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(54) **A transformer for the measurement of current in high-voltage supply networks**

(57) The invention concerns a transformer for the measurement of current in high-voltage networks wherein the shell (7), which compacts in the form of a ring the magnetic cores (6) of the secondary winding, is fixed in its lower part to a central metal tube (20) at the base of the transformer and in its upper part to an insulating tube (22) which centers and keeps taut said elements (22, 7, 20) resulting in advantages both with respect to the construction and for transporation. There are also provided electrodes (28,29) facing one another in order to form a preferential discharge zone in the vicinity of the safety membrane (14) as well as an intermediate shield (36) surrounding the central tube (20) and possibly, in the case of high voltages, a capacitance grading bushing (45) wound around the intermediate shield (36) for a better distribution of the electrical field.

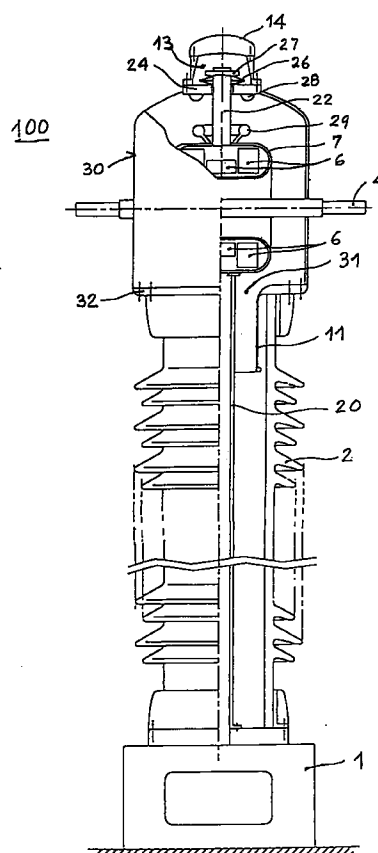


Fig.3

Description

The instant invention relates to a transformer for the measurement of current in high-voltage supply networks.

This kind of instruments is inserted in the medium-voltage (M.V.) or high-voltage (H.V.) lines within the substations for the generation and distribution of electricity in order to supply low-voltage current proportional to the current circulating in the high-voltage line by means of a static transforming device the primary winding of which is constituted by one of the conductors of the distribution line while the secondary windings, duly insulated, are constituted by coils wound on magnetic cores.

Said coils at their end are provided with terminals arranged at the base of the transformer to which terminals the individual consumer can connect himself for receiving the low-voltage signals necessary for measuring the line current and for protecting the line itself.

The insulation between the primary and the secondary, at the present state of the art, is realized through an insulating means which may consist of paper or a film of plastic material impregnated with insulating fluids or of an insulating gas, generally SF₆ which is in overpressure with respect to the atmospheric pressure.

The transformer disclosed herein is of the pressurized gas type.

The state of the art is schematically illustrated in Figures 1 and 2.

Fig.1 is a schematic illustration of the operative insertion of an instrument transformer for measuring the electrical current including, according to the conventional construction, a base 1 to which is linked a porcelain insulating body 2 which supports a head 3 wherein are arranged the elements of the transformer. The primary winding consists of one of the conductors of the line itself, e.g. a three-phase line 5 wherein a high-voltage current circulates.

As again schematically illustrated in Fig.2, though in greater detail, the secondary windings are wound on magnetic cores 6 assembled within a shell 7, said cores as a whole forming a ring surrounding the conductor 4. At present, the ring formed by the magnetic cores 6 is generally supported by an insulating bell 8. In the annular hollow space between the central tube 9 and the interior of the insulating body 2 there are provided, in a known manner, annular shields, e.g. as the one bearing the reference numeral 11, useful for a better distribution of the internal electrical field. On top of the head 3 is, in many instances, arranged a safety membrane 12 forming a weakening point for the rupture of the structure which acts as a vent in case of a sudden overpressure due to an internal short-circuit.

This known solution has several drawbacks such as, e.g.:

- on the insulating bell 8 there can eventually pile up a deposit of particles which reduce the superficial

insulation of the bell;

- the electrical field is particularly critical along the surface of this bell;
- during transportation, the measuring transformer is subject to breakages, especially the insulating bell, which breakages can occur also while in use, in case of seismic stress;
- the compensation of longitudinal, thermal expansions of the unit is particularly critical, above all in climates where strong thermal excursions in relatively short periods of time can occur;
- the insulating bell 8, arranged between the insulating body 2 and the head 3 of the transformer, builds a barrier against the shock wave in case of short-circuits in the lower part thereof, which can cause the burst of the insulating body 2 inasmuch as the membrane does not react with sufficient timeliness so as to efficiently vent the overpressure due to an internal discharge.

