

JOINTING UNDERWATER OPTICAL FIBRE CABLES

This invention relates to the jointing of optical fibre cables suitable for underwater use, and more particularly to the jointing of cables, such as those disclosed in our copending UK Patent Applications Nos. 8509947 (Serial No. (2157847)) and 8509948 (Serial No. (2157848)), which comprise a central tensile resistant member which is covered with at least one layer of plastics material, through-passages being present in the plastics material covering, each through-passage housing at least one optical fibre with the remaining space therein being filled, or substantially filled, with a substantially incompressible fluid, and a metallic water barrier over said plastics material covering, and wherein the cable is devoid of any reinforcement against tensile and radial compressive loadings radially outwardly of the optical fibres thereof. In the above-mentioned applications and in the present 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; and an example of a suitable liquid is silicone oil.

Whenever such cables are required to be laid over very long distances it is necessary to joint successive cable lengths end-to-end with joints which have to be laid with the cable lengths and which will be disposed under water, in service, thus making any maintenance of a joint after laying expensive. Thus there are many requirements for a joint for such cables. Firstly, the connections between the optical fibres in the joint should be secure and reliable. Second, the optical fibres

in the joint should not be subjected to mechanical stresses, since such stresses can give rise to attenuation of the optical signal or may cause the fibres to rupture or break because of their fragile nature. This requirement is particularly important when the joint is intended to be laid under water at great depths, for example at depths greater than 1,000 meters, because of the high radial compressive loading to which the joint will be subjected at such depths due to hydrostatic pressure. Third, the tensile strength of the connection in the joint between the central tensile resistant members of the cables should not be less than that of these members and should decrease the flexibility of the joint as compared with that of the cables as least as possible. Fourth the joint should be reliably watertight so as to prevent damage by water to the internal parts of the joint and the cables. Fifth, the joint should provide reliable electrical continuity between any electrical conductors incorporated in the cables for providing power to optoelectronic repeaters for the optical signals being transmitted by the cables. Additionally, the overall dimensions of the joint should be a minimum to facilitate laying of the cable lengths which are joined thereby.

An object of the present invention is to enable a joint to be provided which meets the above requirements.

In accordance with the invention there is provided a joint joining two optical fibre cables suitable for underwater use, which cables each comprise a central tensile resistant member which is covered with at least one layer of plastics material, through-passages being present in the plastics material covering, each through-passage housing at least one optical fibre with the remaining space therein being filled, or substantially filled, with a substantially incompressible fluid, and a metallic water barrier over said plastics material covering and wherein each cable is devoid of any rein-

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forcement against tensile and radial compressive loadings radially outwardly of the optical fibres thereof; said joint comprising a mechanical tensile resistant connection connecting bared end portions of the central tensile resistant members of the cables end-to-end, a plastics covering comprising one or more layers of plastics material covering said mechanical connection and the bared ends of the plastics material coverings of the cables, through-cavities being provided in the joint's plastic covering extending in the longitudinal direction of the joint and interconnecting respective through-passages of the cables, the optical fibres of the cables in the through-passages extending into said through-cavities and being connected therein with the remaining space in said through-cavities being filled, or substantially filled, with substantially incompressible fluid, and a metallic water barrier extending over, and in contact with, said joint plastics covering between and connected, in a watertight manner, to the end portions of metallic water barriers of the cables, said joint being devoid of any reinforcement against tensile and radial compressive loadings radially outwardly of the optical fibres connected thereby.

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

Figure 1 is a side view of a joint joining two optical fibre telecommunications cables partially broken away to show a longitudinal section of the joint;

Figure 2 is a transverse cross-section of the joint shown in Figure 1 taken along the line II - II in that figure;

Figure 3 is a side view of another joint joining two optical fibre telecommunications cables partially

broken away to show a longitudinal section of the joint;
and

Figure 4 is a transverse cross-section of the
joint shown in Figure 3 taken along the line IV - IV in
that figure.

