

FORM 1

596122

AUSTRALIA

THE PATENTS ACT 1952

APPLICATION FOR A STANDARD PATENT

E/We, FURUKAWA ELECTRIC CO., LTD.

of 6-1 Marunouchi, 2-chome, Chiyoda-ku, Tokyo,  
Japan

hereby apply for the grant of a standard patent for an  
invention entitled: "COATED OPTICAL FIBER"

APPLICATION ACCEPTED AND AMENDMENTS

ALLOWED 13-2-90

which is described in the accompanying complete  
specification.

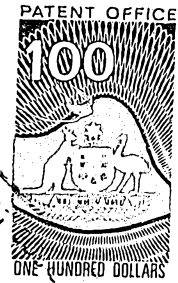
This application is made under the provisions of Section 51  
as a divisional of Australian Patent Application No. 17075/83  
by Furukawa Electric Co., Ltd.

My/Our address for service is care of CLEMENT HACK & CO.,  
Patent Attorneys, of 601 St. Kilda Road, Melbourne, in the  
State of Victoria, 3004, Australia.

DATED this 18th day of October, 1986.

FURUKAWA ELECTRIC CO., LTD.  
CLEMENT HACK & CO.

TO: The Commissioner of Patents



64217/86

*[Handwritten signature]*

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Forms 7 and 8

AUSTRALIA

Patents Act 1952

**DECLARATION IN SUPPORT OF A CONVENTION OR NON-CONVENTION  
APPLICATION FOR A PATENT OR PATENT OF ADDITION**

Name(s) of  
Applicant(s)

In support of the application made by Furukawa Electric Co. Ltd.

Title

for a patent for an invention entitled Coated Optical Fiber

Name(s) and  
address(es)  
of person(s)  
making  
declaration

I/We, Etsuji Kusakabe, President of The Furukawa Electric  
Co., Ltd., No. 6-1, Marunouchi 2-chome, Chiyoda-ku, Tokyo,  
Japan

do solemnly and sincerely declare as follows:—

1. I am/we are the applicant(s) for the patent, or authorised by the abovementioned applicant to make this declaration on its behalf.
2. ~~The basic application(s) as defined by Section 141 of the Act was/were made in the following country or countries on the following date(s) by the following applicant(s) namely:~~

Country, filing  
date and name  
of Applicant  
for the or  
each basic  
application

in \_\_\_\_\_ on \_\_\_\_\_ 19 \_\_\_\_  
by \_\_\_\_\_  
in \_\_\_\_\_ on \_\_\_\_\_ 19 \_\_\_\_  
by \_\_\_\_\_

3. ~~The said basic application(s) was/were the first application(s) made in a Convention country in respect of the invention the subject of the application.~~

Name(s) and  
address(es)  
of this or each  
actual inventor

4. The actual inventor(s) of the said invention is/are  
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Kenichi FUSE, of The Furukawa Electric Co., Ltd., c/o  
Chiba Works, The Furukawa Electric Co., Ltd., No. 6, (\*)  
and Yusei SHIRASAKA, of The Furukawa Electric Co., Ltd., c/o  
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Yahata-kaigandori, Ichihara-shi, Chiba-Pref., Japan

5. The facts upon which the applicant(s) is/are entitled to make this application are as follows:—

The applicant is the assignee of the actual inventors.

See reverse  
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completing  
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DECLARED at Tokyo, Japan this 31st day of August 19 89

Etsuji Kusakabe

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(54) Title  
COATED OPTICAL FIBER

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(56) Prior Art Documents  
US 4239335  
AU 501784 10033/76 G02B 5/16  
AU 498247 87469/75 G02B 5/16

(57) Claim

1. A coated optical fibre comprising an optical fibre, a buffer layer thereon, an externally disposed reinforced coating layer of heat cured resin containing reinforcing fibre materials, and an additional resin layer devoid of reinforcing fibre materials interposed between said buffer layer and said reinforced coating layer, characterised in that said additional resin layer is bonded to said reinforced coating layer, and in that said reinforced coating layer also comprises particles of a filler, which are composed of an inorganic material and have a diameter of less than 30  $\mu\text{m}$ , or are composed of a thermoplastic material having a softening temperature of 120°C or less and have a diameter of less than 50  $\mu\text{m}$ .