Object of the present invention is that of realizing a current transformer for high-voltage networks more reliable with regard to the above mentioned drawbacks and also of a more simple and hence more economic design.

According to the invention, the annular shell compacting the magnetic cores, is supported from below by a metal tube directly fixed to the base of the transformer while at its upper part the shell is fixed to an insulating element which is coaxial to said metal tube. The upper end of the insulating element is slidably centered on a flange, arranged on the base of the safety membrane, thereby attaining a stable transversal centering of the entire unit at the extremities of the supporting shell of the magnetic cores, which proves to be advantageous both during operation and during the transportation of the current transformer.

Said sleeve-magnetic-cores-tube supporting assembly is kept under tension by at least one cup-shaped spring provided between the end of the insulating tube and said spoke flange so as to automatically compensate longitudinal expansions. In this manner any other way of transversal centering as well as the adoption of supporting bells of the magnetic cores is eliminated, thereby simplifying the design and the assembly of the transformer, the head whereof proves therefore to be shorter, with the advantage of lower weight and lower cost.

The lower part of the spoke flange supporting the upper insulating tube presents a ring-shaped projection constituting an electrode facing a second electrode engaged at the point of attachment between the upper insulating tube and the shell of the magnetic cores. In this manner a preferential discharge area is created, shifted towards the weakest point of the electrical insulation in the terminal portion of the transformer's head, viz. in the neighbourhood of the safety membrane. In case of overpressure, the safety membrane timely gives way, thereby avoiding the burst of the transformer, thus

safeguarding its integrity as well as that of the persons and objects in its surroundings.

In addition to what above, an intermediate shield to improve the electrical field is provided consisting of a metal electrode, appended to an insulating supporting tube fixed to the shell of the cores, which electrode is interposed between a conventional electric shield fixed on the flange and the supporting central tube. There is, moreover, provided an additional insertion of a tube of fiberglass reinforced plastics, internally adhering to the porcelain body, for preventing strong thermo-mechanical stresses in case of internal discharges.

The centering of said intermediate shield with respect to the fiberglass reinforced plastic tube, adhering to the inner surface of the porcelain insulator, is achieved with optimum precision by means of adjustable inserts.

The adoption of an intermediate shield is foreseen for high voltages, such as in the area of 245 kV, for conveying and dividing, in an optimal way, the equipotential lines of the internal electrical field in order to avoid discharges along the insulating body.

In the presence of even higher voltages, i.e. above 245 kV, on the above mentioned intermediate screen, which is elongated even more so towards the bottom, there is further provided a winding of insulating material such as a film of polypropylene or of other insulating plastic materials, amongst the turns of which winding there is provided the insertion of conducting or semi-conducting foils such as to constitute a capacitance graded bushing. This bushing allows a better distribution of the electrical field under the transformer head which constitutes the most critical area as well as in the insulating gas channel leading to said head.

The capacity of the capacitance graded bushing is calculated so as to obtain a value equivalent to the capacity between the central supporting tube and the intermediate shield, which is elongated beyond the lower end of the bushing itself, for a controlled voltage distribution.

For voltages equal to or higher than 420 kV, the intermediate shields can be more than one and the condenser winding is made on the outermost one.

Such a partial electric control arrangement achieves the same usefulness as a integral bushing as adopted by some constructors, but with the following advantages:

- the winding is made employing rolls of insulating material of reduced width and hence in a continuous manner, and not by ribboning, as is presently the case;
- the insertion of the conducting armatures occurs in a simple and uniform manner;
- the impregnation with pressurized gas occurs in a much safer way because of the limited width and thickness of the windings;
- the weight of the transformer is practically not affected by the presence of the condenser;

- besides a good longitudinal distribution on the insulating container, a good distribution of the electrical field in the channel leading to the head is also achieved;
- the material used is generally inorganic and thus there are no ageing problems in the course of the operation.

