(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
3 January 2003 (03.01.2003)

PCT

(10) International Publication Number
WO 03/001023 A1

(51) International Patent Classification[7]: E21B 17/02

(21) International Application Number: PCT/GB02/02933

(22) International Filing Date: 26 June 2002 (26.06.2002)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:
0115524.1 26 June 2001 (26.06.2001) GB

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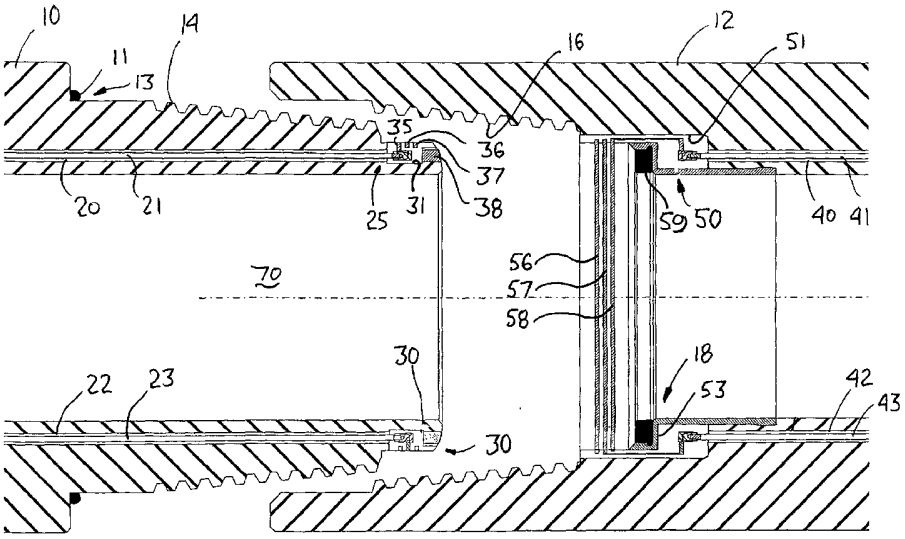
(81) Designated States *(national)*: AE, AG, AL, AM, AT, AU, AZ, BA, BB, BG, BR, BY, BZ, CA, CH, CN, CO, CR, CU, CZ, DE, DK, DM, DZ, EC, EE, ES, FI, GB, GD, GE, GH, GM, HR, HU, ID, IL, IN, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MA, MD, MG, MK, MN, MW, MX, MZ, NO, NZ, PL, PT, RO, RU, SD, SE, SG, SI, SK, SL, TJ, TM, TR, TT, TZ, UA, UG, US, UZ, VN, YU, ZA, ZW.

(84) Designated States *(regional)*: ARIPO patent (GH, GM, KE, LS, MW, MZ, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, CH, CY, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE, TR), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG).

Published:
— *with international search report*
— *before the expiration of the time limit for amending the claims and to be republished in the event of receipt of amendments*

For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.

(54) Title: ELECTRICAL CONDUCTING SYSTEM



(57) Abstract: A generally tubular drill string has a conductive path over a plurality of drill pipe section (10). Each drill pipe section has a first end and a second end, and a wall, and the first end has a first radial sealing surfaces (11) and the second end has a corresponding second radial surfaces (59), such that when the first or second end of one drill pipe section is engaged with the second or first end respectively of another drill pipe section, at least one seal is formed. The drill pipe includes at least one conductor (21) disposed inside it, this conductor being connected to a first contact means at the first end and a corresponding contact means at the second end of each drill pipe section. Ingress protection means (240) are provided to protect the contact means from ingress from inside or outside of the drill pipe section. The ingress protection means comprises a sealed volume surrounding the contact means.

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ELECTRICAL CONDUCTING SYSTEM

The present invention relates to the transmission of power and data within a well bore, in particular, through a drillstring.

When drilling a borehole, or performing operations to maintain the borehole or operations associated with the production of oil or gas, it is often desirable to transmit power to various downhole devices, such as drill bits and traction tools. Various instruments can also be included on a drill string in order to gather data concerning the structure of the environment of the borehole, and the performance of the borehole operations and downhole devices. It is advantageous for this data to be transmitted back to the surface along an electrical conductor.

In one cabling system, each drill pipe section includes a contact ring at each end of the section. A passageway between each ring accommodates an armoured conductor which connects the two contact rings. When the drill pipe sections are made up in a drill string, the contact rings of adjacent drill pipe sections abut and a circuit is formed over the drill string.

Such a system is vulnerable to poor connections between the abutting contact rings. Ideally contact rings should be clean, and a specialised non-conductive "pipe dope" or joining compound (which is more expensive than standard pipe dope) must be used in order not to short the connection. Another disadvantage of this system is that the connection between the amoured cable and the contact rings are subjected to borehole pressure and are susceptible to fail.

Alternative systems (such as disclosed in U.S. Patent No. 4,788,544) use inductive pick-ups between the mating surfaces of adjacent drill pipe sections. Such linkage, whilst reducing the chance of bad connections, is not suitable for all types of telemetry and power transfer.

The object of the present invention is to provide an apparatus and method for reliably disposing cabling in a drill string.

According to the present invention there is provided a generally tubular drill string having a conductive path over a plurality of drill pipe sections, each drill pipe section having a first end and a second end, and having a wall, and the first end having a first radial sealing surfaces and the second end having a corresponding second radial sealing surfaces, such that when the first or second end of one drill pipe section is engaged with the second or first end respectively of another drill pipe section, at least one seal is formed,

wherein the drill pipe includes at least one conductor disposed inside it, this conductor being connected to a first contact means at the first end and a corresponding contact means at the second end of each drill pipe section.

Preferably, ingress protection means are provided to protect the contact means from ingress from inside or outside of the drill pipe section.

The ingress protection means may comprise a sealed volume surrounding the contact means. Alternatively or additionally, the ingress protection means may be a pressure release duct from one side of the contact means to the other. Alternatively or additionally, the ingress protection means may comprise an inner sleeve or seal.

Preferably, the first contact means and the second contact means are provided by corresponding conductive rings coaxial with the drill pipe.

Preferably, the wall of the drill pipe includes within it at least one bore wherein a conductor is disposed.

Preferably, the conductive connection consists of the first conductive rings in contact with an outer ring conductor, or resilient member, wherein the resilient member comprises an annular spring.

According to another aspect of the present invention, there is provided a generally tubular drill pipe having a conductive path over a plurality of drill pipe sections, each drill pipe section having a first end and a second end, and having a wall, and the first end having a first radial sealing surfaces and the second end having a corresponding second radial sealing surfaces, such that when the first or second end of one drill pipe section is engaged with the second or first end respectively of another drill pipe section, at least one seal is formed,
wherein a conductor is connected to a first contact means at one end and a plug at the other end, and,
wherein ingress protection means are provided to protect the contact means from ingress from inside or outside of the drill pipe section.

According to another aspect of the present invention there is provided a drill pipe section as herein defined.

According to another aspect of the present invention there is provided a generally tubular drill pipe having a conductive path over a plurality of drill pipe sections, each drill pipe section having a first end and

a second end, and having a wall, and the first end having a first radial sealing surfaces and the second end having a corresponding second radial sealing surfaces, such that when the first or second end of one drill pipe section is engaged with the second or first end respectively of another drill pipe section, at least one seal is formed,

wherein the wall includes within it at least one bore, the bore having a conductor disposed inside it, this conductor being connected to a first contact means at the first end and disposed to travel through a box sealing carrier at the second end of each drill pipe section,

wherein ingress protection means are provided to protect the contact means from ingress from inside or outside of the drill pipe section.

According to another aspect of the present invention there is provided a conductive connection for use between two tubulars comprising:

a terminating portion of a conductor in a female end of a first tubular;

a mating terminating portion of a conductor around a male end of a second tubular; and,

a sealed volume formed when the first and second tubulars are threaded together, the sealed volume housing the conductive connection.

According to another aspect of the present invention there is provided a first drill pipe section for use in a drill pipe string. The drill pipe section comprising:

a first end and a second end;

a conductive path connecting the first and second ends;

the conductive path being connected to a first contact member and a second contact member at the second end;

a first seal member at the first end and a second seal member at the second end;

the first and second seal members for sealing engagement with a first or second end respectively of a second drill pipe section; and,

the sealing engagement forming a sealed volume and the contact members being within the sealed volume.

A drill pipe section is generally tubular and therefore has a central throughbore often used for the passage of well fluids. The present invention also includes bores formed or situated in the walls of drill pipe sections; and reference to bores refers to these wall bores, whereas the main bore of the drill pipe is identified as the central throughbore.

A telemetering system will now be described, by way of example, with reference to the drawings, of which;

Figure 1 is a longitudinal sectional view of two facing ends of adjacent drill pipe sections in a disengaged state;

Figure 2 is a longitudinal sectional view of two facing ends of adjacent drill pipe sections when engaged;

Figure 3 is a longitudinal sectional view of the middle portion of a drill pipe section;

Figure 4 is a longitudinal sectional view of another embodiment of two facing ends of adjacent drill pipe sections in a disengaged state;

Figure 5 is a longitudinal sectional view of this embodiment when engaged;

Figure 6 is a longitudinal sectional view of a further embodiment of two facing ends of adjacent drill pipe sections in a disengaged state;

Figure 7 is a longitudinal sectional view of this embodiment when engaged;

Figure 8 is a longitudinal sectional view of a further embodiment;

Figure 9 is a cross sectional view through XX of this embodiment; and

Figure 10 is a longitudinal sectional view of part of the embodiment during manufacture.

Figure 11 is a longitudinal sectional view of the male end of an another embodiment.

Figure 12 is a longitudinal sectional view of the female end of this embodiment showing a module connection.

Figure 13 is a longitudinal sectional view of this embodiment when engaged.

Figure 14 is a is a section view an embodiment of the conductive rings when engaged.

Figure 15 is a longitudinal sectional view of the previous female end module.

Figure 16 is a longitudinal sectional view of a further embodiment of two facing ends of adjacent drill pipe sections when engaged.

Figure 1 shows opposing ends of two adjacent drill pipe sections 10,12. One drill pipe 12 has a female receiving thread 16, which is engaged by rotation of the corresponding male thread 14 of the other drill pipe 10. Each drill pipe has three bores drilled longitudinally inside the drill pipe wall, equally spaced around the radius of the drillpipe section (when spaced at 120° around the radius of the drill pipe, a longitudinal section taken centrally through the drill pipe section would not show two bores; two bores 20, 22 are here shown to better illustrate the nature of the connections).

The bore 20 opens at the male end at a region 25 forward of (considering forward to be towards the right in the figure) and proximal to the thread 14. A conductor 21 is introduced into this bore 20. Space or other considerations within the drill pipe, and its wall cavity, wall may require the conductor 21 to have an aspect ration not equal to one. As herein defined, when viewing the cross-sectional area of a conductor 21, aspect ratio is the measurement of the overall length of the conductor divided by the measurement of the overall width of the conductor. As an example, a conductor 21 with a circular cross-sectional area would have equal length and width measurements, and thus would have an aspect ration equal to one. A conductor 21 that is rectangular in cross-sectional area would have a length measurement greater than a width measurement, consequently this conductor would have an aspect ratio greater than one.

Where the bore opens at the male end of the drill pipe section 10, a male connector 30 is attached, the conductor 21 terminating in this male

connector. If necessary, a recess is provided to accept the male connector 30. The male connector is annular, and includes three annular conductive rings 35, 36, 37 having surfaces exposed on the outer circumference of the male connector. Each of the three conductive rings are connected respectively to one of the three conductors. A metal sealing ring 38 is also included in the male connector.

The drill pipe 12 also features three longitudinal bores (40, 42 being visible here) which emerge at the female end of the drill pipe forward of (again considering forward to be towards the right in the figure) and proximal to the thread 16. As for the bores 20, 22 of drill pipe 10, the bores 40, 42 include conductors 41, 43. Where the bores open at the female end of the drill pipe section 12, a female connector 50 is attached, the conductor terminating in this female connector. If necessary, a recess 51 is provided to accept the female connector 50. The female connector is annular, and includes three annular conductive rings 56, 57, 58 having surfaces exposed on its inner circumference. Each of the three conductive rings are connected respectively to one of the three conductors. The female connector includes a radial shoulder 53, this shoulder having a metal sealing surface 54. Incorporated in the radial shoulder is an annular seal 59, such as an elastomeric seal.

Referring to figure 2, when the male thread 14 of drill pipe 10 is introduced into the female end of drill pipe 12, the metal sealing ring 38 of the male connector compresses the annular seal 59 of the female connector until the metal sealing ring 38 abuts the female connector's metal sealing surface 53, sealing the conductive rings from inner wellbore fluid. Preferably, the annual seal is elastomeric in nature. The components of the

female connector 50 lie substantially flush with the inner surface of the drill pipe section's central throughbore 70.

The three conductive rings 35, 36, 37 of the male connector now lie in conjunction with the three conductive rings 56, 57, 58 of the female connector. These connections are sealed on the one hand by the metal to metal seal between the male connector's sealing ring 38 and female connector metal sealing surface 53, augmented by the annular seal 59 which is energised by the metal sealing ring 38, and on the other hand by the mating threads 14, 16 of the male and female ends of the adjacent drill pipe sections. An o-ring seal 11 is included in the shoulder 13 of the male end of the drill pipe section 10. Thus the contacting conductive rings are not exposed to the corrosive components usually present in well fluid.

