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(54) Pressure relief device for a power transformer, and related power transformer

(57) A pressure relief device suitable to be connected to a power transformer comprising a tank filled with an insulating fluid, the pressure relief device comprising a shaped body having:
- a connection flange provided with a through opening and suitable to be connected to the tank;
- an end cap which is spaced apart from the connection flange;
- a valve element which is displaceable between a first position where it is suitable to at least partially close the through opening of the connection flange and a second position where it is spaced away from the through opening;
- at least one elastic element which is operatively connected to the valve element so as to urge it towards the first position; and
- a pressure transducer which is positioned inside the shaped body and is adapted to continuously sense the pressure inside the tank.

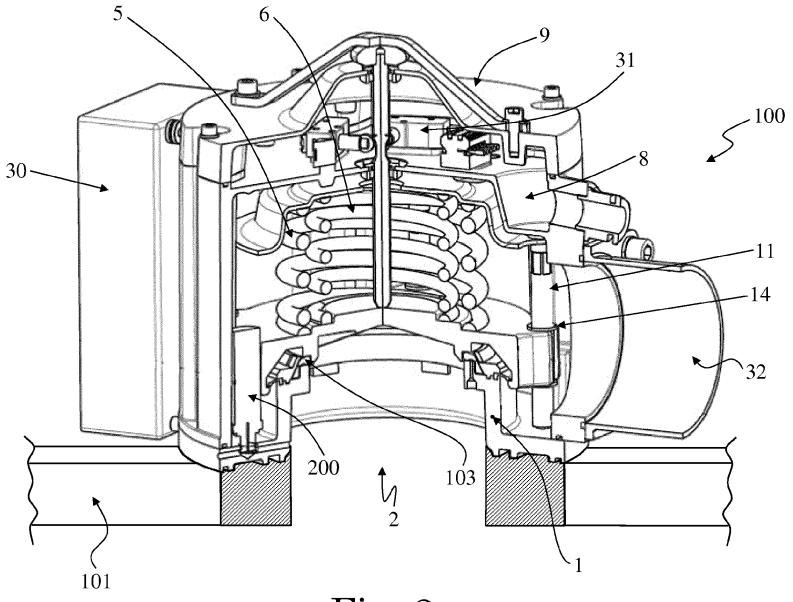

Fig. 2

EP 2 669 909 A1

Description

[0001] The present disclosure relates to a pressure relief device suitable to be connected to a power transformer, and to a power transformer comprising such a pressure relief device.

[0002] As known, power transformers generally comprise a magnetic core composed by one or more legs or limbs connected by yokes which all together form one or more core windows; for each phase, around the legs there are arranged a number of windings, i.e. low-voltage windings, high-voltage windings, control or regulation windings.

[0003] Such components must be properly cooled in order to provide the desired electromagnetic performance without incurring in any malfunctioning or damages; to this end, a power transformer comprises usually a closed tank or vessel which is filled with an insulating fluid, e.g. a mineral oil, used as a coolant for the components of the transformer.

[0004] During operations, it is possible that some failures or disturbances may generate accidental and uncontrolled increases in pressure inside the closed tank; for example, sudden and violent short-circuits inside the tank almost instantly generate an enormous amount of gas with a great increase in interior pressures.

[0005] When the pressure inside the tank exceeds a predefined limit, there is the danger of severe damages for the transformer and even of explosions.

[0006] To mitigate such risks, pressure relief devices are used which are designed to discharge the over-pressure outside the tank into the surrounding atmosphere.

[0007] Known pressure relief devices are usually connected to a wall of the transformer tank, e.g. on top of the tank, and are available in numerous and various constructive solutions.

[0008] Although known pressure relief devices perform their basic functions in a quite satisfying way, they still present some shortcomings.

[0009] For example, at the moment is not possible to have any information about the actual pressure value and the trend over the time of the inside pressure. Indeed, it is known that the inside pressure sometimes might increase at a slow pace and not suddenly. Relevant standards state that a pressure relief device has to withstand a pressure 10 kPa less than the nominal operating pressure without any oil leakage. This means that the pressure inside the tank can be higher than the rated pressure without any information outside.

[0010] Hence, there is desire and room for further improvements; such a desire is fulfilled by a pressure relief device suitable to be connected to a power transformer comprising a tank filled with an insulating fluid, the pressure relief device comprising a shaped body having:

- a connection flange provided with a through opening, said connection flange being suitable to be connected to said tank;
- an end cap which is spaced apart from said connection flange;
- a valve element which is displaceable between a first position where it is suitable to at least partially close said through opening and a second position where it is spaced away from said through opening;
- at least one elastic element which is operatively connected to said valve element so as to urge it towards the first position; **characterized in that** it comprises a pressure transducer which is positioned inside said shaped body and is adapted to continuously sense the pressure inside said tank.