By adding a metallic foil insulated from the central supporting tube the further advantage of realizing a capacitive potential divider is achieved. The relevant capacity and hence an electrical current is able to feed, if the case arises, by means of suitable electronic amplifiers, voltage measuring circuits and protecting circuits in order to build up an integrated, combined, current and voltage measuring device in one single apparatus.

These objects and the consequent advantages are realized according to the instant invention of which the appended drawings show a preferred but not limited solution, with possible variations which can reciprocally be integrated, wherein:

- Fig.3 illustrates a transformer for measuring current, according to the invention, in a first basic embodiment;
- Fig.4 illustrates, on an enlarged scale, an improved embodiment over the device illustrated in Fig.3, having the object of further protecting the transformer from thermo-mechanical stresses; and
- Fig.5 illustrates a further improved embodiment over that of Fig.4, which is employable for very high voltages.

In said figures, identical parts are identified by identical reference numerals.

In Fig.3 the inventive transformer for measuring currents in high-voltage networks, globally identified as 100, is of the pressurized gas insulation type and includes a base 1 to which a porcelain insulating body 2 is fixed, supporting the head 30, through which passes the conductor 4, in which head are contained the elements of the transformer.

According to the invention, the magnetic cores 6 are fitted and compacted within a shell 7 supported below by a central metal tube 20 directly fixed onto base 1. To the upper part of shell 7 is fixed an insulating tube 22, e.g. made of fiberglass reinforced plastic material, which passes slidingly at the centre of a bored flange 24 above which are arranged cup-shaped springs 26 which are opposed to a blocking element 27 which is located at the end of the insulating tube 22. The bored flange 24 allows the passage of the insulating pressurized gas into the chamber 13 closed by the safety membrane 14.

By means of the blocking element 27 the elastic tension of the assembly (22, 7, 20) can be appropriately adjusted so as to automatically compensate the longitudinal thermal expansions. The shell 7 and its magnetic cores 6 remain transversally centered, thus avoiding the need for insulating bells which cause drawbacks of a

dimensional nature, the possible deposit of impurities which substantially weaken the superficial electric insulation and which contribute to preventing a rapid venting of the overpressure from the inside of the insulating body 2 towards the head of the transformer in case of a short circuit.

The lower part of the bored flange 24 presents an annular projection 28 constituting an upper electrode which lies opposite to a lower electrode 29 fitted onto the insulating tube 22 at the engaging point of the latter with shell 7 of the magnetic cores. Said arrangement of the electrodes 28 and 29 forms a preferential reaction point for a possible internal discharge which can thus occur in the immediate vicinity of the breakable safety membrane 14 in order to allow an immediate venting of the overpressure, thus avoiding the explosion of the insulating body 2.

For not too high voltages a conventional grading shield 11 is provided. This is applied at the flange 32 between the insulating body 2 and the head 30 of the transformer.

In Fig.4 is illustrated, on an enlarged scale, another embodiment of the invention which besides the elements described in Fig.3 includes additional elements. In addition to the conventional shield 11 there is provided an intermediate shield 36 made of a metal tube, provided with conventional rings 37 suitable for conveniently distributing the electric field. The intermediate shield 36 is appended by means of an insulating tube 38 to the metallic shell 7 in order to be concentric with the supporting metal tube 20. The tubular supporting element 38 is suitably bored in order to allow a correct passage of the insulating gas along the hollow space between the supporting central tube 20 and the inner wall of the porcelain insulating body 2, within which hollow space said intermediate screen 36 is then arranged.

Furthermore the use of a protecting tube 40 is provided generally made of fiberglass reinforced plastic material, adhering to the inner wall of the insulating body 2 in order to avoid dangerous thermo-mechanical stresses in case of an internal discharge.

In order to space the intermediate shield 36 from protecting tube 40 of fiberglass reinforced plastics there are foreseen adjustable spacing elements 42 which allow an optimum centering of the intermediate screen since the inner surface of tube 40 is of very accurate construction having been molded.

A further embodiment is illustrated in Fig.5.