Each drill pipe section includes both a male end and a female end having respectively male connector and female connector as described, the conductors disposed in the bores running the entire length of each drill pipe section. As these drill pipe sections are made up into a drill string, three conductive paths along the drill string are formed.

The drill pipe section's longitudinal bores 20, 22, 40, 42 ideally run parallel to the drill pipe sections' axes. When two drill pipe sections are undone and are to be remade, the mating threads 14, 16 may not engage to the same position as when they were initially made up. Further, before two separated drill pipe sections are remade, the drill pipe sections' ends may be shortened and/or rethreaded. The male and female connectors 30, 50 will therefore have to be repositioned, and accommodating recesses/profiles in the drill pipe sections have to be remilled. These operations are simplified by the longitudinal bores 20, 22, 40, 42 being essentially parallel to the drill

pipe's axis, so that the radial displacement of the bores remains constant as axial displacement is varied.

Referring to figure 3, the central throughbore of a drill pipe section typically includes a widened middle region 72 between to relatively narrow end regions 73, 74, the end regions having a greater thickness of material to give additional strength in the area where the drill pipes are joined. It may not therefore be possible to produce a straight longitudinal bore along the entire length of the drill pipe section without impinging upon the drill pipe section's threads. When this is the case, two aligned bores 80, 81 are drilled into the drill pipe section, and a tube of resilient material 85 is attached in a sealed manner between the facing mouths 83, 84 of the two bores to form an enclosed bore running the length of the drill pipe section.

The drill pipe section's bores are filled with oil. As the environmental pressure in the well bore hole is increased, this oil may be pressurised in order to equalise the pressure between the connection with the external pressure and so reduce the stress exerted on the seals. The resilient material 85 connected between the facing mouths 83, 84 is compressed in response to increasing external pressure, reducing the volume of the bore 80, 81, increasing the bore's pressure and thus reducing the pressure difference. The equalisation of the bore's pressure could be alternatively or additionally be achieved using, for example, a pressure gauge and actuator mechanism

Referring to figure 4, in an alternative embodiment the male connector 91 installed in a drill pipe section 110 includes two forward facing collars 91, 92.

An annular cavity if formed between the two forward facing collars 91, 92 of the male connector 30. In this cavity is an annular seal 95, biased by a spring 96 to be held covering the surface of the conductive rings 36, 37, 38. The inner collar 92 extends further from the male connector than the outer collar 91. The outer collar includes a ledge 98 which, in conjunction with the drill pipe, forms a circular groove 99.

The adjacent drill pipe section 120 is similar to the drill pipe section 110 just described, and includes three longitudinal bores 140, 142 (only two of which are visible here) located near the inner surface of the drill pipe section. In this embodiment, the bores, rather than being integrally formed in the wall of the drill pipe section, are provided in a lining, or inner sleeve. The conductors are here formed between two coaxial tubes, the conductors being semi-cylindrical elements of similar curvature to the tubes, such that the three conductors can be placed axially upon the inner tube, with spacer means between each conductor, each conductor subtending some angle less than 120° of the tube's circumference. The outer tube is then affixed to the inner tube, and the assemble is then secured in the drill pipe section.

Referring figure 4a, the conductor assembly may be formed in part by an extrusion process, the inner tube being formed using a gas impermeable metal tube, or sleeve, 223 the outer surface of which is coated by extrudate 224, the conductors 120 being affixed to the coated inner tube, and the inner tube and conductors 120 being coated again in another extrusion stage 225 to cover and hold the conductors 120 in a spaced relationship. This assembly may now be introduced to the drill pipe section 110. In general, the inner sleeve shields the conductors from wellbore fluid.

The three semi-cylindrical conductors 120 are each respectively connected to one of the three conductive rings 36, 37, 38 present in the female connector described below.

A portion of the inner surface of the drill pipe at the female end is removed to create a profile 103. If a lining or sleeve is used, the lining may be made up of layers 104, 105, 106 to form the profile; it will be noted that the profile of the male end of the inner surface is the complement of the profile of the female end of the inner surface, so the profile may be achieved by using similar layers of material, with the different layers being axially displaced to create the profile. This profile 103 engages with a female end connector 100. When one side of the drill string is considered in section as shown here, a recess is milled into the drill pipe. The female end connector includes, considering a half section portion, two forward facing collars 134, 135, one of which, the outer collar 134, abuts an inner portion 133 of the drillpipe section 120, and one of which, the inner collar 135, both engages with the recess in the profile 103 and features a shoulder 137 abuts the inner portion of the drill pipe section. The female connector includes three bores 150, 152 similar to those 140, 142 in the drill pipe section 120, these bores being less radially displaced. Conductors run through the bores of the female connector, each conductor being connected via a contact element 151, 153 to the corresponding conductor of drill pipe section.

The female connector also includes two backward facing collars 131, 132. Three axially spaced conductive rings 171, 172, 173 are situated on the outer surface of the cylinder formed by the inner collar 132. The three conductors of the female connector are each respectively connected to one of the three rings.

An annular cavity 136 is formed between the two backward facing collars 131, 132 of the female connector. In this cavity is an annular seal 160, biased by a spring 161 to be held covering the surface of the conductive rings. The inner collar 132 includes a shoulder 163 on its inner diameter.

Referring to figure 5, when the male end of the drill pipe section 110 is fully engaged with the female end of the adjacent drill pipe section 120, the male connector 90 and female connector 100 also engage. Specifically, the forward facing outer collar 91 of the male connector 90 engages in the cavity 136 between the backward facing inner collar 132 and outer collar 131 of the female connector 100, and the outer collar 131 of the female connector engages in the cavity between the forward facing inner collar 92 and outer collar 91 of the male connector. The outer collar 131 of the female connector is accommodated in the circular groove 99 formed between the outer collar 91 of the male connector and the drill pipe 110. The inner collar 92 of the male connector abuts the shoulder 163 of the outer inner collar 132 of the female connector. Thus, the male 90 and female 100 connectors engage to produce an inner surface flush with each other and the drill pipe surface of the central throughbore sections in they are installed.

As the outer forward facing collar 91 of the male connector enters the cavity 136 of the female connector, the annular seal 160 and its spring 161 are displaced deeper into the cavity. As it is displaced, the seal 160 wipes the surface of the conductive rings 171, 172, 173, ensuring that a good contact will be formed. Simultaneously, the outer collar 131 of the female connector displaces the male connector's annular seal 95, wiping the

male connector's conductive rings 36, 37, 38. When the male and female connector's are fully engaged, the three conductive rings 36, 37, 38 of the male connector and the three conductive rings 171, 172, 173 of the female connector slide into conjunction so as to form three conductive paths from the drill pipe 110 to the adjacent drill pipe 120.

The outer surface of the male connector's inner collar 92 includes an o-ring seal 190, which seals against the female connector's inner collar 131. Similarly, the outer surface of the male connector's outer collar 92 includes an o-ring seal 191, which seals against the female connector's outer collar 131.

Each drill pipe section thus features a male connector and female connector as described, so that a three conductive circuits down the length of the drill pipe are produced. As in the previous example, the bores are oil filled in order that they may be balanced with the external pressure.

Referring to figures 6 and 7, the male end of the drill pipe section 10 includes a pressure release valve 165 forward of the shoulder 13. When the drill pipe sections 10, 12 are made up, lubrication grease on the threads is pressurised as it becomes trapped in a decreasing volume between the metal to metal and elastomeric seals 38, 53, 59 of the male and female connectors 30, 50 on the one hand, and the metal to metal seal between the shoulder 13 of the male end of drill pipe section 10 and the end 15 of the female end of drill pipe section 12, and the elastomeric seal 11 on the other hand. The pressure release valve allows excess lubricating grease to escape when a certain pressure is reached. This pressure is set such that it does not stress the seals when the environmental pressure is low, but is sufficient to afford protection to the seals when the environmental pressure is high. Rather

than a pressure release valve, a weep hole may instead be provided. It will be realised that position of the pressure release valve may be varied, for example it could be included at the female end of drill pipe section 12 backward of the female thread, venting excess lubricating grease outside the drill string.

Referring to figure 8 specifically, and generally to figures 8-15, three conductors 21 (here of the semi-cylindrical type as previous described) are longitudinally disposed in a laminate tubular member 108. As previously described, the tubular member may be formed partly by extrusion, for example using a steel tube 223 having an insulating layer 224, the conductors 21 then being set with another insulating layer 225. The tubular member is then inserted in the drill pipe section 110. The tubular member may be formed to follow the inner surface of the drill pipe section, for example being swaged to follow the widened portion commonly present in the mid-section of drill pipe sections. The at a region forward of the male thread of the drill pipe section three radial apertures 201 (only one of which is visible) are bored through the drill pipe section, equally spaced around the circumference of the drill pipe section and each one somewhat displaced axially, corresponding to the axial displacement of the conductive rings 181, 182, 183. A radial conductor 203 and surrounding insulator 204 is set in each aperture, each radial conductor 204 being in contact with one of the axially disposed conductors 181, 182, 183. The conductor 203 protrudes from the insulator 204, so that when the conductive rings are fitted the relevant conductive ring 181 is pressed against the protruding conductor 203 to ensure a good conductive path. This radial conductor is also shown in figure 9.

The female end of the drill pipe section 112 includes similar radial conductors 206 (only on of which is visible), again set in a radial bore 205 using an insulator 207. The radial conductors 206 are connected to a conducting elements 230 set in an insulating collar 231. Each conducting element 230 is attached to a conductive ring 36, 37, 38. When the male end of the drill pipe section 110 is inserted into the female end of drill pipe section 112, these conductive rings 36, 37, 38 align with and form a conductive contact with the conductive rings 181, 182, 183.

This embodiment includes radial metal to metal seals where the hindmost (hindmost being to the left in the figure) part of female thread 210 abuts the shoulder 211 behind the male thread, and the foremost part of the male thread 212 abuts a shoulder insert 213 in front of the female thread. In addition, and o-ring 215 is provided between the male and female threads, and further o-rings 216, 217, 218 are provided to seal a inserted tube securing element 214 and the shoulder insert carrying the conductors. Wiper ring seals 220, 221 either side of the conductive rings 181, 182, 183 and conductive rings are also provided set in the male part of the drill pipe section. As the male part of one drill pipe section is inserted into the female part of another drill pipe section, these wiper rings 220, 221 wipe over the conductive rings 36, 37, 38, 181, 182, 183, cleaning any debris of to ensure a good connection can be made, as well as providing addition seals.

As previously mentioned, the volume between the inner and outer sets of seals are preferably filled with non-conductive lubrication grease or 'pipe dope'. This grease is substantially incompressible, and is also pressurised as the male and female parts are screwed together (and, as previously mentioned, a pressure release valve may be included). If a seal does fail, the penetration of the well bore fluids will be reduced or

eliminated by the presence of the grease in the previously sealed volume, since the fluids will only continue to penetrate the volume until while the pressure of the grease is less than that of the fluids; when the pressures are equalised the fluid penetration will cease, and, since the grease is substantially incompressible, the conductive contacts will not have been exposed but will still be enveloped by the grease. To the extent that some of the sealed volume cannot be filled with grease, or to the extent that the grease is compressible, a grease reservoir may be included one or both sides of the electrical contacts to ensure that grease remains around the contacts even after the grease has been displaced or compressed. Adjoining drill pipe sections could be provided with just a single seal, so that the electrical contact portions (the conductive rings, radial conductors etc.) are open to well bore fluids, but that the volume between the seal and the electrical contacts, and extending somewhat beyond these electrical contacts, is filled with substantially incompressible grease.

Drill pipe sections may also include a by-pass duct 240, as shown in figure 8, which extends from one side of the contacts to the other so that any pressure difference arising between the inside of the drill pipe and the voids in the thread, or due to any leakage of one of the seals, or if only one seal is provided will result in fluids by-passing the contact zone equalising the pressure either side of the electrical contacts without displacing the grease covering the contacts

The radial conductors 206, conductive elements 230 and conductive rings 36, 37, 38 may be set in the insulator by positioning the conducting elements, and the shoulder insert, with the extruded tubular member in situ, as shown in figure 10, using a jig arrangement (not shown) to ensure the correctly spaced arrangement, and a mould (also not shown) to form the

insulating portions using a pourable settable insulator. The arrangement of conductors at the male end may be similarly achieved.

Referring to figure 11, in a modified embodiment, an inserted liner tube 302 extends through the drill pipe section 300. At the male thread end 310, an elastomeric nose seal 304 is located around the outer surface of the liner tube. Situated behind the nose seal (that is, to the left in the drawing) around the liner tube is a bypass collar 306. The bypass collar may be attached to the liner by laser weld. The nose seal 304 engages with the bypass collar 306. Around the bypass collar 306 are three conductive rings 311, 312, 313, axially spaced and set in insulating material 315, preferably an elastomer or ceramic. Each ring includes a radially inwardly extending portion 316 (only one here being visible). As in embodiments previously described, three conductors 318 extend along an annulus in the drill pipe between the inner surface of the drill pipe section and the inner liner tube, each conductor occupying some part of a 120° portion of the drill string's circumference. As noted above, the conductors preferably have a rectangular cross-sectional area. When the rings 311, 312, 313, are fitted to the male thread end 310 each of the inwardly extending portions 316 clamps on the end of a respective annular conductors 318. This embodiment could be implemented with axially running conductors disposed in a bore drilled in the wall of the drill string (that is, dispensing with some or all of the liner tube) as previously described.

