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(54) Pressure switch for detecting passing of a threshold level of a liquid in a tank

(57) There is disclosed a pressure switch (100) for detecting the passing of a threshold level (301) of a liquid (300) in a tank (200).

This pressure switch (100) comprising a chamber (11) that is hermetically divided by an impermeable elastic diaphragm (4) into two compartments (111, 112). The first compartment (111) is fillable with liquid (300) coming from a tank (200). The diaphragm (4) is able to become elastically deformed, varying the volume of the two compartments (111, 112) on the basis of the liquid (300) filling status of the first compartment (111).

Inventively, the pressure switch (100) communicates with open vertical conduits (16, 22) suitable for enabling first the air in the chamber (111) and then the liquid (300) to exit in a vertical direction on the basis of a thrust due to the pressure of the liquid (300).

In this way, it is possible to overcome the drawbacks created by the presence of air that would become compressed inside the chamber (111), and which in the absence of vertical discharge conduits (16, 22) would be generated, and it is thus possible to use this pressure switch in a simple and reliable manner to detect the variation in the level (302, 303) of liquid (300) in the tank (200) (Fig. 2).

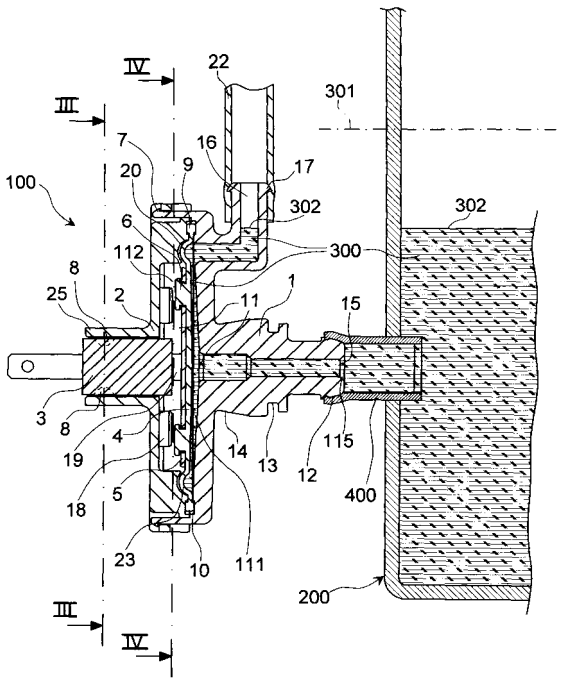

Fig.2

EP 1 916 685 A1

Description

[0001] The present invention relates to a pressure switch for detecting the passing of a threshold level of a liquid in a tank.

[0002] A pressure switch, if it is applied to a tank containing a liquid, is able to detect the passing of the level of the liquid on the basis of the pressure acting inside the pressure switch. As the pressure of a liquid increases with the increasing of the level of liquid in the tank, a pressure switch is generally placed in the zone below the tank, but detects the passing of a threshold level placed at a greater height. Once installed in a tank, a pressure switch is associated with a fixed "threshold level".

[0003] A pressure switch may be in the following two positions:

- a "rest" position: the pressure switch detects that the level of liquid does not pass the threshold level; in this position, inside the pressure switch there is no liquid, or there is low-pressure liquid;
- a "pressurised" position: the pressure switch detects that the level of liquid passes the threshold level; in this position, inside the pressure switch the pressure of the liquid is sufficiently high to trip a mechanism, for example of a circuit breaker of an electric circuit.

[0004] Nevertheless the invention can refer to all types of tanks provided that pressure is generated that is such as to actuate the system.

[0005] Reference will be made to "open" tanks (or to tanks "open at the top"), which, although they may be enclosed, are "open" inasmuch as the seals thereof have openings or are anyway not such as to insulate the tanks barometrically. In fact, the surface of such liquids is subject to atmospheric pressure.

[0006] It is known that in an open tank, i.e. with atmospheric pressure that presses on the surface of the liquid, if detecting passing of the threshold level is assigned to a pressure switch there may be problems that are due to the presence of air inside the body of the pressure switch.

[0007] In a pressure switch, the value of the pressure of air in the body of the pressure switch, varies in function of the change of the level of the liquid inside the tank. This cause the air pressure inside the pressure switch to vary.

[0008] In the case of repeated pressure variations due to the variation in the level of the liquid in the tank, this phenomenon compromises correct operation of the pressure switch. The pressure switch does not send a signal referring only to the height of the liquid but generates a signal compromised by the volume of the compressed air inside the body of the pressure switch, which volume varies through the effect of the compressibility of the air and the increasing and decreasing of the level of the liquid in the tank.

[0009] For this reason, pressure switches are not always used commercially. Often, in order to detect the absence or presence of liquid inside small tanks electronic or flow-switch floating devices are used.

[0010] In the case of float systems, in addition to the cost of the device, significant time is lost over installing and commissioning; what is more, it is necessary to put a seal system against leaks in place.

