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(71) Applicant *(for all designated States except US)*: **ABB VETCO GRAY LTD.** [GB/GB]; Broadfold Road, Bridge of Don Industrial Estate, Aberdeen ABB23 8ES (GB).

(72) Inventors; and

(75) Inventors/Applicants *(for US only)*: **RUESSE, Rolf, August, Heinrich** [DE/DE]; Bungerstrasse 18, 29342 Wienhausen (DE). **BUCHAN, Robert, Samuel** [GB/GB]; 31 Elm Place, Aberdeen AB25 3SN (GB).

(74) Agent: **FORRESTER KETLEY & CO**; Forrester House, 52 Bounds Green Road, London N11 2EY (GB).

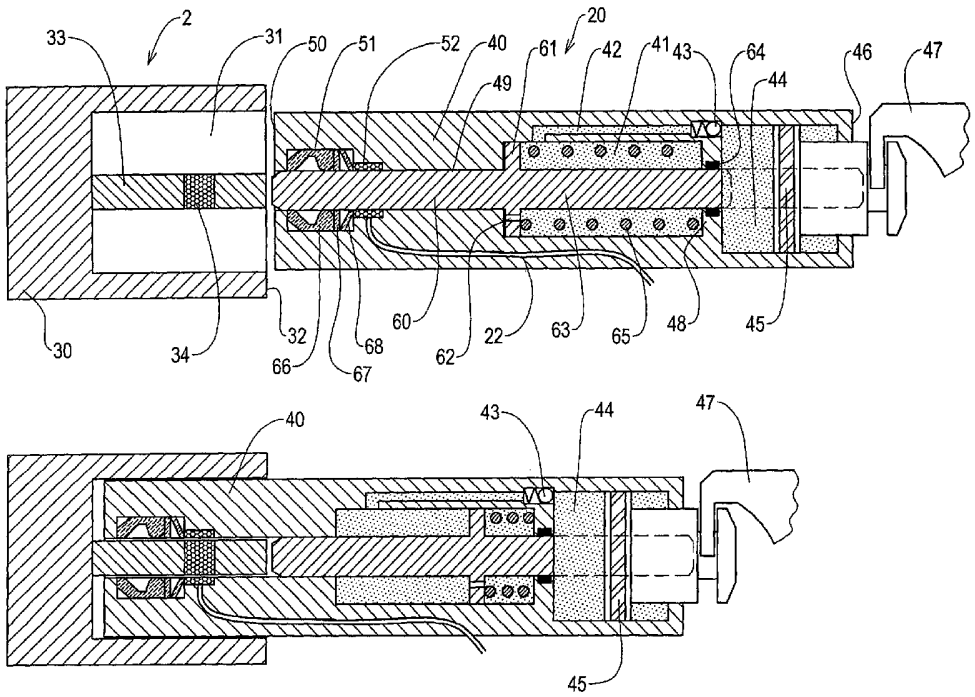
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(54) Title: AN ELECTRICAL CONNECTOR



(57) Abstract: An electrical penetrator connector includes a fixed pin unit (2) incorporating a fixed pin (33), part of the exterior of the pin forming an electrical contact (34). A reciprocatable assembly (20) defines a bore which receives a slideable shuttle pin (60). A dielectric fluid chamber (41) receives part of the pin. A piston (45) applies hydraulic pressure to the dielectric fluid.

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"AN ELECTRICAL CONNECTOR"

THE PRESENT INVENTION relates to an electrical penetrator connector, and more particularly relates to an electrical connector which is a "wet mate" connector. Wet mate connectors are used in many underwater applications. For example, reference may be made to underwater vessels such as submarines, and also to underwater remotely operated vehicles (ROVs).

It is envisaged that connectors in accordance with the present invention may be suitable for use in any underwater application, but may be, in particular, suitable for use in an underwater housing assembly of an oil or gas well. It is to be appreciated that electrical connections are often provided in housing assemblies of well-heads to provide high power circuits, which may be used to supply power to items of equipment such as pumps, and also for control and sensor signalling circuits.

Electrical connectors intended for use in an underwater situation, such as in a submarine, ROV or well-head, must be capable of withstanding the harsh environment to which they will be subjected. Often connections have to be made or un-made whilst parts of the connector are exposed to sea water or well fluid. It is important that a connector that forms part of an oil or gas well

should be reliable, since very substantial expense is incurred in retrieving a connector of this type should a repair be necessary.

The present invention seeks to provide an improved electrical penetrator connector.

According to the invention there is provided an electrical penetrator connector, the electrical penetrator connector comprising of fixed pin unit and a reciprocatable assembly, the fixed pin unit including at least one fixed pin, at least part of the exterior of the pin being of electrically conductive material, the pin having a predetermined diameter, the reciprocatable assembly comprising of body, the body defining of dielectric fluid chamber, there being a dielectric fluid reservoir connected to the dielectric fluid chamber through a non-return valve, and a piston for applying hydraulic pressure to fluid within the reservoir, the chamber being associated with the bore extended from one end of the chamber to one end of the body, the bore containing a retractable pin having substantially the same diameter as the fixed pin, the bore being provided with a seal substantially sealing the pin, part of the wall of the bore between the seal and the dielectric fluid chamber being of electrically conductive material, resilient means being provided to bias a retractable pin to an initial position in which one end of the pin extends through the seal, the retractable pin being moveable, against the bias, upon movement of the reciprocatable assembly such that the end of the fixed pin is brought into engagement with the end of the retractable pin to drive the retractable pin against the resilient bias, to bring the conductive part of the exterior of the fixed into engagement with the conductive part of the bore to establish an electrical connection.

In this Specification the term dielectric fluid includes dielectric fluids which take the form of dielectric gels. The dielectric fluid used in a practicable

embodiment of the invention may be any fluid that is an electric insulator, and which does not support the flow of an electric current.

Preferably a mechanism is provided to move the reciprocatable assembly, the mechanism being configured to apply pressure to the piston such that the piston will increase the hydraulic pressure of fluid within the reservoir.

In one embodiment the drive mechanism applies pressure directly to the piston.

Alternatively the drive mechanism comprises a component having a lost motion connection with the said body, there being a resilient element between the component and the piston such that the resilient element may be compressed to apply pressure to the piston during a lost motion movement of the component relative to the body.

Conveniently the body is provided with a locking dog adapted to lock the body to a fixed member whilst still permitting movement of said component.

Preferably the resilient element is a spring contained within the dielectric fluid chamber.

Advantageously the retractable pin is provided with an extension, the extension extending through a seal provided at the other end of the dielectric fluid chamber so as to extend beyond the chamber upon retraction of the pin such that, on retraction of the pin the effective volume of the chamber is not substantially altered.

Conveniently a pressure relief valve is provided connecting the chamber and the reservoir, the pressure relief valve being configured to open when a predetermined high pressure exists within the chamber.

In one embodiment the fixed pin is provided with a plurality of spaced-apart elements of electrically conductive material each in communication with a respective core of a cable, and the bore is provided with a corresponding plurality of spaced-apart elements of electrically conductive material, also each in communication with a respective core of a cable.

Preferably the fixed pin unit is provided with a plurality of said pins and the reciprocatable assembly is provided with a plurality of said retractable pins.

Conveniently the reciprocatable body is reciprocatable by a reciprocating mechanism accessible from the exterior of the well.

Advantageously the reciprocatable element is connected to a coupler yoke, the coupler yoke having a threaded portion which matingly engages with a corresponding threaded portion provided on a rotatable element, the rotatable element having part thereof accessible to effect rotation thereof from the exterior of the well.

In order that the invention may be more readily understood, and so that further features thereof may be appreciated, the invention will now be described, by way of example, with reference to the accompanying drawings in which:

FIGURE 1 is a part sectional schematic view of part of a well-head illustrating a penetrator that incorporates a connector in accordance with the invention,

FIGURE 2 is a diagrammatic sectional view of components of a connector in accordance with the invention in an initial un-connected condition,

FIGURE 3 is a view corresponding to Figure 2 illustrating the components of the connector in the connected condition,

FIGURE 4 is a view corresponding to Figure 2 illustrating the components of a second embodiment of the invention in the connected condition,

FIGURE 5 is a view illustrating part of a modified connector,

FIGURE 6 is an end view of part of a further modified connector,

FIGURE 7 is a diagrammatic view of yet a further connector in accordance with the invention in a connected condition, with parts being cut-away for the sake of clarity of illustration,

FIGURE 8 is a view of the connector of Figure 6 in the disconnected condition, and

FIGURE 9 is a view on an enlarged scale of part of a modified connector similar to that of Figures 7 and 8.

The invention will be described, with reference to embodiments designed for use with components of a well-head for an oil or gas well, although the described embodiments may be used in other contexts.

Referring initially to Figure 1 of the accompanying drawings, a first component in the form of a hanger body 1 forming part of a well-head is provided with a fixed coupler pin unit 2, which forms part of a releasable electric penetrator connector which will be described in greater detail hereinafter. The fixed couple pin unit 2 is received within a recess 3 which opens into a side-wall of the hanger body 1. The fixed coupler pin unit 2 is electrically connected, by means of a connecting arrangement 4, to a coupler 5 provided within the hanger body which may be coupled to electrical components within a well, such as a motor or sensor or the like.

Part of a second component 6 is shown located adjacent the illustrated portion of the hanger body 1. The second component could, in various applications of the invention, be a well-head, a tubing head which engages directly or indirectly with a well-head, or with a tree, which may be a horizontal tree. In the following description the second component 6 will be identified as being a tree 6.

A small space 7 exists between the tree 6 and the hanger body 2. The space 7 may contain well fluid, for example. Whilst seals may be provided which seal the space 7 in the region of the electrical connector that is to be described, those seals may not be perfect and thus, even with the provision of seals, a hostile environment may exist in the region of the connector.

