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(54) IMPROVEMENTS IN OR RELATING TO DEMOUNTABLE OPTICAL FIBRE CONNECTORS AND OPTICAL FIBRE TERMINATIONS

(71) THE GENERAL ELECTRIC COMPANY LIMITED, of 1 Stanhope Gate, London W1A 1EH, a British Company, 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:—

It is an object of the present invention to provide a demountable connector of relatively simple design, by means of which a pair of optical fibre waveguides can be coupled together end-to-end in accurate coaxial alignment and with minimal longitudinal separation, so that insertion loss occurring at the connection in operation of the waveguide assembly is minimised. It is a further object of the invention to provide an improved method of making an optical fibre termination employing a component of such a connector.

According to the invention, a demountable connector for coupling a pair of optical fibre waveguides together in end-to-end relationship consists of a pair of hollow metal ferrules for supporting end portions of the respective optical fibre waveguides to form fibre terminations, and a sleeve within which the two ferrules can be held in abutment, the exterior surface of each said ferrule being tapered over at least a portion of its length and terminating, at the narrowest part, in a tip which is closed except for an axial aperture of a suitable diameter for accomodating an optical fibre, the interior of each said ferrule being so shaped and arranged that a channel for receiving an optical fibre, and in which the fibre is a sliding fit, can be formed along the axis thereof, in alignment with the centre of said tip aperture, through a body of thermosetting resin introduced into said interior, and the said sleeve being formed of resilient material and having a cylindrical bore into which the tapered portions of the ferrules are insertable with a tight fit and so that the tips thereof abut.

In use of a connector of the form described above, each of the ferrules is employed to form an optical fibre termination, and the ferrules are inserted into opposite ends of the sleeve so that the fibre ends, which are located at the tips of the ferrules, are optically coupled together.

A preferred method of making an optical fibre termination, employing a ferrule which is a component of a demountable connector in accordance with the invention, includes the steps of inserting a mandrel, of diameter equal to that of the optical fibre to be terminated, into the interior of the ferrule so as to extend through the aperture in the tip of the ferrule, casting a liquid thermosetting resin around the mandrel to fill the remainder of the interior of the ferrule, allowing the resin to solidify, withdrawing the mandrel to leave a channel through the resin body, along the axis of the ferrule, inserting an optical fibre into the end of the channel remote from said aperture and pushing the fibre through said channel until the fibre end emerges through said aperture and in the centre thereof, and attaching the fibre to the surface of the resin body remote from said aperture by means of an adhesive.

The mandrel employed for forming the channel through the body of resin in the ferrule may consist, for example, of a length of wire or of optical fibre similar to the fibre to be terminated. The resin employed must be one which will not adhere permanently to the mandrel when the resin is in the solid state: for example casting epoxy resins are suitable.

The optical fibre, when inserted into the channel and through the aperture in the tip of the ferrule, may be so located that the end surface of the fibre is flush with the exterrior end surface of the ferrule tip, the fibre end being precisely located in the centre of said aperture by virtue of the closely fitting support of the fibre in the channel along the axis of the ferrule. Alternatively, the fibre may be pushed slightly further so that its end protrudes a short distance, suitably less than half a millimetre, beyond the exterior end surface

of the ferrule tip, a small pad of transparent resilient material having a refractive index substantially matching that of the fibre material, such as a silicone resin, then being placed around the protruding end of the fibre. The latter arrangement is advantageous since the pad, in addition to protecting the fibre end from damage, provides improved optical continuity between a coupled pair of fibres which are both terminated in this way.

The tapering of the exterior surfaces of the ferrules facilitates insertion of the ferrules into the sleeve. The sleeve is preferably formed of a resilient synthetic polymeric material, for example polytetrafluoroethylene or an acetyl homopolymer of the type sold under the Registered Trade Mark "Delrin". Such materials are advantageous for this purpose, as compared with metal sleeves hitherto used in some optical fibre connectors, since the polymeric materials are resistant to corrosion and long term wear and do not give rise to any "bedding-in" problems. In addition these materials have a low coefficient of friction, and their resilience enables them to provide an accurately fitting sleeve without the necessity for precision machining of either the bore of the sleeve or the exteriors of the ferrules: thus ease of insertion and withdrawal of the ferrules is combined with adequate tightness of the sleeve. If desired each, of the ferrules may be formed with an external shoulder which provides a stop for limiting the extent of insertion of the ferrule into the sleeve.

It will be understood that, before the optical fibres to be coupled are attached to the ferrules, in the manner described above, the free ends of the fibres are prepared in the usual way, by scoring the fibre and breaking an end portion off at the scored point, under tension, to give an end portion off at the scored point, under tension, to give an optically flat end surface orthogonal to the fibre axis. The fibres preferably have a protective resin coating of such properties that it can be retained for the end preparation and fibre termination procedures.

