(19) DANMARK

(10) DK/EP 2642067 T3

(12) Oversættelse af europæisk patentskrift

Patent- og Varemærkestyrelsen

(51) Int.Cl.: *E 21 B 33/08 (2006.01)* *F 16 J 15/16 (2006.01)* *F 16 J 15/32 (2006.01)* *F 16 J 15/40 (2006.01)*

(45) Oversættelsen bekendtgjort den: **2016-08-22**

(80) Dato for Den Europæiske Patentmyndigheds bekendtgørelse om meddelelse af patentet: **2016-05-18**

(86) Europæisk ansøgning nr.: **13172227.4**

(86) Europæisk indleveringsdag: **2009-12-23**

(87) Den europæiske ansøgnings publiceringsdag: **2013-09-25**

(30) Prioritet: **2008-12-23 GB 0823444**

(62) Stamansøgningsnr: **09799690.4**

(84) Designerede stater: **AT BE BG CH CY CZ DE DK EE ES FI FR GB GR HR HU IE IS IT LI LT LU LV MC MK MT NL NO PL PT RO SE SI SK SM TR**

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(54) Benævnelse: **Forbedret forsegling**

(56) Fremdragne publikationer:
US-A- 894 739
US-A- 2 731 282
US-A- 3 199 876
US-A- 3 490 525
US-A- 5 305 854
US-A1- 2003 184 019

DESCRIPTION

Field of the Invention

[0001] The present invention relates to an improved seal. The seal is particularly for use in the oil industry to provide a seal between a piston and a piston housing; or as part of a slip joint in a marine riser.

Background to the invention

[0002] The requirement to provide a seal between separate elements is well known in a wide range of technical fields. Typically this is carried out to prevent passage of a fluid from one region to another, for example due to a requirement to maintain a pressure differential or to prevent the fluid from causing damage outside its use area.

[0003] Where the seal is between two articles undergoing relative motion then the problem becomes more difficult, because if the seal element is to be effective, the seal element needs to engage both articles. The motion then causes wear on the seal element. Additionally, the seal element can impart a force resistive to the motion.

[0004] In the oil industry for example different types of relative motion can be contemplated: both relating to movement of an item of equipment within a generally cylindrical casing. In the case of a casing housing for a drill, then the seal between the drill and the casing needs to be able to withstand the rotatory motion of the drill. In the case of a piston, its longitudinal motion along the axis of the piston and the piston housing causes the difficulty.

[0005] In both of these situations, too soft a seal material can result in rapid wear of the seal element. Too hard a seal material can result in a weak seal as the seal material does not engage well with the various articles. Alternatively, if the seal engages too strongly with the articles then it can inflict wear on these articles and also inhibit their motion.

[0006] US 2003/0184019 describes a stuffing box for a polished rod used with a downhole pump. The stuffing box comprises a chamber for receiving an injectable packing from a reservoir, and seals against the rod in conjunction with anti-extrusion rings.

[0007] Within an oil industry drilling operation it is important that an effective seal be maintained for as long a period as possible, as replacement of the seal element can be both hazardous and expensive. Moreover, some seal elements are in difficult locations many metres underground and so the replacement may not be easy. Further, some seal elements are used in locations where space is at a premium and so the horizontal area taken up by the seal element and the housing therefor should occupy as little space as possible.

[0008] In the particular examples given above, conventional seal elements are sacrificial and comprise a polymeric rubber material, often having a layer of lubricating oils between the seal material and the drill or piston. The material is often housed within a seal block affording access to replace the seal element when required. As indicated however this requires the operation being undertaken to be closed down and for the section containing the seal block to be isolated to prevent backflow from the drill hole.

[0009] It is an object of the present invention therefore to provide a seal to address the above problems. It is a further object of the present invention to provide an improved method of obtaining a seal which addresses the above problems and reduces the frequency with which downtime occurs.