A bore 8 is formed within the tree 6, with the bore 8 being illustrated in alignment with the recess 3 which receives the fixed coupler pin unit 2. The bore has a narrow diameter portion adjacent the space 7 and a wider diameter portion located away from the space 7.

Secured to the tree 6 in alignment with the bore 8 is an actuator bonnet housing 9. The housing bonnet 9 is a hollow cylindrical housing having, at one end, an outwardly directed flange 10 which abuts against an exterior face on the tree 6. A seal 11 is provided between the flanged end 10 of the actuator bonnet housing 9 and the exterior part of the tree 6. The end of the bonnet housing 9 remote from the flanges 10 supports a rotatable element 12 which has an externally accessible drive shaft 13. The rotatable element 12 is rotatably supported by bearings 14, 15, and is associated with a seal 16, so that the rotatable element may be rotated, by means of the externally accessible shaft 13. The rotatable element 12 has, within the actuator bonnet assembly housing 9 a threaded end portion 17.

The threaded end portion 17 is received within a threaded socket 18 formed on a coupling yoke 19. Rotation of the rotatable element 12 may thus move the coupling yoke 19 axially within the actuator bonnet housing 9. The coupling yoke 19 is connected to a reciprocatable assembly 20 which will be described in greater details below. The assembly 20 has an end part thereof which extends through the bore 8.

Extending from a side-wall of the actuator bonnet housing 9 is an external dry coupler 21, adapted to be connected to an external electric cable.

A conductive inner cable 22 extends from the coupler 21 to the reciprocatable assembly 20. The cable 22 is arranged to minimise or eliminate

the potential for the cable to kink during movement of the reciprocatable assembly 20.

As will become clear from the following description, in use of the arrangement illustrated in Figure 1, a diver or remotely operated vehicle may access the external drive shaft 13 and the rotate the drive shaft to cause the reciprocatable assembly 20 to move from an initial disconnected position as shown in Figure 1, towards the left as shown in Figure 1, so that the reciprocatable assembly 20 extends from the bore 8 across the gap 7 and establishes connection with the fixed coupler pin unit 2. Of course, the reciprocatable assembly 20 may subsequently be retracted back to the initial position as shown in Figure 1, thus disconnecting the connector.

Figures 2 and 3 illustrate the principal components of one form of connector, thus showing parts of the fixed coupler pin unit 2 and the reciprocatable assembly 20.

The fixed coupler pin unit 2 comprises a housing 30 which defines a generally cylindrical bore or passage 31 extending into the housing from one face 32 thereof. The face 32 of the housing is directed towards the gap 7 between the hanger body 1 and the tree 6. Extending from the base of the bore is a fixed cylindrical pin 33 which extends axially of the bore. The pin 33 is formed primarily of an electrically resistive material but, at a point intermediate the ends of the pin, an electrically conductive ring 34 is provided which is flush with the outer surface of the pin 33. The electrically conductive ring 34 is connected to the connecting arrangement 4 provided within the hanger body 1.

The reciprocatable assembly 20 comprises a body 40. The body 40 is of cylindrical form and has an outer diameter slightly less than that of the bore 31

formed in the body 30 of the fixed coupler pin unit 2. The body 40 is aligned with the bore 31 formed in the fixed coupler pin unit 2.

Provided within the body 40, at the end thereof remote from the coupler unit 2, is a relatively large diameter dielectric fluid chamber 41. The chamber 41, which may be termed the main chamber 41, is provided with a fluid flow duct 42 to supply dielectric fluid to the main chamber 41. The dielectric fluid flow duct 4 extends through a non-return valve 43 which communicates with a reservoir chamber 44 for dielectric fluid. The reservoir chamber is associated with a piston 45, and part of the piston 45 extends beyond an end wall 46 of the housing where it is engaged by part 47 of the coupling yoke 19.

The reservoir chamber 44 is located adjacent one end wall 48 of the main chamber 41.

A bore 49 extends from the other end of the dielectric fluid chamber 41 to the other end 50 of the body 40, that being the end adjacent to the fixed pin connector unit 2. A terminal part of the bore 49 is provided with an enlarged seal chamber 51. Part of the wall of the bore between the seal chamber 51 and dielectric fluid chamber 41 is formed of conductive material, in the form of a conductive ring 52. Ring 52 is connected electric cable 22.

Contained within the bore 49 is part of a retractable pin 60 which has the same diameter as the fixed pin 33. The retractable pin 60 extends into the dielectric fluid chamber 41 where the pin 60 carries radially outward extending flange 61. The flange 61 has a flow port 62 therethrough, or is not a sealing fit in the chamber 41 so that the flange 61 does not act as a piston. A portion 63 of the retractable pin 60 extends across the dielectric fluid chamber 41 and passes

through the end wall 48 thereof. A seal 64 may be provided between the end wall 48 and the portion 63 of the retractable pin 60.

A spring 65 is provided within the dielectric fluid chamber 41 engaging the flange 61 on the retractable pin 60 and engaging end wall 48 of the chamber 41 and tending to bias the retractable pin 60 towards the left as shown in Figure 2.

A seal 66 is provided within the sealing chamber 51, the seal 60 being associated with a washer 67 and a compressing spring 68 so that the seal effects sealing engagement with the exterior of the retractable pin 60. The seal is designed to prevent the ingress of fluid or liquid past the seal into the dielectric fluid chamber 41, whilst allowing fluid to escape from the dielectric fluid chamber 41 if the fluid within the main chamber 41 is sufficiently pressurised.

A dielectric fluid may fill the dielectric fluid chamber 41, and further fluid may be supplied to the main chamber 41 through the flow duct 42. The dielectric fluid may be any fluid that is an electric insulator, that is to say a fluid that does not support the flow of an electric current. The fluid may be in the form of a gel.

As the reciprocatable assembly 20 is moved towards the left from the position as shown in Figure 2 the end of the fixed pin 33 of the fixed pin connector unit 2 engages the end of the retractable pin 60. The retractable pin 60 will be driven into the body 40 against the bias provided by the spring 65. The extension 63 of the pin 60 will pass across the reservoir chamber 44 and into a recess provided within (or through a hollow core of) the piston 45 as shown in phantom. Thus the components will move to the condition illustrated in Figure 3 in which the electrically conductive ring 34 on

the fixed pin 33 has been brought into engagement with the electrically conductive ring 52 provided in the wall of the bore 49. Thus electrical contact is established between the cable 22 and the connector 5 in the hanger body 1. The seal 66 now seals against the fixed pin 33.

It is to be appreciated that the movement of the reciprocatable body 20 is effected by a force supplied by the connecting yoke 19 to the piston 45. The piston 45 thus applies pressure to the dielectric fluid within the reservoir 44. The pressure of this fluid will rise and, if the pressure of the fluid exceeds the pressure of the fluid within the dielectric chamber 41, fluid will be forced through the non-return valve 43 and through the dielectric fluid supply duct 42 into the dielectric fluid chamber 41. The high pressure fluid may flow along the bore 49 past the electric contacts 34 and 52 and may weep through the seal 51 if the pressure within the main chamber 41 is sufficiently high, so that the pressure within the main chamber 41 exceeds the pressure in the gap 7 by a predetermined threshold. This will effect a cleaning of the contacts and the removal of any debris that may have entered the bore 49.

Figure 4 illustrates an alternative embodiment of the invention which operates on the same principle as that of Figures 2 and 3. In the embodiment of Figure 4 there is again a fixed pin unit 2 comprising a body 70 defining a bore 71 open at one end 72 of the body, there being an axially extending pin 73, the pin 73 being formed of electrically insulating material but having a ring 74 of electrically conducting material positioned between the ends thereof.

The fixed pin unit 2 is to co-operate with a reciprocatable assembly 80. The reciprocatable assembly 80 comprises a body 81 of generally cylindrical form having an end region 82 dimensioned to be received within the bore 71 defined by the body 70. The exterior of the body defines a first recess 83 to

receive a dog and a second elongate recess 84 to form part of a lost motion connection.

The main part of the body 81 is received within a cylindrical sleeve 85 which forms part of a connecting yoke. An end wall of the sleeve 85 is provided with an internal threaded axial extension 87, the extension 87 engaging the threaded portion 17 of the rotatable element 12. The sleeve 85 is provided with an opening 88 which receives a locking dog 89 which can move radially outwardly to engage (in a position shown in Figure 4) a locking recess 90 which is formed in the inner wall of the bonnet housing 9 and thus coupling the body 81 to the bonnet housing 9.

The sleeve 63 is provided with a double detent element forming an upper detent 91 and a lower detent 92. The upper detent is received in an axial groove 93 formed in the bonnet housing 9 and thus axial movement of the sleeve 85 is permitted while rotation is prevented. The lower detent is received in the elongate recess 84 in the body 81.

Defined within the body 81 is a dielectric fluid chamber 94. The dielectric fluid chamber 94 is connected, by means of a dielectric fluid supply duct 95, which incorporates a non-return valve 96, to a dielectric fluid reservoir 97 of annular form which is defined in at the end part of the body 81 remote from the first end part 82 described above. A further dielectric fluid flow duct 98 associated with a further non-return valve 99 also connects the dielectric fluid chamber 92 and the annular reservoir 95, but the non-return valve 99 has the opposite orientation to the non-return valve 94 and serves as a high pressure relieve valve.

An annular piston 100 is provided which extends into the open mouth of the annular reservoir 95, being sealed by seals 101, 102. An annular spring washer 103 is provided located between the piston and the end wall 86 of the cylindrical sleeve 85.

A bore 103 extends from the dielectric chamber 94 to the end wall of the body at the described first end 82. The bore 103 is provided with a seal chamber 104. Located between the seal chamber 104 and dielectric chamber 94 part of the wall of the bore 103 is provided with a conductive ring 105. The ring 105 is connected to the cable 22.

