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(54) **SEmi-capacitance graded bushing insulator of the type with insulating gas filling, such as SF<sub>6</sub>**

(57) A semi-capacitance graded bushing comprises a conductor (1) fixed in the upper part to a plate (2) of the head (3) and in the lower part by way of a movable contact (4) to the fixed electrode (5) of the gas-insulated bus-duct (6), an insulating capacitance body (7) formed by a winding of insulating material in which are inserted the conductive or semiconductive foils (8), and a tube (9) which is prolonged with respect to the insulating capacitance body (7) to function as an electrode which is duly screened with end rings (10), the insulating capacitance body (7) being supported by the flange (11) which is fixed with respect to the external porcelain (12) by way of a cemented collar (13). A glass fibre-reinforced resin tube (14) is disposed in the interior of the porcelain (12). The whole assembly is filled with insulating gas under pressure, generally SF<sub>6</sub>.

The capacitance, having as armatures the conductor (1) and the electrode (9) and as dielectric the gas, is in cascade relationship with the capacitance of the insulating capacitance body (7).

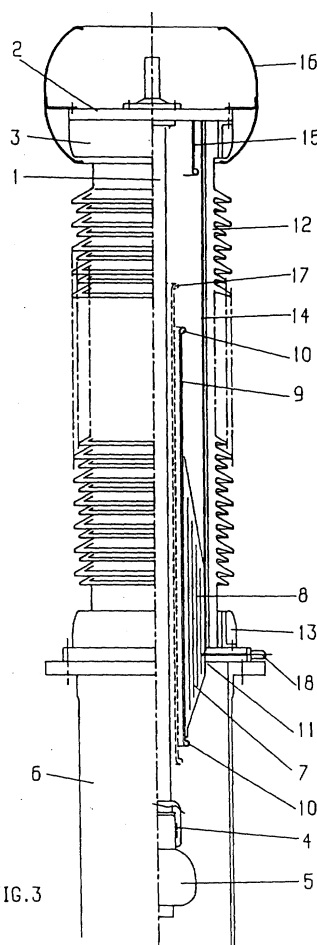


FIG. 3

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## Description

**[0001]** The present invention concerns a semi-capacitance graded bushing insulator of the type with insulating filling of a gas, such as for example sulphur hexafluoride (SF<sub>6</sub>).

### Field of the invention

**[0002]** The present invention aims to provide a semi-capacitance graded bushing insulator which permits the exposure in air of a high-tension conductor capable of carrying current in the connection between an aerial line and an electrical apparatus such as for example a switch, a gas insulated system (GIS), a gas insulated line (GIL) and similar, containing gas under pressure.

### Prior art

**[0003]** The current state of the art involves three systems for affording a graded bushing insulator of the type indicated, namely:

**[0004]** 1 - A graded bushing insulator filled with gas, generally SF<sub>6</sub>, with a fixed electrode or electrodes for improved distribution of the radial and longitudinal electrical gradient (Figure 1).

**[0005]** This system is normally used for voltages which are not very high, that is to say up to 220 kV, and is certainly the most economical but it does not permit ideal distribution of the electrical field both in the radial direction and the longitudinal direction. When there is a wish to use it for voltages of higher than 220 kV the dimensions, both in terms of length and diameter, become very large and, bearing in mind also the mechanical stresses which derive therefrom, the costs involved are very high.

**[0006]** 2 - Insulator having an insulating capacitance body of the resin impregnated paper type (Figure 2).

**[0007]** In this case distribution of the electric field is much better since it is ensured by a discrete number of plates or foils which are inserted during winding of the insulating body. While being of smaller dimensions, they do not exploit the highly insulating properties of sulphur hexafluoride but do use the technology normally employed in the various types of graded bushings used in conjunction with apparatuses filled with oil or in a wall bushing.

**[0008]** The disadvantage of that system lies in the high level of cost and the excessive weight of the assembly.

**[0009]** 3 - Capacitance graded bushing gas impregnated plastics film type insulator (Figure 2).

**[0010]** In this case also, the same advantages and disadvantages as described hereinbefore are involved. Having regard to the limited dimensions of the reels of plastics film, the operation of winding the insulating body has to be implemented, not continuously with a single sheet of film but by means of ribbons, with a system sim-

ilar to that used in cables. A negative aspect is also linked to the greater degree of difficulty of introducing the foils or plates and longitudinal impregnation of the gas in insulating bodies of dimensions involving some metres in length.

### Summary of the invention

**[0011]** The main object of the present invention is that of reducing to the maximum extent the cost of the apparatus for voltages equal to or greater than 220 kV.