[0011] Electronic systems are costly, they cannot be applied to metal tanks and, lastly, require an additional electronic system that is able to decode and then retransmit the signal.

[0012] Flow-switch systems, in addition to having a still greater cost and needing electronic transducers, have drawbacks of clogging and reliability, inasmuch as they may transmit false signals due to the dirt.

[0013] The object of the present invention is to devise a pressure switch that is able to overcome the drawbacks of the aforesaid known devices, and is thus able to detect the absence or presence of liquid in a tank in a precise, sensitive manner, is simple to install and easily positionable in function of the needs of the user.

[0014] According to the invention, this object is achieved by means of a pressure switch for detecting passing of a threshold level of a liquid in a tank, comprising a chamber that is hermetically divided by an impermeable elastic diaphragm into at least a first and second compartment, said first compartment being fillable with liquid coming from said tank, said second compartment being free of said liquid, said diaphragm being able to become elastically deformed by varying the volume of said first and second compartment on the basis of the liquid filling status of said first compartment, characterised in that said first compartment communicates with vertical conduits open at the top that are suitable for enabling first air and then liquid to exit in a vertical direction on the basis of a thrust due to the pressure of the liquid of said tank, through said vertical conduits.

[0015] In this way, when the level of liquid inside the tank reaches the threshold level of the connection of the pressure switch, the fluid enters inside the first compartment, expelling the air through the vertical conduits, outside the pressure switch. This enables a total absence of air inside the first compartment of the pressure switch to be obtained, preventing the presence of compressed air inside the chamber.

[0016] The liquid ascends the vertical conduits connected to the outlet of the pressure switch as far as the level of the liquid in the tank.

[0017] In the embodiments of the present invention, the pressure exerted by the liquid in the tank on the diaphragm causes the elastic deformation of the diaphragm, which pushes an actuator that is able to switch the status of a microswitch, commanding an electric circuit to open or close.

[0018] Further, as the pressure switch has a constant actuation force, determined by the forces of reaction of the various components that act in the opposite direction to the force that elastically deforms the diaphragm, it is

possible to position the pressure switch at a fixed height with respect to the reference level. The pressure switch, if connected to a flexible hose, thus becomes settable; it is positionable vertically with respect to the tank inasmuch the sensibility of the pressure switch always remains the same regardless of the quantity of liquid present.

[0019] Through the effect of the principle of communicating vessels, the liquid in the vertical conduits has the same level as the liquid present inside the tank to be measured; if such conduits are transparent and have a graduated scale they enable the height of the liquid to be displayed with certainty even if the tank is built with non-transparent materials.

[0020] The use of an elastic diaphragm made of a material such as silicone is advisable inasmuch as of all the usable materials it is the one that is characterised by the greatest elastic memory.

[0021] These and other features of the present invention will be made clearer by the detailed description of an embodiment thereof illustrated by way of non limiting example in the attached drawings, in which:

figure 1 shows a perspective view of a pressure switch according to the invention;
figure 2 shows a view in vertical section of the pressure switch in figure 1 when the latter is in the rest position;
figure 3 shows a section view according to line III-III in figure 2;
figure 4 shows a section view according to line IV-IV in figure 2;
figure 5 shows a view similar to the view in figure 2 when the pressure switch is in the pressurised position.

[0022] A pressure switch 100 is able to detect the passing of a threshold level 301 of a liquid 300 contained in an open tank 200. Said pressure switch 100 is disclosable above all by means of figure 2, when the pressure switch 100 is in the rest position, and by figure 5, when it is in the pressurised position.

[0023] Said pressure switch 100 comprises a base 1, which has a metal means that is suitable for connecting said base 1 to said tank 200, containing liquid 300; such means is:

- a pipe holder fitting 12 with radial symmetry, by means of which the pressure switch can be fixed to the connecting pipe 400 of the pressure switch on the tank (this the type of connection used in figures 2 and 5);
- a groove 13 with radial symmetry that is suitable for being inserted inside a recess of the tank;
- a taper 14 suitable for being coupled on an elastic or deformable supporting structure;
- or directly on the tank without the help of pipes with the help of the radial symmetry pipe holder fitting 12 .

[0024] The base 1 has an internal conduit 15, which is placed in a horizontal position, such as to connect an opening 115 to the chamber 11 (the function of which will be disclosed below). Through the conduit 15, the liquid of the tank is enabled to exit freely.

[0025] The base 1 incorporates, in an upper position, a perpendicular elbow conduit 16; it should be noted how this conduit 16 is initially horizontal but then extends in a vertical direction. The conduit 16 connects the chamber 11 to a vertical pipe 22 by means of pipe holder fitting 17.

[0026] This vertical pipe 22 is made of transparent rubber and has scale markings that are able to indicate to an external observer the level of liquid (302 in figure 2, 303 in figure 5) in the tank. The upper top of this vertical pipe 22 is open so that before the liquid arrives the air exits completely and the liquid present is subjected to atmospheric pressure.