Summary of the Invention

[0010] According to a first aspect of the invention there is provided a device to provide a seal between a housing for a moving element and the moving element, the device comprising:

a storage well to retain a seal material, the storage well having an aperture in a housing connecting the storage well with an external surface of the moving element and enabling the seal material to pass into the space between a housing and the moving element;

and pressurising means to pressurise the seal material and force the seal material out of the aperture and into contact with the moving element to form a seal; characterised in that the seal material comprises a solid resilient seal material, wherein the device is configured to enable additional seal material to be introduced into the storage well between the pressurising means and the solid resilient seal material to replenish the solid resilient seal material;

and wherein the pressurising means is configured to pressurise the additional seal material against the solid resilient seal material.

[0011] The seal can therefore be continually renewed without the requirement to shut down an operation.

[0012] Preferably, the seal precursor comprises one or more monomers, the or each monomer reacting to form a polymer. Polymeric materials can be selected to have the properties required of the seal material. Moreover, the reaction between monomers can be tailored to suite any change in seal material required.

[0013] Optionally, the seal precursor includes a chemical initiator such as free radical or free radical producer to accelerate the reaction between monomers. Again therefore, further control over the polymer material is obtained.

[0014] Alternatively or further optionally, reaction between monomers is initiated thermally.

[0015] Conveniently, the device includes temperature control means to control the temperature of the seal material.

[0016] Optionally, the seal precursor includes a particulate material distributed throughout the seal precursor distributed throughout its volume. The particulate material further optionally includes polytetrafluoroethylene or a silica glass.

[0017] The pressure exerted on the piston is advantageously provided by hydraulic pressure.

[0018] Optionally, the pressure exerted on the seal material precursor is provided by a piston operated by hydraulic pressure.

[0019] Advantageously, means are included to determine the volume of seal material in the well enabling an operator to determine when replacement seal material needs to be added.

[0020] Conveniently the piston surface in contact with the seal material is profiled to increase the surface area of the piston surface and aid mixing of and integration between seal material precursor and seal material. Further conveniently, the surface is serrated.

[0021] Preferably a pressure indicator is included to determine the pressure in the well.

[0022] The device preferably includes a level indicator to show the level of seal material in the well. The indicator is further preferably a rod whose lower end rests on the surface of the seal material, the rod passing through the housing.

[0023] According to a second aspect of the invention there is provided a method of producing a seal, the method comprising the steps of:

1. (i) providing a device comprising a storage well for retaining seal material and a housing, the housing enclosing a portion of a reciprocating or rotating article with which a seal is to be made and comprising an aperture connecting the storage well with the external surface of the article;
2. (ii) providing a solid resilient seal material in the storage well of the device;
3. (iii) applying pressure via a pressurising means to force the solid resilient seal material through the aperture into an open volume between the housing and the article to seal the space between the housing and the article;
4. (iv) replenishing the solid resilient seal material by introducing additional seal material into the storage well of the device and pressurising the additional seal material against the solid resilient seal material.

Brief Descrption of the Drawings

[0024] The invention will now be described with reference to the accompanying drawings which show by way of example only, two examples of a seal. In the drawings:

Figure 1 is a cut away side view of a sealing block and cylinder;

Figure 2 is a top view of a block;

Figure 3 is a cut away side view of a double seal assembly;

Figures 4a, b, & c illustrate the operation of the sealing block of Figure 1;

Figure 5 illustrates the sealant retainer in a block; and

Figure 6 illustrates piston profiles;

Figures 7a-7c illustrate an embodiment of an indicator rod; and

Figures 8a-8c illustrate a housing usable in an embodiment of a seal.

Detailed Description of the Invention

[0025] The requirement to form a seal between two elements of a machine, to prevent fluid flow, has been known for centuries and a large variety of solutions proposed. The most common of these solutions involves simply interposing a fluid impermeable barrier, which barrier conforms to the shape of each element and so does not allow fluid across.