**[0012]** The insulating space between the central conductor and the flange is divided into two parts. The first part is formed by the insulating gas and the second part, nearer the flange, is formed by an insulating capacitance body of reduced dimensions having (i) an insulation of plastics material, usually polypropylene, impregnated with SF<sub>6</sub>, or (ii) an insulation of resin-impregnated paper. The dimensions of the insulation, while being limited by the width of the insulating sheet, permit good distribution of the electrical field around the flange and along a good part of the external insulator. Distribution of the electric field relative to the upper part is ensured by the prolongation of the tube on which the insulating capacitance body is wound and which operates as a distribution electrode. That distribution electrode and the upper electrode, at the potential of the head 3 and the upper plate 2, permit good longitudinal distribution also in the upper zone of the porcelain and in the contiguous region of the head of the graded bushing.

**[0013]** The electric field, including the radial field, is distributed uniformly by taking account of the capacitance of the two insulating means calculated with the respective dielectric constants. The gradients are contained in the limits permitted by the two types of dielectric.

**[0014]** The advantages of that system lie in the use of an insulating capacitance body, of reduced dimensions and weight, which can be wound continuously with the advantage of easier insertion of the plates or foils and with the option, in the case of plastics film, of impregnation which is facilitated by the reduced longitudinal dimensions.

**[0015]** The other great advantage is that the gas which surrounds the conductor also acts as a carrier for transfer of the heat produced by the current flowing in the conductor.

**[0016]** Those advantages manifest themselves in a substantial cost reduction.

**[0017]** The semi-capacitance graded bushing according to the present invention is described hereinafter with reference to two embodiments which are illustrated in Figure 3.

**[0018]** As illustrated in Figure 3 the bushing is formed by a conductor 1 fixed to a plate 2, in the upper part, and in the lower part it is fixed by way of a movable contact 4 to the fixed electrode 5 of the gas insulated bus-duct 6. The bushing also includes an insulating capacitance

body 7 formed by a winding of insulating material, in general plastics film or resin-impregnated paper, into which conductive or semi-conductive foils 8 are inserted as armatures, wound on a tube 9 which is prolonged with respect to the insulating body in such a way as to operate as an electrode which is suitably screened with end rings 10. The insulating capacitance body 7 is supported within a flange 11 which is fixed with respect to the external porcelain 12 by way of a cemented collar 13, and is fixed to an insulating tube 14 of glass fibre-reinforced resin disposed in the interior of the porcelain 12 to forestall the thermal shock caused by a possible internal short-circuit. The assembly is filled with insulating gas under pressure, generally  $\text{SF}_6$ . The capacitance, comprising the conductor 1 and the electrode 6 as plates or foils, and the gas as dielectric, is disposed in cascade relationship with the capacitance of the insulating capacitance body and thus stabilises distribution of the voltage which is suitably calculated taking into account the respective dielectric constants.

[0019] In order further to improve distribution of the electrical field in the zone around the terminal electrode 16, an electrode 15 is connected to the plate 2 and thus to the full voltage.

[0020] In addition there can be provided further intermediate electrodes 17, shown in broken lines in Figure 3, which are used in particular for very high voltages, that is to say higher than 550 kV.

[0021] As a further alternative, instead of the external porcelain 12 it would be possible to use a cylindrical insulating container which may or may not be equipped with fins of a polymer material such as silicone, EPDM and others.

[0022] In both the embodiments there is also provided a capacitance tap 18 which, besides checking the capacitance and the  $\text{tg}\delta$  of the bushing, can with suitable capacitive matching be used as a tap for measuring the voltage and/or for actuation of members for protecting the high-tension line.

## Claims

1. A semi-capacitance graded bushing characterised by comprising:-

a conductor (1) fixed, in the upper part, to a plate (2) of the head (3) and, in the lower part, by way of a movable contact (4) to the fixed electrode (5) of the gas insulated bus-duct (6); an insulating capacitance body (7) formed by a winding of insulating material, generally plastics film or resin-impregnated paper, into which are inserted the conductive or semi-conductive foils as armatures (8);

a tube (9) which is prolonged with respect to the insulating capacitance body (7) in such a way as to operate as an electrode suitably

screened with end rings (10), the insulating capacitance body (7) being supported by the flange (11) which is fixed, with respect to the external porcelain (12), by way of a cemented collar (13); and

a glass fibre-reinforced resin tube (14) disposed in the interior of the porcelain (12), in that the assembly is filled with insulating gas under pressure, generally  $\text{SF}_6$ , and in that the capacitance having the conductor (1) and the electrode (9) as foils and the gas as dielectric, is in cascade relationship with the capacitance of the insulating capacitance body (7) and thus stabilises distribution of the voltage which is suitably calculated taking into account also the respective dielectric constants.

