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

(11) Publication number: **0 509 185 A1**

(12) EUROPEAN PATENT APPLICATION

(21) Application number: **91830155.7**

(22) Date of filing: **19.04.91**

(51) Int. Cl.5: **F04B 15/08**, F04B 21/00, F04B 21/02

(43) Date of publication of application: **21.10.92 Bulletin 92/43**

(84) Designated Contracting States: **DE ES FR GB NL**

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(54) Feeding device for reciprocating piston pumps for liquids under saturation conditions.

(57) A feeding device or reciprocating pumps comprising a vertical conduit (11) communicating at the upper end with the liquid tank and at the lower end with the pumping chamber (2), a gravity bowl valve (12) disposed near the lower end and formed of a cap having the form of a spherical bowl cooperating with a sealing seat formed in the conduit (11) and resting under opened condition on a pierced washer (9) so as to allow any gas fraction or steam bubbles to be returned from the pumping chamber (2) to the feeding tank during the suction stroke.

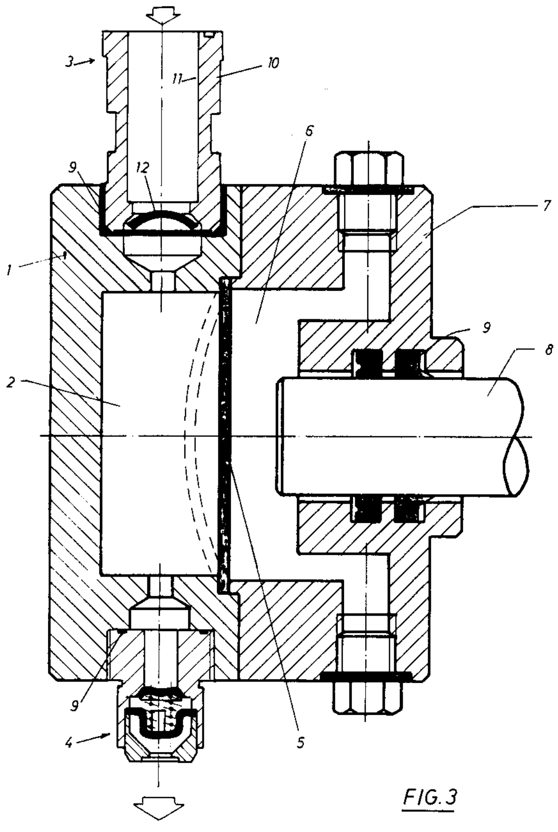

FIG. 3

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The present invention relates to an improvement in the reciprocating pumps, in particular diaphragm pumps operating with liquids under saturation conditions as well as with the usual subcooled liquids as in the absorption heat pumps or refrigerators.

In the particular case of the near saturated solution pumps used in the above mentioned applications, the following conditions should be satisfied:

- high pumping head (20-30 atm);
- capacity of pumping near saturated liquids (boiling point) without the danger of a block caused by steam pockets;
- capacity of "dry" operation, i.e. without liquid to be pumped;
- absolute tightness in order to avoid both fluid leakage and air inlet into the system;
- good pumping efficiency.

Such performance can be achieved by using both reciprocating and rotary displacement pumps; among the absorption heat pumps on the market the near saturated solution pumps are diaphragm reciprocating pumps because the latter can assure the perfect tightness to the outside.

Several types of pumps to solve such problem have been designed and manufactured. The German company Orlita manufactures a reciprocating pump and also a rotating piston pump transferring the liquid from the low to the high pressure by means of pockets. Even if such pump solves the problem of the suction of the saturated liquid, it has a great mechanical complexity and a high cost apart from the poor possibility of dry operation because the piston and the gears are lubricated by the liquid to be pumped.

The Columbia Gas System Service Corp. allowed W.M. Nichols Company to manufacture a gear pump which in spite of a simple structure has likely problems of cavitation, does not reach high heads for long times, and cannot be used for dry operation as the preceding pump.

In the USA Patent No. 3,357,203 issued on 12/12/67 to S.W. Briggs a water-ammonia pump for refrigeration cycles is described and claimed; such pump is essentially formed of a diaphragm body hydraulically operated by pressurized oil, two check valves for the suction and the delivery, respectively, and a cylindrical body storing a liquid amount useful at the starting.

A very similar pump as the preceding one is used by the company Arkla manufacturing water-ammonia absorption refrigerators and selling components to the European manufacturers of absorption heat pumps. Such pump has check valves formed of metallic disks pushed by coil springs; this solution causes a pressure loss remarkable during the suction with consequent cavitation. For such reason the spring of the suction valve is very weak, and the pumping body has a very small dead volume which should allow the mixed liquid-steam phases to be pumped.