[0027] The vertical pipe 22 and the conduit 16 (at least in the vertical portion thereof) are collectively indicated by the term "vertical conduits".

[0028] In other embodiments of the present invention, other types of vertical conduits can be used.

[0029] The base 1 comprises traditional hooks 7 that protrude in a direction opposite the chamber 11.

[0030] By means of these hooks 7, the base 1 is coaxially hooked to a cap 2, such as to show externally (as in figure 1) that said base 1 and said cap 2 mate. The particular conformation of the base 1 and of the cap 2 is such as to form the aforesaid chamber 11 (it will be seen subsequently how said chamber 11 is in reality divided to form two hermetically separate compartments).

[0031] In particular, the base 1 and the cap 2 cooperate to form a toroidal cavity 10 with a rectangular section and horizontal axis (the function of the toroidal cavity 10 will be explained below).

[0032] Further, inside said chamber 11, the cap 2 comprises a semitoroidal notch 20 with a horizontal axis (the function of said semitoroidal notch 20 will be explained below).

[0033] The cap 2 comprises supports 18 that extend horizontally, inside said chamber 11, in the direction of the diaphragm 4.

[0034] The cap 2 has a rectangular cavity that is suitable for housing, by means of four tapered pivots 8, a microswitch 3. The latter is a bistable element that may commute to ON status (when the pressure switch is in the pressurised position and level 303 passes the threshold level 301, as in figure 5) or in OFF status (when the pressure switch is in the rest position and level 302 does not pass the threshold level 301, as in figure 2).

[0035] This microswitch 3 is driven by an actuator 19.

[0036] These tapered pivots 8, which are arranged on flexible baffles 25, enable the cap 2 to adapt perfectly to the hooking points of the microswitch, completely cancelling possible differences between one microswitch and another, maintaining said microswitch 3 in a firm and stable position.

[0037] Inside said chamber 11 there is housed an im-

permeable silicone diaphragm 4 (other embodiments of the invention could provide other types of flexible materials). Said diaphragm 4 is housed, in a vertical position, such as to separate hermetically the chamber 11 into two compartments:

- a first compartment 111 (in figures 2 and 5 it appears to the right of the diaphragm 4) within which liquid 300 can exit from and to the tank 200;
- a second compartment 112 (in figures 2 and 5 it appears to the left of the diaphragm 4) devoid of outlets for the liquid of the tank.

[0038] Inventively, the first compartment 111 is connected, by means of the conduit 16, to the pipe 22, so that it is possible that liquid of the tank exits into the first compartment 112 and subsequently into the pipe 22, owing to the thrust of the liquid in the tank (as illustrated in figures 2 and 5). Further, the position of the meeting point between the vertical conduit 16 and the chamber 11 that is the most external as possible with respect to the entry of the liquid by means of the conduit 15 enables all the air in the compartment 111 to be expelled through the vertical conduit 16 and the pipe 22 thus avoiding the drawbacks of variations in the volume of the air inside the body of the pressure switch.

[0039] Said diaphragm 4 incorporates:

- a toroidal end 9 with a semicircular section and horizontal axis, housed in the aforesaid toroidal cavity 10 (the toroidal cavity 10 has in fact the function of stably containing the edge of said diaphragm 4 in addition to avoiding problems of leaks of liquid);
- inside the toroidal end 9, a circular fold 23, with a horizontal axis (the semitoroidal notch 20 has in fact the function of enabling the coupling with said fold 23 when the pressure switch is in the pressurised position as in figure 5, so as to avoid the deformation of the diaphragm 4, under the action of the pressure);
- two mushroom protrusions 6 (clearly deducible from the comparison between figure 2 and figure 4); these protrusions are directed towards to the outside, approximately opposite the supports 18.

[0040] A stiffening disc 5 in stiff material with a horizontal axis, is placed inside said second compartment 112, in a position adjacent to said diaphragm 4 so that such stiffening disc 5 is interposed, without the possibility of exiting therefrom, between the diaphragm 4 and the actuator 19. Lastly, the stiffening disc 5 comprises through holes 24 such that the two mushroom protrusions 6 can be inserted thereinto (the function of this insertion is to maintain the diaphragm 4 and the stiffening disc 5 fixed).

[0041] The function of the stiffening disc 5 is to impose uniform stress on the actuator 19, maintaining the central part of the diaphragm 4 substantially undeformed.

[0042] The pressure switch 100, in figure 2, is in the rest position. To the rest position corresponds the fact that the level 302 in the tank 200 is lower than the threshold level 301, the liquid inside said first compartment 111 has low pressure, that is not able to push the diaphragm 4 so that the latter pushes on the actuator 19; the microswitch 3 is in the rest state. The same situation would occur if there were no liquid 300 inside said first compartment 111.

