

This invention relates to insulating equipment for an aerial electric line pole according to the preamble of claim 1.

5 The invention concerns also a method for manufacturing such an equipment.

The electric lines used to carry electricity under low, medium, and high tension are supported by poles or pylons by means of brackets called "equipment" provided with insulators.

10 In the embodiment known to date, this equipment is made up of metallic pieces provided with means for attachment to the pole and with means for hanging the electrical line in a direction perpendicular to the equipment.

15 These braces are rigid, and thus cannot be bent by forces applied to the electrical lines. But the electrical lines may be subjected to unusually heavy loads due to frost, snow, or wind.

20 Since these loads do not lead to any deformation of the equipment, the above-mentioned unusually heavy loads may cause the line to break, the latter in turn being able to cause torque that can lead the pole to break.

25 To avoid such drawbacks it has been proposed that the equipment be made of a flexible material of glass fiber-reinforced synthetic resin and having a cross section that decreases regularly from the pole.

30 Ideally this equipment should have the greatest possible longitudinal flexibility, while also being able to support the greatest possible vertical loads. In practice, such a compromise is difficult to realize.

The object of this invention is to create equipment that makes it possible to attain the above-mentioned objective, while also being inexpensive.

35 The equipment of this invention comprises a flexible arm which is provided at one end with means for

attaching it to the pole, and at the other end with means for attaching to it an electric line substantially perpendicularly to the arm. The arm has a rectangular cross section, with a height of the section measured in a plane perpendicular to the electrical line being greater than the width of the section measured in a direction parallel to the electrical line.

According to the invention, the width of this cross section decreases regularly from the point at which the equipment is attached to the post to the point at which it is attached to the electrical line; whereas the height of the cross section is constant; the arm, in the direction of its thickness, has a series of layers of continuous mineral fibers extending in the direction of the arm's length, each separated by a layer of randomly-oriented short mineral fibers, these fibers and layers being bonded to one another by a synthetic resin.

This succession of layers of mineral fibers coated in a synthetic resin gives the equipment, by virtue of its geometry, great longitudinal flexibility, as well as great resistance to vertical loads.

The layers containing continuous fibers extending along the length of the equipment, and embedded in the synthetic resin, because they are disposed in vertical planes, give the equipment great resistance to vertical loads, as well as high bending strength. Moreover, because the cross section of the equipment has a greater dimension in the vertical than in the longitudinal direction of the electric line, and because this section decreases regularly from the pole, the equipment has great longitudinal flexibility.

The layer containing randomly-oriented short fibers make it possible to distribute the thermal and mechanical stress among the above-mentioned layers of continuous fibers.

Moreover, this intermediate layer of randomly-oriented short fibers makes it possible to perforate the arm. In fact, if the equipment had only continuous longitudinal fibers, perforation of the equipment would cause delamination.

To increase the equipment's resistance to torsional stress, a layer of a fabric of mineral fibers is placed on each side of the arm between the first layer of short fibers and the next layer of continuous fibers. This fabric preferably encloses fiber filaments placed at $+45^\circ$ and -45° to the direction of the length of the equipment, which gives optimal resistance to torsion.

Thus, the functions of the different successive layers of the equipment, according to the invention, jointly contribute to making an equipment with the desired mechanical properties.

According to a preferred embodiment, the proportion of continuous fibers is greater than that of short fibers.

This proportion is based on the primary role of the continuous fibers in obtaining the sought-after mechanical properties. It is thus advisable to use the greatest possible number of continuous fibers.

According to a preferred version of the invention, certain layers of short fibers are separated from the next layer of continuous fibers by a supplementary layer of short fibers that extends over only a part of the length of the arm from the end that attaches to the pole. The length of this layer of short fibers diminishes progressively from the exterior to the middle of the width of the arm to produce a regularly decreasing width of the arm from the pole to the end of the equipment intended to support the electric line.

Preferably, the exterior surface of the arm is covered by a plastic coating resistant to electric arcing, inclement weather, and ultra-violet rays, made of

a material such as an ethylene-propylene-diene-methylenic (EPDM) copolymer.