At the other end of the dielectric chamber 94 a bore 106 is provided which extends through the centre of the annular reservoir 97. The bore 103 and the bore 106 are of the same diameter and receive portions of a slideable retractable pin 120 which has the same diameter as the fixed pin 53. The slideable pin 120 has a first portion 121 dimensioned to be a sliding substantially sealing fit within the bore 103. The portion 121 extends into the dielectric chamber 94 where the pin is provided with a radially outwardly extending flange 122. The flange 122 should not be a sealing fit within the chamber 94 or should be provided with a fluid flow passage 123 extending through the flange so that the flange may move within the dielectric fluid chamber 94 without exerting a "piston" effect. The flange 122 provides an abutment surface which is engaged by a compression spring 124, the other end of which abuts the end of the dielectric fluid chamber 94 adjacent the flow passages 95 and 98. The retractable pin 120 carries a stop flange 126 at a position spaced from the flange 122, the stop flange 126 being adapted to engage the end of the bore 106 which passes through the annular reservoir 97 when the retractable pin is in the fully retracted position as shown in Figure 4.

A seal 127 is provided in the seal chamber 104 to engage the retractable pin 120 or the fixed pin 73. Again the seal is designed to prevent the ingress of liquid or fluid into the bore 103 or dielectric fluid chamber 94.

It is to be appreciated that the embodiment of Figure 4 will operate in generally the same manner as that described with reference to Figures 2 and 3.

In an initial condition the retractable pin 120 will be in a fully-left hand most position with the flange 122 driven fully to the left by the spring 124 with the portion 121 of the pin 120 extending through the bore 103 and through the seal 127 provided within the seal cavity 104.

Initially the threaded extension 17 at the rotatable element 12will rotate, thus driving the yoke sleeve 85 towards the left. The yoke sleeve 85 can move axially but cannot rotate due to engagement of the upper detent 92 with the groove 93 in the bonnet housing 8. The entire assembly will move leftwards. The free end of the retractable pin 120 will engage the free end of the fixed pin 73 and a retractable pin will retract within the body 81, thus effectively moving rightwards relative to the body 81, compressing the spring 124 and forcing the portion of the pin that is to the right of the stop flange 126 into the bore 106. The volume of the retractable pin 120 within the chamber 94 does not effectively change during this motion of the pin.

As the dog 89 becomes aligned with the recess 90 the dog 89 is moved radially outwardly thus engaging the recess 90 and also engaging the body 81. Thus the body 81 cannot move further relative to the bonnet housing 9. However, the cylindrically yoke sleeve 85 may still move axially because the dog extends through the elongate slot 88 in the cylindrical yoke sleeve 85. As

the cylindrical yoke sleeve 85 moves further to the left, so a force is applied, through the spring washer 103, to the piston 100, thus increasing the hydraulic pressure applied to the dielectric fluid within the reservoir 97. The lower detent 91 at this stage moves along the groove 84. When a sufficient pressure level is reached within the reservoir 97 the non-return valve 96 opens permitting fluid to enter the dielectric fluid chamber 97 through the flow duct 95. If the pressure within the chamber is sufficiently high the fluid may flow through the bore 103, past the aligned electric contacts 74 and 105, weeping out past the seal 127 provided in the seal cavity 74, thus flushing away undesirable well fluid or sea water and flushing out any debris whilst simultaneously cleaning the contacts. Of course, the seal 127 is designed to permit a minimum of weepage, and also to prevent the ingress of fluid or liquid.

When the connection is to be broken, the threaded extension 17 is rotated to move the yoke 85 towards the right. At this stage the dog 89 is disengaged from the recess 90. As the yoke housing 85 moves towards the right the lower detent 91 on the cylindrical housing 85 moves along the groove 84 formed in the exterior of the body 81, which forms a lost motion connection, until the lower abutment engages the end of the groove 84, and then the body 81 begins to move towards the right. As the body 81 begins to move towards the right, as shown in Figure 4, the retractable pin 120 moves towards the left (relative to the body) under the influence of the biasing spring 124 so that the end of the retractable pin 120 is maintained in firm contact with the end of the fixed pin 73, until the retractable pin has returned to its initial condition.

The non-return valve 99 is to open only at a very high pressure and is provided to act as an "emergency" pressure relief valve should the pressure of

dielectric fluid within the chamber 94 reach an unacceptably high level. Should the pressure relieve valve 99 open fluid will be reintroduced to the reservoir 97.

When the electrical connector is used as a subsea connector the reservoir 97 will be filled with sufficient fluid to last until it is expected that the connector will be brought again to the surface, at which time the reservoir may be recharged with a fresh supply of fluid.

Figure 5 illustrates a modified embodiment of the invention in which a fixed pin unit 130 is provided having a connector pin 131 with two spaced apart conductive areas 132, 133. The pin co-operates with a reciprocatable assembly having a body 134 which defines a bore 135 which initially receives a retractable pin 136, the bore 135 being provided with two spaced apart electrically conductive elements 137, 138, which are positioned to be co-aligned with the conductive areas 132, 133. Each of the conductive areas 132, 133 is in communication with a respective core of a cable which forms part of the connecting arrangement 4, and each of the conductive elements 137, 138 in the bore is in communication with a respective core of cable 22 which extends from the coupler 21 to the reciprocatable assembly 20. This modification may be applied to any of the described embodiments of the invention. Also, it is to be understood that more than two conductive rings may be provided on the fixed pin and in the bore that receives the retractable pin. Thus, there may be a plurality of three, four, or even more conductive rings on the pin to co-operate with an equivalent plurality of rings in the bore. It is thus to be appreciated that a single connecting pin may be provided with a plurality of conducting elements to enable a plurality of conductive parts to be established.

Figure 6 illustrates a modified embodiment of the invention wherein a single reciprocatable unit is provided with a plurality of bores 140, 141, 142

each bore containing its own retractable pin 143, 144, 145. It is to be understood that the reciprocatable assembly of Figure 6 is to co-operate with a fixed pin unit having three fixed pins. Thus a single electrical connector may include multiple pairs of connecting pins and each pair of connecting pins may have multiple electrical contacts thereon.

The invention will be further described with reference to Figures 7 and 8 which show an embodiment designed specifically for use with components of an undersea wellhead for an oil or gas well. Thus, again, the described components are intended for use at a substantial depth under the surface of the sea and may be expected to be subjected to relatively high sea water pressure.

Referring now to Figures 7 and 8 a first component, in the form of a fixed coupler pin unit 201 is provided which is adapted or configured to be received within a recess formed within a hanger body forming part of a wellhead. The coupler pin unit 201 is to co-operate with a releasable electrical penetrator which will be described in greater detail hereinafter.

The coupler pin unit comprises a body 202 defining a recess 203. A coupler pin 204 extends axially of the recess, extending from the base of the recess towards an open mouth of the recess. The coupler pin has an electrically conductive frusto-conical tip 205 which forms an electric contact. An internal cable 206 is connected to this electrically conductive tip.

To co-operate with the coupler pin unit a reciprocatable component 207 is provided. The reciprocatable component 207 can, as will become clearer from the following description, be moved axially so as to be connected to and disconnected from the coupler pin unit 201 to make or break an electrical connection.

The reciprocatable component 207 is mounted on a hollow actuator stem 208. Any appropriate mechanism may be provided to driving actuator stem axially to the left or right as shown in Figure 7. The stem 208 is connected to a generally tubular actuation sleeve 209. The sleeve 209 is of tubular form and carries, at its forward end, inwardly directed open jaws 210 (part of the lower jaw is cut-away for the sake of illustration). The jaws 210 engage projections 211 formed on the exterior of a generally cylindrical connector housing 212 which will be described in greater detail below.

The connector housing 212 is an elongate body of cylindrical form being dimensioned, at its forward end, to be received within the recess 203 of the coupler pin unit 201.

A forward part of the connector housing 212 defines an axially extending bore 213. An initial part of the bore is provided with an outer seal formed by two adjacent sealing elements 214, 215, each being a unidirectional seal, the seals having opposite senses. The inner portions of the seal define a diameter which is equivalent to the diameter of the pin 204 of the coupler unit 201. The seal closest to the end of the bore 213 is oriented to prevent the ingress of fluid from the exterior of the bore, whereas the inner seal is oriented to prevent the escape of fluid from within the bore.

Adjacent the outer seals 214m 215 is an annular filter element 216, the annular filter element defining an internal passageway having a diameter slightly greater than the diameter of the pin 204.

At the side of the filter element 216 which is furthest from the open end of the bore 213 is a further inner seal 217. The inner seal 217 is a uni-

directional seal configured to prevent or minimise the flow of fluid in a direction as if coming from the open end of the bore. The seal has a nominal internal diameter equivalent to the diameter of the coupler pin 204.

Adjacent the seal, further towards the interior of the connector housing 212, a terminal part 218 of an electrically conducting sleeve 219 which may, for example, be formed of copper or copper alloy is aligned with the seals. The terminal part of the conducting sleeve 219 is provided with a plurality of resiliently inwardly biased contact elements configured (as will be explained in greater detail below) to establish electrical contact with the electrically conducting tip 205 of the coupler pin 204 of the fixed coupler pin unit 201. The configuration of the contact elements is such that a fluid may flow axially past the contact elements. The terminal part 218 of the sleeve 219 terminates with an inwardly directed collar 220 located between the terminal part of the sleeve, and the main part of the sleeve.

The sleeve 219 and the seals and filter described above are all received within a cylindrical cavity 221 present within the connector housing 212. The cavity 221 is closed, at its inner end, by means of a plug 222. The plug 222 is associated with packing elements 223 located between the plug 222 and the innermost end of the electrically conducting sleeve 219. The innermost end of the electrically conducting sleeve is provided with an electrical termination 224 which is connected to a conductor 225 present within a cable 226. The cable extends from the terminator 224 through an aperture 227 formed within the plug 222, the cable then passing out through one of the projections 211 provided on the connector housing 212.

