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(54) **Title**: SAFETY APPARATUS AND MONITORING METHOD FOR A POWER TRANSFORMER, AND RELATED POWER TRANSFORMER

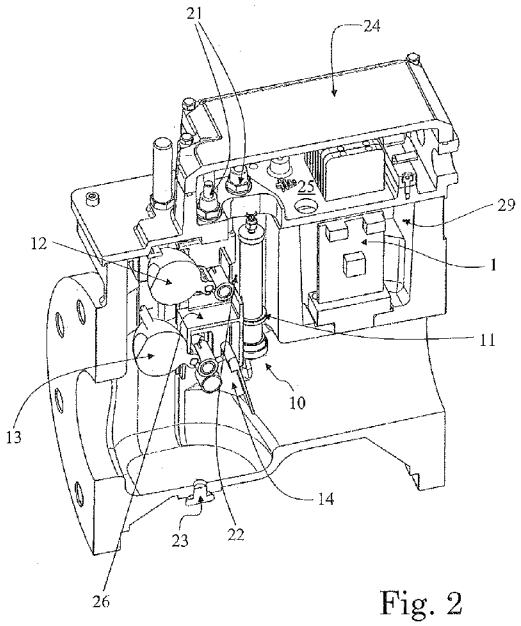


Fig. 2

(57) **Abstract**: A safety apparatus suitable to be associated to and a method for monitoring a liquid-filled power transformer wherein there is provided a sensing device associated to an electronic unit. The sensing device is suitable to be at least partially immersed into the liquid and comprises at least one movable part displaceable by movements of the liquid; the electronic unit detects signals indicative of the actual position of the movable part and is arranged to elaborate, based on the detected signals, data related to actual conditions of the transformer and/or of its cooling liquid.

SAFETY APPARATUS AND MONITORING METHOD FOR A POWER TRANSFORMER, AND RELATED POWER TRANSFORMER

The present disclosure relates to a safety apparatus for an associated liquid-filled power transformer, to a related method for monitoring a power transformer, and to a power transformer comprising such a safety apparatus.

It is widely known in the art the use of electrical induction devices, e.g. power transformers, which exploit the electromagnetic induction for properly transmitting and distributing electricity over power lines.

Most common power transformers comprise live parts, e.g. a magnetic core composed by one or more legs or limbs connected by yokes which together form one or more core windows; for each phase, around the legs there are arranged a number of windings, for instance low-voltage windings, high-voltage windings, et cetera.

Due to the intrinsic structural characteristics and functioning of these devices, important aspects of power transformers concern the electric insulation among the various components and cooling thereof which must be guaranteed in order to provide the desired electromagnetic performance without incurring in any malfunctioning or damage.

To this end, a power transformer comprises usually a closed main tank which is filled with an insulating fluid; the insulating fluid is usually a liquid, for example a highly-refined mineral oil that is stable at high temperatures and has excellent electrical insulating properties; combustion-resistant vegetable oil-based dielectric coolants are also becoming increasingly common as alternatives to mineral oils.

In addition, power transformers are usually provided with expansion vessels generally indicated as oil conservators; such conservators are positioned above the main tank, and have the function of compensating the unavoidable volume changes of the cooling fluid used in the tank, which volume changes result mainly from temperature fluctuations.

Since the insulating liquid helps cooling of the transformer and also contributes to the electrical insulation between live parts inside the tank, it must remain stable at high temperatures for an extended period.

During the working life of a power transformer, it is possible that gas is generated or present inside the tank and this is a clear indication of a possible problem.

For example, the gas may be the result of decomposition/degradation of the solid or liquid insulation inside the transformer caused by overheating or by the strike of electric arcs, or the gas may come from the insulating oil itself due to unsatisfactory de-gassing prior to filling the tank.

In addition, rapid movements, also indicated as rapid currents or flows, of the transformer liquid can be caused by an internal arc, short circuit, or hot spot; these rapid movements are indicative of possible abnormal or dangerous conditions and must be properly faced.

To this end, power transformers are equipped with safety devices, for example Buchholz relays, so that the generation of gas and the presence of rapid movements are detected and related risks mitigated to the extent possible.

Although known solutions perform their functions in a rather satisfying way, there is still desire and room for further improvement.

Such a desire is fulfilled by a safety apparatus suitable to be associated to a power transformer comprising a tank filled with a cooling liquid, characterized in that it comprises:

- an electronic unit;
- a sensing device suitable to be at least partially immersed into said cooling liquid and comprising at least one movable part which is displaceable by movements of said cooling liquid, said sensing device being arranged to output signals indicative of the actual position of said at least one movable part, and wherein said electronic unit is arranged so as to elaborate, based on said output signals, data related to actual conditions of the transformer or of its cooling liquid.

This desire is also achieved by a method for monitoring a power transformer

of the type comprising a tank filled at least partially with a cooling liquid, characterized in that it comprises the following steps:

(a) providing a sensing device suitable to be at least partially immersed into said cooling liquid and comprising at least one movable part (11) which is displaceable by movements of said cooling liquid, said sensing device being arranged to output signals indicative of the actual position of said at least one movable part; and

(b) based on said output signals, elaborating, by means on an electronic unit data related to actual conditions of the transformer or of its cooling liquid.

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

Figure 1 is a view illustrating a power transforming equipped with a safety apparatus according to the present disclosure;

Figure 2 is a perspective view, partially cut, showing a first exemplary embodiment of a safety apparatus according to the present disclosure;

Figure 3 is a perspective view illustrating some components of the safety apparatus of figure 2;

Figure 4 is a perspective views showing a possible embodiment of a sensing device usable in the safety apparatus according to the present disclosure;

Figure 5 is a schematic view illustrating a second exemplary embodiment of a safety apparatus according to the present disclosure;

Figure 6 is a block diagram schematically representing a method for monitoring a power transformer according to the present disclosure.

