

UNDERWATER OPTICAL FIBRE CABLE

This invention relates to an optical fibre cable suitable for underwater use.

Such cables are subjected to tensile loading during laying and in use to radial compressive loading due to hydrostatic pressure which increases in relation to the depth at which the cable is laid and is present for the entire life of the cable. In order to protect the optical fibres of known optical fibre underwater cables from mechanical stresses caused by such loadings on the cable which would give rise to attenuation of the optical signal and may cause the fibres to break in view of their fragile nature, it has heretofore been the practice to provide underwater optical fibre cables with metallic reinforcement radially outwardly of the fibres against the tensile and the radial compressive loading to which it will be subjected. Examples of an optical fibre cable provided with metallic reinforcement disposed radially outwardly of the optical fibres thereof are disclosed in GB-A-2021282 and GB-A-2082790.

The presence of the metallic reinforcement in the known underwater optical fibre cables reduces the flexibility of the cables and increases the weight per unit length of the cable both of which factors make the laying of the cables more difficult. Further, as will be appreciated the deeper a cable is to be laid, the greater the amount of metallic reinforcement required radially outwardly of the optical fibres, thus increasing

the difficulty of the cable laying operation.

Also the greater the amount of metal per unit length in an optical fibre cable the greater the risk of metal corrosion giving rise to the production of hydrogen which acts on the optical fibres to increase the attenuation of the optical signals being transmitted thereby.

An object of the present invention is to provide an optical fibre cable suitable for use underwater having a construction which eliminates the need to provide the cable with metallic reinforcement radially outwardly of the optical fibres thereof against tensile and radial compressive loading dependent upon the depth at which the cable is to be laid underwater.

The present invention provides an optical fibre cable suitable for underwater use, comprising a central tensile resistant stranded member, a plurality of tubes, each of which houses at least one optical fibre, with the remaining space within the tube being filled, or substantially filled, with a substantially incompressible fluid, or a plastics material, said tubes extending helically about said member, the central member and tubes being embedded in plastics material and the spaces defined between the strands of the central member being filled with a substantially incompressible fluid.

In this application the term 'fluid' as used in the expression 'substantially incompressible fluid' is intended to include viscous substances such as petroleum jelly and silicone grease, in addition to liquids. An example of a suitable liquid is silicone oil.

In one embodiment of the invention disclosed in more detail hereinafter, said tubes are disposed on the outer surface of said central member and the plastics material comprises a layer having an inner surface which conforms to the outer surface presented by the central member with the tubes thereon.

In two other embodiments of the invention disclosed hereinafter, the plastics material comprises a covering layer for the central member having an inner surface which conforms to the outer surface presented by the central member and outer surface on which said tubes are disposed, and a further layer having an inner surface which conforms to the outer surface presented by the covering layer with the tubes thereon.

A water barrier, which typically comprises a metal sheath, is preferably provided over said plastics material and may be in contact with the outer surface thereof.

In the preferred embodiments of the invention the cable is devoid of any reinforcement against either tensile or radial compressive loading radially outwardly of the fibres.

The strands of the central member may comprise for example, steel wires, aromatic polyamide threads or carbon fibre threads, and preferably they include an electrically conductive element such as a copper wire.

In order that the invention may be better understood, some embodiments thereof, which are given by way of example only, will now be described with reference to the accompanying drawings, in which:

Figure 1 is a radial cross-section of a submarine optical fibre telecommunications cable;

Figure 2 is an enlarged detail of Figure 1; and

Figure 3 is a similar view to Figure 2 but of an alternative cable.

Referring now to Figure 1, there is shown a submarine optical fibre telecommunications cable suitable for use underwater at depths greater than 1000 metres. The cable has a central tensile resistant member 1 as its radially innermost constituent which is designed to provide the cable with sufficient tensile strength to withstand substantially all of the tensile loadings thereon during laying of the cable. The central member 1 comprises a compact antitorsionally stranded member having a plurality of

strands 2 arranged in coaxial layers with the strands in adjacent layers extending helically in opposite senses.

The strands 2 are formed of a material having high tensile strength and for example are typically steel wires. Alternatively they may comprise aromatic poly-  
5 amide threads or carbon fibres which have a tensile strength comparable to that of steel wires but have the advantage of reducing the metal content of the cable.