The end of the electrically conducting sleeve 219 adjacent the plug 222 defines an aperture 228 through which a fluid may flow. With the conducting

sleeve 219, adjacent the aperture a valve seat 229 is formed which co-operates a non-return valve member 230. The non-return valve member is in the form of a disc adapted to engage the seat 229. Extending from the centre point of the disc is a guide stem (not visible in the figures), the guide stem being surrounded by a helical compression spring 231.

The guide stem and compression spring extend into a bore 232 formed within an inner cylindrical guide element 233 which is received within a chamber defined between the non-return valve 230 and the shoulder 220 of the conducting sleeve 219. The spring engages a shoulder 234 formed part-way along the bore 232.

The guide element 233 is of cylindrical form having an outer diameter which is less than the internal diameter of the electrically conducting sleeve 219, the axis of the guide element 233 being co-aligned with the axis of the electrically conducting sleeve 219. At the end of the guide element 233 adjacent the non-return valve member 230, a plurality of radially outwardly directed arms 235 (seen most clearly in Figure 9) are provided to secure the guide element in position whilst defining fluid flow passages for fluid to flow past the guide element.

A shuttle pin biasing spring 236 is mounted within the chamber formed in the main part of the electrically conducting sleeve 219, the spring 236 being dimensioned to surround, at one end thereof, the guide element 233 and to engage the radially outwardly directed arms 235. The other end of the shuttle pin biasing spring 236 engages an enlarged diameter end portion 237 formed at one end of a retractable shuttle pin 238. The end portion 337 has a diameter greater than the internal diameter greater than the internal diameter of the collar 220. The enlarged diameter end portion 237 may be formed by a

plurality of angularly spaced-apart radially outwardly extending fingers formed at the end of a shank 239, the shank having a diameter less than the internal diameter of the seals. At the other end of the shank 239 is an engagement formation 240, the engagement formation having a diameter equal to that of the coupler pin 204 and equivalent to the internal diameter of the seals and defining, at its free end, a recess 241 configured to receive the frusto-conical electrically conducting tip 205 of the coupler pin 204 of the fixed coupler pin unit 201. The outer diameter of the engagement formation 240 is thus such that it establishes a sliding sealing fit with each of the seals 214, 215 and 219 as described above.

Formed within the connector housing 212 are two passageways 242, 243 located in the wall of the connector housing 212 which surrounds the cylindrical cavity 221 which accommodates the electrically conductive sleeve 219. The passageways 242, 243 extend from ports 244, 245 adjacent the filter element 216 to the interior of a reservoir or compensation chamber 246 located adjacent the plug 222 associated with the cable 226.

The reservoir or compensation chamber 247 is defined by a generally hollow cylindrical housing 248, one end 249 of which is closed by an end wall, the end wall having a compensation aperture 250 formed in it.

Contained within the generally cylindrical housing 248 is a compensating piston unit 251, the piston unit itself being of generally tubular or cup-shaped form, having a closed end 252 with a further compensation aperture 253. Adjacent an open end of the main compensating piston 247 there is an outwardly directed flange 254 which may be provided with an "O" ring seal so it is a sliding sealing fit within the interior of the hollow cylindrical housing 248. A compression spring 255 engages the flange and also engages

the closed end 249 of the generally tubular housing 248 to bias the compensating piston unit 247 towards the plug 222 associated with the cable 226.

It is to be understood, therefore, that the compensating piston 247 has a tubular body of cup-shape, with the base of the cup defining the compensating opening 253. Contained within the tubular body of the compensating piston 247 is a secondary piston 255 which has a sliding sealing fit.

It is to be understood that initially the compensation chamber or reservoir 46 and the chamber defined between the non-return valve 230 and the shoulder 220 of the conductive sleeve 219 are filled with dielectric fluid. The dielectric fluid will also fill the space surrounding the shank 239 of the retractable shuttle pin and the fluid flow passageways 242, 243 which extend from the filter 216 to the reservoir or compensation chamber 246. The quantity of dielectric fluid present initially will be such that the main compensation piston 247 will be moved almost fully towards the right within the cylindrical housing 248, substantially compressing the spring 255. Typically the dielectric fluid is initially under a pressure of approximately 2 bar.

At this stage it should be made clear that in this embodiment of the invention the dielectric fluid may be any fluid that is an electric insulator, that is to say a fluid that does not support the flow of an electric current. The fluid may be a fluid which flows readily or, alternatively, may be in the form of viscous fluid or a thixotropic fluid possessing the properties of a gel.

Figure 7 illustrates the connector in the connected position. If the connector is to be disconnected the reciprocatable component 207 will be moved towards the left as shown in Figure 7. As the connector housing 212

moves towards the left so the biasing force applied to the retractable shuttle pin 237 by the shuttle pin drive spring 236 will cause the shuttle pin to move towards the left as shown in Figure 7. The combination of the terminal part of the connector pin 204 of the fixed pin unit 201, and the engagement formation 240 provided at the end of the shank 239 of the retractable shuttle pin 238 will move, together, past the innermost seal 219, and will subsequently move past the filter 216 and past the outer seals 215 and 214. Since the outer diameter of the engagement formation and also the outer diameter of the connector pin 204 are each equal to the diameter of the bore formed by the seals, the seals make a sealing sliding fit to prevent the egress of dielectric fluid.

As the retractable shuttle pin 238 moves towards the left, the shuttle pin is effectively withdrawn from the chamber defined between the non-return valve 230 and the collar 220. Effectively the internal volume of the chamber is reduced and the pressure of dielectric fluid within the chamber falls. The pressure within the reservoir or compensation chamber 246 is maintained by the action of the spring 255. Thus the non-return valve 230 is opened, compressing the spring 231 contained within the bore 232 of the guide element 233. Dielectric fluid, within the compensation chamber or reservoir 246 flows through the aperture 227 formed in the plug 222 and also through the aperture 228 formed in the end of the electrically conducting cylinder 219 adjacent the electrical termination 224. The non-return valve 230 is spaced from the co-operating seat 229, permitting the dielectric fluid to flow into the chamber.

The movement of the shuttle pin 238 towards the left is terminated when the large diameter end portion provided on the shuttle pin 238 engages the shoulder 220 present in the electrically conducting sleeve 219. During this

process the compensation piston 247 will move towards the left, under the influence of the compression spring 255, thus compensating for the dielectric fluid which has passed from the reservoir or compensation chamber 246 into the chamber between the non-return valve 230 and the collar 220.

When the connector again makes a connection the reciprocatable component 207 is moved towards the fixed coupler pin unit 201 until the frusto-conical conductive tip 205 is received within the co-operating recess 241 provided in the engagement formation 240 provided at the end of the retractable shuttle pin 238.

Continued movement of the reciprocatable component 207 will cause the retractable shuttle pin 238 to be driven towards the right, into the chamber. Effectively the volume of the chamber is thus reduced and consequently pressure within the dielectric fluid within the chamber will rise. The non-return valve 230 will become firmly closed, with the non-return valve 230 being pressed securely into engagement with the seat 229. Continued inward movement of the retractable shuttle pin 238 will tend to further increase the pressure of dielectric fluid by further reducing the internal volume of the chamber, and the fluid will then flow between the radially outwardly directed fingers forming the enlarged diameter end region 237 and past the sides of the relatively narrow shank 239, flowing past the seal 219 which is configured to make a sealing engagement with the engagement formation 240 provided at the end of the shank 239 which, it is recalled, has a larger diameter than the diameter of the shank. The fluid flows past the electric contacts provided in the terminal region 219 of the electrically conducting sleeve 220 sweeping away any contaminants and thus ensuring that this region is clean and will make a good electric contact. The fluid flows through the filter 216 and through the fluid flow passageways 242, 243 into the reservoir or compensation

chamber 246, causing the compensation piston to move to the right against the bias of the spring 255. The fluid will not flow past the outer seals 214, 215.

As the coupler pin 204 of the coupler pin unit 201 effectively moves further into the interior of the connector housing 212, fluid continues to flow, flowing through the circulation path constituted by the passageways 242, 243.

Even when the engagement formation 240 becomes aligned with the inner seal 219 fluid can still flow as the seal 219 is a uni-directional seal, only preventing the flow of fluid into the chamber defined between the non-return valve 230 and the collar 220 whilst permitting the egress of fluid from that chamber. Fluid continues to flow, consequently, until the coupler pin 204 is in the fully inserted position shown in Figure 207 in which the electrically conductive frusto-conical tip 205 is in engagement with the contacts provided at the end of the electrically conducting sleeve 219.

The described apparatus is then ready to repeat the above-described cycle of operation.

It is inevitable, even though high quality seals may be provided, that at each make-and-break of the connector some of the dielectric fluid will escape past the seals and be lost. As the quantity of dielectric fluid within the described arrangement is reduced the compensation piston 247 will be gradually driven towards the left, as shown in Figures 7 and 8, under the effect of the spring 255. Should a situation arise in which the flange 254 provided on the main compensation piston 247 should engage with the innermost end wall of the cylindrical housing 248 adjacent the plug 222, the inner piston 255 may move within the main compensation piston 247 in response to pressure applied thereto by sea water, the sea water passing through the hollow stem 8, the

compensation aperture 250 formed in the end of the cylindrical housing 248 and the further compensation aperture 253 formed in the end wall 252 of the main compensation piston 247.

It is envisaged that, if necessary, a burst disc or emergency vent valve may be provided, in case an unexpectedly high pressure should be generated, for some unforeseen cause, within the connection housing 212.

Figure 9 shows a modified embodiment of the invention. In this embodiment of the invention the end of the cylindrical housing 248, between the innermost end of the main compensation piston 247 and the plug 222 is enlarged and modified. A first chamber 260 is provided in the upper part of the cylindrical housing 248. The chamber 260 is closed by means of a plug 261, whilst still communicating with the compensation chamber or reservoir 246. The chamber 260 may contain an appropriate desiccant such as, for example, dried silica gel.