It should be noted that in the detailed description that follows, identical or similar components, either from a structural and/or functional point of view, 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 describe the present disclosure, the drawings may not necessarily be to scale and certain features of the disclosure may be shown in somewhat schematic form.

Figure 1 shows an exemplary power transformer 101 comprising a tank 102 filled with a cooling/insulating liquid 103 (hereinafter referred to as cooling liquid 103 for the sake of conciseness) of a type known per se, e.g. a mineral or vegetal oil; an expansion vessel or conservator 104, also filled with the cooling liquid 103, is mechanically connected to the tank 102 and is positioned as shown on top of the tank 102 itself.

A suitable pipe system 105 realizes the fluid communication between the conservator 104 and the tank 102.

As illustrated in the exemplary embodiment of figure 1, the transformer 101 is equipped with at least one safety apparatus 100 according to the present disclosure, which is for instance fitted in the pipe system 105 along the fluid path leading from the tank 102 to the conservator 104.

The safety apparatus 100 according to the present disclosure comprises an electronic unit 1 and a sensing device 10 suitable to be at least partially immersed into the cooling liquid 103; in particular, as it will be described more in detail hereinafter, the sensing device 10 comprises at least one movable part 11 which is displaceable by movements of the cooling liquid 103 itself, and is arranged to output signals, e.g. electric signals, indicative of the actual position assumed by the movable part 11 as a consequence of movements of the cooling liquid 103.

In the exemplary embodiments illustrated, the sensing device 10 comprises preferably a potentiometer having a displaceable cursor fitted inside a float 11, e.g. a linear position

transducer type IC marketed by Gefran.

For example, the sensing device 10 can be immersed into the cooling liquid 103 directly for example in a dedicated space of the pipe system 105 where gas-accumulation may occur, or, as schematically represented in figure 5 (or figure 2), it can be preferably fitted inside a suitably shaped body, e.g. a shaped body 20, which is connected for instance along the pipe system 105 and has an inner gas-accumulation space or chamber 22 to be filled at least partially with the cooling liquid 103 with the sensing device 10 immersed in it. A cover 24 is connected to the lower part of the shaped body 20 and forms a second inner space 25 inside which there are terminals 21 which are connected to output cables 17 of the sensing device, connected on a flange 16.

The electronic unit 1 is operatively connected to the sensing device 10; for instance the electronic unit is connected (connections not illustrated for simplicity of illustration) to the terminals 21 wired to the sensing device 10 and is positioned inside a further inner space 29 of the body 20, or it can be positioned inside the space 25 together with the terminals 21. The electronic unit 1 is arranged so as to elaborate, based on the output signals produced by the sensing device 10, data related to actual conditions of the transformer 101 and/or of its cooling liquid 103.

Preferably, the electronic unit 1 is arranged so as to remotely transmit the elaborated data related to actual conditions of the transformer 101 and/or of the cooling liquid 103.

According to an exemplary embodiment of the present disclosure, the electronic unit 1 is arranged so as to elaborate at least data indicative of the actual quantity of gas accumulated by the safety apparatus 100 coming from tank 102 to conservator 104 through pipe 105, which gas accumulated is indicative of the quantity of gas generated into the transformer 101 for whatever reason.

According to a further exemplary embodiment of the present disclosure, the electronic unit 1 is arranged so as to output an alarm signal if the elaborated data indicative of the actual quantity of gas generated in the transformer 101 exceed a predetermined first threshold. Such an alarm signal can be of any type, e.g. acoustic or visual, and direct or indirect, e.g. it can cause switching of a lamp device or a siren, or can be routed to a switch which in turn actuates a lamp or a siren, and can be transmitted locally and/or remotely in whatever manner possible, e.g. through wires or wireless.

According to a further exemplary embodiment, the electronic unit 1 is arranged to output a trip signal if the elaborated data indicative of the actual quantity of gas present in the transormer 101 exceed a predetermined second threshold. This trip signal can be routed,

locally and/or remotely, to an associated switch or trip unit whose intervention disconnects electric power feeding the power transformer 101.

According to a possible further embodiment, the electronic unit 1 can be also arranged to elaborate data indicative of the actual flow rate of the cooling liquid 103, i.e. the speed of such liquid and to output a trip signal if the elaborated data indicative of the flow-rate of the cooling liquid 103 exceed a predetermined third threshold. Also this trip signal can be routed, locally and/or remotely, in whatever manner, e.g. through cabling or wireless, to an associated switch or trip unit whose intervention disconnects electric power feeding the power transformer 101.

As those skilled in the art may appreciate, the electronic unit 1 can comprise any suitable and commercially available micro-processor based electronic unit which elaborates digital data and outputs corresponding digital signals, e.g. a micro-processor NXP type LPC21.

According to yet a further exemplary embodiment illustrated in figures 2-3, the safety apparatus 100 comprises a shaped body 20 (functionally equivalent, and can be also structurally the same or similar to the body 20 of figure 5) which is made for instance of cast aluminum alloy and is shaped to be connected to the pipe system 105 and to have a first inner gas-accumulation space 22 suitable to be filled with the cooling fluid 103; an oil drain plug 23 can be provided at the bottom part of the inner space 22.

Also in this exemplary embodiment, the body 20 is for example provided with a cover 24 shaped so as to form with the upper part of the body 20 a second inner space 25.

Inside the inner spacer 22 there is provided a frame 26 for instance (see figure 3) on which seats 27 are formed for accommodating two switches 28, e.g. magnetic switches.

Each of the switches 28 is of a per se known type and for instance has, inside a bulb, a magnet and electrical contacts, not shown in the figures, which are directly connected, in this case, to an alarm circuit and to a disconnection circuit, respectively.

