

The present invention relates to a method of mechanical locking of an inner member into an outer body, which makes use of locking pieces introduced into radial holes in the outer body and bearing against the inner member, see FR-A-2157481. In this document radial holes are formed through a plastics matter which is cast into the holes.

By way of a particular application which is in no way restrictive the method in accordance with the present invention may be employed for fixing an optical fibre in a connector ferrule, the inner member being then preferably a tubular cylindrical member, preferably metallic, in particular of steel, inside which the optical fibre is fixed in particular by gluing, the outer body being then a ferrule body.

The Applicant Company has thus already described in its patent application EP-A2-0063085 a connector which makes use of such mechanical locking which enables an optical fibre to be fixed in a centred position in a connector ferrule.

The connector described in the previous application and for which the method in accordance with the present invention may equally well be put into effect, is of the type including two male ferrules mounted at the respective ends of the fibres which are to be connected and a restoring female connector which includes a longitudinal bore for supporting and aligning the two ferrules face to face.

The female connector includes in the central portion of it inside its longitudinal bore a stop body for the male ferrules, in particular a sphere which exhibits an axial aperture passing through it and round the latter a contact bearing surface facing each of the male ferrules, each of the male ferrules exhibiting a tubular axial protuberance capable of engaging in the aperture in the said body and a passage into which the optical fibre may be introduced with play and fixed so that the end of it coincides with the end of the protuberance, and surrounding the rear portion of the latter an annular hollow the wall of which defines a bearing surface for contact with the facing bearing surface on the stop body of the female connector under the action of longitudinal pressure means, the facing bearing surfaces on the stop body and on each of the male ferrules being arranged so that at the time of any relative movement of the bearing surfaces in contact, the end of a fibre at the level of the endface of the protuberance from one male member is kept at a constant predetermined distance from the centre of the stop body.

In the aforesaid patent application EP-A2-0063085, each of the male ferrules includes a ferrule body which exhibits at the end of it the said annular hollow and an inner tubular member, preferably metallic, in particular of steel, which is put into place in a corresponding axial hole in the ferrule body and the end of which forms the said protuberance means of mechanical locking being provided for fixing the inner tubular member in the ferrule body, these locking means comprising preferably a plurality of balls forced into corresponding radial holes in the ferrule body and coming to bear against the inner tubular member.

As described in the previous patent application the adjustment of the ferrule body is carried out by micro-movements of the balls forced into the corresponding radial holes in the ferrule body in order to bring the centre of the optical fibre onto the axis of the stop member such as a pierced sphere which in turn bears against the wall which preferably has a conical profile, of the annular hollow in the male ferrule.

The forces for movement of the balls are very much dependent upon the tightness of each ball in the radial hole in which it is engaged, which leads to very close manufacturing tolerances as well as to the necessity of a very clean state of the surface of the balls and of the radial holes. Again, it is not always ensured that the balls engaged in the radial holes always ensure the definite fixing of the inner tubular member with respect to the ferrule body.

The axial positioning of the fibre must in practice be accurate to at least 2 micrometres so that the displacement of the balls must be carried out with at least the same accuracy.

The present invention proposes to achieve a method which enables mechanical locking to be ensured for an inner member, in particular a cylindrical tubular member, in an outer body which is in particular tubular, the method being simple and rapid to put into effect and in particular avoiding accurate and complicated machining of the pieces concerned.

The method in accordance with the invention is characterized by the characteristics of Claim 1.

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Preferably four radial holes are provided, distributed at equal angular spacing in the form of a cross.

The pieces of deformable matter, in particular in the shape of balls or cylinders, are advantageously produced from a soft metal such as lead, tin or a tin-lead alloy, it being understood that any malleable matter may be employed and in particular any other malleable alloy which is deformable under low stress.

In accordance with the invention there is preferably effected on the periphery of the inner member in the zone of the radial holes at least one neck and preferably two adjacent necks of concave profile.

The method which has just been described may advantageously be employed for the putting in place of an optical fibre in a connector ferrule which includes a tubular cylindrical member which forms the inner member described above and is put in place in a tubular ferrule body which forms the outer body described above. The method in accordance with the invention is put into effect in order to form between the inner member and the ferrule body by deformation of the pieces of deformable matter, a plug of deformed matter which ensures the retention of the inner member and then preferably by end gluing an optical fibre is fixed in the inner member and by the action of punches engaged in succession in the radial holes in the ferrule body, micro-displacements of the inner member are effected with a view to adjustment, in particular of the axial positioning and of the centring of the fibre in its ferrule for the achievement of a connector.