[0011] Detailed characteristics and advantages will become apparent from the description of some preferred but not exclusive embodiments of a pressure relief device according to the present disclosure, illustrated only by way of non-limitative examples with the accompanying drawings, wherein:

figure 1 is a perspective view schematically illustrating an exemplary embodiment of some parts of a pressure relief device according to the present disclosure;

figure 2 is a perspective view showing a pressure relief device according to the present disclosure with some components partially cut and schematically connected to a tank of a power transformer;

figure 3 is a perspective view showing one exemplary embodiment of some components usable in a pressure relief device according to the present disclosure;

figure 4 is a schematic view showing another exemplary embodiment of a valve element usable in the pressure relief device according to the present disclosure;

figure 5 is a perspective view showing a further embodiment of a pressure relief device according to the present disclosure with some components partially cut.

[0012] It should be noted that in the detailed description that follows, identical or similar components have the same reference numerals, regardless of whether they are shown in different embodiments of the present disclosure. It should also be noted that in order to clearly and concisely disclose the present disclosure, the drawings may not necessarily be to scale and certain features of the present disclosure may be shown in somewhat schematic form.

[0013] Figures 1, 2 and 5 show exemplary embodiments of a pressure relief device according to the present disclosure globally indicated by the reference number 100; the pressure relief device 100 is suitable to be connected to a power transformer, for example to the tank or casing of the transformer, as shown schematically in figure 2 wherein a top wall of a tank is schematically represented by the reference number 101.

[0014] Clearly, the pressure relief device 100 can be connected to any other suitable part or wall of the transformer or to any other component thereof, such as for example an on-load tap changer.

[0015] In the exemplary embodiments illustrated, the pressure relief device 100 has a shaped body comprising several parts mutually assembled to each other in the way that will be described hereinafter. In particular the shaped body comprises a connection flange 1 provided with a through opening 2; the connection flange 1 is suitable to be connected to the tank, e.g. to the top wall 101 of the tank, by means of securing means e.g. screws and/or studs 102, as schematically illustrated for instance in figure 1 and in the way that will be described in more details hereinafter.

[0016] The shaped body of the pressure relief device 100 comprises an end or abutment cap 3 which is spaced apart from the connection flange 1, e.g. above the connection flange 1 and externally with respect to the tank of the transformer; in the exemplary embodiment illustrated, the end cap 3 has a substantially circular, cup-shaped configuration.

[0017] The pressure relief device 100 further comprises a valve element 4 which comprises, as for example illustrated in figure 3, a substantially disk-like body (seen in top or plan view) and is positioned displaceable between the connection flange 1 and the end cap 3; the valve element 4 is displaceable between a first position where it is suitable to at least partially close the through opening 2 (closed position illustrated in figure 1) and a second position where it is spaced away from the through opening 2 (open position) so as to allow venting outside the tank of any dangerous overpressure occurring for whatever reason inside the tank itself. Further, the pressure relief device 100 comprises at least one elastic element 5, e.g. a spring 5, which is operatively connected to the valve element 4 so as to urge it towards the first open position where it is devised to close at least partially the through opening 2 of the connection flange 1; to this end, in order to sealingly close the through opening 2, the device 100 is provided with suitable gaskets 103 according to solutions well known to those skilled in the art and therefore not described herein in details.

[0018] In the exemplary embodiment illustrated in figures 1 and 2, the pressure relief device 100 is shown provided with two elastic elements, i.e. two springs 5 and 6, e.g. two compression springs, which are for instance positioned concentrically to each other; each spring 5, 6, has one end which is operatively connected to the end cap 3 and is placed within the concavity of its cup-shaped body, and the other end which is operatively connected to the valve element 4 so as to urge it towards the connection flange 1 for closing its though opening 2.

[0019] As illustrated in figures 2 and 5, the body of the device 100 comprises also an intermediate cover 8 positioned above the end cap 3, and an outer cover 9 which is positioned over the intermediate cover 8; the intermediate cover 8 and the outer cover 9 delimit an inside closed space 31 inside which it is possible to house components, such as electric cables, terminal, switches, et cetera.

[0020] Advantageously, the pressure relief device 100 according to the present disclosure comprises a pressure transducer 200 which is positioned inside the shaped body of the device 100 itself and is adapted to continuously sense the pressure inside said tank.

[0021] In a first exemplary embodiment illustrated for example in figure 2, the pressure transducer 200 is positioned at the connection flange 1 and is in operative communication with the inside of the tank 101.

[0022] In the exemplary embodiment illustrated in figure 5, the pressure relief device 100 comprises a sleeve 201 which is operatively connected to the valve element 4 at a central portion thereof; the pressure transducer 200 is positioned inside the sleeve 201 and is in operative communication with the inside of the tank 101.

