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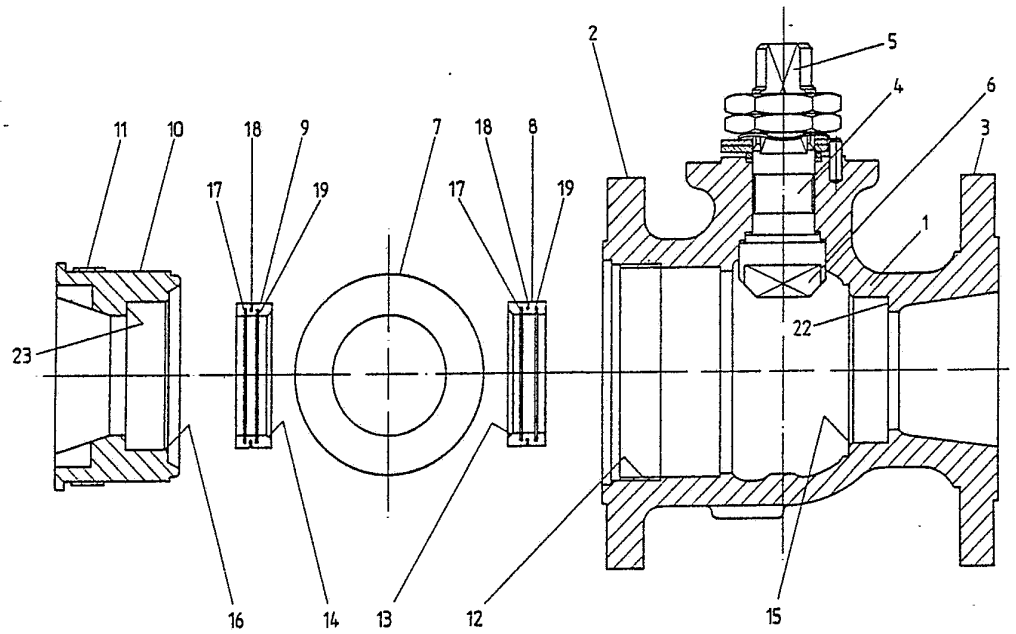

(57) Abstract

A valve seal (8, 9) particularly suitable for cryogenic service comprises a hollow generally cylindrical member fabricated from a material which under cryogenic service conditions is flexible but substantially incompressible. Spaced annular grooves (17, 19) are formed on the inner wall of the member and a further groove (18) is formed on the outer wall between grooves (17, 19). The opposite grooves (17, 19 and 18) overlap slightly to form a 'concertina' like wall cross section. A tapered seating surface (13, 14) is provided to engage the outer surface of a valve ball (7). In service, annular grooves (17, 19 and 18) provide a degree of resilience in a material otherwise incompressible under service conditions.

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A VALVE SEAL SUITABLE FOR CRYOGENIC SERVICE

This invention is concerned with valves incorporating improved valve seats and is particularly although not exclusively related to ball valves and seals therefore.

One of the main difficulties facing a valve manufacturer is the design of valve seals for a variety of different valve types and for operation under widely differing conditions. Although the present invention will be described with reference to a "floating" ball valve, it will be readily apparent that with suitable modifications, it is applicable to other types of valves.

In "floating" ball valves the ball member "floats" within the valve housing and is supported by opposed annular seals for at least limited axial movement between opposed valve seats under the influence of fluid pressure. With the valve ball in the closed position the ball is forced against the seat downstream of the pressure source. A flexible seal associated with the seat is provided to prevent leakage of fluid between the valve seat and the ball as a result of wear or imperfect machining between those surfaces. Usually sealing is effected by resiliently biassing the seal against the ball i.e. by an annual metal spring or by utilizing a resilient seal material.

Generally speaking, for most general service valves, creation of an adequate seal is not greatly difficult. Difficulties do arise however when valves are required, for special service applications such as cryogenic service. Cryogenic service valves are required to operate at temperates between ambient and -196^{o}C but more usually in the range -50^{o}C to -196^{o}C. Under these extreme conditions the valves are expected to give reliable trouble free operation over extended periods of use.

Polytetrafluoroethylene (PTFE) is a widely used resilient valve seal material due to its chemical inertness

and ability to operate over a wide temperature range. Its low friction characteristics make it very suitable as a seal material as it does not retard valve operation due to friction between the ball and the seal. PTFE however is subject to a plastic deformation known as "creep" or "cold flow" which over a period causes a reduction in resilient memory and ultimately permits valve leakage.

It is an aim of the present invention to overcome or alleviate the problems of prior art valve seals and to provide a simple and inexpensive valve seal design suitable for a wide range of valves and operating conditions. According to one aspect of the invention there is provided a sealing member for effecting in use a fluid seal between at least two relatively movable valve members, said sealing member comprising:-

a body of flexible material having sealing surfaces adapted to frictionally engage said valve members, said body being so shaped as to enable a resiliently flexible deformation thereof whereby said sealing surfaces are biassed against respective valve members, said sealing member characterized in that said body is comprised of flexible material and which is substantially imcompressible under conditions of use.