Bristol University proposed two prototypes of pumping systems for absorption heat pumps based upon the self-starting principle which is made possible by the high pressure difference between the tanks of the suction liquid and the delivery liquid. By means of an electrovalve system a high pressure is established in appropriate devices which are able to theoretically pump a liquid with a very low energy consumption becuse of the gravity and the effect of moltiplication of the force generated according to the Pascal's principle.

The disadvantege connected to such equipment is that of using electrovalves operating with a high pressure difference and likely with a high actuation frequency with the consequence of a fast wearing. Furthermore, the use of the gravity force involves a vertical geometry which hardly hinders the requirements of having small dimensions.

The company Bunders SA holds a patent for a pump which generates an overpressure in the suction liquid provided by the rotor acting as booster and delivers the liquid to the same operative pistons. The overpressure effect with consequent subcooling of the liquid is doubtful so that the same authors of the invention suggest an external cooling as precautional measure. Furthermore, the rotor and its bearings are lubricated by the same pumped liquid, which is a non-valid solution since said liquid is usually corrosive (ammonia, lithium bromide).

The company Stiebel Eltron (FRT) developped a near saturated solution gear pump for absorption heat pump operating with organic liquids which has a very simple structure but suffers from the same operation problems as that of the above mentioned Columbia Gas System Service Corp.

The present invention seeks to provide a feeding device for reciprocating pumps which besides the necessary characteristics of reliability, long life and low cost has also a wide range of applications with any type of pump, in particular diaphragm pumps designated to operate with liquids under saturation conditions.

According to the invention a suction device is provided and more in particular a feeding device comprising a tubular conduit having the upper end communicating with the tank of the liquid to be pumped, the lower end opening into the pumping chamber, and a gravity bowl valve disposed near the base of the conduit and formed of a floating body having the form of a spherical bowl cooperating with a conical, annular sealing seat formed in the conduit and resting under opened condition on a pierced washer so as to allow the liquid to pass by gravity from the tank to said chamber and any steam bubble to be returned in an ascending current flow to said tank so as to assure the optimum filling of the pumping chamber with a liquid which is essentially free of gas phase. In such a way the suction stroke is executed by gravity filling (feeding) practically without pressure loss and then without vaporization.

This invention will be described with reference to the annexed drawing showing by way of an illustrative, non-limitative example a preferred embodiment of the invention. In the drawing:

Fig. 1 shows schematically an absorption heat pump system;

Fig. 2 is a section view of a diaphragm pump of the known type with suction and delivery devices provided with spring valves;

Fig. 2A shows the same diaphragm pump as Fig. 2 where the spring valves are replaced by gravity valves according to the known technique;

Fig. 3 is a similar view as Fig. 2 showing a diaphragm pump provided with the suction device according to the invention;

Fig. 4 shows the suction device according to the invention in enlarged scale and in partial section;

Fig. 4A and 4B show the details of the bowl valve and the supporting pierced washer;

Fig. 5 shows a variant of the device of Fig. 4;

Figs. 5A and 5B show two further variants of the device of Fig. 4.

With reference to Fig. 1 the absorption heat pump is a thermodynamic system formed of at least seven basic components connected to one another so as to make a closed circuit comprising generator G, condenser C, evaporator E, abosrber A, the near saturated solution pump PSR, and two laminar flow valves V1 and V2. In such circuit equipment a liquid (in this case a water-ammonia mixture) is subjected to several transformations, thus forming a cyclic process. The effect of such cyclic process is the transmission of heat with an increasing of temperature at the cost of the primary energy, i.e. the fuel for the generator, and of the electric power for energizing the near saturated solution pump PSR.

Pump PSR operates in the cycle to transfer the solution near saturated with ammonia from the absorber (at low pressure) to the generator (at high pressure) so that it is one of the most critical component of the system in which the invention is embodied.

The conventional diaphragm pump (Fig. 2) consists of a body 1 in which a pumping chamber 2 is formed, a suction valve 3 and a delivery valve 4 for the liquid to be pumped, a diaphragm 5, a hydraulic chamber 6 filled with oil and formed in a proper body 7, and a piston 8 capable of reciprocating motion and driven by an electric motor not shown. Sealing members 9 are provided for preventing oil and the liquid to be pumped from leaking off.

The diaphragm pump of Fig. 2 executes a two-stroke pumping cycle, suction and delivery, such strokes being provided by two check valves, one for the suction, the other for the delivery. Such valves are essentially of two types: spring-operated valve as in Fig. 2 and gravity valve as in Fig. 2A.

The pump with gravity valve must have a vertical suction stroke from the lower side so as to cause the liquid to fall down by gravity during the delivery stroke, while the pump with the spring-operated valve may assume any position.

The gravity valves are usually formed of balls resting on conical seats as shown in Fig. 2A, and less usually of other types of closure bodies. In such valves the liquid during the suction stroke keeps the closure body raised and then is subjected to a pressure loss increasing with the weight of the closure body.