[0023] Alternatively, the pressure transducer 200 can be fitted inside the concentric springs 5 and 6; in addition, it would be possible to fit inside the springs 5, 6 also the electronic board. Preferably, the pressure transmitter 200 is adapted to convert the pressure sensed into corresponding electronic signals.

[0024] In particular, as illustrated in figure 2, the pressure relief device 100 comprises an electrical box 30 containing an electronic board which receives the electronic signals output by the pressure transmitter 200. An electronic board can be also in addition/or in alternative placed remotely from the device 100 and can receive the signals from the pressure transmitter 200. As shown in figures 2 and 5, the body of the device 100 can be provided also with a lateral sleeve 32 which can be realized in a unique piece together with the intermediate cover 8 or can be mechanically connected therewith. The lateral sleeve 32 allows oil leaking outside the tank 101.

[0025] The pressure relief device 100 according to the present disclosure comprises also connection means, indicated by the overall reference number 10, which are arranged so as to guide the valve element 4 along a predetermined path when the valve element 4 itself moves between the first closed position and the second position, in both directions.

[0026] The valve element 4 is driven by means of connection means 10 which comprise, according to the exemplary embodiments illustrated in the attached figures, first connection means which mechanically connect the connection flange 1 with the end cap 3 and second connection means operatively connecting the valve element 4 with the first connection means, in the way that will be described hereinafter.

[0027] The first connection means 10 comprise a plurality of substantially rectilinear studs 11, for instance four studs 11; each stud 11 has one end portion 12 which is inserted into a corresponding hole provided on the connection flange 1 and is connected to the flange 1 by means of securing means, e.g. a fixing screw 102. A second end portion 13 of each stud 11 is connected to the

end cap 3, by means of other securing means, e.g. a further screw 102.

[0028] The second connection means comprise for instance a plurality of sleeves 14 and a plurality of seats 15 which are provided on the body of the valve element 4; in particular, as illustrated in more details in figure 3, the seats 15 are placed at the outer rim of the disk-like body of the valve element 4 and are open outwardly; in practice they protrude outwardly from the circumference of the disk-like body.

[0029] According to the exemplary embodiments illustrated in figures 1 and 3, the plurality of seats 15 comprises four seats 15, namely a first seat and a second seat which are positioned substantially symmetrically to each other with respect to the center 104 of the disk-like body, and a third seat and a fourth seat which are also positioned substantially symmetrically to each other with respect to the center 104 of said disk-like body. In practice the four seats 15 are placed at the ends of two perpendicular diameters 21, 22 of the disk-like body of the valve element 4, according to a solution which allows a substantially symmetric distribution of mechanical stresses.

[0030] Each seat 15 is adapted to receive a corresponding sleeve 14 which is inserted therein with a mechanical clearance; alternatively the sleeves 14 could be force-fitted into the respective seats 15.

[0031] In the exemplary embodiment illustrated in figure 3, each sleeve 14 of the plurality of sleeves 14 comprises a central portion and two end portions 16, 17 which protrude transversely from the central portion. Each sleeve 14 and the correspondingly associated seat 15 are sized relatively to each other so as when a sleeve 14 is fitted into the corresponding seat 15, the two end portions 16-17 rest and abut each on a corresponding surface 18, 19 of the valve element 4, respectively. In this way, the sleeves 14 and the valve element 4 are rigidly connected to each other and substantially move together as a unique body.

[0032] In turn, each stud 11 is inserted and passes through an associated sleeve 14; in particular, each stud 11 is inserted into the associated sleeve 14 with a small mechanical clearance left there between so as to allow the movement of the valve element 4 relative to the studs 11 themselves (and hence relative to the end cap 3 and connection flange 1 as well which are rigidly connected with the studs 11).

[0033] According to another exemplary embodiment illustrated schematically in figure 4, the connection means can comprise a plurality of through holes 20 provided on the body of the valve element 4; in this case the sleeves 15 can be omitted and each stud 11 of the plurality of studs 11 can be inserted and passed through an associated through hole 20 of the plurality of through holes 20.

[0034] Also in this case, each stud 11 is inserted into the corresponding through hole 20 with a small mechanical clearance there between, so as to allow the movement of the valve element 4 relative to the studs 11 and therefore relative to the end cap 3 and connection flange 1 as well. Also in this exemplary embodiment illustrated in figure 4, the plurality of through holes 20 comprises four through holes 20, namely a first hole and a second hole which are positioned substantially symmetrically to each other with respect to the center 104 of the disk-like body, and a third through hole and a fourth through hole which are also positioned substantially symmetrically to each other with respect to the center 104 of said disk-like body. In practice the four through holes 20, likewise the four seats 15, are placed at or close to the ends of two perpendicular diameters 21, 22 of the disk-like body of the valve element 4.