Preferably said sealing member includes at least two recessed portions arranged substantially normal to the deformation axis.

Preferably at least two recessed portions are formed in opposed directions.

Preferably said sealing member comprises a hollow body with recessed portions formed on inner and outer surfaces.

Preferably said recessed portions comprise recessed channels.

Preferably said sealing member comprises an annular member adapted to form a fluid seal in a ball valve.

Preferably said sealing member includes a sealing surface on a portion of said body which is not able to undergo resiliently flexible deformation under conditions of use.

According to a further aspect of the invention there is provided a seal assembly for effecting in use a fluid seal between at least two relatively movable valve members, said seal assembly comprising:-

a sealing member substantially as hereinbefore defined;

locating means to locate a first sealing surface of said sealing member in fixed sealing engagement with one of said valve members; and

biassing means to urge into sealing engagement with another of said at least two valve members, a second sealing surface associated with said body of flexible material.

Preferably said locating means includes a ramped surface on an inflexible portion of said sealing member, said ramped surface adapted to engage a complementary surface on said one of said valve members.

Preferably said biassing means includes a resilient biassing means.

Preferably said biassing means includes a transmission member to transmit to said second sealing surface a biassing force from said biassing means located adjacent said first sealing surface.

According to another aspect of the invention there is provided a valve comprising a sealing member as described above.

Most preferably said valve comprises a cryogenic service valve.

Preferred embodiments of the invention will now be described with reference to the accompanying drawings in which:-

FIG. 1 shows an exploded view of a general service ball valve incorporating one embodiment of the invention.

FIG. 2 shows an assembled view of a cryogenic service ball valve in an assembled state.

FIG. 3 shows an enlarged portion of the valve ball of FIG. 2 with a cross sectional view of the sealing member in an undeformed state.

FIG. 4 shows the sealing member of FIG. 3 in a deformed operational state.

FIG. 5 shows a cryogenic service ball valve assembly incorporating an alternative embodiment of the invention.

FIG. 6 shows an enlarged part assembly of the valve of FIG. 5.

FIG. 7 shows an exploded view of the assembly of FIG. 6.

In FIG. 1 the general service valve comprises a body 1 with opposed flanges 2 and 3 with an operating spindle 4. The head 5 of spindle 4 is provided with an appropriately shaped end to receive a spindle extension (not shown) or an operating lever (also not shown). Preferably the head 5 of spindle 4 is generally cylindrical with a pair of opposed flat surfaces formed therein. Alternatively the spindle 4 may be formed with a cylindrical head having a keyway therein. The inner end of spindle 4 is provided with an engaging tip 6 for actuation of ball 7. Ball 7 includes an aperture 7a to enable passage of a fluid therethrough when the ball is in the open position. Body 1 is formed as a single casting and the operative surfaces are machined as required.

The valve is assembled by first inserting through the aperture in flange 2 first seal 8, ball 7 followed by second seal 9 and finally insert portion 10. Insert 10 is retained within body 1 by a screw threaded engagement between threaded portion 11 and a corresponding threaded

portion 12 in body 1.

In this manner ball 7 may be located as a "floating" ball between a primary seat formed by sealing surfaces 13 and 14 on seals 8 and 9 respectively. A secondary seat is formed by surface 15 within body 1 and surface 16 on insert 10.

FIG. 2 shows an assembly of a generally similar type of ball valve to that of FIG. 1 but which is adapted for use in cryogenic service. The main difference in construction relates to the employment of an extended spindle 5a which is located within an extended bonnet 5b. As illustrated, the tip 6 of spindle 4 is engaged with ball 7. Ball 7 is shown in FIG. 2 in the closed position with aperture 7a at right angles to the flow axis of the valve.

As cryogenic valves of the type shown in FIG. 2 operate under very severe conditions such as with liquid nitrogen gas at temperatures as low as -196^{o}C and high pressures, great care must be taken in the design of such valves and the choice of manufacturing materials to ensure reliable service. For this reason, it is preferred to construct the valve as far as possible from components made from the same materials or materials having substantially identical thermal expansion characteristics. A most preferred material for valve construction is Grade 316 stainless steel.

Valve seals 8 and 9 are preferably manufactured from PCTFE (polychlorotrifluoroethylene) marketed by Minnesota Mining and Manufacturing Company under the trade mark "KEL F". This material is a thermoplastic polymer similar in some respects to PTFE but having mechanical properties suitable for cryogenic service. PCTFE has an extremely high resistance to deformation under compressive loads. Under applied pressures of 8000 psi for sustained periods, a permanent set (deformation) of no greater than

4-5% can be measured. At very low temperatures approaching -200°C this material has good elastic memory and recovers rapidly from flexure on load release without cracking. Although PCTFE is a preferred material for valve seals according to the invention, any other material having similar physical and chemical properties would be suitable.

