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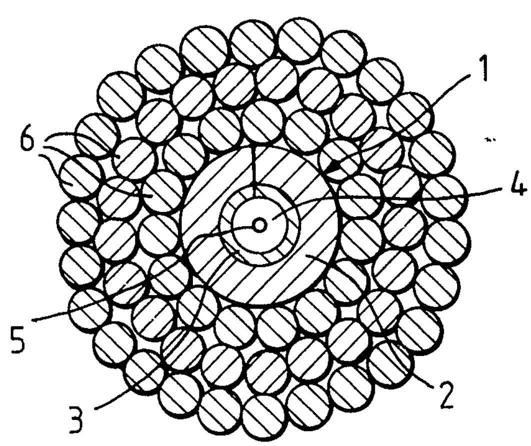
(54) **An improved flexible stranded body**

(57) To reduce the risk of damage to an optical fibre of an overhead electric conductor having an elongate compartment 4 in which an optical fibre 5 is loosely housed arising from heat generated as a result of a fault or lightning, the circumferentially continuous metal wall 2 of the elongate compartment has a circumferentially continuous layer 3 of thermally insulating material bonded or otherwise adhering to it. Preferably, the thermally insulating material 3 is a plastics material of cellular form which will withstand, and thereby protect optical fibres from the effect of, the temperature to which they could be subjected under full clearance overload conditions.



The drawings originally filed were informal and the print here reproduced is taken from a later filed formal copy.

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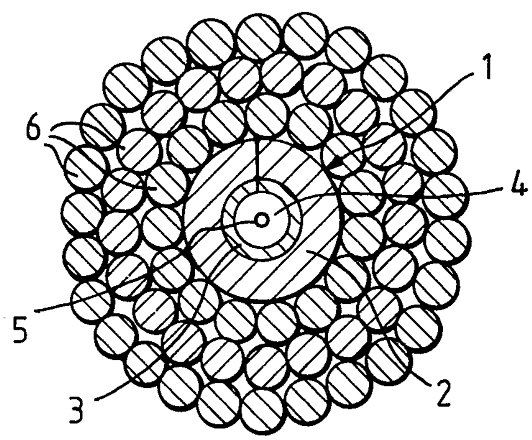
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SPECIFICATION

An improved flexible stranded body

This invention relates to flexible stranded bodies of the kind which comprise a plurality of helically wound bare elongate elements of metal or metal alloy and which are adapted to be freely supported from spaced supports in long lengths. The invention is especially, but not exclusively, concerned with overhead electric conductors of the kind which comprise one or more than one layer of helically wound bare elongate elements of electrically conductive metal or metal alloy but it is to be understood that the invention does not exclude flexible stranded bodies not normally intended to carry electric current, for instance stranded wire ropes.

In the Complete Specification of our British Patent No. 1598438 there is described and claimed a flexible stranded body which includes at least one optical waveguide for use in the communications field adapted for transmission of light and which comprises at least one layer of helically wound bare elongate elements of metal or metal alloy, at least one elongate compartment within and extending throughout the length of the stranded body and, loosely housed in the elongate compartment or in at least one of the elongate compartments, at least one separate optical fibre and/or at least one optical bundle, as defined in the aforesaid Complete Specification.

By virtue of being housed loosely in the elongate compartment of a flexible stranded body of the aforesaid patent, limited relative movement between the or each optical fibre and/or optical bundle and a stranded body can take place when the stranded body vibrates, oscillates or is otherwise flexed, as may, for example, occur in the case when an overhead electric conductor or other freely supported flexible stranded body is subjected to winds. Limited relative movement between the or each optical fibre and the stranded body can also occur when the stranded body is subjected to a changing tensile load during and after its installation due to forces imposed on it by winches and brakes, etc., which are used in tensioning the stranded body to obtain a predetermined sagging condition; after installation, changes in tensile load in a stranded body can also occur due to changes in external loading and in temperature. Limited relative movement between the or each optical fibre and/or optical bundle and the stranded body can also occur whilst the stranded body is in service and creep gives rise to non-elastic extension of the stranded body.