2. A coated optical fibre as claimed in claim 1, characterised in that said additional resin layer is formed of heat or light cured resin.

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Form 10

PATENTS ACT 1952

# COMPLETE SPECIFICATION

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TO BE COMPLETED BY APPLICANT

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Australia.

Complete Specification for the invention entitled: "COATED OPTICAL FIBER"

The following statement is a full description of this invention, including the best method of performing it known to me:—

The present invention relates to a coated optical fibre having a reinforced coating layer formed of fibre reinforced plastics (FRP) around the outer periphery of the optical fibre, and also an additional layer for improving the mechanical and light transmission characteristics (which will be merely termed "transmission characteristics") interposed between the optical fibre and the FRP coating layer.

Generally a coated optical fibre has its strands coated with: a primary coating layer and a buffer layer; or a buffer layer used also as the primary coating layer; and a reinforced coating layer on the outer periphery of the buffer layer.

The reinforced coating layer is generally formed of an FRP, which improves the mechanical characteristics of the coated optical fibre and also increases the transmission loss upon variation in temperature more than a nylon coated optical fibre.

The basic FRP reinforced coating layer (which will be termed "a FRP layer") is, as already known, comprises a glass fibre reinforcing material, disposed along the longitudinal direction of the optical fibre, impregnated with thermosetting resin and cured.

However, the FRP layer has one disadvantage, namely, that when a compression force, twisting, or bending is exerted on the FRP layer from the side, the annular shape of the FRP layer is flattened with the result that longitudinal cracks may occur.

The deformation of the FRP layer is due to the buffer layer which is soft and cannot prevent the flattening effect, with the result that the longitudinal cracks of the FRP layer are formed.

In addition, in the case of a coated optical fibre with an FRP layer, there is still room for improvement in the transmission characteristics.

Furthermore, the surface of the reinforced coating



layer tends to be planed or split when the reinforced coating layer is formed only of reinforced fibrous material and thermosetting resin, thereby exhibiting an improper external appearance.

Such problems in the external appearance have been overcome by including inorganic filler such as calcium carbonate or short glass fibres (having particle diameter above 100  $\mu\text{m}$ ) in the reinforced coating layer. However, it has been found that conventional optical fibres having this filler-containing reinforced coating layer have reduced transmission characteristics at a temperature range of 100 to 150°C.

An object of this invention is to prevent the aforementioned longitudinal cracks and also to produce high transmission characteristics as well as improved external appearance.

According to the present invention there is provided a coated optical fibre comprising an optical fibre, a buffer layer thereon, an externally disposed reinforced coating layer of heat cured resin containing reinforcing fibre materials, and an additional resin layer devoid of reinforcing fibre materials interposed between said buffer layer and said reinforced coating layer, characterised in that said additional resin layer is bonded to said reinforced coating layer, and in that said reinforced coating layer also comprises particles of a filler, which are composed of an inorganic material and have a diameter of less than 30  $\mu\text{m}$ , or are composed of a thermoplastic material having a softening temperature of 120°C or less and have a diameter of less than 50  $\mu\text{m}$ .

The additional resin layer supports the reinforced coating layer and reduces deformation of the reinforced coating layer. Thus, the mechanical characteristics are improved, and the rate of producing the aforementioned



longitudinal cracks is reduced.

Since microbends of the optical fibre caused by the presence of the reinforced coating layer can be prevented by the additional resin layer, the coated optical fibre has high transmission characteristics.

The suitably selected particles of filler also contribute to improve said transmission characteristics, as well as the external appearance.

