

Optical Fibre End Face Angling

This invention relates to a method of angling the end face of an optical fibre for use in a mechanical optical fibre splice.

Optical fibres used in telecommunications are commonly single mode fibres. Typically, such a fibre has a 9 μ m diameter central glass core along which optical signals are transmitted, the core being surrounded by a glass cladding whose diameter is of the order of 125 μ m. The cladding has a refractive index that differs slightly from that of the core. The cladding is surrounded by a protective primary coating. Devices are known for aligning the ends of optical fibres for the purpose of splicing the ends together by butting the core end faces against one another to form a mechanical splice. To function properly, and to form a low loss splice, such a device must align the two cores accurately, for example to within 1 μ m.

Most commercially-available mechanical splices are made in the following manner, namely: -

(1) The fibres to be joined are prepared by stripping the end portions thereof down to bare fibre (that is to say by removing the primary coating and exposing the cladding). The fibre ends are then cleaved to produce blemish-free faces which are perpendicular to the axes of the fibres.

(2) The fibres are inserted into an alignment mechanism, and the cleaved ends are butted together. The fibres are aligned by means of their claddings, and so the alignment of their cores depends upon the cores being concentric with their claddings. Fortunately, owing to the improvement in single mode fibre quality in recent years,

this method of alignment does not give rise to significant insertion losses of mechanical splices.

(3) The interface between the fibres is filled with a gel (or glue) which has a refractive index which closely matches that of the fibre cores. The gel reduces refractive index mismatch, thereby reducing the insertion loss and increasing the return loss of the splice.

(4) The fibres are bonded or clamped in place.

The major problem of such splices is the variability of reflected power with temperature. This variation is due to the refractive index of the matching glue or gel changing at a different rate to that of the silica fibre. There is currently no known material that could be used in this application that would match the refractive index of silica at more than one precise temperature. Typically, as the ambient temperature moves away from room temperature, the return loss decreases and reflection increases. Reflections do not generally cause problems in simplex transmission, but they can have an adverse effect on duplex transmission, where reflections introduce crosstalk, thereby reducing operational receiver sensitivity. It is inadvisable, therefore, to install mechanical splices in fibre networks that may be upgraded to duplex working.

The present invention provides a method of forming an end face on one end portion of an optical fibre at a predetermined angle to the fibre axis, the method comprising the steps of inserting the fibre within a complementary through bore in a support, anchoring a portion of the optical fibre remote from said one end portion to the support, positioning said one end portion of the optical fibre so as to protrude from the through bore by a predetermined distance from one surface of the support, positioning a polishing medium against said one surface of the support, and moving the polishing medium relative to said one surface until the fibre end face is substantially

parallel to said one surface, the axis of the through bore being positioned at said predetermined angle to said one surface, wherein the method further comprises the step of anchoring said remote portion of the optical fibre prior to positioning said one end portion so as to protrude from the through bore.

Where the predetermined angle is 90° , the polishing medium may have a resilient surface.

Advantageously, the method may further comprise the step of cleaving the optical fibre to define said one end portion, the cleaving step being carried out prior to the positioning of said one end portion within the through bore.

Preferably, the method further comprises the step of anchoring said remote portion of the optical fibre so as to lie at an angle to the axis of the through bore.

The invention also provides apparatus for forming an end face on one end portion of an optical fibre at a predetermined angle to the axis of the optical fibre, the apparatus comprising a support formed with a through bore for receiving the optical fibre, and means for fixing the optical fibre to the support so that said one end portion of the optical fibre protrudes from the through bore to lie at a predetermined distance from one surface of the support, whereby a polishing medium can be placed against said one surface of the support and moved relative thereto until the fibre end face is parallel to said one surface, wherein the through bore is positioned at said predetermined angle to said one surface, and wherein the support is constituted by a body portion and a cap portion, the body portion being provided with the through bore, and the cap portion being provided with a clamp for fixing the optical fibre to the support, the cap portion being slidable relative to the body portion so as to move the optical fibre between a first position, in which said one end portion is within the through bore, and a second position, in which said one end

portion protrudes from the through bore by said predetermined distance.