[0026] Such an arrangement is usually successfully and readily achieved where the two elements are stationary relative to one another. However, where the two elements are in relative motion, then difficulties occur. Such a situation can occur where for example, one of the elements is a piston moving in a cylinder or a drill shaft rotating within a guide housing. Due to the seal element being in close contact with the moving element, wear on the seal element can be rapid. The seal will therefore need to be replaced at frequent intervals to prevent leakage of fluid and also damage to the elements. Replacement can be expansive: partially due to the cost of the seals themselves, but also in terms of the loss of production time due to the machine being switched off. Moreover, especially in the oil industry many seals are not easily accessible and working on their replacement can be dangerous. In addition seals are in locations, such as an offshore drilling rig, where the space occupied by the seal and its housing needs to be kept to a minimum.

[0027] The present invention seeks to prolong the lifetime of a seal by providing a seal which is in effect continually being renewed. This is achieved by feeding through, under pressure, the seal material so that as the leading edge of the seal material is worn away, the material behind the leading edge takes its place in contact with the moving element. In addition replacement seal material is added to the volume of seal material, remote from the seal/element interface, to ensure that the seal does not completely wear away. Such replacement material can be added without the drilling operation ceasing or, where safety considerations render this impracticable, with a minimum downtime to the production or manufacturing process.

[0028] With reference therefore to Figures 1 & 2 the basic elements of the seal are shown. The problem as shown here is to provide a seal about the outside of the reciprocating barrel 10. The barrel 10 can be a piston moved, either by chemical or mechanical energy (such as motion induced by the waves at sea), in a direction longitudinal to the axis of the barrel 10.

[0029] The seal material is a solid, resilient material and is retained within a housing 11 made of steel or other suitably strong and corrosion resistant material. To facilitate cleaning of the inner areas of the housing 11, the housing is provided in two sections, held together by housing bolts 12. The housing 11 defines a gel seal cavity 13 in which the seal material is retained. The gel seal cavity 13 defines a first portion 13a which is vertically arrayed and linked via a connection portion to a second, longitudinally orientated portion 13b. Said horizontally orientated

[0030] portion 13b opens onto the barrel 10 which therefore enables the seal material within the cavity 13 to engage the barrel 10.

[0031] In use, pressure is applied to the seal material which forces the seal against the outside of the barrel wall 10a of the barrel 10. In the embodiments, illustrated herein pressure is applied by means of a piston 14, which is urged against the upper

surface of the seal material. To ensure that seal material does not escape around the sides of the piston 14, piston seals 15 are housed around the piston 14.

[0032] It will be readily envisaged that as the piston 14 is designed to pass around the barrel 10 the piston 14 has an annular form.

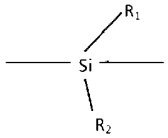
[0033] At various locations around the piston 14, means are provided in the form of a through-piston port 16 to enable fresh seal material to be passed into the gel seal cavity 13. In the embodiment shown this facility is located within a position indicator rod 17. The rod 17 rises and falls in response to the level of seal material in the cavity 13. A further seal 18 ensures that material within the cavity 13 does not leak out.

[0034] Pressure can be exerted on the pistons 14 by the conventional means known in the art. For example hydraulic or pneumatic pressure can be applied via the pressure ports 19. A test or cavity pressure port 20 is provided to indicate to the user the pressure in the seal region.

[0035] The invention described herein is intended for use in conjunction with a seal material which is supplied as a monomeric or partially-polymerised pre - polymer in the form of a freely flowing liquid which can readily flow down the through-piston port 16, but which polymerises within the gel cavity 13 to form a solid polymeric material.

[0036] The pre-polymer can therefore comprise one or more monomers, together with a polymerisation initiator. Alternatively, the monomers can undergo thermal polymerisation, the housing being equipped in that case with a heating element to ensure that the correct temperature is maintained in the cavity to control the polymerisation rate to that which yields the polymer having the correct properties.

