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(12) # EUROPEAN PATENT APPLICATION

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(54) **Connection of rod-like components and down-the-hole hammer drill.**

(57) A connection for rod-like components, such as fluid flow path-defining components in a fluid powered free-piston down-the-hole hammer drill, comprising inner and outer components (7,5) having adjacent overlapping surfaces is characterised by at least one circumferential recess (9,11) in each of the overlapping surfaces, the recesses (9,11) being opposed to define one ore more annular spaces each accomodating an elastomeric sealing/retaining ring (8). The overlapping surfaces are preferably a close fit one within the other and have a plurality of said recesses (9,11) spaced-apart to accommodate correspondingly spaced rings (8) to distribute stresses between the components (7,5) and to maintain alignment thereof.

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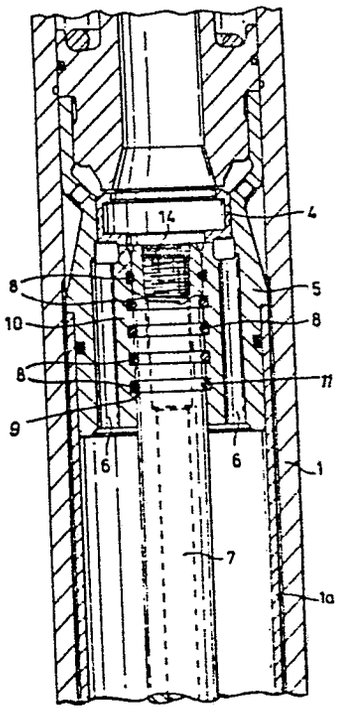

Fig.2.

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"Connection of rod-like components"

TITLE MODIFIED
see front page

THIS INVENTION concerns the connection of rod-like components to one another or to other components. The invention is especially concerned with establishing such connections in systems subject to high stress and/or vibration levels.

The invention is especially concerned with the establishment of reliable fluid-tight connections between components, e.g. components defining fluid flow paths, within fluid-powered devices such as pneumatic tools, e.g. hammer drills, and the invention will be described in relation to such applications.

In a hammer drill such as a down-the-hole rock drill unit, a piston is caused to reciprocate within a cylinder and to deliver blows to an anvil surface on a bit shank. The reciprocation of the piston is accomplished by alternately admitting pressure fluid such as compressed air to working chambers at opposite ends of the cylinder, this admission of pressure fluid to the working chambers, and the exhaust of fluid from these chambers, being controlled at least partly by the motion of the piston within the cylinder and relative to ports formed in the cylinder wall and/or in the piston or in a tube extending therein or therethrough. There may be further control of the fluid flows by a valve system or the arrangement may be "valveless" and rely entirely on the motion of the piston relative to other components to accomplish the necessary control of fluid flows into and out of the working chambers.

In many such hammer drills and similar fluid-powered free-piston devices, certain of the fluid flow paths

involve tubes that extend within the device and that are connected to or closely associatedwith components subject to high levels of stress and/or vibration. For instance, the piston may carry a tube that extends from one or other end thereof so as to reciprocate with the piston and enter passages in a related component to accomplish a fluid control function during parts of the travel of the piston within the cylinder. In other cases the piston reciprocates relatively to a central tube that is fixed at one or other of its ends and has ports that communicate with the working chambers in accordance with the position of the piston relatively to the tube. In yet other cases a tube is fixed within one or other of the working chambers to enter a passage in the piston for part of the cycle of motion of the latter: a typical instance of this latter arrangement is the so-called foot valve that comprises a tube fixed to a central exhaust passage in the bit shank of a hammer drill and that co-operates with the piston to control the exhaust of pressure fluid from the working chambers.

It is a common experience in the operation of hammer drills and like devices that such fluid-conveying tubes as above discussed are prone to failure at their connections to the components to which they are fixed. It is therefore common to adopt connection arrangements that involve the interposition of resilient material to damp the transmission of vibration energy between the respective parts and to effect fluid-tight sealing of the connection. However, the arrangements hitherto used or proposed have in general been rather complex and difficult to manufacture and/or involve problems of assembly in manufacture, so leading to difficulties in servicing in the field, or have shown a lack of reliability in service.

An object of the present invention is therefore to provide an interconnection system that avoids the difficulties experienced hitherto in the above discussed situations and that is simple and economical to manufacture.