A plurality of tubes 6 of plastics or metallic  
10 material extend helically about the central member. The tubes are spaced from one another, for example equally spaced, and each tube houses at least one optical fibre 7. The central member 1 and the tubes 6 are embedded in plastics material. As shown in Figure 1, this plas-  
15 tics material comprises two layers 4 and 10. Layer 4 covers the central member and has an inner surface which conforms to the outer surface presented by the central member by extending into the grooves defined at the outer surface of the member 1 between adjacent strands.  
20 The layer 4 has a cylindrical outer surface 5 on which the tubes 6 are disposed with a line contact 8 (Fig.2), and the layer 10 has an inner surface which conforms to the outer surface presented by layer 4 with the tubes 6 thereon. This is realised by extruding the layer 10  
25 over the layer 4 with the tubes 6 disposed thereon such that there are no voids between the interfaces of the two layers 4,10 or the layer 10 and the tubes 6. The plastics material of each layer 4,10 may be a polyolefin, such as polyethylene, polyvinylchloride, nylon or other  
30 plastics material having a low coefficient of thermal expansion.

The spaces 3 between the strands 2 of the embedded central member 1 are filled with a substantially incompressible fluid, for example a petroleum jelly or a  
35 silicone grease in order to support the member against

radial compressive loading. As illustrated the strands are circular in cross-section, however when the strands are steel wires they may advantageously have cross-sections which reduce the size of the spaces therebetween, for example they may be trapezoidal in cross-section.

The optical fibres 7 are loosely housed within the tubes 6 and the remaining space within each tube 6 contains a substantially incompressible fluid, for example a petroleum jelly or a silicone grease. The fluid within the tube supports the walls thereof against radial compressive loading. Preferably the remaining space is completely filled with this fluid. If this space is not completely filled with the fluid the tube itself has to be able to withstand the compressive loading to a greater extent than if the space were completely filled. This may be achieved by increasing the wall thickness of the tube.

In an alternative arrangement, when the tube 6 is formed of plastics, the space remaining in the tube may be filled with plastics material which may be the same material as that forming the tube or may be a different material.

A water barrier which comprises a water-tight metal sheath 11 is provided over the layer 10 in contact with the outer surface thereof. A further plastics layer 12, for example of a polyolefin such as polyethylene is provided over the sheath 11 and other layers, for example of anti-ship-worm protection may be provided radially outwardly thereof. However, the cable is not provided with any metallic reinforcement radially outwardly of the optical fibres 7 against either the tensile or the radial compressive loading to which the cable will be subjected to in use underwater and during laying. Such reinforcement which has heretofore been used despite the disadvantages associated therewith previously discussed, has been found unnecessary in the embodiment because of the presence of a central member resistant to all tensile loading and of the virtual elimination of voids in the

construction of the cable by filling the spaces 3 between the strands 2 of the central member with substantially incompressible fluid and also by filling, or substantially filling, the spaces in the tubes 6 housing the optical fibres with substantially incompressible fluid or a plastics material. Thus with the exception of very small voids which are unavoidable in the manufacture of the cable there are virtually no spaces in the structure of the cable which are free from material and which will allow radial collapse of the cable. This feature of the cable enables it to withstand radial compressive loadings due to hydrostatic pressure at any depth underwater. This is in marked contrast with the prior cables where the metallic reinforcement provided radially outwardly of the optical fibres was considered essential and had to be increased with an increase in intended laying depth for the cable.

In connection with the above discussion regarding the metallic reinforcement of prior cables it is to be understood that the metal sheath 11 in the embodiment functions only to provide a water barrier and does not provide any significant mechanical resistance to either tensile or radially compressive loadings on the cable. Typically the thickness of the sheath 11 is of some tenths of a millimetre and remains substantially of that order no matter at what depth the cable is to be laid. The sheath 11 may be of aluminium and may be obtained by extrusion on to the layer 10. Alternatively it may be a metallic tape, again possibly of aluminium, which is wound longitudinally along the layer 10 with its edges either abutting or overlapping and subsequently soldered, welded or sealed with a mastic material.

