

PATENT SPECIFICATION

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(54) IMPROVEMENTS IN OR RELATING TO OPTICAL FIBRES

(71) We, THE PLESSEY COMPANY LIMITED, a British Company, of 2160 Vicarage Lane, Ilford, Essex, 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 optical fibres and more particularly to a method of producing optical fibres and to optical fibres capable of being used in hostile environments.

A disadvantage with most present step-index fibres is that if the outer layers of the fibre are exposed to water vapour for example in the atmosphere their physical strength is considerably reduced due to propagation of cracks in the material from microcracks existing on the surface. Thus at present most fibres are, immediately after manufacture coated with a plastic film (e.g. 10µm of modified polyvinylidene fluoride film) which forms a continuous barrier on the surface. The disadvantage of this fibre is that such coating materials offer protection only up to 100—200° C since above these temperatures the coating melts.

It is an object of the present invention to provide a glass or silica fibre which is suitable for use at temperatures in the range 100 to 500° C with a typical operating temperature of 400° C.

It is also an object of the present invention to provide a fibre which may be secured by soldering or spot welding techniques.

The invention also provides a method of producing an optical fibre capable of withstanding temperatures in excess of 200° C in which an optical fibre core member of optically transparent material is coated with a metal resinate solution, in which the coated core member is heated in an oxygenated atmosphere to produce a metallic coating on the core member and in which the metallic coated core member is subjected to a plating process to increase the thickness of the metallic coating.

The invention also provides a metallic

coated optical fibre made in accordance with the above method.

In the above method a first stage process of cleaning an already plastics coated fibre by immersion in a bubbling acetone bath is necessary. The metal resinate solution is preferably gold or platinum organic solution containing respectively between 8—18% of gold or platinum.

The final plated metal coating is preferably gold or platinum, both being suitable for high temperature work at 400° C or alternately the fibre may be coated with copper for use at lower temperatures. For higher temperatures silica is chosen as a core member since it will withstand such temperatures without melting.

An additional advantage of such metallic coated fibres is that they can be attached to for example printed circuits by soldering techniques or even by spot welding techniques providing a sufficient thickness of coating is present.

The production of a metallic coated fibre will now be described commencing with an existing plastics coated fibre.

The fibre is pulled under slight tension through a bath of bubbling acetone solution to remove the plastics coating from the core member. The core member is then painted with a coating of a liquid metal resinate solution (either gold or platinum 8—18%). The coated fibre is then pulled through a furnace which has a suitably oxygenated atmosphere such that the organics are removed and burnt off to leave a metallic coating on the fibre. The furnace treatment must be long enough to ensure decomposition of the precious metal compound and to then allow diffusion of the precious metal into the surface of the core member.

The above process is then repeated by further painting the core member and reheating in a further furnace, the processes preferably being carried on continuously on a line process. The painting and furnace process is repeated to ensure a uniform coating on the core member and it is in practise normally necessary only to perform the process twice.

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The coated core member is then subjected to a resistivity test to see if it is suitable for the plating process. A resistivity of 1—10 ohms per mm is considered adequate.

- 5 The tested coated core member is then for higher temperature applications plated with a minimum of 5 μm of gold or 20 μm of nickel to protect the core member against water vapour. In practise if it is desired to spot weld the finished fibre a thicker coating will be necessary. If lower temperature working up to 250° C is specified with the ability to be able to solder or spot weld the fibre a plated layer of copper (preferably of 15 between 6—10 μm) is provided.

The gold and nickel plating must be pure in order to be a sufficiently ductile coating to withstand rapid temperature changes.

- 20 Since the preferred firing temperature for the metal resinate solution is between 5 to 600° C a core member of silica is desirable since glass softens at these temperatures and pulling the glass through the furnace will present problems.

25 The coating material must therefore be:—

- 1) Impermeable to water vapour
- 2) Resistant to oxidation by air or H_2O vapour at use temperature (e.g. 400° C)
- 3) Of melting point above use temperature
- 30 4) (For some applications) suitable for bonding to other metals (e.g. by soldering or spot welding)
- 5) Of strength and ductility such that differential expansion stresses during use will not lead to cracking of the coating. If the use temperature is 400° C, and the linear expansion coefficients of fibre and coating are α_1 and α_2 respectively and the Young's modulus of the coating is Y, then at any temperatures T° C during the cooling cycle from 400° C to room temperature the ultimate tensile strength of the coating must exceed $Y(400-T)(\alpha_2-\alpha_1)$ for the coating to remain intact and bonded to the fibre. (This formula assumes the fibre to be incompressible, so must be regarded as approximate — error will be small for thin ductile coatings, e.g. 5 μm of gold, but larger for (say) comparatively thick, less ductile coatings such as 20 μm of nickel).

55 The metallic coated fibre may thus be affixed by various methods but care must be chosen when selecting fibres, coatings and the fixing methods. A few of the criteria are set out below: —

Soldering With gold care is required not to dissolve away the gold when soldering.

With nickel a strong flux is necessary to overcome the nickel oxide coating. 60

Silver Soldering (500—600° C) This can be achieved but care must be taken to avoid excessive localised thermal shock and thereby to limit the oxidation damage. (Copper coated not suitable). 65

Spot Welding This requires force plus localised heat and sufficient metal must be provided to prevent deformation and remove the localised heating. 70

For nickel a preferred coating of at least 25 μm is specified and for gold at least 12 μm . (Copper coating not suitable).

WHAT WE CLAIM IS:—

1. A method of producing an optical fibre capable of withstanding temperatures in excess of 200° C in which an optical fibre core member of optically transparent material is coated with a metal resinate solution, in which the coated core member is heated in an oxygenated atmosphere to produce a metallic coating on the core member and in which the metallically coated core member is subjected to a plating process to increase the thickness of the metallic coating. 75 80 85

2. A method of producing an optical fibre as claimed in claim 1 in which if said optical fibre has a plastics coating the coating is removed by insertion of said fibre into a bubbling acetone bath prior to the coating process. 90

3. A method of producing an optical fibre as claimed in claim 1 or claim 2 in which the metal resinate solution is a gold or platinum organic solution containing 8 to 18% of gold or platinum. 95

4. A method of producing an optical fibre as claimed in any one of claims 1 to 3 in which the metal plated onto the metallically coated core member is gold, platinum or copper. 100

5. A metallic coated optical fibre produced according to the method as claimed in any one of claims 1 to 4.

6. A method of producing an optical fibre capable of withstanding temperatures in excess of 200° C substantially as described. 105

7. A metallic coated optical fibre produced in accordance with the method of claim 1 substantially as described. 110

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10 to spot weld the finished fibre a thicker coating will be necessary. If lower temperature working up to 250° C is specified with the ability to be able to solder or spot weld the fibre a plated layer of copper (preferably of
15 between 6—10 μm) is provided.

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35 will not lead to cracking of the coating. If the use temperature is 400° C, and the linear expansion coefficients of fibre and coating are α_1 and α_2 respectively and the Young's modulus of the coating is Y , then at any temperatures $T^\circ\text{C}$ during the cooling cycle from 400° C to room temperature the ultimate tensile strength of the coating must exceed
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3. A method of producing an optical fibre as claimed in claim 1 or claim 2 in which the metal resinate solution is a gold or platinum organic solution containing 8 to 18% of gold or platinum. 95

4. A method of producing an optical fibre as claimed in any one of claims 1 to 3 in which the metal plated onto the metallic coated core member is gold, platinum or copper. 100

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