(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) EP 0 898 077 A1

(12) EUROPEAN PATENT APPLICATION

(43) Date of publication:
24.02.1999 Bulletin 1999/08

(51) Int Cl.⁶: **F04B 53/16**

(21) Application number: **98306642.4**

(22) Date of filing: **19.08.1998**

(84) Designated Contracting States:
AT BE CH CY DE DK ES FI FR GB GR IE IT LI LU MC NL PT SE
Designated Extension States:
AL LT LV MK RO SI

(30) Priority: **20.08.1997 GB 9717564**

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(54) Pump for shear sensitive material

(57) A pump for pumping shear sensitive material, has a housing (10) with an internal displacement chamber (42), an inlet (20), an outlet (22), a displacement rod (16) which passes sealingly and reciprocably into the displacement chamber through an aperture in the wall of the pump housing and first seal means (18) surrounding the displacement rod partially defining the displacement chamber. The pump also has an annular volume (V) surrounding the displacement rod on the opposite side of the first seal means (18) from the displacement chamber, the annular volume communicating with the exterior of the housing.

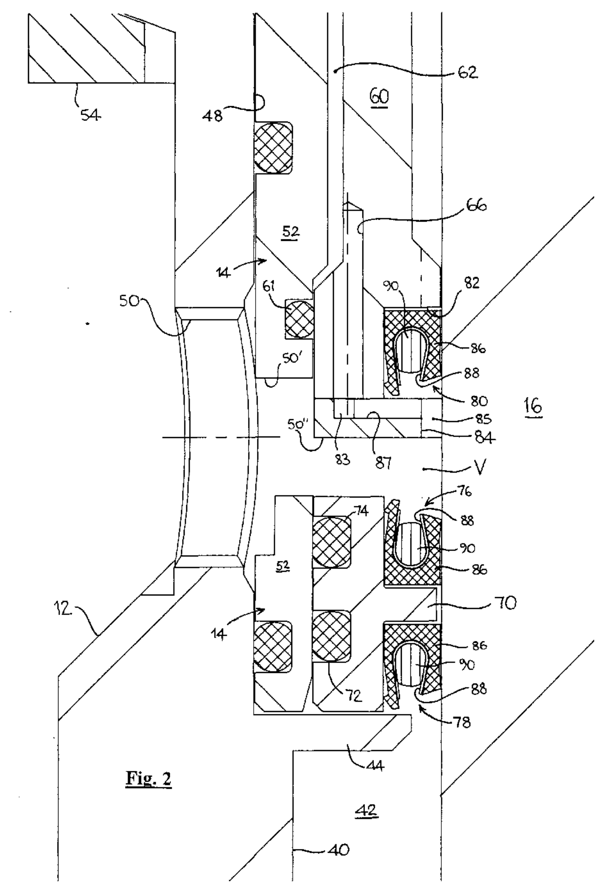

Fig. 2

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Description

[0001] The present invention relates to pumps for pumping shear sensitive material and in particular, but not exclusively, to pumps for pumping viscous fluids which are prone to set if subjected to high frictional forces.

[0002] One such viscous fluid is UV ink, which is an ink of a high viscosity which cures when subjected to ultra-violet radiation. The properties of the UV ink which enable it to set when it is irradiated unfortunately render it very sensitive to friction. Viscous fluids require the build up of a high pressure in order for them to be pumped.

[0003] One pump which is known to provide very little frictional force on the material being pumped is a double-diaphragm pump. Double-diaphragm pumps do not have a sliding surface between which the material to be pumped travels and therefore there is little chance of a high frictional force being generated which might cure the material. However, due the inherent limitation of the flexible diaphragm material these pumps are restricted to low pressure applications, namely a maximum of about 13.6 atmospheres (200 Psi). Thus, such pumps are not suitable for pumping material of a high viscosity.

[0004] Other known pumps include single and double-acting pumps which have a piston which is reciprocated between an inlet and an outlet such that fluid is forced from below the piston to above the piston during a pumping cycle. In a double-acting pump fluid is forced between two separate chambers in the pump and the piston doubles as a valve between the chambers whereby the fluid is forced through small apertures which open between the two chambers during displacement of the piston. In some types of pump the piston has several small apertures through which the fluid is forced, during the reciprocating movement of the piston, in order to move fluid from the inlet to the outlet.

[0005] Each of the above pumps therefore has the drawback that the small clearances and the meshing of several opposing surfaces can produce a high frictional force on the fluid being pumped which cause shear sensitive materials such as UV ink to cure within the pump and consequently cause the pump to fail.

[0006] In a further known type of single-acting pump using for pumping light viscosity fluids a displacement rod is reciprocated within a displacement chamber by which means fluid is drawn in through the inlet into the displacement chamber on one cycle of the rod and from the displacement chamber out through the outlet on the other cycle of the displacement rod. However, if such pumps are used to pump highly viscous fluids voids form in the displacement chamber, thereby making them unsuitable for pumping such fluids.

[0007] We have devised a pump which overcomes many of the problems associated with pumping shear sensitive materials. This pump is disclosed in EP-A-0677658. Whilst this pump overcomes the majority of problems associated with the prior art and works far better than any other pump with UV and EB (electron beam) inks there are nevertheless problems from time to time with small quantities of fluid that pass the seals. Such fluid sets and then rubs against the displacement rod. If such set ink then breaks off and moves back towards the seal the seal contact area can be damaged. This leads to failure of the pump but owing to its simple design the pump can normally be inexpensively refurbished.

[0008] However, some shear sensitive fluids are more sensitive to friction than others. In particular, EB (electron beam) set ink has proved to be more prone to cause seal failure.

[0009] There is thus a desire to have a pump for shear sensitive materials which is even less prone to failure than our existing design of pump.

[0010] In accordance with a first aspect of the present invention, a pump for pumping shear sensitive material comprises a housing having an internal displacement chamber, an inlet, an outlet, a displacement rod which passes sealingly and reciprocably into the displacement chamber through an aperture in the wall of the pump housing and seal means surrounding the displacement rod partially defining the displacement chamber, wherein the pump further comprises an annular volume surrounding the displacement rod on the opposite side of the seal means from the displacement chamber, the annular volume communicating with the exterior of the housing.

