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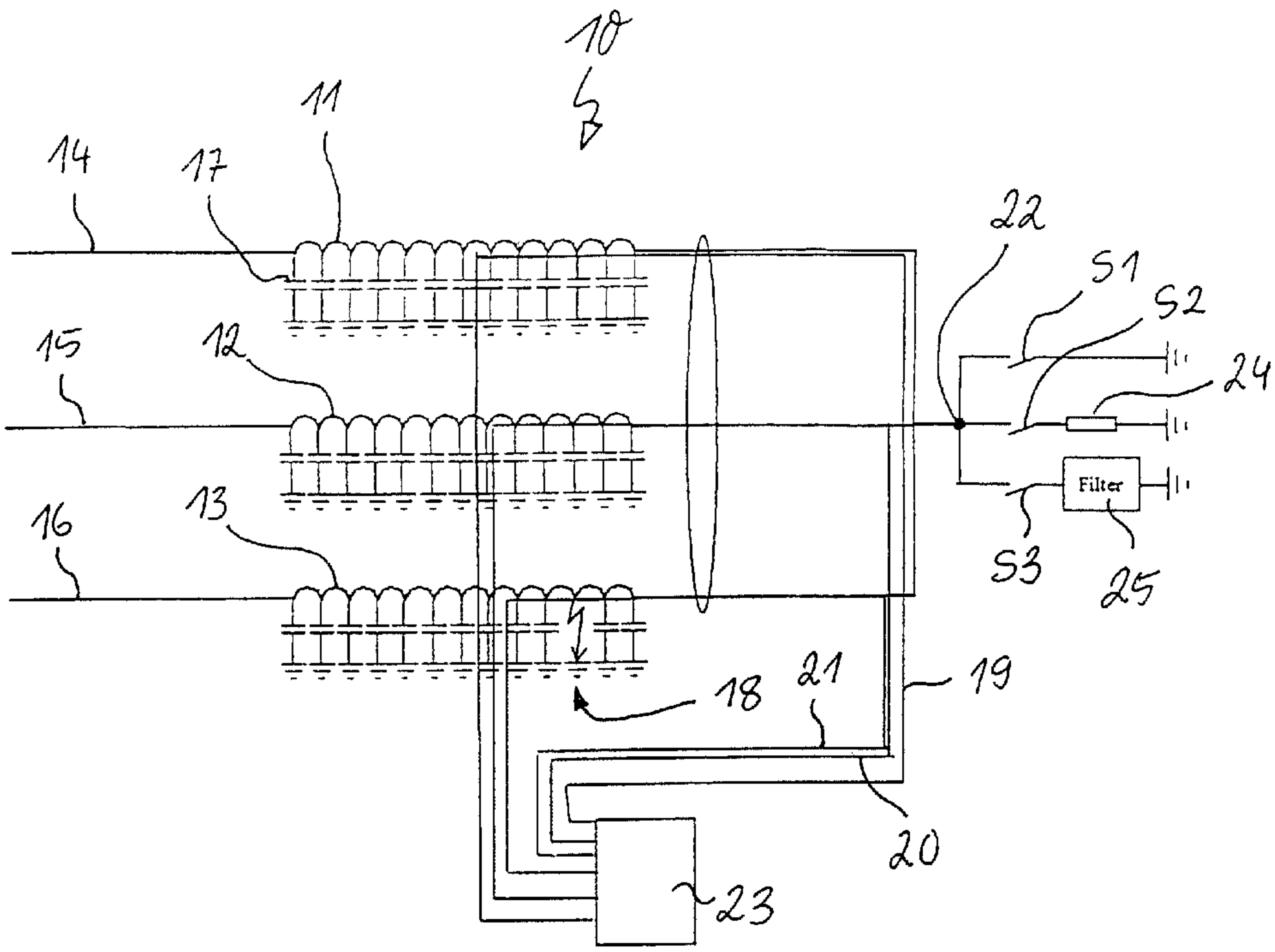
(54) Titre : DETECTEUR DE MISE A LA TERRE POUR BOBINAGES
(54) Title: SHORT-TO-GROUND DETECTOR FOR WINDINGS