Embodiments of the present invention will now be more particularly described by way of example and with reference to the accompanying drawings, in which:

Figure 1 is a sectional view showing the representative construction of one embodiment of a coated optical fibre;

Figure 2 is a sectional view of another embodiment of coated optical fibre;

Figure 3 is an enlarged sectional view of the reinforcing fibre material; and

Figures 4 and 5 are explanatory views showing schematically methods of fabricating the coated optical fibre.

In Figures 1 and 2, reference numeral 1 designates an existing quartz optical fibre formed of a core and a clad. In Figure 1, a primary coating layer 2 and a buffer layer 3 of silicone resins or the like are formed on the outer periphery of the optical fibre 1. These two layers 2 and 3 may be combined, both being formed of the same substance, as in Figure 2, where the buffer layer 3 is used also as the primary coating layer.

Reference numeral 4 denotes a resin layer formed on the outer periphery of the buffer layer 3, and 5 designates a reinforced coating layer formed on the outer periphery of the resin layer 4. The resin layer 4 is therefore interposed between the buffer layer 3 and the reinforced coating layer 5 in the laminar structure as shown.

The reinforced coating layer 5 is formed of long



reinforcing fibre materials 6 and thermosetting resin 7.

The reinforcing fibre materials 6 are formed of rovings or yarns of extremely fine fibre, glass fibre, carbon fibre, Aramide fibre, molten silica fibre, multicomponent ceramic fibre (E glass, S glass) or quartz.

The resin 7 comprises a suitable heat-curable resin such as unsaturated polyester, epoxy, silicone or vinyl ester, heat-curable polyamide e.g. of bis-maleimide and triazine.

The resin layer 4 may be formed of the same or a different material, but comprises heat-curable or photo-curable resin, possibly heat resistant, and preferably having a high Young's modulus. Examples are polyester resin or polyamide resin (nylon).

The resin layer 4 exhibits high adhesiveness to the heat-curable resin layer 7 of the reinforced coating layer 5 and a large break elongation.

The resin may comprise a thermosetting resin, such as nylon, polycarbonate, polymethylmethacrylate (PMMA), polystyrene, or heat-curable and photo-curable (ultraviolet ray-curable) resin such as epoxy acrylic compound, silicone acrylic compound, urethane acrylic compound or copolymer of them.

The resin layer 4 is thinner than the reinforced coating layer 5, and the ratio in thickness of the resin layer 4 to the reinforced coating layer 5 is approximately 1:3 to 1:10.

In the coated optical fibre of Figure 1, the optical fibre 1 has a core diameter/outer diameter of 50  $\mu\text{m}$ /125  $\mu\text{m}$ , the reinforced coating layer 5 has an outer diameter of approximately 950  $\mu\text{m}$  to 1 mm, and the buffer layer 3 has a thickness of 200  $\mu\text{m}$  or less and a Young's modulus of 30  $\text{kg/mm}^2$  or higher at ambient temperature. It is noted that the subsequent values of Young's modulus herein are also at ambient temperature. The resin layer 4 has a thickness of 50  $\mu\text{m}$  or lower and a Young's modulus of 70 to 100  $\text{kg/mm}^2$ .



In order to reduce improper external appearance such as scratches or burrs on the surface of the layer 5, ultrafine particles, generally called "a filler", are mixed in the coating layer 5.

In conventional examples, inorganic filler, such as calcium carbonate or short glass fibres, is mixed in the reinforced coating layer to improve the external appearance. However, while the external appearance is improved, the transmission characteristic decreases in the high temperature range at the time of moulding the reinforced coating layers (100 to 150°C).

Since the radial linear expansion coefficient of the reinforced coating layer is  $5 \times 10^{-3}$ , in the relative relationship between the buffer layer and the reinforced coating layer, while the primary coating layer and the buffer layer (e.g., silicone rubber) is  $5 \times 10^{-4}$ , the buffer layer exhibits more thermal expansion in the high temperature range. When side pressure due to thermal expansion acts on the optical fibre, the filler in the reinforced coating layer causes an irregular response to the pressure, with the result that there are microbends in the optical fibre, thereby increasing the transmission loss.