[0011] In such a valve, if any ink makes it way past the valve seal it will enter the annular volume and can then be exhausted to the exterior of the housing, for example to atmosphere.

[0012] In a preferred embodiment, the annular volume is supplied with pressurised fluid, for example pressurised air. This results in a flushing action which assists in the removal of any material which has made its way past the valve seal.

[0013] The valve seal may comprise two separate seals, a first seal for preventing or restricting the passage of fluid from the displacement chamber and the second seal preventing or restricting passage of fluid from the annular volume towards the displacement chamber.

[0014] They may also be an additional, third seal whereby the annular volume is located between the third and first seal, in order to prevent movement of material past the annular volume.

[0015] The seals can be of many different types.

[0016] By way of example only, specific embodiments of the present invention will now be described, with reference to the accompanying drawings, in which:-

Fig. 1 is a longitudinal cross section through a first embodiment of pump in accordance with the present invention;

Fig. 2 is a detailed cross section through the sealing portion A of the pump of Fig. 1;

Fig. 3 is a longitudinal cross section through a second embodiment of pump in accordance with the present invention;

Fig. 4 is a detailed cross-section through the sealing portion B of the pump of Fig. 3;

Fig. 5 is a detailed cross-section through the sealing portion of a third embodiment of pump in accordance with the present invention; and

Fig. 6 is a detailed cross-section through the sealing portion of a fourth embodiment of pump in accordance with the present invention.

[0017] Referring firstly to Figs. 1 and 2, much of the construction of the pump is very similar to that disclosed in our prior publication EP-A-0677658. A pump housing 10, formed from a generally tubular lower housing portion 12 and a generally tubular upper housing portion 14, is open at one end and a displacement rod 16 is reciprocable into and out of the housing through the open end by means of a pump actuator (not illustrated). A conventional chamber C containing a solvent or lubricant (or a mixture of the two) is also secured over the open end of the upper housing portion 14 for supplying fluid to the displacement rod in order to minimise the likelihood of seizure of the pump by hardened ink.

[0018] The displacement rod 16 is sealed with respect to the housing by means of a seal assembly 18 which will be discussed in more detail later. An inlet valve housing 20 is secured to the lower end of the lower housing portion 12 and an outlet valve housing 22 is secured to the side wall of the lower housing portion 12 and communicates with the interior of the housing by means of a port 24 in the housing wall.

[0019] The inlet valve 20 is very similar to that described in EP-A-0677658 and comprises a valve closure member 26 formed from a metal bob weight 28 and a flat-faced part-spherical plastics head 30 secured to the bob weight 28 which is sealingly engageable with a frusto-conical valve seat 32 within the inlet valve housing 20. The maximum displacement of the valve closure member 26 from the valve seat 32 is limited by means of a pin 34 extending diametrically across the valve housing and the valve housing 20 is secured to the main valve housing 10 by means of an annular clamp 36.

[0020] The outlet valve 22 is very similar to the inlet valve 20 and similar reference numerals with the addition of a dash indicate corresponding features. It will be noted, however, that the outlet valve 22 has an inlet port 37 whose longitudinal axis extends radially with respect to the longitudinal axis of the displacement rod 16. The outlet valve 22 also has an outlet port 38 for conveying pumped fluid to the desired location.

[0021] It will be observed that between the seal assembly 18 and the inlet valve 20 a gap exists between the displacement rod 16 and the inner bore 40 of the housing 10, forming a pump working chamber 42. In a cycle of normal pump operation the displacement rod 16 is partially withdrawn from the working chamber 42, causing the valve closure member 26 of the inlet valve 20 to be lifted from its valve seat 32 and thereby drawing fluid into the pump working chamber. When the displacement rod 16 reaches its uppermost displacement and begins to move downwards in the opposite direction, the valve closure member 26 of the inlet valve 20 is reseated on the valve seat 30. This is assisted by the relatively large weight of the bob weight 28 which causes the valve to snap shut quickly. Further downward displacement of the displacement rod 16 increases the pressure in the working chamber 42 resulting in displacement of the outlet valve closure member 26' from its valve seat 32' and causing fluid within the working chamber 42 to be displaced through the outlet valve 22 and out of the outlet 38.

[0022] The operation of the valve is thus conventional. However, the sealing arrangement is significantly different, as will be explained in more detail.

[0023] Referring to the construction of the main housing 10 in more detail, the lower housing portion 12, as mentioned above, is generally tubular and the first cylindrical bore 40 defines the pump working chamber 42. A radially inwardly directed annular shoulder 44 is also provided to support the sealing arrangement 18 and a larger diameter internal bore 48 is formed in the lower housing portion on the opposite side of the shoulder 44 from the first bore 40. The lower housing portion 12 is also provided with three radially extending outlet ports 50 in the side wall, equally angularly spaced around the periphery of the wall in the vicinity of the sealing arrangement 18.

[0024] The upper portion 14 of the valve housing is also generally tubular and is provided with a lower tubular portion 52 which is sealingly received in the uppermost portion of the bore 48 of the lower housing portion 12 and whose lowermost end is seated on or adjacent to the shoulder 44. The lower portion 12 and upper portion 14 are secured together by means of an annular clamping band 54 which clamps together aligned complementarily-shaped peripheral flanges 56, 58 on the two housing portions.

[0025] The upper housing portion 14 receives a locating and bearing sleeve 60 internally. The upper end of the sleeve 60 is a sealing fit within the bore of the housing portion 14 but the middle portion of the locating and bearing sleeve 60 is of a slightly smaller external diameter whereby an annular gap 62 exists between the inner bore of the upper housing member 14 and the outer surface of the locating sleeve 60. The lowermost portion of the sleeve 60 is of increased external diameter and is received in the lowermost portion of the lower tubular portion 52 of the upper housing member 14 which is of increased internal diameter. An 0-ring seal 61 provides a sealing contact between the sleeve 60 and the tubular portion 52 of the upper housing member 14.

