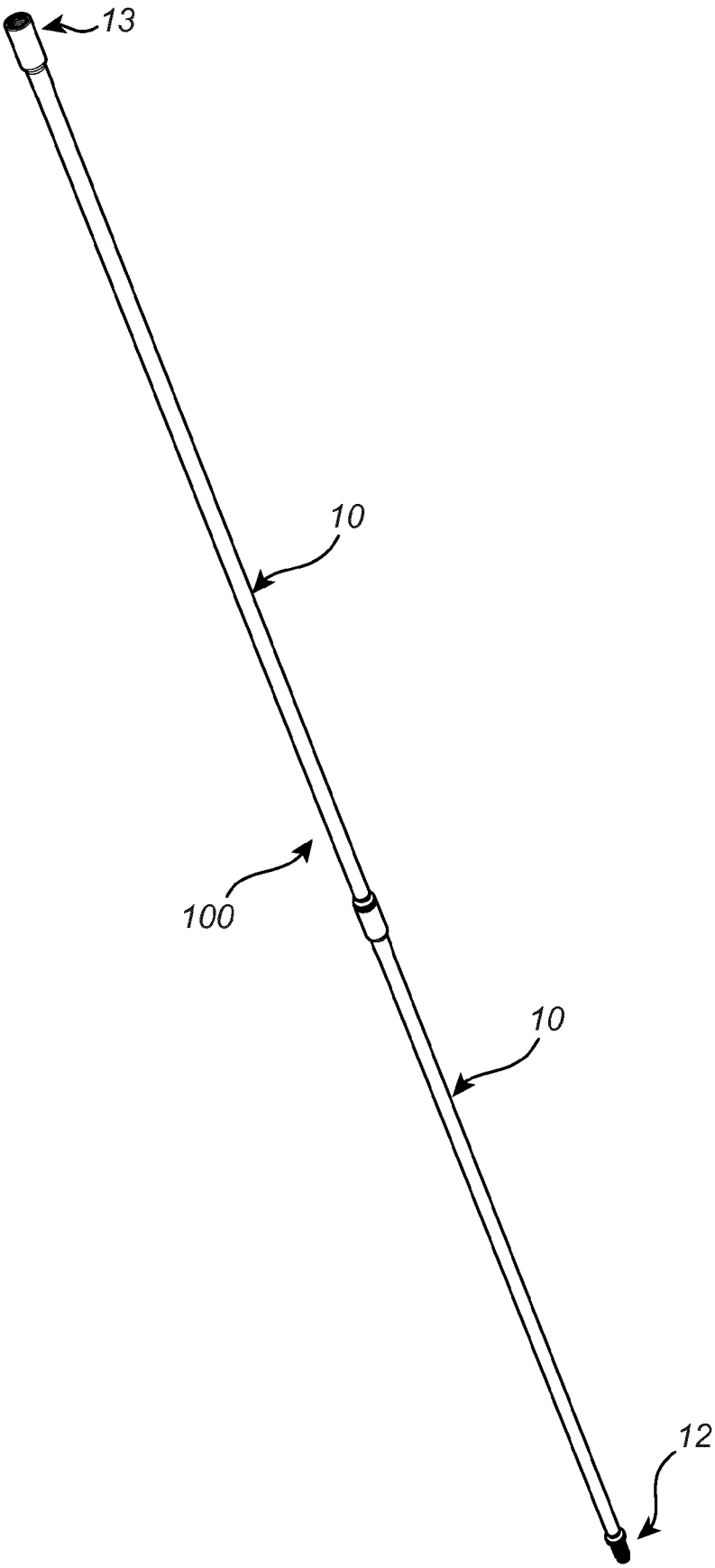

Fig. 2

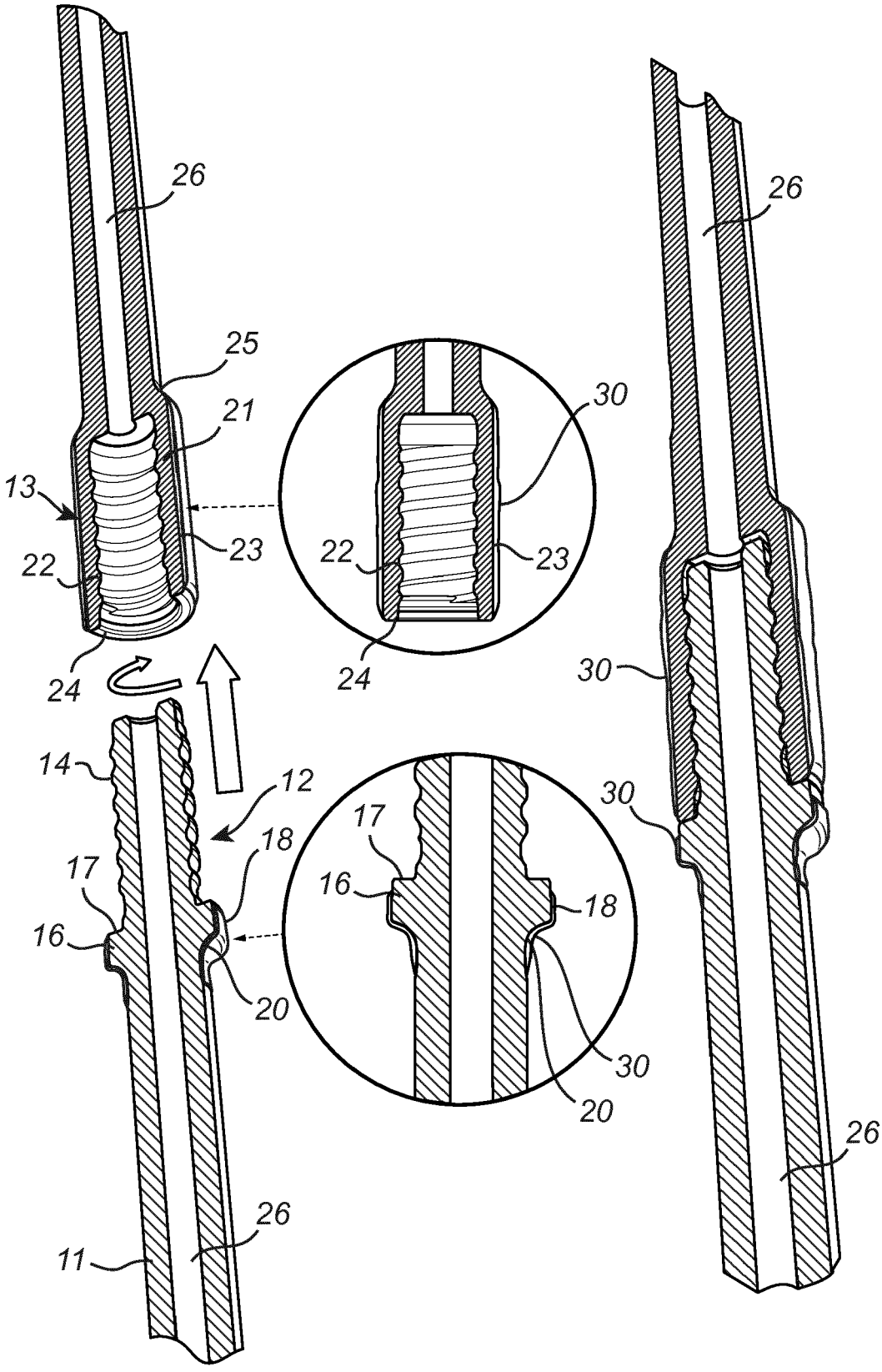
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Fig. 3A

Fig. 3B

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EUROPEAN SEARCH REPORT

Application Number
EP 19 17 6255

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
X A	US 8 678 447 B2 (CHIN DAVID [US]; NAT OILWELL VARCO LP [US]) 25 March 2014 (2014-03-25) * column 13, lines 63-37; claim 13; figures 3A,3B,4A *	1-5,7-13 6	INV. E21B17/04
X	US 3 067 593 A (GRESHAM MCCOOL MARCUS) 11 December 1962 (1962-12-11) * the whole document *	1-5,7-13	
A	US 3 537 738 A (FISCHER HANS CHRISTIAN PEDER ET AL) 3 November 1970 (1970-11-03) * column 3, lines 61-75 *	1-13	
A	WO 01/38686 A1 (SANDVIK AB [SE]) 31 May 2001 (2001-05-31) * figures 1-3 *	1-13	
A	EP 2 845 991 A1 (SANDVIK INTELLECTUAL PROPERTY [SE]) 11 March 2015 (2015-03-11) * figures 1,2 *	1-13	TECHNICAL FIELDS SEARCHED (IPC)
A,D	EP 2 845 992 A1 (SANDVIK INTELLECTUAL PROPERTY [SE]) 11 March 2015 (2015-03-11) * the whole document *	1-13	E21B

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
Munich	6 November 2019	Beran, Jiri

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
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EPO FORM 1503 03.82 (P04C01)

ANNEX TO THE EUROPEAN SEARCH REPORT ON EUROPEAN PATENT APPLICATION NO. EP 19 17 6255