The lower-most part of the cylindrical housing 248, at a position directly opposed to that of the chamber 260, is provided with a recess or well 262 which again communicates with the compensation chamber or reservoir 246. The well 262 is located in such a position that if there is any water entrained with the dielectric fluid, the water will tend to accumulate within the well 262. It is believed that the combination of the chamber containing desiccant and the well to trap water will ensure that the dielectric fluid is, effectively, water-free and retains appropriate dielectric properties.

Whilst the invention has been described with reference to embodiments in which there is a single coupler pin in the coupler pin unit and a single reciprocatable shuttle pin within a single bore, it is envisaged that it will be

practicable to produce embodiments in which there are a plurality of coupler pins and a plurality of bores each containing a respective retractable shuttle pin, to co-operate with the plurality of fixed coupler pins. In such an arrangement the fluid flow passages associated with each bore may communicate with a common compensation chamber or reservoir for dielectric fluid. However, to ensure an appropriate flow of fluid in each bore it may be necessary for the passageways to be provided with appropriate flow control valves.

In the present Specification "comprises" means "includes or consists of" and "comprising" means "including or consisting of".

The features disclosed in the foregoing description, or the following Claims, or the accompanying drawings, expressed in their specific forms or in terms of a means for performing the disclosed function, or a method or process for attaining the disclosed result, as appropriate, may, separately, or in any combination of such features, be utilised for realising the invention in diverse forms thereof.

CLAIMS:

1. An electrical penetrator connector, the electrical penetrator connector comprising of fixed pin unit and a reciprocatable assembly, the fixed pin unit including at least one fixed pin, at least part of the exterior of the pin being of electrically conductive material, the pin having a predetermined diameter, the reciprocatable assembly comprising of body, the body defining of dielectric fluid chamber, there being a dielectric fluid reservoir connected to the dielectric fluid chamber through a non-return valve, and a piston for applying hydraulic pressure to fluid within the reservoir, the chamber being associated with the bore extended from one end of the chamber to one end of the body, the bore containing a retractable pin having substantially the same diameter as the fixed pin, the bore being provided with a seal substantially sealing the pin, part of the wall of the bore between the seal and the dielectric fluid chamber being of electrically conductive material, resilient means being provided to bias a retractable pin to an initial position in which one end of the pin extends through the seal, the retractable pin being moveable, against the bias, upon movement of the reciprocatable assembly such that the end of the fixed pin is brought into engagement with the end of the retractable pin to drive the retractable pin against the resilient bias, to bring the conductive part of the exterior of the fixed into engagement with the conductive part of the bore to establish an electrical connection.

2. A connector according to Claim 1 wherein a mechanism is provided to move the reciprocatable assembly, the mechanism being configured to apply pressure to the piston such that the piston will increase the hydraulic pressure of fluid within the reservoir.

3. A connector according to Claim 2 wherein the drive mechanism applies pressure directly to the piston.

4. A connector according to Claim 2 wherein the drive mechanism comprises a component having a lost motion connection with the said body, there being a resilient element between the component and the piston such that the resilient element may be compressed to apply pressure to the piston during a lost motion movement of the component relative to the body.

5. A connector according to Claim 5 wherein the body is provided with a locking dog adapted to lock the body to a fixed member whilst still permitting movement of said component.

6. A connector according to any one of the preceding Claims wherein the resilient element is a spring contained within the dielectric fluid chamber.

7. A connector according to any one of the preceding Claims wherein the retractable pin is provided with an extension, the extension extending through a seal provided at the other end of the dielectric fluid chamber so as to extend beyond the chamber upon retraction of the pin such that, on retraction of the pin the effective volume of the chamber is not substantially altered.

8. A connector according to any of the preceding Claims wherein a pressure relief valve is provided connecting the chamber and the reservoir, the pressure relief valve being configured to open when a predetermined high pressure exists within the chamber.

9. A connector according to any one of the preceding Claims wherein the fixed pin is provided with a plurality of spaced-apart elements of electrically conductive material each in communication with a respective core of a cable, and the bore is provided with a corresponding plurality of spaced-apart elements of electrically conductive material, also each in communication with a respective core of a cable.

10. A connector according to any one of the preceding Claims wherein the fixed pin unit is provided with a plurality of said pins and the reciprocatable assembly is provided with a plurality of said retractable pins.

11. A connector according to any one of the preceding Claims wherein the fixed pin unit is mounted in a component of a gas or oil well, and the reciprocatable assembly is mounted on a co-operating component of the well.

12. A connector according to Claim 11 wherein the reciprocatable body is reciprocatable by a reciprocating mechanism accessible from the exterior of the well.

13. A connector according to Claim 12 wherein the reciprocatable element is connected to a coupler yoke, the coupler yoke having a threaded portion which matingly engages with a corresponding threaded portion provided on a rotatable element, the rotatable element having part thereof accessible to effect rotation thereof from the exterior of the well.

