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"COMPOSITE OVERHEAD TRANSMISSION LINE AND METHOD OF
MANUFACTURING SUCH A LINE"

5 This invention relates to a composite overhead
transmission line including an optical fibre cable, the
line being formed by stranding a plurality of
conductors.

10 Optical fibre cables have been extensively used as
signal transmission media, and have specific features
in that not only are they large in data transmission
capacity, but they are also free from electromagnetic
induction. Accordingly, an optical fibre cable can be
incorporated in an overhead line or an ordinary power
line. That is, the optical fibre cable provides a great
economical effect in that it is unnecessary to
15 additionally install a communication cable.

20 Heretofore, in order to incorporate the optical fibre
cable into an overhead transmission line, some of the
stranded conductors forming the line are replaced by an
optical fibre cable unit (hereinafter referred to as
"an optical fibre unit") which is obtained by
incorporating a plurality of optical fibres in a metal
tube. In the above-described conventional construction,
the wall thickness of the metal tube covering, the
optical fibre unit is generally small because of
25 dimensional limitations. Accordingly, the metal tube is
insufficient in mechanical strength and accordingly
cannot sufficiently protect the optical fibres from
damage. Thus, the outer cover is liable to be damaged
and water may enter the optical fibre unit.

30 On the other hand, since it is difficult to increase
the inside diameter of the metal tube, it is difficult
to increase the degree of twist of the optical fibre

cable itself, and accordingly it is impossible to form a cable with the optical fibre slackened.

5 It is an object of the present invention to provide an overhead transmission line incorporating an optical fibre cable, wherein the above-described difficulties are minimised, and a method of manufacturing such a line.

10 In accordance with the present invention there is provided a composite overhead transmission line comprising: at least one stranded wire layer which includes a plurality of conductor wires made of metal or metal alloy; a central optical fibre unit which includes a spacer formed with spiral grooves in its outer peripheral surface, and a metal cover disposed
15 over said spacer in close contact therewith; and optical fibres housed in said spiral grooves each optical fibre being smaller in diameter than the depth of its respective groove and being positioned at a radially outer portion of its respective groove.

20 In accordance with a further aspect of the present invention, there is provided a method of manufacturing a composite overhead transmission line of the type having at least one stranded wire layer which includes
25 a plurality of conductor wires made of metal or metal alloy, comprising the steps of: providing a cylindrical spacer member extending along the longitudinal axis of said layer, said spacer member having spiral grooves in the outer surface thereof, filling said spiral grooves
30 with a jelly-like material, burying an optical fibre, the diameter of which is less than the depth of the grooves, in the jelly-like material in each of said grooves, each optical fibre being positioned at a radially outer portion of its respective groove,

applying a cover member around said spacer member in contact therewith, thereby forming an optical fibre cable unit.

5 One example of the invention will be described with reference to the accompanying drawings, wherein:

Figures 1 and 2 are sectional views showing an overhead composite transmission line;

Figure 3 is an explanatory diagram illustrating a method of manufacturing the line;

10 Figures 4a-4e are sectional views of the line at various manufacturing steps; and

Figures 5a and 5b are explanatory diagrams showing a collecting die of Figure 3.

15 Figure 1 shows one example of a composite transmission line incorporating an optical cable. An optical fibre unit 2 is disposed along the common axis of stranded electrical conductors 1. The optical fibre unit 2 is made up of a spacer 2-1 having spiral grooves 2-2 in its outer walls, a metal tube 2-3 which covers the
20 outer wall of the spacer 2-1, and optical fibres 3. The spiral grooves 2-2 are filled with a jelly-like material 4, which is fluidic or substantially fluidic at room temperature, such as an aqueous solution of petroleum jelly, polyisobutylene, non-bridged
25 (non-crosslinked) silicon resin, silicon oil or polyvinyl alcohol.

The optical fibres 3 are placed in the grooves cut in the spacer, and the spacer is covered with the metal tube 2-3. Therefore, the optical fibres are
30 sufficiently protected from external forces, and are packaged in a substantially water-proof manner.

Since the grooves of the spacer are filled with the jelly-like material, the composite transmission line is efficiently protected from the entrance of water even when the metal tube is damaged, and the optical fibres are stably arranged in the grooves toward the outer wall of the spacer.