2. A semi-capacitance graded bushing according to claim 1 characterised in that an electrode (15) for distribution of the electrical field in the zone around the terminal electrode (16) is connected to the plate (2) and thus to the full voltage.
3. A semi-capacitance graded bushing according to claim 2 characterised in that there is provided inside the tube at least one further intermediate electrode (17) which is used in particular for very high voltages, that is to say voltages higher than 550 kV.
4. A semi-capacitance graded bushing according to any one of claims 1 to 3 characterised in that there is provided a capacitance tap (18) which, besides controlling the capacitance and the  $\text{tg}_\delta$  of the graded bushing, can with suitable capacitive matching be used as a tap for measuring voltage and/or for actuation of members for protection for the high-tension line.
5. A semi-capacitance graded bushing according to any one of claims 1 to 4 characterised in that the insulating capacitance body (7) is wound on the tube (9) and fixed to the glass fibre-reinforced resin tube (14), the outer armature (8) being optionally connected to the flange (11).
6. A semi-capacitance graded bushing according to any one of the preceding claims characterised in that, instead of the external porcelain (12), there is used a cylindrical insulating container which may or may not be equipped with fins of a polymer material such as silicone, EPDM or others.

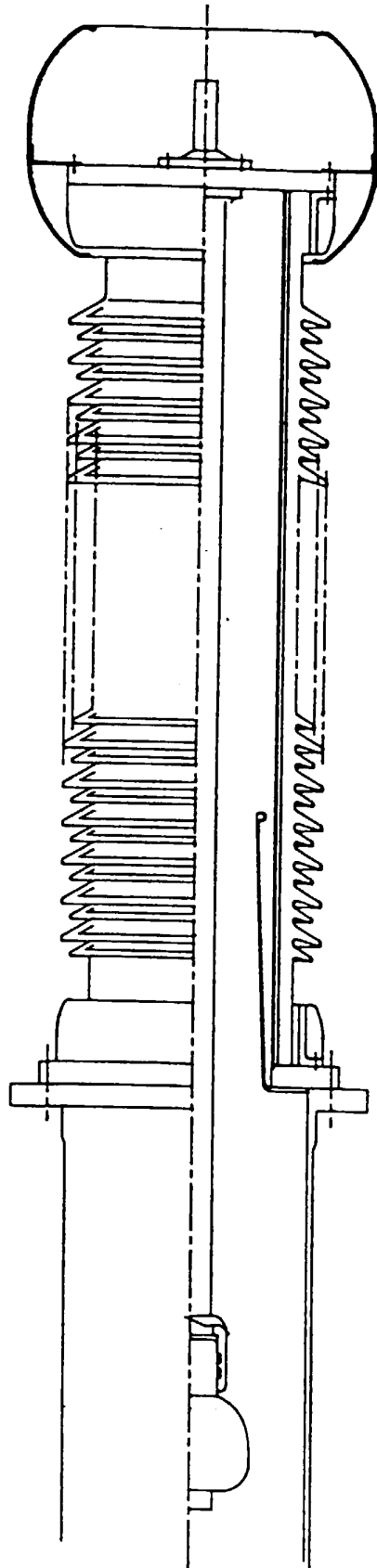


FIG.1

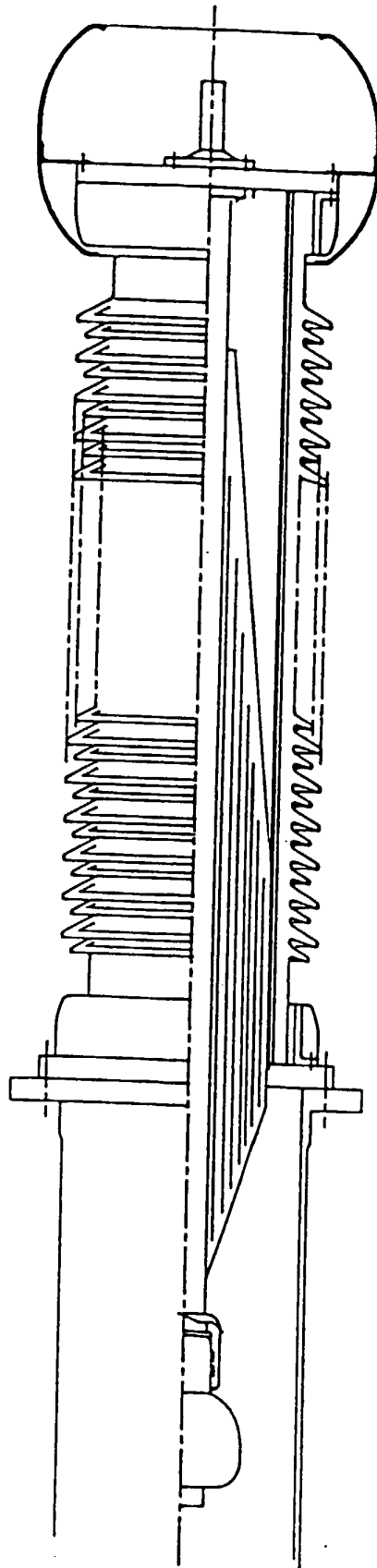


FIG.2