[0043] In figure 5, the pressure switch 100 is in the pressurised position. In this position, the level 303 in the tank is greater than the threshold level 301, and therefore the liquid 300 coming from the tank 200 fully fills said first compartment 111 and has pressure that is sufficiently high to push the diaphragm 4, so that the latter pushes on the actuator 19; the microswitch 3 has changed its status. Liquid 300, is present inside the vertical conduits up to the same level 303 inside the tank 200.

[0044] The microswitch 3 is a component that can be only in ON or OFF status.

[0045] The transition from the rest position to the pressurised position occurs in the following manner:

- the liquid 300 is initially as in figure 2; the microswitch is in OFF status; the pressure switch 100 is in the rest position; it is possible that there is liquid 300 in the first compartment 111 and in the conduit 16, but the pressure of the liquid 300 is such that it is not able to push and deform the diaphragm 4 to the point that it permits switching of the microswitch 3;
- the liquid 300 enters the tank 200: the level of liquid 300 in the tank 200 increases, the pressure of the liquid 300 increases and the liquid 300 flows along the conduit 15 to inside the first compartment 111, tending to deform the diaphragm 4, pushing the diaphragm to the microswitch 3;
- the diaphragm 4 is deformed elastically so as to push the stiffening disc 5, which moves to the microswitch 3, thus increasing the volume of the first compartment 111 to the detriment of the volume of the second compartment 112;
- simultaneously, the stiffening disc 5 tends to push the actuator 19 to the microswitch 3;
- simultaneously with the exit of liquid from the tank 200 to the first compartment 111, the level of part of the liquid rises towards the pipe 16 to reach the level 303 of the liquid 300 in the tank 200, making the air exit completely that is in the chamber 111 and in the vertical conduit 16;
- when the pressure switch goes to the pressurised position (figure 5) the microswitch 3 changes status, switching from OFF status to ON status;
- positioning in the pressurised position is locked through the effect of the supports 18, which lock the stiffening disc 5, preventing the force being discharged that the liquid exerts on the microswitch 3; this lock (and thus the positioning in the pressurised position and the OFF status of said microswitch 3) will remain unaltered until when the level of liquid

300 returns to below the threshold level 301.

[0046] The sensibility of the pressure switch 100 according to the invention can be varied by modifying the features of the following components by changing:

- the thickness or the material of the stiffening disc 5;
- the hardness of the diaphragm 4;
- the parameters of the microswitch 3 and of the actuator 19.

[0047] The setting of such a pressure switch 100 with respect to the tank to which it is connected is carried out simply, by trial and error. For example, if the pressure switch 100 is connected to the tank 200 by means of a flexible hose, it is possible to vary the threshold level 301 by simply varying altimetrically the position of the pressure switch 100. Guides can be provided that are suitable for fixing the positioning of the pressure switch in a vertical direction and locking means in this position.

[0048] The advantages of the present invention are summarised as:

- sensibility of the pressure switch 100 that is able to detect and send an electric signal with a column of water of approximately 10/15 mm regardless of the surface of the tank;
- simplicity, repeatability and reliability of the setting;
- reduction of costs due to the simplicity of the pressure switch 100 and the use of materials without particular features;
- simplicity and speed of assembly, as specific or particular equipment is not required;
- adjustability, it being possible to move vertically the pressure switch 100 in function of the needs of the user, means may be provided for said vertical adjusting (guide, vertical pipes and the like).

Claims

1. Pressure switch for detecting passing of a threshold level (301) of a liquid (300) in a tank (200), comprising a chamber (11) that is hermetically divided by an impermeable elastic diaphragm (4) into at least a first and second compartment (111, 112), said first compartment (111) being fillable with liquid (300) coming from said tank (200), said second compartment (112) being free of said liquid (300), said diaphragm (4) being able to become elastically deformed by varying the volume of said first and second compartment (111, 112) on the basis of the liquid (300) filling status of said first compartment (111), **characterised in that** said first compartment (111) communicates with vertical conduits (16, 22) open on the top that are suitable for enabling the total exit of first the air and then the liquid (300) vertically on the basis of a thrust due to the pressure of the liquid (300) of said tank, through said vertical conduits (16, 22).

2. Pressure switch according to claim 1, **characterised in that** said diaphragm (4) is made of silicone.

3. Pressure switch according to any one of claims 1 or 2, **characterised in that** said pressure switch is connected to said tank (200) by means of a flexible hose, said pressure switch having means that enables said pressure switch (100) to be positioned vertically and locked.

4. Pressure switch according to any preceding claim, **characterised in that** it comprises a microswitch (3) that is able to switch an electric circuit, said microswitch (3) being switchable through the effect of a force due to the pressure of the liquid (300) present in said first compartment (111).

5. Pressure switch according to any preceding claim, **characterised in that** it comprises a stiffening disc (5) **in that** is made of stiff material and is adjacent to said diaphragm (4).

6. Pressure switch according to any preceding claim, **characterised in that** it comprises at least a pipe-holder fitting (12), by means of which the pressure switch can be fixed to the connecting pipe connecting the pressure switch to the tank (200).