In general, both of the illustrated joints join
optical fibre telecommunications cables which comprise a
central tensile resistant member which is covered with
at least one layer of plastics material, through-passages
being present in the plastics material covering, each
through-passage housing at least one optical fibre with
the remaining space therein being filled, or substantially
filled, with a substantially incompressible fluid, and
a metallic water barrier over said plastics material
covering and wherein each cable is devoid of any rein-
forcement against tensile and radial compressive loadings
radially outwardly of the optical fibres thereof.

In Figures 1 and 2, there is shown a joint 1 which
joins two such cables 2 and 3 (end portions of which only
are shown) which have a construction as disclosed in our
above-mentioned UK Patent Application No. 8509947. As
can be seen from the longitudinal section of cable 2,
these cables each comprise a central tensile resistant
member 5, which preferably takes the form of a compact
antitorsionally stranded member with spaces between the
strands thereof being filled with a substantially incom-
pressible fluid, such as a petroleum jelly or a silicone
grease. The plastics material covering of the member 5
comprises two layers 7 and 14 of plastics material and the
through-passages in this covering are defined by tubes 11.
each of which forms a loose jacket for at least one op-
tical fibre 10 and is embedded in the outer plastics lay-
er 14. The metallic water barrier for the cable over the
covering is designated 15 and a plastics layer 19 is pro-
vided over the water barrier. Other layers, for example

of anti-ship-worm protection may be provided over layer 19.

The various components of the cables 2 and 3 are stripped back at each end portion to be joined in a staggered manner as illustrated in the longitudinal section in the case of cable 2. The joint 1 joining the cables 2 and 3 comprises a mechanical tensile resistant connection connecting the bared end portions of the tensile resistant members 5 of the cables end-to-end. As illustrated this mechanical connection comprises a metallic clamp 4, but it may take other forms and for example may instead comprise a hardened weld between the members 5. The illustrated metallic clamp 4 is disposed about the bared end portions of the members and clenched thereonto whereby radially inwardly extending projections 6 of the clamp engage in recesses formed thereby in the members 5. Any spaces inwardly of clamp 4 not occupied by the members 5 are filled with the same substantially incompressible fluid which is used for filling the spaces between the strands of the members 5.

The configuration and dimensions of the clamp 4 are such that as to resist tensile loadings which may be placed on the joint during cable laying or picking-up operations. Furthermore, the clamp 4 also provides a reliable electrical connection between the members 5 of the cables 2 and 3, which members 5 may, for example, include, or have wound therearound, one or more electrically conductive elements such as copper wires.

A first layer 8 of a plastics covering of the joint covers the clamp 4 and the bared end portions of the inner plastics layer 7 of each cable 2 and 3, the layer may be applied by moulding in situ, by extrusion, or by winding tapes of plastics material about the joint. Suitable plastics materials include polypropylene, polyvinyl chloride and nylon. The axial end portions of the layer 8 are

tapered externally and the bared end portions of the tubes 11 which define the through-passages of the cables for the optical fibres are laid over these tapered end portions. Each connection 9 between the optical fibres 10 is made on the external surface of the layer 8 between the tapered end portions thereof, and the connection 9 shown comprises two optical fibres 10 joined by fusion at 10' and disposed within a sleeve 12, which may be metallic or plastics and which circumscribes the fused joint 10'. The connected fibres are loosely housed in the sleeve with an excess length such that they may take up an undulatory path therein, as illustrated. The remaining space within the sleeve contains a substantially incompressible fluid, such as a petroleum jelly or a silicone grease. The fluid within the sleeve 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 sleeve itself has to be able to withstand the compressive loading to a greater extent than if the sleeve were completely filled. This may be achieved by increasing the wall thickness of the sleeve.

The sleeve 12 rests on the layer 8 and each end of the sleeve is connected to a respective bared end portion of a tube 11.

