

PATENT SPECIFICATION (11)

1 506 405



(21) Application No. 24356/75 (22) Filed 6 June 1975 (19)
 (31) Convention Application No. 49/065 202 (32) Filed 7 June 1974 in
 (33) Japan (JP)
 (44) Complete Specification published 5 April 1978
 (51) INT. CL.³ G02B 5/14
 (52) Index at acceptance
 G2J 34A4

(54) OPTICAL FIBRE CABLE

(71) We, SUMITOMO ELECTRIC INDUSTRIES LTD., a Japanese Company of No. 15 Kitahama 5-chome, Higashi-ku, Osaka-shi, Osaka, Japan, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

The present invention relates to an optical fibre cable.

As is well-known, developments have generally been made in various optical fibres comprising a core made of highly pure fused silica doped with titanium oxides and a cladding layer of highly pure silica which can transmit the optical signals at lower loss. However, these optical fibres are still unsatisfactory for incorporation into cables for practical use in view of their low flexibility, elongation, and breaking strength. Optical fibres that can be used for practical applications have not been developed, before now.

An object of the present invention is to provide an optical fibre cable which is capable of obviating or mitigating the foregoing technical problems.

According to the present invention, there is provided an optical fibre cable comprising a layer of optical fibres, cushion layers disposed adjacent said layer of optical fibres, a low friction layer disposed between each cushion layer and said optical fibres, a strengthening member extending in the direction of extent of the optical fibres so that, in use, almost all of the tensile force exerted on the optical fibre cable is taken over by said strengthening member, and a protection layer for protecting the above structure.

Embodiments of the present invention will now be described, by way of example, with reference to the accompanying drawing, in which Figures 1 to 3 are respective cross sections of three different embodiments of an optical fibre cable according to the present invention.

Referring to Figure 1, a first embodiment of the optical fibre cable comprising a strengthening member 1, a plastics layer 2 covering the strengthening member 1, an inner cushion layer 3 provided on the plas-

tics layer 2 and a thin, low friction layer 4 provided on the cushion layer 3. A layer of optical fibres 5 surround the layer 4, and a further thin, low friction layer 4¹ is provided between the optical fibres 5 and an outer cushion layer 3¹. Finally, a reinforcing layer 6 made of plastics material, metal, or composite material consisting of plastics material and metal is applied to the exterior of layer 3¹ to make a cable of about 500 μ diameter. In this particular embodiment, the reinforcing layer 6 is composed of a composite material comprising a metal sheath and plastics material. The optical fibres 5 are generally made of highly pure silica fibre of about 200 μ diameter, and may each be a single fibre strand or a bundle composed of several optical fibres. The strengthening member 1 may be made of steel wire, plastics material, reinforced plastics material, carbon fibre or glass fibre. The cushion layer 3¹ is provided for preventing stress caused by the bending of the cable from concentrating on the optical fibres, and consists of non-woven plastics fibres, foamed plastics material, or non-woven glass fibre. As low friction material for the layers 4 and 4¹, tapes such as those made of polyethylene, polyesters, fluorinated ethylene propylene copolymer, polytetrafluoroethylene, having slippery surfaces are used.

The optical fibre cable shown in Figure 1 is subjected to bending and tensile forces when it is installed or transported. This applies tension and bending forces to the optical fibres disposed in the optical fibre cable in two different manners, that is, lengthwise tension along the cable when the entire cable is pulled along its length, and local compression and tension when the cable is bent or twisted. The optical fibres 5 are often broken due to such local stress.

Concerning the first-mentioned forces, the elongation of optical fibres is much lower than that of copper or steel wires, and it is considered to be less than 0.5%. Accordingly when the cable is pulled or bent in a laying operation, the optical fibres are easily broken by the local stress caused by such tension and bending. Therefore, the strength-

ening member 1 of the optical fibre cable is required to have a sufficient cross section to take over and withstand almost of the tension force exerted on the cable.

Concerning the second-mentioned forces, local tensile stress or concentrated bending stress is moderated by the cushion layers 3 and 3¹ which are provided on either side of the layer of optical fibres 5, and in addition by the low frictional layer 4 and 4¹, which are provided between the optical fibres 5 and the cushion layers 3 and 3¹ respectively. With such a construction, the optical fibres 5 can slide between these layers in a direction which reduces the tension applied to the optical fibre layer 5, thereby dispersing the local bending stress which would otherwise be concentrated in the optical fibre.

