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

(11) Publication number: 0 322 388 A2

(12) EUROPEAN PATENT APPLICATION

(21) Application number: 88850426.3

(51) Int. Cl.4: H 01 H 33/56

(22) Date of filing: 16.12.88

(30) Priority: 22.12.87 NO 875392

(43) Date of publication of application:
28.06.89 Bulletin 89/26

(84) Designated Contracting States:
CH DE FR GB IT LI SE

(71) Applicant: EB DISTRIBUSJON A.S.
Peter Feilbergsgt. 4B
N-3700 Skien (NO)

(72) Inventor: Eriksen, Jan Morten
Gautes vei 12
N-3700 Skien (NO)

Daalder, Jaap E.
Havundvn. 141
N-3700 Skien (NO)

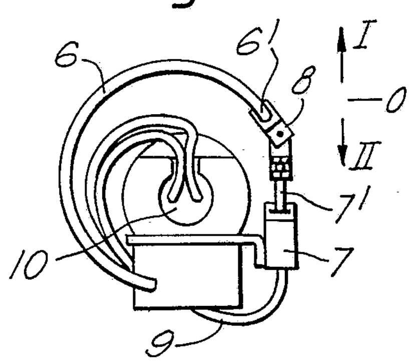
Ciboldi, Pietro
Bergamo (IT)

(74) Representative: Delmar, John-Ake
AB Delmar & Co Patentbyra Östermalmsgatan 45
S-114 26 Stockholm (SE)

(54) A leak indicator.

(57) A leak indicator for a gas filled electrical plant, with the leak indicator being of the Bourdon tube kind, the Bourdon tube being filled with a gas having the same properties as the gas surrounding the Bourdon tube, and being in a sealed state, the nominal gas pressure in the plant deviating from the ambient atmospheric pressure. The free end of the Bourdon tube is arranged to influence a switch means, preferably a multi-step switch having at least two terminals. The leak indicator may be supplied with voltage directly from the plant, irrespective of the direction of supply to the plant, as a first terminal of the switch means may be capacitively connected with a high voltage bushing in the plant, and a second terminal may be connected with a first clamp of a voltage indicator, the second clamp of said voltage indicator being connected to earth, and as there will be contact between said first and second terminals in case of a normal state of the plant, and as there will be no contact between said terminals in case of a deviation from the normal state.

Fig.4.



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Description

A LEAK INDICATOR

The present invention relates to a leak indicator for a gas filled plant, said leak indicator being of the Bourdon-tube kind, where the Bourdon-tube is filled with a gas which has the same properties as the gas surrounding the Bourdon-tube, and is in a sealed state, with the nominal gas pressure in the plant deviating from the ambient atmospheric pressure in the plant.

A leak indicator is previously known which is mounted inside one of the applicant's plants for compact, gas filled high voltage switches with the utilized gas being SF_6. The leak indicator may be red through a window in the incapsulation of the plant. The known indicator 1, shown in Figure 1, has a graduation with three zones, a green zone 2 indicating correct pressure, a red zone 3 indicating a leak in the plant, and a white zone 4 bordering said green zone and indicating a fault of the indicator.

The leak indicator is compensated for tempeature by the fact that the Bourdon-tube (not shown) of the indicator is filled with the same kind of gas as the gas used in the plant.

Normally, a decrease of temperature would result in a lower pressure inside the incapsulation of the plant, in the same manner as an increase of temperature would cause an increase of pressure. The leak indicator is, however, unaffected by such variations, and will only indicate decreasing pressure inside the incapsulation due to SF_6-gas leaking to the surroundings.

The position of the indicator marker in case of normal operation is on the left hand side of the green zone, close to the white zone, as indicated by dot-dash-arrow 5′. In case of a defect, e.g. a gas leak from the incapsulation of the plant, marker 5 will move towards red zone 3. In case of a defect of the indicator per se, i.e. a leak of the Bourdon- tube, marker 5 will move across to white zone 4.

The known leak indicator comprises a manometer operating with a sealed Bourdon-tube. The Bourdon tube is filled with SF_6 gas at a nominal pressure of 1.4 bar abs. at 20°C.