As illustrated, the end portions of the tubes 11 extend into the end portions of the sleeve 12. When the sleeve is formed of plastics, the plastics material used is advantageously heat shrinkable so that the sleeve end portions can be heat shrunk onto the tube end portions.

A second layer 13 of the joint's plastics covering is provided over the plastics layer 8 by moulding in situ, or by extrusion. Through-cavities extending in the longitudinal direction of the joint disposed adjacent the radially innermost surface of the layer 13 are defined by sleeves 12 and

the end portions of the tubes 11 which are disposed on the radially outer surface of the layer 8. The plastics material of the layer 13 adheres to the sleeves 12 and tube end portions and as will be appreciated from the foregoing the through-cavities in the joint's plastics covering interconnect respective through-passages of the cables defined by the tubes 11, the optical fibres of the cables extending into the through-cavities and being connected therein with the remaining space in the through-cavities being filled, or substantially filled, with a substantially incompressible fluid. The layer 13 covers the ends of the layers 14 of the two cables 2 and 3 and adheres to the end surfaces 7' and 8' of the layers 14 and the cables' metallic water barriers 15 respectively. The outer diameter of the layer 13 is substantially equal to the outer diameter of the cables' metallic water barriers 15 and the radially outermost surface of the layer is in direct contact with a metallic covering 16, for example of aluminium, which extends over the joint's plastics covering between the end portions of the cables' water barriers 15 to which it is connected in a watertight manner, for example by welding, as indicated at 17. The covering 16 thus forms a metallic water barrier for the joint which provides continuity of the water barrier formed by the cables' water barriers 15. Furthermore, the covering 16 provides a reliable electrical connection between the cables' water barriers which may be used as an electrical conductor for providing power to optoelectronic repeaters for the optical signals being transmitted by the cables.

The wall thickness of the covering 16 may be the minimum value required to enable the covering 16 to be fitted in the joint since the covering functions only as a water barrier and, in some cases, as an electrical connection and is not required to provide any significant

mechanical resistance to either tensile or radially compressive loadings on the joint. Typically the thickness of the covering is of some tenths of millimetres and this thickness remains of substantially that order no matter at what depth the joint is to be laid.

A plastics layer 18 is provided over the metallic covering 16. This layer 18 extends between and adheres to the ends of the plastics layers 19 over the cables' water barriers 15 and, as illustrated, the outer diameter of the layer 18 is preferably the same, or substantially the same, as the outer diameter of the layers 19.

Further layers, for example of anti-ship-worm protection, are provided over layer 18 if corresponding layers are provided on the cables' layers 19.

In the joint shown in Figures 1 and 2, the layer 8 of the joint's plastic covering may be omitted, in which case the sleeves 12 will rest directly on the clamp 4 and the layer 13 will form the plastics covering of the joint by itself, the layer 13 covering and adhering to the clamp 4 and the bared ends of the layers 7 and 14 of the cables 2 and 3, and embedding, as before, the sleeves 12 and end portions of the tubes 11 forming the through-cavities in the joint.

In Figures 3 and 4, there is shown a joint which is particularly suitable for joining optical fibre telecommunications cables which have a construction as disclosed in our above-mentioned UK Application No. 8509948, although, as will be explained hereinafter, this joint may also be used for joining other cables.

The joint 20 shown in Figures 3 and 4 is illustrated in Figure 3 joining two cables 23 and 24 (end portions of which only are shown) which have a construction as disclosed in our UK Patent Application No. 8509948. As can be seen from the longitudinal section of cable 23, these cables each comprise a central tensile resistant