(57) Abrégé/Abstract:
The invention relates to a method for detecting a short-to-ground (18) occurring in the proximity of a neutral point (22) in a multiphase electrical device, particularly an electrical machine (10) or a transformer, which is operated with a basic frequency and has a number of windings (11, 12, 13) assigned to the individual phases. These windings are each connected, with one end, to the neutral point (22) and, with the other end, directly to a supply mains via a mains connection (14, 15, 16). A simple and reliable detection is achieved by virtue of the fact that the change in physical quantities that is linked to a short-to-ground (18) is measured and evaluated in the immediate surroundings of the earth-to-ground (18).

ABSTRACT

The invention relates to a method for detection of a ground fault (18), which occurs in the vicinity of a neutral point (22), in a polyphase electrical device which is operated at a fundamental frequency, in particular an electrical machine (10) or a transformer which has a number of windings (11, 12, 13), which are associated with the individual phases, one end of each of which windings (11, 12, 13) is connected to the neutral point (22) and the other end of each of which windings (11, 12, 13) is connected directly to a power supply network via a power supply system connection (14, 15, 16).

Simple and reliable detection is achieved in that the change in the physical variables which is associated with a ground fault (18) is measured in the immediate vicinity of the ground fault (18), and is evaluated.

(Figure 1)

DESCRIPTION

METHOD FOR DETECTION OF A GROUND FAULT, WHICH OCCURS IN THE VICINITY OF A NEUTRAL POINT IN AN ELECTRICAL DEVICE, AS WELL AS AN APPARATUS FOR CARRYING OUT THE METHOD

TECHNICAL FIELD

The invention relates to the field of protection of electrical devices such as electrical machines or transformers. It relates in particular to a method for detection of a ground fault, which occurs in the vicinity of a neutral point, in a polyphase electrical device, which is operated at a fundamental frequency, as claimed in the precharacterizing clause of claim 1. It also relates in particular to an apparatus for carrying out the method as well as to an application of the method.

PRIOR ART

A large number of methods are known from the prior art, by means of which ground faults or ground shorts in the windings of rotating machines such as synchronous generators are detected, and the machine can thus be protected against the negative effects of ground faults. These methods include the use of an overvoltage or overcurrent relay at the neutral point, a zero voltage (zero sequence) overvoltage relay, or a residual current differential protection circuit.

Ground fault protection for a generator based on overvoltage or overcurrent determination results in simple and reliable protection. However, it has one major disadvantage: ground faults which occur in the windings close to the neutral point of the generator are not detected. It has therefore already been proposed (Charles S. Mozina, Upgrading Hydroelectric

Generator Protection Using Digital Technology, Waterpower '97, Atlanta GA, August 5-8 (1997)) for one hundred percent ground fault protection to be achieved by combining a conventional overvoltage protection circuit (for 95% of the stator winding) with an undervoltage protection circuit which is tuned to the third harmonic of the generator fundamental frequency (for the remaining 5% of the winding close to the neutral point). This proposal is based on the fact that, in many synchronous generators, the inducted electromotive voltage at the neutral point contains higher harmonics, which produce a corresponding high harmonic current in the connection from the neutral point to ground, in general a resistance. If an earth fault occurs in the vicinity of the neutral point, it acts as a bypass for this resistance. The reduction in the voltage drop which results from the bypass can then be detected as an undervoltage. These known ground fault protection methods are supported by the use of step-up transformers between the generator and the power supply system, which allow the generator to be isolated from the power supply system with regard to grounding.

However, recently, power station configurations are being increasingly used in which there is no need for the conventional step-up transformers, since the generators produce the power supply system voltage directly. This is achieved by means of a special winding technology, in which the windings of the generator use high-voltage cables. Generators such as these have become known by the name "Powerformer" (see, for example, M. Leijon, "Powerformer - a radically new rotating machine", ABB review 2/98, pp. 21-26 (1998)).