With the aim of letting the invention be better understood there will now be described by way of an example which is in no way restrictive a mode of putting it into effect for the achievement of a connector for optical fibres, by referring to the attached drawing in which:

- Figure 1 is a view partially in section, illustrating the putting into effect of the method in accordance with the invention for the putting in place of an inner tubular member in a connector ferrule body;
- Figure 1a illustrates a variant upon the deformable piece which may be employed for putting into effect the method of the invention;

- Figure 2 is a view corresponding with Figure 1 after putting into effect the method of the invention;
- Figure 3 is a section along III-III in Figure 2;
- Figure 4 illustrates a gauge which may be employed in one phase of preparation of the ferrule;
- Figure 5 illustrates the phase of centreing a fibre in a male ferrule employing a self-collimating lens;
- Figure 6 represents partially in section a connector for optical fibres achieved by putting into effect the method of the invention;
- Figure 7 is a section through a male ferrule of the connector as in Figure 4; and
- Figure 8 is a section along VIII-VIII in Figure 7.

In Figures 1 to 3 is illustrated the putting into effect of the method in accordance with the invention, applied to the achievement of a male connector ferrule.

The ferrule 1 exhibits a body 2 the end of which includes an annular hollow exhibiting a cavity with a wall of conical shape 3.

The body 2 includes a longitudinal axial hole 4 inside which is put in place a tubular cylindrical metallic member 5 which includes an axial passage 6 inside which an optical fibre will be put in place.

The ferrule body 2 exhibits a plurality of radial holes 7, four in number in the example shown, the holes being arranged in a cross as may best be seen in Figure 3.

The inner tubular member 5 includes in addition two adjacent concave necks 8 in its outer periphery.

For putting into effect the method in accordance with the invention one

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engages in the radial holes 7 deformable pieces such as balls 9 (Figure 1) or cylindrical slugs 10 (Figure 1a), these pieces being produced from a soft metal, tin in the example illustrated.

These pieces 9 or 10 respectively are compressed and deformed in the zone of the necks 8 in the member 5 by engaging punches 11 simultaneously in the radial holes 7 in the directions shown by the arrows in Figure 1. The flow of the matter forming the pieces 9 or 10 respectively is restricted by the engagement of a ring 12 which includes a tubular end 13 and simultaneously ensures precentring of the member 5 in the ferrule body 2. In Figure 2 is illustrated the ferrule after putting into effect the method of mechanical locking in accordance with the invention.

It may be seen that by deformation of the pieces 9 or 10 respectively under the action of the punches 11 a plug of matter 14 is formed, one portion of which is engaged in the space between the member 5 and the body 2 in and in the vicinity of the zone of the necks 8, one portion of the plug 14 overflowing into the radial holes 7. A very good mechanical retention is thus ensured of the member 5 in the body 2. It will be understood that the radial holes 7 may have very large manufacturing tolerances, for example, of about 0.1mm and similarly the pieces 9 or 10 respectively which are intended for being introduced into these radial holes.

It must be clear that the necks 8 provided in the peripheral wall of the member 5 are only an optional measure which nevertheless favours the movement of the matter forming the pieces 9 or 10 at the time of their deformation by the punches 11.

For the achievement of a connector, after having put into effect on each of the male ferrules the method in accordance with the invention, one puts in place in the axial passage in each member 5 an optical fibre 15 which is fixed by gluing at the end of the axial passage and then one proceeds to a stage of axial positioning of the fibre in each of the male ferrules. For doing that, as explained elsewhere in the previous application, a gauge is employed such as that represented in Figure 4.

This gauge designated as a whole by 16 includes a body 17 similar to a female half-connector and a stop body, in the present case a hemisphere

18 equipped with a longitudinal bore 19 and levelled along a plane 20 recessed a few micrometres, for example, of the order of 3 to 4 micrometres, with respect to its centre 21.

After having put the ferrule in place in the gauge 16 and polishing against an abrasive surface, an axial positioning of the fibre is obtained in the male ferrule.

In order then to carry out the centreing of the fibre in the male ferrule a gauge such as that illustrated in Figure 5 is employed, designated as a whole by 22 and including a body 23 reproducing the characteristics of a female half-connector and a sphere 24 equipped with a longitudinal bore 25, the ferrule mounted in the gauge as illustrated in Figure 5 being placed in front of the objective of a self-collimating lens 26.

The general principle of such a centreing phase has already been described in the patent application EP-A2-0063085 and has no need of being described in detail here.