[0037] One of a polymeric material suitable for use arc compounds belonging to the polysilicone family. Such materials have a general formula :



where R is an alkyl group, linear or branched. The catalyst is of a type known in the art and can comprise, -for example, a metal or polymetallic complex having organic ligands. The seal material contemplated can have a Shore Hardness of around 70.

[0038] In addition to the polymeric material a particulate solid can be included to provide a lubricator means which assists in reducing friction between the seal material and the barrel 10 said beads can be a low friction material such as polytetrafluoroethylene (PTFE). Additionally or alternatively an abrasive material can be used either as a replacement for or in addition to the lubricating material. An abrasive material can strip the rust or other irregularities from the surface of the barrel 10. It can be envisaged that the seal material include regions or slices containing abrasive material to enable periodic cleaning of the barrel 10 to be carried out.

[0039] Figure 3 is a second embodiment of a seal, functioning in the same fashion as the embodiment in Figure 1, the second embodiment of housing 30 providing however a double seal, each of which is produced as outlined above.

[0040] The process by which a seal is formed and maintained is shown in Figures 4a-4c. In these figures, those parts referred to, which are shown in Figure 1 are shown with the same reference numbers.

[0041] In Figure 4a, the seal material is shown, in solidified form, filling the cavity 13 (this is shown in more detail in Figure 5). Pressure is exerted on the seal material via the piston pressure ports 19. Pressure is typically exerted by a hydraulic fluid.

[0042] The fluid acts to push the piston 14 onto the seal material and cause the plug of seal material to be pushed out of the aperture (not shown) until the material is against the barrel 10 in sufficient amount and with sufficient pressure to cause a seal to be formed. It will be recognised that the solidified seal material should possess sufficient elasticity to enable the seal material to form into the shape of the barrel wall 10a.

[0043] The piston position indicator 17 at this point is at its maximum extension out of the housing 11 indicating the cavity 13 is full. As the seal material wears away due to the motion of the barrel 10, and referring now to Figure 4b, the pressure maintained on the seal material forces the plug of seal material along the cavity 13. The piston 14 therefore is moved along the cavity 13, the

hydraulic fluid moving into the volume 41 formerly occupied by the piston 13 to maintain the pressure on the piston. As the level of seal material drops this is indicated by the position indicator 17.

[0044] Once the level of seal material drops below a preset level, un-reacted pre-polymer is added along through the gel injection port 16 to bring the level in the cavity 13 back up to the full mark. The pre-polymer polymerises within the cavity 13 and in sufficient time for it to be solid before it reaches the aperture to the barrel 10.

[0045] In the above manner a seal is continually maintained and renewed without the need for the action of the barrel 10 to be stopped. Downtime of the machine or process, of which the barrel 10 is a part, is therefore considerably reduced.

[0046] Operation of the device to introduce pre-polymer into the cavity 13 when the level of the piston 14 drops, can be done either manually or automatically. For example, when the indicator rod 17 drops to a preset level this can be set up to cause a warning signal to be given off. An operator then adds pre-polymer to the cavity 13. The pre-polymer is added under sufficient pressure to force the piston 14 upwards, and addition is continued until the level in the cavity 13 is at the required level.

[0047] Alternatively, the drop in the indicator rod 17 can be configured to trigger automatic filling of the cavity 13 with pre-polymer.

[0048] In order to increase the mixing and integration of introduced pre-polymer into the solid material of the set polymeric seal material, the lower edge of the piston which engages the seal material, can be profiled.

[0049] As illustrated in Figure 6, a number of different profiles can be used In Figure 6a, the lower surface 61 of the piston 60 is concave, causing a discontinuity in the surface of the seal material which enables better bonding. Similarly, the surface 63 of the piston 62 in Figure 6b produces an indentation in the surface of the material.

[0050] The surfaces 65, 67 of pistons 64, 66 respectively are serrated, which serrations provide sharp discontinuities and possibly score marks in the seal material which enable the pre-polymer to penetrate the bulk of the seal material and so minimise the discontinuity between the newly introduced seal material and the already present material once the new pre-polymer has set.