A specific form of demountable optical fibre connector in accordance with the invention will now be described by way of example with reference to the diagrammatic drawing accompanying the Provisional Specification, in which

Figure 1 is a longitudinal section through one of the two identical ferrules included in the connector, and

Figure 2 shows, in part-sectional elevation, the connector, incorporating a pair of optical fibre terminations, assembled to form an end-to-end coupling between the optical fibres.

Figure 1 shows an elongated hollow ferrule, suitably of brass, consisting of a relatively narrow front portion 1, having a cylindrical bore and tapered externally to a tip 2 with a small central aperture 3, and a wider rear portion 4, also with a cylindrical, bore, and externally forming a shoulder 5.

The connector shown in Figure 2 consists of a pair of ferrules 6, 7, each of the form shown in Figure 1, terminating the respectivce optical fibres 8, 9, and coupled together by a polytetrafluoroethylene sleeve 10, which has a cylindrical bore fitting tightly over the narrower ends of the tapered portions of the ferrules. The interior of each of the ferrules is filled with epoxy resin 11, in which a channel 12 has been formed, along the axis of the ferrule, by casting an epoxy resin around a wire mandrel of the same diameter as the fibres 8, 9. The fibre terminations are completed, after setting of the resin and withdrawal of the wire mandrel, by inserting the fibres through the channels so that the prepared ends of the fibres extend approximately 0.05 mm beyond the tips of the ferrules, and each fibre is fixed in position by means of a drop of adhesive epoxy resin 13 applied around the fibre at the rear end of the channel, small pads of resilient silicone resin 14 are placed on the ferrule tips around the protruding fibre ends.

The connection between the fibres is made by inserting the narrow portions of the ferrules into the opposite ends of the sleeve 10, until the ferrule tips 2 abut: although the internal diameter of the sleeve is equal to the external diameter of the ferrules at their tips, insertion of nearly the whole of the tapered portions of the ferrules into the sleeve is readily achieved by virtue of the resilience of the sleeve material, the sleeve fitting tightly over the whole of the inserted lengths of the ferrules. The space between the tips 2 is exaggerated in Figure 2 of the drawing, in order to show the pads 14: the resilience of these pads allows the ferrule tips to be pressed close together to provide optical continuity between the fibre ends.

In a specific example of a connector of the form shown in the drawing, for coupling together a pair of optical fibres each consisting of a silica fibre waveguide 120 microns in diameter with a protective coating consisting of several layers and titania in the outer layers, giving overall diameter of 150 microns for the coated fibre, the components of the connector have the following dimensions:—

The front portion 1 of each ferrule has an overall length of 7 mm, a bore diameter of 1 mm, an external diameter at the tip end of 1.5 mm, and an angle of taper of 0.5°, and the aperture 3 is 0.5 mm in length and 0.1 to 0.3 mm in diameter. The rear portion 4 of

each ferrule is 4 mm long and has a bore diameter of 1.5 mm and an external diameter of 3 mm. The sleeve 10 is 12 mm long, has a bore diameter of 1.5 mm and an external diameter of 3 mm.

The connector of the invention provides a simple demountable "plug and socket" form of coupling between two optical fibres, in which the fibres are accurately coaxially aligned as a result of the precise location of the fibres in the channels in the ferrules, and are in optical contact. Furthermore the fibre ends in the terminations are accessible for cleaning, if necessary, prior to making the connection. Connectors of this form can be employed for coupling together lengths of multi fibre optical cable, a separate connector being provided for each corresponding pair of fibres in the cable lengths. These connectors are also suitable for use in forming optical paths on printed circuit boards, for example in rack mounted equipment, as well as for connections in free single optical transmission lines.

WHAT WE CLAIM IS:—

1. A demountable connector for coupling a pair of optical fibre waveguides together in end-to-end relationship, which consists of a pair of hollow metal ferrules for supporting end portions of the respective optical fibre waveguides to form fibre terminations, and a sleeve within which the two ferrules can be held in abutment, the exterior surface of each said ferrule being tapered over at least a portion of its length and terminating, at the narrowest part, in a tip which is closed except for an axial aperture of a suitable diameter for accommodating an optical fibre, the interior of each said ferrule being so shaped and arranged that a channel for receiving an optical fibre, and in which the fibre is a sliding fit, can be formed along the axis thereof, in alignment with the centre of said tip aperture, through a body of thermosetting resin introduced into said interior, and the said sleeve being formed of resilient material and having a cylindrical bore into which the tapered portions of the ferrules are insertable with a tight fit and so that the tips thereof abut.

2. A demountable connector according to Claim 1, wherein each of the said ferrules is formed with an external shoulder which provides a stop for limiting the extent of insertion of the ferrule into the said sleeve.

3. A demountable connector according to Claim 1 or 2, wherein the said sleeve is formed of a resilient synthetic polymeric material.