Referring also to figure 14, the outer curved surface of each conductive ring 311, 312, 313 of the male thread end 310 includes an annular groove wherein an outer conductor, or resilient member, ring is disposed. This resilient member may consist of a conductive garter spring 341, 342, 343, so that when the drill pipes are mated, the garter springs also

contact the corresponding conductive ring of the joining drill pipe. Consequently, a circuit is formed wherein the electrical power or telemetry data is linked through the garter spring. One advantage to using the spring instead of abutting the contact rings is that the mating tolerances of the drill pipe sections are lessened, allowing for easier make-up. A second advantage is decreased wear on the conductive rings due to less frictional stress occurring during the make-up process.

Two o-ring seals 301, 303 are provided, one fitted forward of the conductive rings on the bypass collar, and one behind the conductive springs on the in an annular groove on the end of the drill pipe section. The bypass collar 306 includes a portion that extends somewhat into the annular region between the drill string and the liner tube, the bypass collar included a bypass channel 352 which communicates, via a radially extending port 354 through the bypass collar 306, with the environment forward of the conductive rings 311, 312, 313 and forward o-ring 301, and, via a radially extending port 355 through the an adjacent part of the drill string, to the environment behind the conductive rings and rear o-ring 303.

Referring again to figure 2, the drill pipe section's longitudinal bores 20, 22, 40, 42 ideally run essentially parallel to the drill pipe sections' axes. When two drill pipe sections are undone and are to be remade, the mating threads 14, 16 may not engage to the same position as when they were initially made up. Further, before two separated drill pipe sections are remade, the drill pipe sections' ends may be shortened and/or rethreaded. The male and female connectors 30, 50 will therefore have to be repositioned, and accommodating recesses/profiles in the drill pipe sections have to be re-milled. Turning now to the female threaded end 320 shown in figure 12, the liner tube 302 extends along the bore of the drill string

section past the internal recess shoulder 321 of the female thread end. Each annular conductor 318 is terminates at a plug 319 adjacent to the internal recess shoulder. The plugs 319 are set in insulating material 323, such as an elastomer. Set into the internal recess shoulder 321 is at least one retaining threaded insert 325.

Shown is a representative female end module, the module being selectively removable. Although not shown, a male end module of a similar nature is also envisioned and included herein. A female thread end module 330 is fitted to the female thread end 320, a portion of the female thread end module 330 inserted to extend between the liner tube 302 and the inner surface of the drill string section 300. The female thread end module 330 includes three sockets 329, which respectively engage with the three plugs 319 connected to the annular conductor 318. At the end of the female thread end module 330 proximal to the female opening, are located three conductive rings 331, 332, 333 having exposed inner surfaces, these rings correspondingly spaced to align with the three conductive rings 311, 312, 313 situated on the male end 310 of the adjacent drill string section. Each of the conductive rings 331, 332, 333 of the female thread end module is electrically connected by conductive lines 317 to the plugs 319. The rings and plugs are set in an insulating material 324. Abutting the edge of the liner tube 318, a sealing member 334 includes o-rings 336 that seal the female thread end module 330 against the liner tube 318. A bore extends through the sealing member and insulating material so that a screw, such as an extended socket head screw 338 engaging with the retaining threaded insert 325 retains the female thread end module 330 in the female thread end. A distance between the conductive rings 331, 332, 333 and the liner tube 302 is provided for the accommodation of the male thread end 310.

As described herein, a module connector arrangement facilitates quicker and less expensive rebuilds and repairs.

Referring to figure 13, when the individual drill pipes are joined, the male threaded portion 310 of one drill string section being inserted into the female threaded portion 320 of an adjacent drill pipe section, the conductive rings 311, 312, 313 of the male threaded end are brought into contact with the conductive rings 331, 332, 333 of the female thread end module 330, the garter springs of the male threaded end pressing against the female thread end module's conductive rings 331, 332, 333 to ensure a good electrical contact is made. As shown, the liner tubes 302 of the two drill pipe sections meet to form a continuous throughbore, although they need not. The electrical components are sealed against the inner bore of the drill string 300 by the o-rings 336 of the female thread end module's sealing member and the nose seal and bypass collar forward o-rings 301 of the male thread end. Similarly, the electrical components are sealed against the environment outside the drill string by the rear o-ring 303 of the male thread end. Non-conductive pipe dope is applied to the threads prior to joining, and some of this pipe dope is retained in a pressurised state in a small volume between the end of the female thread end module 330 the male thread 310 of the adjacent drill pipe. The bypass channel 352 communicates with this volume via one of the bypass ports. It will be seen, in a similar manner to previous embodiments, that the seals 301, 303 forward of and behind the abutting conductive rings can be dispensed with, and that if they are retained and fail, there will not be ingress of fluid between the conductive rings from the surrounding environment.

Referring to figure 14, wiper o-rings 345, 346 may be provided between each of the male thread end's conductive rings 311, 312, 313 so

that the conductive rings 331, 332, 333 of the female thread end module are wiped clean of pipe dope prior to a connection being made. The o-rings 301, 303 forward and behind the conductive rings (which as shown may be doubled) also perform a wiping function. This figure also shows in more detail the connection rings and the annular conductor. A flat metallic portion 350 extends from the annular conductor 318 into an aperture this part of the conductive ring. A grub screw 351 then ensures a good electrical contact with the flat portion of the annular conductor 350. The garter spring 341 rests upon the head of the grub screw 351, as well as pressing upon the conductive ring 331 of the female thread end module 330.

When drill string joints are to be reused, the female thread may be worn and it is often desirable to re-cut the thread. As part of the process, a part of the of the female thread end 320 is removed (typically 2 cm or ¾ of an inch). Referring to figures 15a to 15c, to accommodate this process, the female thread end module 330 is removed, and the length of the liner tube 302 is reduced by the distance that the female thread end 320 is to be reduced by (or the liner tube 302 is replaced by a correspondingly shorter liner tube.) A new female thread end module 330 having a reduced distance between the socket 329 and the sealing member 334 is then introduced to the female thread end 320, so that the distance between the end of the female thread and the female thread end module's conductive rings 331, 332, 333 remains constant after re-cutting, and may be used as before. The extended socket head screw 338 length is either shortened or replaced with a shorter screw. The female thread end 320 may be re-cut on several occasions, with correspondingly shorter female thread end modules 330 being used after each re-cutting operation. The male thread end may also be re-cut; in this case, the liner tube 302 will again have to be re-sized,

the annular conductors 318 shortened and reconnected, and a fresh bypass bore 335 drilled through the male end 310 of the drill pipe section.

Referring to figure 16, in a modified embodiment, a box sealing carrier 404 is inserted into the box end of the drill pipe 400. The box sealing carrier 404 is preferably metallic in nature, and contains an annular groove 410 on its innermost surface (that is, to the left in the drawing). This annular groove 410 is designed to receive a metal gasket ring 411, such as a type R ring gasket. The box to box sealing carrier connection, with the metallic gasket 411 disposed in between, forms a soft metal seal. The box sealing carrier 404 is preferably attached to the box end of the drill pipe 400 by means of a screw or bolt (numeral 402 referring to a bolt hole or screw cavity). Such attachment method yields to easy removal, repair, and replacement.

As shown, the conductor 408 travels through the bore and through a passageway 412 in the box sealing carrier 404, opening to an annulus 414 proximate to the first conductive rings (first conductive ring carrier 416 is shown in the Figure). Also disposed within the box sealing carrier is an annular groove 407 designed to carry an elastomer seal 406 in order to further seal the conductive rings from wellbore fluid. This elastomer seal 406 is referred to as an internal electric contact seal. The internal electric contact seal is located in contact with the box sealing member 404 and the box shoulder or collar area. Preferably too, the internal electric contact seal is capable of being energized to further seal the conductive rings from internal wellbore fluid.

The provision of three conductors means that a three phase power supply may be transmitted down the drill string. Naturally, fewer or further

conductive paths may be provided using the principles described herein. In particular, a telemetry wireline may be provided over such a conductive path.

Claims

1. A generally tubular drill string having a conductive path over a plurality of drill pipe sections, each drill pipe section having a first end and a second end, and having a wall, and the first end having a first radial sealing surfaces and the second end having a corresponding second radial sealing surfaces, such that when the first or second end of one drill pipe section is engaged with the second or first end respectively of another drill pipe section, at least one seal is formed,
wherein the drill pipe includes at least one conductor disposed inside it, this conductor being connected to a first contact means at the first end and a corresponding contact means at the second end of each drill pipe section.

2. A drill string according to claim 1 wherein ingress protection means are provided to protect the contact means from ingress from inside or outside of the drill pipe section.

3. A drill string according to any previous claim, characterised in that the ingress protection means comprises a sealed volume surrounding the contact means.

4. A drill string according to any previous claim wherein the ingress protection means may comprise an inner sleeve or a seal.

5. A drill string according to any previous claim, characterised in that the ingress protection means is a pressure release duct from one side of the contact means to the other.

6. A drill string according to any previous claim wherein the first contact means and the second contact means are provided by corresponding conductive rings coaxial with the drill pipe.

7. A drill string according to any previous claim wherein the wall includes within it at least one bore.

8. A drill string according to any previous claim wherein the conductor is disposed within the bore.

9. A drill string according to any previous claim wherein there are provided three bores each including a conductor, and these conductors respectively connected to a first three conductive rings at the first end, and a second three conductive rings at the second end, such that when the first or second end of one drill pipe section is engaged with the second or first end respectively of another drill pipe section, the three conductive connections are formed in the sealed volume to provide three conductive paths over the plurality of drill pipe sections

10. A drill string according to any previous claim wherein the first three conductive rings are axially spaced, and the second three conductive rings are axially spaced.

11. A drill string according to any previous claim wherein the first three conductive rings are notched to receive an outer ring conductor, such that the conductive connections consist of the first three conductive rings in contact with the outer ring conductor.

12. A drill string according to any previous claim wherein the outer ring conductor comprises an annular spring.

13. A drill string according to any previous claim wherein the bore is essentially parallel to the axis of the drill pipe section.

14. A drill string according to any previous claim wherein the aspect ratio of the conductor is not equal to one.

15. A drill string according to any previous claim wherein the cross-sectional form of the conductor is essentially rectangular in nature.

16. A drill pipe section according to any previous claim wherein there is provided a moveable seal, such that when the first or second end of one drill pipe section is engaged with the second or first end respectively of another drill pipe section, the moveable seal is displaced over the surface of the contact means.

17. A drill string according to any previous claim wherein there is included a pressure balancing means capable of varying the pressure of the sealed volume to reduce the pressure difference between the sealed volume and the environment.

18. A drill string according to any previous claim wherein the pressure balancing means includes a pressure relief valve.

19. A drill string according to any previous claim wherein the bore includes first and second portions formed in the wall of a drill pipe section, these first and second portions being joined by tubing means.

20. A drill pipe section according to any previous claim.

21. A generally tubular drill pipe having a conductive path over a plurality of drill pipe sections, each drill pipe section having a first end and a second end, and having a wall, and the first end having a first radial sealing surfaces and the second end having a corresponding second radial sealing surfaces, such that when the first or second end of one drill pipe section is engaged with the second or first end respectively of another drill pipe section, at least one seal is formed,
wherein a conductor is connected to a first contact means at one end and a plug at the other end, and,
wherein ingress protection means are provided to protect the contact means from ingress from inside or outside of the drill pipe section.

22. A drill pipe according to claim 21 wherein the plug connects to a module by means of an electrical socket.

23. A drill pipe according to claim 22 wherein the module contains a second contact means.

24. A drill pipe according to claim 23 wherein the first contact means and the second contact means are provided by corresponding conductive rings coaxial with the drill pipe.

25. A drill pipe according to claim 24 wherein the wall includes within it at least one bore, the bore having a conductor disposed inside it, and this conductor being connected to a first conductive ring at the first end, and a plug at the second end, wherein the plug is capable of receiving a module

therein containing an equal number of conductive rings, such that when the first or second end of one drill pipe section is engaged with the second or first end respectively of another drill pipe section, the conductive connections are formed in the sealed volume to provide conductive paths over the plurality of drill pipe sections.

26. A drill string according to claim 24 wherein the first three conductive rings are axially spaced, and the second three conductive rings are axially spaced.

27. A drill string according to claim 26 wherein the first three conductive rings are notched to receive an outer ring conductor, such that the conductive connections consist of the first three conductive rings in contact with the outer ring conductor.

28. A drill string according to claim 27 wherein the outer ring conductor comprises an annular spring.

29. A generally tubular drill pipe having a conductive path over a plurality of drill pipe sections, each drill pipe section having a first end and a second end, and having a wall, and the first end having a first radial sealing surfaces and the second end having a corresponding second radial sealing surfaces, such that when the first or second end of one drill pipe section is engaged with the second or first end respectively of another drill pipe section, at least one seal is formed,
wherein the wall includes within it at least one bore, the bore having a conductor disposed inside it, this conductor being connected to a first contact means at the first end and disposed to travel through a box sealing carrier at the second end of each drill pipe section,

wherein ingress protection means are provided to protect the contact means from ingress from inside or outside of the drill pipe section.

30. A drill pipe according to claim 29 wherein the box sealing member has an inner cavity for the conductor to travel through, wherein further the conductor is connected to a second contact means at the second end of the drill pipe.