[0051] In an additional embodiment, an indicator rod (see Figures 7a-7c) is removable which particularly facilitates the cleaning out of excess seal material which has hardened within the indicator rod during the introduction of fresh liquid seal precursor. The indicator rod is formed of two main elements, an outer jacket 71 and a removable tubular lining insert 72. The tubular part 73 of the insert 72 is passed down the central channel of the outer jacket 71 and the insert 72 are retained together by means of a screw threaded fitment, at the proximal end of the rod. The outer surface of the outer jacket 71 has a screw thread at its distal end to allow the rod 70 to be fitted in position.

[0052] The above arrangement enables the insert 72, once the sealant material has set, to be removed. The removal is facilitated by the narrowing 74 of the insert 72 at its distal end 75. The narrowing results in the sealant material at that point being weaker, and the twisting action moreover, as the insert 72 is unscrewed causes the sealant material to break away allowing the resultant apertures to be capped off. Alternatively, the insert 72, once cleaned can be replaced and its end capped off.

[0053] A further means of utilising the housing is shown in Figure 8. In this mode, there is no indicator rod or means of topping up the sealant material. The seal element is provided as a preformed ring which is inserted into the block 11. The preformed element can include a seal arrangement moulded or fitted to its top edge which prevents hydraulic pressurising fluid from penetrating between the element and the housing. Means are provided to apply pressure to the seal element to fuse it against the original seal already contained within the block 11.

[0054] In addition to the above embodiment of Figure 8 means can also be provided to bond or join together the original seal element and the newly inserted element. Said means can be in the form of an adhesive material or a portion of primer which can partially solubilise the surfaces of the elements, subsequently binding together when the premix sets.

[0055] It will of course be understood that the invention is not limited to the specific details described herein, which are given by way of example only, and that various modifications and alterations are possible within the scope of the invention.

REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- US20030184019A [0006]

Patentkrav

1. Indretning til tilvejebringelse af en forsegling mellem et hus (11) til et bevægeligt element og det bevægelige element (10), hvilken indretning omfatter:
en oplagringsboring (13) til tilbageholdelse af et forseglingsmateriale, hvilken oplagringsboring har en åbning i et hus, som forbinder oplagringsboringen med en udvendig overflade (10a) af det bevægelige element og giver forseglingsmaterialet mulighed for at passere ind i hulrummet mellem et hus og det bevægelige element;
og tryksætningsorgan (14) til tryksætning af forseglingsmaterialet og tvinge forseglingsmaterialet ud af åbningen og i kontakt med det bevægelige element (10) til dannelse af en forsegling;
kendetegnet ved, at forseglingsmaterialet omfatter et fast elastisk forseglingsmateriale, hvor indretningen er udformet til at give det yderligere forseglingsmateriale mulighed for at blive indført i oplagringsboringen (13) mellem tryksætningsorganet og det faste elastiske materiale for at komplettere det faste elastiske forseglingsmateriale;
og hvor tryksætningsorganet er udformet til at sætte det yderligere forseglingsmateriale under tryk mod det faste elastiske forseglingsmateriale.

2. Indretning ifølge krav 1, hvor indretningen er udformet til at optage en flydbar forseglingsmaterialeprækursor mellem tryksætningsorganet og det faste elastiske forseglingsmateriale for at komplettere det faste elastiske forseglingsmateriale.

3. Indretning ifølge krav 2, hvor indretningen er udformet til at give den flydbare forseglingsmaterialeprækursor mulighed for at hærde i indretningen.

4. Indretning ifølge krav 3, hvor forseglingsmaterialeprækursoren omfatter en eller flere præpolymerer, hvor præpolymeren eller hver præpolymer reagerer i indretningen til dannelse af en polymer.

5. Indretning ifølge krav 3 eller krav 4, yderligere omfattende en indløbsport for at give den flydbare forseglingsmaterialeprækursor mulighed for at blive

indført i oplagringsboringen.