The nominal pressure inside the encapsulation of the compact plant is 1.2 bar abs. at 20°C. Thus, the indicator which is placed inside the encapsulation will under normal conditions show an overpressure of 0.2 bar (green zone). In case of a leak the pressure inside the encapsulation will drop towards atmospheric pressure. Indicator marker 5 will consequently move towards red zone 3 (in accordance with a differential pressure of 0.4 bar between the pressure in the indicator and the pressure in the encapsulation). A leak in the indicator (Bourdon tube) will equalize the pressure between indicator and encapsulation, and the indicator marker will move towards white zone 4.

Temperature compensation is, as mentioned, automatically achieved by this concept. A change of temperature will cause the same change of pressure inside and outside the Bourdon tube. This means that the differens of pressure inside the Bourdon tube and the pressure inside the encapsulation will stay constant, and so the position of indicator marker 5 will remain constant, independently of operation temperature. This method provides an exceptionally simple and reliable control of the pressure inside the encapsulation. The advantage of this known leak indicator will be especially obvious when compared to other instrumentation used by producers of SF_6 compact plants.

The known concept shown in Figure 1 was used for some time for the applicant's SF_6 plant for compact gas filled high voltage switches with voltage levels of 12 and 24 kV.

A commonly known method for measuring the SF_6 pressure inside a plant encapsulation is utilization of a pressure gauge is provided externally on the encapsulation.

This known concept,however, shows some weak points, as it is influenced by differencies of temperature inside and outside the encapsulation and by atmospheric pressure differencies.

Changes of temperature and atmospheric pressure may cause pressure differencies in the encapsulation of several tenths of a bar. For this reason it is necessary to use graphs showing the SF_6 pressure inside the encapsulation as a function of temperature and atmospheric pressure, such graphs commonly being shown on a signboard which is placed close to the manometer. Correct indication of pressure, however, can only be achieved if the temperature of the SF_6 gas is known, but this is an information commonly not available. Dependent on the electrical load on the plant, and ambient conditions the temperature of the SF_6 gas will be highly variable, and may be much different from the external ambient temperature. Precise readings of the manometer are, thus, difficult, especially considering the fact that the nominal difference of pressure inside the encapsulation and outside is only in the order of 0.2 bar.

Basically, a user of a SF_6-plant is not interested in the pressure inside the encapsulation and how it varies dependent on the load on the plant, temperature, and atmospheric conditions. The only information relevant to the user is whether the encapsulation is tight or not. Utilization of a leak indication as mentioned above in connection with Figure 1 will provide the user with a quite unambiguous answer to that question. It was, however, desirable to provide remote transmission of the measurements of a manometer or a leak indicator, and, thus, to provide a mechanically more simple leak indicator than those previously known.

To this end, the free end of the closed Bourdon tube is arranged to influence, in a manner known per se, a switch means, preferably a multi-step switch with at least two terminals, and that the leak indicator may be supplied with voltage directly from the plant, irrespective of direction of supply to the plant, as a first terminal of the switch means may be voltage connected capacitively to a high voltage bushing in the plant, and a second terminal may be connected with the first clamp of a voltage indicator, the second clamp of said voltage indicator being connected to earth, and with contact between said first and second terminals in a normal plant condition, but with no contact between terminals in case of a deviation from the normal state.

Further characterizing features of the leak indicator mentioned above will appear from the following claims as well as from the following disclosure with reference to enclosed drawings.

Figure 1 shows a known leak indicator.

Figure 2 illustrates a completely mounted leak indicator according to the invention.

Figures 3 and 4 show a side elevation, and an end view, respectively of the leak indicator according to the invention.

Figure 5 illustrates the functional concept of the leak indicator according to the invention.

Figure 6 shows a wiring diagram for testing in connection with leak indicator of Figures 2-4 according to the invention.

Figure 7 is a diagrammatic illustration of the principle for capacitive voltage switch off.

The indicator function proper is based on a manometer principle with a Bourdon tube 6 actuating a switch 7, via a flexible coupling 8, as will appear from Figure 4, where the free end 6′ of the Bourdon tube is conencted with an end of flexible coupling 8, whereas the other end of the flexible coupling is connected with a shift arm 7′, on switch 7.