member 22, which has a similar construction to that of member 5 described above, and which is embedded in, and covered by, a layer 26 of plastics material. The outer surface of the layer 26 is cylindrical and provided with a plurality of helically extending grooves 28 which define through-passages in the layer 26. Each through-passage houses at least one unjacketed optical fibre 29 with the remaining spaces therein being filled with a substantially incompressible fluid, such as a petroleum jelly or a silicone grease. The grooves 28 are closed by a layer 32 disposed over and in contact with the layer 26 and this layer in the illustration comprises a metallic water barrier. A plastics layer 35 is provided over the water barrier layer 32, and other layers, for example of anti-ship-worm protection, may be provided over layer 35. The various components of the cables 23 and 24 are stripped back at each end portion to be joined in a staggered manner as illustrated in the longitudinal section in the case of cable 23. The joint 20 joining the cables 23 and 24 comprises, as in the case of the joint 1 described above, a mechanical tensile resistant connection connecting the bared end portions of the tensile resistant members 22 of the cables. This connection may be formed by a hardened weld, but as illustrated is formed by a metallic clamp 21 which is identical to the clamp 4 of joint 1. As with clamp 4, any spaces inwardly of clamp 21 not occupied by the tensile resistant members are filled with the same substantially incompressible fluid which is used for filling the spaces between the strands of the members 22, such as a petroleum jelly or a silicone grease.

A first layer 25 of a plastics covering of the joint covers clamp 21 and the surfaces 26' of the bared ends of the cables' plastics layers 26. As illustrated the layer 25 is in direct contact with, and adheres to, the clamp 21 and the surfaces 26', onto which it is

moulded. The radially outermost surface of layer 25 which is cylindrical and, as illustrated, of the same diameter as the outer diameter of the cables' layer 26, is provided with grooves 27 which extend in the longitudinal direction of the joint and are aligned with and interconnect respective grooves 28 in the plastics layers 26 of the cables 23 and 24. The grooves 27 define through-cavities in the joint's plastics covering layer 25 and the optical fibres 29 of the cables in the grooves 28 extend into and are connected therein by fusion, as shown at 30. The connected fibres are loosely housed in the grooves 27 with an excess length such that they may take up an undulatory path therein, as illustrated, and the remaining space within each groove 27 is filled with a substantially incompressible fluid, such as petroleum jelly or a silicone grease.

A second layer 31 of the joint's plastics covering is provided over the outer surface of layer 25 and closes the grooves 27. This layer 31 may be applied by moulding in situ, or by extrusion, or by winding tapes of plastics material about the layer 25.

The radially outermost surface of the plastics layer 31 has a diameter which is preferably equal to the outer diameter of the cables' metallic water barriers 32, and is in direct contact with a metallic covering 33. The covering 33 extends over and adheres to the layer 31 between the end portions of the cables' water barriers 32 to which it is connected in a watertight manner, for example by welding, as indicated at 33'. The metallic covering 33, like the covering 16 of joint 1 forms a water barrier for the joint and may also form a reliable electrical connection between the cables' water barriers when required.

A plastics layer 34 is provided over the metallic covering 33 and extends between and adheres to the ends

of the plastic layers 35 over the cables' water barriers 32. The outer diameters of the layer 34 and the layers 35 are preferably the same, or substantially the same. As with the joint 1, further layers may be provided over layer 34 if corresponding layers are provided on the cables' layers 35.

In the joint shown in Figures 3 and 4, the second plastics layer 31 may be omitted, in which case the layer 25 will be formed such that its radially outermost surface is in direct contact with the metallic covering 33 which forms the joint's water barrier. In this case the covering 33 closes the grooves 27 rather than the layer 31 which in the illustrated embodiment is interposed between the layer 25 and the metallic covering 33.