Preferably, the through bore is defined by a ferrule, the internal bore of which may have an inner diameter which is greater than the external diameter of the optical fibre by between $1\mu\text{m}$ and $4\mu\text{m}$.

Advantageously, the base of the body portion is provided with a plurality of support balls for engaging the polishing medium, the spherical surfaces of the balls remote from the base of the body portion defining said one surface.

The apparatus may further comprise a spring for biasing the cap portion away from the body portion thereby to position the optical fibre in its first position.

Conveniently, the clamp is formed with a bore whose walls clamp against the optical fibre, the axis of the bore in the clamp being offset with respect to the axis of the through bore.

Preferably, the ferrule is positioned within the body portion, the body portion being formed with a cylindrical chamber leading to the ferrule.

Advantageously, the apparatus further comprises a blade for cleaving the optical fibre to define said one end portion. Preferably, the blade forms part of a setting tool, the setting tool being engageable with the cap portion of the support to move the optical fibre into its first position, prior to the cleaving operation.

The invention will now be described in greater detail, by way of example, with reference to the accompanying drawings, in which: -

Fig. 1 is a schematic side elevation of a jig which utilises the underlying principle of the invention and is used to prepare fibre end faces;

Fig. 2 is a schematic side elevation of a jig which is constructed in accordance with

the invention and is used to prepare fibre end faces; and

Fig. 3 is a schematic side elevation of the jig of Fig. 2 together with a setting tool.

5 Referring to the drawings, Fig. 1 shows a jig 1 which can be used to form angled end faces on optical fibres. A standard fibre connector ferrule 2 is mounted within the jig 1 in such a manner that the ferrule subtends an angle of ϕ with respect to the perpendicular to the lower surface 1a of
10 the jig. A capillary tube 3 is inserted co-axially into the upper end of the ferrule 2, the capillary tube being held at the required angle (ϕ to the perpendicular to the upper surface 1b of the jig 1) by a support plate 4 fixed to the jig upper surface.

15 The capillary tube 3 constitutes a guide for a partially-stripped fibre 5 to be inserted into the ferrule 2, the fibre having a bare portion 5a and a coated portion 5b. The internal diameter of the bore in the ferrule 2 is between $1\mu\text{m}$ and $4\mu\text{m}$ larger than the external diameter of the

5 bare portion 5a of the fibre 5. The fibre 5 is pushed through the ferrule 2, stripped end first, until approximately 0.5mm of stripped fibre protrudes from the ferrule. In this position, the ferrule 2 supports the bare or stripped fibre 5a, and the capillary tube 3 supports the coated fibre 5b. The coated fibre 5b is clamped (at 6) to the support plate 4. The clamp 6 is positioned 1cm from the free end of the capillary tube 3.

10 When the lower surface 1a of the jig 1 is placed onto a polishing medium (not shown), an axial load is applied to the fibre 5, this load tending to force the fibre back into the ferrule 2, and bending the fibre between the capillary 3 and the clamp 6. As the fibre 5 attempts to straighten, its end face is pressed against the polishing medium. The end face can then be polished by moving the polishing medium relative to the lower surface 1a of the jig 1 (or vice versa). As the fibre 5 is tightly constrained within the ferrule 2, insufficient bending occurs to damage the fibre. Polishing continues until the fibre end face is parallel to the polishing medium, and thus has an end angle determined by the angle ϕ between the axis of the ferrule 2 and the perpendicular to the jig lower surface 1a. In this way, it is relatively easy to angle the end face of the fibre 5 accurately. Thus, by accurately angling the end face of the fibre 5 so as to be between 4° and 12° , the fibre can be used with a similar fibre to form good mechanical splice having a greatly-reduced return loss sensitivity to temperature.

30 In addition to the enhanced performance of the splice, the cost of the polishing jig 1 is significantly less than that of a cleaver. A fibre can be crudely cut (e.g. with scissors) before it is positioned in the polishing jig 1, without reducing the quality of the finished end face. A standard polishing cycle can be determined that will produce an acceptable finished end face from any initial fibre end. This is achieved by increasing the amount of polishing

carried out until it is sufficient to remove all of the fibre damaged by the crude cutting. This is made possible by continuously feeding fibre to the polishing medium until the fibre is fully relaxed. As the damaged region does not normally extend to more than 0.5mm, most cut ends can be polished to produce an acceptable end face. The polishing process can be accelerated by the use of rough papers to remove the majority of the material, and a final polish to produce the required finish. It will be appreciated, however, that the use of the jig enables accurate angled end faces to be formed on optical fibres in a quick and easy manner.