7. Pressure switch according to any preceding claim, **characterised in that** it comprises at least a groove (13) suitable for being inserted inside a recess of the tank (200);

8. Pressure switch according to any preceding claim, **characterised in that** it comprises at least a taper (14) that is suitable for being coupled on an elastic or deformable supporting structure.

9. Pressure switch according to any preceding claim, **characterised in that** it comprises at least a horizontal conduit (15) that is able to connect said pressure switch (100) to said tank (200), to enable the liquid (300) of the tank (200) to exit freely.

10. Pressure switch according to any preceding claim, **characterised in that** it comprises at least a vertical pipe (22) made of transparent rubber, said pipe (22) having suitable scale markings to show an external observer the level of liquid (300) in the tank (200).

11. Pressure switch according to any preceding claim, **characterised in that** said chamber (11) comprises a toroidal cavity (10) and a semitoroidal notch (20).

12. Pressure switch according to any preceding claim,

characterised in that it comprises supports (18) protruding horizontally inside said second compartment (112).

13. Pressure switch according to any one of claims 11 or 12, **characterised in that** said diaphragm (4) incorporates a toroidal end (9) stably housed in the aforesaid toroidal cavity (10), a circular fold (23) that is accommodable in the aforesaid semitoroidal notch (20), and mushroom protrusions (6) directed approximately opposite said supports (18).

14. Pressure switch according to any one of claims 5-13, **characterised in that** said stiffening disc (5) is placed, inside said second compartment (112), in a position adjacent to said diaphragm (4) so that said stiffening disc (5) is interposed, without the possibility of exiting therefrom, between the diaphragm (4) and an actuator (19) that is able to switch said microswitch (3), said stiffening disc comprising holes (24) hooking said diaphragm (4) by means of mushroom protrusions (6).

15. Pressure switch according to any preceding claim, **characterised in that** it has means (4, 5, 15, 19) suitable for configuring said pressure switch between a rest position and a pressurised position, said rest position providing for the absence of liquid (300) inside said first compartment (111) and said pressurised position providing for the presence of liquid (300) inside said first compartment (111), there being provided means (3) suitable for switching an electric circuit on the basis of the transition from said rest position to said pressurised position.

16. Pressure switch according to any preceding claim, **characterised in that** said vertical conduits (16, 22) with open top enable the air in the chamber (111) to exit completely and the liquid inside to be subjected to atmospheric pressure.

17. Pressure switch according to any preceding claim, **characterised in that** it comprises tapered pivots (8) for supporting the microswitch (3), positioned on flexible baffles (25) that are suitable for zeroing possible physical differences between one microswitch and another, maintaining the aforesaid microswitch in a stable position.