Because the indicator must be temperature compensated, as mentioned above, it is placed inside the plant, as will appear from Figures 2 and 3. The Bourdon tube activates switch 7, as shown in Figure 4. Switch 7 may be a multi-step switch, but in the shown embodiment it is a three-step switch with a central position and two extreme positions, as indicated by designations I, 0, and II at the right hand side in Figure 4. From step switch 7 wiring 9 is extended through a seal 10, e.g. silicone matter, to the outside, providing a possibility for external testing and control.

Bourdon-tube 6 has a defined volume which is filled with SF_6 gas at 20° C to an overpressure of 0.4 bar. The Bourdon tube is provided inside the plant, generally designated 11, which defines a SF_6 gas chamber with chamber 11 filled with SF_6 gas at 20° C to an overpressure of 0.2 bar. The indicator will, thus, indicate a differential pressure of 0.4 minus 0.2 bar, i. e. 0.2 bar, independently of temperature and pressure variations in the plant. In Figure 2 reference number 12 designates an enclosure, preferably made of steel, for plant 11. Reference number 13 indicates air at atmospheric pressure and, thus, the space outside the enclosure of the plant. In order to ensure good sealing between plant chamber 11 and the outside 13 of the enclosure a seal means, e.g. an O-ring 14 is suitably provided on plant side 11, with said seal means 14 forming a gas tight seal against the surroundings 13 when a nut 15 is tightened on a mantle screw 16 and in contact with the outside of enclosure 12.

With reference to Figure 4, it will be understood that switch 7 will have its shift arm 7′ in position "0" in case of normal operation. In case of a defect, i. e. a leak, in plant 11 the overpressure in the plant will disappear, and the differential pressure between pressure in the Bourdon tube and in the plant will increase towards 0.4 bar. The Bourdon tube will then seek to "straighten" and will, thus, cause shift arm 7′ to move to position "I". In case of a defect, i.e. a leak in the indicator proper (Bourdon tube), the differential pressure between pressure in the Bourdon tube and in the plant will disappear, and end 6′ of Bourdon tube 6 will move downwards in Figure 4. This will cause shift arm 7′ to move into position "II

The functional principle of switch 7 will be briefly disclosed with reference to Figure 5. During normal operation switch 7′ is in position 0, as shown in Figure 5. In case of said defect of the plant the differential pressure between pressure in the Bourdon tube 6 and in the plant will increase towards 0.4 bar in the shown embodiment, so that arm 7′ moves to position I. If switch 7 is incorporated in a circuit which is driven by an external feed source 17, e. g. an alternating voltage, and an indicator, e.g. a lamp 18 or, e.g. a voltmeter, lamp 18 will turn off when shift arm 7′ reaches terminal I to indicate that normal conditions no longer prevail. If desired, an alarm might, thus, be given if lamp 18 is, e.g. replaced by an alarm device which is activated when voltage disappears.

In a corresponding manner shift arm 7′ will move to position II in case of a leak in the Bourdon tube, the differential pressure between the pressure in Bourdon tube 6 and plant 11, thus, disappearing. Lamp 18 will turn off or an alarm will be given, indicating a deviation from the normal condition.

If a leak control does not lead to detection of voltage or if an infinitely large resistance is measured at clamping points 19, 20 in Figure 5, there is probably a leak in the plant, and a representative of the manufacturer's must be fetched. The user of the plant should normally do nothing with the plant, apart from seeing to it that the plant is in a normal condition, and summoning assistance if there is a deviation from the normal conditions.

Before the plant is possibly turned off, the leak indicator proper is tested, so that the user may ascertain whether it is a defect of the Boudon tube 6 that caused the fault indication. If such a defect exists shift arm 7′ will be in position II, and the representative from the factory will make a check by arranging a short circuit 23 between terminals 21 and 22 representing switch terminals 0 and II, respectively. If lamp 18 lights, this indicates that there is a defect in the leak indicator proper. If lamp 18 still does not light it means that shift arm 7′ is in position I, ascertaining that there is a leak in the plant proper or a so called tank leak.