The joint shown in Figures 3 and 4 may also be used for connecting cables in which the optical fibres are disposed in through-passages defined by tubes which form loose jackets for the fibres and which are filled with substantially incompressible fluid. In this case sleeves, identical to the sleeves 12 of joint 1 are located in the grooves 27 to circumscribe the fused connections 30 of the optical fibres, and the sleeves are connected at their ends to respective bared end portions of the tubes which define the through-passages of the cables. These bared end portions are located in the axial end portions of the grooves 27 and define, with the sleeves to which they are connected, through-cavities in the layer 25 interconnecting the through-passages of the cables. The through-cavities contain substantially incompressible fluid which fills, or substantially fills, the spaces there-within not occupied by the connected optical fibres. In this construction of the joint, the plastics layer 31, when moulded or extruded, can be formed with a cylindrical inner surface provided with radially inwardly extending ribs which extend into the grooves 27. These ribs may completely

fill the spaces between the sleeves and tube end portions connected thereto and the grooves 27. In this case, each rib has a radially outwardly opening recess with a configuration conforming to that of the mating surfaces presented by the sleeve and tube end portions in the groove. Thus as in the case of the layer 13 in joint 1, the material of layer 31 extends almost completely about the sleeves and connected tube end portions.

From the foregoing it will be appreciated that the joint 20 can be modified as discussed for use in joining the cables 2 and 3 as shown in Figure 1.

It is also to be understood that the joint 1 shown in Figures 1 and 2 can be used to join cables such as the cables 23 and 24 illustrated in Figure 3 in which the optical fibres are unjacketed. In such a case the unjacketed fibres which extend from the grooves 28 of the stripped back layers 26 of the cables 23 and 24 are inserted into lengths of tubes, which correspond to the bared end portions of tubes 11, and these tubes are interconnected by sleeves 12. The sleeves 12 are disposed on the outer surface of plastics layer 8, or directly on the clamp 4 in the alternative construction of joint 1 described, and covered by plastics layer 13 such that the sleeves and tube lengths connected thereto form the through-cavities of the joint adjacent the radially innermost surface of layer 13.

Both of the illustrated joints, and the alternative constructions thereof described, can be made readily and simply, since the joints are devoid of any reinforcement against tensile and radial compressive loadings radially outwardly of the optical fibres connected thereby. Such reinforcement is unnecessary in the joints since the mechanical connection between the central tensile resistant members of the cables is resistant to all tensile loading on the joint, and since there are virtually

no spaces within the joint which are free from material and which would allow radial collapse of the joint when the latter is subjected to hydrostatic pressure.

5 The illustrated joints have a minimum overall dimension, with the outer diameter of the joint corresponding to that of the cables they join.

10 The weight of the illustrated joints is also not substantially greater than the equivalent length of the cables they join since the mechanical connection between the cables is accomplished using a simple clamp, or hardened weld, connecting the central tensile resistant members of the cables, and the joint is devoid of additional mechanical reinforcement. As will be appreciated reducing the overall dimensions and weight of the joint make it much
15 easier to lay cable lengths which are joined by such joints.

The disclosed joints also provide for reliable electrical continuity between the cables' central tensile resistant members by the mechanical connection therebetween.
20 and between their metallic water barriers by the joint's water barrier, so that the tensile resistant members and the water barriers may be used as respective conductors for providing electric power to optoelectronic repeaters for the optical signals being repeated. With such an
25 arrangement the plastics material covering between the mechanical connection and the joint's water barrier acts as a dielectric and accordingly the plastics layer over the joint's water barrier is not subjected to electrical stresses which together with the action thereon by the
30 surrounding water would lead to the formation of so-called 'water-trees' in that plastics layer and to possible corrosion of the joint's water barrier.