Since the present coated optical fibre has the resin layer 4 interposed between the buffer layer 3 and the reinforced resin layer 5 as described above, this problem is obviated.

The problem caused by the filler can also be eliminated by suitably setting the diameter of the particles of the filler and the quantity of the filler relative to that of the heat-curable resin 7.

The filler includes inorganic ultrafine particles and/or thermoplastic ultrafine particles.

It is preferred that the inorganic ultrafine particles are selected from one or more of calcium carbonate, talc, hydrated alumina, clay and zeolite.

The inorganic ultrafine particles have a maximum



particle diameter of 30  $\mu\text{m}$  or less and a mean particle diameter of 3.0  $\mu\text{m}$  or less, and the ratio of the inorganic ultrafine particles to the heat-curable resin 7, by weight, is  $\rightarrow$  1:4.

The transmission characteristics and the moldability are thereby simultaneously improved and, in an example, a "good" result is obtained when the maximum particle diameter is 25  $\mu\text{m}$  and the mean particle diameter is 30  $\mu\text{m}$ , an "excellent" result is obtained when the maximum particle diameter is 10  $\mu\text{m}$  and the mean particle diameter is 1.0  $\mu\text{m}$ , and a "best" result is obtained when the mean particle diameter is 7.0  $\mu\text{m}$ .

It is preferred that the thermoplastic ultrafine particles are selected from one or more of polystyrene, polystyrene chloride, ABS resin and cellulose plastic, of particle diameter 5 to 50  $\mu\text{m}$ , and a softening temperature of 120°C or less.

The ratio of the thermoplastic ultrafine particles to the heat-curable resin 7 in the reinforced coating layer 5, by weight, is preferably 1:4 or less.

When the thermoplastic ultrafine particles are mixed as a filler for the reinforced coating layer 5, the apparent viscosity of the heat-curable resin 7 increases. This improves the mouldability of the reinforced coating layer 5 such that there are no external appearance problems of the reinforced coating layer 5 (such as a scratch or a burr due to the mould) occur. Since the ultrafine particles are plasticized, there is no irregular side pressure which causes microbends during moulding at high temperature, and the coating layer 5 can be moulded while suppressing the light transmission loss of the optical fibre 1.

When the thermoplastic ultrafine particles in the reinforced coating layer 5 are formed of polystyrene having a mean particle diameter of 30  $\mu\text{m}$  and are mixed 10% by weight to form the reinforced coating layer 5, there is



almost no improper external appearance on the surface of the layer 2, and an increase in the light transmission loss remains within 0 to 0.5 dB/km.

The temperature of the drawing die used during moulding was 160 to 195°C, and the plasticizing temperature of the thermoplastic ultrafine particles was 106°C.

In the following description, the particles of filler as defined above are always included in the reinforced coating layer, although this is not always explicitly specified.

The mechanical characteristics of the coated optical fibre measured by a crushing test will now be described.

In the crushing test samples of coated optical fibre having a length of 50 mm were produced, the samples were set in a crushing jig of an Instron tensile strength testing machine, and a side pressure crushing test was conducted at a speed of 0.5 mm/min.

The crushing point was judged by the maximum load point at which linearity is maintained in a load curve based on time.

As a comparison, a similar test was conducted with a conventional coated optical fibre within resin layer 4.

#### Conventional Example

##### a) Optical fibre 1

Made of Quartz, graded-index (G1) type, specific refractive index difference  $\Delta = 1\%$ , and core/outer diameter = 50  $\mu\text{m}$ /125  $\mu\text{m}$ .

##### b) Primary coating layer 2

None.

