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UNDERWATER TELECOMMUNICATIONS LINE

This invention relates to telecommunications line suitable for use underwater and comprising at least two optical fibre cables which are connected in series with a device containing optoelectronic repeaters therebetween.

5 As is well-known, the optoelectronic repeaters are provided between two optical fibre cables for amplifying and transmitting signals received from the optical fibres of one cable to the optical fibres of the other cable.

10 The connection of the device containing the optoelectronic repeaters to the optical fibre cables must not only provide connections between the optical fibres of the cables and the optoelectronic repeaters of the device but must also ensure continuity of the mechanical strength of the cables and be watertight so as to prevent damage
15 by water to the internal parts of the device and the cables.

A known underwater optical fibre cable has over a metallic water barrier sheath, within which the optical fibres are disposed, metallic reinforcement against tensile and radial compressive loadings, which reinforcement
20 is formed by steel wires laid up around the metallic water barrier sheath. In telecommunication lines suitable for use underwater in which at least two such cables are connected in series with a device containing optoelectronic repeaters therebetween, the continuity between the
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metallic reinforcement of the cables is achieved either by connecting the steel wires of the reinforcement of each cable to a casing of the device by means of slots provided in the casing so that the casing of the device forms part of the reinforcement of the line and therefore has to be capable of resisting mechanical stresses which arise during laying or raising operations on the line or by interconnecting the individual wires of the cables' reinforcement.

10 In each case it is necessary to effect a mechanical connection for each wire of the cables' reinforcement. Thus, ensuring continuity of the cables' reinforcement is a complex and arduous task. Furthermore, the existence of the reinforcement wires on the cables
15 hinders access to the optical fibres and thus makes it difficult to provide reliable connections between the optical fibres of the cables and the optoelectronic repeaters of the device. Also it is difficult to provide a watertight connection between the water barrier sheaths
20 of the cables over the device containing the optoelectronic repeaters because of the presence of the reinforcement wires of the cables over the water barrier sheaths thereof.

An object of the present invention is to provide
25 a telecommunications line suitable for use underwater in which the aforementioned difficulties are avoided.

The present invention provides a telecommunications line suitable for underwater use, comprising at least two optical fibre cables connected in series with
30 a device containing optoelectronic repeaters therebetween; each cable comprising a central tensile resistant member, optical fibres radially outwardly of said member, and a water barrier radially outwardly of the optical fibres, but being devoid of any reinforcement against tensile and
35 radial compressive loadings radially outwardly of the

optical fibres; said device being provided with a through-cavity in which there is located a, or at least part of a, mechanical connection connecting the cables' central members; means being provided for fixing the device relative to the cables' central members; and a watertight casing means sealingly connected with the cables' water barriers and extending over the device.

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

Figure 1 is a longitudinal cross-section of part of a line comprising at least two underwater optical fibre telecommunications cables connected in series with a device containing optoelectronic repeaters therebetween;

Figure 2 is a transverse section of the part of the telecommunications line shown in Figure 1 taken along the line II-II in that figure; and

Figures 3 and 4 are respectively longitudinal cross-sections, similar to Figure 1, of parts of two alternative telecommunication lines.

The underwater telecommunication lines illustrated in the drawings comprise at least two underwater optical fibre cables connected in series with a device containing optoelectronic repeaters therebetween. Typically the lines will comprise a plurality of optical fibre cables connected in series with respective devices containing optoelectronic repeaters between some adjacent pairs of cables other adjacent pairs being connected without the interposition of such a device therebetween.

In the illustrated lines the cables 1 and 2 each have a central tensile resistant member 3 and 4, optical fibres housed in tubes 5 radially outwardly of the central member, and a water barrier sheath 6 and 7

radially outwardly of the optical fibre, but they are devoid of any reinforcement against tensile and compressive loadings radially outwardly of the optical fibres. Cables of such a construction are disclosed in more detail in our UK Patent Applications Nos. 8509947 (Serial No.) and 8509948 (Serial No.).

In the illustrated embodiments of the present invention, the central members 3,4 preferably take the form of a compact antitorsionally stranded member with the spaces between the strands thereof being filled with a substantially incompressible fluid - the term 'fluid' as used in the expression 'substantially incompressible fluid' being used herein 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. The tubes 5 in which the optical fibres are housed form so-called loose jackets therefor and the remaining spaces in the tubes are filled with a substantially incompressible fluid. The water barrier sheath 6,7 may be plastics or metallic, and a plastics layer (19 in Figures 1 and 4) is provided over the water barrier sheath. Other layers, for example of anti-ship-worm protection may be provided over layer 19. The various components of the adjacent end portions of two underwater cables 1 and 2 which are connected in series with a device 10 containing optoelectronic repeaters are stripped back as illustrated in a staggered manner.

The central tensile resistant members 3 and 4 of the cables 1 and 2 are connected by a mechanical connection, at least a part of which is located in a through-cavity 9 of the device 10. The through-cavity 9 is defined by a watertight metallic casing 14 of the device in which the optoelectronic repeaters are housed. These repeaters are of a type known per se and hence are not illustrated.