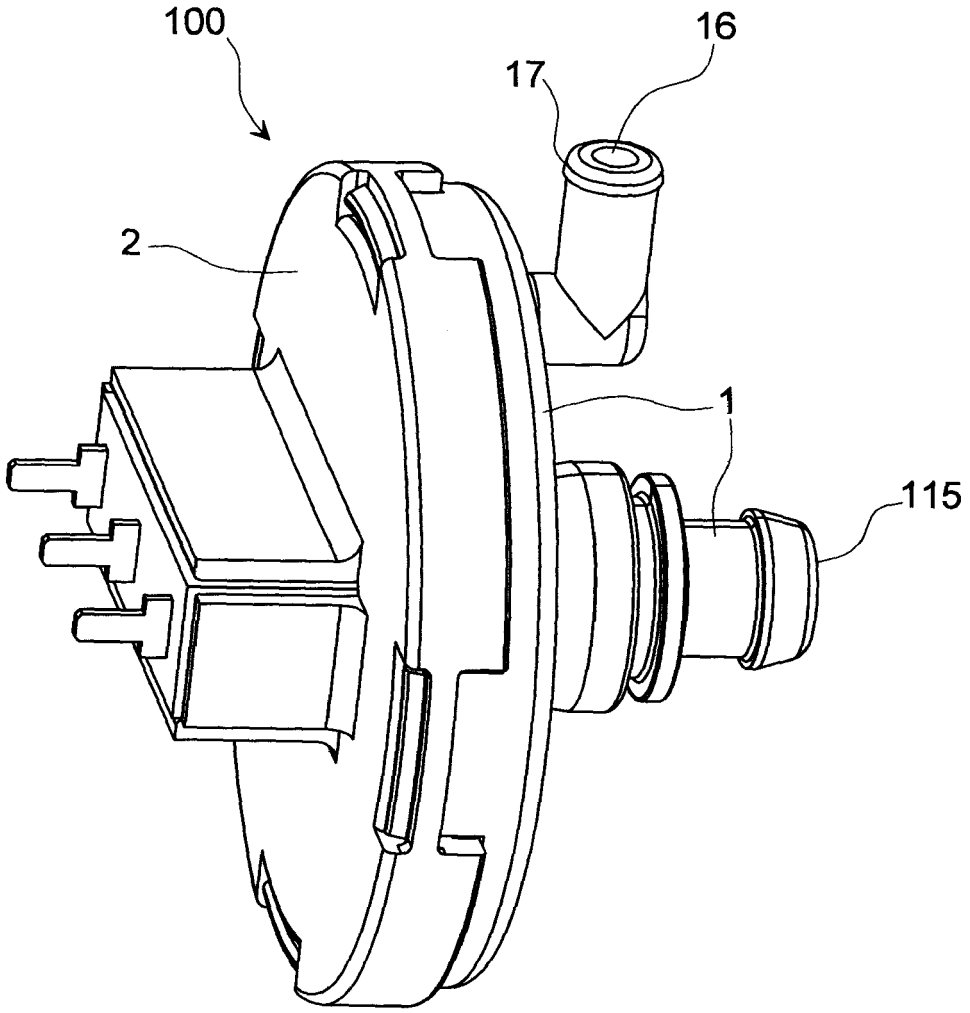

Fig.1

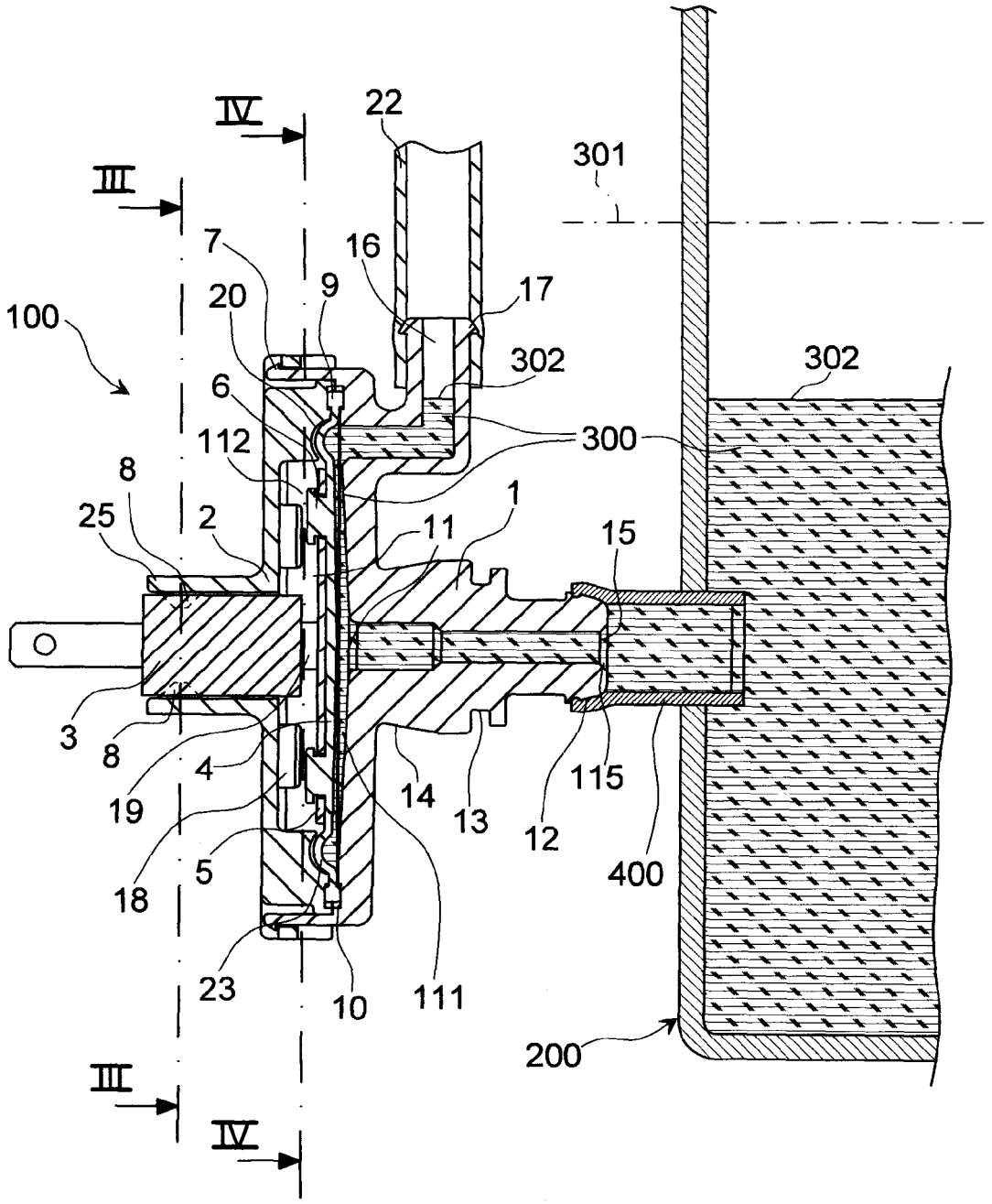
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Fig.2