According to another aspect of the invention, the method for manufacturing insulating equipment for electric line poles comprises the following steps:

- making strips containing a layer of continuous fibers that extend along the length of the strip and a layer of randomly-oriented short fibers pre-impregnated with polyester resin and possibly strips of a fabric of fibers at $\pm 45^\circ$ to the lengthwise direction of the strip;

- cutting these strips to the dimensions of the desired length and height of the equipment;

- stacking the different strips according to the desired placement;

- preheating this stack to a temperature below the polymerization temperature of the polyester resin;

- placing the stack in a mold, and heating and applying pressure to mold the stack.

Other features and advantages of the invention will be described below.

The following drawings are given as non-limiting examples:

- FIG. 1 is an elevation view showing the upper part of a pole outfitted with an equipment according to the invention;

- FIG. 2 is a top plan view of FIG. 1;

- FIG. 3 is a view in transverse cross section, at a larger scale, of the equipment;

- FIG. 4 is a schematic plan view of part of a layer containing continuous longitudinal fibers;

- FIG. 5 is a schematic plan view of part of a layer containing randomly-oriented continuous fibers;

- FIG. 6 is a schematic plan view of part of a fabric of fiber filaments disposed at $\pm 45^\circ$;

- FIG. 7 is a schematic view in longitudinal cross section showing the juxtaposition of the layers of FIGS. 4, 5, and 6;

5 - FIG. 8 is a schematic view of the equipment in longitudinal cross section showing the different layers of this equipment according to the invention;

- FIG. 9 is a longitudinal cross-section of a mold illustrating the method for manufacturing the equipment according to the invention.

10 In the embodiment of FIGS. 1 and 2 a lateral equipment 1 is constituted by a flexible arm having at one end a support 2 to attach it to a pole 3 and at its other end a tip 4 carrying a cable clamp 5 to which is attached an electric line 6 extending perpendicularly to arm 1. Arm 1 has a rectangular transverse cross section (see FIG. 3). The height l of this section measured in a plane perpendicular to the electrical line 6 is clearly greater than the width e of this section measured in a direction parallel to the electrical line 6 in the plane of FIG. 2.

20 As can be observed in FIG. 2, the width e of the transverse cross section of arm 1 decreases regularly from the support 2 of the attachment to the pole 3, toward the tip 4 for attachment to the electrical line 6. In addition, the height l of this section is constant (see FIG. 1).

30 The arm 1 has in the direction of its width e , i.e., in the plane of FIG. 2, a series of layers 7a, 7b, 7c, 7d of continuous glass fibers 10 (see FIGS. 4, 7, 8) extending in the direction of the length L of arm 1. These layers 7a, 7b, 7c, 7d are separated by a layer 8a, 8b, 8c, 8d of randomly-oriented short glass fibers 11 (see FIGS. 5, 7, 8). These two layers and their fibers are bonded by a synthetic resin, such as a polyester resin.

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In addition, layers 9a, 9b of glass fiber fabric are disposed (see FIG. 8), one on each side of the arm 1, between the first layer of short fibers 11 and the next layer 7b of continuous fibers 10.

5 The different layers are distributed symmetrically on either side of the neutral fiber N of arm 1.

10 The different layers, such as 7a, 8a, 9a are bonded by polymerization of the synthetic resin, using a pressure molding operation that will be described below.

15 The proportion of continuous fibers 10 preferably should be greater than that of short fibers 11. The continuous fibers 10 should account for approximately 80% of the weight of all the fibers, the short fibers 11 thus accounting for approximately 20% of the total.

 The continuous fibers 10 and short fibers 11 preferably should account for 50 to 60% of the total mass, the proportion of synthetic resin thus accounting for 40 to 50%.

20 The fabric 9a (or 9b) (see FIG. 6) has a first series of filaments 12a of parallel glass fibers placed at $+45^\circ$ with respect to the direction of the length L of the arm 1, and a second series of filaments 12b of parallel fibers placed at -45° with respect to that
25 direction.

30 Furthermore, one can observe in FIG. 8 that certain layers of short fibers are separated from the next layer of continuous fibers by a layer of short fibers such as 13a, 13b, 13c which extends along only a part of the length L of the arm 1 from the support 2 where it is attached to the pole 3. The length of these layers of short fibers 13a, 13b, 13c diminishes progressively from the exterior toward the middle N of the width of the arm 1 to produce a width e that
35 decreases regularly, as indicated in FIG. 2.