31. A drill pipe according to claim 29 wherein the ingress protection means are provided to protect the contact means from ingress from inside or outside of the drill pipe section, and consists of a soft metal seal formed between the second end of the drill pipe and the box sealing member.

32. A drill string according to claim 30 or claim 31 wherein the ingress protection means consists of an internal electric contact seal located in contact with the box sealing member and a collar of an adjoining drill pipe section.

33. A drill string according to claim 32 wherein the first three conductive rings are notched to receive an outer ring conductor, such that the conductive connections consist of the first three conductive rings in contact with the outer ring conductor.

34. A drill string according to claim 33 wherein the outer ring conductor comprises an annular spring.

35. A conductive connection for use between two tubulars comprising:

a terminating portion of a conductor in a female end of a first tubular;

a mating terminating portion of a conductor around a male end of a second tubular; and,

a sealed volume formed when the first and second tubulars are threaded together, the sealed volume housing the conductive connection.

36. The conductive connection of claim 35 wherein the sealed volume includes a bypass duct from one side of the conductive connection to the other.

37. The conductive connection of claim 35 wherein the sealed volume includes a pressure relief valve.

38. The conductive connection of claim 35 wherein the conductor is covered by a protective member.

39. The conductive connection of claim 38 wherein the protective member is an inner sleeve.

40. The conductive connection of claim 37 wherein the terminating portion of the conductor comprises a contact and the mating terminating portion of the conductor comprises a second contact.

41. The conductive connection of claim 40 wherein the contact and the second contact are connected to the conductor by a connection member.

42. The conductive connection of claim 41 wherein the connection member comprises a plug and socket.

43. The conductive connection of claim 40 wherein the contact comprises a resilient member.

44. The conductive connection of claim 42 wherein the resilient member is an annular spring.

45. The conductive connection of claim 40 wherein the second contact comprises a resilient member.

46. The conductive connection of claim 45 wherein the resilient member is an annular spring.

47. The conductive connection of claim 35 wherein the conductive path comprises a wire having an aspect ration other than one.

48. The conductive connection of claim 40 wherein the contact is selectively removable.

49. The conductive connection of claim 40 wherein the second contact is selectively removable.

50. The conductive connection of claim 42 wherein the connection member is selectively removable.

51. A first drill pipe section for use in a drill pipe string. The drill pipe section comprising:

a first end and a second end;

a conductive path connecting the first and second ends;

the conductive path being connected to a first contact member and a second contact member at the second end;

a first seal member at the first end and a second seal member at the second end;

the first and second seal members for sealing engagement with a first or second end respectively of a second drill pipe section; and,

the sealing engagement forming a sealed volume and the contact members being within the sealed volume.

52. The drill pipe of claim 51 wherein the sealed volume includes a bypass duct from one side of the contact member to the other.

53. The drill pipe of claim 51 wherein the sealed volume includes a pressure relief valve.

54. The drill pipe of claim 51 wherein the conductive path is covered by a protective member.

55. The drill pipe of claim 54 wherein the protective member is an inner sleeve.

56. The drill pipe of claim 51 wherein the first contact member comprises a contact and the second contact member comprises a second contact.

57. The drill pipe of claim 56 wherein the contact and the second contact are connected to the conductor by a connection member.

58. The drill pipe of claim 57 wherein the connection member comprises a plug and socket.

59. The drill pipe of claim 56 wherein the contact comprises a resilient member.

60. The drill pipe of claim 59 wherein the resilient member is an annular spring.

61. The drill pipe of claim 56 wherein the second contact comprises a resilient member.

62. The drill pipe of claim 61 wherein the resilient member is an annular spring.

63. The drill pipe of claim 51 wherein the conductive path comprises a wire having an aspect ration other than one.

64. The drill pipe of claim 56 wherein the contact is selectively removable.

65. The drill pipe of claim 56 wherein the second contact is selectively removable.

66. The conductive connection of claim 58 wherein the connection member is selectively removable.

67. A drill string as described and illustrated herein.

68. A drill pipe section as described and illustrated herein.

69. Any novel and inventive feature or combination of features specifically disclosed herein within the meaning of Article 4H of the International Convention (Paris Convention).

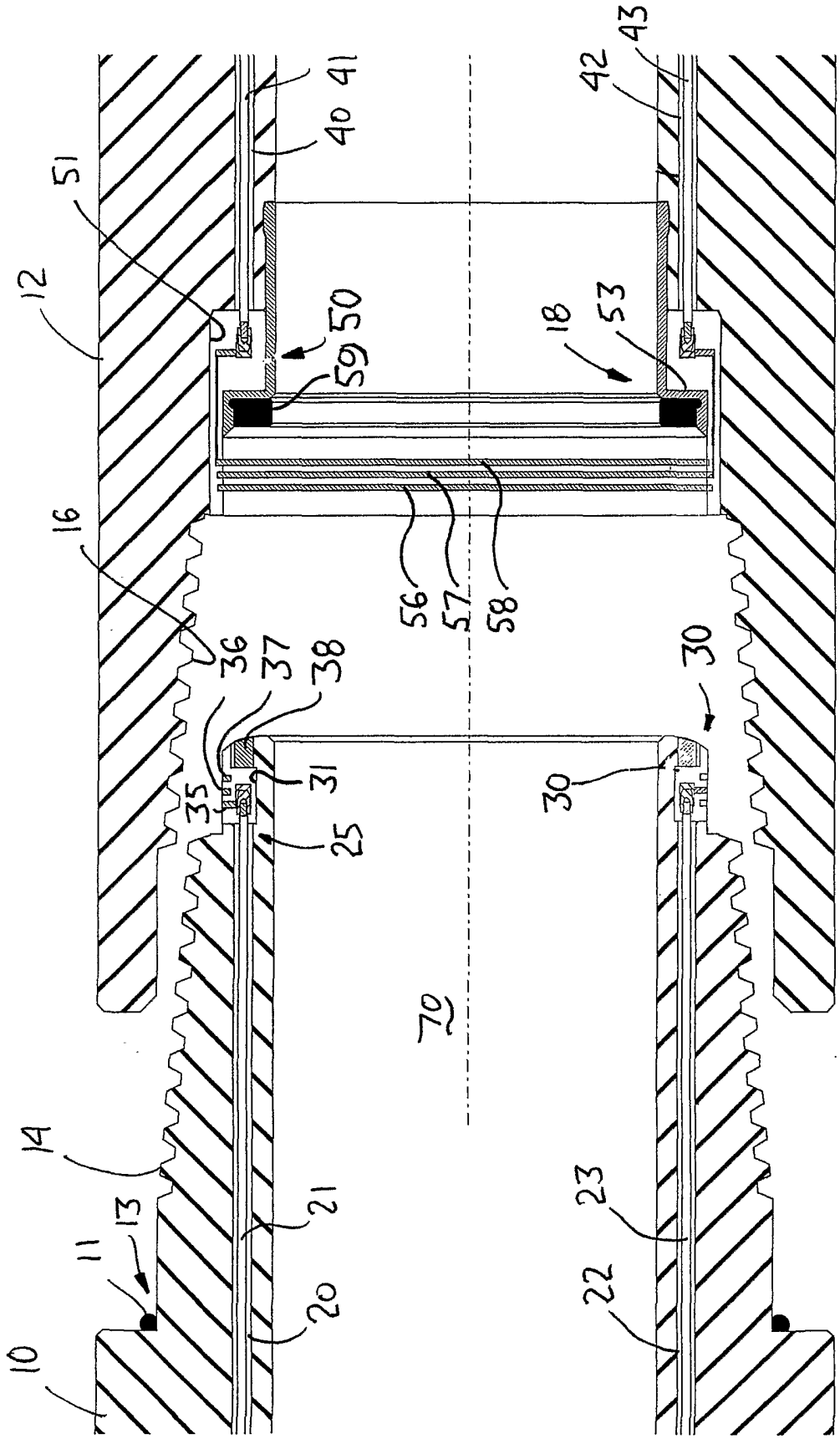
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Fig. 1