In the concept indicated in Figure 5 power source 17 may, if desired by replaced by supply from the network. Figure 6 illustrates the principle of the possibility of checking whether the enclosure is tight, which may be done by the aid of a voltmeter when the plant is in operation, or by the aid of an ohmmeter when the plant is without voltage. The indicator also permits Ohm testing when there is a voltage on the plant.

The compact plant is commonly provided with test points for capacitive voltage testing at the high voltage ducts incorporated in the plant. Capacitive voltage is taken from a metal screen which is embedded in epoxy bushings 37 to which the cables are connected (see Figure 7). For a simple illustration only one phase is shown in Figures 6 and 7 but, as indicated in Figure 7, capacitive voltage take out is possible for all three phases L_1, L_2, L_3 or L_1*, L_2*, L_3*. Such capacitive voltage take out is commonly known to those skilled in the Art and will not be further disclosed. The capacitive voltage point from bushings to phase L_1 and phase L_1*, respectively, is generally indicated by reference number 24. In normal operation of the plant said capacitive voltage points are earthed, as indicated of switches 25. Switches 25 are in an open position 25′ when measuring takes place.

Voltage testing may be carried out with suitable testing equipment which is commercially available. Such testing equipment is, e.g. a so called Pfisterer/Horstmann voltage indicator ± 200 V.

The concept of permitting gastightness of the plant to be checked by use of said capacitive voltage, thus, provides the possibility of using the control equipment used for voltage testing. A voltmeter may also be used. Voltage testing of the high voltage cables is either made at A or at B. When tightness of the plant is to be checked a spring loaded press switch 26 is activated so that voltage is supplied to leak indicator, to terminal 27 of switch 7 (see also Figure 5). If shift arm 7′ is in a normal state, i.e. in connection with terminal 21, the voltage wil also be applied to terminal 29, and voltage may, thus, be measured between terminal 29 and earth by the aid of voltmeter 30. In case of deviation from the normal state there will be no connection between terminal 27 and terminal 29, and a separate test must be carried out by the representative of the manufacturer, as mentioned above. If the Bourdon tube is defect shift arm 7′ will provide a connection between terminals 27 and 22, and following a short circuit between terminals 22 and 21 there will again be a voltage between terminal 29 and earth, clearly indicating a defect of the indicator proper. If there is still no such voltage present, this means that shift arm 7′ forms a connection between terminals 27 and 28. Terminal 28 must not necessarily be accessible, but if it is, a possible short circuit between terminals 28 and 21 will unambiguously indicate whether shift arm 7′ forms a connection between terminals 27 and 28, and it will, thus, be ascertained that there is a leak fault in the plant. During said voltage test contacts 31, 32, 33, and 34 of spring loaded switch 26 will have the positions shown by reference numbers 31′, 32′, 33′, and 34′, respectively.

After completed voltage test between terminal 29 and earth switch 26 is released back to its normal position, represented by contacts 31, 32, 33, and 34. Terminal 27 will, thus, be without voltage, irrespective of terminal 29.

In this position of switch 26 resistance may be measured by the aid of an ohmmeter 35, if desired. Ohmmeter 35 is connected with terminals 29 and 36. If shift arm 7′ is in a normal position the ohmmeter will deflect. If, however, the shift arm is either placed between terminals 27 and 28 or 27 and 22, the ohmmeter will not deflect, and checks as discussed in connection with Figure 5 must be carried out. It will be understood that said measuring of resistance by the aid of the ohmmeter may be carried out whether or not there is a voltage on the plant, as press switch 26 is in a normal position, and there is, thus, no voltage on the circuit between terminals 36 and 29.

During measuring operations with voltmeter 30 or ohmmeter 35, and during any further test operations to ascertain whether a leak is due to a defect of the indicator or of the plant, switch 25 is kept in an open position, as indicated by reference number 25′.

If it is desired to measure the voltage of phase (L1) or phase (L1*), switch 25 will also be in the position indicated by reference number 25′. Voltage is then measured between the terminals indicated by A or B, respectively. Switch 26 will then be in its normal position.

During normal operations, when no measurements or testing of the leak indicator are to be carried out, switch 25 is placed in the position shown by a full line.

