

(19) World Intellectual Property Organization
International Bureau



(43) International Publication Date
7 February 2008 (07.02.2008)

PCT

(10) International Publication Number
WO 2008/015386 A2

(51) International Patent Classification:
G02B 6/44 (2006.01)

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(21) International Application Number:
PCT/GB2007/002802

(81) Designated States (unless otherwise indicated, for every kind of national protection available): AE, AG, AL, AM, AT, AU, AZ, BA, BB, BG, BH, BR, BW, BY, BZ, CA, CH, CN, CO, CR, CU, CZ, DE, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IS, JP, KE, KG, KM, KN, KP, KR, KZ, LA, LC, LK, LR, LS, LT, LU, LY, MA, MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PG, PH, PL, PT, RO, RS, RU, SC, SD, SE, SG, SK, SL, SM, SV, SY, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW.

(22) International Filing Date: 24 July 2007 (24.07.2007)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:
0615183.1 29 July 2006 (29.07.2006) GB
0700003.7 2 January 2007 (02.01.2007) GB

(84) Designated States (unless otherwise indicated, for every kind of regional protection available): ARIPO (BW, GH, GM, KE, LS, MW, MZ, NA, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European (AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HU, IE, IS, IT, LT, LU, LV, MC, MT, NL, PL, PT, RO, SE, SI, SK, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG).

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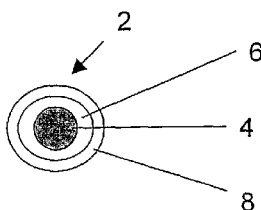
Published:

— without international search report and to be republished upon receipt of that report



WO 2008/015386 A2

(54) Title: SIGNAL TRANSMITTING CABLE



(57) Abstract: An optical fibre cable (2) comprises an optical fibre (4), a first layer (6) of at least one radiation curable material having an elastic modulus greater than 100 MPa but less than 1000 MPa, and a second layer (8) of at least one radiation curable material arranged outwardly of the first layer and having an elastic modulus higher than that of the first layer.

SIGNAL TRANSMITTING CABLE

The present invention relates to signal transmitting cables, and relates particularly, but not exclusively, to optical fibre signal transmitting cables.

Optical fibre cables carry data at very high speeds and as the demand for 'Broadband' internet access grows, there is an increasing requirement for optical fibre cables providing high speed connection to be deployed directly into individual homes or business premises.

It is to be noted that the number of optical fibres which needs to be provided to each individual home or business premises is relatively small. In fact, it is often possible to provide adequate high speed services to an individual home using an optical fibre cable having just one optical fibre.

Typical applications of such optical fibre cables are, for example, providing optical fibre connections to individual premises to provide very high speed broadband internet connections, TV, video and telephony. This application is known as "Fibre to the Home" (FTTH).

Increasingly, optical fibre networks are constructed by setting up a network of tubes, and then subsequently installing the optical fibre cables into the tube network, usually by means of a combination of blowing by means of compressed air, and pushing by means of rollers. EP0108590 describes the basic process of using fluid drag to install optical fibre cables in tubes. The blowing process distributes the installation force along the entire length of the optical fibre cable, and it is desirable for optical fibre cables to have adequate stiffness to facilitate installation by means of blowing. Such stiffness is generally provided by means of reinforcement of the optical fibre cable.

It is known to provide adequate stiffness to an optical fibre cable by means of providing a thick outer sheath, for example. However, in having a thick outer sheath, this type of optical fibre cable suffers from the disadvantage that it is bulky. This is especially

disadvantageous since there is an increasing requirement for optical fibre cables to become more compact, primarily because city networks are congested. Moreover, providing new underground ducts in cities is expensive and involves substantial disruption.

Attempts have been made to solve the problem of providing adequate stiffness to an optical fibre cable without making it too bulky. For example, EP 0157610 discloses an optical fibre cable comprising: one or more optical fibres; an inner sheath having an elastic modulus of 1000 MPa; and an outer sheath having an elastic modulus of less than 1000 MPa. By having an inner sheath having a relatively high elastic modulus, the optical fibre cable possesses the required stiffness to facilitate installation by means of blowing, without being too bulky.

Despite providing a degree of stiffness to facilitate installation by means of blowing without being too bulky, the optical fibre cable of EP 0157610 suffers from the disadvantage that it is inflexible, which inhibits blowing performance particularly in the case where the optical fibre is to follow a curved installation path. This inflexibility potentially negates any positive effects of having the required stiffness to facilitate blowing.

EP 0296836 discloses an optical fibre cable comprising: one or more optical fibres; an inner sheath having an elastic modulus of less than 100 MPa; and an outer sheath. By including an inner sheath having a relatively low elastic modulus, any stresses arising within the cable are distributed in a reasonably uniform fashion, and a degree of flexibility is provided to the optical fibre cable.