[0026] The upper housing portion 14 is also supplied with pressurised air via a radially-extending inlet port 64 which communicates with the annular gap 62 between the locating sleeve 60 and the inner surface of the upper housing member 14. By means of a series of bores 66 (Fig. 2) extending in the longitudinal direction of the valve in the lower portions of the locating sleeve 60 the pressurised air is supplied to the sealing arrangement 18, as will be explained.

[0027] The locating and bearing sleeve 60 is also provided with a conventional bearing 67 at its upper end which bears against the displacement rod 16. The sleeve 60 is held in position within the upper housing portion by an inturned annular shoulder 68 at the upper end of the upper housing portion 14.

[0028] The sealing arrangement 18 comprises an annular, relatively rigid, seal support body 70 which rests against the shoulder 44 of the lower valve body portion 12. The seal support body 70 is sealed with respect to the inner bore of the upper housing portion 14 by means of O-ring seals 72, 74 and carries two further seals 76, 78 which engage the outer surface of the displacement rod 16. The sealing arrangement also comprises a further seal 80 which is held in contact with the outer surface of the displacement rod 16 by engagement with a shoulder 82 on the lower end of the locating sleeve 60, in contact with a spacer ring 84.

[0029] The seals 76, 78 and 80 are identical (except for their orientation, as will be explained) and conventional. Each of the seals is a scraper seal made from a hard low friction plastics material and contacts the displacement rod 16 with a single line of contact. The main body 86 of each seal is spaced from the displacement rod except for the line contact. A spring energiser 88 maintains the contact of the seal on the displacement rod 16 and receives an elastomeric member 90. The open side of each seal is designed to hold pressure. It will be noted that seal 78, which communicates with the working chamber 42, is thus designed to withstand the pressure within the pump working chamber and to prevent, or reduce the amount of, ink travelling past the seal 78. The seal 76 is oriented in the opposite direction with the aim of preventing any material entering the working chamber 42 other than via the inlet valve 20. The seal 86 is oriented in the same direction as the seal 78.

[0030] It will observed that pressurised air fed from the inlet 74 thus makes its way via the annular gap 62 to the spacer ring 84. The spacer ring 84 is spaced from the displacement rod by a further annular gap 85. Thus, an annular volume V (including the annular gap 85) exists around the rod 16 between the seals 76 and 80. The spacer ring engages the lowermost end of the sleeve 60 by means of three equally angularly spaced legs 83, thereby defining a gap between the end of the sleeve 60 and the upper face 87 of the spacer ring 84 which permits air flowing through the annular gap 62 and the bores 66 in the sleeve to flow into the annular volume V and to contact the seals 76 and 80 and the surface of the displacement rod 16 between the seals 76 and 80. The upper housing portion 14 and the spacer ring 84 are also each provided with three ports (50, 50', 50" respectively) equally spaced around their periphery and aligned with the outlet ports 50 in the lower housing portion 12. Thus, any ink which manages to make its way past seals 78 and 76 into the area between seals 76 and 80 will be flushed out of the valve by means of the high pressure air via the outlet ports in the housing.

[0031] Air cannot be sucked into the pump working chamber past seals 76 and 78 on the upward suction stroke of the displacement rod 16 since the seal configuration of seal 76 is able to resist vacuum from this direction.

[0032] Thus, any ink making its way past seals 78 and 76 will be flushed away to atmosphere and will not be able to pass seal 80 into the bearing area of the displacement rod 16, which might otherwise cause severe problems.

[0033] The second embodiment, illustrated in Figs. 3 and 4, is very similar to the first embodiment and only the significant differences as compared with the embodiment of Figs. 1 and 2 will be described, the construction and operation being otherwise identical to the embodiment of Figs. 1 and 2. The only significant difference relates to the bottom seal 90 to replace the seals 76, 78. In contrast to the first embodiment, the seal support body is replaced with a ring 92 of very hard plastics material which bears against shoulder 44 and is still sealed with regard to the inner bore of the upper portion 14 of the valve body by means of two O-rings 94, 96. However, as best seen in Fig. 4, the seal body is arranged to contact the displacement rod 16 only at two spaced-apart lines of contact 98, 100. The lowermost line of contact is held in engagement with the displacement rod 16 by means of an elastomeric seal energiser 102 located in a peripheral groove in the seal body and the seal body otherwise does not contact the displacement rod 16.

[0034] The lowermost line of contact 98 is exposed to the high pressure in the pump working chamber 42 and the other line of contact 100 is connected to atmosphere via the apertures 50, 50', 50". As a result of the elastomeric seal energiser 102 the grip of the seal against the displacement rod at the first point of contact 98 is very great, and provides a very efficient scraping action. The effect between the two lines of seal contact is rather like a non-return valve in that any small amount of ink that does pass the line point of contact 98 will try to pressurise the space between the two lines of contact 98, 100. As the seals 98, 100 are not designed to hold high pressure from this direction most of the pressure bleeds past the second line of contact 100 to atmosphere, which is assisted by the air flush. The residual pressure left behind between the two lines of contact tends to keep the ink close to the surface of the displacement rod 16 and helps prevent the ink from actually filling the space between the two lines of sealing contact. The net result of this is that any ink passing the first line of contact 98 quite quickly also passes the second line of contact 100 and is thereby flushed to atmosphere. Any ink adhering to the displacement rod after it has passed the second line of contact 100 as the rod rises is scraped from the rod by the scraper seal 80. This prevents ink from entering the area where the displacement rod bearings 67 are located. The embodiment is otherwise identical to that of Figs. 1 and 2 and the same reference numerals are used to denote the same features.

[0035] With reference to Fig. 5, the third embodiment is very similar to that illustrated in Figs. 3 and 4 and only the significant differences as compared with the embodiments of Figs. 3 and 4 will be described, the construction and operation being otherwise identical to the embodiment of Figs. 3 and 4. The only significant difference is that the seal 80 of Figs. 3 and 4 has also been replaced with a scraper seal similar to that in Figs. 3 and 4, having a stiff plastics seal body 104 having a single line 106 of sealing contact and an elastomeric seal energiser 108 for urging the seal body into contact with the displacement rod 16 along the line of contact 106. The embodiment is otherwise identical to that of Figs. 3 and 4 and the same reference numerals are used to denote the same features.