Even though the present leak indicator was disclosed, especially with reference to utilization in connection with compact gas filled high voltage switch plants the leak indicator may obviously be used for any desired plant or chamber which is under gas pressure. The disclosure is, thus, only meant as an example of a utilization of the present invention.

Even though switch 7 in Figure 4 is generally described as a switch the shift arm 7′ of which has an essentially linear movement, other equivalent concepts for forming a connection between the shift arm of a swith and end 6′ of Bourdon tube 6 will obviously be covered by the concept of a technical equivalent. The main issue is that the free end of the Bourdon tube acts on switch 7.

Although it was stated in the above disclosure that the Bourdon tube is provided with a nominal pressure above atmospheric pressure, it will obviously be possible to achieve equivalent results if the Bourdon tube were provided with a nominal pressure below atmospheric pressure. It is, however, important that the nominal pressure within the Bourdon tube should not be equal to the atmospheric pressure, since it will always be necessary to create a differential pressure between the pressures in the Bourdon tube and the plant, resp. This differential pressure may have a rather optional value, whether it is positive or negative. The differential pressure of 0.2 bar, as described above, should, thus, only be regarded as an example without limiting the present invention in any way.

Claims

1. A leak indicator for a gas filled electrical plant, with said leak indicator being of the

Bourdon tube kind, the Bourdon tube being filled with a gas having the same properties as the gas surrounding the Bourdon tube, and being in a sealed off state, the nominal gas pressure in the plant deviating from the surrounding atmospherical pressure, **characterized in** that the free end of the closed Bourdon tube is arranged to influence, in a manner known per se, a switch means, preferably a multi-step switch with at least two terminals, and that the leak indicator may be supplied with voltage directly from the plant, irrespective of direction of supply to the plant,as a first terminal of the switch means may be voltage connected capacitively to a high voltage bushing in the plant, and a second terminal may be connected with the first clamp of a voltage indicator, the second clamp of said voltage indicator being connected to earth, and with contact between said first and second terminals in a normal plant condition, but with no contact between terminals in case of a deviation from the normal state.

2. A leak indicator as defined in claim 1, **characterized in** that any possible leak in the Bourdon tube is tested by having a third terminal of the switch means connected with said first clamp of the voltage indicator, since there is contact between the first and the third terminal, and thus a defect of the Bourdon tube in case a voltage is measured.

3. A leak indicator as defined in claim 1, **characterized in** that any possible leak in the plant is checked by contact being established between the first clamp of the voltage indicator and a fourth terminal of the switch means, a leak condition being present in the plant if any voltage is recorded.

4. A leak indicator as defined in claim 1, **characterized in** that when said first terminal is free of voltage, an ohmmeter may be selectively connected between said first terminal and said second terminal of the switch means.

5. A leak indicator as defined in claim 4, **characterized in** that contact between said first terminal and a second terminal of the switch means indicates a normal state, whereas a break of contact between them indicates an abnormal state, that contact between said first terminal and a third terminal indicates a fault of the Bourdon tube, and that contact between said first terminal and a fourth terminal of the switch means indicates a fault in the plant.

6. A leak indicator as defined in claim 5, **characterized in** that one or several further terminals is/are provided between said second and sead fourth terminal to indicate interstages.

Fig.1.

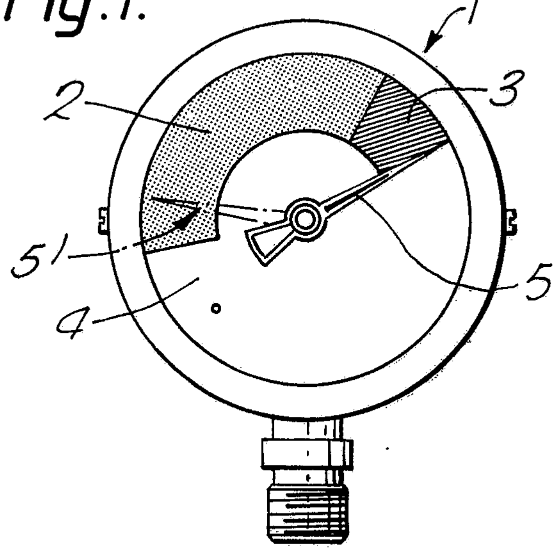


Fig.2.