It has now been found that the known methods for detection of ground faults in these rotating machines and transformers which are designed using the new winding technique do not operate with one hundred percent reliability.

DESCRIPTION OF THE INVENTION

The object of the method is to specify a method and an apparatus which avoid the disadvantages of previously known solutions and, in particular, allow simple and reliable detection of ground shorts or ground faults close to the neutral point of electrical machines and transformers which are wound with cables and are connected directly to the power supply system.

The object is achieved by the totality of the features in claims 1 and 5. The essence of the invention is to use instrumentation to detect the effects of a ground fault in the immediate vicinity of the ground fault, which effects are expressed in a change in specific physical variables such as the temperature or pressure, and to use these effects for detection of the ground fault.

According to a first preferred refinement of the method according to the invention, the temperature and/or the gas or air pressure are/is measured and evaluated as the physical variables. This is achieved in a particularly simple and reliable manner in that the change is measured optically by means of fiber-optic cables which are laid parallel to the high-voltage cable in the windings and are sensitive to temperature and/or pressure fluctuations.

A second preferred refinement of the method according to the invention is distinguished in that a high-voltage cable with a built-in gas-filled tube is used for the windings, and in that the change in the gas pressure in the tube is measured and evaluated.

A corresponding apparatus is characterized in that the measured value recording means comprise fiber-optic cables which are sensitive to temperature and/or pressure fluctuations and are laid parallel to the high-voltage cable in the windings, and in that the high-voltage cables each have a gas-filled tube, and in that the measured value recording means comprise pressure sensors which are connected to the tubes.

BRIEF EXPLANATION OF THE FIGURES

The invention will be explained in more detail in the following text using exemplary embodiments and in conjunction with the drawing, in which:

Figure 1 shows a schematic illustration of a first exemplary embodiment of an apparatus according to the invention for ground fault detection by means of fiber-optic cables which are laid parallel to the winding cables;

Figure 2 shows a cross section through a cable which is used in the windings, having an intermediate space which is suitable for carrying out a ground fault detection method according to one exemplary embodiment of the invention; and

Figure 3 shows a schematic illustration of a second exemplary embodiment of an apparatus according to the invention for ground fault detection by means of pressure sampling in a winding cable as shown in Figure 2.

APPROACHES TO IMPLEMENTATION OF THE INVENTION

According to the invention, a possible ground fault is detected by a measurement of specific physical variables, which change as a result of the ground fault. Figure 1 shows a schematic illustration of a first exemplary embodiment of an apparatus according to the invention for ground fault or ground short detection in the windings 11, 12 and 13 of an electrical machine 10. The windings 11, 12, 13, which are designed using high-voltage cables, are connected on the one side via power supply system connections 14, 15 and 16 directly to a power supply system (which is not illustrated). On the other side, the windings 11, 12 and 13 are connected to a neutral point 22, which can be connected to ground via switches S1,...,S3 either directly, via a resistance 24 or via a filter 25. The windings 11, 12 and 13 have ground capacitances 17 which are distributed with respect to ground, as is indicated in Figure 1.

A fiber-optic cable 19, 20, 21, which is sensitive to temperature and/or pressure fluctuations, is connected at both ends to an evaluation unit and forms a closed measured loop, is in each case laid in the windings 11, 12, 13, in a section close to the neutral point 22 and parallel to the high-voltage cable of the winding. If a ground fault now occurs in one of the windings 11, 12, 13, in the winding 13 in the example in Figure 1, the fault current flowing there results in a local change at least in the temperature, and in general also in the air pressure in the immediate vicinity. These changes affect the optical characteristics of the relevant fiber-optic cable 21, which can be detected and evaluated in the evaluation unit 23, by means of fiber-optic measurement methods which are known per se.