As the optical fibres are located in the grooves adjacent the spacer outer wall, they are maximumly stranded, which will substantially absorb any elongation which may be caused when the composite transmission line is installed.

Figure 2 is a sectional view of an overhead composite transmission line which has been elongated when installed.

When the overhead line is installed, the optical fibres incorporated in the grooves are caused to move from the outer wall to substantially the middle points of the respective grooves, as a result of which the optical fibres are not elongated, i.e. the cable elongation is absorbed. The absorption of elongation depends on the outside diameter D of the spacer, the groove depth h and the spiral pitch P. The absorption is as indicated in the following Table 1, with the outside diameter d of each optical fibre strand being 0.7mm.

Table 1 (P = 150 mm)

D (mm)	4			6		
h (mm)	1.0	1.2	1.3	1.0	1.2	1.5
Absorption of elongation ξ (%)	0.08	0.12	0.14	0.13	0.21	0.25

$$\xi = \frac{2\pi^2 (D - h)(h - d)}{p^2}$$

In the above described composite line, the grooves in the spacer 2-1 are filled with jelly-like material. However, it should be noted that one object of this invention is to allow the cable to be stretched during installation while avoiding any elongation of the fibres, i.e. to form the cable with slackening. In this connection, the optical fibres can be placed in the peripheral portions of the grooves without filling the grooves with the jelly-like material 4. This can be achieved by applying a greater feed force to the optical fibres 3 than that to the spacer 2-1 to avoid any application of tension to the fibres during assembly, to position the optical fibres at radially outward portions of the grooves 2-2.

This arrangement is advantageous in the following points. Even if the thickness of the metal cover 2-3 is reduced, the optical fibre unit is not collapsed nor broken because of the presence of the spacer 2-1. Therefore, the unit is maintained water-proof without filling the grooves with the jelly-like material.

In order to improve the stability of the optical fibres in the grooves, the section of each groove 2-2 should be such that the inner part is equal to or larger than the opening part thereof in size.

The outer cover of the optical fibre unit is a metal tube, as described above. The cover serves not only to protect the cable from external forces or moisture but also to improve the temperature characteristic of the optical fibre. The overhead line often undergoes a high temperature of several hundred of degrees centigrade (C) because of an induction current, lightning current, or short current. If the thermal expansion coefficient of the optical fibres is larger than that of the

spacer, then the optical fibres are brought into contact with the inner wall of the metal tube as shown in Figure 1 when the temperature is increased, and are then moved back as shown in Figure 2 when the temperature is decreased. On the other hand, if the thermal expansion coefficient of the optical fibres is smaller than that of the spacer, then the optical fibres are positioned as shown in Figure 1 at low temperatures for instance at night, and are positioned as shown in Figure 2 at high temperatures, for instance during daytime. Although the optical fibres are thermally expanded and contracted as described, they are not slightly bent, because the plastic covers of the optical fibres are slidable on the surface of the metal tube. Therefore, the transmission loss variation is maintained at a minimum. According to the result of experimentation, it has been confirmed that, in the case where a material such as a coarsely wound tape or string is interposed between the spacer and the metal tube in order to hold the optical fibres in the grooves in the spacer, the fibres cannot smoothly move when the temperature changes, and accordingly the transmission loss is greatly increased.

The spacer may be made of a metal or non-metal. However, in order to maintain the characteristic of the optical fibres stable, it is desirable that the thermal expansion coefficient of the material of the spacer be substantially equal to that of the material of the metal tube. It is advantageous from the point of view of both the thermal expansion coefficient and mechanical strength that the spacer be made of a metal material such as aluminum, iron or copper, or a non-metal material such as fibre reinforced plastic.

Figure 3 shows one example of a method of manufacturing an overhead composite transmission line incorporating an optical fibre unit according to the invention. The spacer 2-1 in which the spiral grooves have been cut is fed from a supply reel 5. The spacer 2-1 thus fed is passed through a jelly-like material filling device 6, so that the grooves 2-2 thereof are filled with petroleum jelly 4. Thereafter, the optical fibre conductors 3 are supplied from rotary cages and are buried in petroleum jelly 4 near the openings of the grooves. In this condition, the spacer is delivered to a metal tube covering device, where the spacer and the optical fibres in the grooves are covered by the metal tube. The metal tube 2-3 is formed by a conventional method in which a shaping device 9 is used to butt-joint a metal tape 8 to provide a butt-jointed cylinder, and the cylinder thus provided is butt-welded. In Figure 3, reference numeral 10 designates a welding electrode.