In accordance with the invention, a connection of rod-like components comprising inner and outer components having adjacent overlapping surfaces is characterised in that each of said overlapping surfaces is formed with at least one circumferential recess, the recesses in the respective components being opposed and together defining an annular space within which an elastomeric sealing/retaining ring is accommodated.

Preferably the overlapping surface of each component is formed with a plurality of said recesses so that there are a plurality of spaced-apart annular spaces each accommodating an elastomeric sealing/retaining ring, the plurality of sealing/retaining rings thus providing both a plural seal structure for preventing flow of fluid between the overlapping surfaces, and spaced-apart resilient connections that distribute stresses between the components and also serve to maintain alignment thereof.

In preferred embodiments of the invention, the overlapping surfaces of the two components are a close fit one within the other and the said recesses are of greater depth in one such surface than the other, whereby the or each sealing/retaining ring is accommodated mainly in the deeper recess so as to facilitate assembly of the connection by telescopic movement of the components relative to one another. The overlapping surfaces may be dimensioned to have an interference fit, but in preferred embodiments they are dimensioned to have a sliding fit.

In preferred embodiments of the invention the elastomeric sealing/retaining rings are O-rings, but rings of other configuration may be employed: in particular, rings of non-circular section may be employed in recesses shaped to co-operate with such rings to provide enhanced sealing performance.

The or each elastomeric sealing/retaining ring may be a free element fixed to neither of the components. However in some embodiments such a ring may be fixed, e.g. by adhesive bonding, in the accommodating recess

of one of the components prior to assembly of the interconnection.

The components may be formed of any desired materials and may be of the same or of different materials. One or the other or both of the components may be of composite construction to provide required properties of structural strength and flexibility or resilience.

To facilitate assembly of the interconnection, the inner component may have a tapered lead-in to its surface formed with the or each said recess therein. That surface may itself initially be tapered, or the component may be formed to permit such surface to distort to tapered form in the course of assembly, provision being made to distort or restore the shape of the surface, after assembly, to a configuration matching the complementary overlapping surface of the outer component.

Thus, for instance, in one embodiment of the invention, the inner component comprises a tube one extremity of which is formed with circumferential recesses and a tapered lead-in, the wall thickness of the tube in the region of this end being such as to enable the tube to distort upon assembly to permit the tube end satisfactorily to enter the outer component having its recesses fitted with elastomeric sealing/retaining rings. Introduction of a plug, for instance, a screw-threaded plug, into the tube end following assembly may then serve to restore the tube end to its initial configuration so that its external surface matches that of the outer component into which it has been so fitted.

By such expedients, the sealing/retaining ring or rings may be placed under substantial radial compression in the fully assembled interconnection, to achieve a required sealing and/or retaining performance.

Some embodiments of the invention are illustrated by way of example in the accompanying drawings in which:

FIGURES 1A and 1B together constitute a part-sectional elevation of a down-the-hole hammer drill unit embodying

the invention;

FIGURE 2 is an enlargement of part of Figure 1A;

FIGURE 3 is an axial section of the valve part constituting the outer component of the interconnection embodied in the drill unit;

FIGURE 4 is an axial section of the exhaust tube constituting the inner component of the interconnection embodied in the drill unit;

FIGURE 5 is a partly schematic axial section of part of another down-the-hole hammer drill unit embodying the invention;

FIGURE 6 shows in axial section one construction of the foot valve, embodying the invention, in the drill unit of Figure 5; and

FIGURE 7 illustrates another construction of the foot valve, embodying the invention, of the drill unit of Figure 5.

The hammer drill unit illustrated in Figures 1A and 1B comprises a casing 1 fitted with a liner 1a within which a piston 2 is reciprocable to deliver blows on the anvil surface at the end of a bit shank, the reciprocation of the piston 2 being effected by the admission of compressed air alternately to working chambers 3, 3a at opposite ends of the liner 1a under the control of a valve mechanism including a valve element 4. The valve element 4 reciprocates within a valve structure including a valve bottom 5 that fits partly within the adjacent end of the liner 1a and has through-flow passages 6 and a central bore.