Unlike most resilient polymers, PCTFE is substantially incompressible and thus it is not possible to use a simple annular sealing ring under compression to obtain a resiliently biassed seal. To overcome this difficulty opposed annular channels 17, 18 and 19 are formed in the inner and outer walls of seals 8 and 9. The bottom or floor of the opposed channels 17, 19 and 18 respectively overlap to give an annular region of discontinuous integrity in the body of the seals 8 and 9. Figure 3 shows an enlarged cross sectional view of seal 8 before assembly of the valve. In this view an optional retaining ring 20 is shown. This ring may be used in large valve seals to prevent distortion of the seal under excess pressures.

In FIG. 4 it can be seen how seal 8 distorts under load when the valve is assembled. Because of the overlapping nature of channels 17, 18 and 19 the body of seal 8 "concertinas" under pressure. The elastic memory of the PCTFE seal material and its ability to flex at low temperatures thus provides a resilient bias which urges seal face 13 into sealing engagement with ball 7 and at the same time urges rear seal face 21 into sealing engagement with wall 23 of the seal pocket in body 1. A similar pocket in insert 10 has a wall 23 for sealing engagement with the rear wall of seal 9.

Accordingly it can be seen that although the PCTFE is substantially incompressible, an analogous state of affairs can be achieved by virtue of the overlapping opposed channels. When body insert 10 is fully inserted into the body, a substantial pressure is created between

ball 7 and seal faces 13 and 14 as well as between the rear walls of seals 8 and 9 and seal pocket walls 22 and 23 respectively to prevent fluid leakage. Notwithstanding this substantial pressure between seal faces 13 and 14 and ball 7, the friction properties of PCTFE are such that the valve is easily operated without excessive spindle torque.

The present invention enables the use of a "soft" valve seat for high pressure applications (and in particular cryogenic service) without the valve seat undergoing plastic deformation leading to leakage.

FIG. 5 illustrates an alternative embodiment of the invention incorporated in a cryogenic service valve. The valve 30 is constructed in a generally similar manner to that of FIG. 2 with a body 31, opposed flanges 32 and 33 and an extended operating spindle 34 located within an extended bonnet 35. The tip 36 of spindle 34 is located within a corresponding recess in ball 37. Ball 37 includes an axial flow aperture 37a. Seal assemblies 38 and 39 are retained within the bore 40 of the valve body 1 by threaded retaining members 41 and 42.

FIG. 6 shows an enlarged view of the seal assembly 38 of FIG. 5 in sealing engagement with ball 37. The seal assembly 38 is retained in an insert member 43. Insert member 43 has a screw threaded portion 44 for engagement within one end of body 31. When insert 43 is removed from body 31 access may be had to the interior of the body 31 for insertion or removal of ball 7. Insert 31 also includes an annular secondary seat face 45.

Seal 46 of PCTFE material is located within the bore of insert 43 adjacent secondary seat 45. Seal 46 includes an inwardly tapered primary seat 47 at one end and an outwardly extending flange 48 at the other end. Flange 48 has an inwardly facing wall 49 which is undercut to engage a ramped shoulder with a complementary outwardly angled wall 50. Between the ends of the seal body are opposed annular

channels 51, 52 and 53 formed in the inner and outer walls of seal 46. Seal 46 is mounted on a support ring 54 with an outwardly extending flange 55 at its rearward end. Seal 46 also includes a shouldered portion 47a adjacent primary seat 47. This shoulder is engaged by the forward end portion 54a of support ring 54.

Retaining member 41 has a forwardly facing annular flange 56 which engages a rear wall of flange 48 on seal 46. Adjacent flange 56 is a shouldered portion 57 which engages a circular spring 58. For the sake of clarity, FIG. 7 shows an exploded view of the assembly of FIG. 6.

The overlapping opposed annular channels 51, 52 and 53 enable a resilient deformation of the central portion of the body of seal 46 between channels 51 and 53 in a manner similar to the embodiment shown in FIGS. 1-4. When assembled it will be clear that under the biassing influence of spring 58 the forward portion 54a of the support ring 54 will be biassed against shoulder 47a of seal 46 to enable a resilient deformation towards ball 37. Primary sealing surface 47 is thus resiliently biassed into sealing engagement with the surface of ball 37.

Also, when assembled, flange 56 of retaining member 41 bears against a solid, substantially incompressible portion of seal 46 and forces complementary ramped faces 49 and 50 into a very tight sealing engagement. The angle of the ramped faces 49 and 50 also permits the radially outer face 48a of flange 48 into sealing engagement with the bore of insert 43. Being manufactured of substantially incompressible material, that portion of the seal under compressive forces from flange 56 will not undergo "creep" or "cold flow", both terms of the art describing plastic deformation under sustained load.

By appropriate selection of spring compression and the dimension and number of annular channels in the body of seal 46 it is possible to design valve seal

assemblies having a predetermined seal engagement force. In addition, it will be apparent that this seal design has a self-compensating adjustment in the event of wear at the primary seat face.