When a flexible stranded body of the aforesaid patent is an overhead electric conductor, in some circumstances an electric current flowing for a limited period along the conductor, as may occur as the result of a fault or lightning, may be of such a value that there is a risk that heat generated during passage of the current will be conducted to the optical waveguide and will result in such damage to the optical fibre and/or optical bundle that its light-transmission efficiency is reduced to an undesirable extent. For example, where an optical fibre is loosely housed in a plastics tube, the generated heat may cause the plastics material to soften and exert such pressure on the optical fibre as to reduce its light-transmission efficiency to an undesirable extent.

It is an object of the present invention to provide an improved flexible stranded body which includes at least one optical fibre for use in the communications field adapted for transmission of light.

According to the invention the improved flexible stranded body comprises at least one layer of helically wound bare elongate elements of metal or metal alloy, at least one elongate compartment which is within and extends throughout the length of the stranded body and which is bounded by a circumferentially continuous wall of metal or metal alloy to which a circumferentially continuous layer of thermally insulating material is bonded or otherwise adheres and, loosely housed in the elongate compartment or at least one of the elongate compartments, at least one optical fibre.

The layer of the thermally insulating material may be firmly bonded to substantially the whole of the surface area of the circumferentially continuous metal boundary wall of the or each elongate compartment, or the layer of thermally insulating material may adhere to mutually spaced portions of the surface area of the circumferentially continuous metal boundary wall of the or each elongate compartment, any air between the thermally insulating layer and the metal wall serving as additional thermal insulation.

The layer of thermally insulating material is preferably a coating of plastics thermally insulating matperial. Preferred plastics thermally insulating materials include silicone rubber, polytetrafluoroethylene and other fluoroethylene polymers and co-polymers, polyetheretherketone, polycarbonates, polysulphones, polyesters and Kevlar. For enhanced thermal insulation, these plastics materials may be in cellular form. These plastics materials will withstand, and thereby protect optical fibres from the effect of, the temperature to which they could be subjected under fault clearance overload conditions.

One plastics thermally insulated material that is especially preferred is that sold by Emerson and Cuming (UK) Ltd. under the trade name ECCOSIL 4640 and comprising a 100% solid syntatic foam RTV silicone rubber which will bond to metals if precoated with an air drying ECCOSIL S-11 primer.

Alternatively, the layer of thermally insulating material may be in the form of a tape, cloth or felt of inorganic thermally insulating material bonded or otherwise adhering to the circumferentially continuous metal boundary wall of the elongate compartment. Preferred inorganic thermally insulating materials include fine glass fibres and silica fibres. Loosely woven tapes or cloth of these materials can be bonded to the metal boundary wall using a thin layer of a high temperature performance pressure sensitive adhesive of the silicone resin type, such as that sold under the trade name Dow Corning 280A or 282 adhesive, which may or may not be cured by the addition of a peroxide curing agent.

Another inorganic thermally insulating material that could be employed is vermicalite foam. In one embodiment, vermicalite foam may be in the form of small free-flowing beads which can be pressed to form a continuous layer under light pressure at ambient temperature. No binder is necessary but inorganic binders such as sodium silicate or silicone resin binders can be used to increase the strength of the compressed material. In another embodiment, vermicalite foam is in the form of a non-woven tissue of E-glass fibres coated with a lamellar silicate mineral composition. A tape of such tissue can be bonded to the circumferentially continuous metal boundary wall of the elongate compartment by a film of silicone adhesive.

For an elongate compartment having an internal diameter lying in the range 3 to 10 millimetres, the layer of thermally insulating material has a wall thickness preferably lying in the range 0.5 to 2.0 millimetres.

In a preferred embodiment, the flexible stranded body comprises a substantially circumferentially rigid central core having an elongate compartment which is within and extends throughout the length of the core and which has a circumferentially continuous boundary wall of metal or metal alloy to which a circumferentially continuous layer of thermally insulating material is bonded or otherwise adheres; at least one optical fibre loosely housed in, and of a length substantially greater than that of, the elongate compartment; and, surrounding the central core, at least one layer of helically wound bare elongate elements of metal or metal alloy.