The 0.5mm protrusion of fibre can be difficult to see unless lighting conditions are good. The measurement of this length could be made easier to achieve by the use of a simple jig device. This could consist of a flat plate, with a 0.5mm shim placed upon it. The jig 1 would be placed on the shim, with the ferrule 2 above a hole in the shim. The fibre would then be fed through the jig 1 until the fibre end rested on the bottom plate, giving a measured length of protruding fibre.

It will be apparent that modifications could be made to the jig described above. For example, a funnel structure could be attached to the capillary tube 3 to aid the initial insertion of the fibre 5. Moreover, in order to protect the fibre 5 which protrudes from the ferrule 2 prior to the fibre being placed on the polishing medium, a protective shield could be utilised. This could be in the form of a sprung concentric tube surrounding either the jig 1 or the end of the ferrule 2.

Fig. 2 shows a modified form of jig 11 having a body portion 12 and a cap 13. The cap 12 is a sliding fit on the body portion 12, the two members being biased apart by a light spring 14. The arrangement is such that the maximum gap between the upper surface 12a of the body portion 12 and

the lower surface 13a of the cap 13 is 1mm. The body portion 12 is formed with a cylindrical bore 15 whose axis subtends an angle of ϕ with respect to the perpendicular to the lower surface 12b of the body portion 12.

5 A fibre clamp 16 is fixed to the cap 13, a fibre guide 17 being supported above the clamp by means of a support arm 18. The axis of the bore (not shown) in the clamp 16 is offset by about 2° from the axis of the bore 15. A ferrule 19 is fixed within a bore formed in the body portion 12, the
10 bore being co-axial with the bore 15 and opening into the lower surface 12b of the body portion. The ferrule 19 projects 2mm below the lower surface 12b. Three equispaced ruby balls 20 (only two of which can be seen in Fig. 2) are fixed to the lower surface 12b, the balls also projecting
15 2mm below the surface 12b so that the end of the ferrule 19 is coplanar with the free end portions of the balls. A fibre guide 21 is provided in the base of the bore 15 to guide an optical fibre (see below) into the ferrule 19.

In use, a partially-stripped optical fibre 22 is
20 inserted into the ferrule 19 via the fibre guide 17, the clamp 16, the cylindrical bore 15 and the fibre guide 21. The fibre 22 has a bare (stripped) portion 22a and a coated portion 22b. The ferrule 19 has a bore (not shown) whose internal diameter is between $1\mu\text{m}$ and $4\mu\text{m}$ larger than the
25 external diameter of the bare fibre portion 22a. The top of the ferrule 19 thus forms a stop for the coated fibre portion 22b, so that, in use, the bare fibre 22a projects about 10mm below the free end of the ferrule. Once the coated fibre portion 22b butts against the coating stop, the
30 fibre 22 is released to allow it to straighten. The clamp 16 is then applied to secure the fibre 22 in this position. The fibre insertion operation is carried out with the cap 13 in its "down" position (that is to say with the spring 14 compressed). When the fibre 22 has been clamped in this
35 manner, the cap 13 is released so that the spring 14 forces

the cap into its "up" position (as shown in Fig. 2), partially retracting the bare fibre portion 22a into the ferrule 19. The bare fibre portion 22a is then cleaved (in a manner described below with reference to Fig. 3) flush
5 with the free end surface of the ferrule 19.