Although the present invention has been described with reference to the valve seats of "floating" ball valves, it will be readily apparent that it is equally applicable to trunnion ball valves and other types of valve seals.

In addition, the seals are suitable for a wide range of pressures (both liquid and gas) over a temperature range from around -200°C to greater than ambient.

It will be readily apparent to a skilled addressee that many modifications and variations may be made to the invention without departing from the spirit and scope thereof.

CLAIMS:

1. A sealing member for effecting in use a fluid seal between at least two relatively movable valve members, said sealing member comprising:-

a body of flexible material having sealing surfaces adapted to frictionally engage said valve members, said body being so shaped as to enable a resiliently flexible deformation thereof whereby said sealing surfaces are biassed against respective valve members, said sealing member characterized in that said body is comprised of flexible material and which is substantially incompressible under conditions of use.

2. A sealing member as claimed in claim 1 wherein said sealing member includes at least two recessed portions arranged substantially normal to the deformation axis.

3. A sealing member as claimed in claim 2 wherein at least two recessed portions are formed in opposed directions.

4. A sealing member as claimed in claim 2 or claim 3 wherein said sealing member comprises a hollow body with recessed portions formed on inner and outer surfaces.

5. A sealing member as claimed in any one of claims 2-4 wherein said recessed portions comprise recessed channels.

6. A sealing member as claimed in any one of the preceding claims wherein said sealing member comprises an annular member adapted to form a fluid seal in a ball valve.

7. A sealing member as claimed in any one of the preceding claims wherein said sealing member includes a sealing surface on a portion of said body which is not able to undergo resiliently flexible deformation under conditions of use.

8. A seal assembly for effecting in use a fluid seal between at least two relatively movable valve members, said assembly comprising:-

a sealing member as defined in any one of claims 1-7;

locating means to locate a first sealing surface of said sealing member in fixed sealing engagement with one of said valve members; and

biassing means to urge into sealing engagement with another of said at least two valve members, a second sealing surface associated with said body of flexible material.

9. A seal assembly as claimed in claim 8 wherein said locating means includes a ramped surface on an inflexible portion of said sealing member, said ramped surface adapted to engage a complementary surface on said one of said valve members.

10. A seal assembly as claimed in claim 8 or claim 9 wherein said biassing means includes a resilient biassing means.

11. A seal assembly as claimed in any one of claims 8,9 or 10 wherein said biassing means includes a transmission member to transmit to said second sealing surface a biassing force from said biassing means located adjacent said first sealing surface.