The optical fibre cable of EP 0296836 suffers from the disadvantage that the inner layer, having a relatively low elastic modulus, offers little "crush" resistance. Moreover, since the stiffness is directly proportional to the elastic modulus, little additional stiffness is conferred by the inner layer, and it is left to the outer sheath to provide the additional stiffness required for installation by means of blowing.

Preferred embodiments of the present invention seek to overcome or at least alleviate the above disadvantages of the prior art.

According to an aspect of the present invention, there is provided signal transmitting cable comprising a signal transmitting portion including at least one signal transmitting member, a first layer of at least one radiation curable material surrounding said signal transmitting portion, wherein said first layer has an elastic modulus greater than 100 MPa but less than 1000 MPa, and a second layer of at least one radiation curable material arranged outwardly of the first layer, wherein the second layer has an elastic modulus higher than that of the first layer

The present invention is based upon the discovery that cables having enough stiffness required to facilitate installation by means of blowing, yet enough flexibility so as not to prohibit installation by the same process, can be manufactured by providing a first layer having an elastic modulus within the range specified above. This provides the advantage that the stiffness required to facilitate installation by means of blowing is provided, even in the case of a relatively thin first layer, whilst still allowing sufficient flexibility to facilitate installation by means of blowing, particularly in non-linear underground ducts where installation of an inflexible cable would be inhibited. The use of radiation curable material provides good blowing and temperature performance, while also making it easy to strip the coatings from the cable when optical fibre connections are to be made. The use of a second layer of higher elastic modulus than that of the first layer and arranged outwardly of the first layer provides the further advantage of giving further protection to the cable while enabling various additives to be used which further improve the blowing performance of the cable.

The second layer may have a thickness less than or equal to the thickness of the first layer.

Outer layers of optical fibre cables are sometimes modified to include a particle coating or inclusion which improves blowing performance. This type of outer layer is expensive. In having a relatively tough first layer however, the thickness of the outer layer may be made to be thinner. This provides the advantage that the manufacturing costs of the optical fibre cable

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may be reduced. In having a thinner outer layer, this provides the further advantage that the outer layer may be stripped away from the first layer more easily, when required.

The second layer may have a thickness of approximately 10% of the thickness of the first layer.

The signal transmitting portion may include a single signal transmitting member.

This provides the advantage that a tighter bending radius may be employed when installing the optical fibre cable in underground ducts. The reason for this is as follows. Bending an optical fibre cable causes strain, and the strain has the largest positive value at the position where the optical fibre is furthest away from the central axis of the optical fibre cable. Optical fibre strain is therefore minimized by keeping the optical fibres as close as possible to the central axis of the optical fibres. A practical result of this is that a cable comprising two or four optical fibres is generally limited to a bend radius of, typically, 50mm whilst a cable comprising only a single optical fibre can safely be subjected to a bend radius of 30mm or even 25 mm. This means that such a cable comprising only a single optical fibre may be stored on commonly used splice trays for prolonged periods.

The first layer may have an outer diameter of approximately 0.4 to 1mm.

This provides the advantage of making the optical fibre cable more compact, which reduces congestion in already crowded underground ducts.

The second layer may include at least one anti-static agent.

This provides the advantage that static build-up on the outer layer is reduced, thereby improving blowing performance.

At least one anti-static agent may comprise a quaternary ammonium compound containing methanol.

Preferably, the coefficient of dynamic friction of the second layer is less than or equal to 0.25.

This provides the advantage of improving blowing performance of the optical fibre cable.

According to another aspect of the present invention, there is provided a signal transmitting cable comprising a signal transmitting portion including at least one signal transmitting member, and a first layer surrounding said signal transmitting portion, wherein said first layer includes undissolved particulate matter dispersed therethrough.

This provides the surprising advantage that the coefficient of thermal expansion of the first layer is reduced, thereby mitigating the effects of thermal expansion which can be detrimental to the performance of the signal transmitting cable.

The particulate matter may comprise aluminium trihydrate and/or antimony trioxide and/or zinc hydroxystannate.

Preferably, the coefficient of thermal expansion of the first layer is approximately $5 \times 10^{-5}/\text{C}$ below T_g and $1.5 \times 10^{-4}/\text{C}$ above T_g , where T_g is the glass transition temperature.

According to a further aspect of the present invention, there is provided a signal transmitting cable comprising a signal transmitting portion including at least one signal transmitting member, and a first layer surrounding said signal transmitting portion, wherein the first layer is made from at least one filled, fire retardant material.