It is well simply to indicate that for correcting the position of the fibre 15 contained in the tubular member 5 with respect to the centre of the sphere 24, one acts by means of a punch 27 introduced into one of the radial holes 7 upon the plug of matter 14 retaining the member 5 in the body 2. Because of the malleable nature of the matter forming the plug 14 it will be understood that the thrust from the punch causes a displacement of the matter of the plug 14 which in its flow generates in the same direction as the punch a displacement of the member 5 with respect to the ferrule body 2.

This operation of thrusting the punch into one or more other radial holes 7 is repeated until the fibre is brought into a position perfectly centred with respect to the sphere.

It will be understood that although by putting into effect the method in accordance with the invention a good retention has been assured of the inner tubular member in the ferrule body, the nature of the matter employed for this retention enables, as has just been explained, subsequent micrometric adjustments.

The force necessary for carrying out these adjustments is independent of the geometric tolerances of manufacture of the components and depends mainly upon the hardness of the matter of the pieces employed, 9 or 10 respectively, as well as upon the shape of the punch 27, the end of which may be rounded as illustrated in Figure 5.

A division is thus ensured at a ratio which may lie between 2 and 5 between the displacement of the punch 27 and the displacement of the inner member 5. Thus for one and the same accuracy of positioning of the fibre, for example, of two micrometres, the accuracy of displacement of the punch will be from two to five times greater or from four to ten micrometres.

In Figure 6 a connector is illustrated which employs two male ferrules illustrated in Figures 7 and 8, which have been produced in the manner previously described, the characteristics of the connector being on the whole similar to those of the connector described in the patent application EP-A2-0063085.

The connector illustrated in Figure 6 comprises in a general way like that described in the previous patent application, two male ferrules 1 arranged in a restoring female connector 28.

The male ferrules are arranged in a longitudinal bore 29 in the female connector and they are locked by means of rings 30 the threads 31 on which cooperate with corresponding threads 32 at the ends of the female connector 28.

In the longitudinal bore 29 in the female connector in the central zone of the latter is put in place a sphere 33 equipped with an axial aperture 34 passing through it.

Each of the male ferrules exhibits as mentioned previously a body 2 which includes an axial hole 4 in which a tubular member 5 has been put in place as previously explained, the retention being effected by the plug of matter 14.

C L A I M S

1. A method of mechanical locking of an inner member into an outer body, which makes use of locking pieces introduced into radial holes in the outer body and bearing against the inner member, characterized by the fact that the inner member (5) is put in place in the outer body (2), that through one end of the said body a ring (12) is introduced to engage round the inner member, that in the radial holes (7) in the outer body deformable pieces (9, 10) of a soft metal are engaged and then the said pieces are compressed and deformed by engaging punches (11) in the radial holes (7) so as to fill the free space existing in the zone of the radial holes between the periphery of the inner member and the wall of the outer body facing it, the said ring being held in position during the phases of putting the deformable pieces (9, 10) in place and compressing them, the front face of the said ring effecting a bearing for the deformed matter (14).
2. A method as in Claim 1, characterized by the fact that the outer body (2) is tubular, the inner member (5) being introduced into an axial hole (4) in the said body.
3. A method as in either of the Claims 1 and 2, characterized by the fact that the inner member (5) is cylindrical.
4. A method as in Claim 3, characterized by the fact that the inner member (5) is tubular and includes an axial duct (6).
5. A method as in any one of the preceding Claims, characterized by the fact that the deformable pieces have the shape of balls (9).
6. A method as in any one of the Claims 1 to 4, characterized by the fact that the deformable pieces have the shape of cylinders (10).
7. A method as in any one of the preceding Claims, characterized by the fact that the said deformable pieces are produced from a soft metal such as lead, tin or a tin-lead alloy.



8. A method as in any one of the preceding Claims, characterized by the fact that beforehand on the periphery of the inner member in the zone of the radial holes at least one neck (8) is effected, and preferably two adjacent necks, of concave profile.
- 5 9. A method of production of a connector ferrule of the type which includes a ferrule body equipped with radial holes and an inner member suitable for receiving an optical fibre, characterized by the fact that after having put in place in the ferrule body an inner member (5) which includes an axial duct (6) one forms by putting into
10 effect the method as in any one of the preceding Claims, between the inner member and the ferrule body a plug of deformed matter (14) which ensures the retention of the inner member, that in the inner member (5) an optical fibre (15) is put in place, which preferably by gluing is fixed in the axial duct (6) in the said inner member, and that by
15 the action of punches (27) engaged in the radial holes (7) in the ferrule body (2), microdisplacements of the inner member with respect to the ferrule body are effected in order to centre the said inner member in the said ferrule body.