The jig 11 is then placed onto a polishing medium (not shown), and the cap 13 is pushed down to compress the spring 14 and force the free end of the bare fibre portion 22a into contact with the polishing medium. When the free end of the
10 portion 22a contacts the polishing medium, it is prevented from protruding further from the ferrule 19, the remainder of the 1mm travel of the jig cap 13 being taken up by the fibre 22 bending within the cylindrical bore 15. As the fibre 22 attempts to straighten, its end face is pressed
15 against the polishing medium. The fibre end face can then be polished by moving the jig 11 with a circular motion relative to the polishing medium, the balls 20 being effective to minimise the friction between the jig and the polishing medium. The bending of the fibre 22 provides the
20 controlled pressure on the fibre end which is desirable for the polishing process. As the bare fibre portion 22a is relatively tightly constrained within the ferrule 19, insufficient bending occurs in this region to damage the fibre. Polishing continues until the fibre end face is
25 parallel to the polishing medium, and this has an end face angle determined by the angle ϕ between the axis of the ferrule 19 and the perpendicular to the jig lower surface 12b. It is preferable to polish the fibre end face on several grades of polishing paper, in order to minimise the
30 polishing time. Usually, coarse, medium and fine grade polishing papers are required, though it may sometimes be possible to achieve a satisfactory polishing performance using only the medium and fine grades.

The bending of the fibre 22 to provide the controlled
35 polishing pressure on the fibre end face is repeatable

because of the offset of the bore of the clamp 16. This ensures that every fibre to be polished bends in the same direction, thereby ensuring a substantially constant polishing pressure.

5 An important advantage of the jig 11 is that the biassing of the cap 13 away from the body portion serves to retract the fibre 22 into the ferrule 19 when the jig is not in contact with the polishing medium, thus protecting the fibre from damage.

10 The fibre guide 17 not only facilitates insertion of the fibre 22 into the bore in the clamp 16, but also provides an indication of when the fibre coating hits the coating stop as the fibre will then bend between the clamp and the fibre guide 17.

15 In a development of this embodiment, polishing is effected at a special workstation which has coarse, medium and fine grade polishing films supported on glass plates forming part of the workstation. The glass plates are mounted on an axle, so that each plate can rock slightly as
20 the jig 11 is moved over the surface of the associated polishing film. The rocking motion is used to activate a microswitch driven counter which logs the number of turns that have been completed. The end point of the polishing process can then be determined by a pre-ordained number of
25 turns (in practice about 20) for each grade of polishing film.

30 Figure 3 shows the jig 11 in conjunction with a setting tool, indicated generally by the reference numeral 31, for facilitating cleaving of excess bare fibre prior to the polishing process. The setting tool 31 includes a container 32 for collecting cleaved fibre ends fixed beneath a base plate 33 and a fixed blade 34. The body portion 12 of the
35 jig 11 is mounted in an apertured support plate 35 which is slidable over the base plate 33. An operating lever 36, which is pivoted (at 37) to an upright 38 fixed to the base

plate 33, is provided for actuating the cleaving operation. The lever 36 has a horizontal arm 36a which presses down on the rim of the cap 13 of the jig 11, and a vertical arm 36b which is engageable with the support plate 35. A compression spring 39, provided between the support plate 35 and a stop member 40, biases the support plate against the vertical arm 36b (that is to say to the right as shown in Fig. 3).

In use, the jig 11 is positioned within the apertured support plate 35, and the cap 13 is pressed down by the horizontal arm 36a of the setting tool 31. The arm 36a holds the cap 13 of the jig 11 down (that is to say with the spring 14 compressed) whilst the fibre 22 is being inserted. When the fibre 22 has been inserted and clamped in position in the manner described above, the lever 36 is depressed. As the lever 36 pivots, its arm 36a allows the cap 13 of the jig 11 to rise, whilst the vertical arm 36b pushes the support plate 35 and the jig 11 to the left (as shown in Fig. 3) so that the bare fibre portion 22a projecting from the ferrule 19 moves towards the blade 34. The setting tool 31 is such that the fibre 22a is cut by the blade 34 only after the cap 13 of the jig 11 has risen to its uppermost position. It also prevents the jig 11 from being removed until the fibre 22a has been cut.