This provides the advantage that the optical fibre cable is provided with improved resistance to fire. In particular a filled acrylate material has been found to be effective. The reason for this is as follows. Conventional acrylate materials frequently burn at room temperature when subjected to an ignition source. This is because conventional acrylates have a limiting oxygen content (LOI) of approximately 20, which means that they burn at an atmospheric level of 20% oxygen (as occurs naturally). However, filled acrylates have an LOI of typically about 30 and so resist burning under room temperature conditions. In view of this, optical fibre cables

having a filled acrylate first layer are capable of passing fire tests such as UL 1581, UL 1666 and UL 1685.

Preferred embodiments of the present invention will now be described, by way of example only and not in any limitative sense, with reference to the accompanying drawings, in which:-

Figure 1 is a schematic cross-sectional view of a cable of a first embodiment of the present invention;

Figure 2 is a schematic cross-sectional view of a cable of a second embodiment of the present invention;

Figure 3 is a schematic cross-sectional view of a cable of a third embodiment of the present invention; and

Figure 4 is a schematic cross-sectional view of a cable of a fourth embodiment of the present invention.

Referring to Figure 1, an optical fibre cable 2 comprises a single optical fibre 4, surrounded by a first layer 6, which itself is surrounded by a second layer in the form of an outer layer 8. The outer layer 8 is formed from a UV-curable acrylate resin material having secant modulus of 250 to 500 Mpa, and is in touching contact with the first layer 6, and is arranged outwardly of the first layer 6. The first layer 6 is made from material having an elastic modulus of greater than or equal to 100 MPa and less than 1000 MPa. The thickness of the outer layer 8 is approximately 10 microns, and the thickness of the first layer 6 is approximately 1mm.

In having an elastic modulus in this range, the optical fibre cable of the present invention possesses the required stiffness to facilitate installation by blowing in underground ducts, yet is not so inflexible that its installation in non-linear underground ducts is impeded.

The outer layer 8 includes an anti-static agent in the form of a quaternary ammonium

compound containing methanol. Moreover, the coefficient of friction of the outer layer 6 is approximately 0.25.

Referring now to Figure 2, an optical fibre cable 2a comprises a single optical fibre 4, surrounded by a first layer 6a, which itself is surrounded by a second layer in the form of an outer layer 8a. The outer layer 8a is arranged outwardly of the first layer 6a. The first layer 6a has undissolved particulate matter 10 dispersed therethrough. The particulate matter 10 serves to reduce the coefficient of thermal expansion of the first layer 6a, and in this way, the coefficient of expansion of the first layer 6a is approximately $5 \times 10^{-5}/\text{C}$ below T_g and $1.5 \times 10^{-4}/\text{C}$ above T_g , where T_g is the glass transition temperature, as will be familiar to persons skilled in the art.

Referring now to Figure 3, an optical fibre cable 2b comprises a single optical fibre 4, surrounded by a first layer 6b, which itself is surrounded by a second layer in the form of an outer layer 8b. The outer layer 8b is arranged outwardly of the first layer 6b. The first layer 6b is made from a filled acrylate material, and in this way, the first layer 6b resists burning under room temperature conditions.

Referring now to Figure 4, an optical fibre cable 2c is similar to that shown in Figure 1, but for the provision of a plurality of optical fibres 4. Likewise, figure 5 is similar to Figure 2 but for the provision of a plurality of optical fibres 4 and figure 6 is similar to Figure 3 but for the provision of a plurality of optical fibres 4.

It will be appreciated by persons skilled in the art that the above embodiments have been described by way of example only, and not in any limitative sense, and that various alterations and modifications are possible without departure from the scope of the invention as defined by the appended claims. In particular, it is to be appreciated that the signal transmitting cable may include additional layers other than the first and second layers discussed above. Moreover, it is to be appreciated that the signal transmitting cable may include any number of optical fibres.

CLAIMS

1. A signal transmitting cable comprising a signal transmitting portion including at least one signal transmitting member, a first layer of at least one radiation curable material surrounding said signal transmitting portion, wherein said first layer has an elastic modulus greater than 100 MPa but less than 1000 MPa, and a second layer of at least one radiation curable material arranged outwardly of the first layer, wherein the second layer has an elastic modulus higher than that of the first layer.
2. A signal transmitting cable according to claim 1 wherein said first layer is formed from a material containing substantially inert filler material and wherein the said second layer is formed from unfilled material
3. A signal transmitting cable according to claim 1 or claim 2, wherein the second layer has a thickness less than or equal to that of the first layer.
4. A signal transmitting cable as claimed in claim 1 or claim 2, wherein said second layer has a thickness of approximately 10% of the thickness of the first layer.
5. A signal transmitting cable as claimed in any one of the preceding claims, wherein the signal transmitting portion includes a single signal transmitting member.
6. A signal transmitting cable as claimed in any one of the preceding claims, wherein the signal transmitting portion includes a plurality of signal transmitting members.
7. A signal transmitting cable as claimed in any one of the preceding claims, wherein the first layer has a thickness of approximately 1mm.
8. A signal transmitting cable as claimed in any one of the preceding claims, wherein the second layer includes at least one anti-static agent.