According to this embodiment, the safety apparatus 100 further comprises a first floating element 12 and a second floating element 13 both structurally independent from the movable part 11 and connected to the frame 26; the floating elements 12 and 13 are suitable to be at least partially immersed in and moved by the cooling liquid 103; the first floating element 12 is operatively coupled to and actuates a first switch 28 when the level of the cooling liquid 103 inside the transformer 101 exceeds a predetermined first threshold. The first switch 28 in this embodiment is operatively connected to an alarm system according to solutions readily available to those skilled in the art and therefore not described herein in detail. In turn, the second floating element 13 is operatively coupled to and actuates a second switch 28 when the

level of the cooling liquid 103 inside the transformer 101 exceeds a predetermined second threshold. The second switch 28 is operatively connected to a disconnection circuit and is suitable to cause, directly or indirectly, and according to solutions readily available to those skilled in the art and therefore not described herein in detail, disconnection of electric power feeding the power transformer 101.

According to this exemplary embodiment, the safety apparatus 100 comprises a further movable element 14, e.g. a flap-shaped element, which is for instance pivotally connected to the frame 26 and is suitable to be at least partially immersed in and moved by the cooling liquid 103; this further movable element 14 is arranged to detect if the actual flow-rate of the cooling liquid 103 exceeds a predetermined third threshold. In particular also the further movable element 14 is operatively coupled to a disconnection circuit, e.g. by means of a switch, such as the same switch 28. In practice when the actual flow rate of the cooling liquid 103 exceeds the related predetermined threshold, the further movable element 14 actuates a switch, e.g. the switch 28 which in turn is suitable to cause, directly or indirectly, and according to solutions readily available to those skilled in the art and therefore not described herein in detail, disconnection of electric power feeding the power transformer 101.

In practice in the exemplary embodiment of figures 2-3 the safety apparatus 100 comprises a gas-accumulation Buchholz type relay with a potentiometer fitted inside the body of the Buchholz type relay, i.e. inside the inner space 22, and the electronic unit 1 placed inside the space 25 together with terminals 21; the first and second floating elements 12, 13, as well as the further movable element 14 that are part of the Buchholz type relay are structurally separated from the potentiometer and its movable part 11.

The operation of the safety apparatus 100 will be now described in more details by reference to the schematic block diagram of figure 6 illustrating an exemplary method 200 for monitoring a power transformer according to the present disclosure.

In particular, once the electronic unit 1 and a sensing device 10 of the type previously described is provided (step 201) immersed into the cooling liquid 103, during the normal functioning of the transformer, any movement of the liquid cooling 103 may cause consequent displacements of the movable element 11 which is transduced by the sensing device 10 into output electric signals; based on such output signals, the electronic unit elaborates (step 202) data related to actual conditions of the transformer 100 and/or of its cooling liquid 103.

More in details, if gas forms or becomes present inside the transformer 100 for whatever reason, it tends to escape upward and accumulates inside the body of the safety apparatus 100,

e.g. inside the upper part of the inner space 22. As a consequence, the gas present lowers the level of the cooling liquid 103 and thus causes the movement of the float 11, e.g. downwards, and also the movement of the potentiometer cursor which is inside the float. Therefore, the potentiometer gives continuously the variation of its resistance values which are detected by the associated electronic unit 1 and are indicative of the actual position reached by the movable element 11 and therefore of the level reached by the liquid as a consequence of the quantity of gas actually generated in the transformer 100.

Based on such output electric signals detected, the electronic unit 1 elaborates data (step 203) indicative of the actual quantity of gas generated in the transformer 100; in this way, since the actual quantity of gas can be continuously derived from the actual level reached by the cooling liquid 103, it is possible to track and have almost complete information about how much gas is present and the trend thereof over the time.

At step 204 the method according to the present disclosure foresees to produce an alarm signal if the quantity of gas present in the transformer 100 exceeds a predetermined first threshold; if the quantity of gas generated in the transformer 100 continues to increase and exceeds a predetermined second threshold, a trip signal is produced at step 205 so as to cause disconnection of electric power feeding the transformer 100.

In particular, according to the exemplary embodiment of figures 4-5, the alarm signal of step 204 and the trip signal of step 205 can be output by the electronic unit 1 when the data elaborated by it and indicative of the actual quantity of gas generated in the transformer 100 exceed the predetermined first threshold or the second predetermined threshold, respectively, i.e. the cooling liquid 103 is lowered (displacing consequently the movable element or cursor 11) below a defined first threshold level and further down below the second predetermined level threshold.

According to the exemplary embodiment of figures 2-3, such alarm signal at step 204 can be produced, in addition or in alternative to the electronic unit 1, by the first floating element 12 and its associated switch 28; indeed, when accumulating, the gas lowers the level of the cooling liquid 103 which lowering is detected also first by the upper floating element 12; when the quantity of gas present is such to lower the first floating element 12 below the predefined first threshold level, the switch 28 produces, directly or indirectly, the alarm signal.

If the accumulation of gas continues it is then detected by the lower second floating element 13; when the quantity of gas present is such that to lower the second floating element 13 below the predefined second threshold level, the switch associated to the second floating

element 13 produces, (also in addition or in alternative to the electronic unit 1) directly or indirectly, the trip signal at step 205 meant to cause disconnection of electric power feeding the transformer 100.

In operation, it is also possible that for some reasons, e.g. a violent and sudden short circuit, strong/rapid currents of the liquid 103 are generated inside the tank; such rapid movements of the liquid are due usually to dangerous or abnormal working conditions and hence, in order to limit the negative effects a related flow rate limit (hereinafter referred to as "third threshold") is defined.

To this end, according to the present disclosure, if desired and in whichever order with respect to or even within one of the previously described steps 202-205, it is possible to detect the actual flow rate of the cooling liquid (i.e. its speed of movement) and to produce a related trip signal if the detected flow-rate of said cooling liquid exceeds the predetermined third threshold.