[0036] The fourth embodiment, shown in Fig. 6, is very similar to that of Fig. 5 and only the significant differences as compared with the embodiment of Fig. 5 will be described, the construction and operation being otherwise identical to the Fig. 5 embodiment.

[0037] In the embodiment of Fig. 5, problems can arise if the pump is incorrectly assembled. In particular, if the spacer ring 84 is incorrectly assembled the seal ring 92 can be damaged by the three legs 83. In order to overcome this potential problem, the embodiment of Fig. 6 further comprises an annular washer 110 which is received in a recess 112 in a modified seal ring 92'. By providing the washer 110 the seal body always contacts a continuous surface on the washer, even if the spacer ring 84 is incorrectly assembled.

[0038] The provision of a recess 112 to receive the washer 110 also allows a reduction of the contact pressure to be made at the upper line of contact 100 of the seal body 92'. This still provides a scraping action on the rod 16 as it descends but allows any ink passing the cover line of contact 98 to pass more easily past the upper line of contact 100 and thereby facilitates exhaust of such ink out of the pump. Moreover, as a result of the recess 112 only a single 0-ring seal 94' is provided to seal between the seal body 92' and the inner surface of the upper housing portion 14.

[0039] The embodiment is otherwise identical to that of Fig. 6 and the same reference numerals are used to denote the same features.

[0040] In all of the embodiments described above, pressurised air is supplied to the annular volume V surrounding the displacement rod. However, this need not be the case. For example, any pressurised gas could be supplied to the annular gap. Moreover, instead of pressurised gas, a pressurised liquid could be supplied to the annular volume. If a pressurised liquid were used it would preferably be one in which set ink is soluble, to assist in the removal of any set ink from the annular volume.

[0041] Instead of supplying pressurised fluid to the annular volume V in order to create a pressure differential between the annular volume and the exterior of the housing in order to create a "flushing" effect within the annular volume V, the annular volume may be connected to a source of suction in order to create the same effect. For example, the outlet ports 50 may be connected to a source of suction, whereby any set ink which has made its way into the annular volume V will be exhausted out of the housing.

[0042] Moreover, there may be circumstances in which it is not necessary to create any pressure differential between the annular volume and the exterior of the housing. In such cases, the pump need not be altered in any way but no pressurised air or suction would be supplied to the annular volume V.

Claims

1. A pump for pumping shear sensitive material, comprising a housing (10) having an internal displacement chamber (42), an inlet (20), an outlet (22), a displacement rod (16) which passes sealingly and reciprocably into the displacement chamber through an aperture in the wall of the pump housing and first seal means (18) surrounding the displacement rod partially defining the displacement chamber, characterised in that the pump further comprises an annular volume (V) surrounding the displacement rod on the opposite side of the first seal means (18) from the displacement chamber, the annular volume communicating with the exterior of the housing.

2. A pump as claimed in claim 1, wherein the first seal means (18) partially defines the annular volume.

3. A pump as claimed in claim 1 or claim 2, further comprising second seal means (80) surrounding the displacement rod on the opposite side of the first seal means from the displacement chamber and being spaced from the first seal means in the longitudinal direction of the rod, the annular volume (V) being located between the first (18) and second (80) seal means.

4. A pump as claimed in claim 3, wherein the annular volume is partially defined by the first and second seal means.

5. A pump as claimed in claim 3 or claim 4, wherein the first and second seal means are separated by a spacer ring (84) which surrounds the displacement rod.

6. A pump as claimed in any of claims 3 to 5, wherein the second seal means is located in a recess (82) in one end of a locating sleeve (60) positioned within the pump housing.

7. A pump as claimed in any of claims 3 to 6, wherein the second seal means (80) comprises a seal (86) for preventing or restricting the passage of fluid from the annular volume.

8. A pump as claimed in any of the preceding claims, wherein the first seal means (18) comprises first and second seals, the first seal (78) for preventing or restricting the passage of fluid from the displacement chamber and the second seal (76) preventing or restricting passage of fluid from the annular volume towards the displacement chamber.

9. A pump as claimed in any of the preceding claims, further comprising means for inducing a pressure differential between the annular volume (V) and the exterior of the housing.

10. A pump as claimed in claim 9, comprising means (64, 62, 66) for supplying pressurised fluid to the annular volume.

11. A pump as claimed in claim 10, comprising means for supplying pressurised gas to the annular volume.

12. A pump as claimed in claim 9, comprising means for applying suction to the annular volume.

13. A pump as claimed in any of claims 9 to 12, wherein the means for inducing a pressure differential to the annular volume comprises a conduit (62) which communicates with the annular volume (V) and which is connected to an inlet (64) to which pressurised fluid is fed.

14. A pump as claimed in claim 13, wherein the conduit is at least partly formed by a gap (62) defined between a portion (48) of the housing (10) and a displacement rod locating sleeve (60) within the housing.

15. A pump as claimed in claim 14, further comprising one or more passageways (66) in the displacement rod locating sleeve (60) connecting the gap (62) between the housing portion and the locating sleeve to the annular volume (V).

16. A pump as claimed in any of the preceding claims, further comprising an exhaust port (50) by means of which the annular volume communicates with the exterior of the housing.

17. A pump as claimed in claim 16, comprising a plurality of exhaust ports (50).

18. A pump as claimed in claim 17 or claim 18, wherein the or each exhaust port is located in the housing.

19. A pump as claimed in any of the preceding claims, further comprising an inlet valve (20) arranged to open when the displacement rod is displaced in a charging direction and arranged to close when the displacement rod is displaced in a discharging direction.

20. A pump as claimed in any of the preceding claims, further comprising an outlet valve (22) arranged to open when the displacement rod is displaced in a discharging direction and arranged to close when the displacement rod is displaced in a charging direction.