[0035] In practice, in normal operating conditions, the valve element 4 is urged by the springs 5, 6 toward the connection flange 1 and closes the through opening 2. The pressure transducer 200 senses continuously the pressure inside the tank 101 and corresponding digital signals are received by the electronic board. Such communication can be executed for example according to MODBUS protocol and by means of an RS 485 connection type.

[0036] In this way, it is possible have a continuous information about the pressure exerted on the valve element 4.

[0037] If for whatever reason the pressure inside the tank increases and reaches a level sufficient enough to overcome the urging force of the springs 5-6, the valve element 4 is moved away by such overpressure towards the end cap 3; during this displacement, the movement of the valve element 4 is guided by the coupling studs 11-sleeves 14 along a predetermined and always the same path, i.e. in the exemplary embodiment illustrated along a rectilinear path. In this way, when the through opening 2 is open, fluids coming from the inside of the tank, e.g. gases or even quantities of the coolant liquid are vented/discharged outside, e.g. through the lateral sleeve 32; as a consequence, the pressure inside the tank is lowered and when the force exerted by the springs 5, 6 (which were compressed by the movement of the valve element 4 towards the end cap 3) on the valve element 4 is again higher than the counteracting pressure, the valve element 4 returns to the previous position along the same predetermined substantially rectilinear path, thus closing again the through opening 2.

[0038] In practice, it has been found that the pressure relief device 100 according to the present disclosure offers a solution which is rather simple, reliable, and allows monitoring the pressure inside the tank. Such results are achieved thanks to a simple solution which makes the pressure relief device 100 according to the present disclosure easy to be used in connection with any type of power transformer, or even components of or for power transformers, such as on-load tap changers, where such safety devices are advisable.

[0039] Hence, the present disclosure also encompasses a power transformer comprising at least one pressure relief device 100 of the types previously described and

as defined in the appended claims. Clearly more than one pressure relief device can be used in a single power transformer.

[0040] The pressure relief device 100 thus conceived is susceptible of modifications and variations, all of which are within the scope of the inventive concept as defined in particular by the appended claims; any possible combination of the previously disclosed embodiments can be implemented and has to be considered within the inventive concept of the present disclosure; all the details may furthermore be replaced with technically equivalent elements. For example, any of the previously described components may be differently shaped, or used in a different number or parts or elements, or the components previously described can be differently connected with respect to each other.

[0041] Also the materials used, so long as they are compatible with the specific use and purpose, as well as the dimensions, may be any according to the requirements and the state of the art.

Claims

1. A pressure relief device (100) suitable to be connected to a power transformer comprising a tank (101) filled with an insulating fluid, the pressure relief device comprising a shaped body having:

- a connection flange (1) provided with a through opening (2), said connection flange being suitable to be connected to said tank;
- an end cap (3) which is spaced apart from said connection flange (1);
- a valve element (4) which is displaceable between a first position where it is suitable to at least partially close said through opening (2) and a second position where it is spaced away from said through opening (2);
- at least one elastic element (5) which is operatively connected to said valve element (4) so as to urge it towards the first position;

characterized in that it comprises a pressure transducer (200) which is positioned inside said shaped body and is adapted to continuously sense the pressure inside said tank.

2. Pressure relief device (100) according to claim 1, wherein said pressure transducer (200) is positioned at said connection flange (1).

3. Pressure relief device (100) according to claim 1, wherein it comprises a sleeve (201) operatively connected to said valve element (4) at a central portion thereof and inside which said pressure transducer (200) is positioned.

4. Pressure relief device (100) according to one or more of the previous claims, wherein said pressure transmitter is adapted to convert the pressure sensed into an electronic signal.

5. Pressure relief device (100) according to claim 4, wherein it comprises an electrical box (30) containing an electronic board which receives said electronic signal.

6. Pressure relief device (100) according to one or more of the previous claims, wherein it comprises an intermediate cover (8) positioned above said end cap (3), and an outer cover (9) positioned over said intermediate cover (8), said intermediate cover (8) and said outer cover (9) delimiting an inside closed space.

7. Pressure relief device (100) according to one or more of the previous claims, wherein it comprises connection means (10) arranged so as to guide said valve element (4) along a predetermined path when it moves between said first and second positions, said connection means (10) comprising first connection means which mechanically connect said connection flange (1) with said end cap (3) and second connection means operatively connecting said valve element (4) with said first connection means.

8. Pressure relief device (100) according to one or more of the preceding claims, wherein said first connection means (10) comprise a plurality of studs (11), each stud (11) having its end portions (12, 13) connected to said connection flange (1) and said end cap (3), respectively, and wherein said second connection means comprise a plurality of sleeves (14), each stud (11) of said plurality of studs (11) being inserted and passing through an associated sleeve (14) of said plurality of sleeves (14).