An exhaust tube 7 is fitted to the bore of the valve bottom 5 by an interconnection embodying the present invention and consisting of circumferential recesses in the overlapping surfaces of the bore of the valve bottom 5 and of the exhaust tube 7, respectively, the recesses in these components together defining a series of five annular spaces that accommodate elastomeric sealing/retaining rings 8.

The configuration of the valve bottom 5 is best seen in Figures 2 and 3 that show the bore to be of untapered cylindrical configuration formed with recesses 9 of rectangular cross-section. The internal corners of the recess cross-section are radiussed and the edges at the bore surface are relieved to avoid sharp corners and edges. This valve bottom 5 is formed of steel, case-hardened after all machining operations have been completed.

Figure 4 shows the form of the exhaust tube 7 prior to assembly. This tube is formed of a high strength plastics material such as carbon fibre or glass fibre reinforced plastic, or of a material such as the acetal plastics material sold by DuPont under the Trade Mark "Delrin". As shown the tube has an end portion 10 formed with five part-circular section circumferential recesses 11 at intervals corresponding with the spacing of the recesses 9 in the bore of the valve bottom 5.

It will be observed that the recesses 9 in the bore of the valve bottom 5 are of substantially greater depth than the recesses 11 on the exhaust tube 7. Thus the elastomeric sealing/retaining rings 8 are mainly accommodated in the recesses 9 and will be reliably retained in their respective recesses during assembly of the interconnection by endwise introduction of the exhaust tube 7 into the bore of the valve bottom. The different shapes of the cross-sections of the respective recesses also ensure retention of the sealing/retaining rings 8 during assembly, and ease the assembly operation.

The extremity of the exhaust tube 7 has a tapered lead-in 12 and the end portion 10 of the tube has a central bore that is formed with a tapered screw thread 13 for part of its length.

As initially formed, the end portion 10 of the tube 7, apart from the lead-in 12, is of untapered cylindrical form with an overall diameter such as to provide a sliding fit with the bore of the valve bottom 5. In assembling

the interconnection between the exhaust tube and the valve bottom, the elastomeric sealing/retaining rings 8, suitably O-rings, are fitted to the recesses 9 of the valve bottom bore whereafter the exhaust tube 7 is forced endwise into position in the bore. To assist the introduction of the tube 7 into the bore a suitable lubricant is applied to the tube and to the sealing ring-fitted valve bottom bore: the lubricant may be a light oil or a soap or like solution.

Under the compressive loads imposed upon the tube end portion 10 by the sealing/retaining rings 8 as the tube is forced into position and the rings 8 ride over the lands between the recesses 11, the tube end portion 10 tends to distort and take a slight taper "set". Accordingly, when the tube 7 has been forced fully into place with its recesses 11 aligned with the corresponding recesses 9 of the valve bottom bore, a screw-threaded plug 14 is screwed into the bore of the end portion 10 and because of the taper of the screw thread 13 in that bore, causes progressive expansion of the tube end portion 10 into close conformity with the bore of the valve bottom.

The sealing/retaining rings 8 in the assembled condition of the parts as illustrated in Figures 1 and 2 provide multiple stress paths between the inner component constituted by the exhaust tube 7 and the outer component constituted by the valve bottom 5. These rings also provide multiple seals against leakage between these components and thus reliably hold the tube 7 in place in the valve bottom, notwithstanding high levels of vibration to which the components are subjected during operation, while preventing leakage of pressure fluid from the region of the valve 4 along the outer wall of the tube 7.

Figure 5 illustrates schematically and in axial section part of the leading end of a down-the-hole hammer drill unit of the valveless type and having a foot valve

arrangement involving an interconnection embodying the invention.

The drill unit illustrated in this Figure 5 comprises a casing 20 defining a cylinder within which a piston 21 is reciprocable to deliver blows on the anvil surface at the end of a bit shank 22 so secured in the end of the casing 20 by means of a chuck 23 and a retaining and sealing ring 24 as to have limited freedom for axial movement relatively to the casing 20. The bit shank 22 is formed with an exhaust passage 25 that extends to outlets in the bit head (not shown) and that is fitted with a foot valve tube 26 that enters a bore in the piston 21 as this approaches its illustrated power stroke-end position, so as to cut off the exhaust flow path for air in the adjacent working chamber of the cylinder whilst providing a flow path for exhaust of air through the piston from the working chamber at the other end of the cylinder defined by the casing 20.