For nominal voltages, generally above 245 kV, in order to reduce the diameter of the insulating body 2 and to allow a better superficial distribution of the electric field, use has been made of a partial capacitive distribution. According to the instant invention, the insulating space inside the insulating container is subdivided into two parts in order to avoid the use of a complete capacitance bushing distribution, as adopted in certain prior art embodiments, which demands the construction of a gas impregnated bushing element of considerable weight and size constituting an economical

and technical burden as a result of a more difficult impregnation of the insulating wrapping,

A first part, formed by the zone lying within the central metal tube 20 and the intermediate shield 36 is insulated by means of a gas whereas the second part consists essentially of a capacitance graded bushing 45 of limited dimensions which however allows a good distribution of the electric field in that part which usually is more stressed. The bushing 45 tied to the intermediate shield 36 is made up by a winding made of an insulating material such as a film of polypropylene or other plastic material within the turns of which are inserted conducting or semiconducting foils so as to form a capacitance graded bushing which allows a good distribution of the electric field in the highest zone 48 of the insulating body 2, i.e. immediately below the head 30, as well as within opening 31 forming a channel for the insulating gas which leads to said head. With this arrangement the intermediate shield 36 is extended downwards beyond the lowest edge of the capacitance graded bushing 45.

The percent distribution of the voltage is computed considering the capacities resulting from the first gas insulated part and the second bushing part and relevant ratio. Also in this embodiment, for a better centering of the intermediate shield 36 and for mechanical safety reasons during transportation, use is made of insulating elements 42 applied between the protecting fiberglass tube 40 and the intermediate shield 36. Said elements are obviously placed in the lowest areas where the electric field is minimal.

For voltages higher than 420 kV, the intermediate shields could be more than two and the capacitance graded bushing will be tied only to the last one, where the longitudinal distribution of the electrical field is more critical.

Said bushing can be made of windings of polypropylene sheets or similar dielectric plastic materials, or of paper, all impregnated with insulating gas.

A further advantage of the windings of limited width is the fact that they can be made of a continuous winding without any, certainly less reliable, ribbon winding.

In case of a partial capacitive distribution, since the value of the capacity can be in the order of many tens of picofarads, one can make a voltage capacitive divider by winding onto the central tube 20 a cylindrical condenser 50 with a capacity to be calculated case by case, from which a tap 52 for energizing suitable measuring or protective circuits can be obtained.

When such circuits are of the electronic type, one can directly use a signal, otherwise, for a higher burden, one has to provide an amplifying circuit, e.g. when an electromagnetic circuit has to be energized.

In a different embodiment the porcelain body 2 can be replaced by a simple, possibly finned, insulating tube.

Claims

1. A transformer for the measurement of current in

high-voltage networks, of the gas-insulated type made up of a base (1) on which a porcelain insulating body (2) is fixed supporting the head (3) of the transformer which is passed through by one of the conductors (4) of a high-voltage line (5), wherein said conductor (4) is the primary of the transformer and produces a magnetic field which interacts with the turns of a secondary wound onto ring-shaped magnetic cores (6) and compacted within an insulating shell (7), at the terminals of which turns of the secondary winding there being provided the low-voltage signals, proportional to the primary current, necessary for measuring purposes and for the protection of the transmission line, characterized by the fact that the shell (7) of the magnetic cores (6) is bound at its bottom to a central metal tube (20) directly fixed onto a base (1) of the pressurized gas insulated transformer whereas on the upper part the shell is bound to an insulating tube (22) so as to build an assembly of elements (22, 7, 20) joined to one another and aligned on the same axis which can adjustably be made taut by means of a spring system (26) blocked between the upper end of said insulating tube (22) and a flange (24) located at the top of the head (30) of the transformer, the upper end of said insulating tube (22) being slidably engaged in the central hole of flange (24) so as to maintain at the same time the insulating tube centered on the axis of the transform and axially free to slide vertically in order to compensate possible longitudinal expansions of said assembly (22, 7, 20).

2. A transformer according to Claim 1, characterized by the fact that the spring system (26) preferably comprises one or more cup-shaped springs locked between the flange (24) and a blocking element (27) located at the extremity of the free end of the insulating element (22).

3. A transformer according to Claims 1 and 2, characterized by the fact that the flange (24) is a disc provided with apertures to allow the pressurized insulating gas to pass to the chamber (13) closed by a breakable safety membrane (14).

4. A transformer according to Claims 1 to 3, characterized by the fact that the flange (24) presents in its lower part an annular projection (28) constituting an upper electrode which lies opposite to a second, lower electrode (29) surrounding the insulating tube (22) and fixed at its upper part to the shell (7) of the magnetic cores (6) in order to form a preferential zone for the electric discharge in the vicinity of the breakable membrane (14) in case of an internal short circuit.

