

TRANSLATION from the original French

EP 0 267 870 B1

Lightning protection system

Description

1/ It is known that lightning protection installations give rise to serious hazards because, when they are struck by lightning, discharges known as high-energy side flashes occur between their standard earthing bare copper conductors and objects or people in their vicinity.

2/ Owing to the ever greater heights of the structures to be protected, the lightning currents can no longer remain confined in the bare earthing conductors without the occurrence of flashovers with often disastrous consequences:

- fires;
- strikes on people;
- destruction of electrical and electronic equipment;
- etc.

3/ The originator of the present invention has already proposed a lightning earthing system remedying this major drawback (US-A-3 919 956) and consisting in fitting a metal sheath around the earthing conductor held off said conductor by a layer of insulating material, said metal sheath itself being enclosed in an insulating layer, with the whole earthed.

4/ It has been possible to make the improvements described in the present invention

- over conventional earthing conductors
 - over all prior-art lightning protection installations which cannot be integrated into an electrically sealed whole, possible only if a coaxial structure providing a hermetic seal is available
 - and finally over the patent cited in paragraph 3/ above
- by using concepts pertaining to high-voltage technology.

5/ Side-flashes occur along bare or insulated earthing conductors simply when the voltage gradient becomes greater than the withstand voltage. The electric field at the surface of a cylindrical conductor depends on its diameter and the environment. The voltage appearing on this conductor when a lightning current is flowing depends on its longitudinal a.c. ohmic resistance.



6/ This resistance may be calculated by solving the Maxwell equations for a cylindrical conductor by means of the Bessel functions. A representative view of the phenomenon is given by the concept of depth of penetration. It is thus possible to demonstrate the "part of the conductor actually used". The frequency spectrum making up lightning current extends from 20 to 100 kHz. For a cylindrical copper conductor, we obtain 0.48 and 0.21 mm respectively for the depth of penetration. Hence a hollow cylindrical conductor has advantages over a solid one of equivalent cross-section.

Example:

bare copper wire, $\varnothing$ 6 mm

$R_{ca} = 2.1 \text{ m}\Omega/\text{m}$ (20 kHz)

$R_{ca} = 4.6 \text{ m}\Omega/\text{m}$ (100 kHz)

EF special cable

$R_{ca} = 0.9 \text{ m}\Omega/\text{m}$ (20 kHz)

$R_{ca} = 2.2 \text{ m}\Omega/\text{m}$ (100 kHz)

Improvement factor about 2

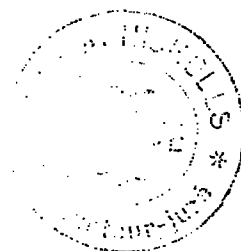
The above figures were calculated using conventional formulae taken from the 3 references below:

- (1) Hochspannungsfelder, H. Prinz, Verlag Oldenburg
- (2) Hochspannungstechnik, lecture, Prof. K. Berger
- (3) Wirbelströme und Schirmung in der Nachrichtentechnik, Dr. H. Kaden, Springer Verlag.

7/ These figures were verified by laboratory measurements for the structure concerned by the present invention. The results are given below:

- i/ When the intermediate insulation layer is of the correct size, side-flashes are never produced and no damage to the structure is found even if overvoltages arise in the central conductor;
- ii/ What are observed during these overvoltages are very low-energy glow discharges which may appear around the structure without damaging it. These discharges were already observed by Tesla a century ago during his experiments on high-frequency currents.

8/ As the value of the overvoltages in a lightning conductor depend on the peak value and wave form of the discharges, in investigating the behaviour of the earthing of the system concerned by the present invention and defining its characteristics, the inventor has been able to take advantage of the very full data on lightning current pulses recently presented by Anderson and Eriksson. The present invention makes it possible to provide an earth capable of withstanding all lightning currents. The invention relates to a lightning conductor as claimed in claim 1 and a lightning protection system as claimed in claim 3.



9/ An extensive examination of all these parameters has revealed that the impedance, i.e. the ohmic resistance and the inductance of the lighting conductor and the metal sheath, has an unfavourable effect and should therefore be reduced to the minimum. Screened cables use a central conductor consisting of a set of metal wires helically wound about a core of insulating material and the metal sheath is likewise made using metal wires or strips helically wound around the insulating layer surrounding the inner conductor.

10/ The result is that, even if the turns forming the inner conductor and the sheath are adjacent or even overlapping (if they are not wires but metal strips) the inevitable coating of oxide on these wires or strips make the current follow a helical path, not a straight one, whence increased ohmic resistance and inductance.