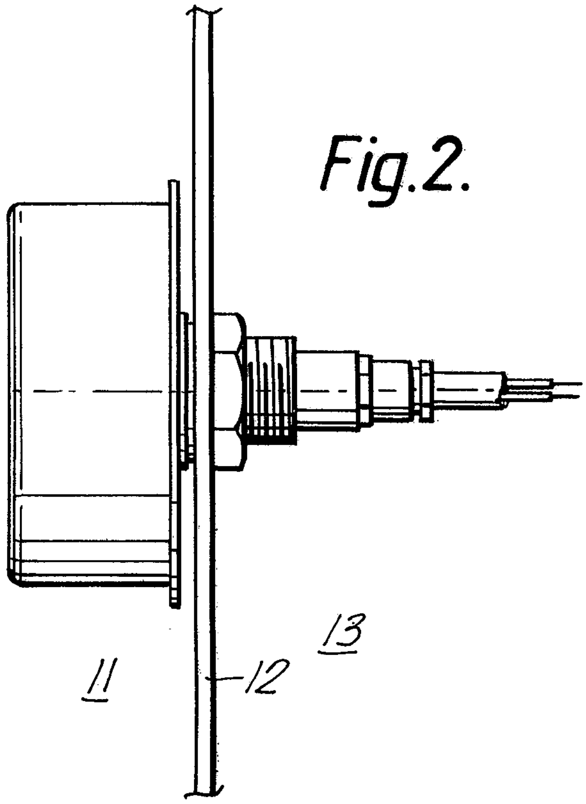


Fig.3.

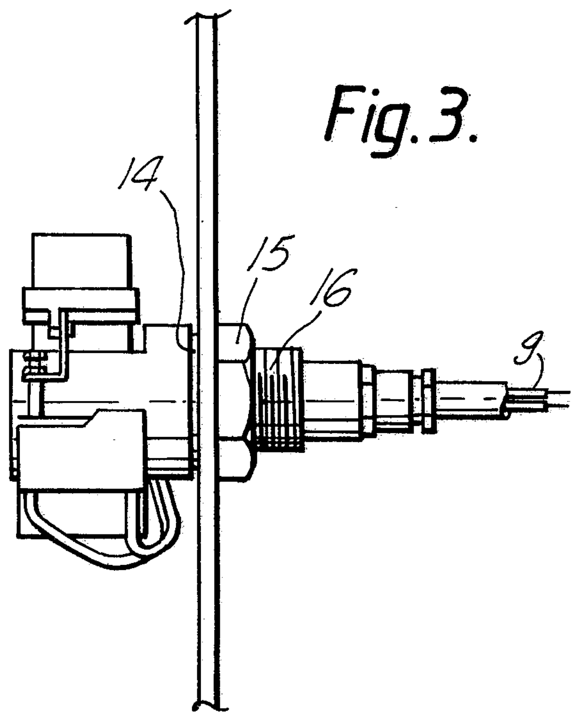


Fig.4.

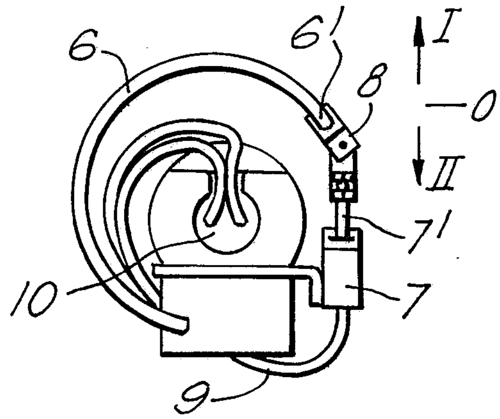


Fig.5.

