

Description

This invention relates to an optical fiber termination, a process of terminating an optical fiber and an apparatus for terminating an optical fiber.

Optical fibers made of such a material as quartz, multi-component glass or synthetic resins are known. Because of their generally very small diameter, they are susceptible to permanent deformation when under-going a force exerted in a direction at right angles to the fiber axis. For example, optical fibers made of quartz or multi-component glass are liable to break, and those made of synthetic resins are liable to bend or break, under such a force. Generally, the optical fibers are protected by flexible plastic primary coats to avoid permanent deformation (such as breaking or bending) during processing and handling or in the process of distribution to end users or to prevent them from becoming fragile upon being hydrolyzed by adhering water.

However, under conditions encountered in actual use where the optical fibers frequently undergo a relatively large external force, the above plastic primary coats are not so strong as to ensure accurate prevention of permanent deformation. Since such a plastic coat generally has a large clearance from the optical fiber, and a slip agent such as a silicone exists in the clearance, it cannot fix the optical fiber under a large force exerted in the axial direction of the fiber and permits the optical fiber to get out of place.

In protecting an optical fiber from a relatively large exterior force or fix it against an external force, it has been the previous practice to cover it with a ferrule. For example, an optical connector plug is produced by providing a ferrule having a passage formed by high-precision boring at its central part and an outer configuration conforming to the optical connector plug, inserting an optical fiber into the passage of the ferrule, and fixing it with an adhesive. The passage of the ferrule is bored with a high precision so that it conforms as much as possible to the outer configuration of the optical fiber. But for insertion of the optical fiber, the passage should be larger than the outside dimension of the optical fiber, and the use of an adhesive is essential to the fixation of the optical fiber.

The fixing of optical fibers in ferrules in the prior art has the drawback that the use of adhesives complicates the process steps, a long period of time is required for the solidation of the adhesives, and the yield of the product is poor.

JP-A-5255650 discloses an optical fiber connection in the form of a pipe having an additional rubbery elastic inner layer into which two fiber ends are inserted. The pipe is then crimped by two

opposing forces and then secured with adhesive, which requires time to cure. Use of this connector is not straightforward and not suitable for field use.

US-A-3768146 discloses a method of splicing optical fibers whereby a metallic sleeve is placed around the bare fiber ends to be joined. The sleeve is then crimped by means of a v-shaped groove co-acting with a hinged compression plate to mechanically secure the fibers. The crimping means causes three forces to act against the sleeve. The fiber ends are coated in glycerine to reduce transmission losses.

GB-A-1549928 discloses a complicated six-part arrangement for coupling fibers. The arrangement employs an outer sleeve having a mid-section of triangular cross-section and circular cross-section end pieces. Three metallic cylindrical rods are positioned within the triangular mid-section and frusto-conical plugs are placed at either end of the sleeve. Bare fiber ends are introduced and then force is applied to the mid-section to crimp the sleeve. This method is overly complicated for field use.

It is an object of this invention to provide an improved optical fiber termination, a process and an apparatus for the production of the same suitable for use anywhere.

According to a first aspect of this invention there is provided an optical fiber termination as defined in claim 1.

According to another aspect of the invention there is provided a process for terminating an end portion of an optical fiber with a termination member having a monolithic structure of plastically deformable material initially with a substantially cylindrical structure prior to deformation of predetermined length and an axial passage, comprising of the steps of:

inserting the end portion of the optical fiber through the axial passage of the termination member so that the termination member surrounds an outer peripheral surface of the optical fiber for a predetermined distance from its end; and

applying force against the outer periphery of said termination member at at least two separate peripheral locations disposed substantially symmetrically to each other with respect to the fiber axis, in a manner such that said force plastically deforms said termination member toward said optical fiber progressively only along a central portion of the predetermined distance so as to establish direct tight fitting contact between the central portion of the termination member and the fiber without additional bonding means while end portions of the termination member are substantially free of tight fitting contact with the fiber; wherein the deformation of said termination member crimps the fiber snugly with the central portion so that inner

curved surfaces of the passage make tight fitting contact with peripheral outer surface portions of said optical fiber along the central portion, said contacted peripheral outer surface portions of the optical fiber being disposed substantially symmetrical to each other with respect to the axis of the optical fiber and being separated from each other by minute spaces between the deformed termination member and the optical fiber, said spaces being disposed substantially symmetrically to each other with respect to the longitudinal axis of the fiber.

According to a further aspect of the invention, there is provided a portable manually-operable press bonding apparatus for terminating an end portion of an optical fiber with a termination member of monolithic structure of predetermined length formed of plastically deformable material initially having a substantially cylindrical shape prior to deformation with an axial passage through which the end portion of the optical fiber is inserted, said apparatus comprising a pressing member adapted to receive said termination member with the inserted end portion of said optical fiber, said pressing member having at least two pressing surfaces at least one of which is movable, said pressing surfaces being disposed substantially symmetrical to each other with respect to the axis of the optical fiber wherein said pressing surfaces are capable of applying force against the outer periphery of said termination member at at least said two separate peripheral locations in a manner so as to plastically deform the termination member progressively only along a central portion of the termination member so as to make tight fitting contact between the fiber and said the central portion, the end portions of the termination member remaining substantially non-deformed and the outer peripheral surface of the fiber being substantially free of tight fitting contact with the end portions of the termination member, the central portion of the termination member being crimped to the fiber snugly to make direct contact between curved surfaces of the passage and at least two separate peripheral portions of said optical fiber without additional bonding means such that the peripheral surface portions of said optical fiber are disposed substantially symmetrical to each other with respect to the fiber axis and are separated from one another by minute spaces thereby achieving the tight fitting contact between the central portion of said plastically deformed termination member and said peripheral outer surface portions of the optical fiber.