5. A transformer according to Claims 1 to 4, characterized by the fact that there is provided an intermediate shield (36) concentric to the central metal tube

(20), and inside the annular shield (11), said intermediate shield (36) being appended to an insulating tube (38) fixed to the shell (7) of the magnetic cores (6).

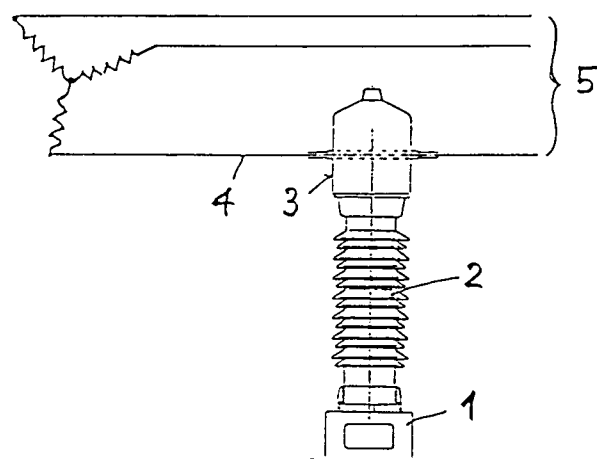
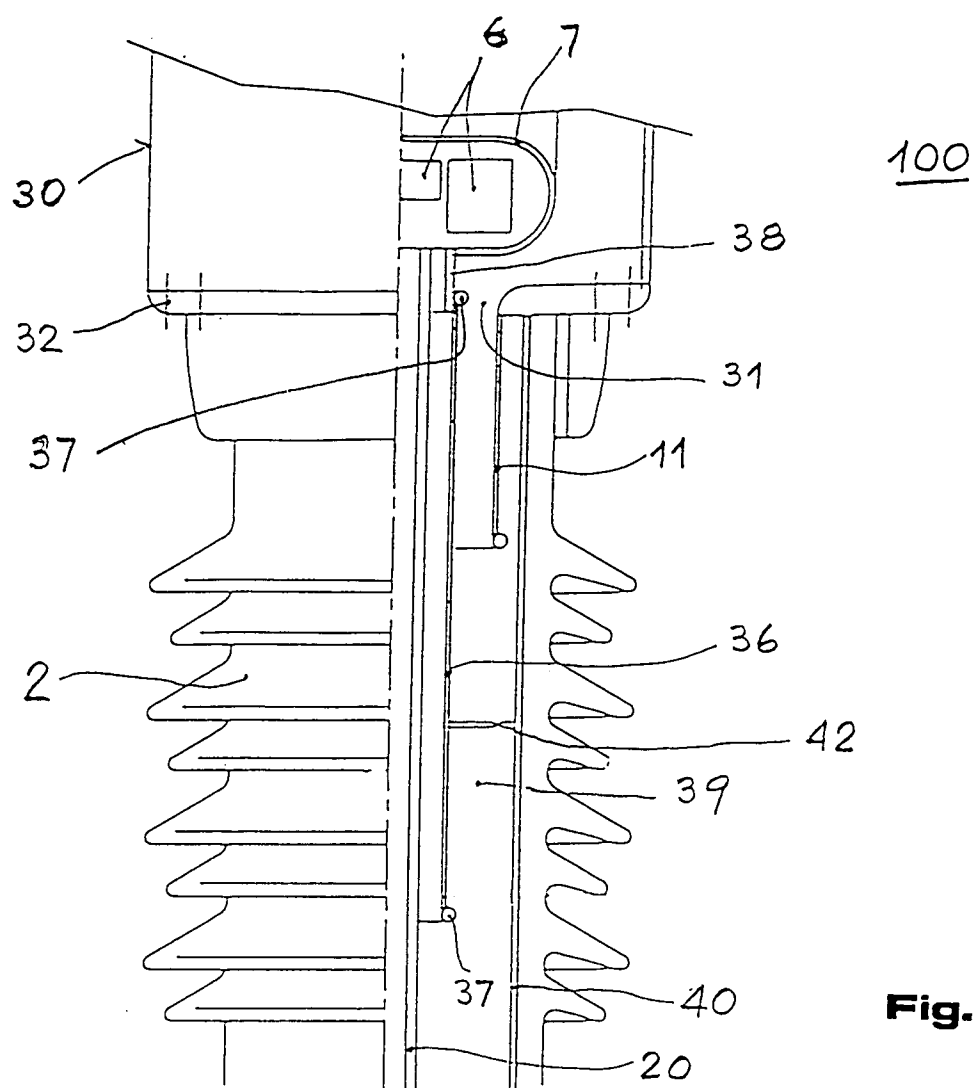
6. A transformer according to Claims 1 to 5, characterized by the fact that there is provided the insertion of a protecting tube (40), e.g. of fiber-glass reinforced plastic material, adhering to the inner wall of the outer insulating body (2) from which the intermediate shield (36) is kept spaced in precise manner by means of radial adjustable spacing elements (42).