An optical fibre cable of about 20 mm outside diameter and 250 m length having a structure as shown in Figure 1 shows no breaks in its optical fibres when it is installed under a tension of 50 kg. Also, when it is wound around a rod of 80 mm radius and subjected to repeated flexure for about ten times, the optical fibres again show no breaks.

In this embodiment, string-shaped or strand cushion members, such as strings of roving jute or roller thin plastic string, may be inserted between adjacent optical fibres or units 5 composed of a plurality of optical fibres bundled together, in order to obtain a better buffering effect.

It has been confirmed experimentally that, while the elongation of each optical fibre should be about 0.5% for producing a 1% elongation at break in a conventional optical fibre cable, i.e. having no cushion layers, the apparent elongation of the optical fibre cable according to this invention can be increased to as high as 5%.

Further embodiments of the present invention are shown in Figures 2 and 3, the same reference numerals as in Figure 1 being used to represent corresponding components. In the embodiment of Figure 2, the numeral 7 denotes power lines or other communication lines which run in parallel with the optical fibre cable and which are disposed centrally of the cable. The strengthening member 1 is now provided on the exterior of the layer 6.

In the optical fibre cable shown in Figure 3, a plurality of optical fibres are bundled into seven units, each of which is covered with a low friction layer 4¹. The units are surrounded by a cushion layer 3 with a low friction layer 4 disposed between the said units and the layer 3, and a protection sheath layer 6 is provided over the layer 3. As in the cable shown in Figure 2, the strengthening member 1 is provided on the exterior of layer 6.

In the optical fibre cable of the present invention, local tension and compression ex-

erted on the optical fibres, caused by pulling and bending forces applied to the entire cable at the time of installing, can be moderated by the provision of cushion layers and low friction layers disposed adjacent the fibres. Moreover, by providing a strengthening member which extends in the direction of extent of the optical fibre cable, almost all of the tension applied to the cable is taken over by this member, thereby preventing the tension from being exerted on the optical fibres during installation of the cable. Thus, an excellent optical fibre cable, in which the individual optical fibres are highly resistant to breaking, can be obtained according to this invention.

WHAT WE CLAIM IS:—

1. An optical fibre cable comprising a layer of optical fibres, cushion layers disposed adjacent said layer of optical fibres, a low friction layer disposed between each cushion layer and said optical fibres, a strengthening member extending in the direction of extent of the optical fibres so that, in use, almost all of the tensile force exerted on the optical fibre cable is taken over by said strengthening member, and a protection layer for protecting the above structure.
2. An optical fibre cable as claimed in claim 1, wherein the strengthening member is made of steel wire.
3. An optical fibre cable as claimed in claim 1, wherein the strengthening member is made of plastics material.
4. An optical fibre cable as claimed in claim 1, wherein the strengthening member is made of reinforced plastics material.
5. An optical fibre cable as claimed in claim 1, wherein the strengthening member is made of carbon fibre.
6. An optical fibre cable as claimed in claim 1, wherein the strengthening member is made of glass fibre.
7. An optical fibre cable as claimed in any preceding claim wherein said cushion layers each consist of non-woven plastics fibres.
8. An optical fibre cable as claimed in any one of claims 1 to 6, wherein said cushion layers each consist of foamed plastics material.
9. An optical fibre cable as claimed in any one of claims 1 to 6, wherein said cushion layers each consist of non-woven glass fibre.
10. An optical fibre cable as claimed in any preceding claim, wherein the low friction layers each consist of polyethylene tape.
11. An optical fibre cable as claimed in any one of claims 1 to 9, wherein the low friction layers each consist of polyester tape.
12. An optical fibre cable as claimed in any one of claims 1 to 9, wherein the low friction layers each consist of fluorinated ethylene propylene copolymer tape.

ening member 1 of the optical fibre cable is required to have a sufficient cross section to take over and withstand almost of the tension force exerted on the cable.

Concerning the second-mentioned forces, local tensile stress or concentrated bending stress is moderated by the cushion layers 3 and 3¹ which are provided on either side of the layer of optical fibres 5, and in addition by the low frictional layer 4 and 4¹, which are provided between the optical fibres 5 and the cushion layers 3 and 3¹ respectively. With such a construction, the optical fibres 5 can slide between these layers in a direction which reduces the tension applied to the optical fibre layer 5, thereby dispersing the local bending stress which would otherwise be concentrated in the optical fibre.