Moreover, the exterior surface of the arm 1 is covered (see FIG. 3) with a coating 14 made of elastomer resistant to electric arcing, inclement weather, and ultra-violet rays, such as an ethylene-propylene-diene-methylenic (EPDM) copolymer.

The support 2 that attaches the arm 1 to the pole 3, as well as the tip at end 4, preferably are made of aluminum and are fixed to the arm 1 by gluing. Of the common metals, aluminum has the expansion coefficient closest to that of the composite material (glass fibers, polyester resin) of which arm 1 is made, so that the bonding of the support 2 and the tip 4 to the arm 1 do not run the risk of being affected by variations in temperature.

Following is a detailed description of the method for manufacturing the equipment in accordance with the invention.

In a first step, a strip is made that comprises, in succession, a layer of continuous glass fibers 10 that extend along the length of the strip, a layer of randomly-oriented short fibers 11, and a layer of fabric 9a of glass fiber filaments 12a, 12b forming an angle of $\pm 45^\circ$ with respect to the length L of the strip. Together these layers are pre-impregnated with a polyester resin.

The make-up of this strip might be, for example, as follows:

	- polyester resin:	18%
30	- shrink-proof thermoplastic agent:	12%
	- adjuvant, coloring catalyst:	3%
	- mineral fillers:	12%
	- glass fibers:	55%

The strips, pre-impregnated with polyester resin, are then cut to the dimensions of the arm 1.

The strips are then stacked following the distribution illustrated in FIG. 8.

5 The stack thus made is then placed in a high-frequency pre-heater for heating to approximately 70°C (a temperature less than the polymerization temperature of the polyester resin).

This preheating makes it possible in particular to diminish the thermal stress within the material when the molding is performed.

10 The resulting stack 15 is then placed in a mold (see FIG. 9) of two parts 16 and 17 placed in a press. The stack 15 is heated to the polymerization temperature of the polyester resin, all the while applying pressure (see arrows F in FIG. 9).

15 The stack 15 is then withdrawn from the mold, trimmed, cooled, and then sanded or pumiced to obtain the best possible surface.

The aluminum support 2 and tip 4 are then bonded to the ends of the stack.

20 The adhesive used for this can be a semi-conductive adhesive to avoid problems of partial discharges. The exterior surface of the arm thus obtained is then coated with an adherence primer and then a coating of EPDM.

25 For a given flexibility, the equipment thus produced is more resistant to vertical loads than equipment of constant cross section and inertia produced, for example, by drawing through a die.

30 Thus, such equipment produced in accordance with the invention, with a length L equal to 150 cm, a height l equal to 90 mm, and a width e decreasing from 25 to 20 mm supports a static vertical load greater than 240 daN and has a longitudinal flexibility greater than 5 mm/daN.

35 These mechanical properties result from the fact that the equipment encompasses a large proportion of

continuous longitudinal fibers 10. The fabric having glass fiber filaments 12a and 12b forming angles of + 45° and - 45° with the direction of the length L of the equipment makes it possible to increase the torsion resistance of the equipment, while the layers enclosing the randomly-oriented short glass fibers 11 make it possible to distribute the thermal and mechanical stresses among the fabric and the adjacent long-fiber layers and to perforate the arm 1 without risk of delamination.

In the case in which the equipment is intended to withstand less torsional stress, the presence of fabric 9a, 9b is not necessary.

It should be understood that the invention is not limited to the embodiments which have just been described; various modifications can be made within the framework of the invention.

For example, the glass fibers can be replaced by other mineral fibers such as rock fibers.

Also, the polyester resin can be replaced by another heat set or thermoplastic resin.

In addition, the dimensions of the arm 1 can be modified according to needs.

Also, arm 1, instead of being perpendicular to the pole 3 can be placed at an oblique angle.

In addition, in the method for manufacturing the equipment, instead of stacking the strips of pre-impregnated fibers, cut to the dimensions L and l of the equipment, on top of one another, one can proceed as follows:

A sheet having a length L of the equipment and having a layer of continuous fibers and a layer of short fibers pre-impregnated with resin is rolled so as to form a flattened spiral comprising strips of maximum height equal to l bonded to one another. Thus, a stack is made

composed of successive layers of continuous fibers and short fibers.

5 To obtain a decreasing width, variable length strips, such as the short-fiber layers (13a, 13b, 13c) shown in FIG. 8, are intercalated between the layers of the spiral.