Figure 3 shows a schematic illustration of a second exemplary embodiment of an apparatus according to the invention for ground fault detection in the windings 11, 12 and 13 of an electrical machine 10. The same reference symbols in this case denote the same elements as in Figure 1. In this case, a specific high-voltage cable 30 is used to form the windings 11, 12, and 13, and its internal design is shown in simplified form in the cross-sectional illustration in Figure 2. Like the high-voltage cable which is used for the windings 11, 12, 13 in Figure 1, the high-voltage cable 30 is a so-called XLPE cable (XLPE in this case stands for cross-linked polyethylene, see, for example, the article by B. Dellby et al. "High-voltage XLPERFORMANCE cable technology, ABB review 4/2000, pages 35-44 (2000)). In the XLPE cable, the central conductor 32 is generally surrounded by insulation composed of XLPE. The special feature of the high-voltage cable 30 shown in Figure 2 is now that an intermediate space 33 is arranged between first and second insulation 31 and 34, respectively. A tube which is filled with gas can be laid in a spiral shape in this intermediate space 33. Sulfurhexafluoride is used, in particular, as the filling gas in this case.

According to Figure 3, pressure sensors 26, 27, 28 can now be arranged at one or more points on the high-voltage cable 30 and on the windings 11, 12, 13. In the event of a ground fault 18, gas emerges from the tube, and the pressure change which is associated with this can be measured by means of the pressure sensors 26, 27, 28, and can be evaluated in a connected evaluation unit 29.

LIST OF REFERENCE SYMBOLS

10	Electrical machine
11, 12, 13	Winding
14, 15, 16	Power supply system connection
17	Ground capacitance
18	Ground fault
19, 20, 21	Fiber-optic cable
22	Neutral point
23	Evaluation unit
24	Resistance
25	Filter
26, 27, 28	Pressure sensor
29	Evaluation unit
30	High-voltage cable (XLPE)
31	Insulation (XLPE)
32	Conductor
33	Intermediate space
34	Insulation (XLPE)
35	Tube (filled, for example, with SF_6)
S1, S2, S3	Switch

PATENT CLAIMS

1. A method for detection of a ground fault (18), which occurs in the vicinity of a neutral point (22), in a polyphase electrical device which is operated at a fundamental frequency, in particular an electrical machine (10) or a transformer which has a number of windings (11, 12, 13), which are associated with the individual phases, of a high-voltage cable (30), one end of each of which windings (11, 12, 13) is connected to the neutral point (22) and the other end of each of which windings (11, 12, 13) is connected directly to a power supply network via a power supply system connection (14, 15, 16), characterized in that the change in the physical variables which is associated with a ground fault (18) is measured in the immediate vicinity of the ground fault (18), and is evaluated.

2. The method as claimed in claim 1, characterized in that the temperature and/or the gas or air pressure are/is measured and evaluated as the physical variables.

3. The method as claimed in claim 2, characterized in that the change is measured optically by means of fiber-optic cables which are laid parallel to the high-voltage cable (30) in the windings (11, 12, 13) and are sensitive to temperature and/or pressure fluctuations.