Where the elongate compartment is within a substantially circumferentially rigid central core, the or each optical fibre loosely housed in the elongate compartment may be secured to the layer of thermally insulating material at longitudinally spaced positions along the length of the stranded body, the part of the or each optical fibre extending between any two adjacent positions at which the optical fibre is secured to the layer of thermally insulating material being loosely housed in, and of a length substantially greater than that of, that part of the elongate compartment extending between said two adjacent positions. The spacing between any two adjacent positions at which the optical fibre is secured to the layer of thermally insulating material will be such that, when the flexible stranded body is suspended between two pylons or other upstanding supports under its own weight, the part of the optical fibre between any two adjacent positions will not be bent or otherwise distorted to such an extent that the optical transmission efficiency of the optical fibre is impaired to an undesirable extent. The or each optical fibre may be secured to the layer of thermally insulating material at each of said longitudinally spaced positions by any technique that will not have a detrimental effect on the optical transmission efficiency of the optical fibre but, in one preferred embodiment, it is secured to the layer of thermally insulating material at each position by a local deposit of resin or other material that bonds both to the optical fibre and to the layer of thermally insulating material. For this purpose, it is preferred to employ a high temperature performance pressure sensitive adhesive of the silicone resin type, such as that sold under the trade name Dow Corning 280A or 282 adhesive, which may or may not be cured by the addition of a peroxide curing agent. In another preferred embodiment, the or each optical fibre is secured to the layer of thermally insulating material at each of said longitudinally spaced positions by a small plug of bulk inorganic thermally insulating fibrous material which, when introduced into the elongate compartment, is lightly compressed and which expands radially outwardly to anchor the fibre against the thermally insulating layer.

Those parts of the or each elongate compartment not occupied by the optical fibre or optical fibres may be substantially filled with a water-impermeable medium of a greaselike nature which is of such a consistency that the or each optical fibre is free to move relative to the flexible stranded body when the flexible stranded body vibrates, oscillates or is otherwise flexed. The greasy water-impermeable medium may consist of, or may comprise as a major constituent, petroleum jelly.

Although the or each optical fibre of the improved flexible stranded body is preferably separate and unsupported, in some circumstances it may be a component element of an optical bundle (by which is meant a group of optical fibres or a group of fibres including at least one optical fibre and at least one non-optical reinforcing fibre or other reinforcing elongate member) or it may be supported by a flexible elongate carrier member which is loosely housed in the elongate compartment. The flexible elongate carrier member may be at least one tape on or within which the or each optical fibre is secured or it may be a flexible fibrous rope which is loosely housed in the elongate compartment and around which the or each optical fibre is helically wound. In the latter case, the fibrous rope is preferably made of fine glass fibre or silicon fibre in bulk form (similar to cotton wool) which will support the optical fibre or fibres in place and will act as an excellent shock absorber under vibration conditions or the fibrous rope may comprise a glass fibre roving core member around which is applied a layer of vermicalite foam as above described.

The invention also includes a method of manufacturing a flexible stranded body, which method comprises causing a preformed elongate member of metal or metal alloy of approximately C-shaped transverse cross-section to travel in the direction of its length; applying to the internal surface of the advancing C-shaped elongate member a circumferentially continuous layer of thermally insulating material in such a way that the layer bonds or otherwise adheres to said surface; feeding into the space bounded by the advancing C-shaped elongate member at least one optical fibre; transversely folding or otherwise shaping the advancing C-shaped elongate member in such a way as to form a substantially circumferentially rigid central core having a closed elongate compartment which is within and extends throughout the length of the core, to which a circumferentially continuous layer of thermally insulating material is bonded or otherwise adheres and in which the or each advancing optical fibre is loosely housed; and applying around the central core so formed at least one layer of helically wound bare elongate elements of metal or metal alloy.

The thermally insulating material may be applied to the internal surface of the advancing C-shaped elongate member by any convenient means but, where it is a plastics material, preferably it is sprayed on to the surface. If desired, the plastics thermally insulating material may incorporate a chemical blowing agent and the advancing C-shaped elongate member may be heated to effect controlled blowing of the blowing agent to provide a thermally insulating layer of cellular form.

Preferably, the C-shaped elongate member is formed by extrusion and the layer of thermally insulating material is applied to the internal surface of the advancing C-shaped elongate member downstream of the extrusion machine.