9. Pressure relief device (100) according to one or more of the preceding claims, wherein said valve element (4) comprises a plurality of seats (15) receiving each a corresponding sleeve (14).

10. Pressure relief device (100) according to claim 9, the seats (15) of said plurality of seats (15) are placed at the outer rim of said valve element (4) and are open outwardly.

11. Pressure relief device (100) according to one or more of the preceding claims, wherein each sleeve (14) of said plurality of sleeves (14) comprises a central portion and two end portions (16, 17) protruding transversely from said central portion and abutting each on a corresponding surface of said valve element (4).

12. Pressure relief device (100) according to one or more

of the preceding claims, wherein said valve element (4) comprises a disk-like body, and wherein said plurality of seats (15) comprises a first seat and a second seat positioned substantially symmetrically to each other with respect to the center of said disk-like body, and a third seat and a fourth seat positioned substantially symmetrically to each other with respect to the center of said disk-like body.

13. Pressure relief device (100) according to claim 7, wherein said second connection means comprise a plurality of through holes (20) provided on the body of said valve element (4), each stud (11) of said plurality of studs (11) being inserted and passing through an associated through hole (20).

14. A power transformer **characterized in that** it comprises at least one pressure relief device (100) according to one or more of the previous claims.

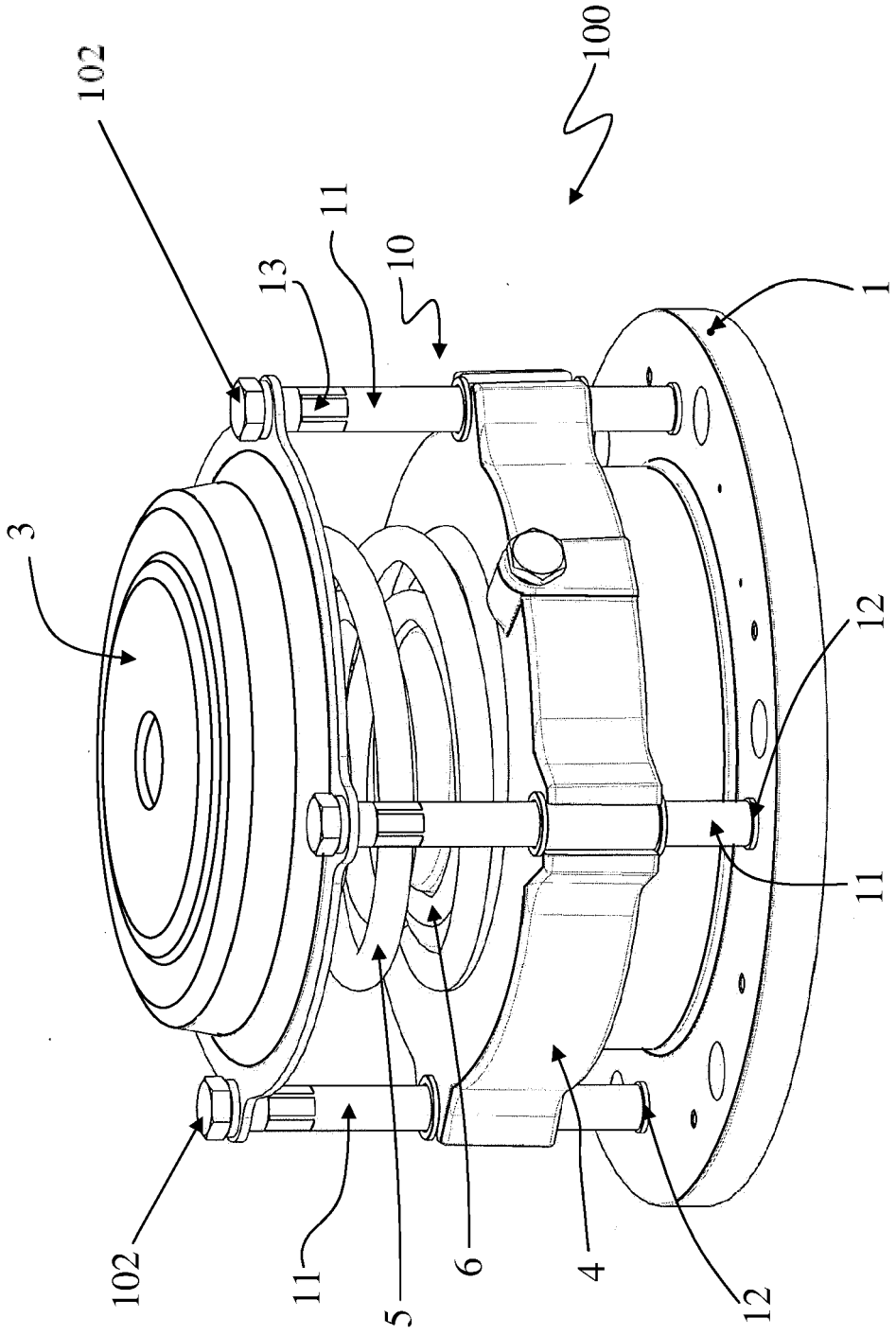

Fig. 1

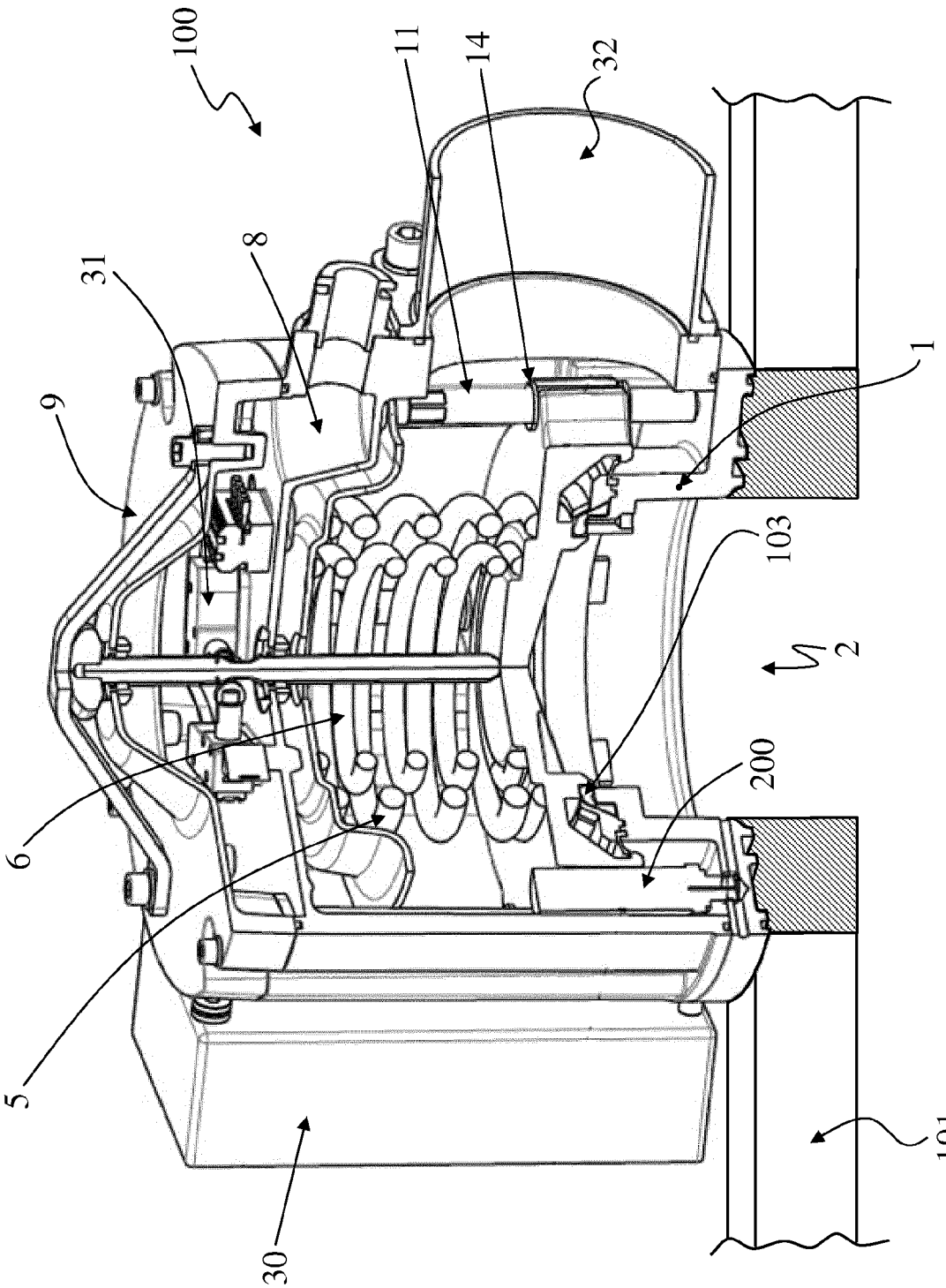

Fig. 2