The foot valve tube 26, because it is fixed to the bit shank and protrudes from the anvil surface thereof, experiences intense shock and vibration loading in the region of its connection to the bit shank. The interconnection arrangement of the invention is therefore well suited to securing the foot valve tube 26 in the bit shank.

Figure 6 illustrates one constructional form of this interconnection and it will be seen that in this case the foot valve tube 26 is formed with rectangular cross-section circumferential recesses that oppose part-circular section circumferential recesses in an enlarged portion of the bore 25 of the bit shank, the opposed recesses together defining a series of spaced-apart annular spaces each accommodating an elastomeric sealing/retaining ring 27. The tube 26 may be made of any suitable material and if desired may be fitted, after assembly, with a pressed-in sleeve to remove any inwards distortion of the tube caused during assembly and to

ensure a required fit between the tube and the bore of the bit shank.

Figure 7 illustrates another construction in which the foot valve tube is of composite configuration, having an end portion 26a formed of one material, for instance metal, and constituting the inner component of the interconnection, and an extension portion 26b formed of a different material (e.g. a plastics material) and suitably attached to the end portion 26a, before or after fitment of the latter to the bit shank 22. The composite construction of the foot valve tube in Figure 7 enables the respective portions thereof to be formed of materials chosen to provide the required properties in those portions of the tube. Thus the end portion 26a may be formed of metal to provide appropriate rigidity to withstand stresses transmitted through the sealing/retaining rings 27, whereas the portion 26b may be of a material chosen to provide appropriate resilience to seal within the piston bore and to tolerate slight misalignments between the bit and the piston, and/or to be of low mass. Alternatively, the portion 26a might be made of a plastics material and the portion 26b of metal, to provide appropriate properties to meet certain performance requirements: for instance to enable the components to withstand the erosion effects that result from water injection.

CLAIMS

1. A connection of rod-like components comprising inner and outer components having adjacent overlapping surfaces, characterised in that each of said overlapping surfaces is formed with at least one circumferential recess, the recesses in the respective components being opposed and together defining an annular space within which an elastomeric sealing/retaining ring is accommodated.

2. A connection according to claim 1, further characterised in that each component is formed with a plurality of said recesses providing a plurality of spaced-apart annular spaces each accommodating an elastomeric sealing/retaining ring.

3. A connection according to claim 1 or 2, further characterised in that said overlapping surfaces are a close fit one within the other and said recesses are of greater depth in one such surface than the other.

4. A connection according to claim 1, 2 or 3, further characterised in that the or each said sealing/retaining ring is an O-ring.

5. A connection according to any preceding claim, further characterised in that the or each said sealing/retaining ring is a free element fixed to neither of said components.

6. A connection according to any preceding claim, further characterised in that the components are formed of different materials.

7. A connection according to any preceding claim, further characterised in that the inner component has a tapered lead-in to its surface formed with the or each said recess.

8. A connection according to claim 7, further characterised in that the inner component is a tube having a recessed surface formed at one end thereof behind said tapered lead-in, the wall thickness of the tube in the region of said end being selected to distort on assembly of the connection, the connection further comprising a plug that is introduced into said tube end, after assembly thereof in said outer component, to restore the tube end to a configuration matching the outer component recessed surface.

9. A fluid-powered free-piston down-the-hole hammer drill comprising flow path-defining components including inner and outer components having adjacent overlapping surfaces, characterised in that each said overlapping surface is formed with at least one circumferential recess, the recesses in the respective components being opposed and together defining an annular space within which an elastomeric sealing/retaining ring is accommodated.

10. A hammer drill according to claim 9, further characterised in that said inner and outer components comprise a connection in accordance with any one of claims 2 to 9.