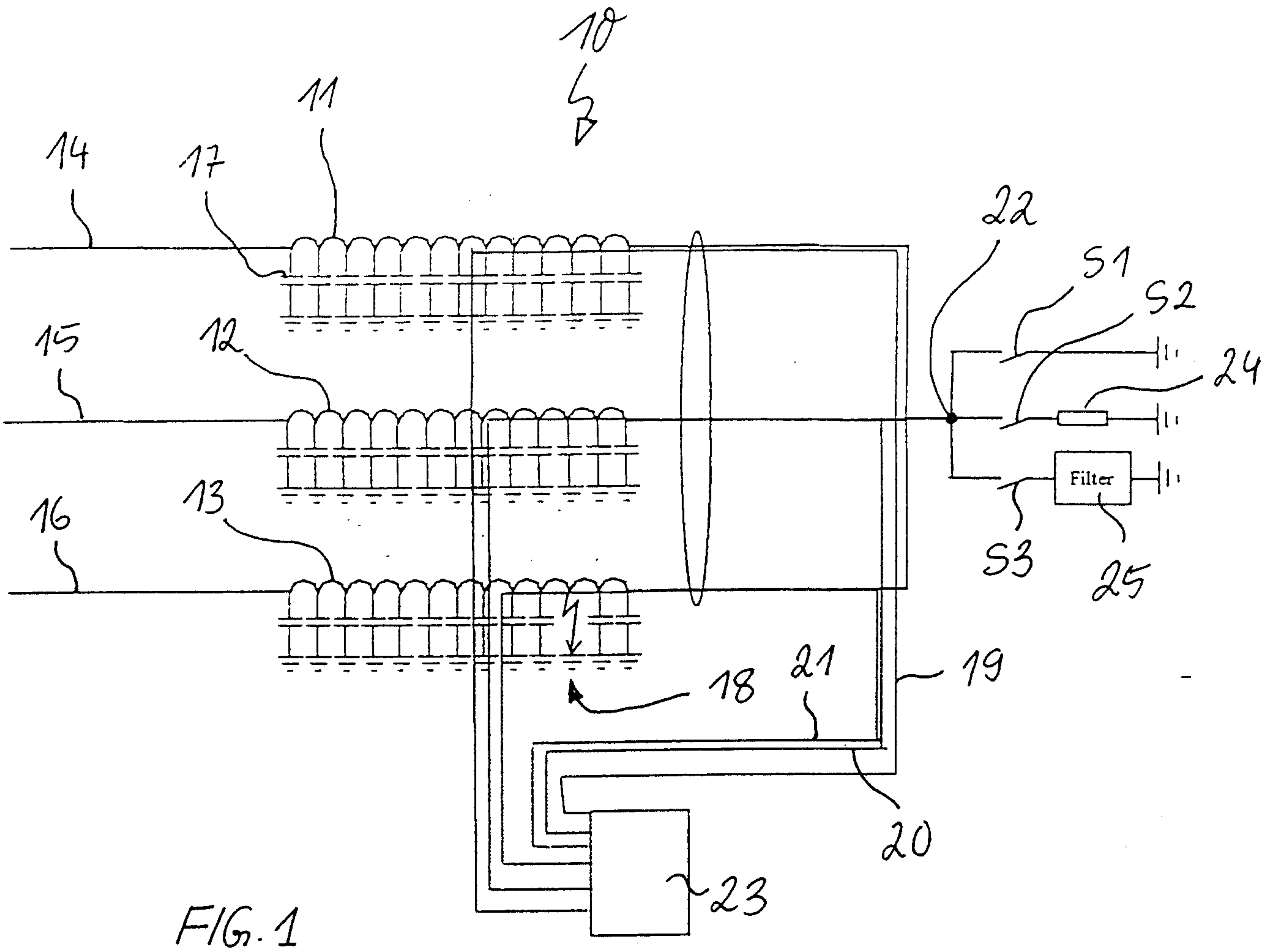
4. The method as claimed in claim 1, characterized in that a high-voltage cable (30) with a built-in gas-filled tube (35) is used for the windings, and in that the change in the gas pressure in the tube (35) is measured and evaluated.

5. An apparatus for carrying out the method as claimed in claim 1, characterized in that means (19,...,21; 26,...28) for measured value recording of

physical variables which change when a ground fault occurs in the windings (11, 12, 13) are arranged on the individual windings (11, 12, 13), and in that the measured value recording means (19,...,21; 26,...28) are connected to an evaluation unit (23, 29).

6. The apparatus as claimed in claim 5, characterized in that the measured value recording means comprise fiber-optic cables (19, 20, 21) which are sensitive to temperature and/or pressure fluctuations and are laid parallel to the high-voltage cable in the windings (11, 12, 13).

7. The apparatus as claimed in claim 5, characterized in that the high-voltage cables (30) each have a gas-filled tube (35), and in that the measured value recording means comprise pressure sensors (26, 27, 28), which are connected to the tubes (35).