9. A signal transmitting cable as claimed in claim 8, wherein at least one said anti-static agent comprises a quaternary ammonium compound containing methanol.
10. A signal transmitting cable as claimed in any one of the preceding claims, wherein the coefficient of dynamic friction of the second layer is less than or equal to 0.25.
11. A signal transmitting cable comprising a signal transmitting portion including at least one signal transmitting member, and a first layer surrounding said signal transmitting portion, wherein said first layer includes undissolved particulate matter dispersed therethrough.
12. A signal transmitting cable according to claim 11, wherein the particulate matter includes aluminium trihydrate and/or antimony trioxide and/or zinc hydroxystannate.
13. A signal transmitting cable as claimed in claim 11 or 12, wherein the coefficient of thermal expansion of the first layer is approximately $5 \times 10^{-5}/\text{C}$ below T_g and $1.5 \times 10^{-4}/\text{C}$ above T_g , where T_g is the glass transition temperature
14. A signal transmitting cable comprising a signal transmitting portion including at least one signal transmitting member, and a first layer surrounding said signal transmitting portion, wherein the first layer is made from at least one filled acrylate material.
15. A signal transmitting cable substantially as hereinbefore described with reference to the accompanying drawings.

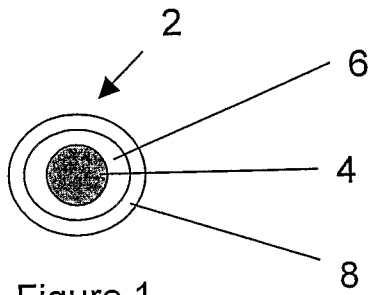


Figure 1

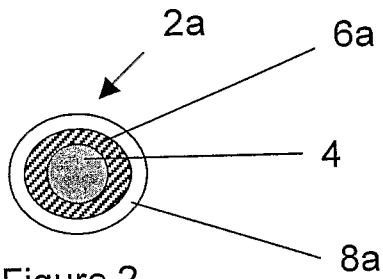


Figure 2

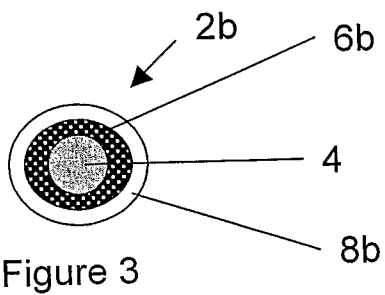


Figure 3

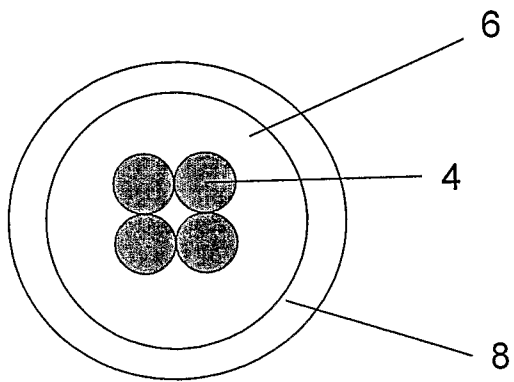


Figure 4

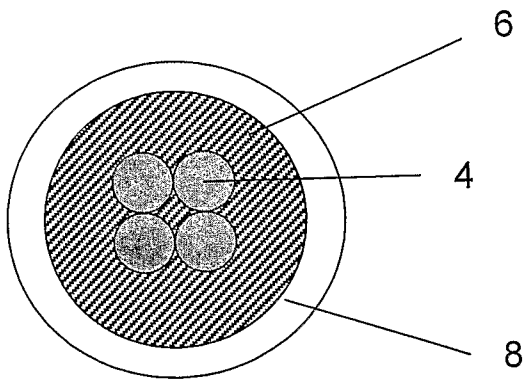


Figure 5

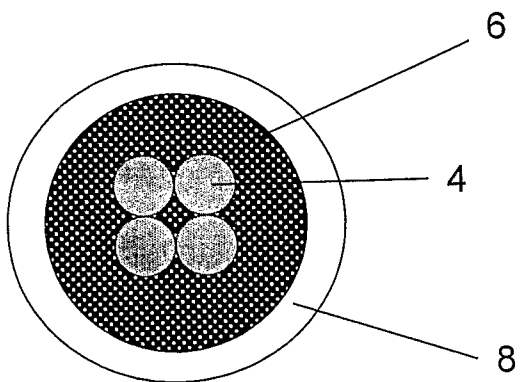


Figure 6