The spring-operated valves are formed of a spherical closure body having the form of a plate or a bowl, as shown in Fig. 2, which is pushed against the seat by a spring. Also in this case a pressure loss during the suction stroke is provided as the liquid flowing through the valve has to overcome the force of the spring; the pressure loss may be reduced by using weak springs.

These two types of valves are not able to pump liquids under saturation conditions.

A pressure loss causes the saturated liquid to vaporize within the pumping chamber: if the volume of the steam is considerable, the operation of the pump is stopped because the steam cannot be compressed to the pressure that allows the delivery valve to be opened and further liquid cannot be let in during the subsequent suction stroke either, because the latter causes the liquid to further vaporize so that the requested pressure release opening the suction valve cannot be provided. Therefore the steam remains in the pumping chamber and cannot be let out with the consequence of an interruption of the pumping action.

The inventive step at the base of the present invention is that of filling the pumping chamber (suction stroke) with a liquid so as to practically avoid any pressure loss and any vaporization as already mentioned above.

This aim is achieved (Fig. 3) by changing the direction of flow of the liquid during the suction stroke, i.e. from the top to the bottom of the chamber, and by eliminating the valve spring pushing the closure body against the seat. In such a way the valve during the suction stroke (feeding) is completely opened so that the filling is effected by gravity only.

At the end of the suction stroke the closure of the pumping chamber is no longer effected by the spring but by the hydrodynamic action of the liquid against the closure body which is in turn pushed by diaphragm 5 assuming the position shown with dashed lines in the figure.

Any steam contained in the chamber cannot cause the same effect and lets out upwards because of the lesser density so as to be replaced by an equal volume of liquid.

The suction or feeding device (see also Figs. 4, 4A and 4B) is mounted so that the liquid to be pumped flows from the top to the bottom thereof. Such device is formed of a body 10 with a conduit 11 having such a diameter as to allow at the same time the steam to flow from the bottom to the top of the conduit and the liquid to flow in the opposite direction, a closure member 12 having suitable form and weight such as to oppose a low resistance to the input flow and a much higher resistance to the reverse flow, a pierced rest washer 13 limitating the stroke of the closure member and having openings the size of which is such as to allow liquid and steam to flow together, and finally a sealing seat 14 formed in the body 10 above the washer 13.

In the operation the closure body 12 rests during the suction stroke on the rest washer 13 and allows the pumping liquid to fall down to chamber 2; in the delivery stroke the closure member 12 is pushed upwards so as to close the conical seat 14 during the whole pumping or delivery stroke. In case liquid to be pumped is failing or if steam is formed in the pumping chamber 2 because of the very low density of the steam lapping the valve, the closure member does not move upwards and then the pump ejects the steam through the opened suction valve. The pumping begins again as chamber 2 is filled with further liquid by gravity.

From the foregoing it is apparent that the pump features a feeding stroke or a filling by gravity rather than a real suction stroke.

In order to blow off steam from the pumping chamber 2 the suction conduit 11 has a large diameter and extends vertically so that the steam bubbles can easily ascend to the tank of the liquid which is not thus prevented from falling down.

Preferably the cylindrical body 10 is made of stainless steel of which both the conical seat 14 and the closure member 12 having the form of a spherical bowl are also made. The rest washer 13 consists of a ring provided with radial tabs (Figs. 4A and 4B).

In Figs. 5, 5A and 5B three variants of the above described device are shown.

In Fig. 5 the function of the rest washer 13 is performed by stem 15 integral with disk 16 and closure member 12, while in Figs. 5A and 5B the closure member is mounted on a compression spring 17 or an extension spring 18. The operation is quite similar as that already described.

Another advantageous feature of the device according to the present invention is that the pump can also operate without hydraulic head regardless of the sub-cooled or saturated condition of the liquid. Such property can be exploited in the field of the absorption heat pump to avoid the necessary adjustment for maintaining a constant level of the liquid in the absorber which is the feeding tank of the pump. It is sufficient to slightly oversize the pump with respect to the maximum flow rate provided by the process in order that the absorber can be kept constantly empty due to the above mentioned feature.

The present invention is illustrated and described according to a preferred embodiment thereof but it should be understood that structural modifications can be made thereto without parting from the scope of the present industrial invention.

Claims

1. A feeding device for a reciprocating pump intended to operate with liquids under saturation conditions, characterized in that it comprises in combination a conduit between the tank of the liquid to be pumped and the pumping chamber, a closure member cooperating with a sealing seat formed in said conduit and resting under opened conditions on a pierced washer placed at the base od said conduit.

2. The feeding device of claim 1, characterized in that the suction conduit is vertically disposed so that the liquid is let in from the top, and said closure member is normally in the opened position because of the gravity and is closed by the hydrodynamic force of the liquid in the pumping chamber during the delivery stroke.