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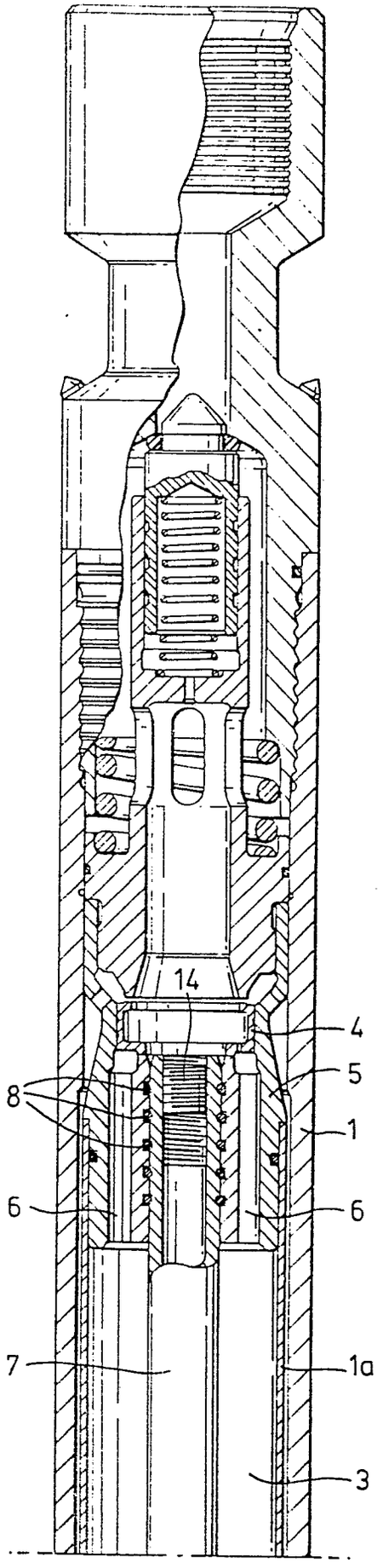
Fig. 1A.



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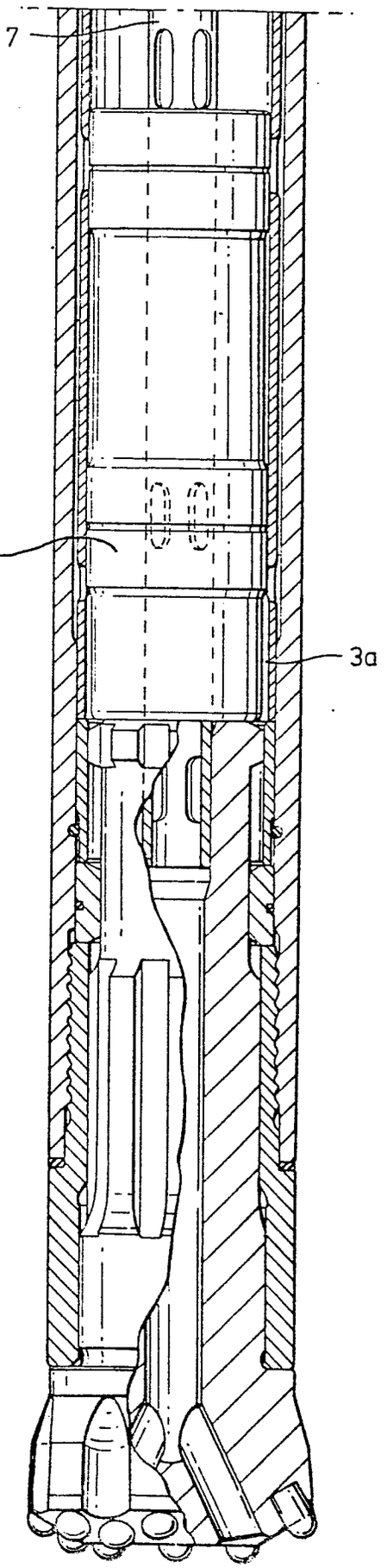

Fig.1B.