An optical fibre cable of about 20 mm outside diameter and 250 m length having a structure as shown in Figure 1 shows no breaks in its optical fibres when it is installed under a tension of 50 kg. Also, when it is wound around a rod of 80 mm radius and subjected to repeated flexure for about ten times, the optical fibres again show no breaks.

In this embodiment, string-shaped or strand cushion members, such as strings of roving jute or roller thin plastic string, may be inserted between adjacent optical fibres or units 5 composed of a plurality of optical fibres bundled together, in order to obtain a better buffering effect.

It has been confirmed experimentally that, while the elongation of each optical fibre should be about 0.5% for producing a 1% elongation at break in a conventional optical fibre cable, i.e. having no cushion layers, the apparent elongation of the optical fibre cable according to this invention can be increased to as high as 5%.

Further embodiments of the present invention are shown in Figures 2 and 3, the same reference numerals as in Figure 1 being used to represent corresponding components. In the embodiment of Figure 2, the numeral 7 denotes power lines or other communication lines which run in parallel with the optical fibre cable and which are disposed centrally of the cable. The strengthening member 1 is now provided on the exterior of the layer 6.

In the optical fibre cable shown in Figure 3, a plurality of optical fibres are bundled into seven units, each of which is covered with a low friction layer 4¹. The units are surrounded by a cushion layer 3 with a low friction layer 4 disposed between the said units and the layer 3, and a protection sheath layer 6 is provided over the layer 3. As in the cable shown in Figure 2, the strengthening member 1 is provided on the exterior of layer 6.

In the optical fibre cable of the present invention, local tension and compression ex-

erted on the optical fibres, caused by pulling and bending forces applied to the entire cable at the time of installing, can be moderated by the provision of cushion layers and low friction layers disposed adjacent the fibres. Moreover, by providing a strengthening member which extends in the direction of extent of the optical fibre cable, almost all of the tension applied to the cable is taken over by this member, thereby preventing the tension from being exerted on the optical fibres during installation of the cable. Thus, an excellent optical fibre cable, in which the individual optical fibres are highly resistant to breaking, can be obtained according to this invention.

WHAT WE CLAIM IS:—

1. An optical fibre cable comprising a layer of optical fibres, cushion layers disposed adjacent said layer of optical fibres, a low friction layer disposed between each cushion layer and said optical fibres, a strengthening member extending in the direction of extent of the optical fibres so that, in use, almost all of the tensile force exerted on the optical fibre cable is taken over by said strengthening member, and a protection layer for protecting the above structure.
2. An optical fibre cable as claimed in claim 1, wherein the strengthening member is made of steel wire.
3. An optical fibre cable as claimed in claim 1, wherein the strengthening member is made of plastics material.
4. An optical fibre cable as claimed in claim 1, wherein the strengthening member is made of reinforced plastics material.
5. An optical fibre cable as claimed in claim 1, wherein the strengthening member is made of carbon fibre.
6. An optical fibre cable as claimed in claim 1, wherein the strengthening member is made of glass fibre.
7. An optical fibre cable as claimed in any preceding claim wherein said cushion layers each consist of non-woven plastics fibres.
8. An optical fibre cable as claimed in any one of claims 1 to 6, wherein said cushion layers each consist of foamed plastics material.
9. An optical fibre cable as claimed in any one of claims 1 to 6, wherein said cushion layers each consist of non-woven glass fibre.
10. An optical fibre cable as claimed in any preceding claim, wherein the low friction layers each consist of polyethylene tape.
11. An optical fibre cable as claimed in any one of claims 1 to 9, wherein the low friction layers each consist of polyester tape.
12. An optical fibre cable as claimed in any one of claims 1 to 9, wherein the low friction layers each consist of fluorinated ethylene propylene copolymer tape.



13. An optical fibre cable as claimed in any one of claims 1 to 9, wherein the low friction layers each consist of polytetrafluoroethylene tape.

5 14. An optical fibre cable as claimed in any preceding claim, wherein the optical fibres are grouped in bundles.

10 15. An optical fibre cable as claimed in claim 14, further including insulating conductors for transmitting electrical signals or electrical power.

16. An optical fibre cable substantially as hereinbefore described with reference to Figure 1 or Figure 2 or Figure 3 of the accompanying drawing.

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Printed for Her Majesty's Stationery Office by Burgess & Son (Abingdon), Ltd. 1978.
Published at The Patent Office, 25 Southampton Buildings, London, WC2A 1AY,
from which copies may be obtained.