7. A transformer according to Claims 1 to 6, characterized by the fact that on the intermediate shield (36) is wound a capacitance grading bushing (45) of limited dimensions in order to allow a better distribution of the electric field in the upper part of the outer insulating body (2) and in the channel (31) for the insulating gas located between the intermediate shield (36) and the shield (11), which channel leads to the head (30) of the transformer.

8. A transformer according to Claims 1 to 7, characterized by the fact that there is provided the insertion of cylindrical condenser (50) insulated from the central metal tube (20) so as to form with the capacity of the capacitance grading bushing (45) and the capacity between the intermediate shield (36) and said cylindrical condenser (50), a capacitive divider which can be employed for measuring the voltage in the high-voltage line (5) and for the voltage protecting system by means of measuring instruments and relays of the electric or electronic type.

9. A transformer according to Claim 8, characterized by the fact that electronic amplifiers are provided when eletromagnetic apparatus is employed.

10. A transformer according to one or more of Claims 1 to 9, characterized by the fact that the outer porcelain body (2) is replaced by a simple, possibly finned, insulating tube.



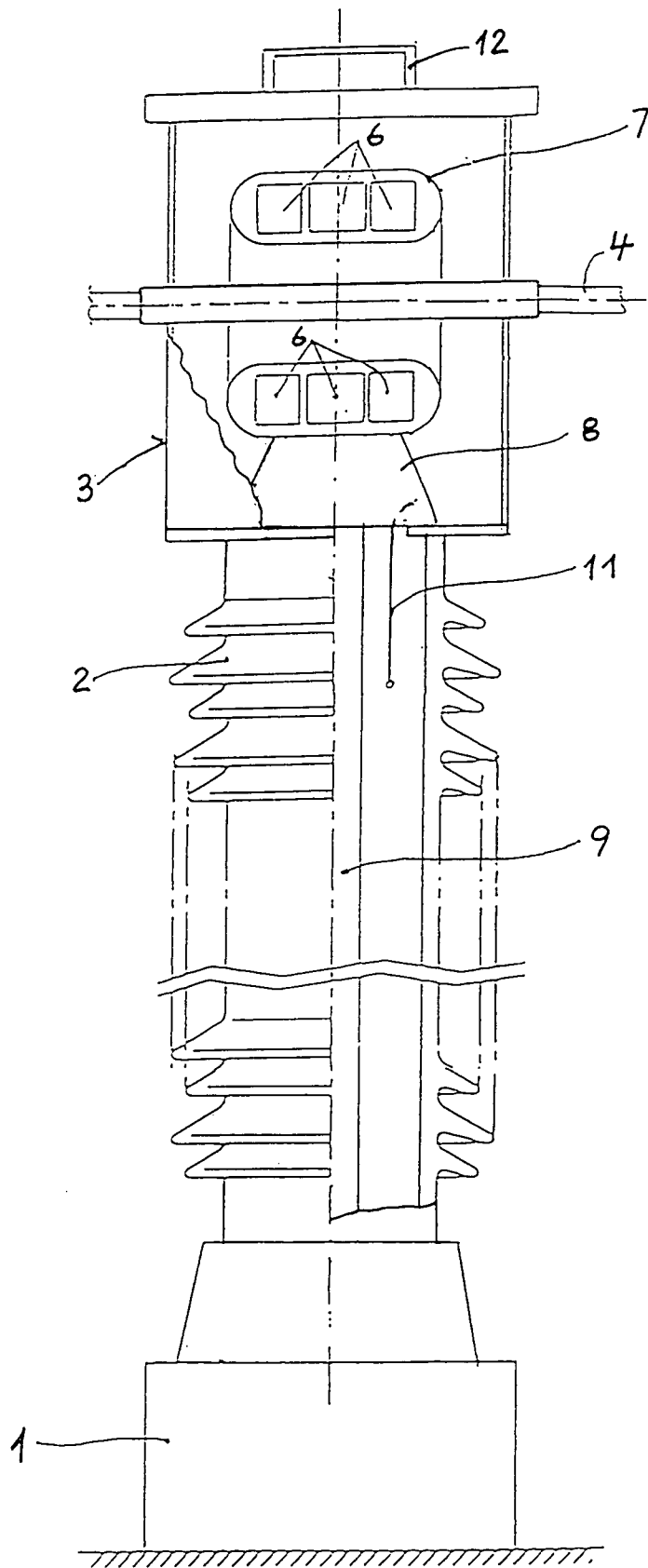


Fig.2

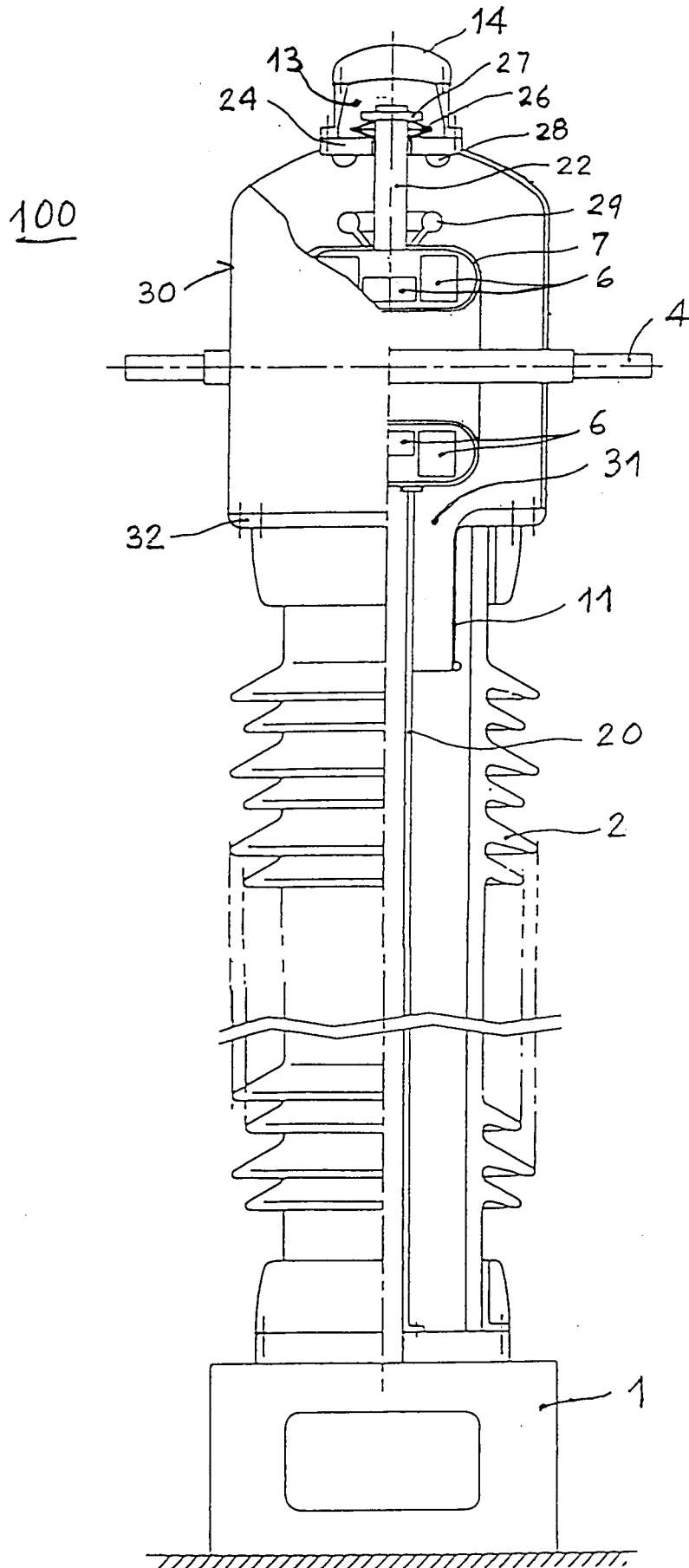


Fig. 3