6. Indretning ifølge et af de foregående krav, hvor tryksætningsorganet omfatter et stempel (14), som bliver drevet af hydraulisk eller pneumatisk tryk.

7. Indretning ifølge et af de foregående krav, hvor indretningen er udformet til at optage et på forhånd udformet fast forseglingselement for at komplettere det faste elastiske forseglingsmateriale.

8. Indretning ifølge et af de foregående krav, yderligere omfattende en trykindikator (17) til at bestemme niveauet af forseglingsmateriale i oplagringsboringen.

9. Fremgangsmåde til fremstilling af en forsegling, hvilken fremgangsmåde omfatter de følgende trin:
(i) at tilvejebringe en indretning, der omfatter en oplagringsboring (13) til tilbageholdelse af forseglingsmateriale og et hus (11), hvor huset omslutter en portion af en reciprokerende eller roterende genstand (10), hvormed der skal foretages en forsegling, og omfatter en åbning, der forbinder oplagringsboringen med genstandens (10) udvendige overflade;
(ii) at tilvejebringe et fast elastisk forseglingsmateriale i indretningens oplagringsboring;
(iii) at påføre tryk via et tryksætningsorgan (14) for at tvinge det faste forseglingsmateriale gennem åbningen og ind i et åbent volumen mellem huset og genstanden for at forsegle hulrummet mellem huset og genstanden;
(iv) at komplettere det faste elastiske forseglingsmateriale ved at indføre yderligere forseglingsmateriale i indretningens oplagringsboring og at sætte det yderligere forseglingsmateriale under tryk mod det faste elastiske forseglingsmateriale.

10. Fremgangsmåde ifølge krav 9, hvor det yderligere forseglingsmateriale omfatter en flydbar forseglingsmaterialeprækursor, og fremgangsmåden omfatter at hærde forseglingsmaterialeprækursoren i indretningen til dannelse af et fast elastisk forseglingsmateriale.

11. Indretning ifølge krav 10, hvor den flydbare forseglingsmaterialeprækursor omfatter en eller flere præpolymerer, hvor præpolymeren eller hver præpolymer reagerer i indretningen til dannelse af en polymer.

12. Fremgangsmåde ifølge krav 10 eller krav 11, omfattende at indføre den flydbare forseglingsmaterialeprækursor i oplagringsboringen gennem et indløb (16) af indretningen.

13. Fremgangsmåde ifølge krav 9, hvor det yderligere forseglingsmateriale er et på forhånd udformet fast forseglingselement.

14. Fremgangsmåde ifølge krav 9-13 omfattende at sætte det yderligere forseglingsmateriale under tryk ved hjælp af et stempel (14), der er drevet af hydraulisk eller pneumatisk tryk.

15. Fremgangsmåde ifølge krav 9-14 omfattende at bestemme et niveau af forseglingsmateriale inden i oplagringsboringen under anvendelse af en trykindikator (17) af indretningen.