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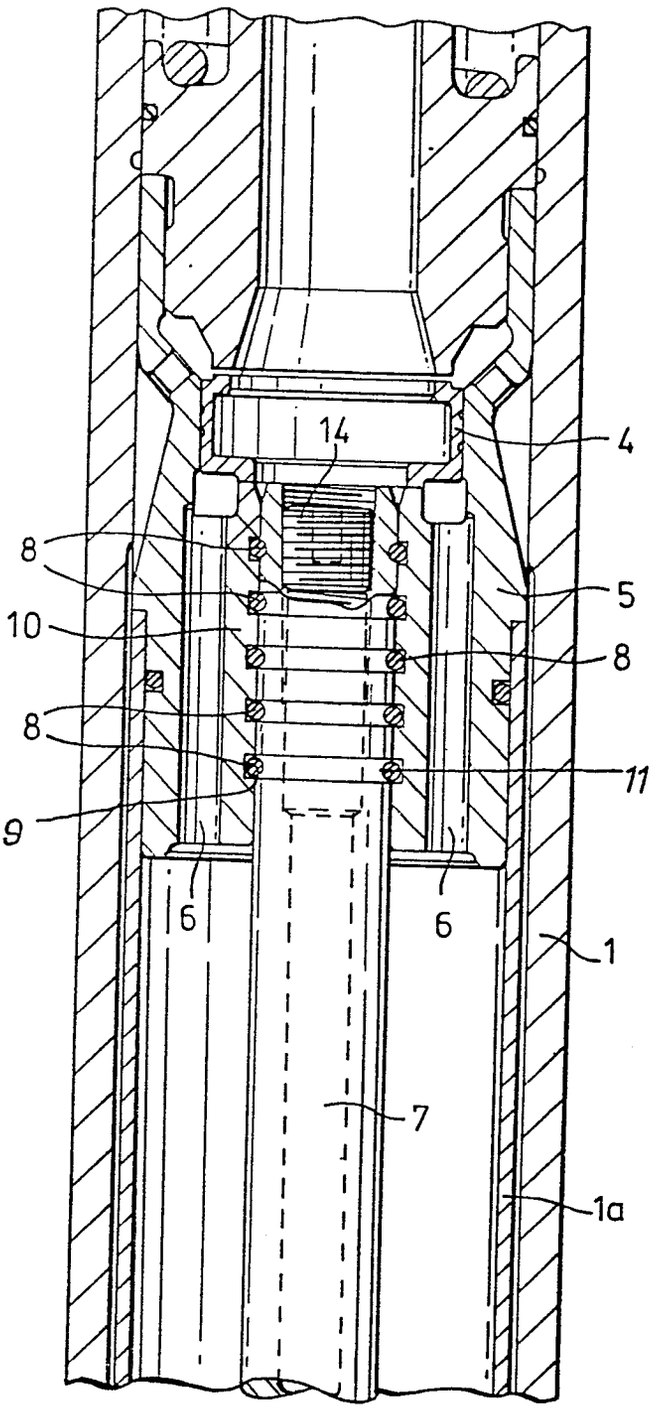

Fig.2.

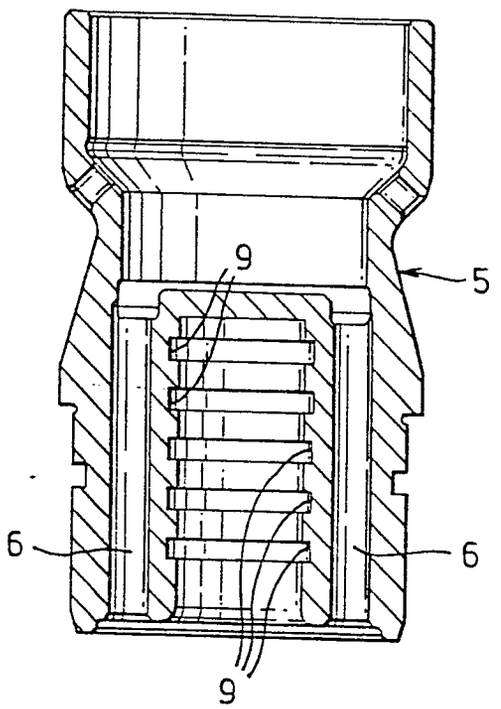

Fig. 3.

