

OPTICAL FIBRE SPLICING

This invention relates to effecting a fusion splice between two optical fibres, one or each of which may be a component of an optical cable, and is particularly concerned with preparation of the optical fibres immediately prior to the actual fusion splicing operation.

In order that a satisfactory fusion splice can be effected between two optical fibres, it is necessary to ensure that:

- (i) each optical fibre has a substantially flat end face lying in a plane radial to the fibre axis;
- (ii) end parts of the optical fibres are so disposed that the cores of the fibres are in substantially axial alignment for optimum transfer of light from one fibre to the other; and
- (iii) the end faces of the axially aligned end parts of the optical fibres are spaced a predetermined distance apart, which predetermined distance is such that, after the fusion splicing operation has commenced and end parts of the optical fibres are in an appropriate softened state, the end part of one or each optical fibre can be moved axially towards and against the end part of the other optical fibre to a predetermined extent and at a predetermined rate to complete the fusion splice.

Many sophisticated methods and apparatus have been proposed and are used to effect axial alignment of the prepared end parts of optical fibres to be fusion

spliced and to ensure that the end faces of the axially aligned optical fibres are spaced apart by the required distance. The majority of these sophisticated methods and apparatus operate automatically or semi-automatically and require accurately tooled equipment, complicated electronic circuitry and, in some cases, video cameras and display devices. As a consequence, the equipment for effecting axial alignment, and spacing of the end faces, of prepared end parts of optical fibres to be fusion spliced is expensive and represents a substantial proportion of the overall cost of fusion splicing apparatus.

It is an object of the present invention to provide an improved method of, and an improved component for use in, positioning two optical fibres relative to one another for the purpose of effecting a fusion splice therebetween, which improved method and improved component enable the cost of the equipment required for effecting axial alignment, and spacing of the end faces, of optical fibres to be fusion spliced to be greatly reduced as compared with equipment hitherto proposed and used for this purpose, with a consequential substantial reduction in the overall cost of fusion splicing apparatus.

According to the invention, the improved method comprises the steps of:-

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- (i) applying to each optical fibre at a position spaced from the end to be spliced a one-piece collar which is so disposed on the fibre that relative lengthwise movement therebetween cannot be effected without the application of a substantial force;
- (ii) cleaving each optical fibre at a position between the collar and said end of the fibre to leave protruding from the collar an optical fibre tail of a predetermined length having a substantially flat end face lying in a plane radial to the axis of the fibre; and
- (iii) introducing said optical fibre tails into opposite ends of an open-ended substantially rectilinear guide passage in the splicing station of fusion splicing apparatus in such a way that the collars about the remote faces of longitudinally spaced upstanding abutments and the optical fibre tails are in substantially axial alignment, the predetermined lengths of the optical fibre tails having regard to the distance between said abutments being such that said end faces of the optical fibre tails are disposed a predetermined distance apart appropriate for fusion splicing of the optical fibre tails.

After the two optical fibre tails have been prepared and positioned in accordance with the improved

method hereinbefore described, fusion splicing of the optical fibre tails can be effected.

The open-ended substantially rectilinear guide passage into opposite ends of which the optical fibre tails are introduced may be in the surface of an elongate table in the splicing station of fusion splicing apparatus but, preferably, the open-ended substantially rectilinear guide passage extends between opposite ends of a preformed substantially rigid elongate support member which is positioned in the splicing station of fusion splicing apparatus and which has, at a position intermediate of its ends to enable which fusion splicing to be effected, a slot or aperture which intersects said guide passage and extends transversely across the width of the support member.

Preferably, the transversely extending slot or aperture in the support member is centrally disposed between the ends of the member and the support member is so positioned between the longitudinally spaced abutments that the transversely extending slot or of the support member is centrally disposed between the remote faces of the abutments. As a consequence, the lengths of the optical fibre tails to be fusion spliced will be substantially equal to one another.

At least the remote faces of the abutments preferably are substantially flat and lie in planes substantially radial to the axis of the guide passage of

the support member and, preferably also, the end faces of the collars caused to abut the remote faces of the abutments are substantially flat and lie in planes radial to the axes of the collars.