Figure 4 shows sections of the optical fibre unit in various stages of the manufacturing process in the case where the unit is manufactured according to the above described method. More specifically, Figure 4a shows the petroleum jelly 4 filled in the grooves 2-2 in the spacer 2-1 at the point A immediately after the filling device 6, Figure 4b shows the optical fibres being put on the petroleum jelly 4 near the openings of the grooves at the point B, and Figure 4c shows the optical fibre unit at the point C immediately after a collecting die 7. Figure 4d shows the optical fibre unit including the metal tube at the point D immediately after a cooling device 11, and Figure 4e shows the optical fibre unit at the point E immediately after a diameter reducing device 12 arranged before a winding reel 13. In the manufacturing method, after the

petroleum jelly or the like is filled in the grooves cut in the spacer, the optical fibres are buried in the petroleum jelly in the grooves and near the periphery of the spacer. Under this condition, the spacer is
5 covered with the metal tube, to form the optical fibre unit. Therefore, the method is advantageous in that the optical fibres can be stably and positively arranged in the grooves in the spacer and near the periphery of the latter.

10 In the above described embodiment, the metal tube or cover is made according to a welding method; however, it goes without saying that it may be manufactured according to other conventional tube manufacturing
15 method. It is desirable that the collecting die be designed so that it, as shown in Figures 5a and 5b, includes an internal cavity 7-1 and a passage 7-2 extended outwardly from the cavity 7-1. In this case, even if the petroleum jelly is partly pushed out of the
20 grooves when the optical fibres are buried in the grooves, the petroleum jelly thus pushed out can be removed, and the operation of incorporating the optical fibres in the grooves can be protected from being affected by excessive jelly.

25 It will be understood that the transmission line can be an overhead earth line of a transmission system.

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CLAIMS:

1. A composite overhead transmission line comprising: at least one stranded wire layer which includes a plurality of conductor wires made of metal or metal alloy; a central optical fibre unit which includes a spacer formed with spiral grooves in its outer peripheral surface, and a metal cover disposed over said spacer in close contact therewith; and optical fibres housed in said spiral grooves each optical fibre being smaller in diameter than the depth of its respective groove and being positioned at a radially outer portion of its respective groove.
2. A composite overhead transmission line as claimed in claim 1, wherein said spacer and said cover member have substantially equal coefficient of thermal expansion.
3. A composite overhead transmission line as claimed in claim 1, wherein said spacer and said cover are both made of metal.
4. A composite overhead transmission line as claimed in claim 1, wherein said spacer is made of electrically insulating material and said cover is made of metal.
5. A composite overhead transmission line as claimed in claim 1, further comprising a jelly-like material filling said grooves, said optical fibres being movable within said jelly-like material near the inner wall of said cover.



6. A composite overhead transmission line as claimed in claim 5, wherein said optical fibres are movable within said jelly-like material so as to migrate toward the axis of the transmission line thereof when the line is elongated.

7. A composite overhead transmission line as claimed in claim 5, wherein said jelly-like material is selected from the group comprising petroleum jelly, polyisobutylene, non-cross-linked silicon resin, silicon oil and polyvinyl alcohol.

8. A method of manufacturing a composite overhead transmission line of the type having at least one stranded wire layer which includes a plurality of conductor wires made of metal or metal alloy, comprising the steps of: providing a cylindrical spacer member extending along the longitudinal axis of said layer, said spacer member having spiral grooves in the outer surface thereof, filling said spiral grooves with a jelly-like material, burying an optical fibre, the diameter of which is less than the depth of the grooves, in the jelly-like material in each of said grooves, each optical fibre being positioned at a radially outer portion of its respective groove, applying a cover member around said spacer member in contact therewith, thereby forming an optical fibre cable unit.

9. A method of manufacturing a composite overhead transmission line, as claimed in claim 8, wherein said optical fibres are buried in said jelly-like material by laying the optical fibres atop the jelly-like material and passing the spacer and the conductors through a collecting die.

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10. A method of manufacturing a composite overhead transmission line as claimed in claim 8, wherein said cover member is applied by applying sheet in the form of a tape, and welding said tape to form a cylinder.