12. A valve including a sealing member as defined in any one of claims 1-7.

13. A valve including a seal assembly as defined in any one of claims 8-11.

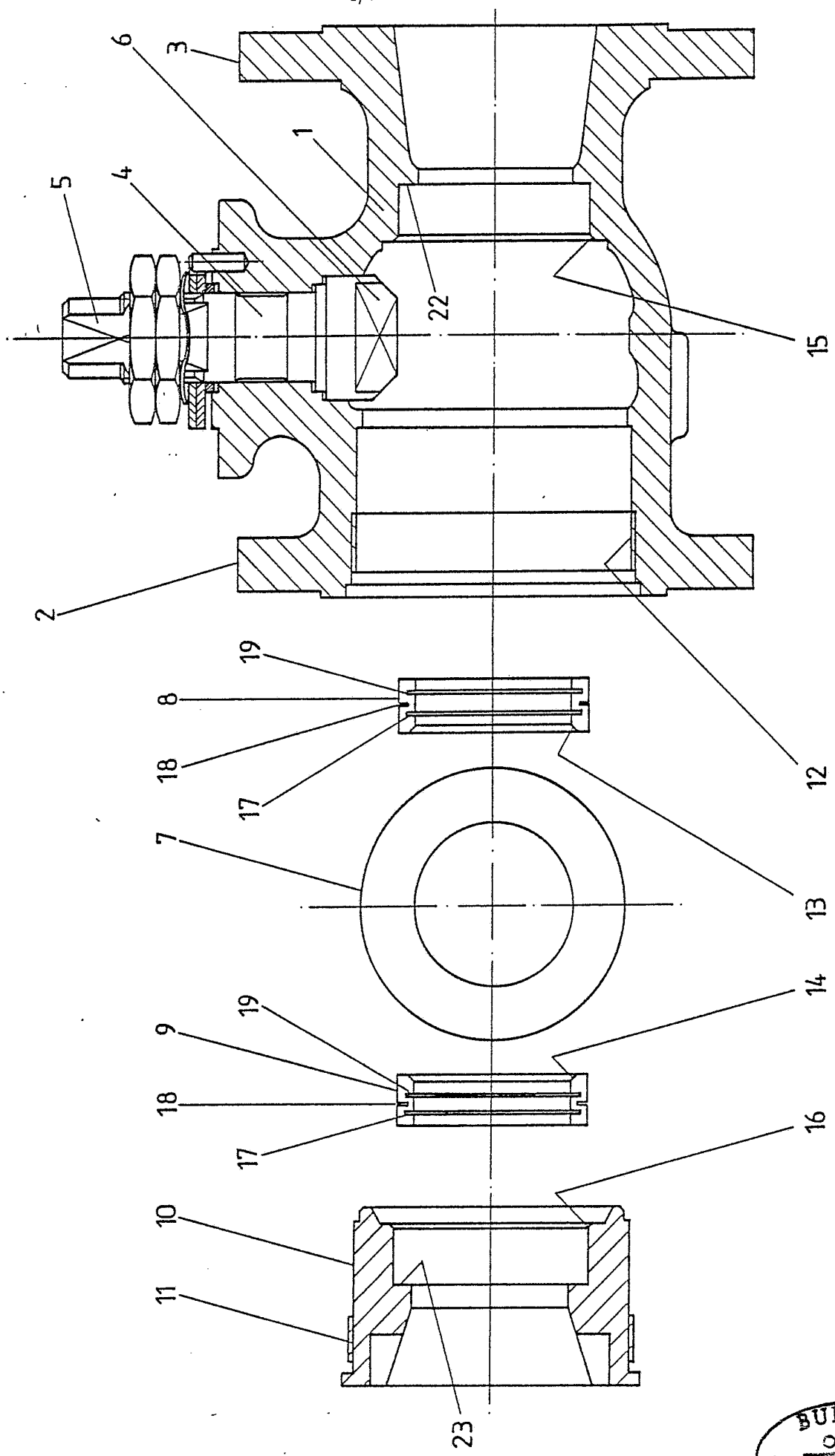


FIG. 1

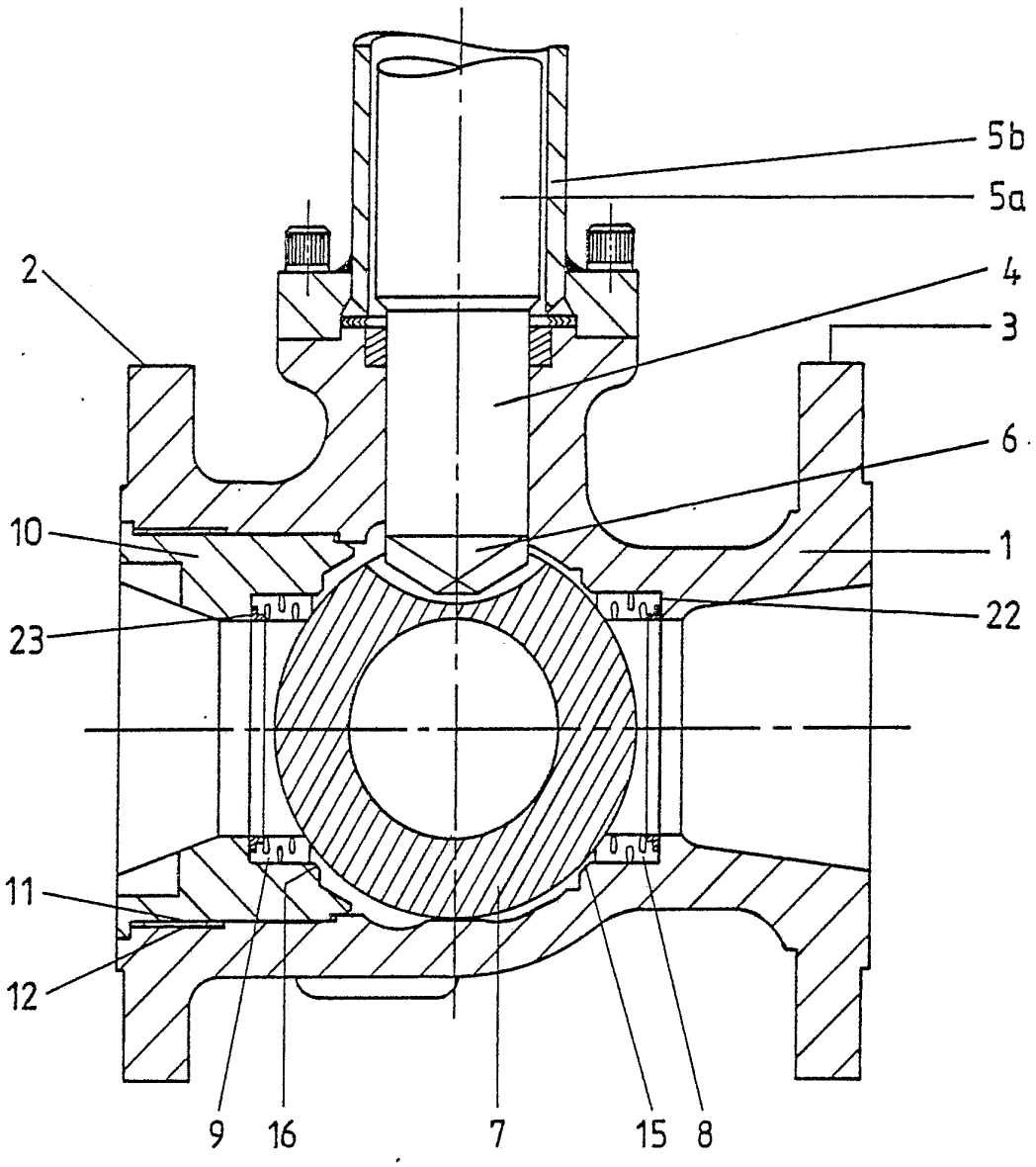
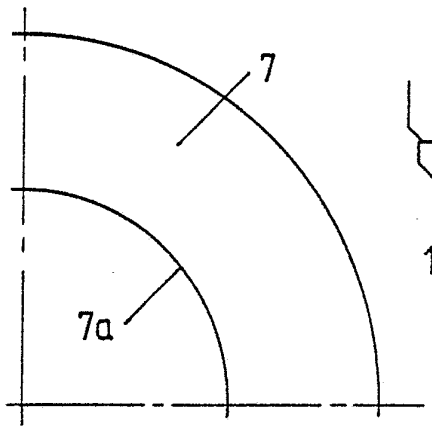