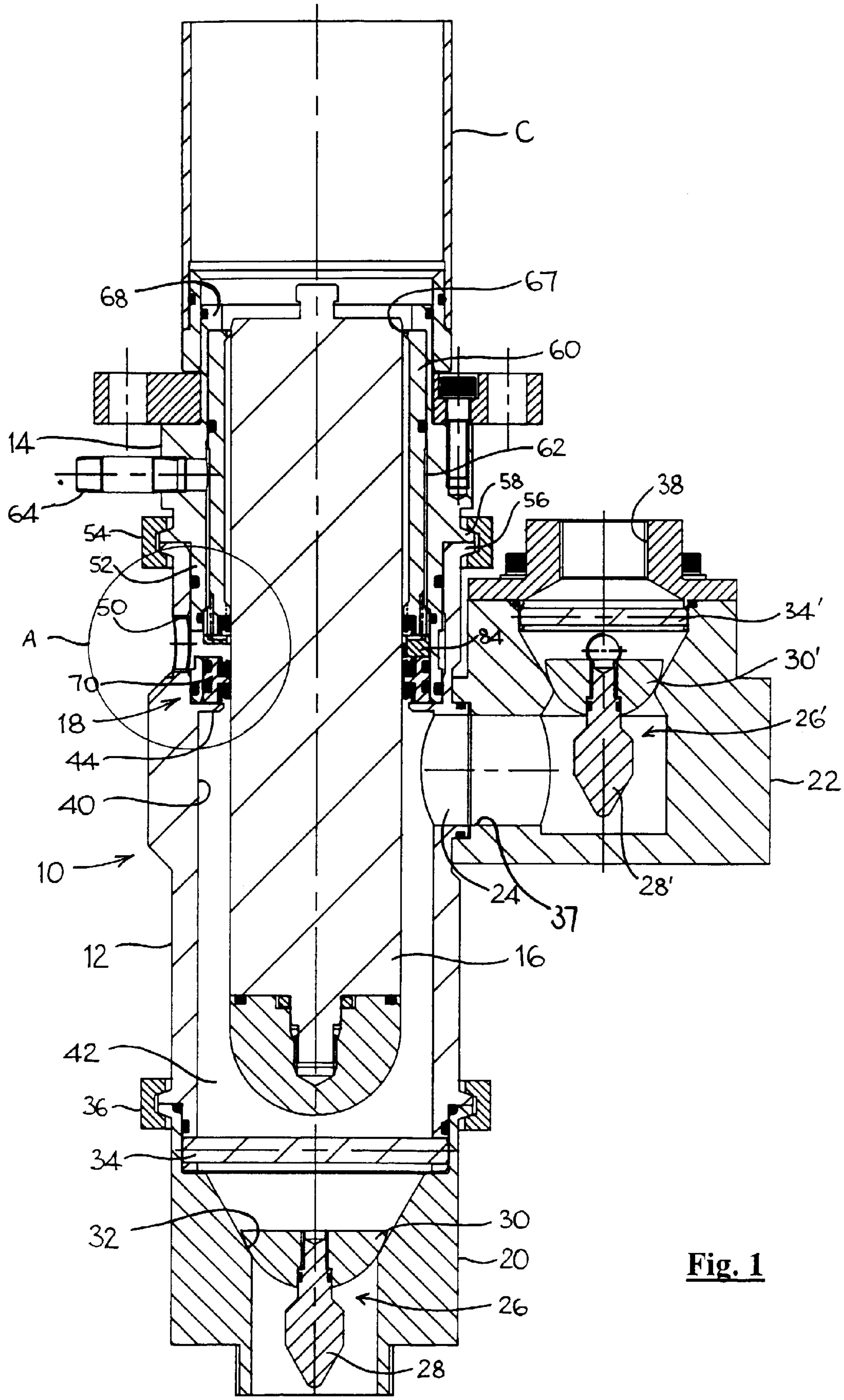
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Fig. 1

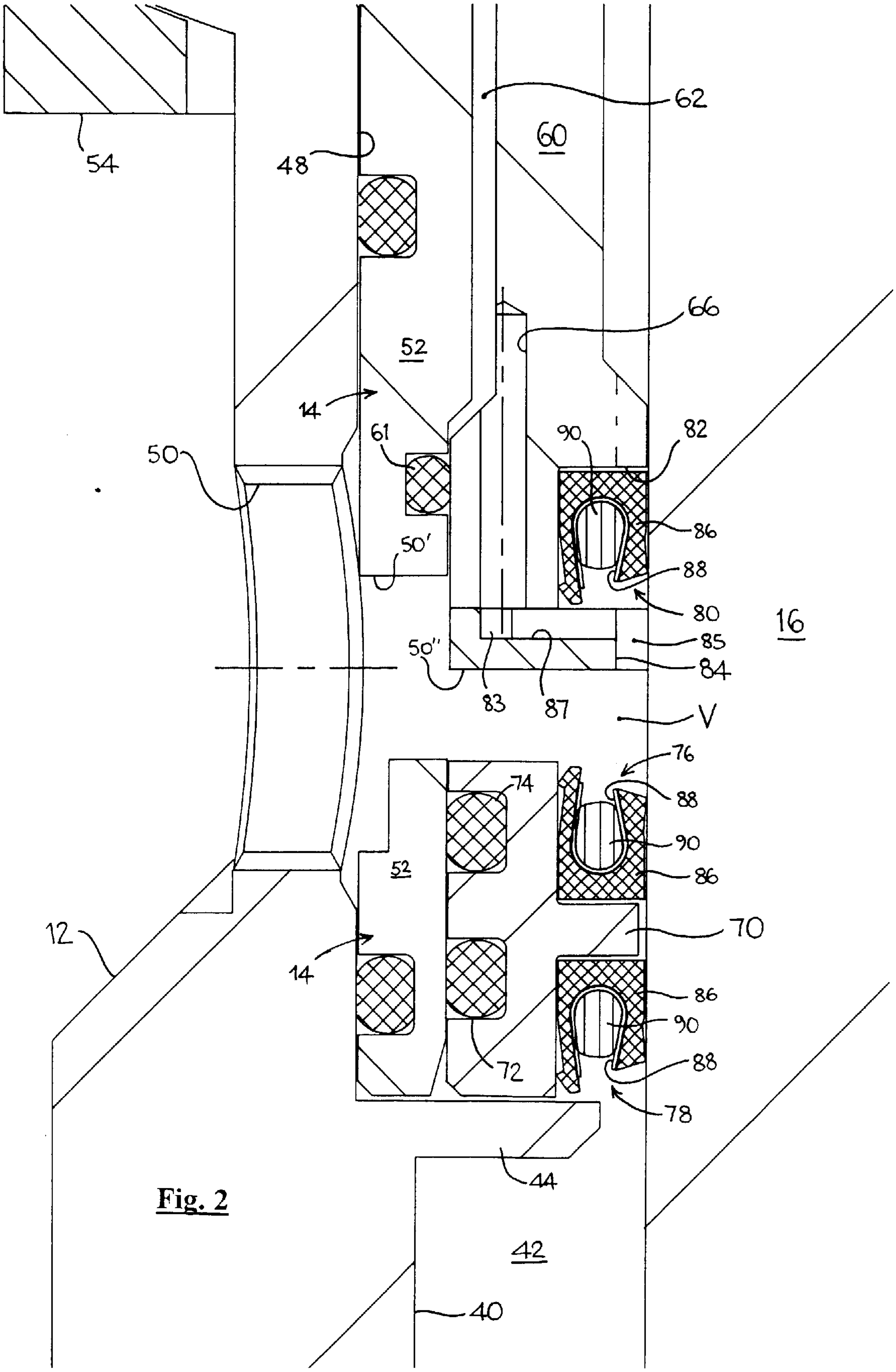
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Fig. 2