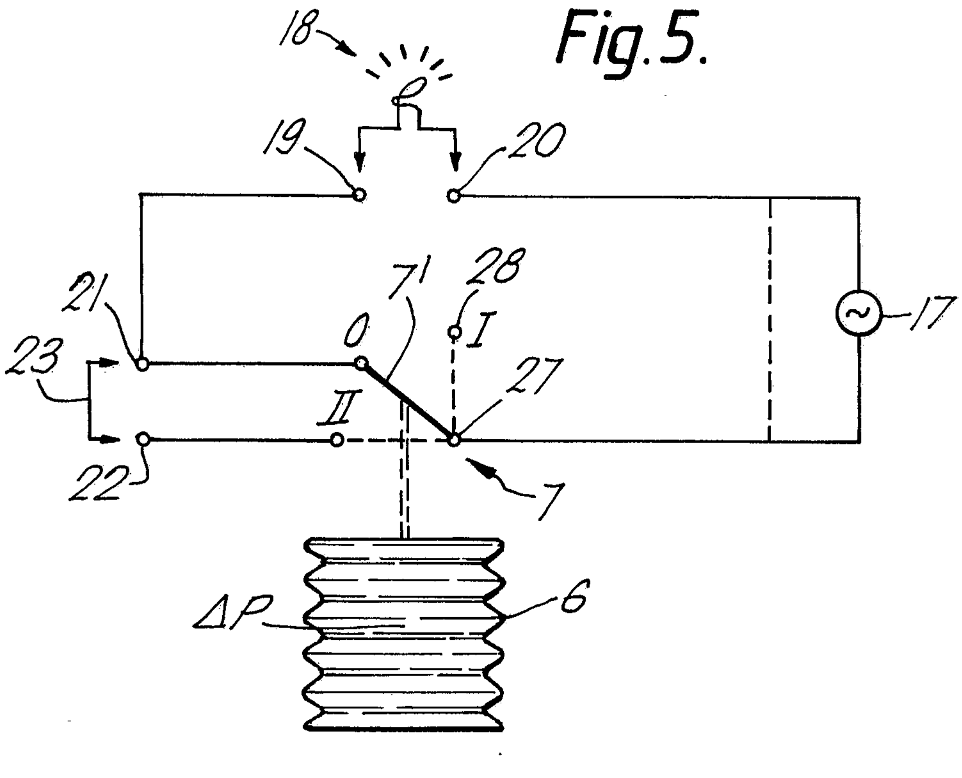
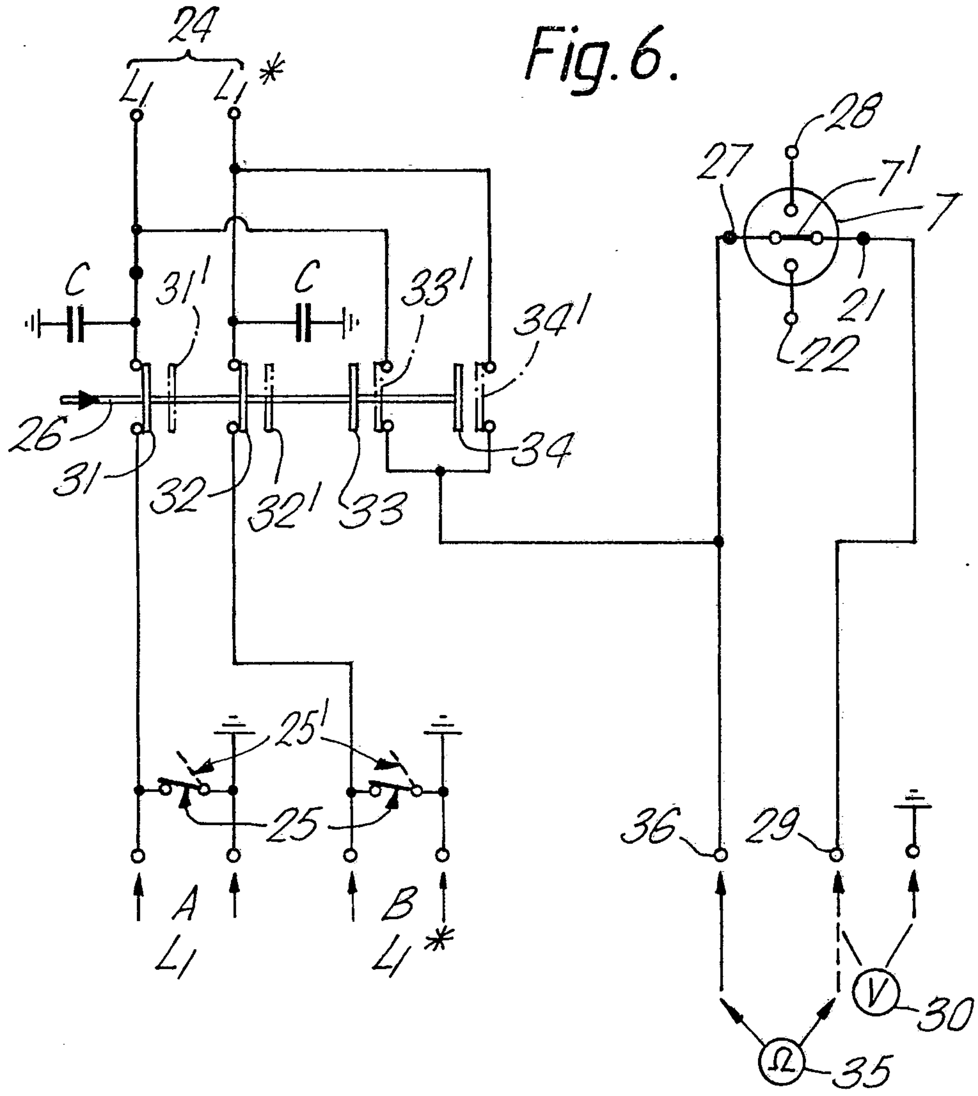