FIG. 2



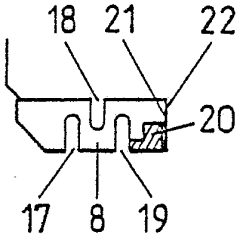


FIG 3

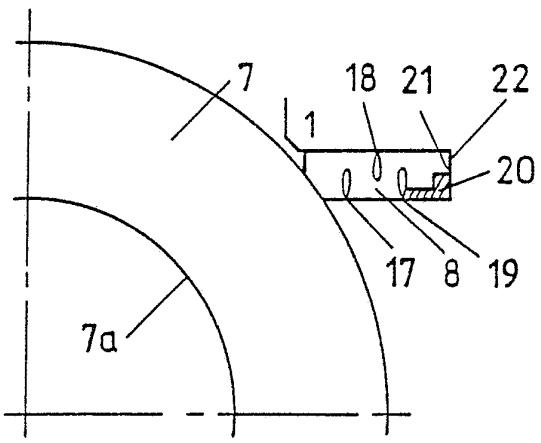


FIG 4

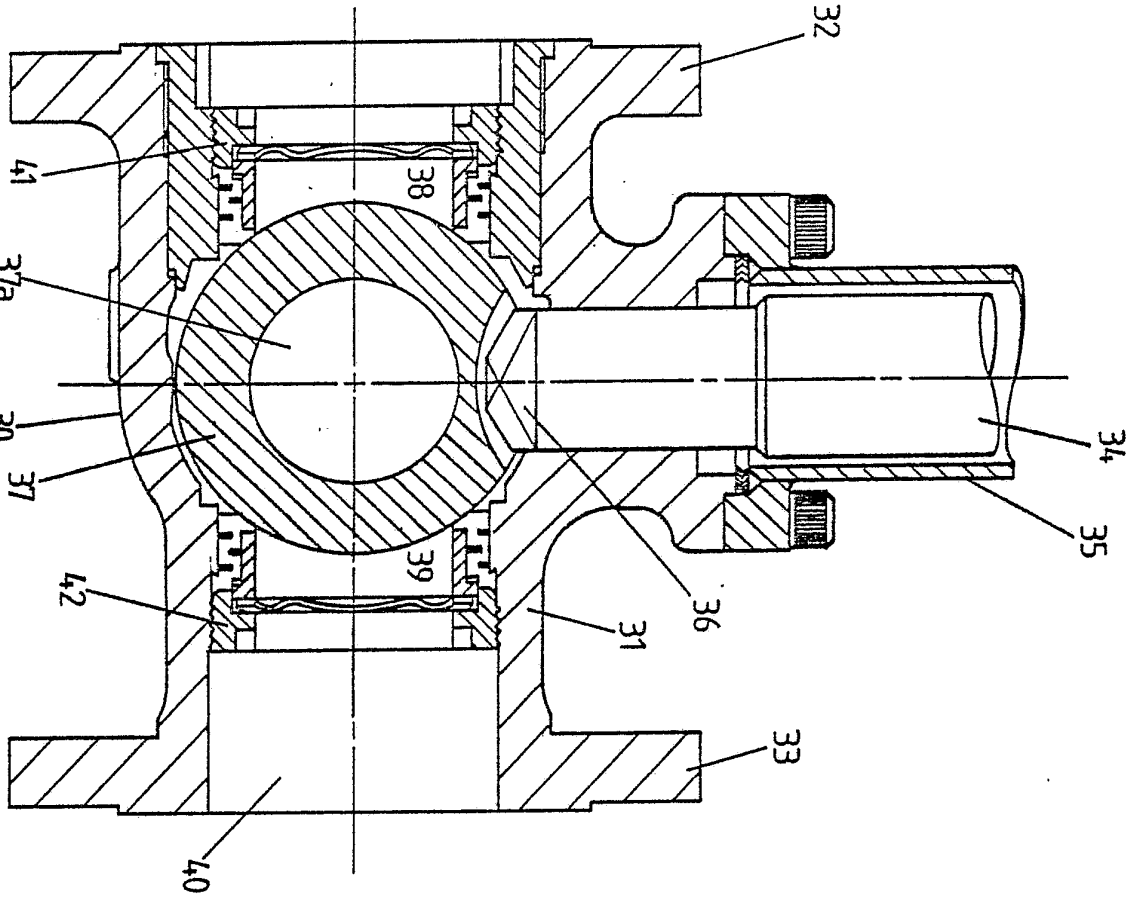


FIG 5

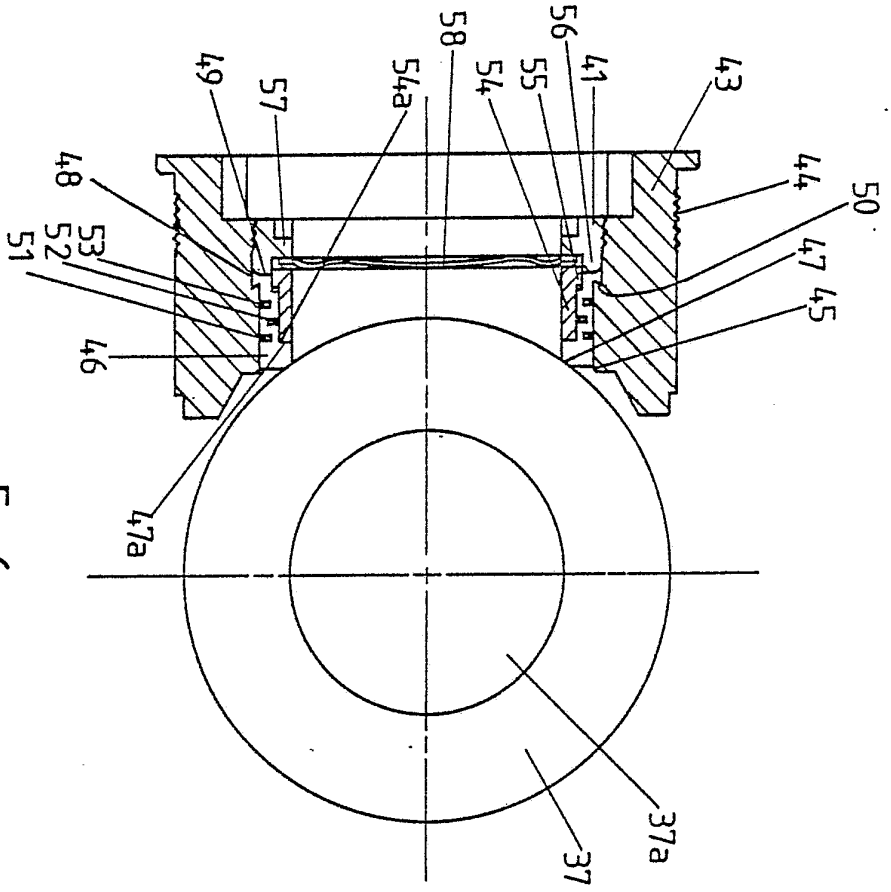


FIG 6

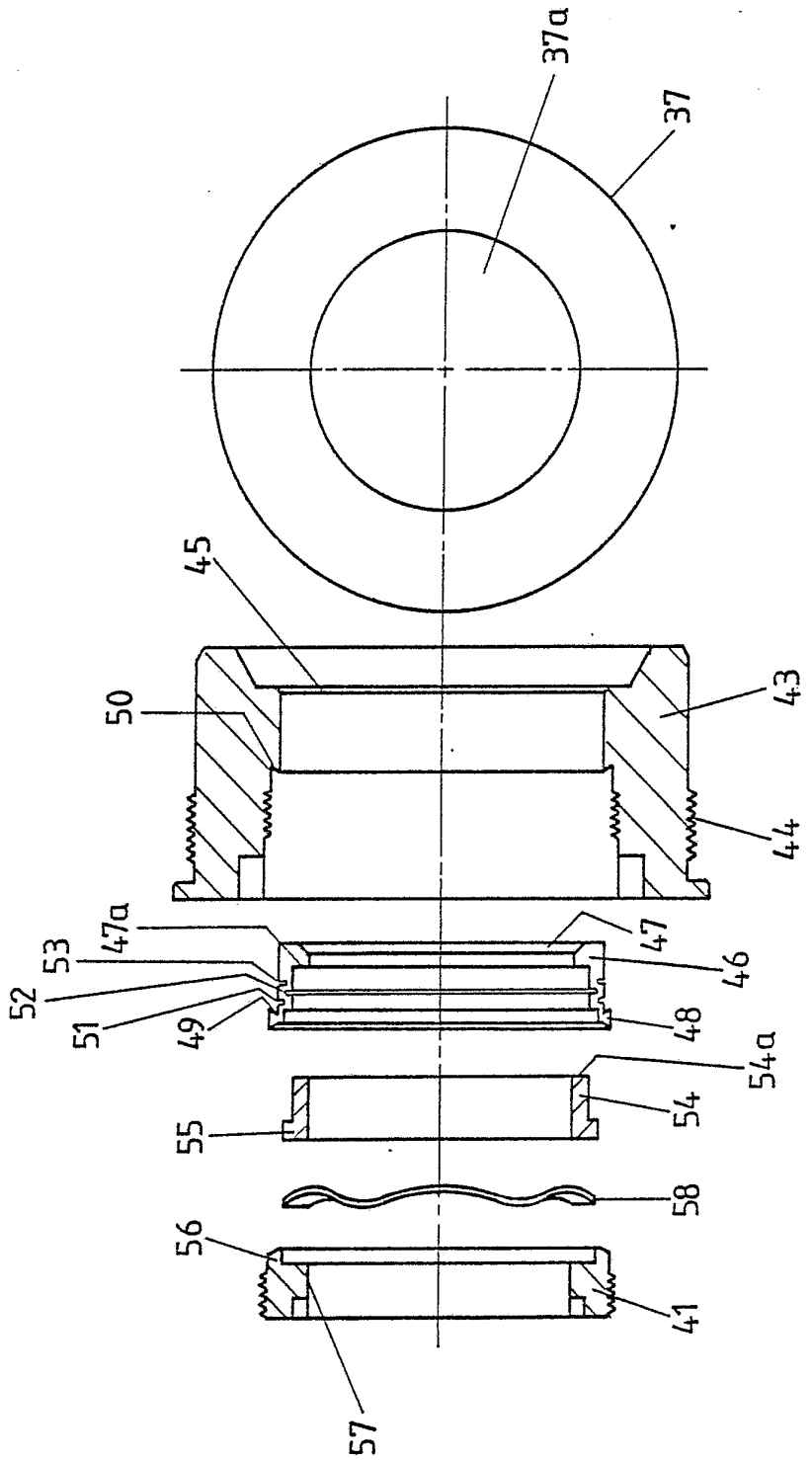


FIG 7

INTERNATIONAL SEARCH REPORT

International Application No PCT/AU 84/00092

I. CLASSIFICATION OF SUBJECT MATTER (if several classification symbols apply, indicate all) [3]

According to International Patent Classification (IPC) or to both National Classification and IPC

Int.Cl.[3] F16K 5/06, 5/08, 5/20, 1/226

II. FIELDS SEARCHED

Minimum Documentation Searched [4]

Classification System	Classification Symbols
IPC	F16K 5/06, 5/08, 5/20, 1/226

Documentation Searched other than Minimum Documentation to the Extent that such Documents are included in the Fields Searched [5].