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CLAIMS

1. A joint joining two optical fibre cables suitable for
underwater use, which cables each comprise a central ten-
sile resistant member which is covered with at least one
layer of plastics material, through-passages being pre-
5 sent in the plastics material covering, each through-
passage housing at least one optical fibre with the re-
maining space therein being filled, or substantially
filled, with a substantially incompressible fluid, and
a metallic water barrier over said plastics material
10 covering and wherein each cable is devoid of any rein-
forcement against tensile and radial compressive loadings
radially outwardly of the optical fibres thereof; said
joint comprising a mechanical tensile resistant connect-
ion connecting bared end portions of the central tensile
15 resistant members of the cables end-to-end, a plastics
covering comprising one or more layers of plastics mater-
ial covering said mechanical connection and the bared ends
of the plastics material coverings of the cables, through-
cavities being provided in the joint's plastic covering
20 extending in the longitudinal direction of the joint and
interconnecting respective through-passages of the cables.
the optical fibres of the cables in the through-passages
extending into said through-cavities and being connected
therein with the remaining space in said through-cavities
25 being filled, or substantially filled, with substantially
incompressible fluid, and a metallic water barrier ex-
tending over and in contact with, said joint plastics
covering between and connected, in a watertight manner,
to the end portions of metallic water barriers of the
30 cables, said joint being devoid of any reinforcement
against tensile and radial compressive loadings radially
outwardly of the optical fibres connected thereby.
2. A joint as claimed in claim 1, wherein each cable is
provided with a plastics layer over its metallic water



barrier, and wherein the joint is provided with a plastics layer over its metallic water barrier, the outside diameter of the plastics layers over the respective metallic water barriers being the same, or substantially the same.

5 3. A joint as claimed in claim 1 or 2, wherein said mechanical tensile resistant connection is formed with a metallic clamp which is disposed about the bared end portions of the tensile resistant members of the cables, any spaces inwardly of the clamp not occupied by said
10 tensile resistant members being filled with a substantially incompressible fluid.

4. A joint as claimed in any one of claims 1 to 3, wherein said through-cavities are defined at least partially by respective sleeves which circumscribe the connections between the optical fibres therein.
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5. A joint as claimed in claim 4, wherein said through-cavities are disposed adjacent the radially innermost surface of the or a layer of the joint's plastics covering, the radially outermost surface of said layer being
20 in direct contact with the metallic water barrier of the joint.

6. A joint as claimed in claim 5, wherein said through-cavities are defined by said sleeves and bared end portions of respective tubes which define the through-passages of the cables, each sleeve being connected at
25 each end thereof to a respective tube end portion, and the plastics material of said layer adhering to said sleeves and tube end portions.

7. A joint as claimed in claim 5 or 6, wherein said radially innermost surface of said layer of the joint's plastics covering in which said through-cavities are disposed is in direct contact with, and adheres to the mechanical connection.
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8. A joint as claimed in claim 5 or 6, wherein between
35 said layer of the joint's plastics covering in which said



through-cavities are disposed and said mechanical connection, there is interposed a further plastics layer of the joint's plastics covering.

- 5 9. A joint as claimed in claim 1, 2 or 3, wherein said through-cavities are defined by, or located within, grooves in the radially outermost surface of the or a layer of the joint's plastics covering, which layer is in direct contact with, and adheres to, the mechanical connection.
 - 10 10. A joint as claimed in claim 9, wherein said radially outermost surface of said layer is in direct contact with the metallic water barrier of the joint.
 - 15 11. A joint as claimed in claim 9, wherein a further plastics layer of the joint's plastics covering is interposed between said layer provided with the grooves and the metallic water barrier of the joint.
 - 20 12. A joint as claimed in claim 11, wherein said further layer of plastics has a cylindrical inner surface provided with radially inwardly extending ribs which extend into said grooves.
 - 25 13. A joint as claimed in claim 12, wherein said through-cavities are defined by respective sleeves which circumscribe the connections between the optical fibres therein and bared end portions of respective tubes which define the through-passages of the cables, each sleeve being connected at each end thereof to a respective tube end portion, and each sleeve and tube end portions connected thereto being disposed in a respective one of said respective grooves, the ribs of said further layer of plastics filling the spaces between the sleeves and tube end portions connected thereto and the grooves.
 - 30 14. A joint joining two optical fibre cables and substantially as hereinbefore described with reference to Figures 1 and 2 or 3 and 4 of the accompanying drawings.
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