Where the or each optical fibre is secured to the layer of thermally insulating material at longitudinally spaced positions along the length of the stranded body, preferably the flexible stranded body is manufactured by the method described in the Specification of our co-pending British Patent Application No. 8135917.

Where those parts of the elongate compartment not occupied by the or each optical fibre are substantially filled with a water-impermeable medium of a grease-like nature, preferably the flexible stranded body is manufactured by the method described and claimed in the Specification of our co-pending British Patent Application No. 8131275.

The improved flexible stranded body of the present invention is especially suitable for use as a conductor of an overhead electric transmission system because, by virtue of the fact that the or each elongate compartment is bounded by a circumferentially continuous layer of thermally insulating material, the risk that the optical transmission efficiency of the or an optical fibre will be effected to a detrimental extent by heat emitted by the conductor is substantially reduced.

The invention is further illustrated by a description, by way of example, of a preferred overhead electric conductor with reference to the accompanying diagrammatic drawing which shows a transverse cross-sectional view of the conductor.

Referring to the drawing, the overhead electric conductor comprises a central core 1 consisting of a tube 2 formed by transversely folding a substantially C-shaped extrudate of aluminium-based alloy, which tube has a bore 4 of diameter 5.5 mm. A thermally insulating layer 3 adheres to the inner surface of the tube 2, the layer having a radial thickness of 1.0 mm. Loosely housed in the bore 4 is an optical fibre 5. The central core 1 is surrounded by three layers 6 of helically wound round wires of aluminium-based alloy, the directions of lay of adjacent layers being of opposite hand.

CLAIMS

1. A flexible stranded body comprising at least one layer of helically wound bare elongate elements of metal or metal alloy, at least one elongate compartment which is within and extends throughout the length of the stranded body and which is bounded by a circumferentially continuous wall of metal or metal alloy to which a circumferentially continuous layer of thermally insulating material is bonded or otherwise adheres and, loosely housed in the elongate compartment or at least one of the elongate compartments, at least one optical fibre.

2. A flexible stranded body comprising a substantially circumferentially rigid central core having an elongate compartment which is within and extends throughout the length of the core and which has a circumferentially continuous boundary wall of metal or metal alloy to which a circumferentially continuous layer of thermally insulating material is bonded or otherwise adheres; at least one optical fibre loosely housed in, and of a length substantially greater than that of, the elongate compartment; and, surrounding the central core, at least one layer of helically wound bare elongate elements of metal or metal alloy.

3. A flexible stranded body as claimed in Claim 2, wherein the or each optical fibre loosely housed in the elongate compartment is secured to the layer of thermally insulating material at longitudinally spaced positions along the length of the stranded body, the part of the or each optical fibre extending between any two adjacent positions at which the optical fibre is secured to the layer of thermally insulating material being loosely housed in, and of a length substantially greater than that of, that part of the elongate compartment extending between said two adjacent positions.

4. A flexible stranded body as claimed in Claim 3, wherein the or each optical fibre is secured to the layer of thermally insulating material at each position by a local deposit of resin or other material that bonds both to the optical fibre and to the layer of thermally insulating material.

5. A flexible stranded body as claimed in Claim 3, wherein the or each optical fibre is secured to the layer of thermally insulating material at each of said longitudinally spaced positions by a plug of bulk inorganic thermally insulating fibrous material which, when introduced into the elongate compartment, is lightly compressed and which expands radially outwardly to anchor the fibre against the thermally insulating layer.

6. A flexible stranded body as claimed in any one of the preceding Claims, wherein the layer of thermally insulating material adheres to mutually spaced portions of the surface area of the circumferentially continuous metal boundary wall of the or each elongate compartment, any air between the thermally insulating layer and the metal wall serving as additional thermal insulation.

7. A flexible stranded body as claimed in any one of the preceding Claims, wherein the layer of thermally insulating material is a coating of plastics thermally insulating material.

8. A flexible stranded body as claimed in Claim 7, wherein the layer of plastics thermally insulating material is in cellular form.