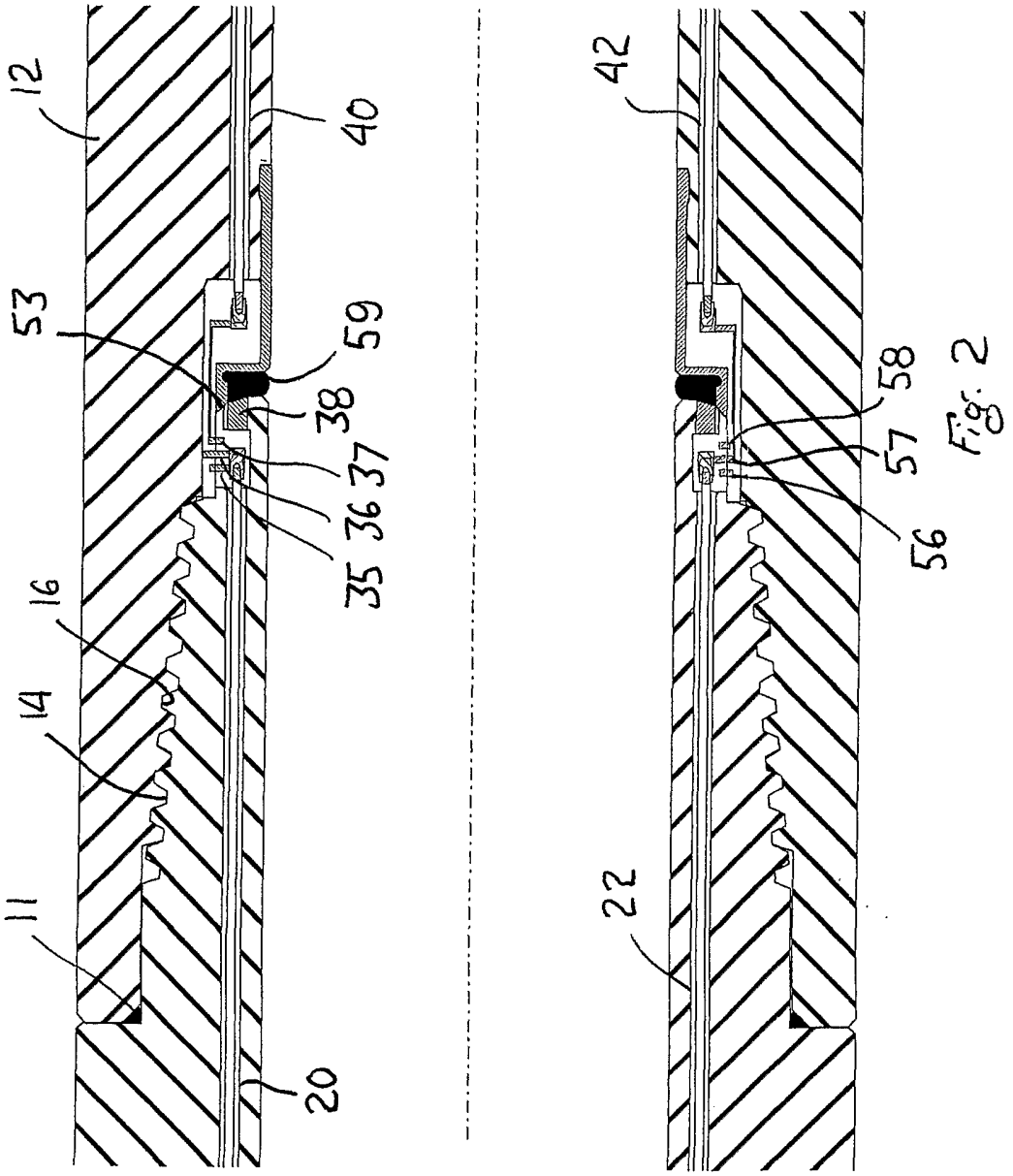

Fig. 2

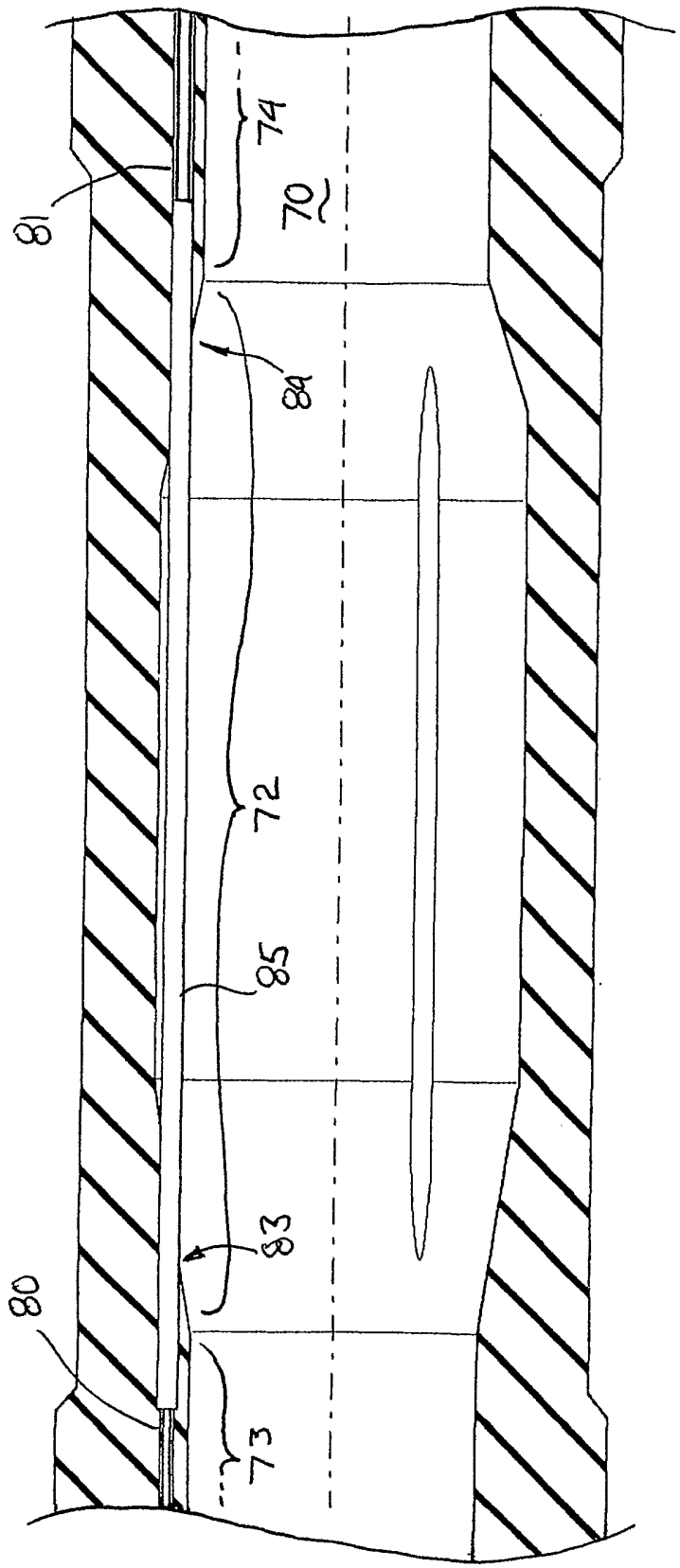

Fig. 3

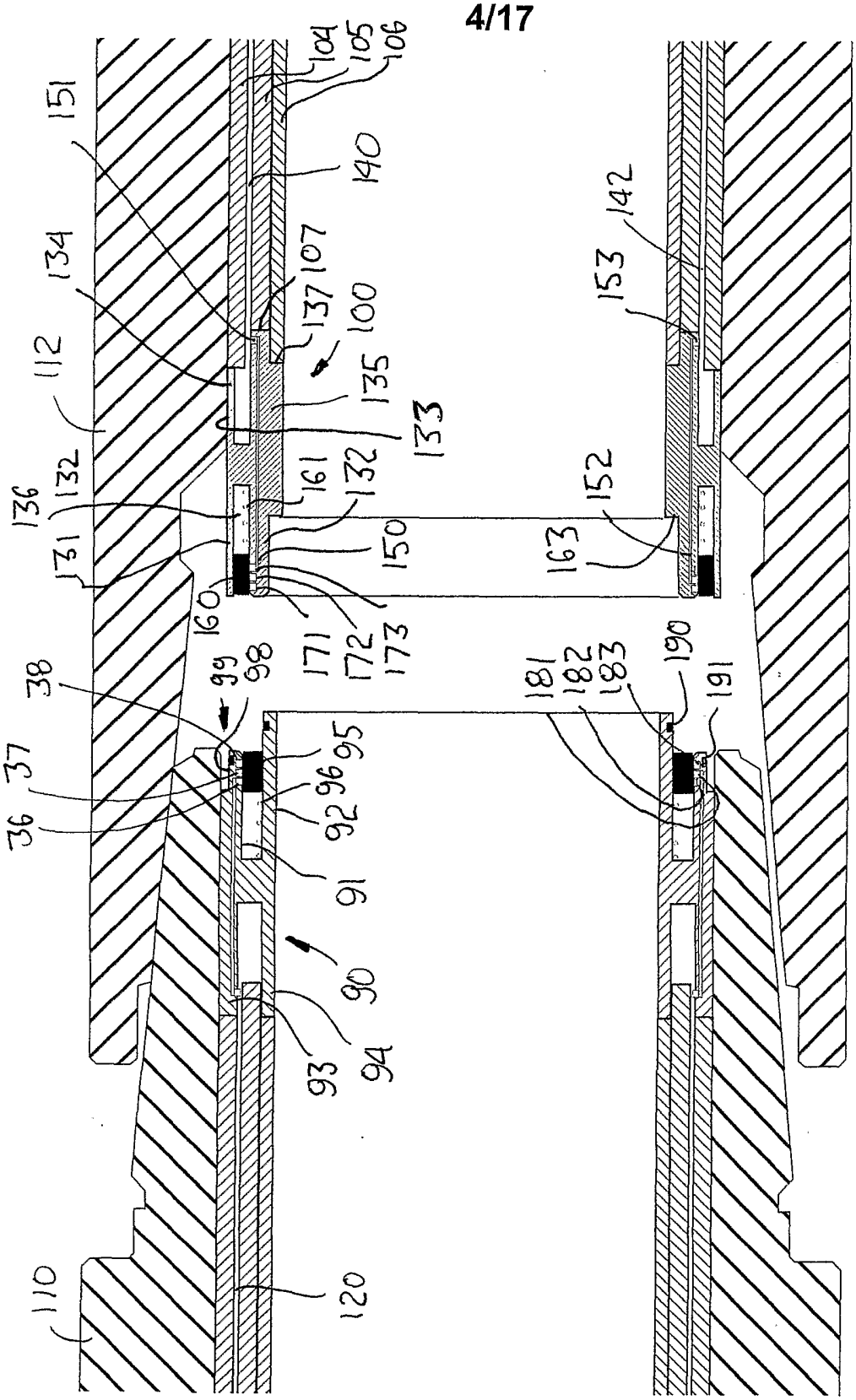
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Fig. 4

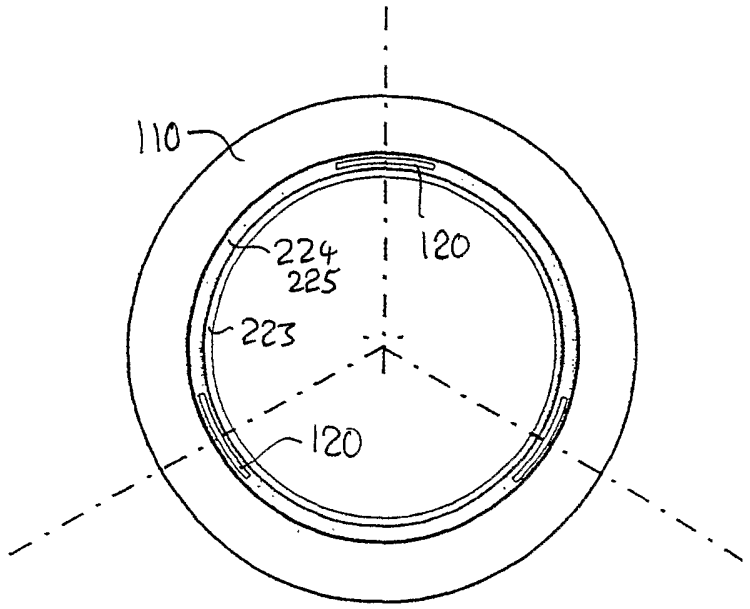

Fig. 4a

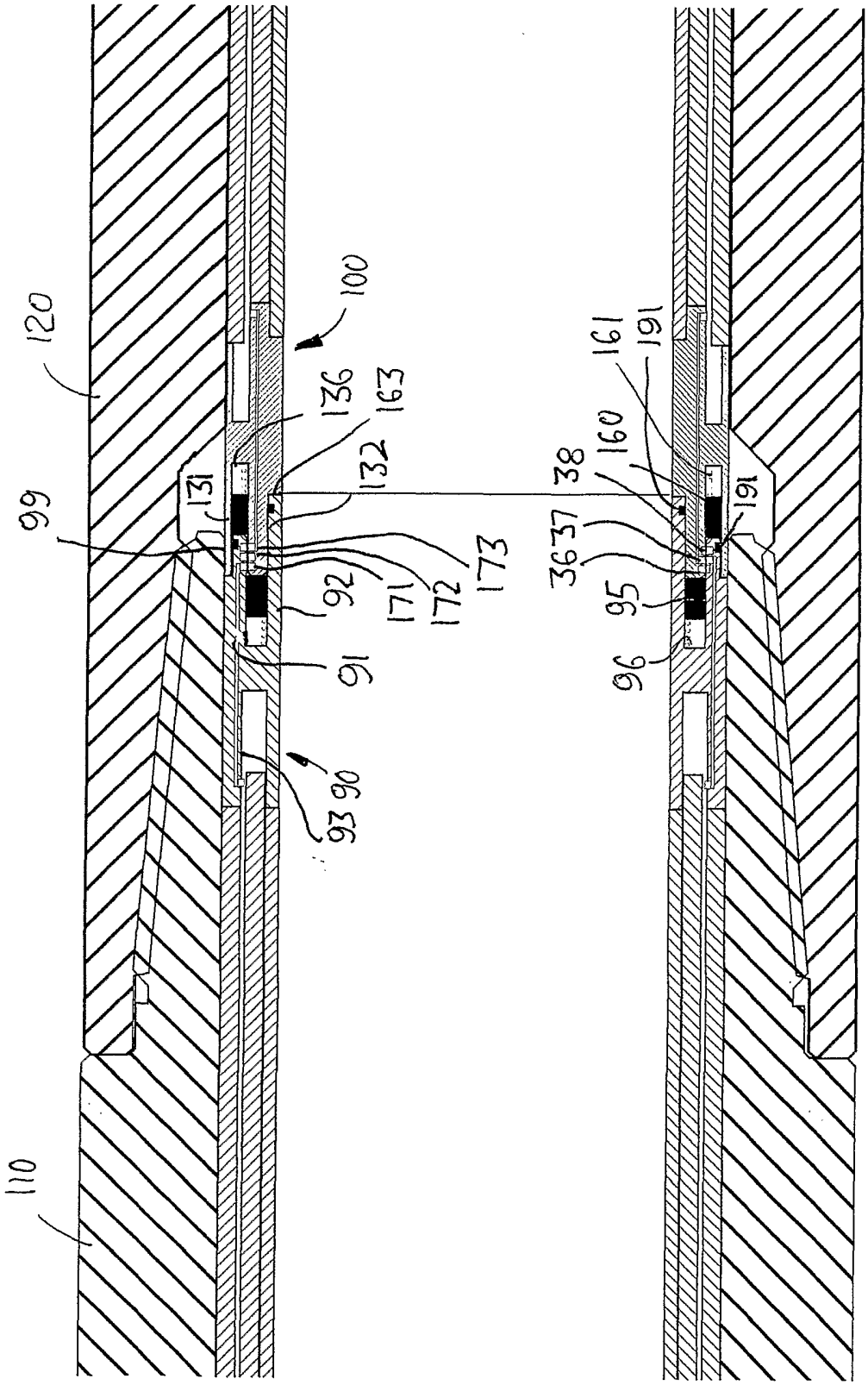
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Fig. 5