##### c) Buffer layer 3

Made of silicone rubber, Young's modulus = 20 kg/mm<sup>2</sup>, and outer diameter = 400  $\mu\text{m}$ .

##### d) Optical fibre 1 with buffer layer 3

Transmission loss = 2.7 dB/km  
(wavelength  $\geq 0.85 \mu\text{m}$ ).



e) Resin layer 4

None.

f) Reinforced resin layer 5

Outer diameter = 950  $\mu\text{m}$ , glass content rate = 65 vol%.

Reinforcing fibre material 6

Roving formed by gathering several hundreds of E glass fibre having outer diameter of approximately 10  $\mu\text{m}$ .

Heat-curable resin 7

Unsaturated polyester.

In the conventional example of the above-described structure, the side pressure crushing strength was 1.0 to 1.5 kg/mm, and the transmission loss after forming the reinforced coated layer 5 was 4 to 5 dB/km.

#### Embodiment 1

The same as the conventional one in the above paragraphs a), b), c) and d).

However, the outer diameter in the above paragraph c) was 350  $\mu\text{m}$ .

e) Resin layer 4

Urethane acrylic compound, Young's modulus = 50 kg/mm<sup>2</sup>

Outer diameter = 400  $\mu\text{m}$ .

f) The same as the conventional one above.

g) Relation to the layers 3 and 4

The buffer layer 3 and the resin layer 4 were isolated by an ultrafine gap, and the resin layer 4 and the reinforced coating layer 5 were bonded to each other.

In case of this embodiment 1, the side pressure crushing strength was increased as compared with the conventional example to 1.3 to 1.6 kg/mm, and the transmission loss after the coated layer 5 was formed was 3.0 dB/km or less, and, thus, considerably decreased.



#### Embodiment 2

The same as those of the embodiment 1 for the above paragraphs a) to g). However, the Young's modulus in the above paragraph e) was 75 kg/mm<sup>2</sup>.

In embodiment 2, the side pressure crushing strength was improved as compared with the conventional example to 1.5 to 20 kg/mm, and the transmission loss after the coated layer 5 was formed was 3.0 dB/km or less.

#### Embodiment 3

The same as those of the embodiment 1 for the above paragraphs a) to g). However, the Young's modulus in the above paragraph e) was set to 95 kg/mm<sup>2</sup>.

In embodiment 3, the side pressure crushing strength again improved over embodiment 2 to 2.5 to 2.8 kg/mm, and the light transmission loss after the coated layer 5 is formed was 3 dB/km or less.

#### Embodiment 4

The same as those of the embodiment 1 for the above paragraphs a) to g). However, the material in the above paragraph e) was epoxy acrylic compound having Young's modulus of 120 kg/mm<sup>2</sup>.

In embodiment 4, the transmission loss after the coated layer 5 was formed was 3 dB/km or less, but the side pressure crushing strength was further increased to 3.0 to 3.3 kg/mm.

#### Embodiment 5

The same as those of the embodiment 1 for the above paragraphs a), b), c), d), and f). As to paragraph e), nylon 12 having an outer diameter of 400  $\mu$ m was employed.

In this embodiment 5, the side pressure crushing strength was 2.0 to 2.8 kg/mm, but the transmission loss after the coated layer 5 was formed was 5 to 6 dB/km.

The reason is believed to be that the nylon resin



layer 4 was thermally fusion-bonded locally to the inner surface of the coating layer 5, thereby producing ruggedness on the boundary surface between the layers 4 and 5, thereby producing a microbend, thereby increasing the transmission loss.

Embodiment 6

The same as those of the conventional example for the above paragraphs a), b), c) and d). However, the material for the above paragraph c) was silicone resin.

e) Resin layer 4

Made of unsaturated polyester. Young's modulus = 100 kg/mm<sup>2</sup>, and outer diameter = 450  $\mu$ m.

For the above paragraph f), the same as those in which the outer diameter = 1.0 mm was set.