In the line illustrated in Figures 1 and 2, the mechanical connection comprises a clamp 8, which is disposed entirely within the through cavity 9 of the casing 10, and which is formed as a cylindrical sleeve which is compressed onto end portions of the cables' central members 3 and 4 received therein to connect the members 3 and 4 end-to-end. As an alternative to the illustrated clamp 8, the ends of the members 3 and 4 may be mechanically interconnected within the through cavity 9 by means of a hardened weld.

The device 10 is fixed relative to the members 3 and 4 such that it does not rotate or move axially relative thereto. This is achieved by connecting each end surface 12 of the casing 14 of the device with respective central members 3 and 4 by means of a fitting comprising a collar 13 which grippingly engages the central member and is provided with an integral radially outwardly extending flange 11 which is secured, for example by welding or by means of threaded fasteners, to the casing end surface 12.

A watertight casing 16 is sealingly connected with the cables water barrier sheaths 6 and 7 as indicated at 17 for example by welding if the sheaths 6 and 7 are metallic or by use of mastic materials if the sheaths are formed of plastics materials.

The casing 16 extends over the device 10 and is mechanically connected to the latter by means of an annular flange 15 which is integral with and extends radially outwardly from the device casing 14 and is mechanically connected to the casing 16, for example by an annular weld 23.

Over the watertight casing 16 there is provided a plastics layer 18 which extends between and is secured to the plastics layers 19 of the cables 1 and 2. Further layers, for example of anti-ship-worm protection, are

provided over layer 18 if corresponding layers are provided over the cables' layers 19.

The watertight casing 16 which extends over the device 10 and is sealingly connected to the water barrier sheaths 6 and 7 of the cables is a metallic casing which is resistant to radial compressive loads due to hydrostatic pressure to which it will be subjected when the line is laid underwater. As illustrated the casing 16 comprises two symmetrically disposed sleeves, each comprising first and second substantially cylindrical end portions 21 and 22 interconnected by an intermediate frustoconical portion 20. The smaller diameter first end portions 21 of the sleeves fit over and are sealingly and fixedly connected to the stripped end portions of the sheaths 6 and 7 of the cables 1 and 2 at 17 for example by welding or with mastic material as discussed above. The larger diameter second end portions 22 are sealingly interconnected and fixed relative to the device 10 by being welded to the flange 15 of the device casing 14 by weld 23. Thus, there is provided a mechanical connection between the metallic casing 16 and the device 10, which itself is mechanically connected through fittings 11, 13 to the central tensile resistant members 3 and 4 of the cables. As a consequence, the weight of the casing 16 is supported by the members 3 and 4 rather than the sealing connections 17 between the casing 16 and the sheaths 6 and 7 during laying or raising operations on the line and these connections are thus maintained substantially stress-free. Alternative means for supporting the weight of the metallic casing to the flange 15 such that the sealing connections 17 are substantially stress-free may be provided. For example, in a non-illustrated embodiment the flange 15 is omitted and a metallic covering is disposed around the casing 16 over the outer surface of the layer 18 thereon and over adjacent predetermined lengths

of the outer surfaces of the layers 19 of the cables 1 and 2 in frictional engagement therewith. The only function of this metallic covering is to transfer the weight of the casing 16 onto the outer surfaces of the cables.

5 Connections 24 connecting the optical fibres of the cables which are housed in tubes 5 and optical fibres connected to the optoelectronic repeaters of the device, which extend from the device casing end surfaces 12 in sealed tubes 25, are disposed within the casing 16.
10 Preferably the remaining space within the casing 16 is filled with a substantially incompressible fluid such as a petroleum jelly, a silicone grease or silicone oil.

 It will be understood that if the optical fibres of the cables 1 and 2 areunjacketed - that is not provided with loose-jackets formed by tubes, the optical
15 fibres of the cables 1 and 2 would be connected to the optical fibres of the device 10 by fusion splicing.

 Electric power for the electric circuits of the
20 device 10 is provided by conductors incorporated in the cables 1 and 2, for example by the central tensile resistant members and metallic water barrier sheaths (or by conductors adjacent the water barrier sheaths if the latter are plastics), and it will be understood that electric
25 connections between these conductors and the device 10 are housed inside the casing. An alternative embodiment illustrated in Figure 3 differs from the above-described embodiment only with respect to the mechanical connection connecting the central tensile resistant member
30 3 and 4 of the cables 1 and 2. In the embodiment shown in Figure 3, this mechanical connection is only partly disposed in the through-cavity 9 of the device 10 and comprises a tensile resistant element 26 which extends through the through-cavity 9 with each end portion 27,28
35 of the element 26 being disposed outwardly of the through-

cavity over a predetermined distance. The element may be a metal rod or a length of compact antitorsionally stranded rope, for example. The fittings whose flanges 11 are secured to the end surfaces 12 of the device casing 14 have their collars 13 grippingly engaged with the element 26, and respective clamps 29, similar to clamp 8 discussed above, connect the free end portions 27,28 of the element 26 to the ends of the cables' central members 3,4 externally of the through-cavity 9. Alternatively the central members 3,4 can be mechanically connected end-to-end with the respective end portions 27,28 of the element 26 by means of hardened welds.