3. The feeding device of claims 1 and 2, characterized in that said pierced washer allows both the liquid to flow by gravity from the tank to the pumping chamber and any steam bubble to ascend at the same time to said tank so as to assure the filling of the pumping chamber with liquid essentially free of the gas phase.

4. The feeding device of claims 1 to 3, characterized in that said member has the form of a reversed cap or spherical bowl with concavity towards the pumping chamber so as to keep the pressure loss of the suction liquid to the minimum and the closing force against said sealing seat to the maximum.

5. The feeding device of claim 1, characterized in

that the axis of the suction conduit is inclined to the vertical.

6. The feeding device of claim 1, characterized in that said closure member under opened condition is mounted on a compression or extension spring.

7. The feeding device of claim 1, characterized in that said closure member under opened condition is integral with an axial stem and mounted on a disk resting on a peripheral projection formed in the inner wall of the suction conduit.

8. A feeding device for a reciprocating pump, in particular of the diaphragm type, intended to operate with liquids under saturation conditions according to claims 1 to 7 and as essentially described and illustrated.

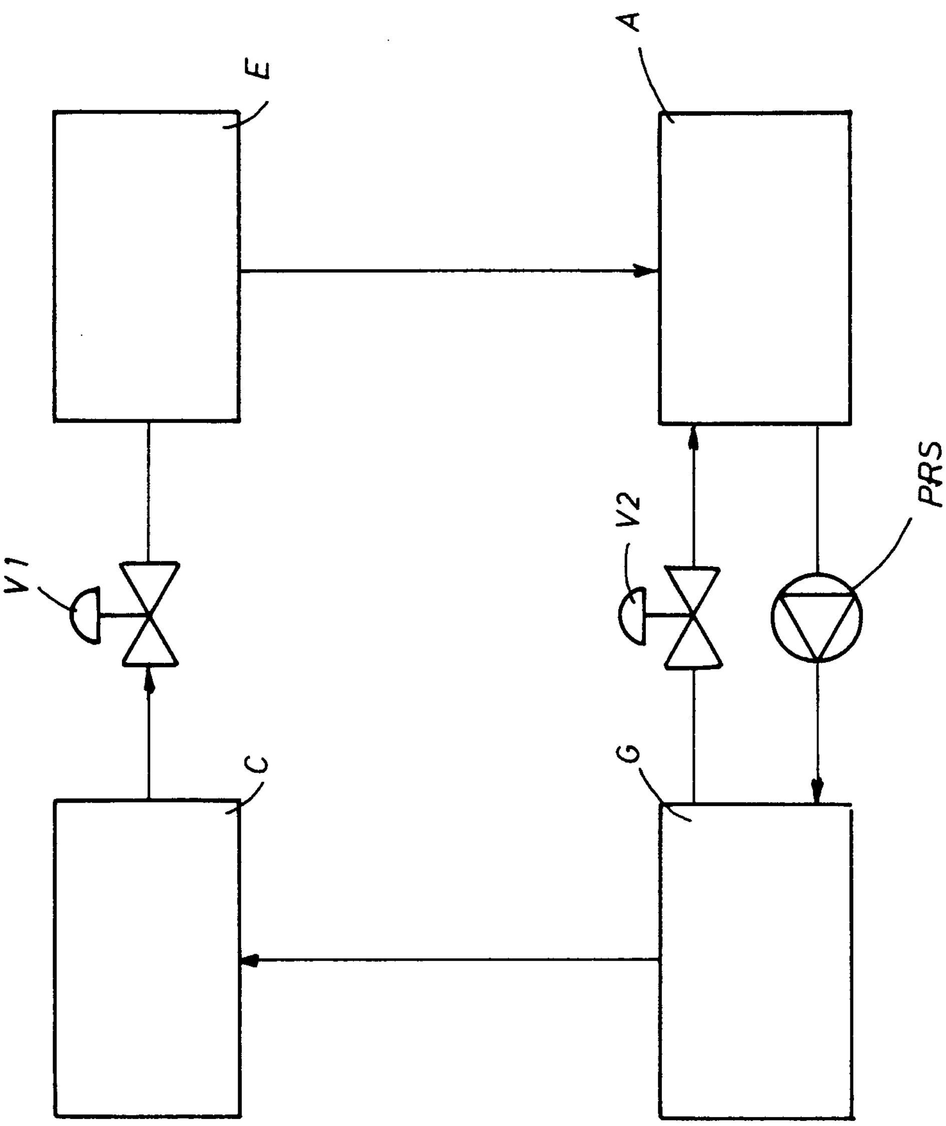

FIG.1

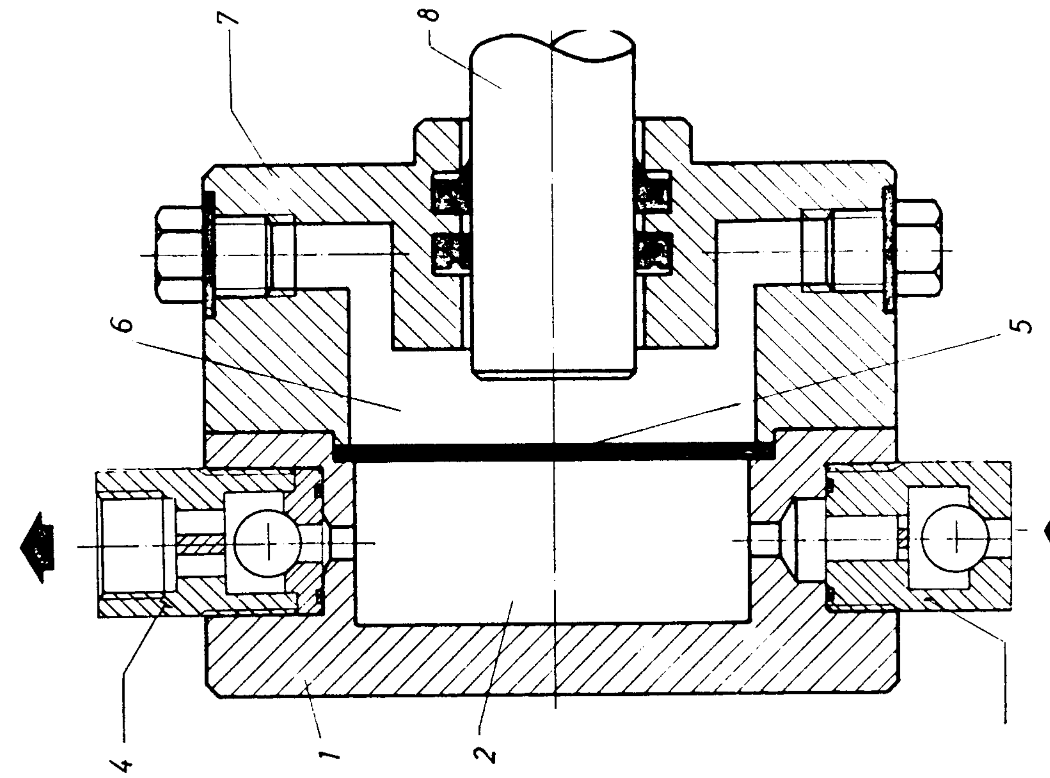

FIG. 2A

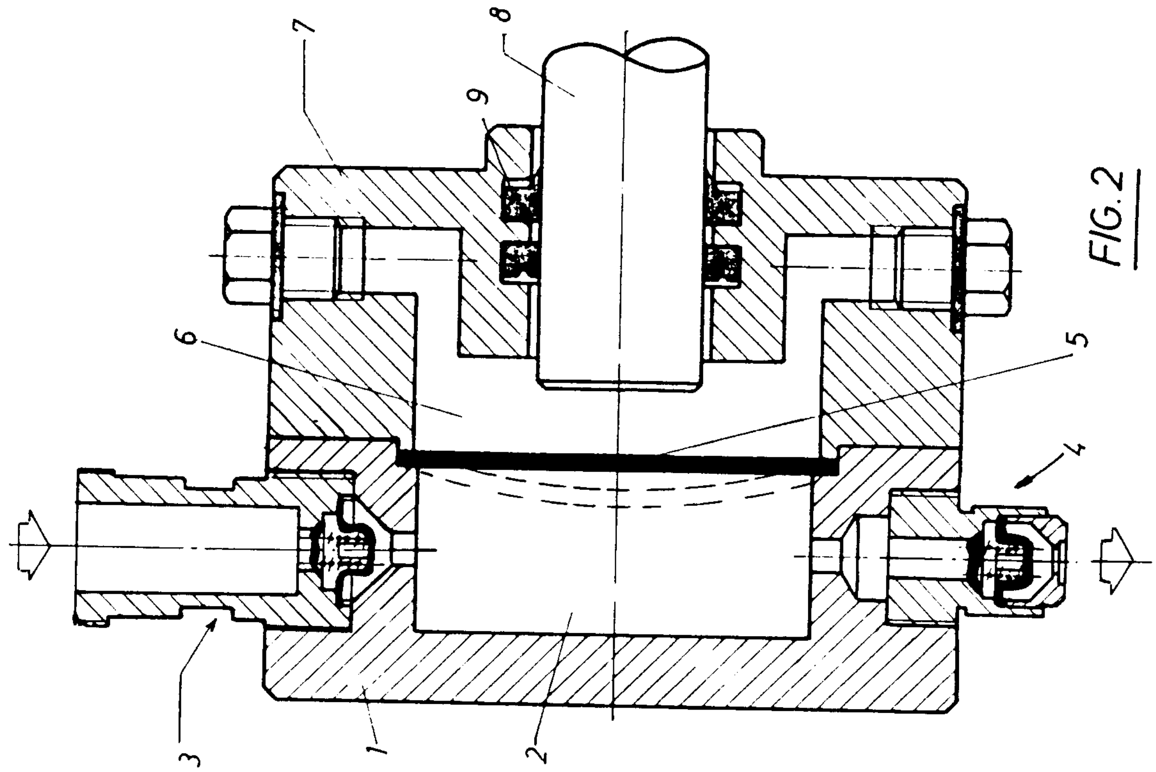

FIG. 2

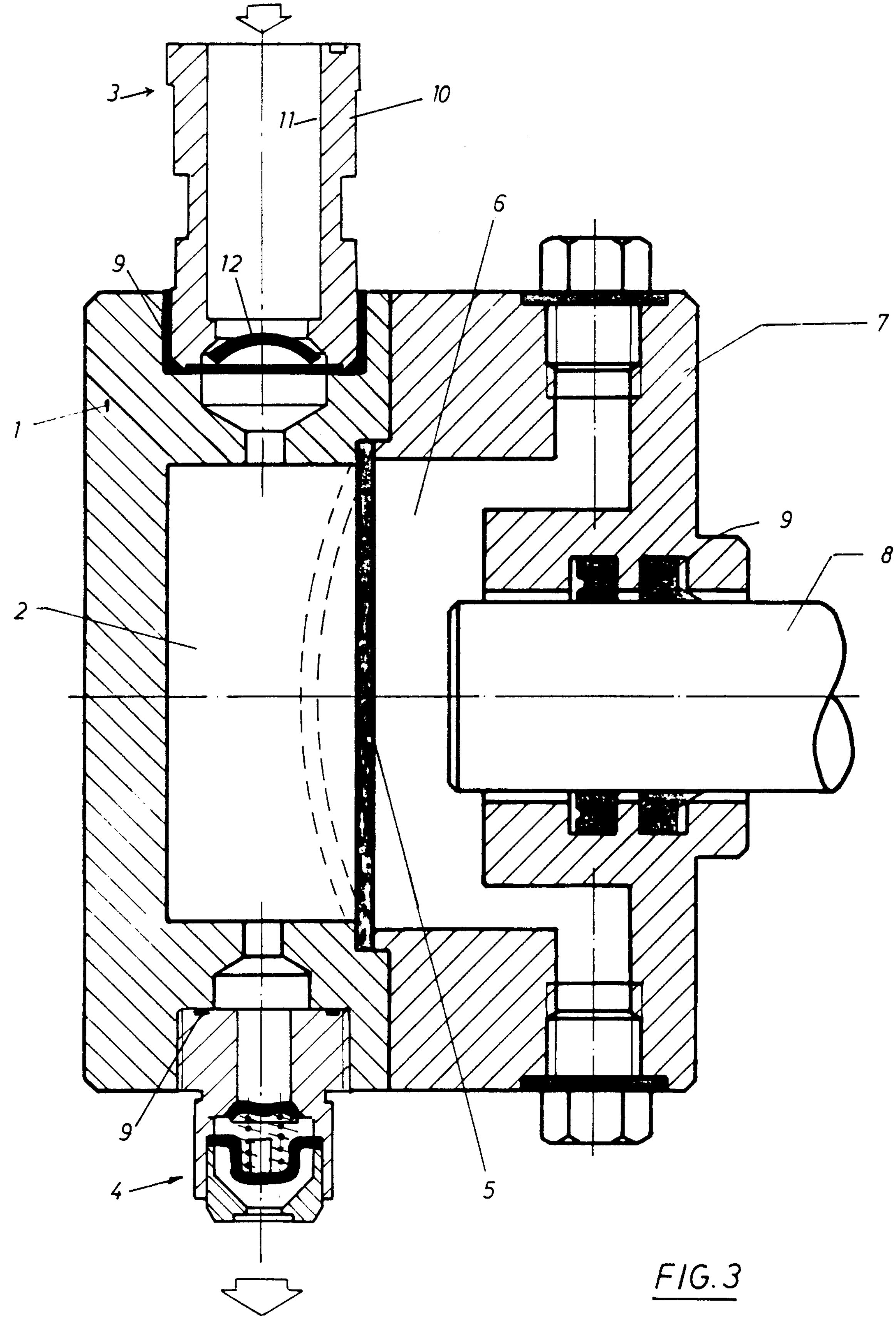

FIG. 3

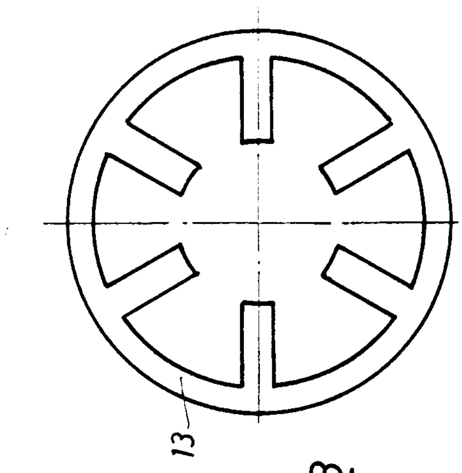

FIG. 4 B