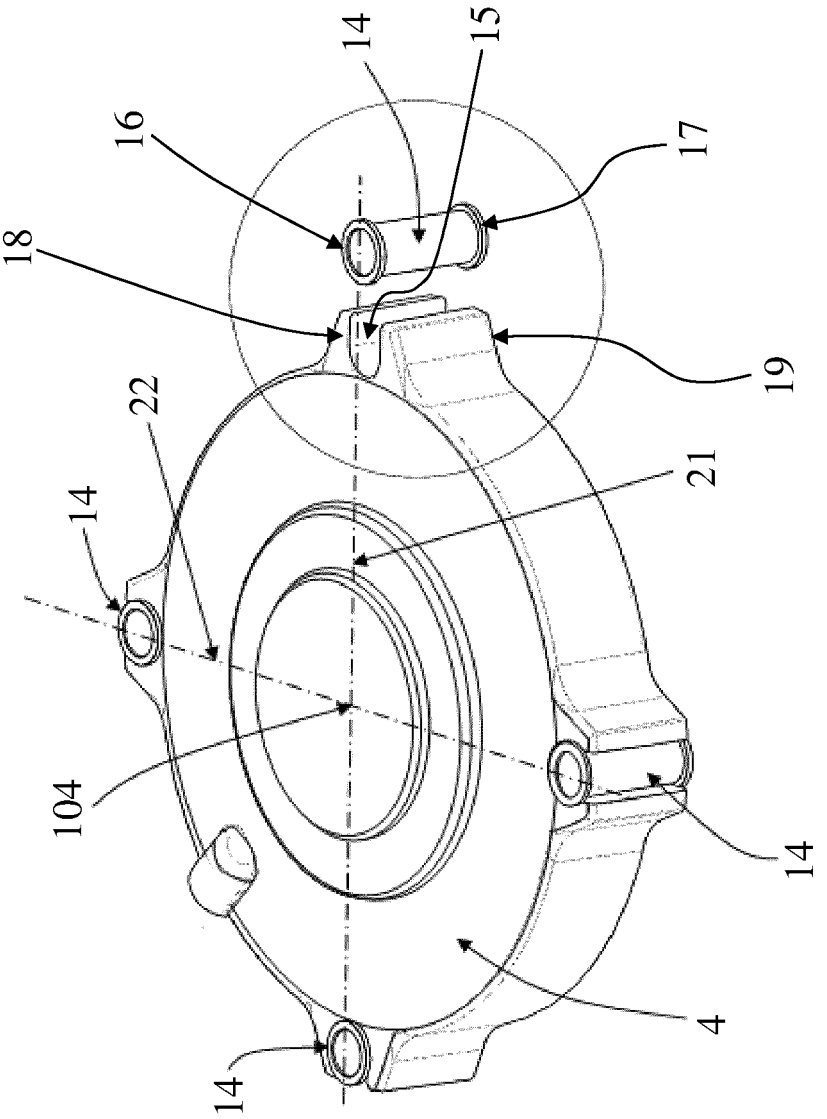

Fig. 3

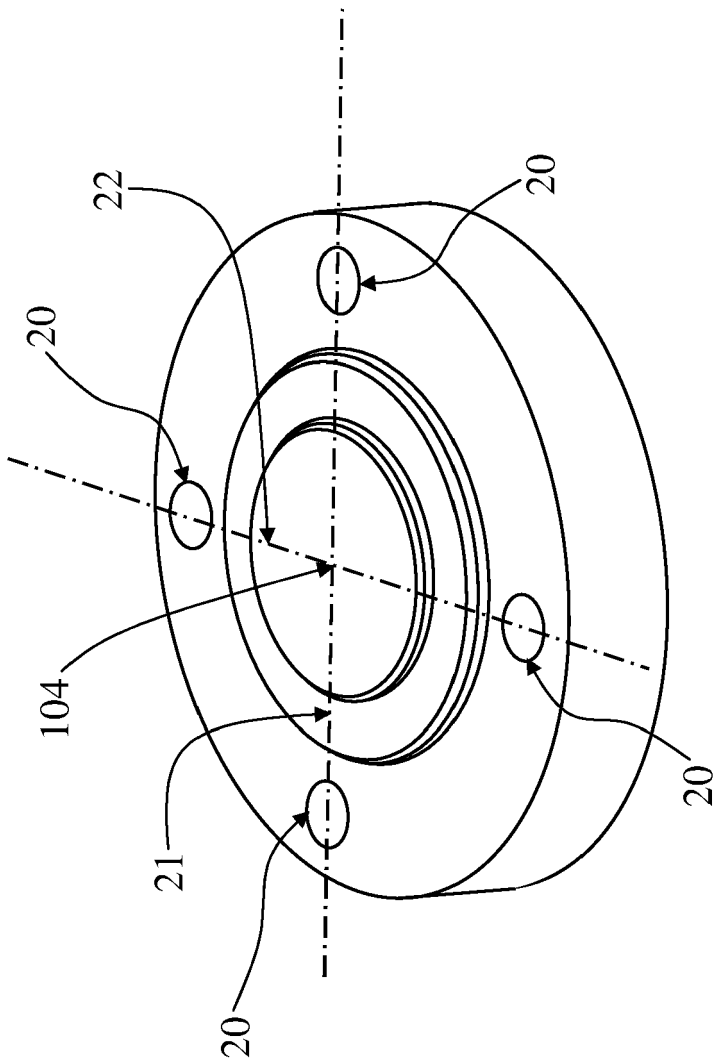

Fig. 4

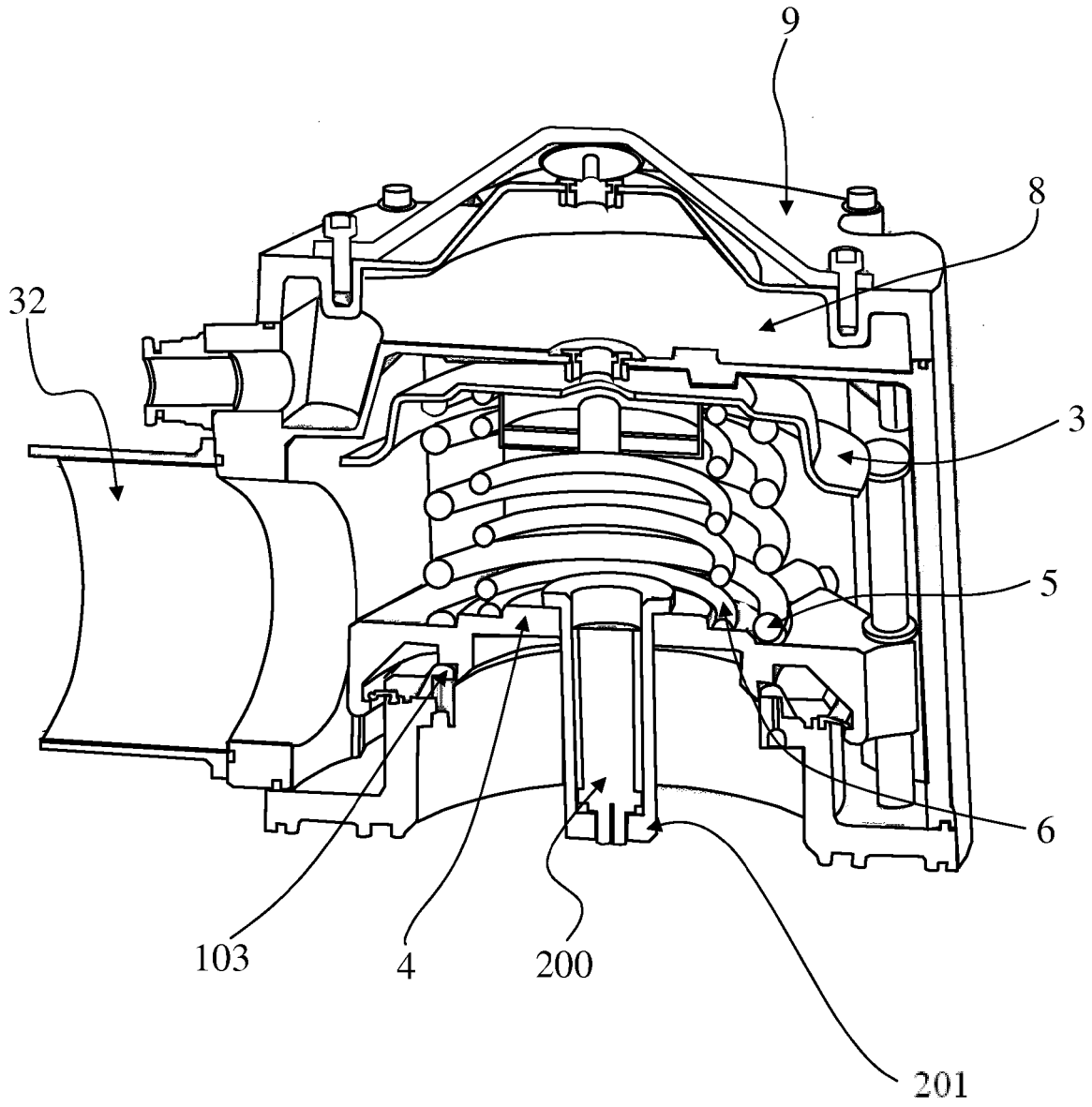

Fig. 5

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EUROPEAN SEARCH REPORT

Application Number
EP 12 17 0509

DOCUMENTS CONSIDERED TO BE RELEVANT

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TECHNICAL FIELDS SEARCHED (IPC)
H01F F16K

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
Munich	5 October 2012	Winkelman, André

CATEGORY OF CITED DOCUMENTS

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