DRAWINGS

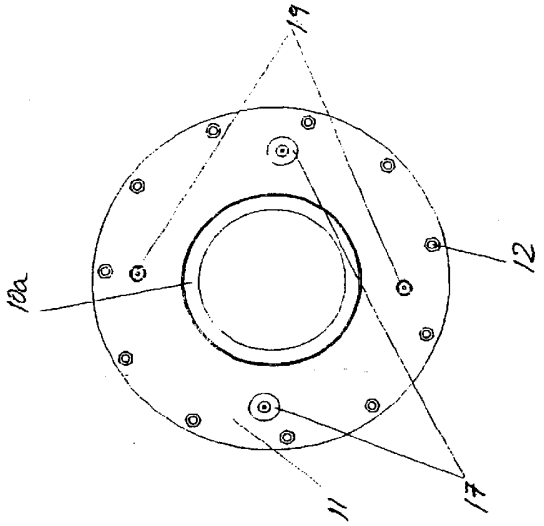


FIGURE 2

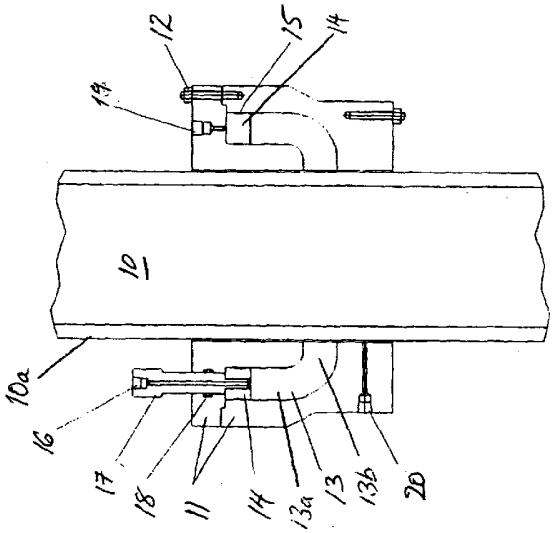


FIGURE 1

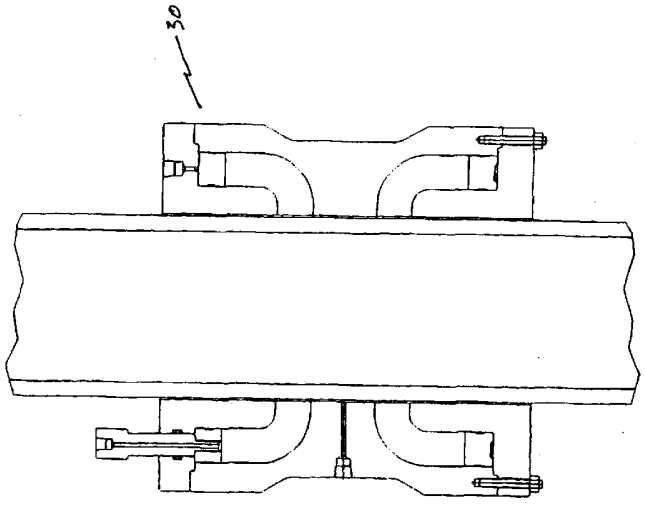


FIGURE 3

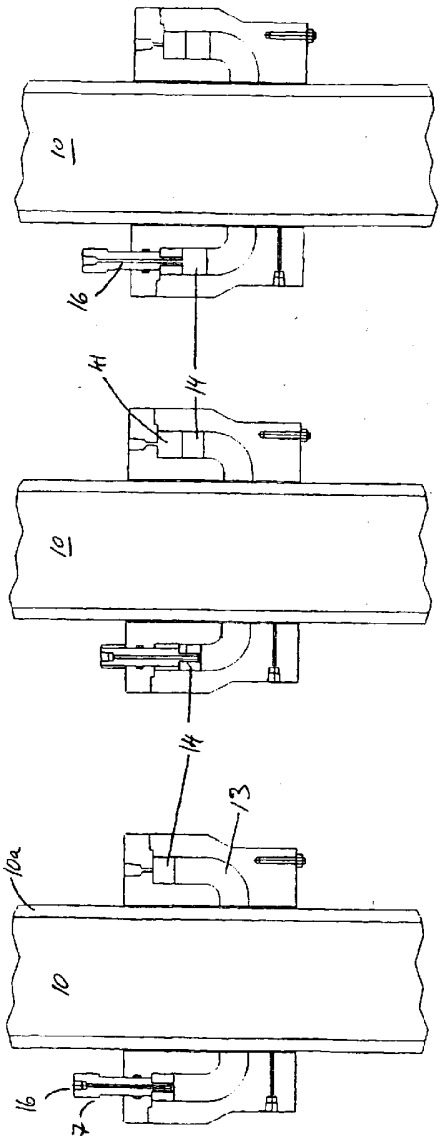


FIGURE 4c

FIGURE 4b