In embodiment 6, the side pressure crushing strength was 1.7 to 2.2 kg/mm, and the light transmission loss was 3 dB/km or less.

In embodiments 1 to 4, and 6, an explanation for the transmission loss after the coating layer 5 was formed can be decreased to 3 dB/km or less, is set out below.

Since the reinforcing fibre material 6 is prevented, by the resin layer 4, from contacting the buffer layer 3 directly in a random manner, irregular side pressure exceeding the absorption capacity of the buffer layer 3 is not produced, thereby holding the low transmission loss state of the optical fibre 1.

The Young's modulus of the resin layer 4 may be more than twice that of the buffer layer 3.

The foregoing embodiments have been described for an optical fibre disposed within the coating layer 5. However, the resin layer 4 may be disposed within the coating layer 5, and a plurality of optical fibres with buffer layers may be disposed inside the layer 5.

A general method of producing a coated optical fibre



as described above, comprises the steps of impregnating a reinforcing fibre material made of rovings or yarns of extremely fine fibre with liquid heat-curable resin; longitudinally attached the reinforcing fibre material impregnated with resin along the periphery of the optical fibre strand (which is an optical fibre with a buffer layer), and drawing them through a heating type drawing mould to thereby cure the resin. The optical fibre strand should be covered without eccentricity. If the degree of eccentricity is large, the transmission loss increases, or the protecting effect on the optical fibre strand against crushing or bending decreases.

In order to alleviate these problems, the amount of reinforcing fibre material should be increased and the optical fibre should be enclosed within many reinforcing fibres. Thus, the degree of eccentricity can be reduced, and the transmission characteristic, temperature characteristic and mechanical characteristics are improved.

However, as the amount of reinforced fibre material increases, the drawing resistance in the drawing mould increases, with the result that breakage of fibre is caused, thereby leading to improper flexibility, irregular impregnation of the resin, and improper external appearance.

To overcome these problems, in the present coated optical fibre, the volumetric ratio  $C$  of A to B, i.e.,  $C = (B/A + B) \times 100$  is set to  $45 \leq C \leq 75$ , where A is the quantity of the heat-curable resin 7, and B is the quantity of the reinforced fibre materials 6. Further, the ratio  $Dr$  of the outer diameters  $d_1$  to  $d_2$ , i.e.  $Dr = (d_2/d_1) \times 100$  is set to  $0 < Dr < 6$ , where  $d_1$  is the outer diameter of the optical fibre strand (the outer diameters of the) buffer layer 3);  $d_2$  is the mean diameter of the extremely fine fibres 6'.

The reasons for setting  $45 \leq C \leq 75$  and  $0 < Dr < 6$  will now be described.

In the case of  $C \leq 75$ , when  $C$  exceeds 75% by volume, excessive reinforcing fibre is present with the result of

breakage of fibre at drawing time, improper flexibility, irregular impregnation of the resin, and/or improper external appearance occur.

Accordingly, the upper limit value of C is 75% by volume.

In the case of  $45 \leq C$ , when C decreases lower than 45% by volume, there is an eccentricity of the optical fibre strand, an increase in the transmission loss, a decrease in the temperature characteristic and a decrease in the mechanical characteristics, caused by the excessive resin (on the contrary, lack of fibre) as described above.

Accordingly, the lower limit value of C is 45% by volume.

It is not only  $45 \leq C \leq 75$  as described above that is needed to satisfy the requirement.

For example, when the respective reinforcing fibre materials 6, as rovings and impregnated with the resin are introduced into the drawing mould while enclosing the optical fibre strand, the reinforcing fibre materials 6, are opened, and the extremely fine fibres 6' exist at random in the reinforced coating layer 5. Where the diameter of the extremely fine fibre 6' is large when  $45 \leq C \leq 75$ , the number of the fibres 6' as the component unit of the reinforcing fibre material 6 becomes less, and the effect of enclosing the optical fibre strand diminishes.