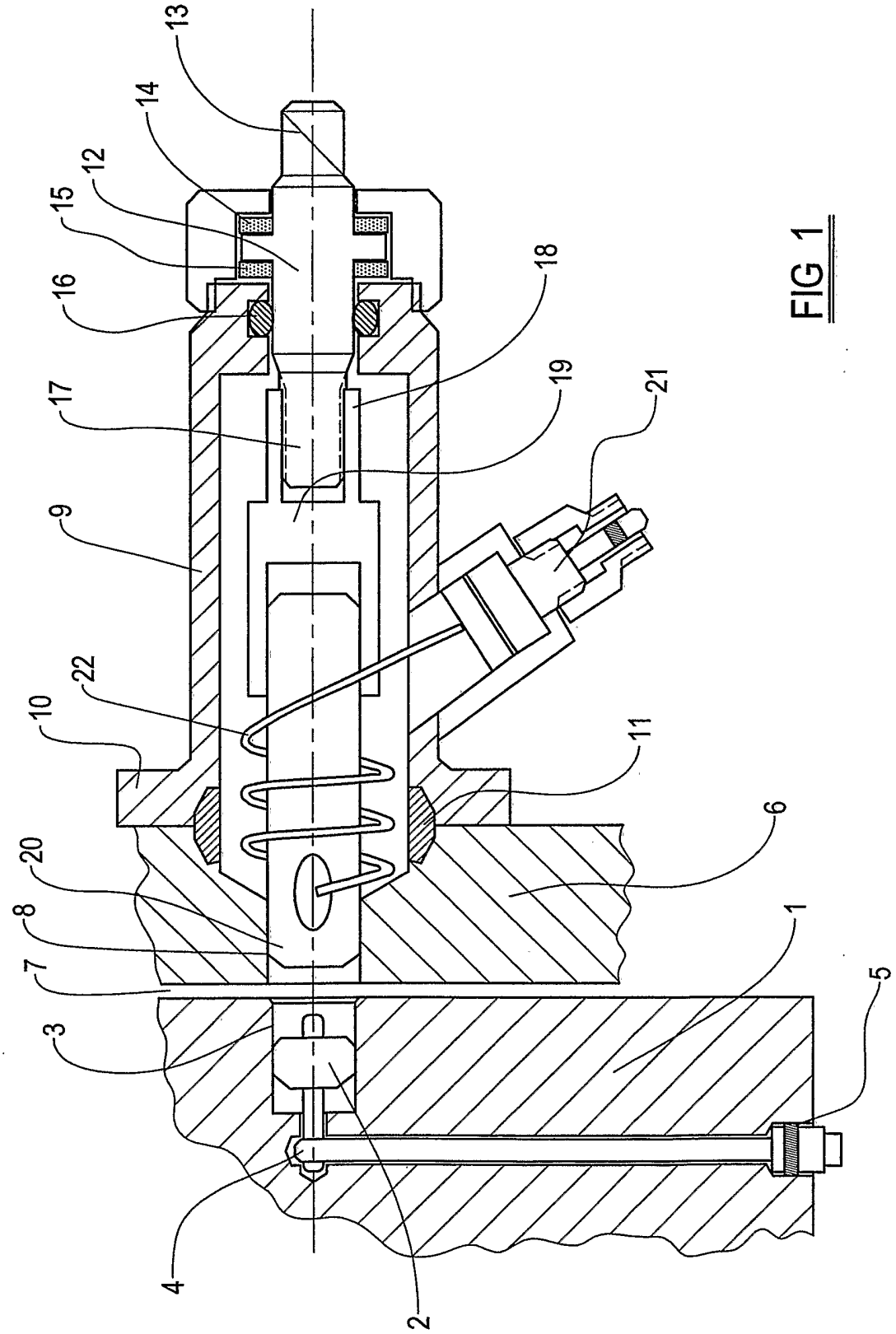


FIG 1

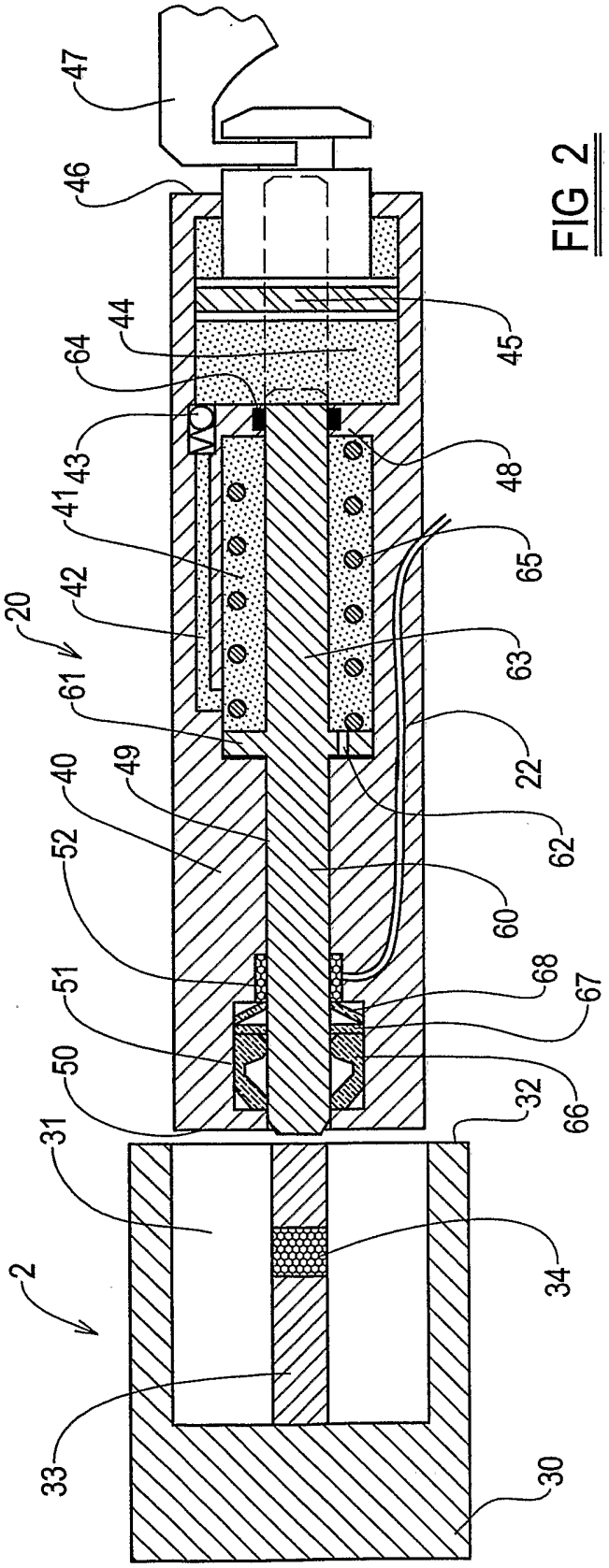

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FIG 2

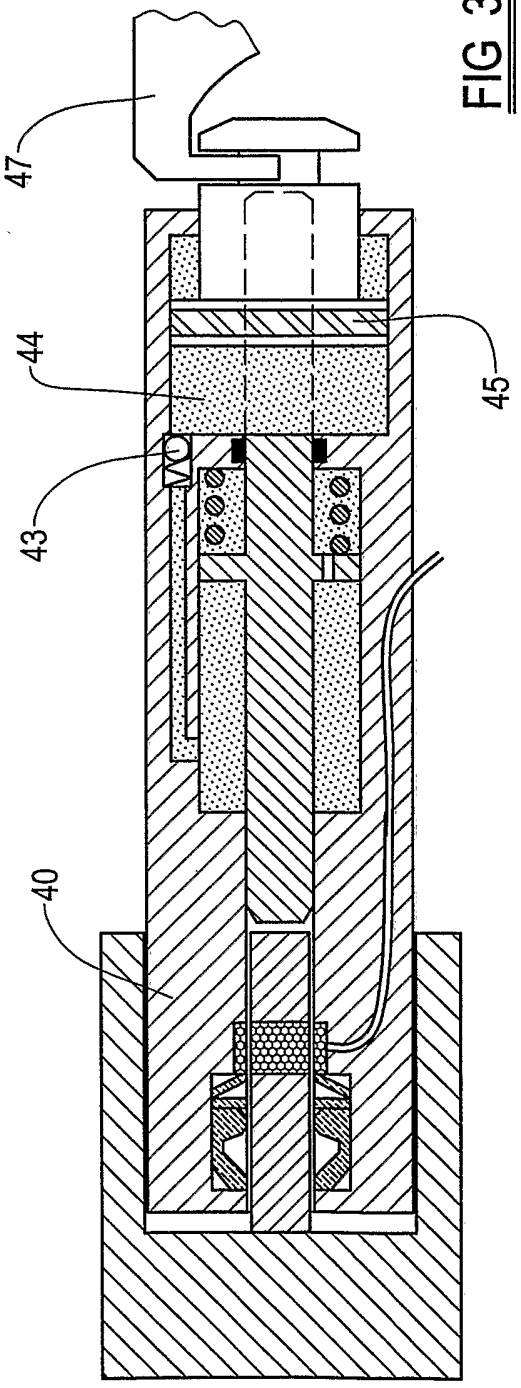

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FIG 3

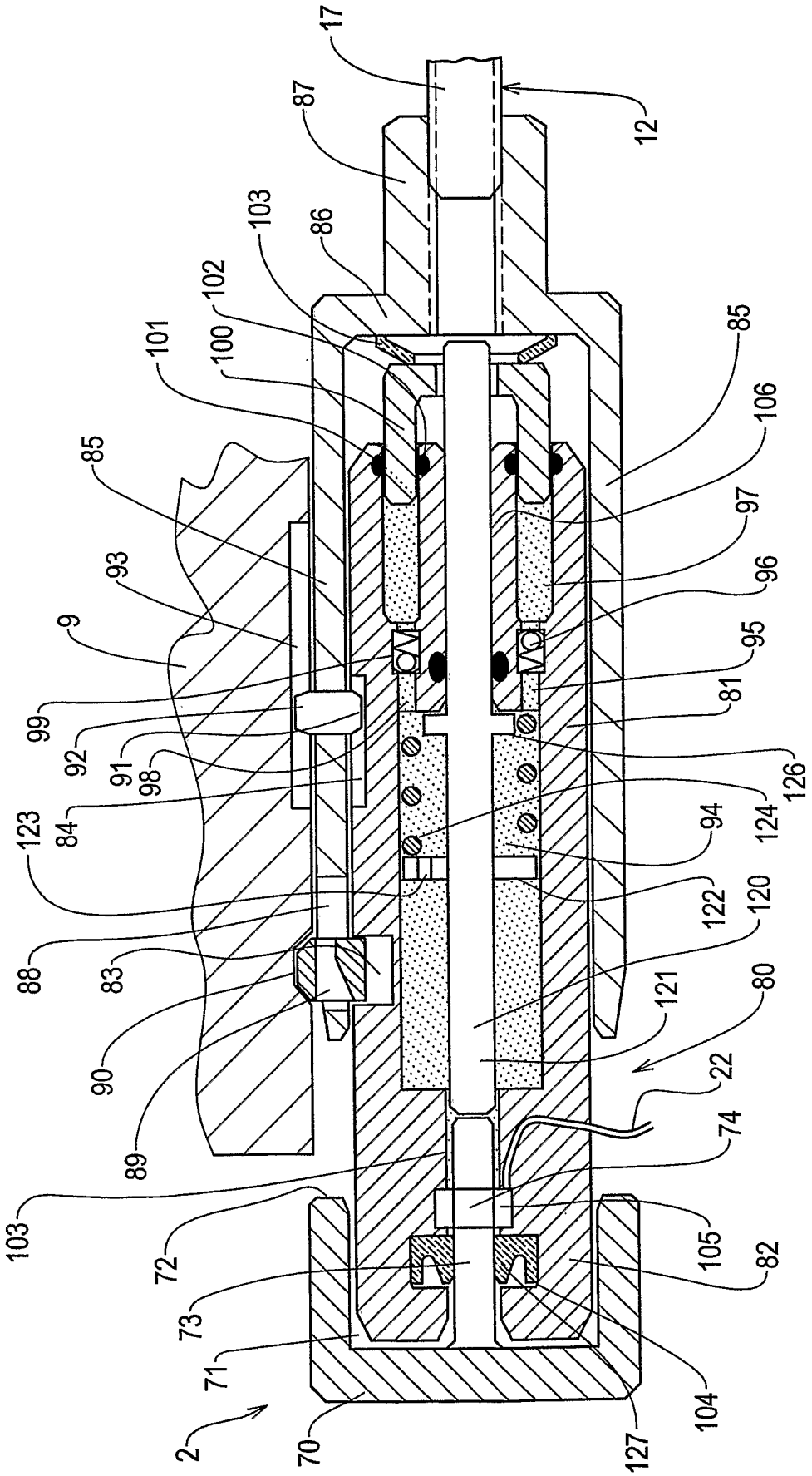

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FIG 4

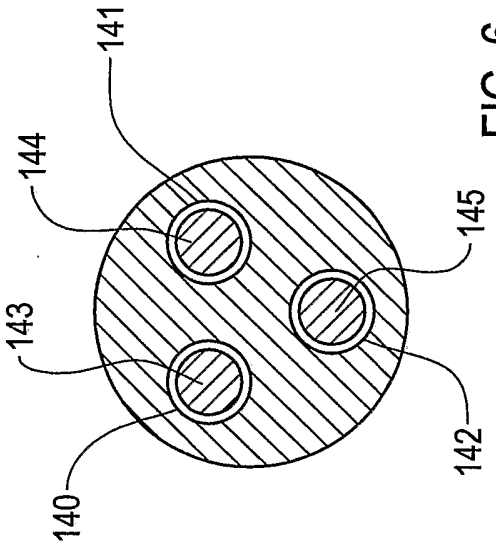


FIG 6

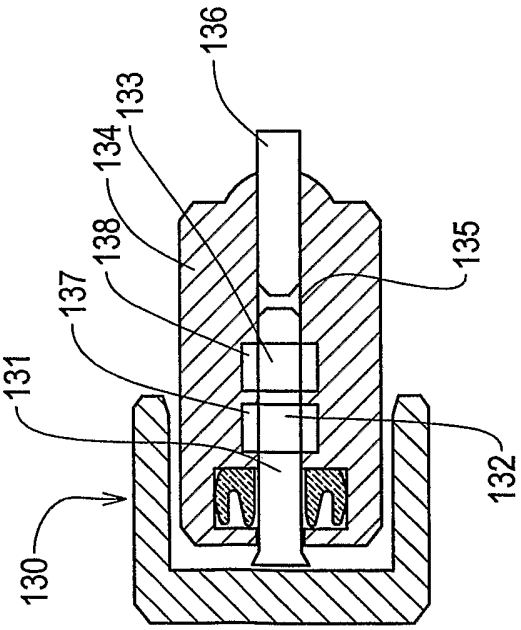


FIG 5

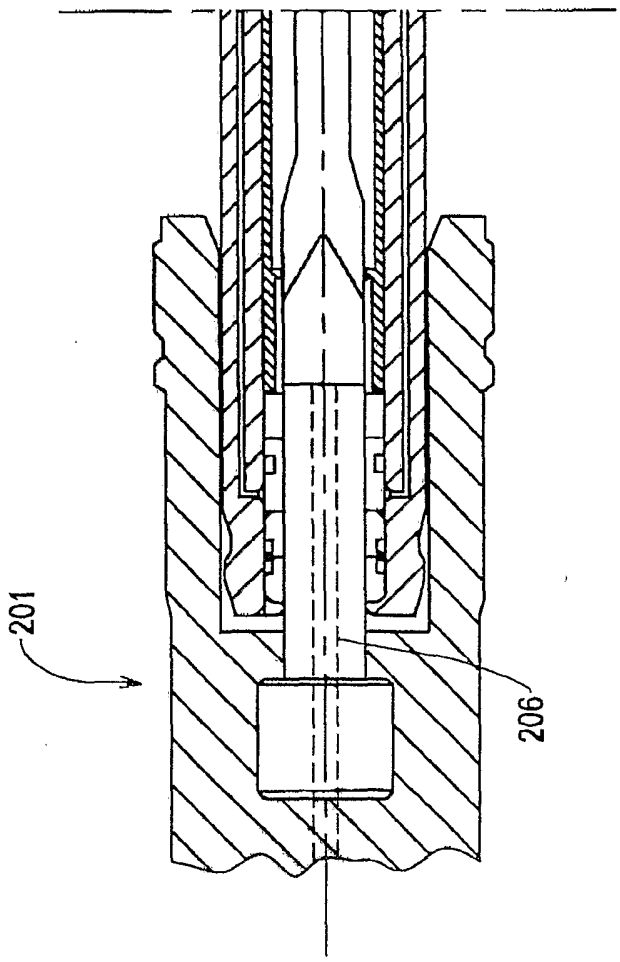


FIG 7a

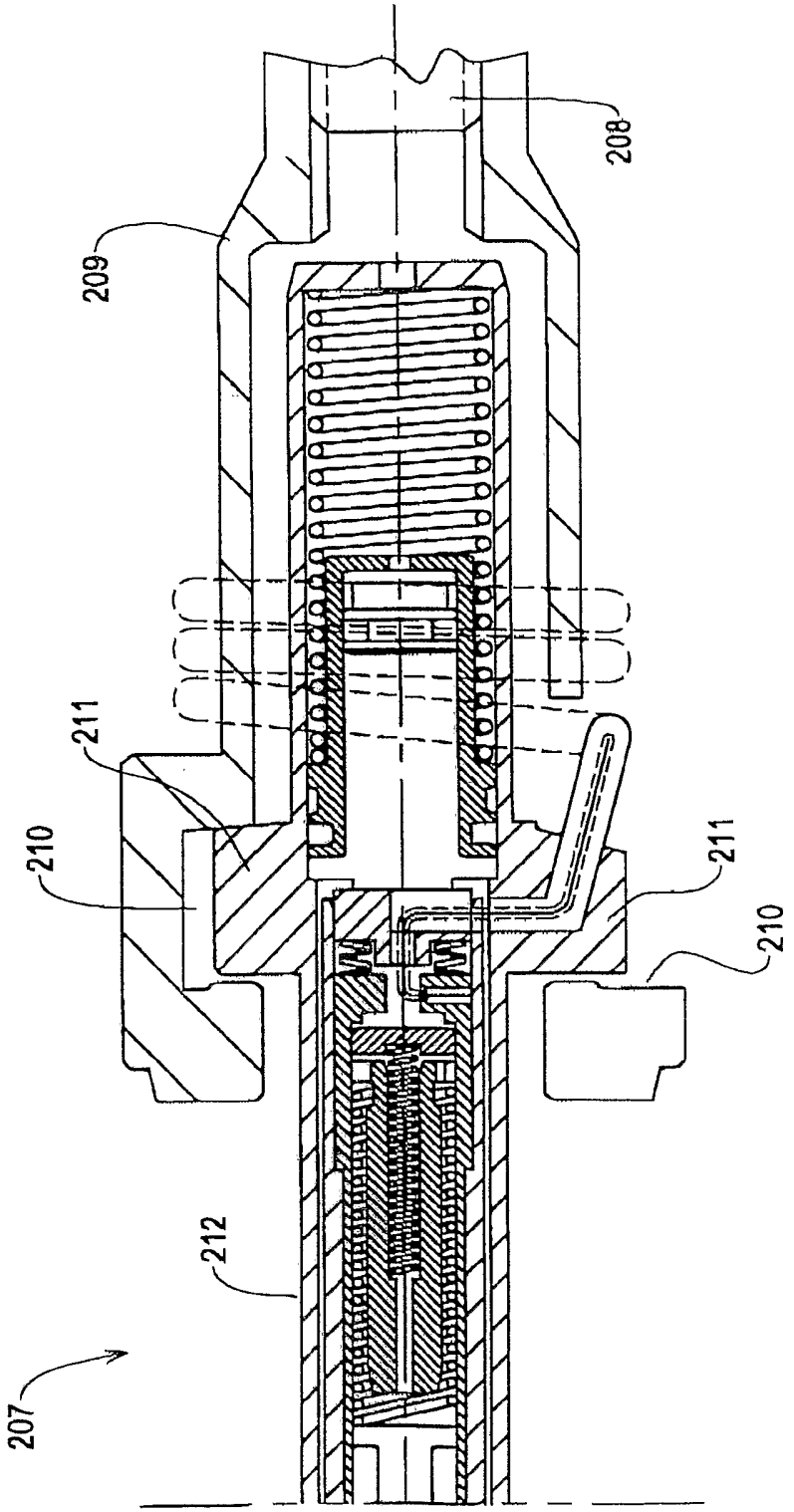


FIG 7b

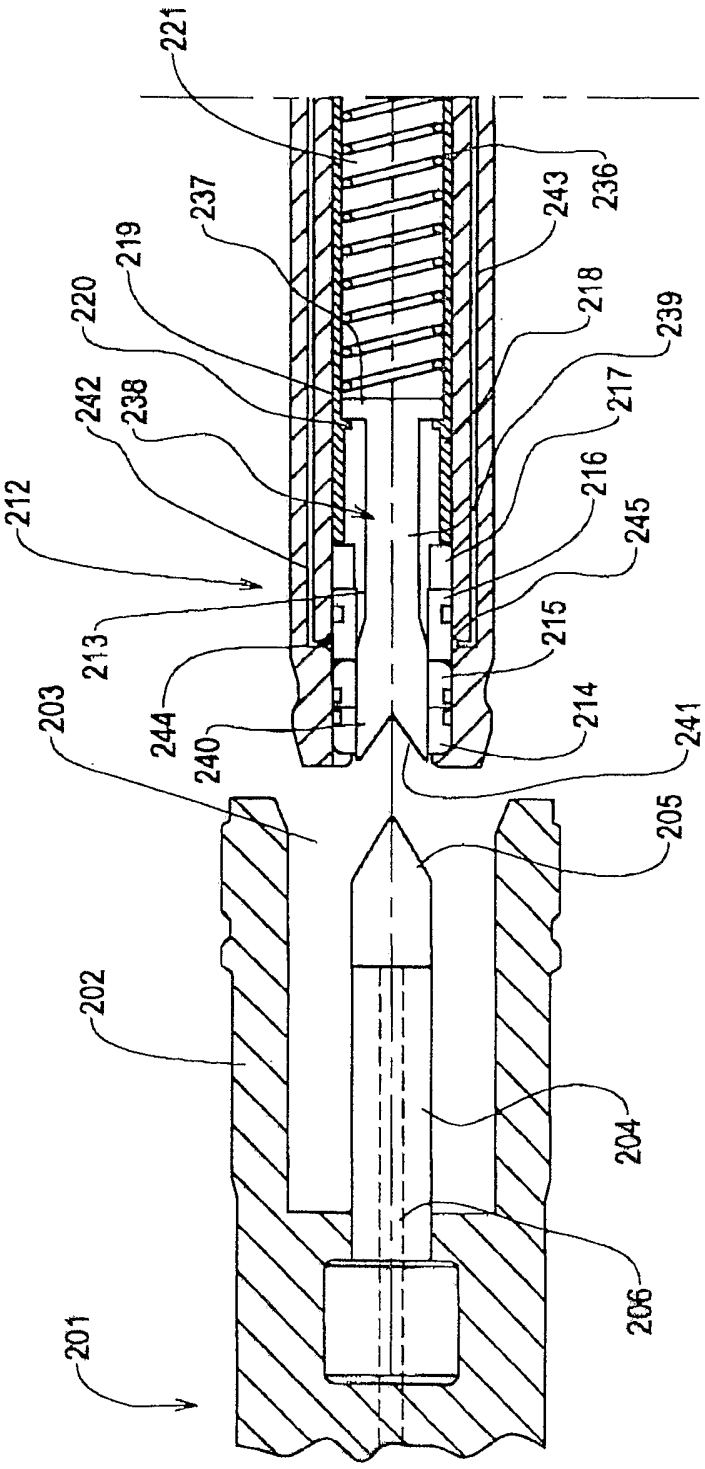

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FIG 8a

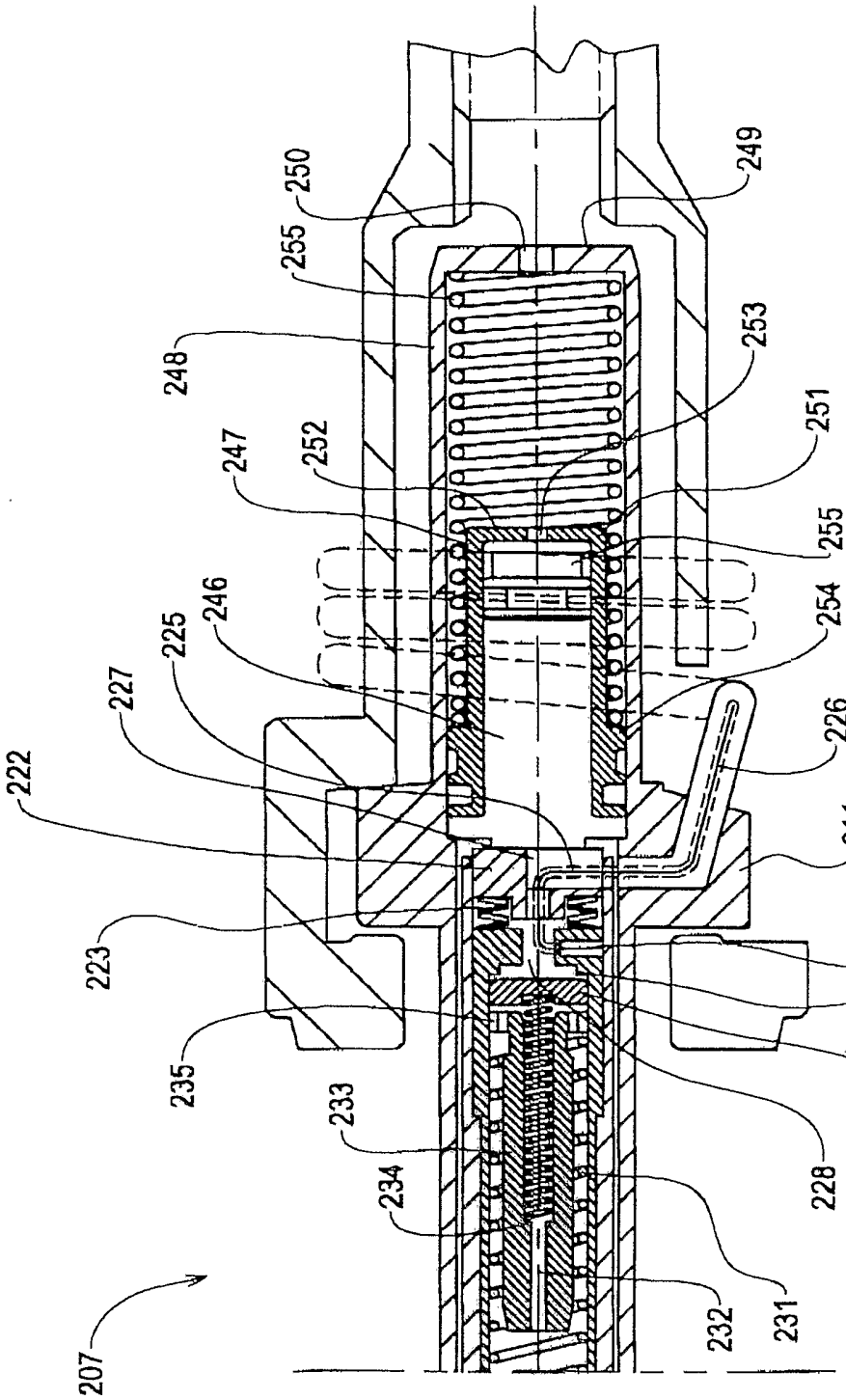

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FIG 8b

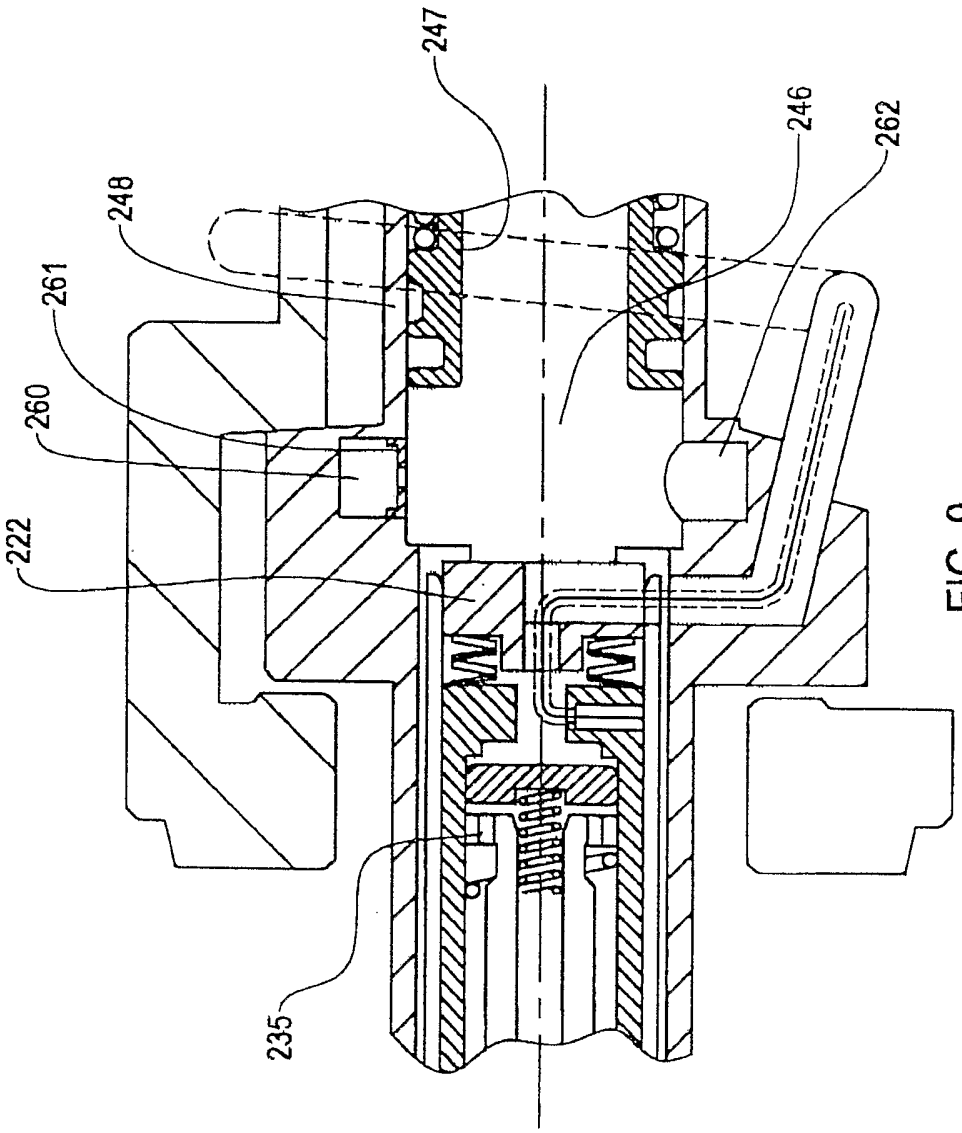


FIG 9

INTERNATIONAL SEARCH REPORT

International Application No
PCT/GB 03/02433

A. CLASSIFICATION OF SUBJECT MATTER
IPC 7 H01R13/523

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 H01R

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.