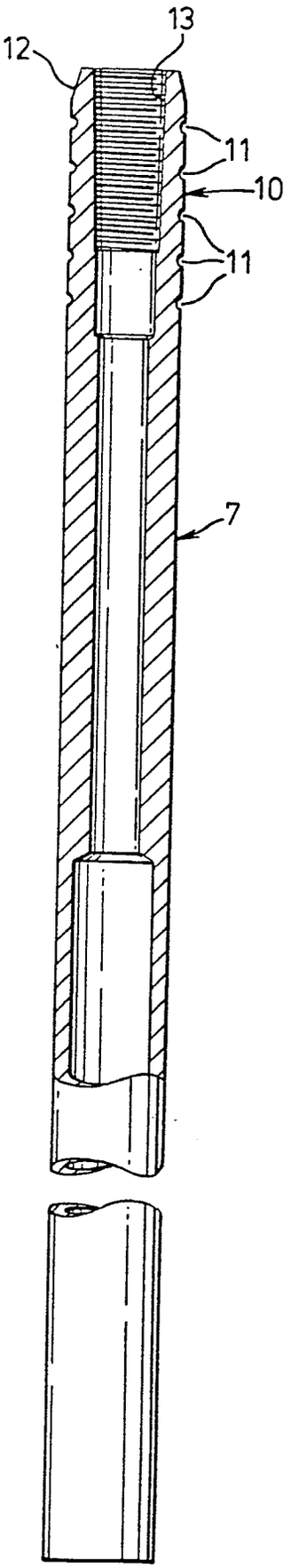

Fig. 4.

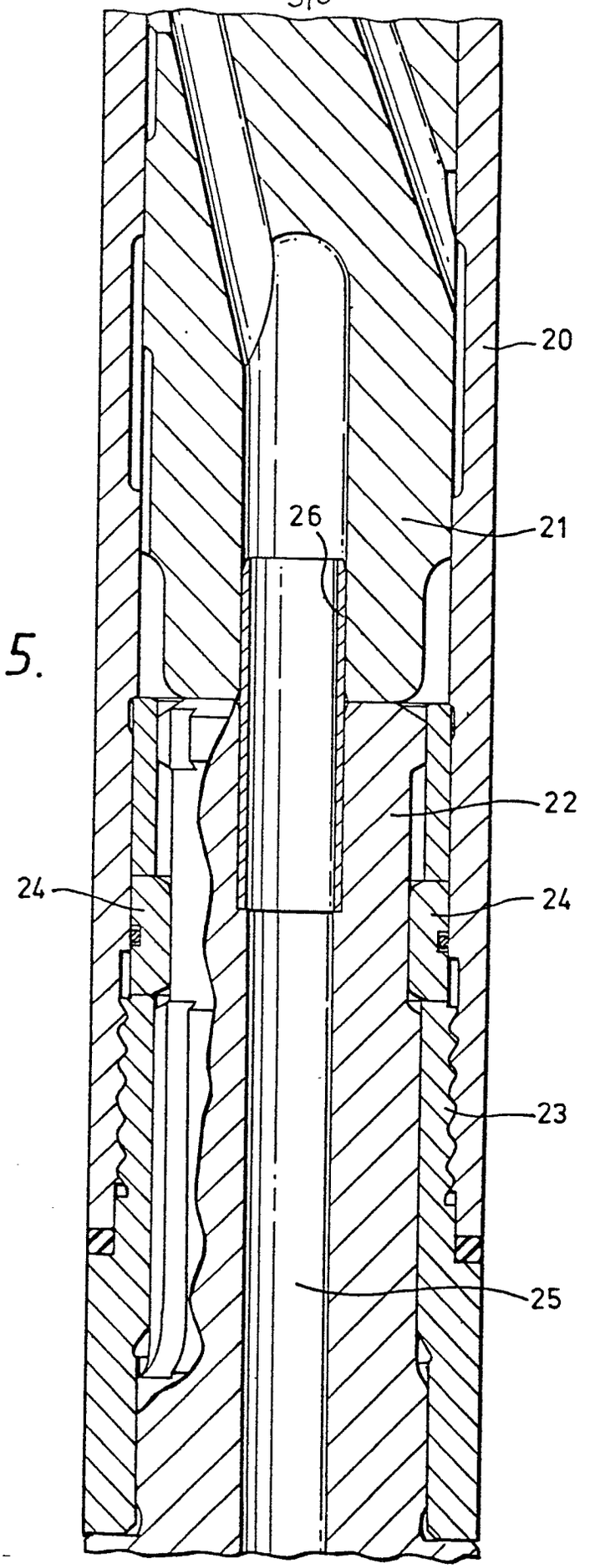

Fig. 5.