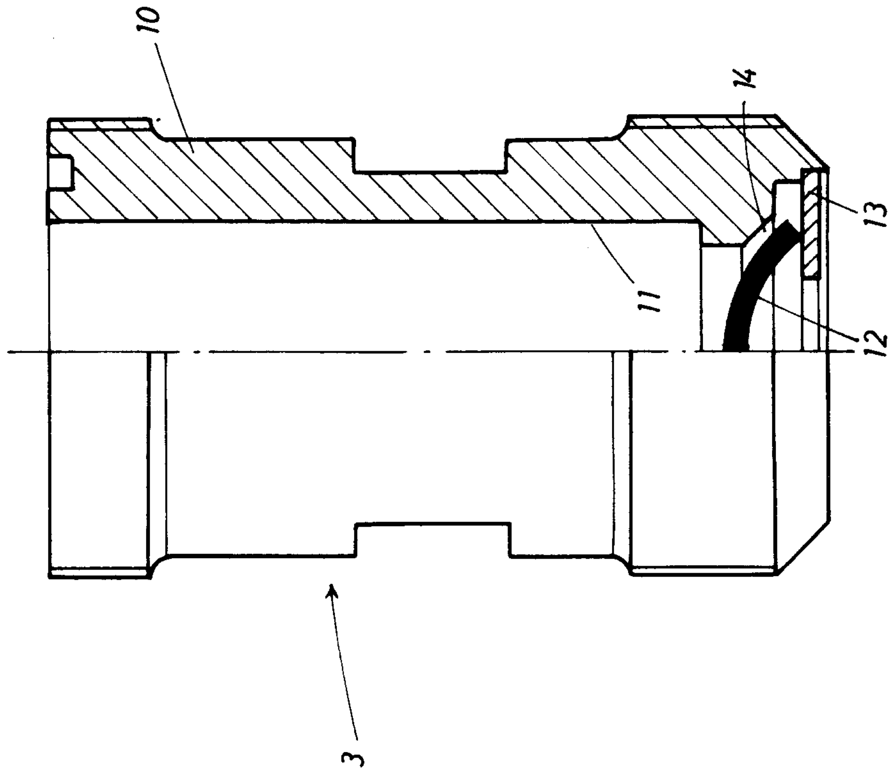

FIG. 4

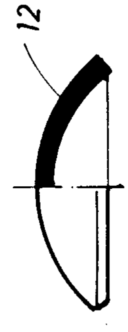

FIG. 4A

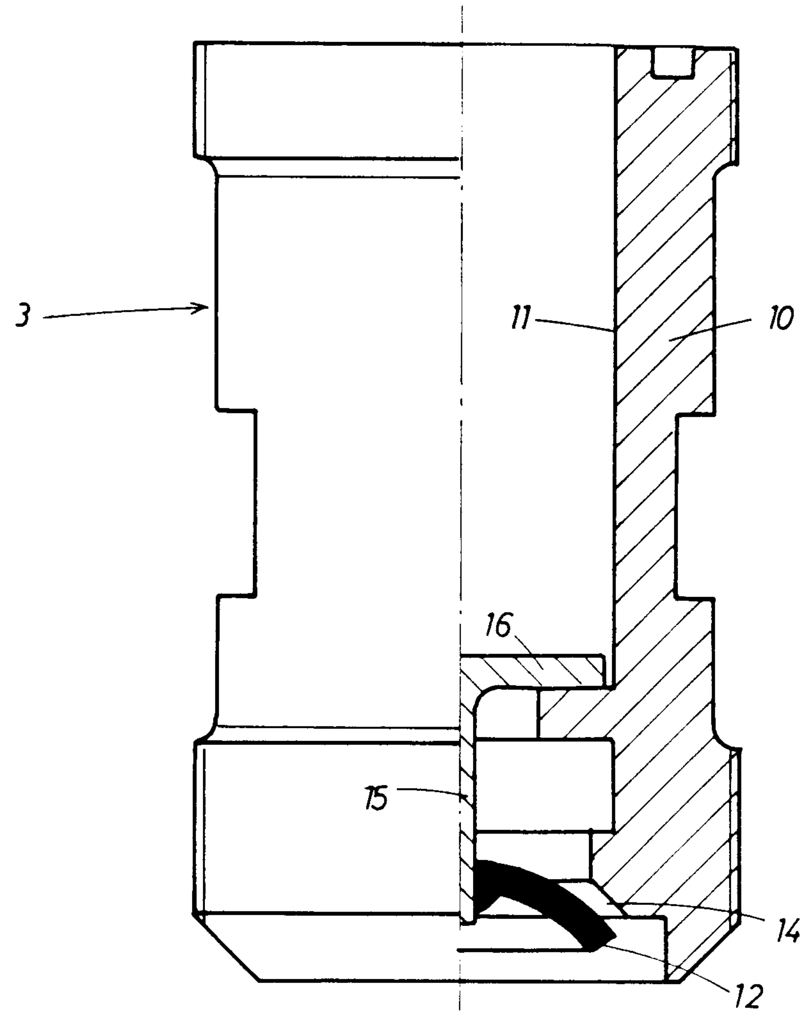

FIG. 5

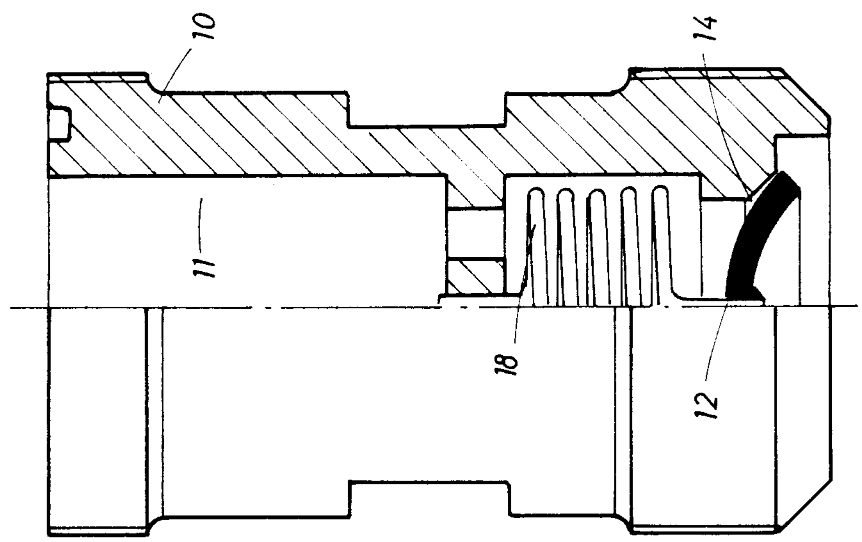

FIG. 5B

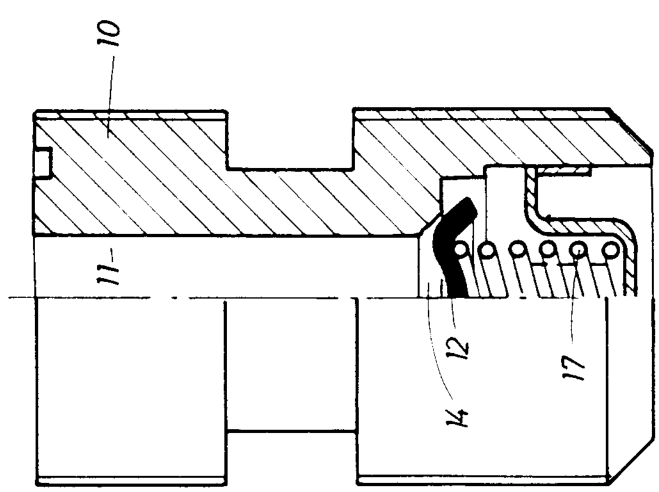

FIG. 5A

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EUROPEAN SEARCH REPORT

Application Number

EP 91 83 0155

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.5)
X	US-A-3 083 648 (PUTMAN) * The whole document * ---	1-5,7	F 04 B 15/08 F 04 B 21/00 F 04 B 21/02
X	DE-A-1 453 465 (THIER) * Page 2, paragraph 3 - page 6, paragraph 4; fig. * ---	1-3	
X	FR-A- 496 324 (DELLGREN) * The whole document * ---	1,6	
X	FR-A-1 224 446 (PAGLIASSO) * Page 1, left-hand column, paragraph 9 - right-hand column, paragraph 3; figure 1 * ---	1,6,8	
A	FR-A- 895 290 (CLOOS) * Page 2, lines 33-68; figures 1,2 * -----	2,3,4,7	

TECHNICAL FIELDS SEARCHED (Int. Cl.5)

F 04 B

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	18-12-1991	VON ARX H.P.

CATEGORY OF CITED DOCUMENTS

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