A	US 6 332 787 B1 (CAIRNS JAMES L ET AL) 25 December 2001 (2001-12-25) the whole document ---	1-13
A	US 5 645 442 A (CAIRNS JAMES L) 8 July 1997 (1997-07-08) the whole document ---	1-13
A	US 3 508 188 A (BUCK JON R) 21 April 1970 (1970-04-21) figures 3A,3B,4 ---	1
A	US 4 859 196 A (DURANDO PIERRE ET AL) 22 August 1989 (1989-08-22) the whole document --- -/--	2

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

[X] Patent family members are listed in annex.

° Special categories of cited documents :

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"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

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"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
4 September 2003	15/09/2003

Name and mailing address of the ISA	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL – 2280 HV Rijswijk Tel. (+31-70) 340-2040, Tx. 31 651 epo nl, Fax: (+31-70) 340-3016	Arenz, R

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INTERNATIONAL SEARCH REPORT

International Application No
PCT/GB 03/02433

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication,where appropriate, of the relevant passages	Relevant to claim No.
A	US 4 589 492 A (GREINER TOM D ET AL) 20 May 1986 (1986-05-20) figure 1	2
A	US 5 171 158 A (CAIRNS JAMES L) 15 December 1992 (1992-12-15) figure 2	9

INTERNATIONAL SEARCH REPORT

Information on patent family members

International Application No
PCT/GB 03/02433

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 6332787 B1	25-12-2001	AU 8118601 A	04-03-2002
		WO 0217440 A2	28-02-2002
US 5645442 A	08-07-1997	AT 217736 T	15-06-2002
		AU 4760096 A	07-08-1996
		BR 9607250 A	30-11-1999
		DE 69621224 D1	20-06-2002
		DE 69621224 T2	19-12-2002
		EP 0804818 A2	05-11-1997
		NO 973348 A	19-09-1997
		WO 9622617 A1	25-07-1996
US 3508188 A	21-04-1970	NONE	
US 4859196 A	22-08-1989	FR 2618613 A1	27-01-1989
		AU 604348 B2	13-12-1990
		AU 1979788 A	27-01-1989
		BR 8803662 A	14-02-1989
		GB 2208337 A ,B	22-03-1989
		IT 1226325 B	08-01-1991
		NO 883272 A ,B,	24-01-1989
US 4589492 A	20-05-1986	GB 2165284 A ,B	09-04-1986
US 5171158 A	15-12-1992	WO 9115882 A1	17-10-1991