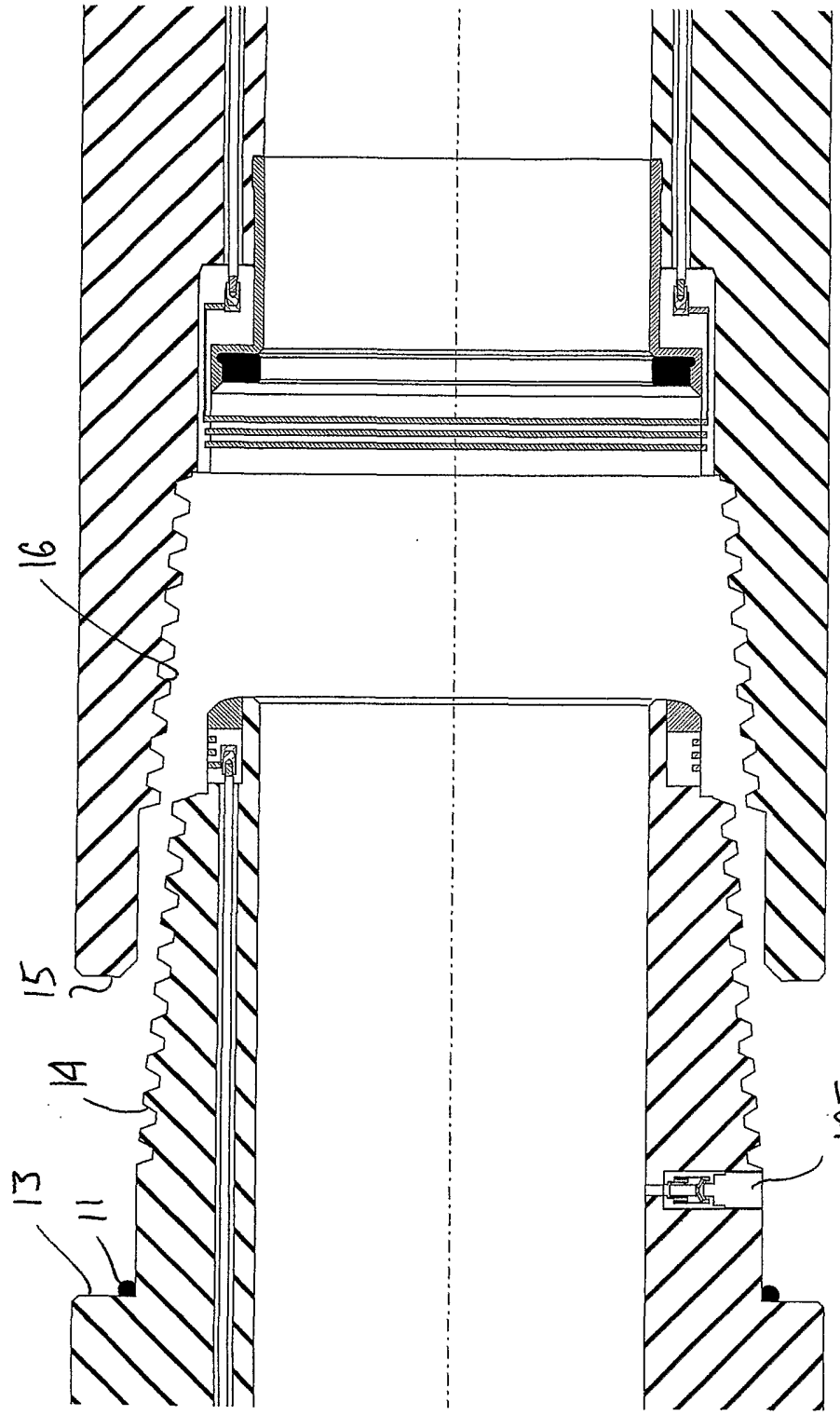
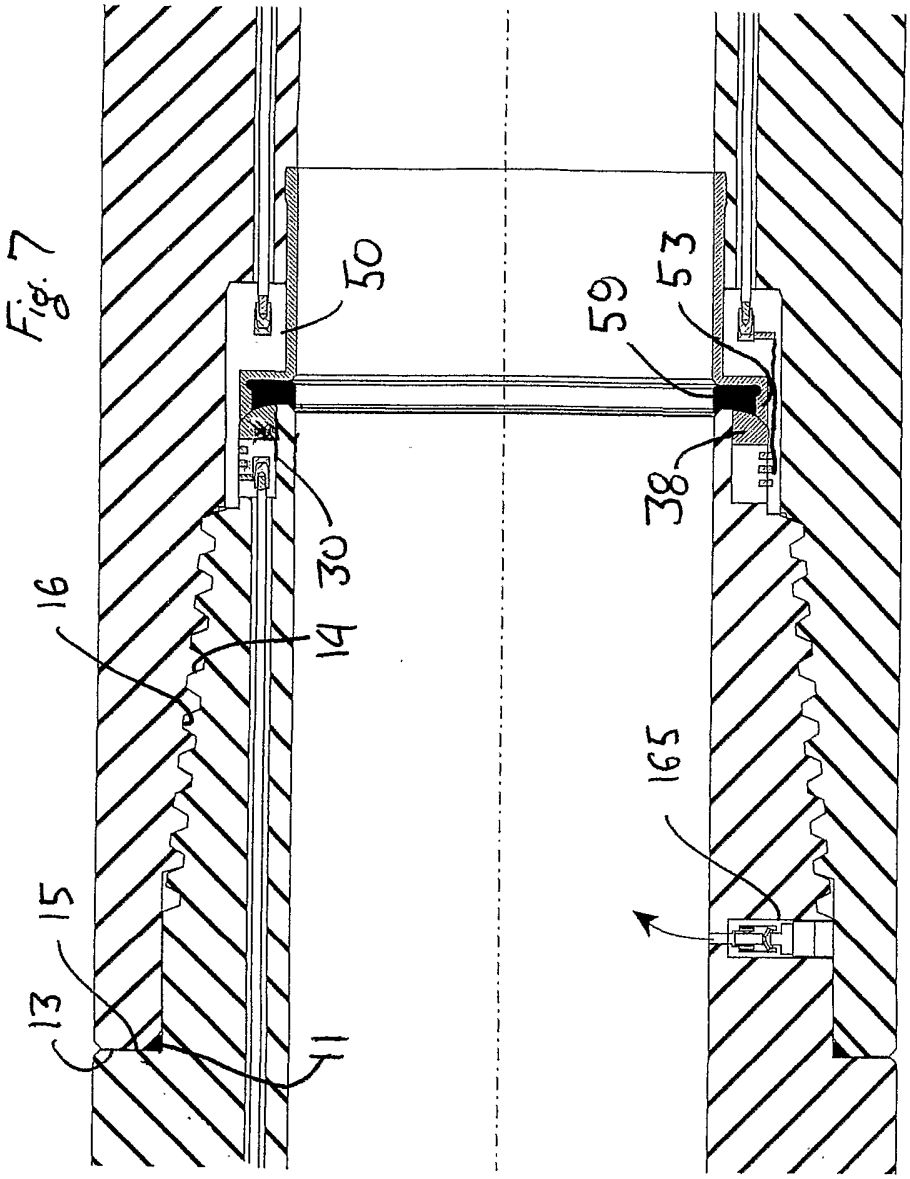