10
11
14
17
22
S1
S2
15
12
24
Filter
13
16
S3
25
21
19
18
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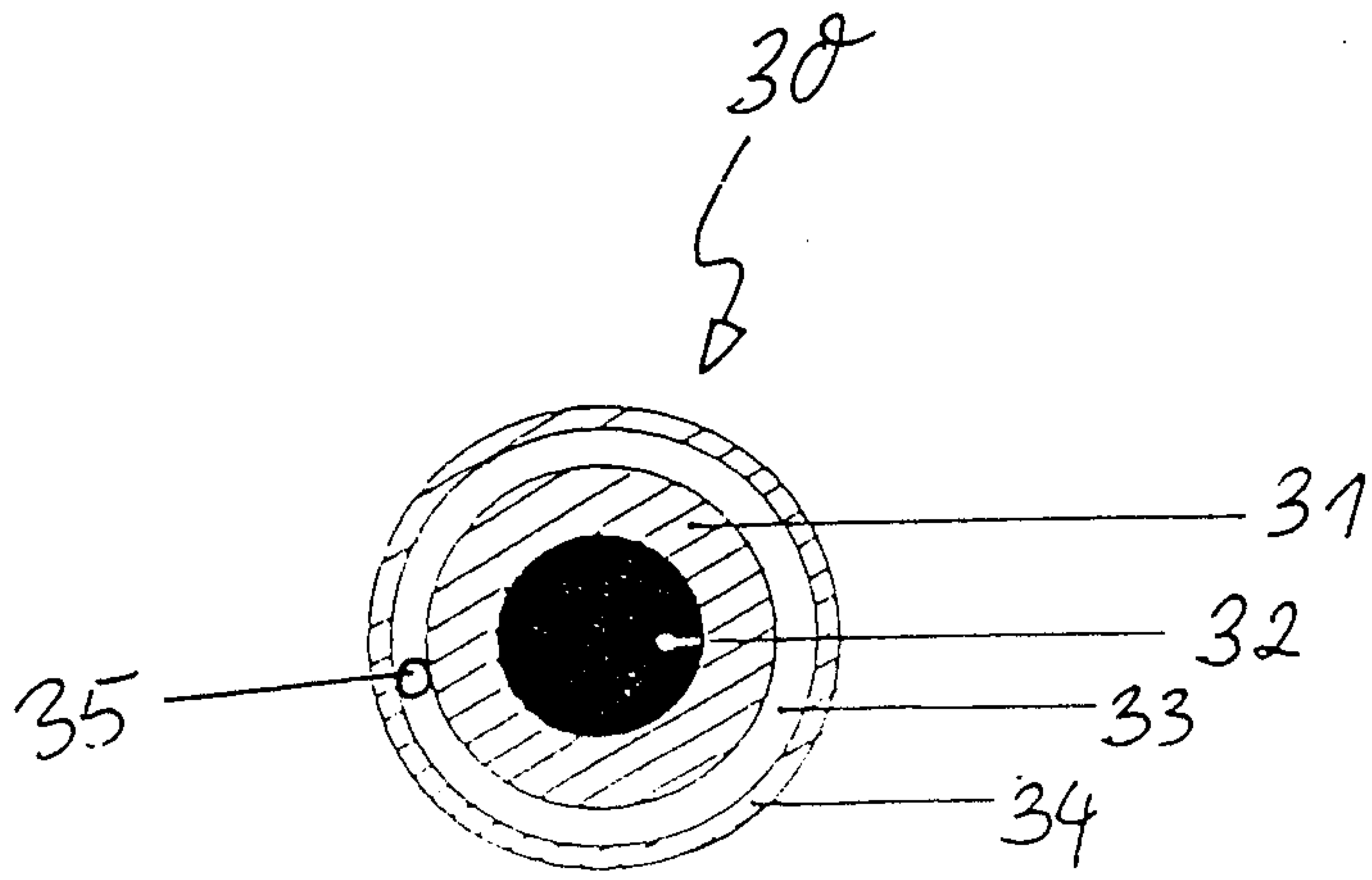
23