In particular, according to the exemplary embodiment of figures 4-5, movements of the liquid 103, in this case rapid movements caused for instance by a short circuit, displace the movable element or cursor 11 which induces corresponding output electric signals at the terminal 21 each indicative of the actual position of the movable element 11 itself; the electronic unit 1 detects such electric signals and is arranged to elaborate also data indicative of the actual flow rate of the cooling liquid and to output a trip signal so as to cause disconnection of electric power feeding the transformer 100 if the data elaborated indicative of the actual flow rate of the cooling liquid exceeds the predetermined third threshold. For example in this case the electronic unit can elaborate two digital data in a determined interval of time. If the ratio between the difference of the values of such two digital data and the determined interval of time during which they were elaborated exceeds a predetermined threshold, then the trip signal is output by the electronic unit 1 itself.

According to the exemplary embodiment of figures 2-3, such trip signal can be produced, also in addition or in alternative to the electronic unit 1, by the further movable element 14 and its associated switch, e.g. the switch 28. According to this exemplary embodiment the flow rate and therefore rapid currents or movements of the cooling liquid causes the displacement, e.g. rotation, and hence are detected by the further movable element 14; if the flow rate of the cooling liquid exceeds the predefined third threshold then the movement of the element 14 is such that to actuate the associated switch, e.g. the switch 28, which produces, directly or indirectly, the trip signal meant to cause disconnection of electric power feeding the transformer 100.

In practice, it has been found that the safety apparatus 100 and method 200 according to the present disclosure offer a solution which is rather simple, reliable, flexible and allow to obtain more information about the conditions of the transformer and/or of its cooling liquid, in particular about the presence and trend over the time of gas and the occurrence of rapid liquid currents or movements inside the tank. For example, such information can be made available locally, or even remotely transmitted; calibration can be easily determined based on customer requirements.

In addition, as previously described, depending on customer requirements the functionalities needed can be achieved according to a solution predominantly electronic, e.g. according to the embodiment of figures 4-5 wherein the electronic unit 1 is arranged to elaborate data related to the actual quantity and the actual trend of gas present into the transformer as well as related to the actual flow rate of the liquid, and in case to output also intervention signals if the detected conditions require so. Alternatively and according to the embodiment of figures 2 and 3, it is possible to adopt a hybrid solution where some functionalities are performed basically by the electronic unit 1 with its associated potentiometer, while some others are devoted to mechanical or electromechanical components; for example as described, the electronic unit 1 can be used just to track almost continuously the presence and evolution over the time of the gas inside the transformer, while the floating elements 12, 13, 14 can be used to produce the signals indicating discrete conditions, namely; the actual presence of gas is above the first threshold (floating element 12 and associated switch), or is above the second threshold (floating element 13 and associated switch 28) or the flow rate of the liquid currents exceeds the third threshold (third element 14 and associated switch 28).

Such results are achieved thanks to a solution which in principle makes the safety apparatus 100 according to the present disclosure easy to be used in connection with any type of power transformer.

Hence, the present disclosure also encompasses a power transformer comprising at least one safety apparatus 100 of the type previously described and as defined in the appended claims. Clearly more than one safety apparatus 100 can be used in a single power transformer.

The apparatus and method thus conceived are 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. For example, the cover 24 can be realized in a unique piece with the rest of the body 20 or can be a separate part connected therewith; the movable part 11 can be differently shaped so as to be able to better detect the presence of rapid currents or an additional movable element, e.g. a flap-shaped element can be added to the sensing device for such a purpose; or a movable element like the movable flap 14 of figure 2 can be associated with the sensing device 10 of figure 5 in order to allow measuring the actual flow rate of the liquid 103.

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; for example the various floating or movable elements are preferably made totally or partially of plastic materials but any suitable different material may be used.

CLAIMS

1. A safety apparatus (100) suitable to be associated to a power transformer (101) comprising a tank (102) filled with a cooling liquid (103), characterized in that it comprises:
   - an electronic unit (1);
   - a sensing device (10) suitable to be at least partially immersed into said cooling liquid and comprising at least one movable part (11) which is displaceable by movements of said cooling liquid, said sensing device (10) being arranged to output signals indicative of the actual position of said at least one movable part, and wherein said electronic unit is arranged so as to elaborate, based on said output signals, data related to actual conditions of the transformer or of its cooling liquid.
2. Safety apparatus (100) according to claim 1, wherein said electronic unit is arranged so as to remotely transmit said elaborated data.
3. Safety apparatus (100) according to one or more of claims 1-2, wherein said electronic unit is arranged so as to elaborate data indicative of the quantity of gas generated inside the transformer (101).
4. Safety apparatus (100) according to claim 3, wherein said electronic unit is arranged so as to output an alarm signal if the elaborated data indicative of the actual quantity of gas generated inside the transformer (101) exceed a predetermined first threshold.
5. Safety apparatus (100) according to one or more of the preceding claims, wherein said electronic unit is arranged so as to output a trip signal if the elaborated data indicative of the actual quantity of generated inside the transformer (101) exceed a predetermined second threshold.
6. Safety apparatus (100) according to one or more of the preceding claims wherein said electronic unit is arranged so as to elaborate data indicative of the actual flow rate of said cooling liquid and to output a trip signal if the elaborated data indicative of the actual flow-rate of said cooling liquid exceed a predetermined third threshold.
7. Safety apparatus (100) according to one or more of the previous claims, wherein said sensing device comprises a potentiometer.
8. Safety apparatus (100) according to one or more of the previous claims, wherein it comprises a first floating element (12) suitable to be at least partially immersed in and moved by said cooling liquid and an alarm switch (28) suitable to be actuated by said first floating element when the level of said cooling liquid generated exceeds a predetermined first threshold.