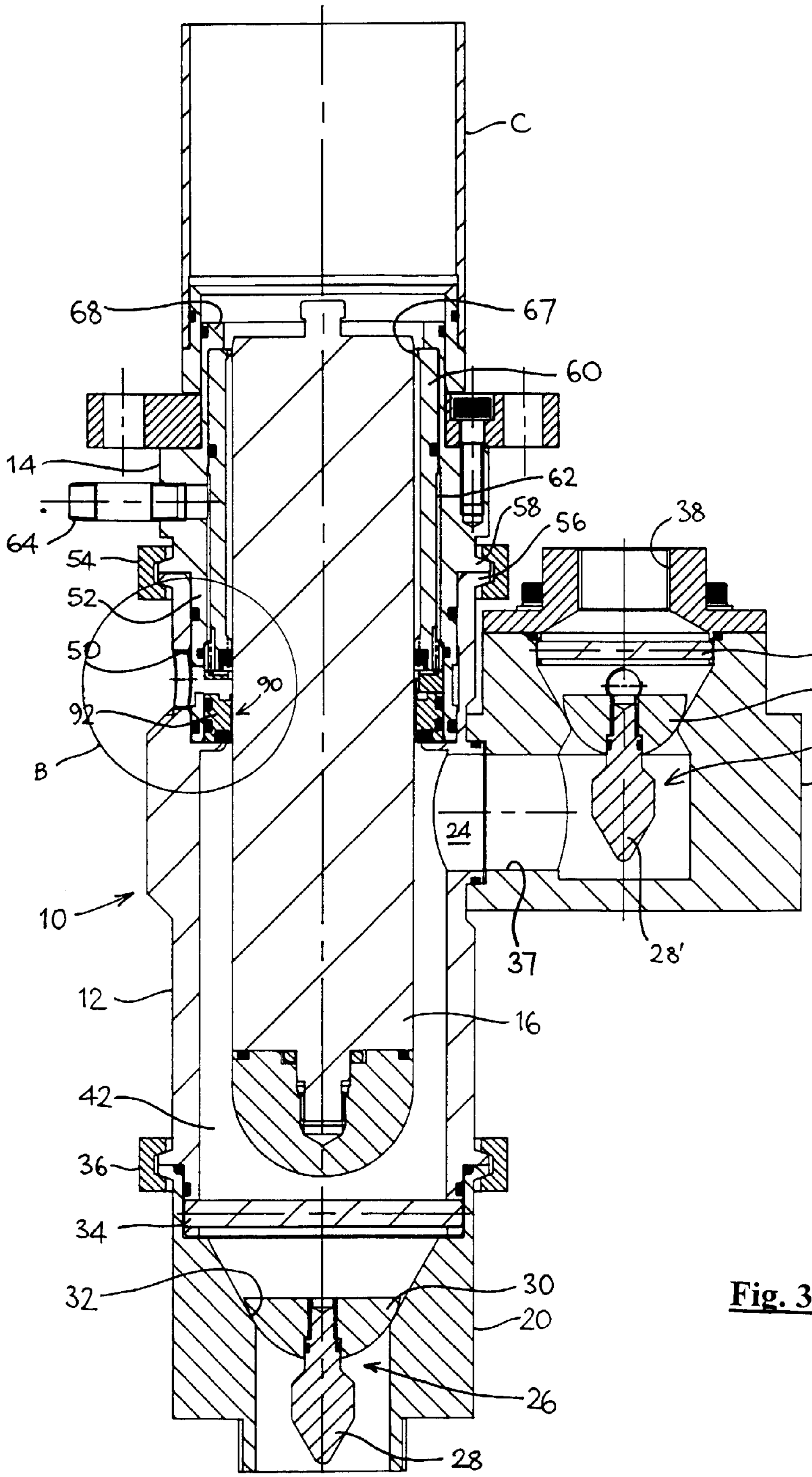
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Fig. 3