FIG. 1


30
31
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35
33
34

FIG. 2

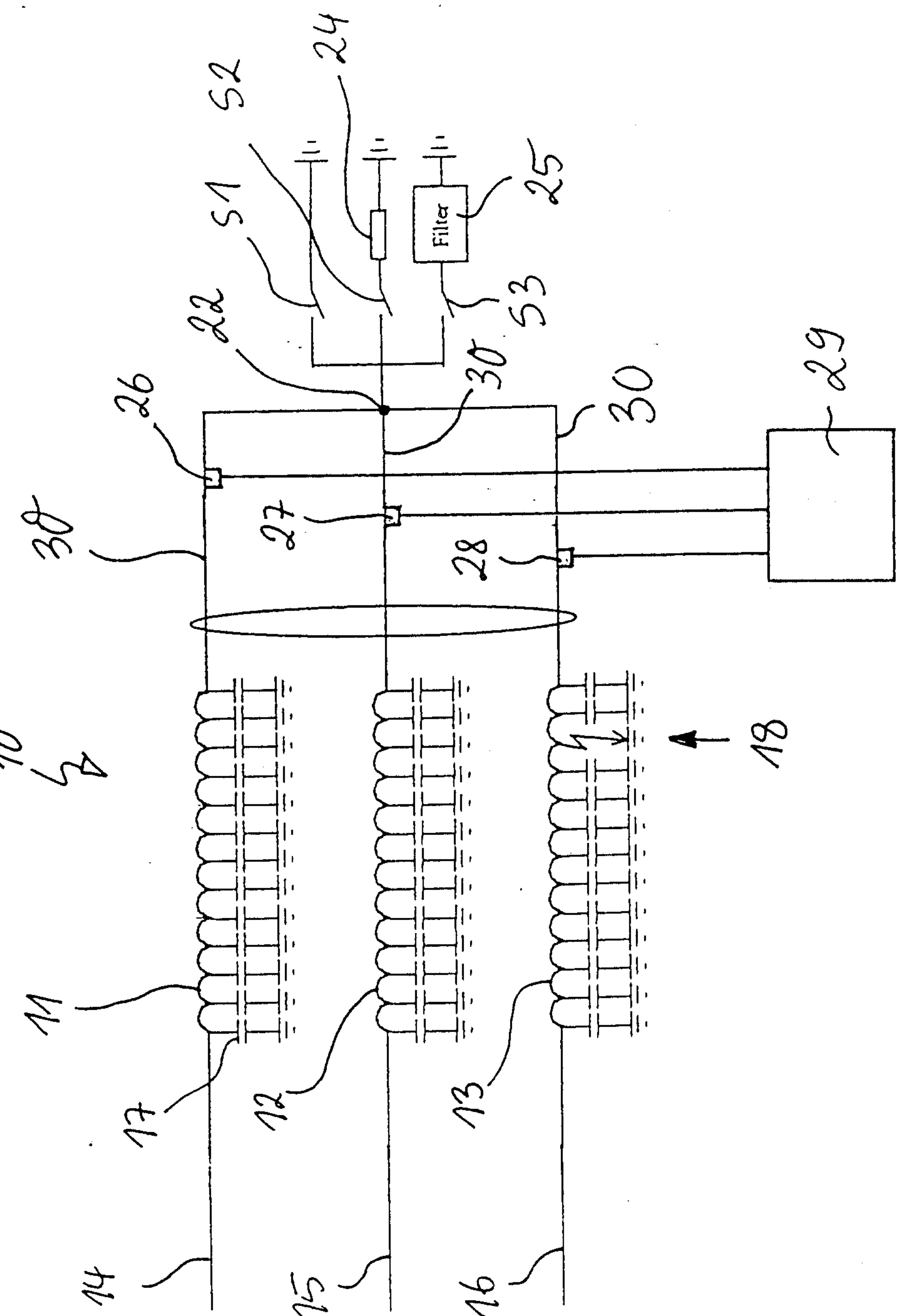