Another alternative embodiment illustrated in Figure 4 differs from the embodiment shown in Figures 1 and 2 by the provision of two auxiliary casings 30 disposed within the casing 16. Each auxiliary casing 30 is metallic and generally frusto-conical in form. The smaller diameter end 31 of each auxiliary casing 30 is sealingly connected to the water barrier sheath of a respective cable at a connection 32 and each casing 30 extends to and has its larger diameter end 33 sealingly connected to an adjacent side wall of the device casing 14 via an annular flange 34 thereof.

The connections 24 connecting the optical fibres of the cables which are housed in tubes 5 and the optical fibres connected to the optoelectronic repeaters of the device which are housed in tubes 25 are disposed within the auxiliary casings 30 with the remaining spaces within the casings 30 filled with a substantially incompressible fluid, such as a petroleum jelly, silicone grease or silicone oil. Thus, the provision of the auxiliary casings 30 further protects the connections 24 from possible damage by water.

It will be appreciated that this further protection provided by the auxiliary casings 30 makes their

provision particularly advantageous when the optical fibres of the cables are un-jacketed - that is not provided with loose-jackets formed by the tubes 5.

From the above, it will be appreciated that in
5 connecting the two cables 1 and 2 in series with the device 10 therebetween in the embodiments, the mechanical continuity between the central tensile resistant members 3 and 4 of the cables by means of a mechanical connection which is located at least partly in the through-bore 9 of
10 the device 10 can be rapidly and easily effected. It will be noted that each tensile resistant member 3,4 is connected to the mechanical connection in a single operation to establish the mechanical continuity between those members, whereas in the known telecommunications
15 lines discussed hereinbefore the equivalent step of establishing mechanical continuity between the metallic reinforcement of the cables involves making connections with the individual wires of the reinforcement which are laid up around the water barrier sheaths of the cables.

20 Furthermore, the absence of any reinforcement against tensile and radial compressive loadings radially outwardly of the optical fibres in the cables 1 and 2 greatly assists access to the optical fibres at the stripped ends of the cables and hence enables more reliable connections to be made between the optical fibres of
25 the cables and of the device 10.

Furthermore, the sealing connections between the cables water barrier sheaths 6,7 and the casing 16 (and the auxiliary casings 30, when provided) can be reliably
30 made since access to their locations is also not impaired by reinforcement wires on the cables water barrier sheaths.

CLAIMS:

1. A telecommunications line suitable for underwater use, comprising at least two optical fibre cables connected in series with a device containing optoelectronic repeaters therebetween; each cable comprising a central
5 tensile resistant member, optical fibres radially outwardly of said member, and a water barrier radially outwardly of the optical fibres, but being devoid of any reinforcement against tensile and radial compressive loadings radially outwardly of the optical fibres; said
10 device being provided with a through-cavity in which there is located a, or at least part of a, mechanical connection connecting the cables' central members; means being provided for fixing the device relative to the cables' central members; and a watertight casing means
15 sealingly connected with the cables' water barriers and extending over the device.
2. A line as claimed in claim 1, wherein said mechanical connection comprises a clamp which is disposed within said through-cavity and about the end portions of the
20 cables' central members to connect said members end-to-end.
3. A line as claimed in claim 1, wherein said mechanical connection comprises a tensile resistant element which extends through said through-cavity with each end
25 of said element being disposed outwardly thereof, and respective clamps which connect the ends of said element to the ends of said cables' central members.
4. A line as claimed in claim 1, 2 or 3, wherein said watertight casing means comprises two symmetrically disposed
30 sleeves each comprising first and second



substantially cylindrical end portions interconnected by an intermediate frusto-conical portion, each first end portion being sealingly connected with the water barrier of a respective cable and the second end portions being sealingly interconnected.

5. A line as claimed in claim 4, wherein two auxiliary casings are disposed within said watertight casing means each auxiliary casing being sealingly connected to the water barrier of a respective cable and to an adjacent wall of said device to which the auxiliary casing extends.

6. A line as claimed in claim 5, in which said auxiliary casings are metallic.

7. A line as claimed in any one of the preceding claims in which said casing means is metallic.

8. A line as claimed in any one of the preceding claims, comprising means for supporting the weight of the casing means such that the sealing connections thereof with the cables' water barriers are substantially stress free.

9. A line as claimed in claim 8, wherein said supporting means comprises flange means extending radially outwardly from the device and secured to said casing means.

10. A line as claimed in claim 9, when claim 8 is appended to claim 4, 5 or 6 or to claim 7 when claim 7 is appended to claim 4, 5 or 6, wherein said flange means extends between and is connected to said second end portions of the sleeves of the watertight casing means.



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11. A line as claimed in claim 8, wherein said supporting means comprises a metallic covering disposed around said casing means and over adjacent predetermined lengths of outer surfaces of the two cables in frictional engagement therewith.

12. A telecommunications line suitable for underwater use, substantially as herein described with reference to Figures 1 and 2, Figure 3 or Figure 4 of the accompanying drawings.

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