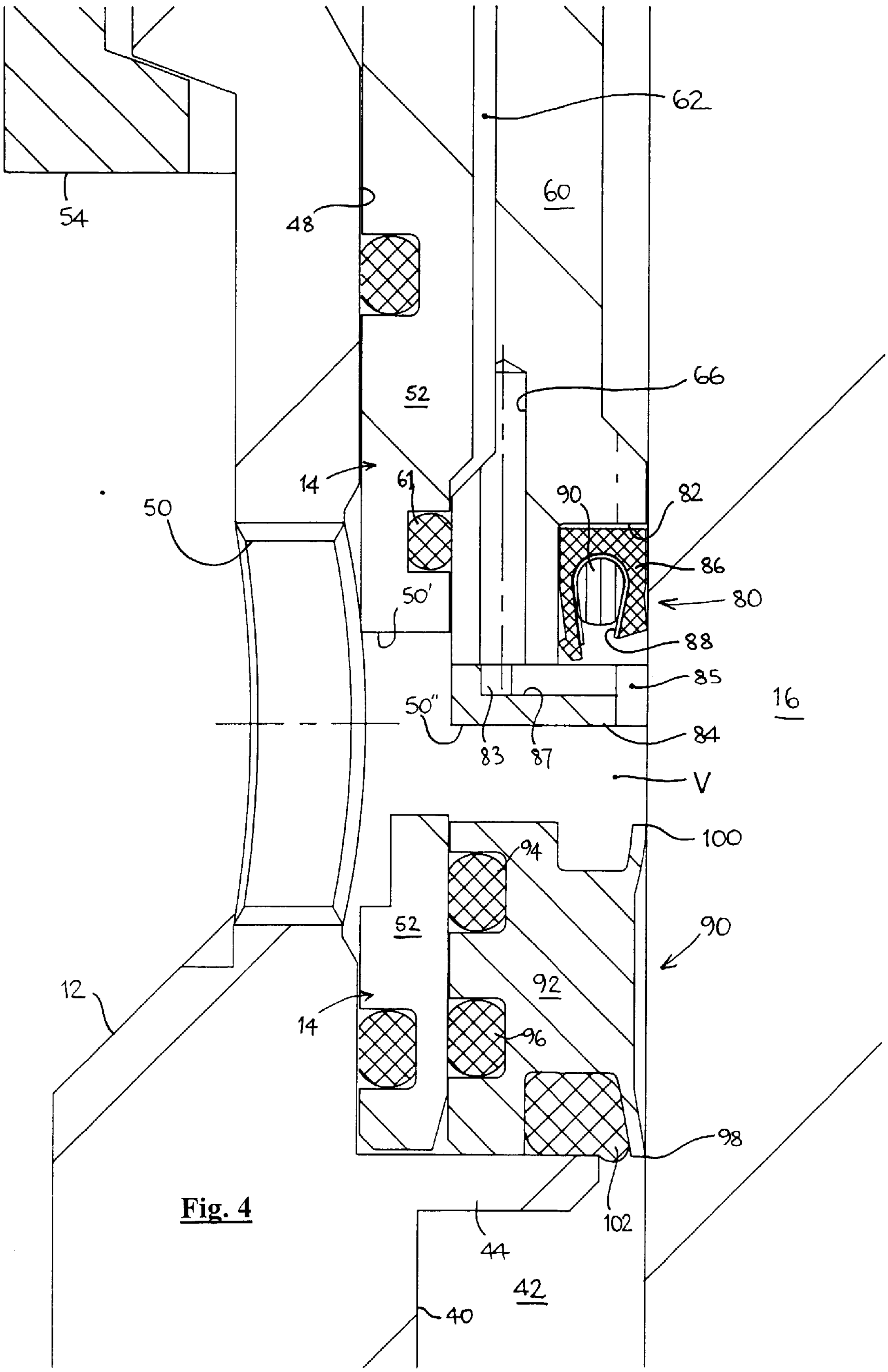
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Fig. 4

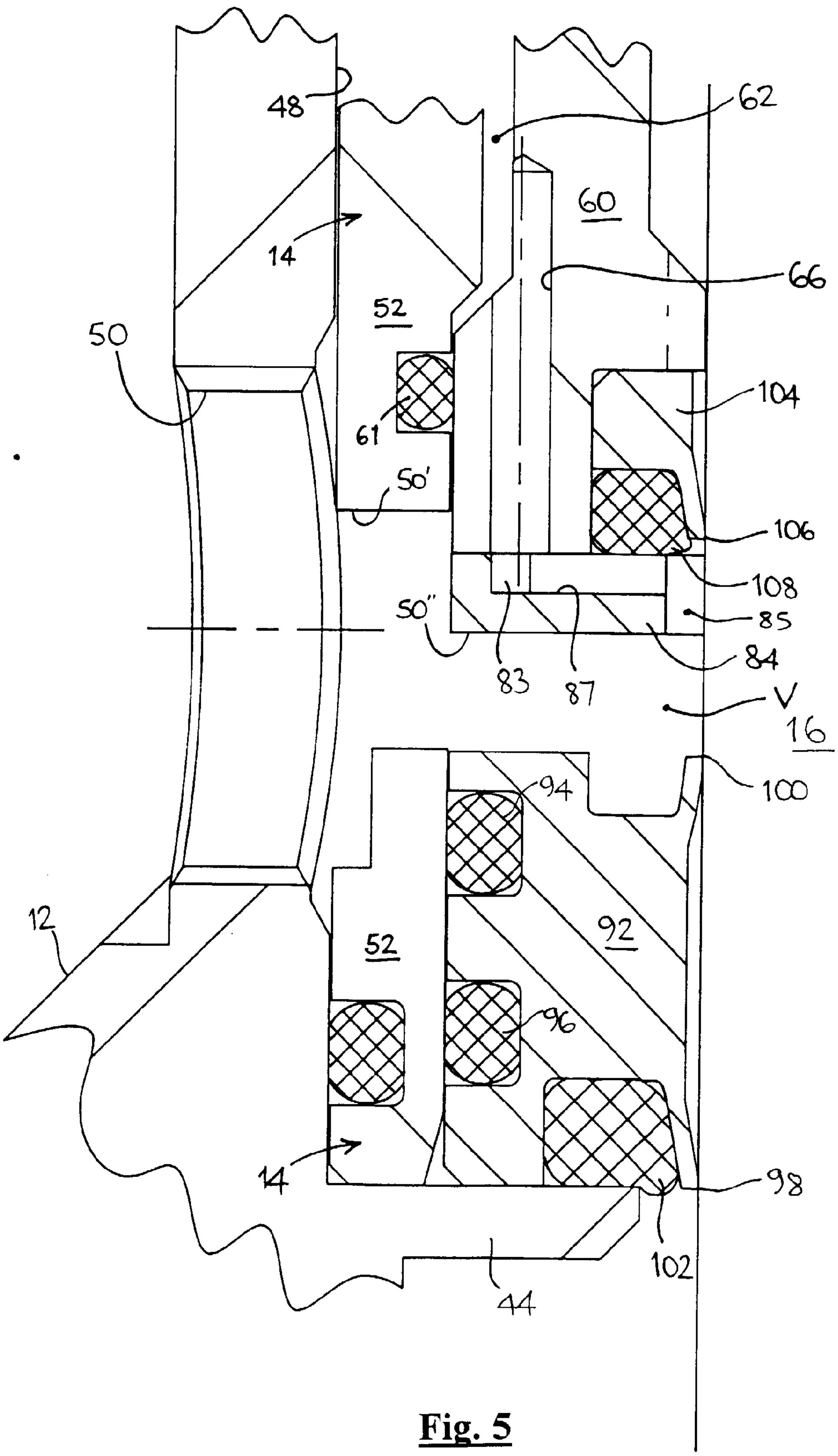
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Fig. 5