In addition to the one-piece collar serving as a stop which engages one of the upstanding abutments to ensure that the end face of the optical fibre tail protruding from the collar is correctly positioned with respect to the end face of the other optical fibre tail, the collar when initially positioned on an optical fibre can be positively located in an optical fibre cleaving tool with respect to the cutting blade of the tool to ensure that, after the cleaving operation has been effected, an optical fibre tail of a required length is obtained.

The preformed substantially rigid elongate support member will be made of a material which is capable of withstanding the temperature to which it will be subjected during fusion splicing of the fibres and which will have no deleterious effect on the fibres. The substantially rectilinear optical fibre guide passage in the support member may be a bore which extends over at least parts of the length of the member immediately adjacent and on opposite sides of the transversely extending slot or aperture or it may be a channel in a surface of the member, which channel may be of any transverse cross-section suitable for accommodating aligned optical fibre tails; preferred cross-sectional

shapes include V-, U- and square cross-sectional shapes. Where the guide passage of the support member at least in part comprises a channel in a surface of the support member, a preformed elongate lid may be secured to that surface of the support member in which the channel lies. The preformed elongate lid may be made of the same material as the elongate support member. If desired, the preformed lid may be temporarily applied to said surface of the support member after the optical fibre tails have been introduced into the channel and before fusion splicing is effected to serve to retain the optical fibre tails in the channel during fusion splicing.

The preformed substantially rigid elongate support member may be made of a ceramic, vitreous or sintered material or it may be made of a moulded plastics material.

The support member, and the elongate lid when employed, may be used to provide permanent mechanical protection for the fusion splice between the optical fibre tails and, in this case, at least any space in the transversely extending slot or aperture not occupied by the fusion spliced optical fibre tails may be substantially filled with a curable material in a liquid or semi-liquid state which is permitted or caused to set.

The one-piece collars disposed on the optical fibres may additionally be employed as end walls of a

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protective enclosure subsequently assembled around the fusion splice.

The one-piece collar may be made of a resilient material, e.g.. rubber or a resilient plastics material, or it may be made of a metal or metal alloy or of a substantially rigid plastics or other suitable non-metallic material. Preferably, the one-piece collar is made of a resilient or substantially rigid plastics material because one-piece collars of such materials can be readily made in quantity at low cost by injection moulding or by extrusion and high quality cleaving of the extrudate.

Where the one-piece collar is made of a resilient material, preferably the open-ended collar is made of a resilient material, preferably the open-ended passage of the collar is a throughbore of such a transverse cross-

sectional shape and size that an optical fibre disposed in the passage will be resiliently gripped by the collar. To this end, in one preferred embodiment the one-piece collar of resilient material has a throughbore which is of a non-circular transverse cross-section and which, in a first plane containing the axis of the collar, has a transverse dimension less than the diameter of an optical fibre to be resiliently gripped by the collar and which, in a second plane containing the axis of the collar and substantially normal to said first plane, has a transverse dimension greater than the diameter of said optical fibre; for example, the throughbore may have a transverse cross-section of approximately elliptical shape. By radially compressing opposite sides of the resilient collar in directions substantially normal to said first plane, the transverse cross-sectional shape of the throughbore of the collar can be temporarily modified to approximately circular shape so that a length of optical fibre can be fed therethrough and, after a length of optical fibre has been fed through the distorted throughbore of the collar, said compressive forces can be removed so that the throughbore of the collar will return towards its original non-circular shape and the collar will so resiliently grip the optical fibre that relative lengthwise movement between the fibre and the collar cannot be effected without the application of a substantial force. In one alternative embodiment the one-piece collar of resilient material has a throughbore

of substantially circular transverse cross-section whose diameter decreases smoothly and gradually from the end face and over a part of the length of the collar to a diameter such that an optical fibre disposed in the throughbore will be resiliently gripped by the collar over the other part of the length of the collar.

Where the one-piece collar is made of a metal or metal alloy or of a substantially rigid plastics or other suitable non-metallic material, preferably the open-ended passage of the collar is a channel opening into the peripheral wall of the collar and of such an approximately key-hole shaped transverse cross-section that the collar can be applied transversely to an optical fibre and the optical fibre can effect a "snap-fit" in the root of the channel.

In all cases, preferably, the one-piece collar has an external transverse cross-sectional shape which is substantially uniform throughout the length of the collar.