AU: IPC as above; Australian Classification 74.711340, 74.711343

III. DOCUMENTS CONSIDERED TO BE RELEVANT [14]

Category *	Citation of Document, [16] with indication, where appropriate, of the relevant passages [17]	Relevant to Claim No. [18]
X	GB, A, 1546621 (CRANE LIMITED) 23 May 1979 (23.05.79)	(1-7)
X	GB, A, 1599135 (ACF INDUSTRIES INCORPORATED) 30 September 1981 (30.09.81)	(1, 8-11)
X	GB, A, 1009984 (SAUNDERS VALVE CO.LTD.) 17 November 1965 (17.11.65) See Fig. 4	(1-7, 8-11)
X	US, A, 4220172 (STAGER) 2 September 1980 (02.09.80)	(1-6)
X	US, A, 3399863 (FAWKES) 3 September 1968 (03.09.68) See Figs. 5 & 7	(1-6)
X	US, A, 3233862 (MARSH) 8 February 1966 (08.02.66) See col. 2, lines 12-30 and fig. 3	(1-7, 8-11)
X	US, A, 3118650 (COOPER ET AL) 21 January 1964 (21.01.64)	(1, 8-11)
Y	AU, B, 14227/70 (439927) (B.C.RICHARDS & CO.PTY.LTD.) 28 October 1971 (28.10.71)	(8-11)

(continued)

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IV. CERTIFICATION

Date of the Actual Completion of the International Search [2]	Date of Mailing of this International Search Report [2]
20 August 1984 (20.08.84)	(30-08-84) 30 AUGUST 1984
International Searching Authority [1]	Signature of Authorized Officer [20]
AUSTRALIAN PATENT OFFICE	P. WHITE

III. DOCUMENTS CONSIDERED TO BE RELEVANT (CONTINUED FROM THE SECOND SHEET)

Category *	Citation of Document, [16] with indication, where appropriate, of the relevant passages [17]	Relevant to Claim No [18]
Y	AU, B, 26999/67 (421835) (B.C. RICHARDS & CO.PTY.LTD.) 19 March 1970 (19.03.70)	(1, 8-11)
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