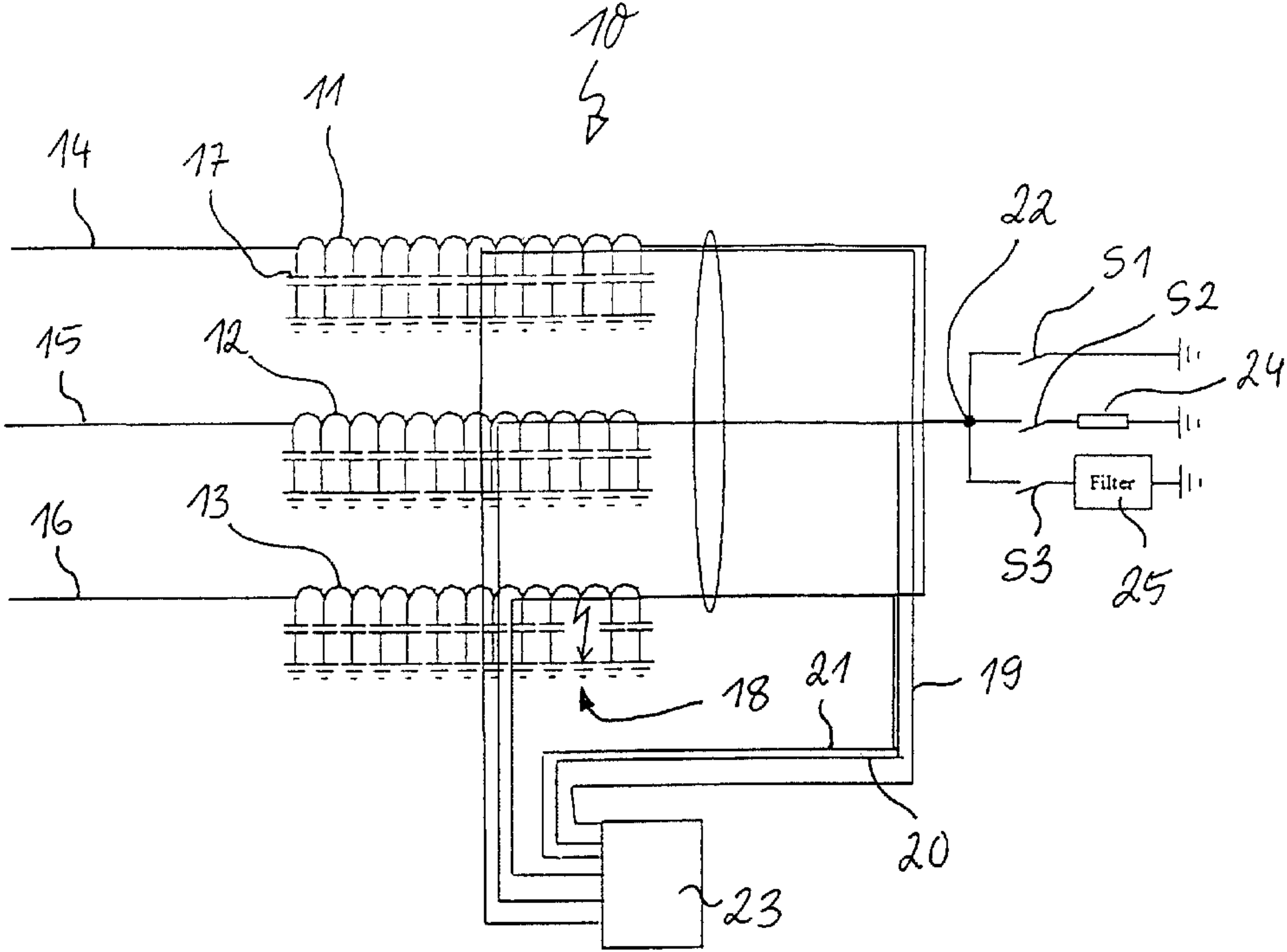


FIG. 3



10
11
14
17
22
S1
S2
15
12
24
Filter
16
13
S3
25
18
21
19
20
23