It is to be understood that the improved method of the invention, and the one-piece collar for use therein, can be readily modified to provide an improved method of, and a one-piece collar for use in, positioning relative to one another two optical fibre ribbons, each comprising a plurality of optical fibres extending side-by-side, for the purpose of effecting fusion splices between the optical fibres thereof and that such

modifications fall wholly within the scope of the invention.

The invention is further illustrated by a description, by way of example, of two preferred one-piece collars for use in the improved method of positioning two optical fibres relative to one another for the purpose of effecting a fusion splice therebetween, and of the preferred method of positioning two optical fibres relative to one another for the purpose of effecting a fusion splice therebetween, with reference to the accompanying drawings, in which:-

Figure 1 is a transverse cross-sectional view, on a greatly enlarged scale, of the first preferred one-piece collar;

Figure 2 is a transverse cross-sectional view, on a greatly enlarged scale, of the second preferred one-piece collar, and

Figure 3(a) to (c) shows, diagrammatically, the steps in the preferred method of positioning two optical fibres relative to one another for the purpose of effecting a fusion splice between them.

Referring to Figure 1, the first preferred one-piece collar comprises a moulded body 1 of resilient plastics material, which body is of a uniform transverse cross-section throughout its length having two diametrically opposed flat surfaces 3 which extend parallel to one another and two diametrically opposed convexly-curved surfaces 4. The body 1 has centrally

disposed within the body a throughbore 2 having a transverse cross-section approximating in shape to that of an ellipse. The cross-sectional size of the elliptically-shaped throughbore 2 is such that in one plane containing the axis of the body 1 the throughbore has a transverse dimension less than the diameter of an optical fibre on which the collar is to be applied and in a second plane containing the axis of the body and normal to the first plane the throughbore has a transverse dimension greater than the diameter of the optical fibre. By radially compressing the convexly-curved surfaces 4 of the resilient collar 1 in directions normal to the first plane, the transverse cross-sectional shape of the throughbore 2 can be temporarily modified to approximately circular shape so that a length of optical fibre can be fed therethrough and, after a length of optical fibre has been fed through the distorted throughbore, the compressive forces can be removed so that the throughbore will return towards its original approximate elliptical shape and the collar will so resiliently grip the optical fibre that relative lengthwise movement between the fibre and the collar cannot be effected without the application of a substantial force.

The preferred one-piece collar shown in Figure 2 is a moulded body 6 of rigid plastics material, which body has throughout its length a uniform transverse cross-sectional shape of approximately circular form.

The body 6 has extending between its ends an open-ended passage in the form of a channel which opens into the peripheral wall of the body and which is of approximately key-hole shaped transverse cross-section. The transverse dimensions of that part of the passage 7 bounding the central axis of the body 6 are such that the collar can be applied transversely to an optical fibre so that the optical fibre effects a "snap-fit" in that part of the passage bounding the central axis of the collar, the snap-fit being such that relative lengthwise movement between the fibre and the collar cannot be effected without the application of a substantial force.

In the preferred method of positioning two optical fibres relative to one another for the purpose of effecting a fusion splice between them as illustrated diagrammatically in Figure 3, a one-piece collar 1 is applied to each optical fibre F at a position spaced from the end to be spliced, the collar so resiliently gripping the optical fibre that relative lengthwise movement between the fibre and the collar cannot be effected without the application of a substantial force (Figure 3a). Each optical fibre F with the resilient collar 1 disposed thereon in turn is positioned in an optical cleaver in such a way that the end face of the collar nearer the end of the fibre to be spliced abuts an upstanding abutment 11, the length of fibre protruding from the collar passing through a passage or

channel in the abutment and across a table 12 immediately under a cutting blade 14. The cutting blade 14 then cleaves the optical fibre F to leave protruding from the collar 1 an optical fibre tail T having a flat end face lying in a plane radial to the axis of the fibre. Since the rectilinear distance between the cutting blade 14 and the face of the abutment 11 remote from the cutting blade is fixed, the optical fibre tail T will have a predetermined length. This operation is then repeated for the second of the two optical fibres F so that each optical fibre to be spliced has an optical fibre tail T of the same predetermined length protruding from the collar 1 disposed on the fibre (Figure 3b).