In the embodiment shown in Figures 1 and 2, the tubes 6 are in line contact with the outer surface 5 of plastics layer 4. In an alternative arrangement the

cable construction is the same as that illustrated in Figure 1 except that as shown in Figure 3, the radial outer surface 5 of plastics layer 4 is provided with helical grooves 9 each of which is part-circular in section with a radius equal to that of the outer surface of the tubes 6. The grooves have a depth smaller than the radius of the tubes 6 and function to stabilise the positions of the tubes on the surface 5 during the application of plastics layer 10.

10 In another embodiment which is not shown in the drawings, the tubes 6 are disposed directly on the outer surface of the central member 1 and the plastics material in which the central member 1 and tubes 6 are embedded comprises a layer having an inner surface which  
15 conforms to the outer surface presented by the central member and the tubes thereon. This plastics material may be applied by extrusion. In other respects this embodiment is the same as those previously described.

In any of the above described embodiments the  
20 strands of the central member may include an electrically conductive element, for example a copper wire, which is used together with the metal sheath 11 to provide electric power to optoelectronic repeaters for the optical signals being transmitted. One or more of such conductive elements may be embedded in the other strands 2 or  
25 wound around those strands. In prior arrangements, the metal sheath has been used to supply power to such repeaters with the water surrounding the cable functioning as the return conductor and a plastics layer over the metal sheath acting as a dielectric. In the proposed arrangements for the embodiments of the invention, it is the plastics material between the central member 1 and the  
30 sheath 11 which acts as a dielectric and accordingly the plastics layer covering the sheath is not subjected to electrical stresses which together with the action thereon of the surrounding water leads to the formation of so-called  
35 'water-trees' in this plastics layer and to corrosion of the metal sheath, in the prior arrangement.

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From the foregoing it will be appreciated that  
embodiments of the invention can be made more flexible  
and easier to handle than prior underwater optical fibre  
cables which have utilised metallic reinforcement  
5 radially outwardly of the optical fibres and that the  
elimination of such reinforcement reduces the risk of  
hydrogen being produced and acting on the optical fibres  
to increase the attenuation of the optical signals  
being transmitted thereby.



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CLAIMS:

1. An optical fibre cable suitable for underwater use, comprising a central tensile resistant stranded member, a plurality of tubes, each of which houses at least one optical fibre, with the remaining space within the tube being filled, or substantially filled, with a substantially incompressible fluid, or a plastics material, said tubes extending helically about said member, the central member and tubes being embedded in plastics material and the spaces defined between the strands of the central member being  
10 filled with a substantially incompressible fluid.
2. A cable as claimed in claim 1, wherein said tubes are disposed on the outer surface of said central member and the plastics material comprises a layer having an inner surface which conforms to the outer surface presented by the central member with the tubes thereon.  
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3. A cable as claimed in claim 1, wherein the plastics material comprises a covering layer for the central member having an inner surface which conforms to the outer surface presented by the central member and outer  
20 surface on which said tubes are disposed, and a further layer having an inner surface which conforms to the outer surface presented by the covering layer with the tubes thereon.
4. A cable as claimed in claim 1, 2 or 3, wherein a  
25 water barrier is provided over said plastics material.
5. A cable as claimed in claim 4, wherein said water barrier comprises a metal sheath.
6. A cable as claimed in claim 4 or 5, wherein said  
30 water barrier contacts the outer surface of said plastics material.
7. A cable as claimed in any one of the preceding claims and devoid of any reinforcement against tensile and radial compressive loading radially outwardly of the fibres.



8. A cable as claimed in any one of the preceding claims, wherein the strands of said central member comprise steel wires.
- 5 9. A cable as claimed in any one of claims 1 to 7, wherein the strands of said central member comprise aromatic polyamide threads.
- 10 10. A cable as claimed in any one of claims 1 to 7, wherein the strands of said central member comprise carbon fibre threads.
- 10 11. A cable as claimed in any one of the preceding claims, wherein the strands of said central member include at least one electrically conductive element.
12. A cable as claimed in claim 11, wherein the or each electrically conductive element comprises a copper wire.
- 15 13. A cable as claimed in any one of the preceding claims, wherein said central member is adapted to withstand substantially all of the tensile loadings on the cable during laying of the cable.
- 20 14. An optical fibre cable suitable for underwater use as claimed in claim 1 and substantially as herein described.
- 25 15. An optical fibre cable suitable for underwater use and substantially as herein described with reference to Figures 1 and 2 or Figures 1 and 3 of the accompanying drawing.
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