Fig. 6

Fig. 7



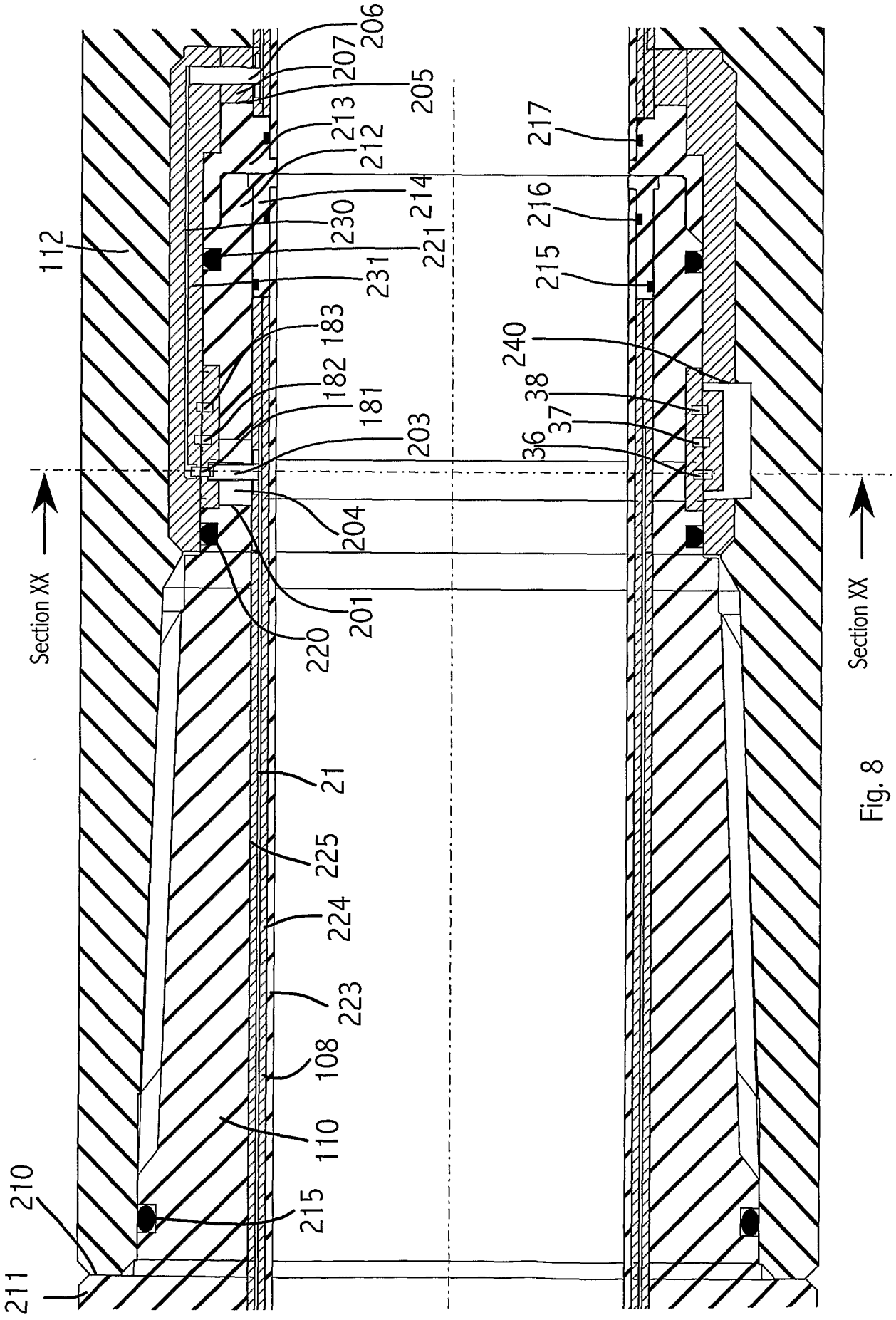

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Fig. 8

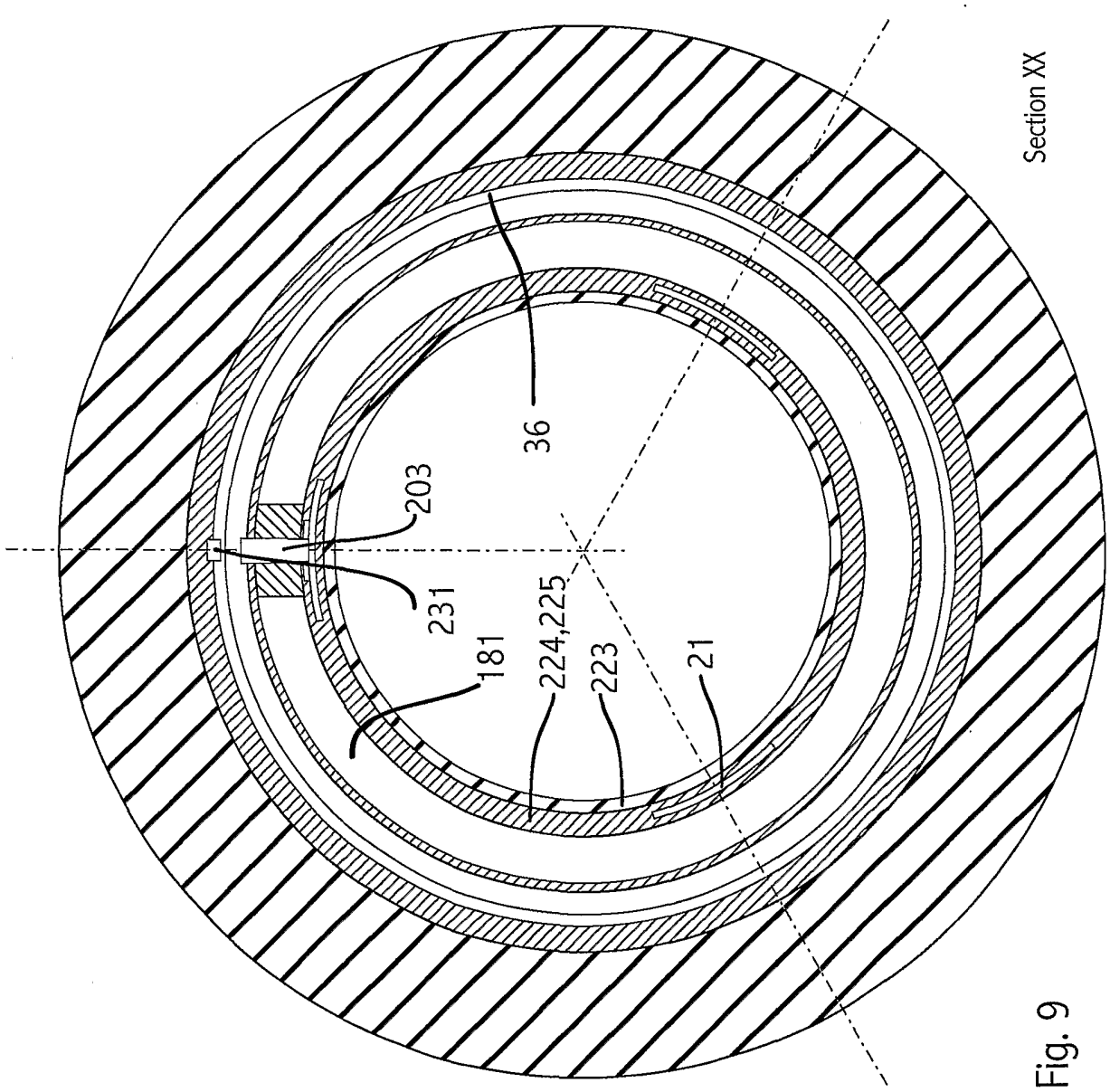

Fig. 9

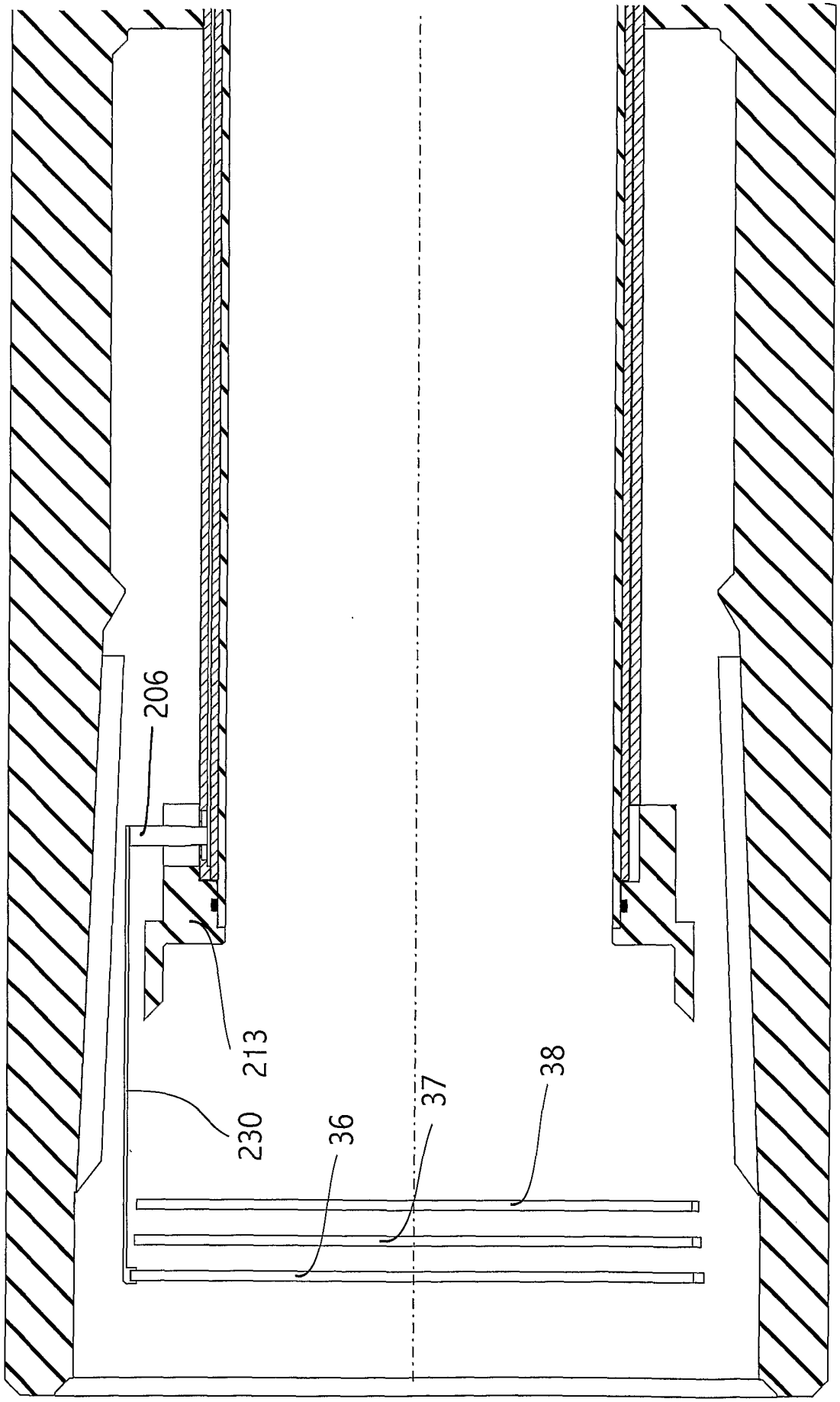

Fig. 10

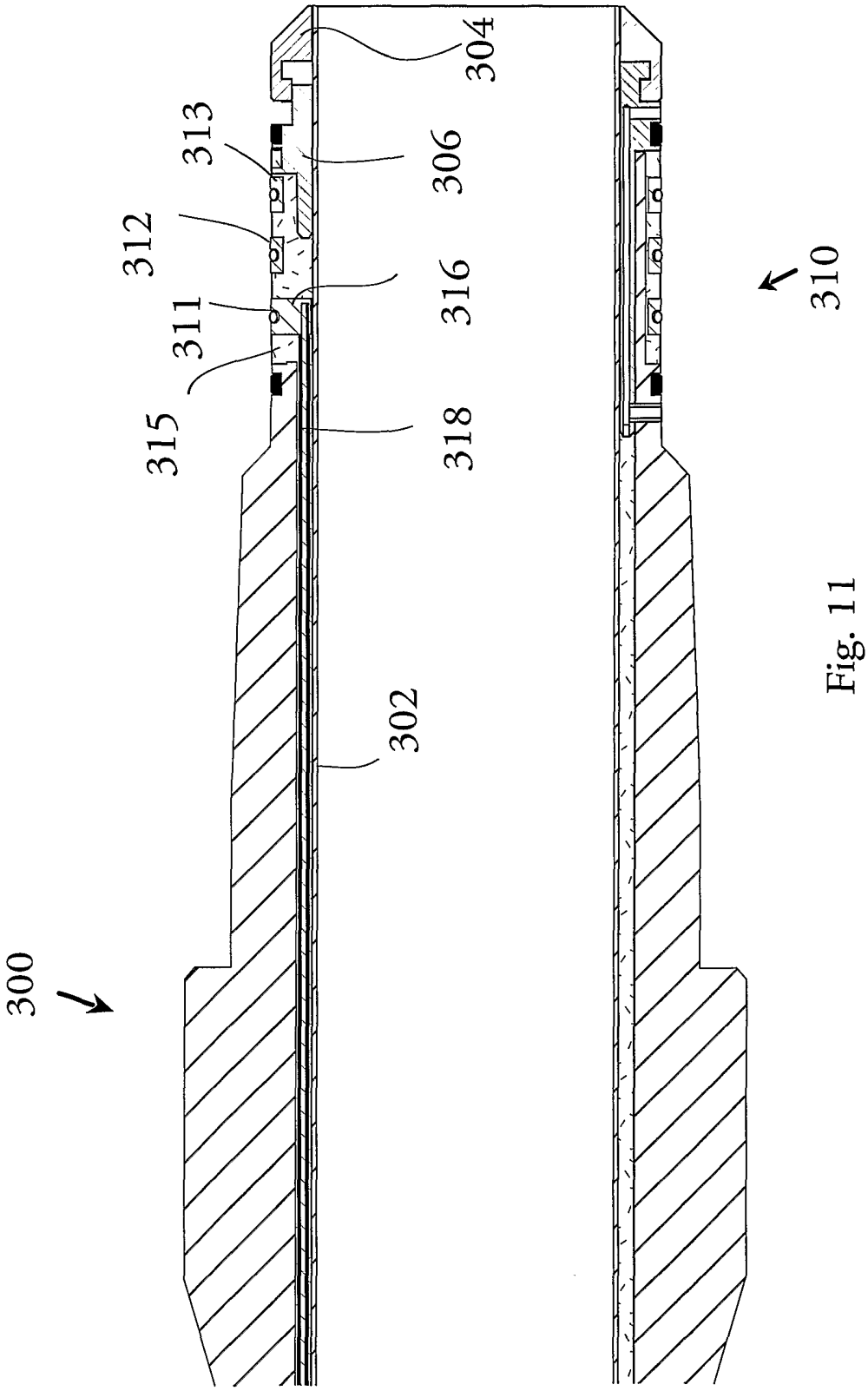

Fig. 11

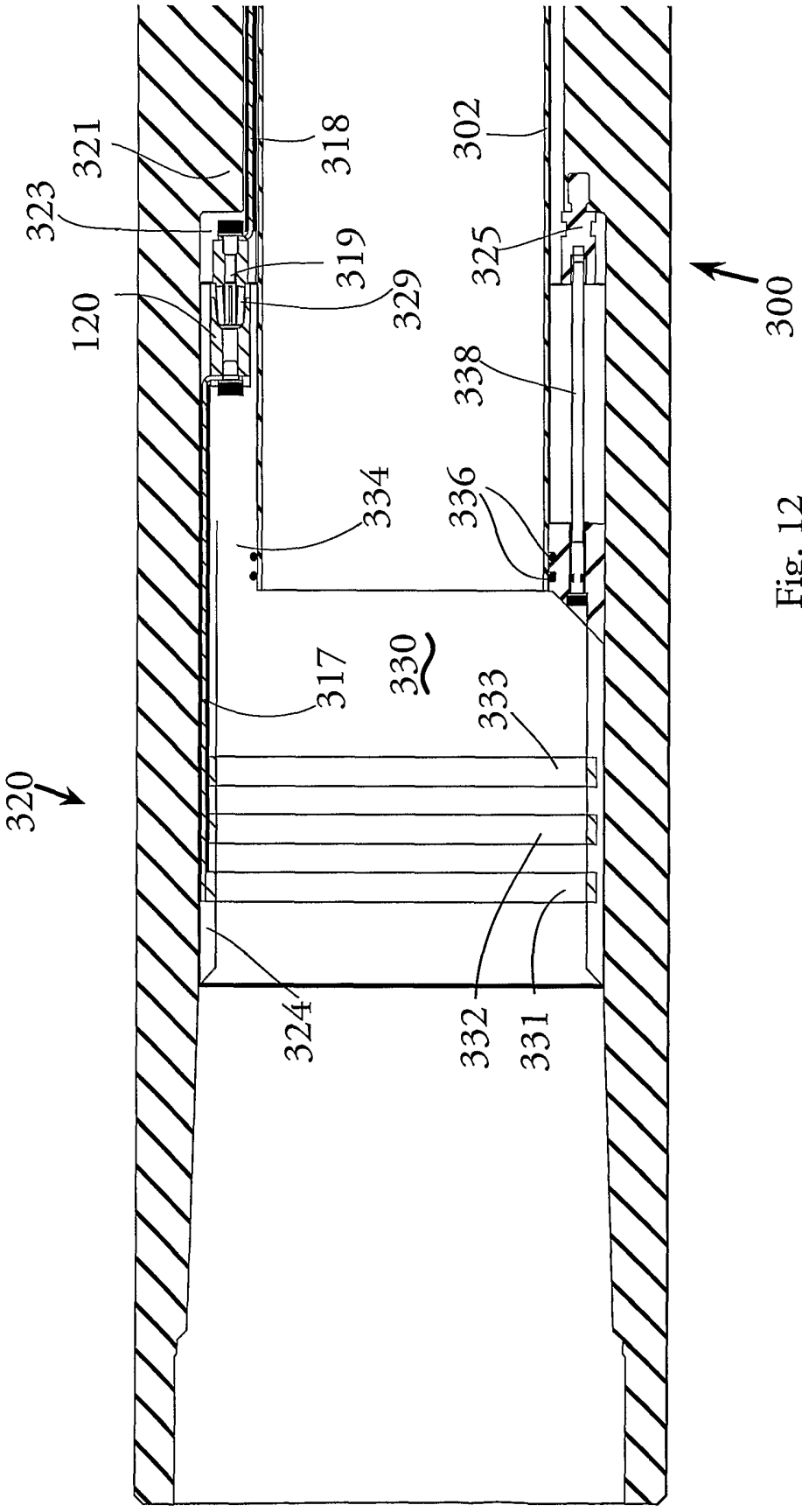
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Fig. 12

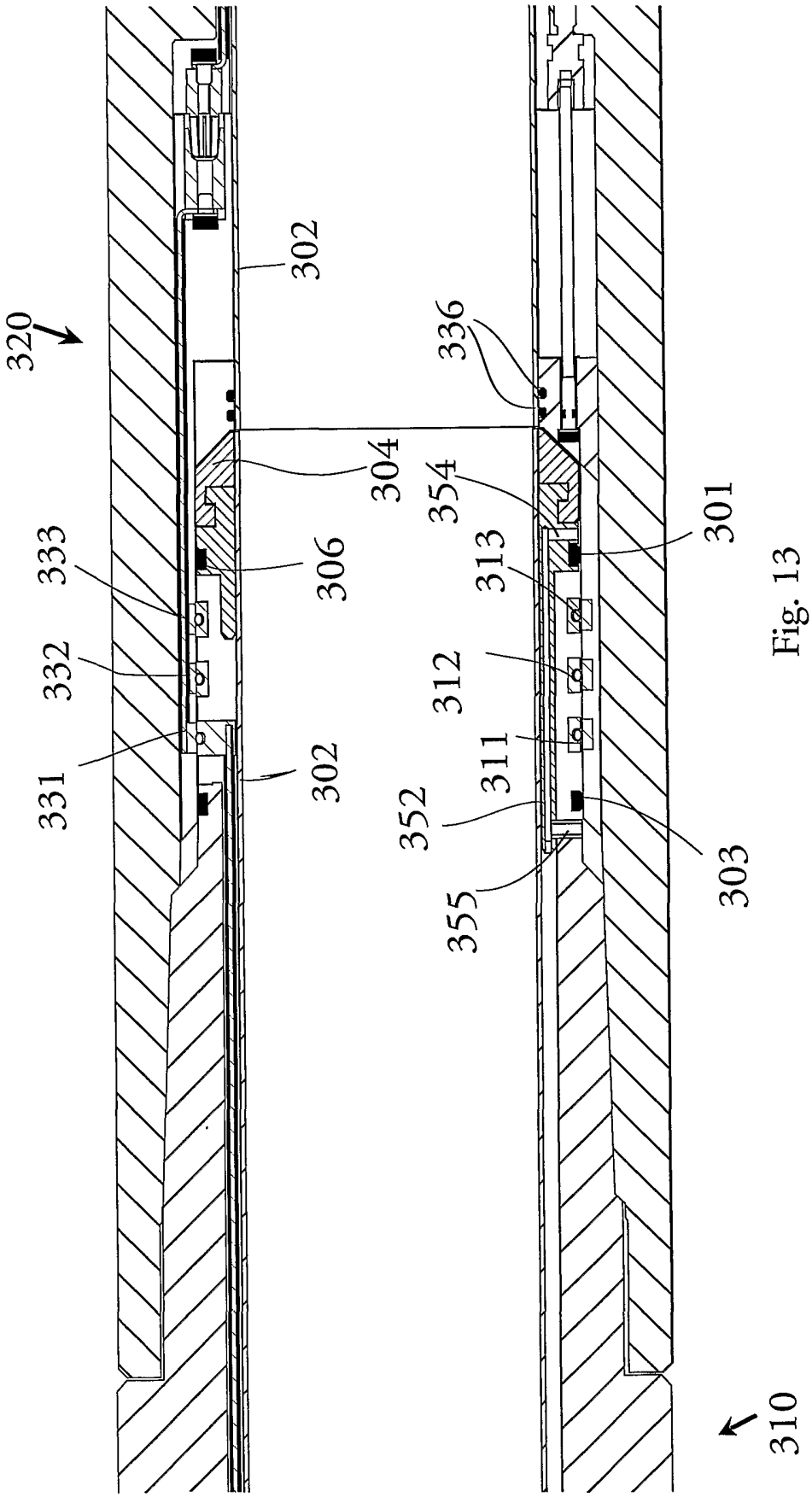
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Fig. 13