It is, of course, possible to use each of the jigs described above to form an accurately angled end face on an optical fibre where the end face is at any desired angle (including 90°) to the fibre axis. Thus, the angle the end face of an optical fibre makes with the fibre axis is determined by the angular position of the ferrule 2 (or 19) within the jig 1 (or 11). The jigs are, therefore, extremely versatile in that they can be used to form perpendicular end faces as well as "angled" end faces. Where the end face of an optical fibre is to be perpendicular to the fibre axis, it may be advantageous to round this end face so that the

5 fibre cladding forms a dome whose top is constituted by the fibre core. This rounding can be achieved by carrying out the polishing step using a resilient polishing pad. Fibre end faces formed in this manner can be butted together so as to have improved core-to-core contact, thereby enabling low loss conventional mechanical splices to be made.

CLAIMS

1. A method of forming an end face on one end portion of an optical fibre at a predetermined angle to the fibre axis, the method comprising the steps of inserting the fibre within a complementary through bore in a support, anchoring a portion of the optical fibre remote from said one end portion to the support, positioning said one end portion of the optical fibre so as to protrude from the through bore by a predetermined distance from one surface of the support, positioning a polishing medium against said one surface of the support, and moving the polishing medium relative to said one surface until the fibre end face is substantially parallel to said one surface, the axis of the through bore being positioned at said predetermined angle to said one surface, wherein the method further comprises the step of anchoring said remote portion of the optical fibre prior to positioning said one end portion so as to protrude from the through bore.

2. A method as claimed in claim 1, wherein said predetermined angle is 90° , and the polishing medium has a resilient surface.

3. A method as claimed in claim 1 or claim 2, further comprising the step of cleaving the optical fibre to define said one end portion, the cleaving step being carried out prior to the positioning of said one end portion within the through bore.

4. A method as claimed in any one of claims 1 to 3, further comprising the step of anchoring said remote portion of the optical fibre so as to lie at an angle to the axis of the through bore.



5. Apparatus for forming an end face on one end portion of an optical fibre at a predetermined angle to the axis of the optical fibre, the apparatus comprising a support formed with a through bore for receiving the optical fibre, and means for fixing the optical fibre to the support so that said one end portion of the optical fibre protrudes from the through bore to lie at a predetermined distance from one surface of the support, whereby a polishing medium can be placed against said one surface of the support and moved relative thereto until the fibre end face is parallel to said one surface, wherein the through bore is positioned at said predetermined angle to said one surface, and wherein the support is constituted by a body portion and a cap portion, the body portion being provided with the through bore and the cap portion being provided with a clamp for fixing the optical fibre to the support, the cap portion being slidable relative to the body portion so as to move the optical fibre between a first position, in which said one end portion is within the through bore, and a second position, in which said one end portion protrudes from the through bore by said predetermined distance.

6. Apparatus as claimed in claim 5, wherein the base of the body portion is provided with a plurality of support balls for engaging the polishing medium, the spherical surfaces of the balls remote from the base of the body portion defining said one surface.

7. Apparatus as claimed in claim 5 or claim 6, further comprising a spring for biasing the cap portion away from the body portion thereby to position the optical fibre in its first position.

8. Apparatus as claimed in any one of claims 5 to 7, wherein the clamp is formed with a bore whose walls clamp



against the optical fibre, the axis of the bore in the clamp being offset with respect to the axis of the through bore.

9. Apparatus as claimed in any one of claims 5 to 8, wherein the through bore is defined by a ferrule.

5 10. Apparatus as claimed in claim 9, wherein the internal bore of the ferrule has an inner diameter which is greater than the external diameter of the optical fibre by between 1 μ m and 4 μ m.

10 11. Apparatus as claimed in claim 9 or claim 10, wherein the ferrule is positioned within the body portion, the body portion being formed with a cylindrical chamber leading to the ferrule.

15 12. Apparatus as claimed in any one of claims 5 to 11, further comprising a blade for cleaving the optical fibre to define said one end portion.

20 13. Apparatus as claimed in claim 12, wherein the blade forms part of a setting tool, the setting tool being engageable with the cap portion of the support to move the optical fibre into its first position, prior to the cleaving operation.

14. Optical fibre end face angling apparatus substantially as hereinbefore described with reference to, and as illustrated by, Figs 2 and 3 of the accompanying drawings.

25 15. An optical fibre end face angling method substantially as hereinbefore described with reference to the accompanying drawings.