On the other hand, the thermosetting resin 7 in liquid uncured state impregnated into the respective reinforcing fibre materials 6, is adhered to the surfaces of the fibres 6', and carried to the drawing mould. Thus, the quantity of carried resin is determined depending upon the total surface areas of the fibres 6'. When the diameter of the fibres 6' is large and the number of the fibres 6' is less, the total surface area becomes small, thereby reducing the resin carrying quantity.

As a result, the setting of  $45 \leq C \leq 75$  is difficult.





Therefore, with respect to the extremely fine fibres 6,  $0 < D_r < 6$  should be satisfied as described above, and the above-described problems arise if  $D_r$  exceeds 6.

According to experimental examples, coated optical fibres falling within the aforementioned range of the set values exhibited desired results of moldability, transmission characteristic, temperature characteristic, presence or absence of eccentricity. However, coated optical fibre which were out of the aforementioned range of the set values exhibited one or more problems of improper moldability, an increase in the transmission loss, improper temperature characteristics, eccentricity.

Preferred values are  $C = 60$  and  $D_r = 3.5$  and in this case the optical fibre exhibited preferably results not only in mechanical properties but also in flexibility.

In the aforementioned  $C = (B/A + B) \times 100$ , when the filler is thermoplastic ultrafine particles, the particles are contained in A, and when the filler is formed of the inorganic ultrafine particles, they are contained in B.

It is preferable that the optical fibre with buffer layer, has 0.01 to 0.10% of tensile distortion, since the optical fibre strands have tensile distortion in the reinforced coating layer, and thereby compression distortion causing the microbend seldom arises. Even if the reinforced coating layer is not accordingly contracted due to the variations in the external force and the temperature, an increase in the transmission loss of the optical fibre does not occur.

An example of fabricating a coated optical fibre will now be described with reference to Figures 4 and 5.

In Figure 4, an optical fibre 1 with buffer layer 3 is supplied from a supplying machine 8, passed through an impregnation tank 9, where liquid resin to form the resin layer 4 is uniformly adhered on the outer periphery of the buffer layer 3. Reinforcing fibre materials 6 in roving state are supplied from other supplying machines 10 to pass



through impregnation tanks 11, where the materials 6 are impregnated with liquid-state heat-curable resin 7.

The resin is adhered and impregnated on the optical fibre 1 and the respective reinforcing fibre materials 6, which are, in turn, passed through a comb board 12, to join them. Then, the materials are passed through a drawing mould 13 having a heating furnace and a curing furnace 14 to form a predetermined resin layer 4 and a reinforced coating layer 5. The coated fibre thus manufactured is drawn by a drawing machine 15, and then wound by a winding machine 16.

The example of Figure 5 is substantially similar to that in Figure 4, but differs at the point that, after liquid resin for the resin layer 4 is adhered to the outer periphery of the buffer layer 3, the optical fibre 13 with the liquid-state resin 4 is passed through a curing furnace 17 to retain the shape of the resin 4.

In an alternative, the resin layer 4 is formed on the outer periphery of the optical fibre 1 in another step, and the tank 9 is described in Figures 4 and 5 may be omitted.

In the embodiments shown in Figures 4 and 5, a preliminary heating furnace (not shown), may be disposed between the impregnation tank 11 and the comb board 12, and the resin 7 on the surface of the reinforcing material 6 may be preliminarily cured.

In this case, the period of heating to cure the resin in the drawing mould 13 may be shortened, thereby increasing the drawing and moulding velocity.

As regards mixing of the filler in the reinforced coating layer 5, said filler is stirred to mix the predetermined ultrafine particles in the respective tanks 11.

The resin layer 4 has an adhesiveness to the reinforced coating layer 5, and the resin layer 4 is thermally expanded in the furnace 14, and the layers 4 and 5 are bonded one to another in this state.