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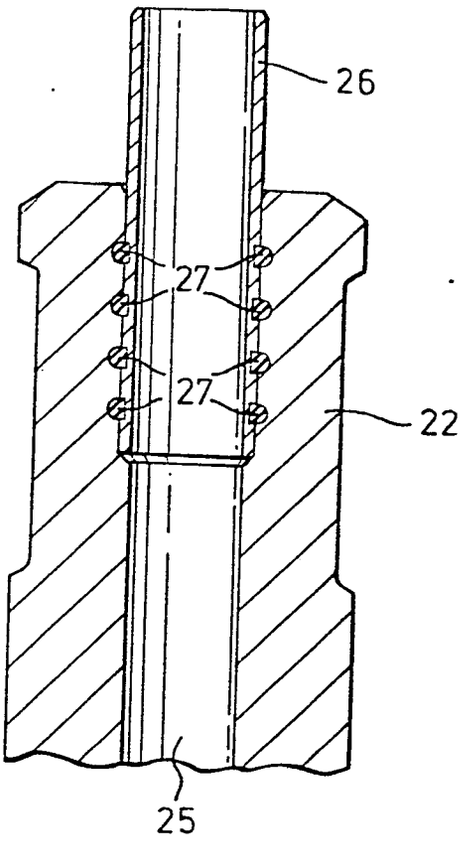

Fig.6.

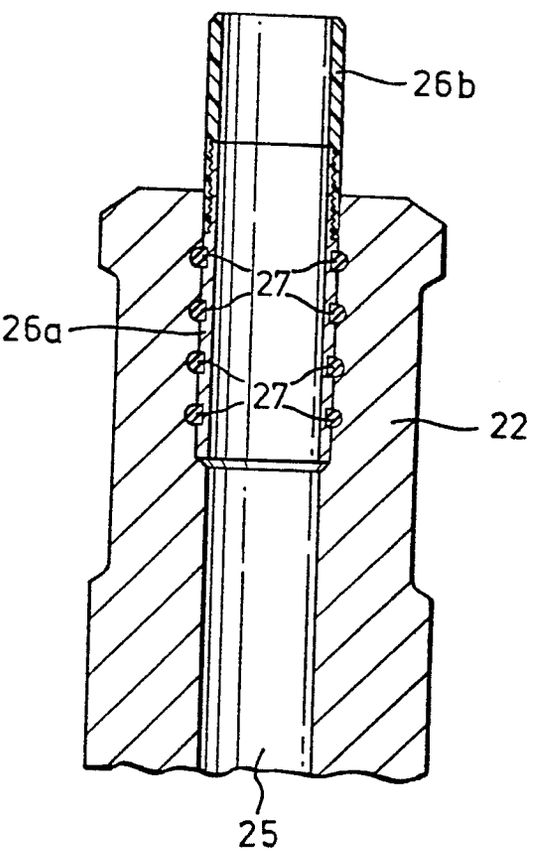

Fig.7.

European Patent Office

EUROPEAN SEARCH REPORT

0011219
Application number
EP 79104336.7

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim
X	EP - A1 - 0 004 946 (WALTER) + Fig. 1a, pos. 26,27; claim 1+	1
A	DE - B - 2 609 376 (H. P. WALTER) +	1,2
A	DE - B - 2 551 292 (INSTITUT GORNOGO) + Column 3, lines 62-66 and fig. 1 +	1,2,8
A	DE - B - 2 362 724 (HALIFAX) + Fig. 1 +	1
A	DE - B - 2 062 690 (ATLAS COPCO) + Column 4, lines 30-33; fig. 1b and fig 4 +	1,2
A	GB - A - 1 462 743 (BAKERDRILL) + Page 7, lines 10-31 +	1,2
A	US - A - 3 970 335 (BAKERDRILL) + Column 3, lines 63-66; column 5, lines 25-47 +	1,2
A	US - A - 3 791 462 (CURINGTON) + Fig. 3b, pos.35; column 3, lines 47-54 +	1
A	AT - A - 317 813 (MISSION MANUFACTURING) + Page 5; claim 1 +	1

CLASSIFICATION OF THE APPLICATION (Int. Cl.) 3

F 16 P 7/00
E 21 B 4/06
E 21 C 3/04

TECHNICAL FIELDS SEARCHED (Int.Cl.) 3

E 21 B 4/00
F 21 B 10/00
E 21 C 3/00

CATEGORY OF CITED DOCUMENTS

X: particularly relevant
A: technological background
O: non-written disclosure
P: intermediate document
T: theory or principle underlying the invention
E: conflicting application
D: document cited in the application
L: citation for other reasons

&: member of the same patent family, corresponding document

X The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
VIENNA	01-02-1980	DRNOWITZ

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