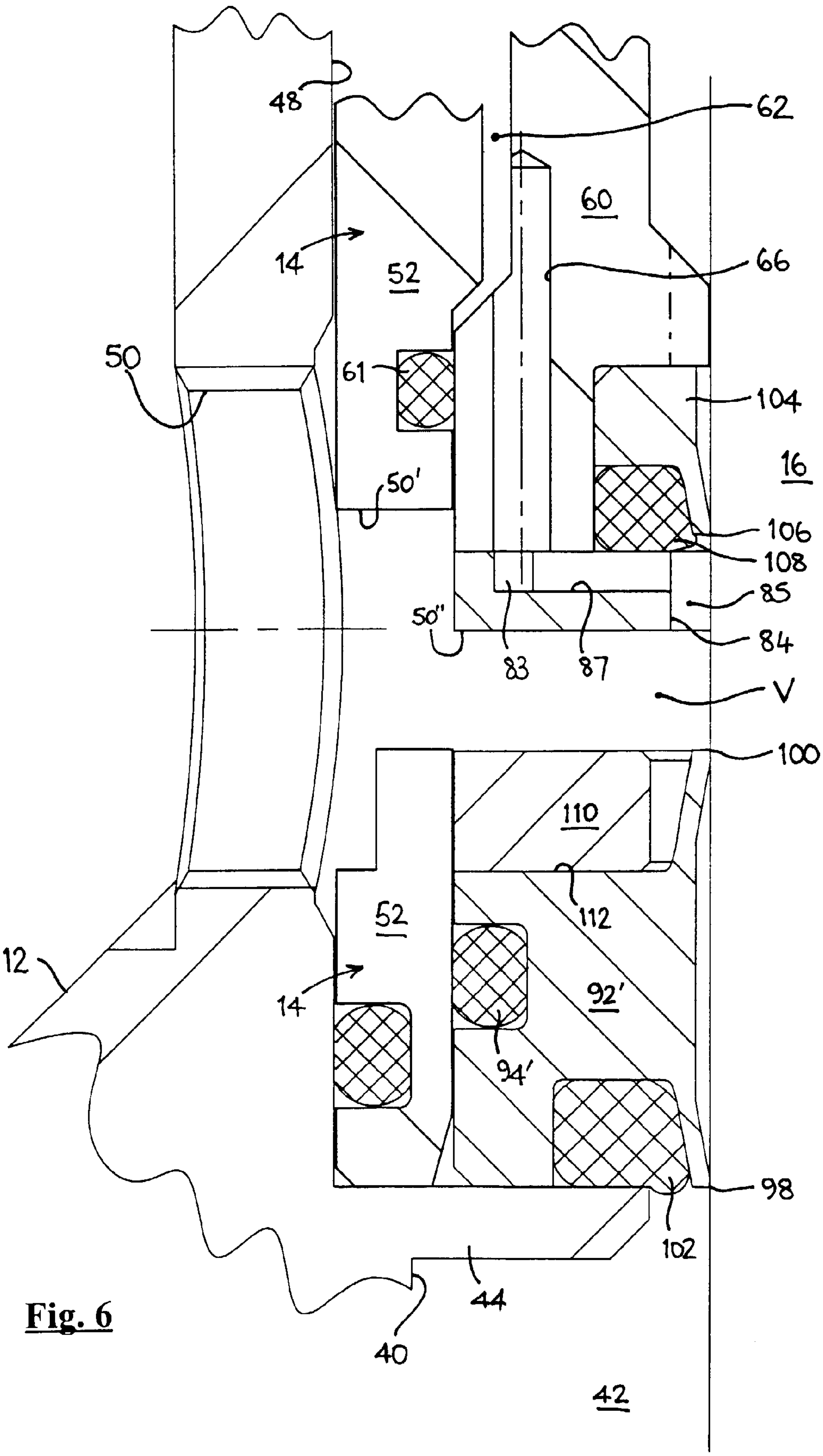
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Fig. 6

European Patent Office

EUROPEAN SEARCH REPORT

Application Number
EP 98 30 6642

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.6)
X Y	WO 95 07412 A (ELOPAK SYSTEMS) 16 March 1995 * page 5, line 13 - page 10, line 14; figures 1-3 *	1-4,6,7, 16-19 5,8-10, 12,13,20	F04B53/16
Y	US 4 086 029 A (CRANE ROBERT M ET AL) 25 April 1978 * column 1, line 63 - column 3, line 12; figures 1,2 *	5,9,10, 13,20	
Y	WO 86 06453 A (BERTIN & CIE) 6 November 1986 * page 9, line 8 - page 14, line 16; figures 4-7 *	8	
Y	FR 2 499 634 A (POMPES INDLES HAUTE PRESSION) 13 August 1982 * page 1, line 25 - line 30; figures 1,2 *	12	
X	DE 93 08 066 U (LINCOLN GMBH) 9 September 1993 * the whole document *	1	TECHNICAL FIELDS SEARCHED (Int.Cl.6) F04B
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The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	24 November 1998	Ingelbrecht, P

CATEGORY OF CITED DOCUMENTS

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ANNEX TO THE EUROPEAN SEARCH REPORT ON EUROPEAN PATENT APPLICATION NO. EP 98 30 6642

This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report.
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