After the reinforced resin layer 5 is cured, the respective layers cool and contract, but the bonding between the resin layer 4 and the coating layer 5 is maintained, while the buffer layer 3 and the resin layer 4 are isolated from one another due to the difference of the thermal expansion coefficient therebetween.

In the foregoing description, the term "outer diameter" means "diameter".

Since the coated optical fibre has high transmission characteristics, it is mainly used for communication purposes, and since the optical fibre has particularly excellent mechanical properties and temperature characteristics, it is adapted for optical fibre core wire for underground buried communication cables, aerial inner optical cables, power and photo composite cables.



THE CLAIMS DEFINING THE INVENTION ARE AS FOLLOWS:

1. A coated optical fibre comprising an optical fibre, a buffer layer thereon, an externally disposed reinforced coating layer of heat cured resin containing reinforcing fibre materials, and an additional resin layer devoid of reinforcing fibre materials interposed between said buffer layer and said reinforced coating layer, characterised in that said additional resin layer is bonded to said reinforced coating layer, and in that said reinforced coating layer also comprises particles of a filler, which are composed of an inorganic material and have a diameter of less than 30  $\mu\text{m}$ , or are composed of a thermoplastic material having a softening temperature of 120°C or less and have a diameter of less than 50  $\mu\text{m}$ .

2. A coated optical fibre as claimed in claim 1, characterised in that said additional resin layer is formed of heat or light cured resin.

Dated this 31st day of January, 1990

FURUKAWA ELECTRIC CO., LTD.

By their Patent Attorneys:

GRIFFITH HACK & CO.

Fellows Institute of Patent  
Attorneys of Australia.



Fig. 3

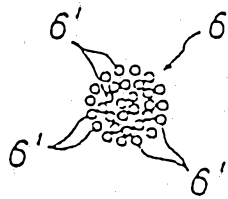


Fig. 2

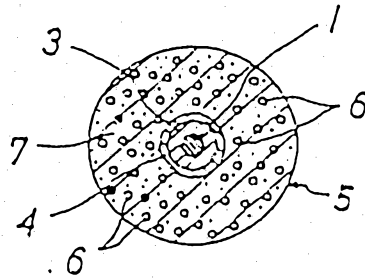


Fig. 1

64217/86

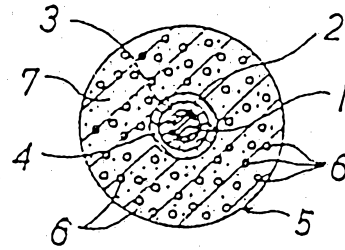


Fig. 4

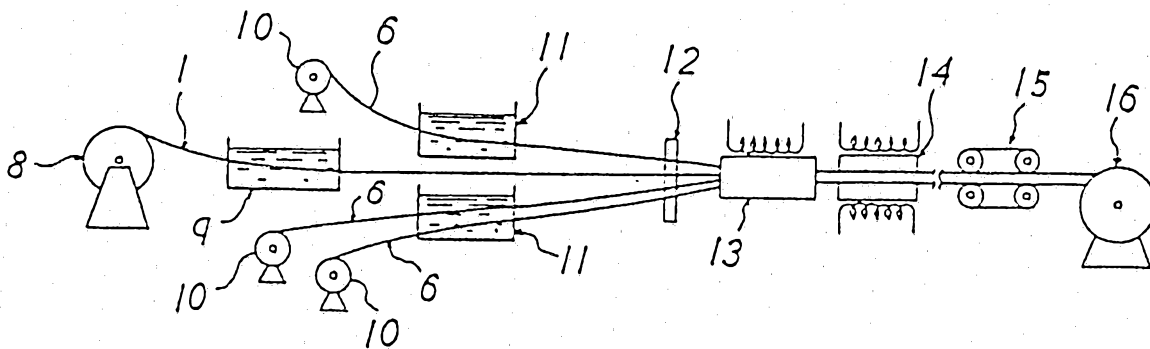


Fig. 5