This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report. The members are as contained in the European Patent Office EDP file on
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06-11-2019

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 8678447 B2	25-03-2014	US 2010308577 A1	09-12-2010
		US 2014143998 A1	29-05-2014
US 3067593 A	11-12-1962	FR 1293769 A	18-05-1962
		GB 912930 A	12-12-1962
		US 3067593 A	11-12-1962
US 3537738 A	03-11-1970	NONE	
WO 0138686 A1	31-05-2001	AT 271183 T	15-07-2004
		AU 775893 B2	19-08-2004
		BR 0015601 A	09-07-2002
		CA 2391158 A1	31-05-2001
		DE 60012216 T2	18-11-2004
		EP 1232321 A1	21-08-2002
		JP 3806033 B2	09-08-2006
		JP 2003515022 A	22-04-2003
		US 6767156 B1	27-07-2004
		WO 0138686 A1	31-05-2001
EP 2845991 A1	11-03-2015	EP 2845991 A1	11-03-2015
		WO 2015032660 A1	12-03-2015
EP 2845992 A1	11-03-2015	AU 2014317266 A1	10-03-2016
		CA 2922461 A1	12-03-2015
		CL 2016000522 A1	02-09-2016
		CN 105593455 A	18-05-2016
		EP 2845992 A1	11-03-2015
		KR 20160053952 A	13-05-2016
		PE 03322016 A1	04-05-2016
		RU 2016113379 A	16-10-2017
		US 2016215572 A1	28-07-2016
		WO 2015032659 A1	12-03-2015

EPO FORM P0459

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REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- EP 2845992 A **[0003]**