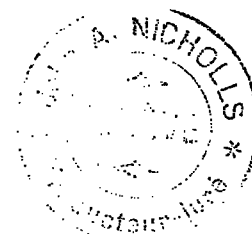
11/ The impedance is very substantially reduced and the performance of a lightning conductor of the present invention is improved by the use of metal wires or strips parallel to the central line of the cable.

12/ The attached drawing represents an embodiment of this lightning conductor. Figure 1 is a partial side elevation with cut-outs showing its internal structure. Figure 2 is a transverse cross-section along 2-2 of Figure 1.

13/ This lightning conductor is a structure in which 1 is the core of insulating material with a circular cross-section around which are arranged adjacent metal wires 2 extending parallel to the centre-line 3 which is the axis of the assembly if it is straight. All of these wires 2 constitute a first earthing member of a lightning protection installation from the top (not shown) of the installation to the earth terminal (not shown). Owing to the pellicular effect of high-voltage electric current, there is no need to fill the space occupied by insulating core 1 with conductive wires 2.

14/ At 4 is a layer of insulating material surrounding the layer of wires 2, the thickness and quality of which are designed to resist overvoltages occurring in component 2 when the lightning current passes through it. At 5 there is a second set of adjacent metal wires also extending parallel to central axis 3. The assembly of these wires 5 constitutes a second conductor completely surrounding insulating sheath 4 and hence also first conductive component 2. This assembly of wires 5 constitutes an electric screen for wires 2 and is earthed at its lower end (not shown).

15/ Around the layer of conductive wires 5 is fitted a protective sheath 6 of insulating material of suitable size. Wires 5 may be overlapping parallel metal strips so that the assembly forms a proper conductive tube.



16/ It might be thought that the second conductive component (5) is truly tubular but that would have the serious drawback of making it difficult to wind this structure without damaging it and putting it on a reel as is customary in the storage and transport of cables. The construction of a corrugated tube would facilitate such winding but increase the ohmic resistance and above all the inductance, since here the current in this component would follow a corrugated path.

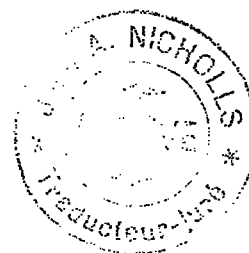
17/ The electrical strain on the insulation must be defined over the entire length of the structure regardless of outside conditions, whence the need, as in high-voltage cables, to use a concentric conductive screen. Thus this lightning conductor can be fitted near points or metal edges without any adverse effects on its electrical behaviour.

18/ The high-voltage insulation must be mechanically protected to prevent any risk of damage during transport, fitting and commissioning. The robust metal assembly and a sheath resistant to extreme climatic conditions does so perfectly.

19/ Finally, because of the protective screen it is possible at any time to check the condition of the high-voltage insulation by two simple electric tests.

20/ All these considerations have made it possible to make a down lightning protection installation meeting the requirements of the modern world, with a side-flash hazard 45 to 90 times lower than that of a bare conductor. Laboratory experiments and the calculated values confirm the sound basis of this design.

21/ With a coaxial structure which, however is neither manufactured nor used like conventional coaxial cables, the inventor has for the first time been able to discover in the laboratory, using mathematical models and wide experience in nature, that the lightning protection can be effective only if it does not electrify the structures. For this fundamental reason he has designed a high-voltage terminal through which the present system can conduct lightning to earth without electrifying the structures.





Claims

1. A lightning down conductor (Fig. 1) comprising a first component (2) conducting the lightning, an insulating sheath (4) surrounding said conductive component and a second conductive component (5) completely surrounding said insulating sheath, earthed at its lower end, in which the two said conductive components (2 and 5) are each made up of an assembly of adjacent metal conductors in the form of wires or strips all extending parallel to the centre-line (3) of the assembly consisting of these two conductive components (2 and 5) and the intermediate insulating sheath (4).
2. A lightning down conductor as claimed in claim 1 (Fig. 2) in which the second conductive component (5) is made up of overlapping strips together forming a metal cylinder.
3. A lightning protection system making use of a lightning down conductor as claimed in claims 1 and 2, in which the upper section is fitted with a high-voltage terminal (Fig. 3) designed to allow all the components of the system to constitute an electrically sealed lightning protection installation.

Geneva, 7th February, 1992

Certified true and correct translation