CLAIMS

1. Insulating equipment for a pole (3) to support electric lines (6) constituted by a flexible arm (1) comprising at one end means (2) for attaching it to the pole (3) and at the other end means (4, 5) for attaching an electric line (6) in a way substantially perpendicular to the arm, this arm (1) having a rectangular transverse section, the height (1) of this section measured in a plane perpendicular to the electric line (6) being greater than the width (e) of this section measured in a direction parallel to the electric line (6), characterized in that the width (e) of this section decreases regularly from the means (2) for attaching it (2) to the pole (3) towards the means (4) for attaching it to the electric line (6), the height (1) of this section being constant, in that the arm (1) has in the direction of its width, a succession of layers (7a, 7b, 7c, 7d) of continuous mineral fibers (10) extending in the direction of the length (L) of the arm, separated by a layer (8a, 8b, 8c, 8d) of short mineral fibers (11) randomly oriented, these fibers and these layers being bonded to each other by a synthetic resin.

2. Equipment according to claim 1, characterized in that a layer (9a, 9b) of fabric of mineral fibers is placed on each side of the arm (1) between the first layer of short fibers and the following layer of continuous fibers.

3. Equipment according to claim 1, characterized in that the proportion of continuous fibers (10) is greater than the proportion of short fibers (11).

4. Equipment according to claim 3, characterized in that the proportion of continuous fibers is superior to the proportion of short fibers.

5. Equipment according to one of claims 1 to 4, characterized in that the mass of fibers (10, 11) accounts for 50 to 60% of the total mass.



6. Equipment according to one of claim 1 to 5, characterized in that the synthetic resin is a polyester resin.

5 7. Equipment according to one of claims 2 to 6, characterized in that the fabric (9a, 9b) has a first series (12a) of parallel fiber filaments placed at $+45^\circ$ with respect to the direction of the length (L) of the arm (1) and a second series (12b) of parallel fiber filaments placed at -45° with respect to this direction.

10 8. Equipment according to one of claims 1 to 7, characterized in that certain layers of short fibers 11 are separated from the next layer of continuous fibers (10) by a layer of short fibers (13a, 13b, 13c) or of continuous fibers that extends over only a part of the
15 length (L) of the arm from the means of attachment (2) to the pole, the length of this layer (13a, 13b, 13c) of short fibers or continuous fibers diminishing progressively from the exterior towards the middle (N) of the width of the arm resulting in a width (e) that
20 decreases regularly.

9. Equipment according to one of claims 1 to 8, characterized in that the exterior surface of the arm (1) is covered by a coating (14) of elastomer resistant to the electric arcing, inclement weather, and
25 ultraviolet radiation.

10. Equipment according to claim 8, characterized in that coating (14) is an ethylene-propylene-diene-methylenic copolymer.

11. Method for manufacturing insulating
30 equipment for a pole (3) to support electric lines (6), in accordance with one of claims 1 to 10, characterized in that it comprises the following stages:

35 - strips enclosing a layer (7a, 7b, 7c, 7d) of continuous fibers (10) extending along the length of the strip and a layer (8a, 8b, 8c, 8d) of randomly-oriented short fibers (11) are made pre-impregnated with polyester



resin and possibly strips of material (9a, 9b) of fibers at $\pm 45^\circ$ with respect to the direction of the length (L) of the strip.

5 - one cuts strips down to the dimensions of the length (L) and of the height (1) desired for the equipment.

 - one stacks the different strips according to the placement desired.

10 - one preheats the stack (15) obtained at a temperature lower than polymerization of the polyester resin.

 - one places the stack (15) in a mold (16), and one molds this stack applying pressure on it. g

15 12. Method according to claim 11, characterized in that the stack (15) of strips is preheated at about 70°C in a high-frequency preheater.

20 13. Method for the manufacturing of insulating equipment in accordance with one of claims 1 to 10, characterized in that one uses a sheet having the length L of the equipment and with a layer of continuous fibers and a layer of short fibers pre-impregnated with resin, one rolls this sheet so as to form a flattened spiral made up of strips bonded to one another to make a stack with the successive placement of continuous-fiber
25 layers and short fiber layers and, to obtain a decreasing width, one intercalates between layers of the spiral, layers of variable length having short fibers (13a, 13b, 13c) or continuous fibers.