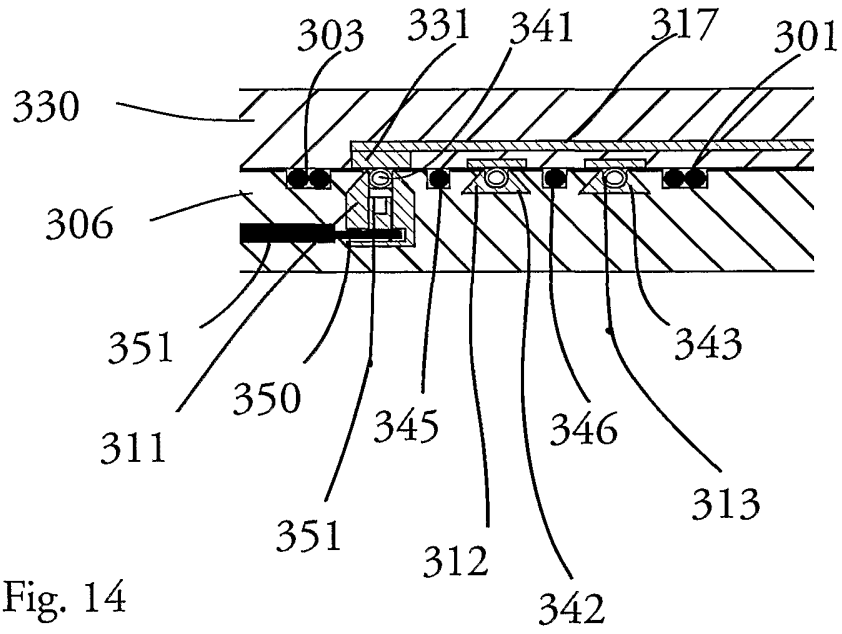
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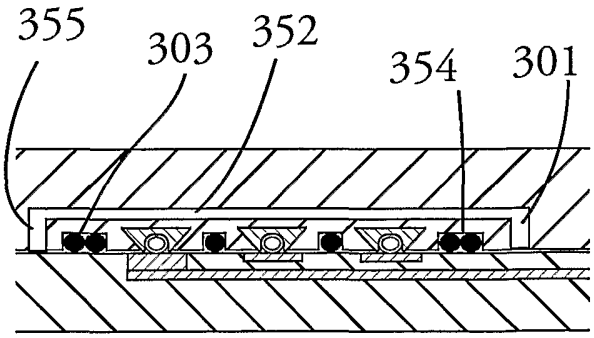
Fig. 14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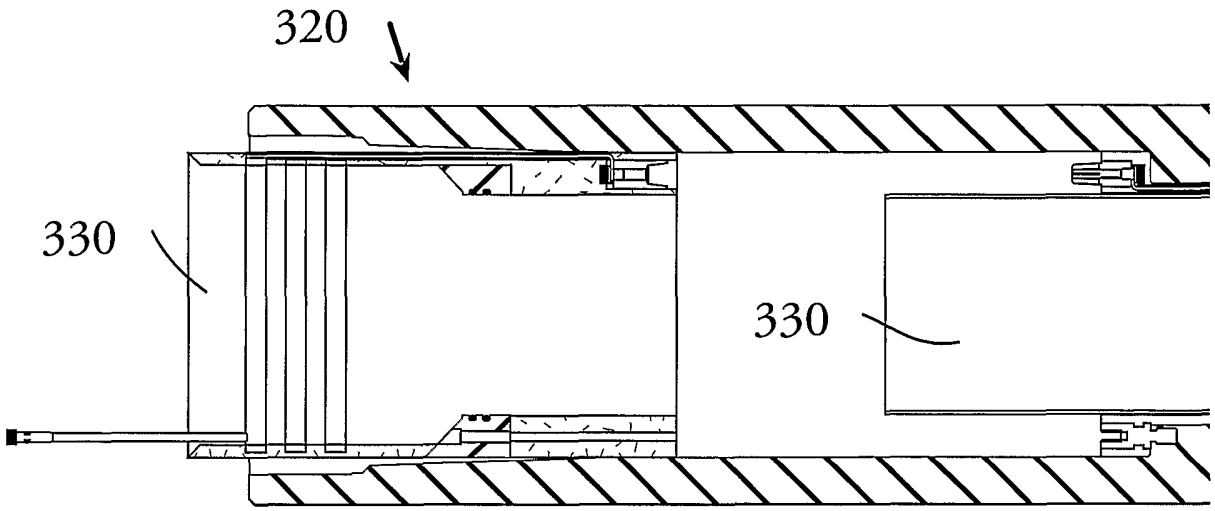

Fig. 15a

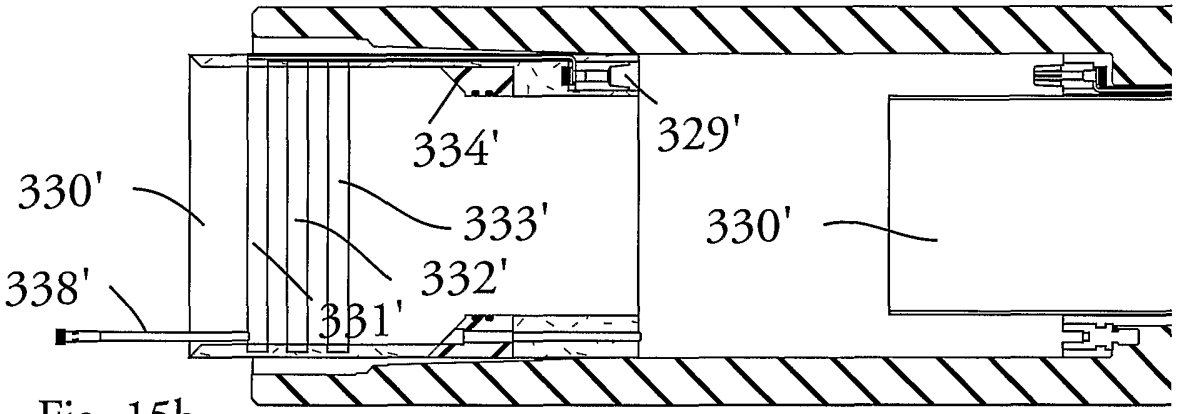

Fig. 15b

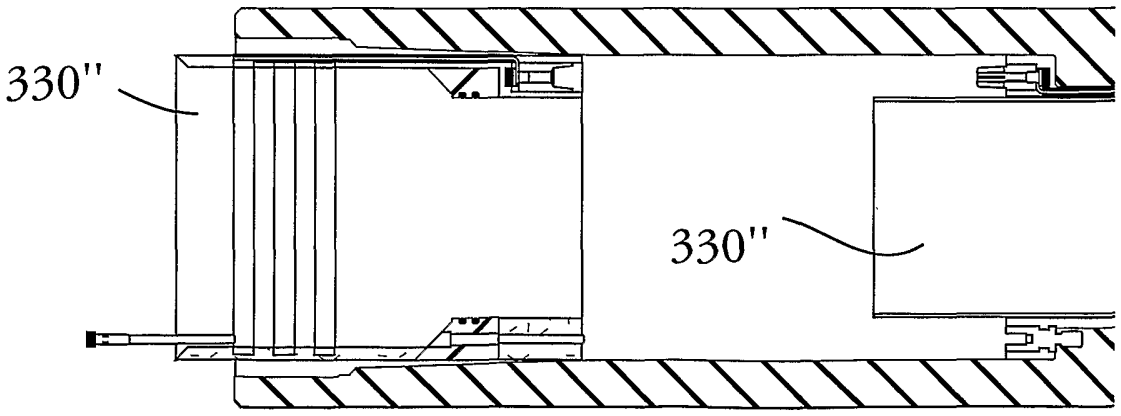

Fig. 15c

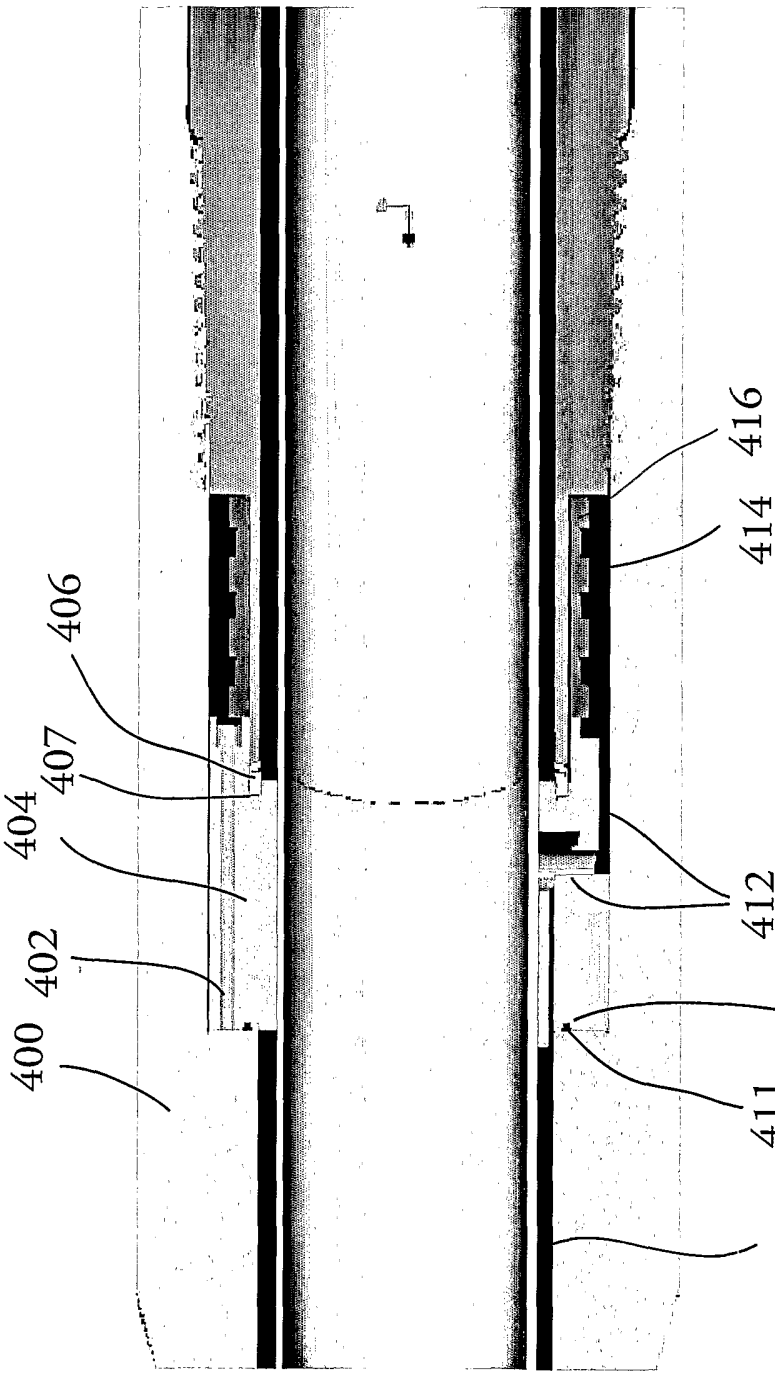

FIG. 16

INTERNATIONAL SEARCH REPORT

International Application No
PCT/GB 02/02933

A. CLASSIFICATION OF SUBJECT MATTER
IPC 7 E21B17/02

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 7 E21B

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

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)
EPO-Internal

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 3 518 609 A (FONTENOT JOHN E JR) 30 June 1970 (1970-06-30) the whole document	1-4,7,8, 13,19, 20,35, 38-40, 43-46,51
X	US 4 557 538 A (CHEVALIER ANDRE) 10 December 1985 (1985-12-10) the whole document	21-30,35
X	DE 11 89 934 B (JOHANN GRUBER) 1 April 1965 (1965-04-01) the whole document	1-3,35, 51
X	US 3 879 097 A (OERTLE DON H) 22 April 1975 (1975-04-22) the whole document	1,35,51

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[X] Further documents are listed in the continuation of box C.

[X] Patent family members are listed in annex.

° Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance
"E" earlier document but published on or after the international filing date
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.
"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
18 October 2002	07/11/2002

Name and mailing address of the ISA	Authorized officer
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Form PCT/ISA/210 (second sheet) (July 1992)

INTERNATIONAL SEARCH REPORT

ational Application No
PCT/GB 02/02933

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

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