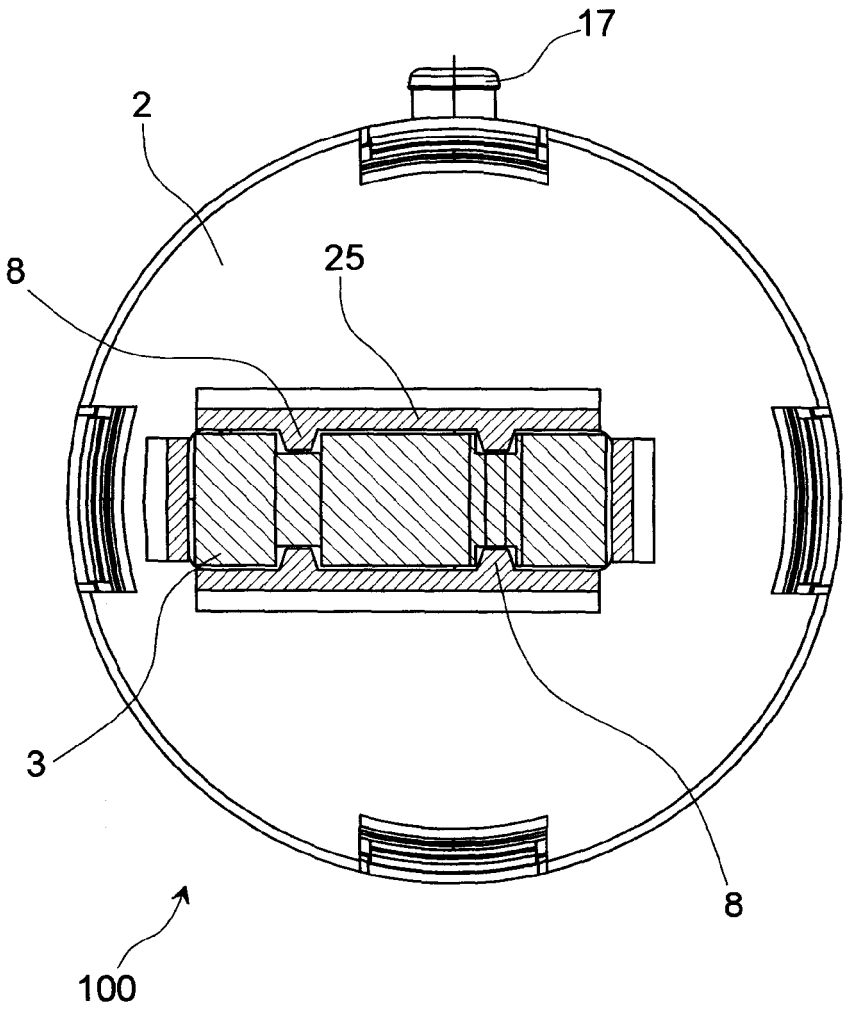

Fig.3

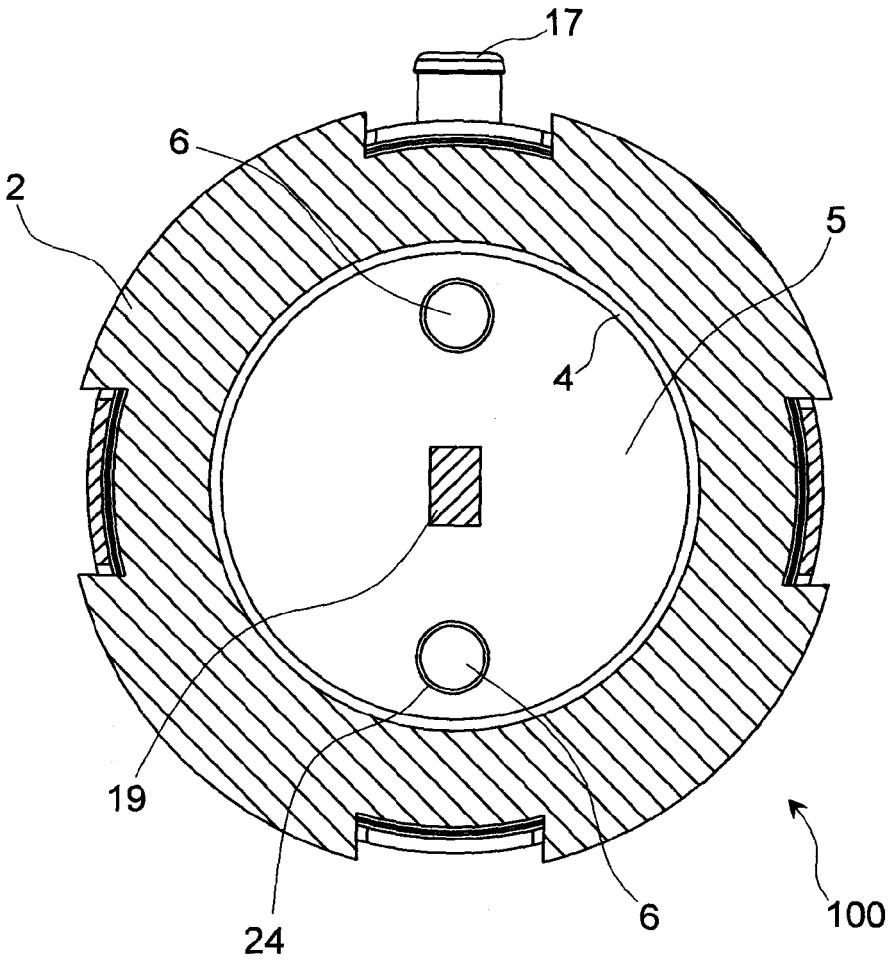

Fig.4

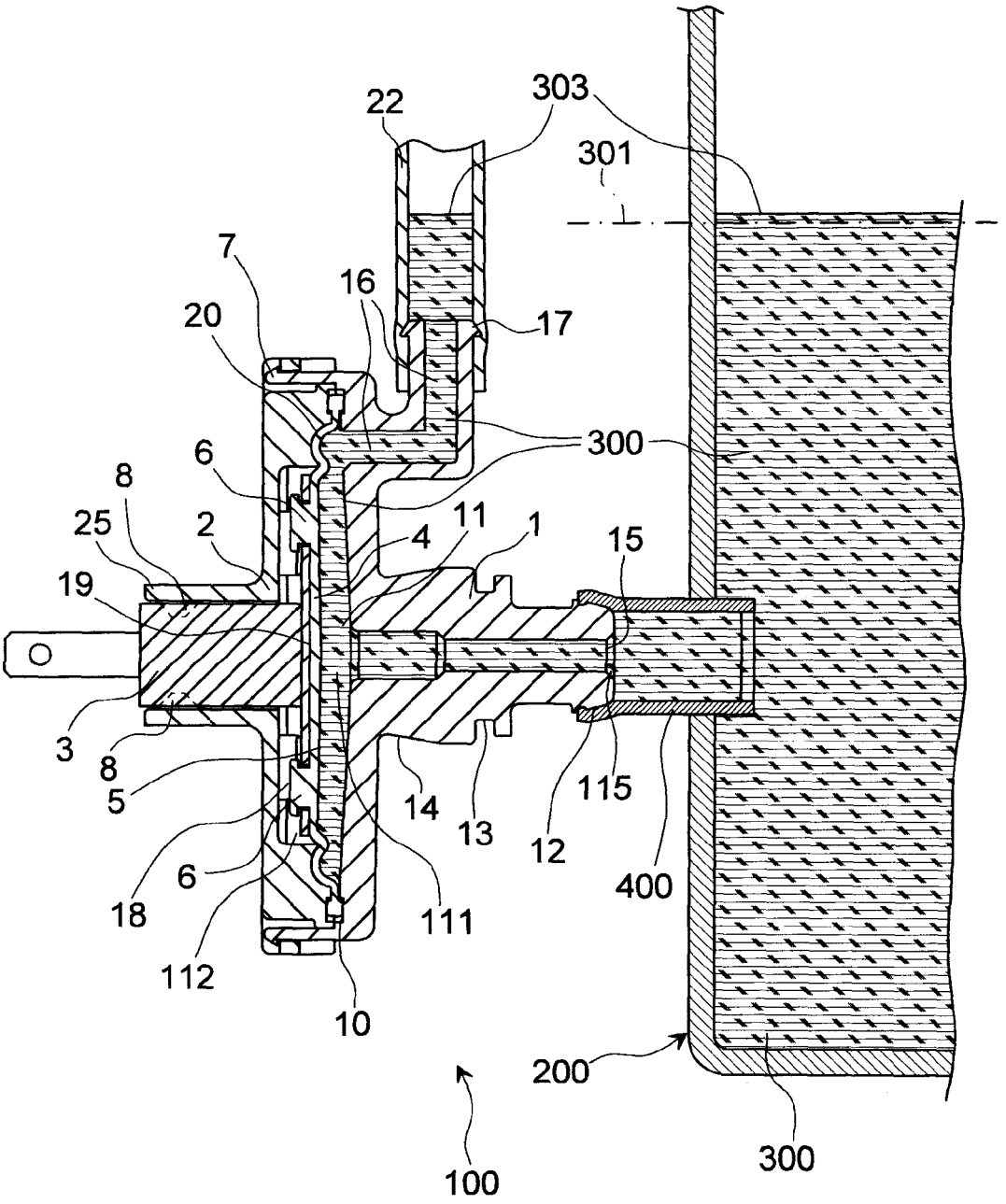
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Fig.5

European Patent Office

EUROPEAN SEARCH REPORT

Application Number
EP 07 11 8477

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
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TECHNICAL FIELDS SEARCHED (IPC)

H01H
G05D
G01F

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
Munich	19 February 2008	Nieto, José Miguel

CATEGORY OF CITED DOCUMENTS

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