Fig. 6.


24
L1
L1*
C
31'
C
33'
34'
27
28
7'
7
21
22
26
31
32
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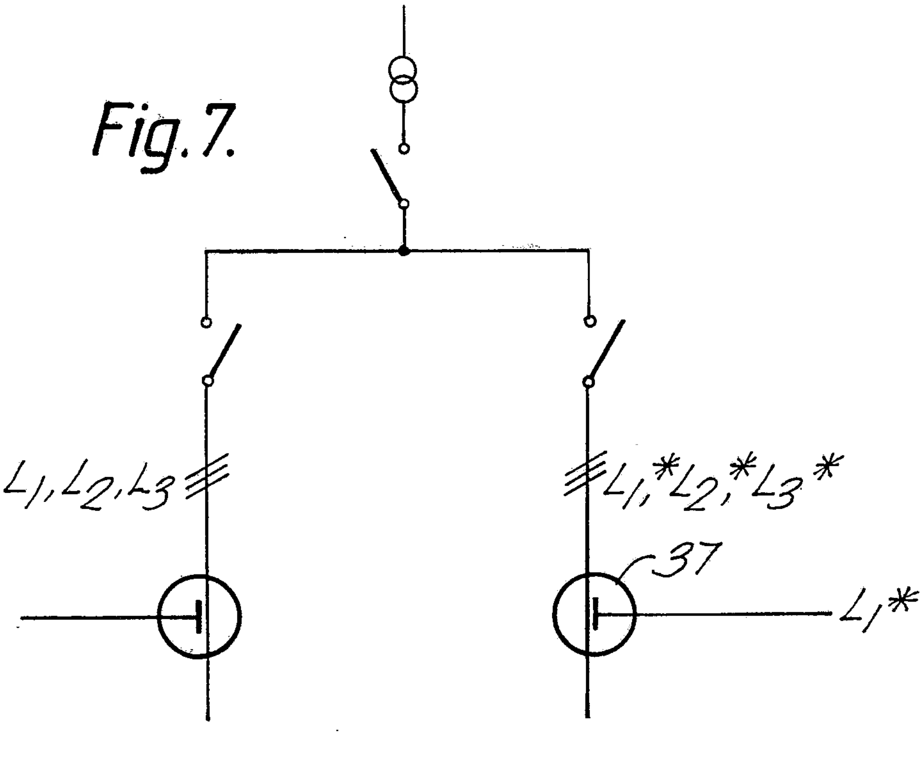
34
25'
25
36
29
A
L1
B
L1*
V
30
Ω
35

Fig. 7.


L1, L2, L3
L1,* L2,* L3*
37
L1*