FIGURE 4a

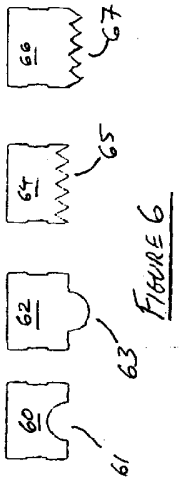


FIGURE 6

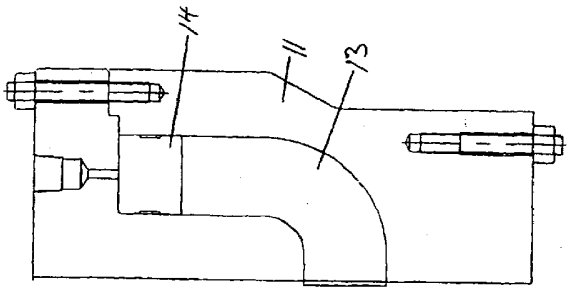


FIGURE 5

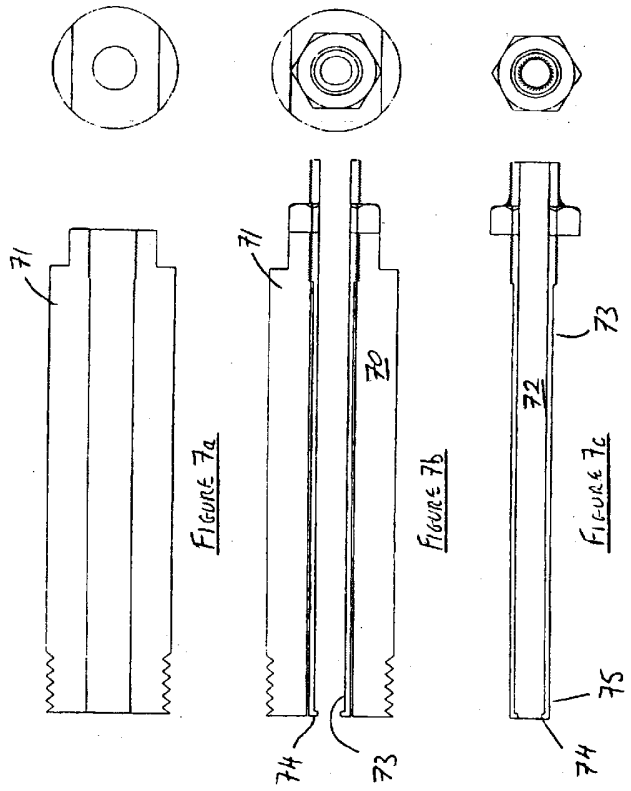


FIGURE 7a FIGURE 7b FIGURE 7c

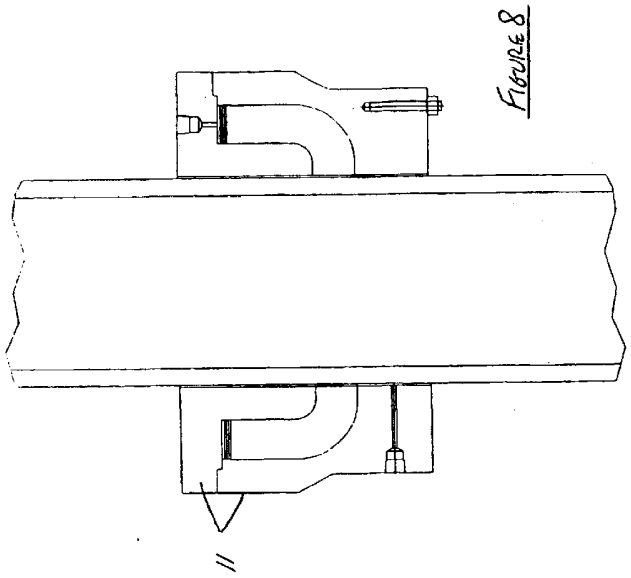


FIGURE 8