4. A demountable connector according to Claim 3, wherein the said sleeve is formed of polytetrafluoroethylene or an acetyl homopolymer.

5. A method of making an optical fibre termination, employing a said ferrule which is a component of a demountable connector according to Claim 1, which includes the steps of inserting a mandrel, of diameter equal to that of the optical fibre to be terminated, into the interior of the ferrule so as to extend through the aperture in the tip of the ferrule, supporting both ends of the mandrel so that it is held taut and straight along the axis of the ferrule, casting a liquid thermosetting resin around the mandrel to fill the remainder of the interior of the ferrule, allowing the resin to solidify, withdrawing the mandrel to leave a channel through the resin body, along the axis of the ferrule, inserting an optical fibre into the end of the channel remote from said aperture and pushing the fibre through said channel until the fibre end emerges through said aperture and in the centre thereof, and attaching the fibre to the surface of the resin body remote from said aperture by means of an adhesive.

6. A method according to Claim 5, wherein the said mandrel consists of a length of wire or or optical fibre similar to the fibre to be terminated.

7. A method according to Claim 5 or 6, wherein the said resin is a casting epoxy resin.

8. A method according to Claim 5, 6 or 7, wherein the optical fibre, when inserted into the said channel and through the said aperture in the tip of the ferrule, is so located that the end surface of the fibre is flush with the exterior end surface of the ferrule tip.

9. A method according to Claim 5, 6 or 7, wherein the opitcal fibre, when inserted into the said channel and through the said aperture in the tip of the ferrule, is so located that the fibre end protrudes beyond the exterior end surface of the ferrule tip, and a pad of transparent resilient material having a refractive index substantially matching that of the fibre material is placed around the protruding end of the fibre.

10. A method according to Claim 9, wherein the said pad consists of a silicone resin.

11. An optical fibre termination formed by a method according to any of the preceding Claims 5 to 10.

12. A demountable optical fibre connector according to Claim 1, substantially as shown in, and as hereinbefore described with reference to, the drawing accompanying the Provisional Specification.

13. A demountable optical fibre connector incorporating a butted pair of optical fibre terminations according to Claim 11, substantially as shown in, and as hereinbefore described with reference to, the drawing accompanying the Provisional Specification.

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For the Applicants

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1594617 PROVISIONAL SPECIFICATION
1 SHEET *This drawing is a reproduction of the Original on a reduced scale*

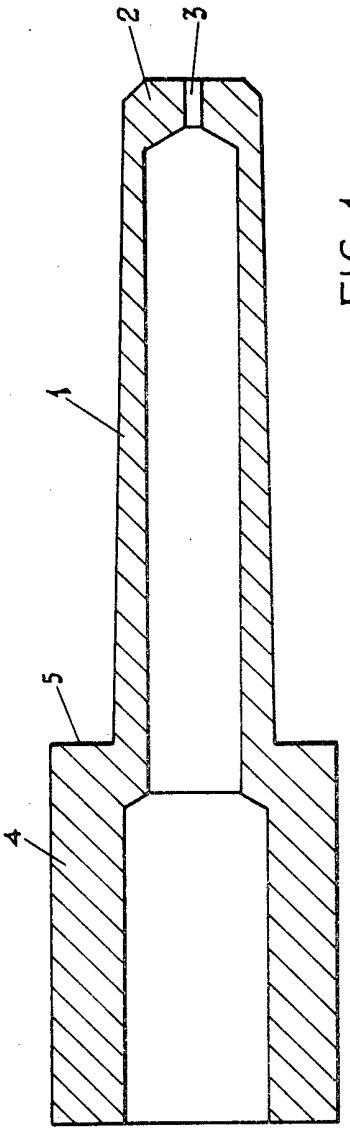

FIG. 1.

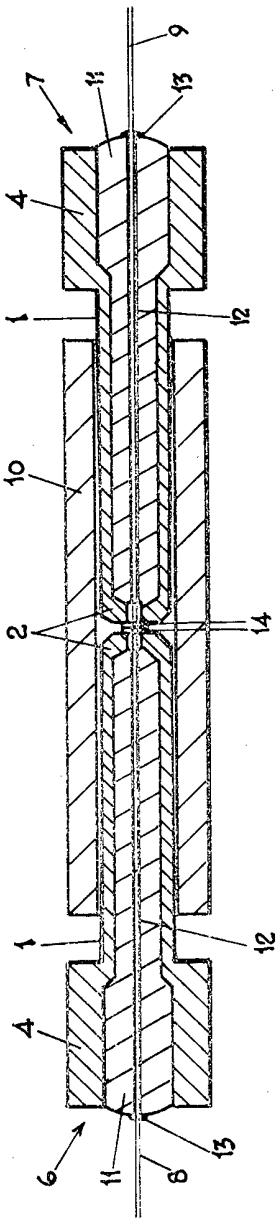

FIG. 2.