9. Safety apparatus (100) according to one or more of the previous claims, wherein it comprises a second floating element (13) suitable to be at least partially immersed in and moved by said cooling liquid and a trip switch (28) suitable to be actuated by said second floating element and to disconnect electric power feeding said power transformer when the level of said cooling liquid exceeds a predetermined second threshold.

10. Safety apparatus (100) according to one or more of the previous claims, wherein it comprises a further movable element (14) suitable to be at least partially immersed in and moved by said cooling liquid, said further movable element being arranged to detect if the actual flow rate of said cooling liquid exceeds a predetermined third threshold and to actuate an associated switch suitable to disconnect electric power feeding said power transformer.

11. Safety apparatus (100) according to one or more of the preceding claims, wherein it comprises a gas-accumulation Buchholz type relay with said potentiometer fitted inside the body of the Buchholz type relay itself, and wherein said first and second floating elements are part of said Buchholz type relay and are structurally separated from said potentiometer.

12. Power transformer (101) comprising a tank (102) at least partially filled with a cooling liquid (103), characterized in that it comprises at least one safety apparatus (100) according to one or more of the previous claims.

13. A method (200) for monitoring a power transformer (101) of the type comprising a tank (102) filled at least partially with a cooling liquid (103), characterized in that it comprises the following steps:

(a) providing (201) a sensing device (10) suitable to be at least partially immersed into said cooling liquid and comprising at least one movable part (11) which is displaceable by movements of said cooling liquid, said sensing device (10) being arranged to output signals indicative of the actual position of said at least one movable part; and

(b) based on said output signals, elaborating (202), by means on an electronic unit (1) data related to actual conditions of the transformer or of its cooling liquid.

14. A method according to claim 13, wherein said step (b) comprises elaborating (203) data indicative of the actual quantity of gas generated inside the transformer (101).

15. A method according to one or more of claims 13-14, further comprising producing (204) an alarm signal if the quantity of gas generated inside said transformer exceeds a predetermined first threshold.

16. A method according to one or more of claims 13-15, further comprising producing (205) a trip signal if the quantity of gas generated inside said transformer exceed a predetermined second threshold.

17. A method according to one or more of claims 13-16, further comprising elaborating (206) data indicative of the actual flow rate of said cooling liquid.

18. A method according to one or more of claims 13-17, further comprising producing (207) a trip signal if the actual flow-rate of said cooling liquid exceeds a predetermined third threshold.