The optical fibre tails T of the optical fibres F are then introduced into opposite ends of an open-ended rectilinear guide channel 16 extending between opposite ends of a preformed rigid elongate support member 15 of a ceramic material which is positioned in the splicing station of fusion splicing apparatus and which has, at a position mid-way between its ends to enable fusion splicing is to be effected by electrodes 19, a slot 17 which intersects the guide channel and extends transversely across the width of the support member. The collars 1 disposed on the optical fibres F abut the remote faces of longitudinally spaced upstanding abutments 20 each having a slot 21 therein for passage therethrough of the optical fibre tail T, the rectilinear distance between each of said remote

faces of the longitudinally spaced upstanding abutments and the transverse axis extending between the electrodes 19 being such that the optical fibre tails T protrude into the transversely extending slot 17 and are disposed a predetermined distance apart appropriate for fusion splicing of the tails (Figure 3c). Fusion splicing of the optical fibre tails T can then be effected, one or each of the longitudinally spaced abutments 20 being releasable so that one or each optical fibre tail can move a predetermined distance towards the other during the splicing operation.

Thereafter, the elongate support member 15 may be used to provide permanent mechanical connection for the fusion splice between the optical fibre tails T as described and claimed in our co-pending British Patent Application No: 9111007.2 (Serial No: 2245083). To this end, after fusion splicing of the optical fibre tails T has been effected, any space in the guide channel 16 not occupied by the fusion spliced optical fibres and the transversely extending slot 17 are filled with a hot melt adhesive. Before the adhesive has set, a preformed elongate lid (not shown) of a ceramic material is applied to the support member 15 so that, on setting of the hot melt adhesive, the lid will be bonded to the support member and the two-part component will provide permanent protection for the fusion splice between the optical fibres.

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The collars 1 may then be cut away or they may be used as end walls of a protective sleeve surrounding the two-part component.

**Claims:**

1. A method of positioning two optical fibres relative to one another for the purpose of effecting a fusion splice therebetween, which method comprises the steps of:

- (i) applying to each optical fibre at a position spaced from the end to be spliced a one-piece collar which is so disposed on the fibre that relative lengthwise movement therebetween cannot be effected without the application of a substantial force;
- (ii) cleaving each optical fibre at a position between the collar and said end of the fibre to leave protruding from the collar an optical fibre tail of a predetermined length having a substantially flat end face lying in a plane radial to the axis of the fibre; and
- (iii) introducing said optical fibre tails into opposite ends of an open-ended substantially rectilinear guide passage in the splicing station of fusion splicing apparatus in such a way that the collars abut the remote faces of longitudinally spaced upstanding abutments and the optical fibre tails are in substantially axial alignment, the predetermined lengths of the optical fibre tails having regard to the distance between said abutments being such that said end faces of the optical fibre tails are disposed a predetermined distance apart appropriate for fusion splicing of the optical fibre tails.



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2. A method as claimed in Claim 1, wherein the open-ended substantially rectilinear guide passage into opposite ends of which said optical fibre tails are introduced extends between opposite ends of a preformed substantially rigid elongate support member which is positioned in the splicing station of fusion splicing apparatus and which has, at a position intermediate of its ends to enable fusion splicing to be effected, a slot or aperture which intersects said guide passage and extends transversely across the width of the support member.

3. A method as claimed in Claim 2, wherein the transversely extending slot or aperture in the support member is centrally disposed between the ends of the member and the support member is so positioned between the longitudinally spaced abutments that the transversely extending slot or aperture of the support member is centrally disposed between the remote faces of the abutments.

4. A method as claimed in Claim 2 or 3, wherein at least the remote faces of the abutments are substantially flat and lie in planes substantially radial to the axis of the guide passage of the support member.

5. A method as claimed in Claim 4, wherein the end faces of the collars caused to abut the remote faces of the abutments are substantially flat and lie in planes radial to the axes of the collars.



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6. A method as claimed in any one of the preceding Claims, wherein, when cleaving each optical fibre, the collar disposed thereon is positively located in an optical fibre cleaving tool with respect to the cutting blade of the tool to ensure that, after the cleaving operation has been effected, an optical fibre tail of a required predetermined length is obtained.

7. A method as claimed in any one of the preceding Claims, wherein, after fusion splicing of the optical fibre tails has been effected, the one-piece collars disposed on the optical fibres are employed as end walls of a protective enclosure assembled around the fusion splice.

8. A method of positioning two optical fibres relative to one another for the purpose of effecting a fusion splice therebetween substantially as hereinbefore described with reference to Figure 3 of the accompanying drawings.