9. A flexible stranded body as claimed in any one of Claims 1 to 6, wherein the layer of thermally insulating material is in the form of a tape, cloth or felt of inorganic thermally insulating material bonded or otherwise adhering to the circumferentially continuous metal boundary wall of the elongate compartment.

10. A flexible stranded body as claimed in Claim 9, wherein the tape, cloth or felt is of fine glass fibres or silica fibres.

11. A flexible stranded body as claimed in any one of Claims 1 to 6, wherein the layer of thermally insulating material is of vermicalite foam.

12. A flexible stranded body as claimed in Claim 11, wherein the vermicalite foam constituting the layer of thermally insulating material is in the form of small free flowing beads which have been pressed to form a continuous layer.

13. A flexible stranded body as claimed in Claim 11, wherein the vermicalite foam constituting the layer of thermally insulating material is in the form of a non-woven tissue of E-glass fibres coated with a lamellar silicate mineral composition.

14. A flexible stranded body as claimed in any one of the preceding Claims, wherein the or each elongate compartment has an internal diameter lying in the range 3 to 10 mm and the layer of thermally insulating material has a wall thickness lying in the range 0.5 to 2.0 millimetres.

15. A flexible stranded body as claimed in any one of the preceding Claims, wherein those parts of the or each elongate compartment not occupied by the optical fibre or optical fibres are substantially filled with a water-impermeable medium of a grease-like nature which is of such a consistency that the or each optical fibre is free to move relative to the flexible stranded body when the flexible stranded body vibrates, oscillates or is otherwise flexed.

16. A flexible stranded body as claimed in any one of the preceding Claims, wherein the or each optical fibre is a component element of an optical bundle.

17. A flexible stranded body as claimed in any one of Claims 1 to 15, wherein the or each optical fibre is supported by a flexible elongate carrier member which is loosely housed in the elongate compartment.

18. A flexible stranded body as claimed in Claim 17, wherein the flexible elongate carrier member is at least one tape on or within which the or each optical fibre is secured.

19. A flexible stranded body as claimed in Claim 17, wherein the flexible elongate carrier member is a flexible fibrous rope which is loosely housed in the elongate compartment and around which the or each optical fibre is helically wound.

20. A flexible stranded body as claimed in Claim 19, wherein the fibrous rope is made of fine glass fibre or silicon fibre in bulk form which will support the optical fibre or fibres in place and will act as a shock absorber under vibration conditions.

21. A flexible stranded body as claimed in Claim 19, wherein the fibrous rope comprises a glass fibre roving core member around which is applied a layer of vermicalite foam.

22. A flexible stranded body as claimed in any one of the preceding Claims, wherein the flexible stranded body is an overhead electric conductor.

23. A method of manufacturing a flexible stranded body which comprises causing a preformed elongate member of metal or metal alloy of approximately C-shaped transverse cross-section to travel in the direction of its length; applying to the internal surface of the advancing C-shaped elongate member a circumferentially continuous layer of thermally insulating material in such a way that the layer bonds or otherwise adheres to said surface; feeding into the space bounded by the advancing C-shaped elongate member at least one optical fibre; transversely folding or otherwise shaping the advancing C-shaped elongate member in such a way as to form a substantially circumferentially rigid central core having a closed elongate compartment which is within and extends throughout the length of the core, to which a circumferentially continuous layer of thermally insulating material is bonded or otherwise adheres and in which the or each advancing optical fibre is loosely housed; and applying around the central core so formed at least one layer of helically wound bare elongate elements of metal or metal alloy.

24. A method as claimed in Claim 23, wherein the layer of thermally insulating material is applied to the internal surface of the advancing C-shaped elongate member by spraying plastics material on to the surface.

25. A method as claimed in Claim 24, wherein the plastics thermally insulating material incorporates a chemical blowing agent and the advancing C-shaped elongate member is heated to effect controlled blowing of the blowing agent to provide a thermally insulating layer of cellular form.

26. A method as claimed in any one of Claims 23 to 25, wherein the C-shaped elongate member is formed by extrusion and the layer of thermally insulating material is applied to the internal surface of the advancing C-shaped elongate member downstream of the extrusion machine.

27. An overhead electric conductor substantially as hereinbefore described with reference to and as shown in the accompanying drawing.

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