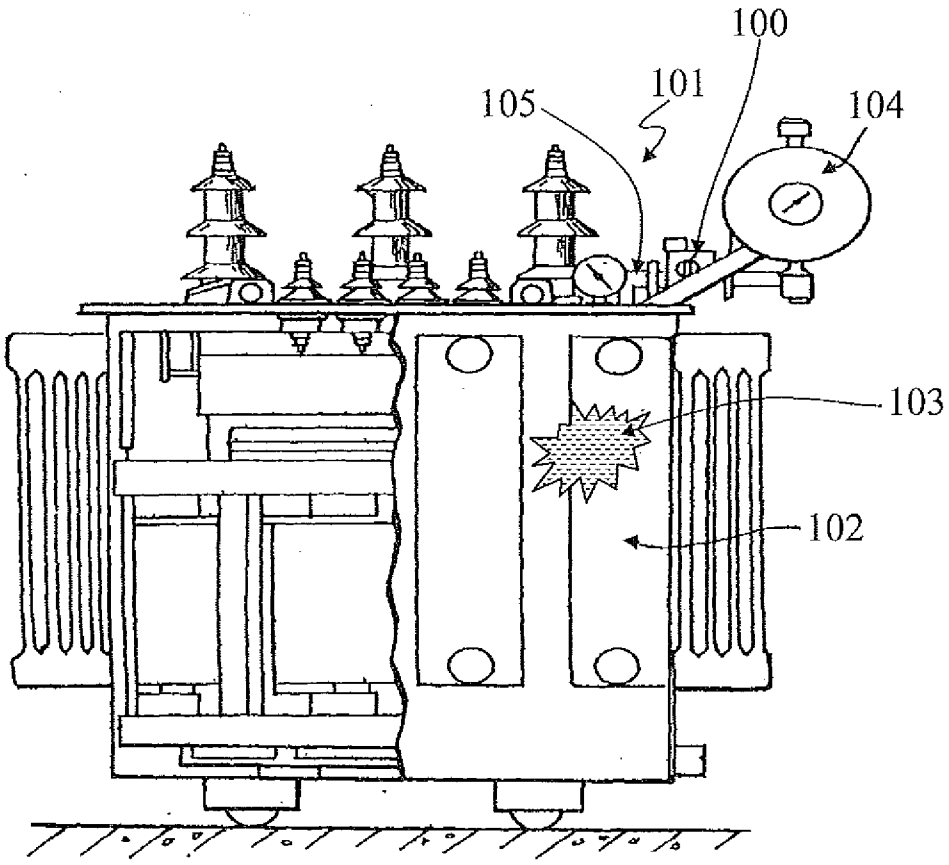


Fig. 1

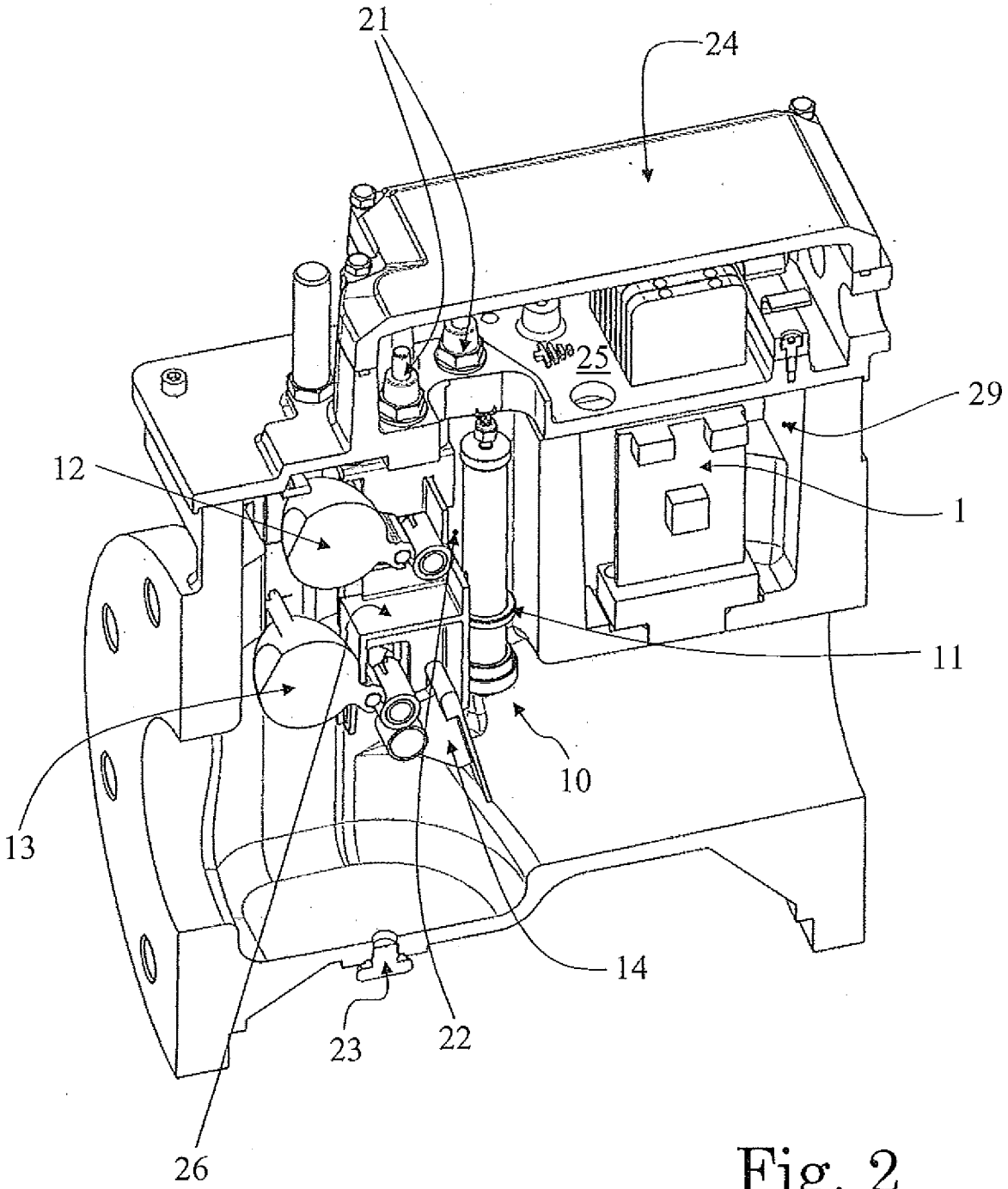


Fig. 2

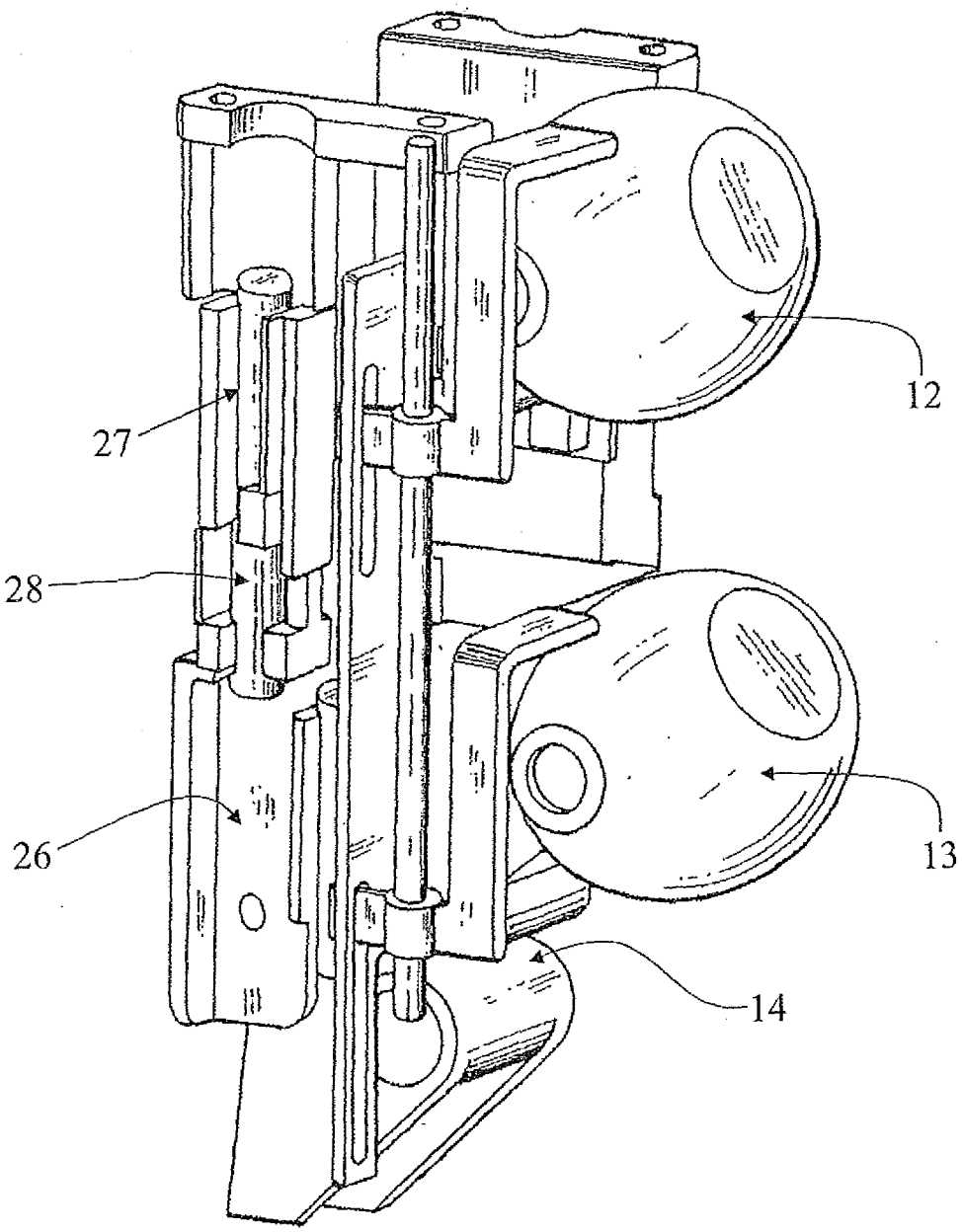


Fig. 3

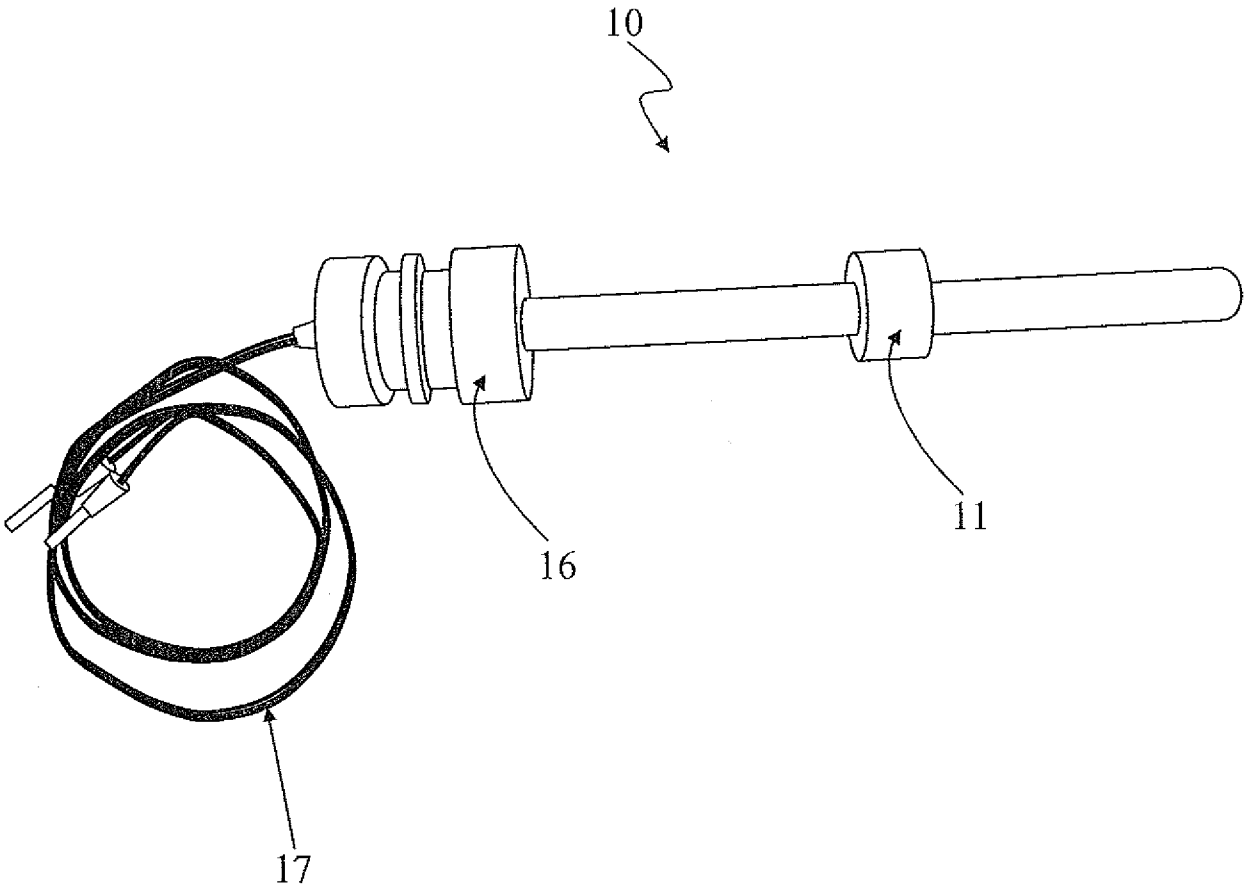


Fig. 4

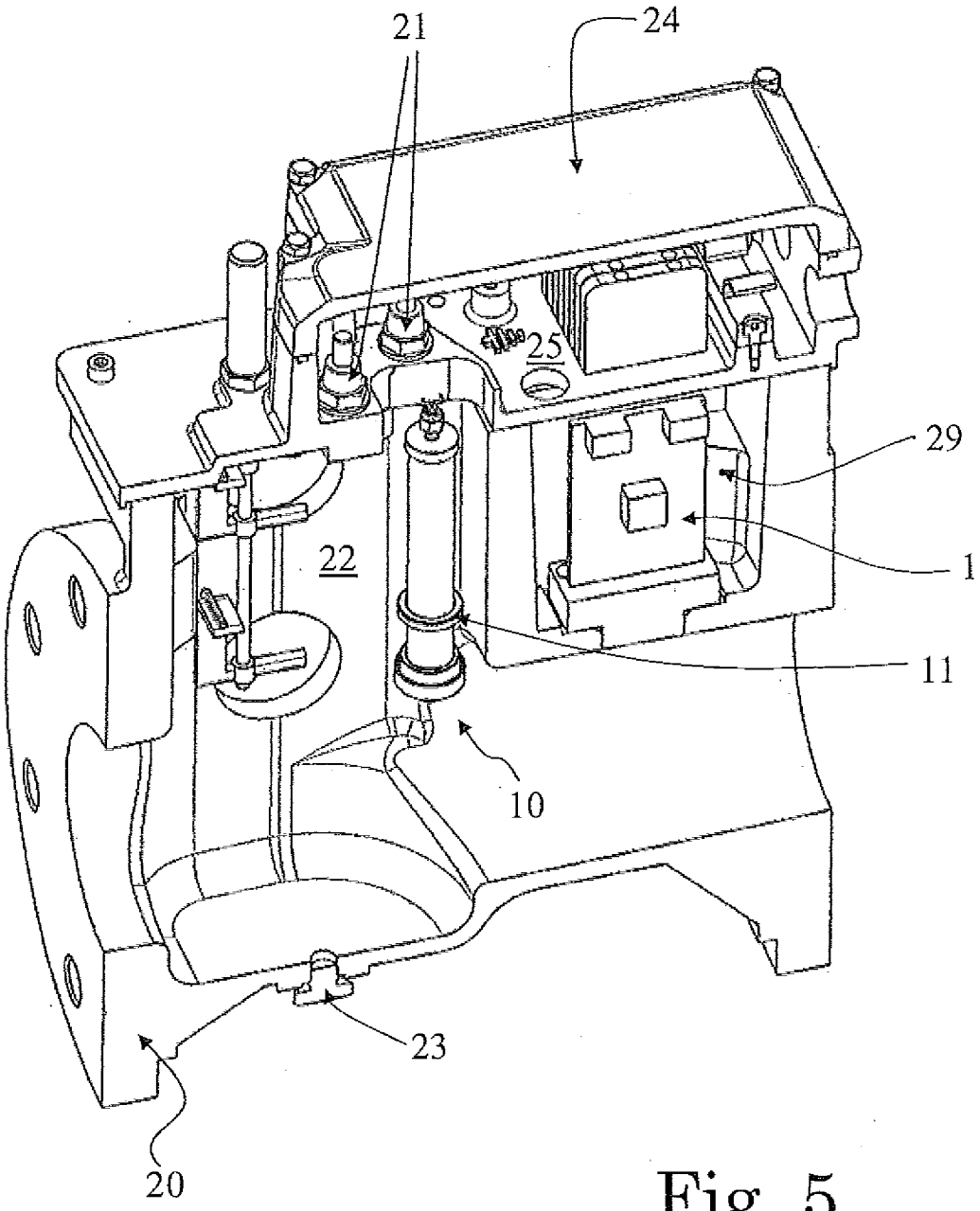


Fig. 5

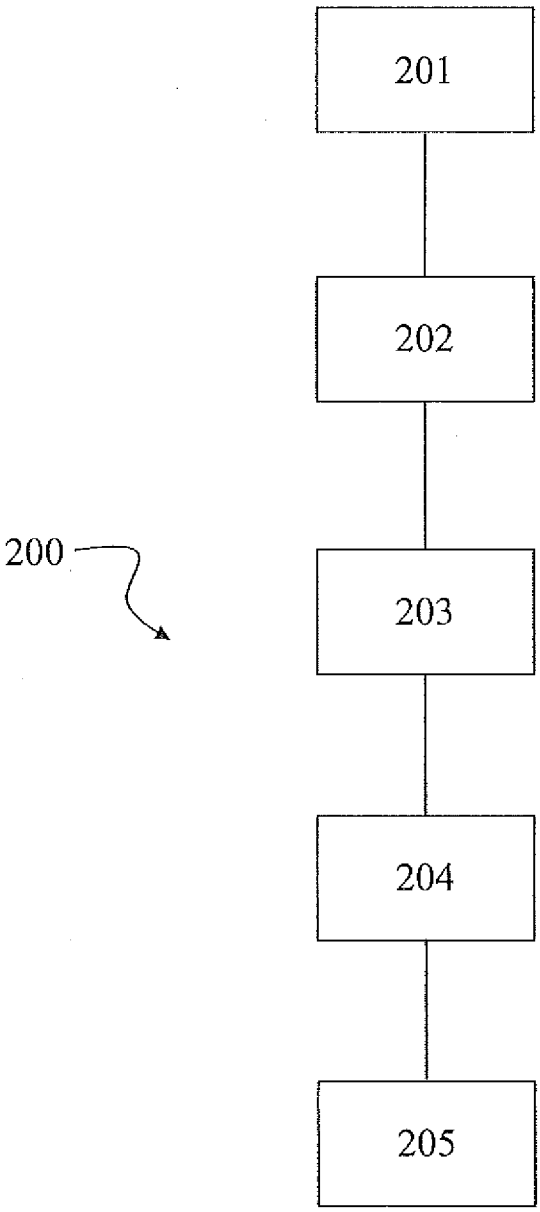


Fig. 6

INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2011/062760

A. CLASSIFICATION OF SUBJECT MATTER
INV. H01F27/14 H01F27/40
ADD.

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
H01F H01H

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	WO 03/098763 A1 (WILLIAMS JOHN OWEN [AU]) 27 November 2003 (2003-11-27) page 1, paragraphs 0,6,7 page 2, paragraph 13 - page 3, paragraph 28 -----	1-18
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[X] Further documents are listed in the continuation of Box C.

[X] See patent family annex.

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"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
25 June 2012	03/07/2012

Name and mailing address of the ISA/	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016	Gols, Jan

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Form PCT/ISA/210 (second sheet) (April 2005)

INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2011/062760

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

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