Further features and advantages of the invention will become apparent from the following description in conjunction with the accompanying drawings, wherein:

Figure 1 is a perspective view of one example of a pipe used as a termination member in this invention;

Figure 2 is a perspective view of one example of a rod used as a termination member in this invention;

Figure 3a is a schematic sectional view showing an optical fiber as it is inserted into a hollow axial passage formed in the pipe of Figure 1; Figure 3b is a schematic view for explaining the application of a force to a pipe in the state shown in Figure 3a in one embodiment of this invention;

Figures 3c, 3d and 3e are schematic sectional views of one embodiment of the optical fiber termination of this invention;

Figure 4a is a schematic view for explaining the application of a force to a pipe in the state shown in Figure 3a by a pressing surface having a groove in an embodiment different from that shown in Figure 3b;

Figure 4b is a schematic sectional view of the optical fiber termination of this invention obtained by the process shown in Figure 4a;

Figure 5a is a schematic view for explaining the application of a force to a pipe in the state shown in 3a in another embodiment of this invention;

Figures 5b, 5c and 5d are schematic sectional views of another embodiment of the optical fiber termination of this invention;

Figures 6a and 7a are respectively schematic view for explaining the application of a force to a pipe in the state shown in Figure 3a by different pressing members having four pressing surfaces;

Figures 6b and 7b are schematic sectional views of the optical fiber termination of this invention obtained by the processes shown in Figures 6a and 7a, respectively;

Figure 8 is a view showing the application of a force to a pipe in the state shown in Figure 3a by eight pressing surfaces;

Figure 9a is a sketch showing a pipe, and in contact with it, pressing surfaces having a gentle convex shape in the axial direction of the pipe;

Figure 9b is a schematic view for explaining the deformation of the pipe and its passage by causing the pressing surfaces to approach further from the state shown in Figure 9a;

Figure 10 is a schematic side elevation of another example of the rod used as a termination member in this invention;

Figure 11 is a top plan view showing one example of the press-bonding apparatus of this invention;

Figure 12 is a sketch showing a different mode of connection of the arms of the bonding ap-

paratus of the invention from that shown in Figure 11;

Figure 13 is an enlarged perspective view of an opening portion in the apparatus shown in Figure 11;

Figure 14 is a top plan view showing another example of the bonding apparatus of the invention;

Figure 15, 16 and 17 are sketches showing different component parts of the bonding apparatus shown in Figure 14;

Figure 18 is a sectional view of one example of an optical connector plug built by using the optical fiber termination of this invention; and

Figure 19 is a sectional view of the forward end portion of an optical connector plug built by using the optical fiber termination of this invention whose end is processed into a spherical shape.

An optical fiber termination of this invention can be produced by a first process of this invention which comprises inserting an optical fiber into at least one hollow or slit-like axial passage formed in a termination member in the form of a pipe or rod made of a plastically deformable material, and applying a force at least partly to facing peripheral surface portions of the pipe or rod wrapping the optical fiber in the meridian direction of a cross-section of the optical fiber and/or in a direction parallel to it, thereby tightly holding the optical fiber inserted in the hollow or slit-like passage.

An optical fiber termination of this invention can be produced by a second process of this invention which comprises inserting an optical fiber into at least one hollow or slit-like axial passage formed in a termination member in the form of a pipe or rod made of a plastically deformable material, and applying substantially equal forces directed toward the center of the pipe or rod to the peripheral surface of the pipe or rod in at least three sites on said peripheral surface in a cross-section taken at right angles to the longitudinal direction of the pipe or rod, thereby tightly holding the optical fiber inserted in the hollow or slit-like passage.

The pipe or rod having a passage for insertion of optical fibers is monolithic structure made of a plastically deformable material. The plastically deformable material is such that when a force is exerted on facing peripheral surfaces of the pipe or rod in accordance with the process of this invention, the aforesaid passage undergoes deformation and is kept deformed to an extent sufficient to hold the optical fiber tightly even after the applied force is removed. Examples of preferred plastically deformable materials are metals such as copper, zinc, lead and aluminum or alloys containing these metals (e.g., brass), and synthetic resins.

The pipe has at least one such hollow axial passage for insertion of an optical fiber, and the rod has at least one slit-like axial passage for insertion of an optical fiber. The outer shape of the pipe or rod may be any desired one, for example circular, elliptical or rectangular in sectional contour. The fiber inserting passage may be of any cross-sectional shape so long as it has a space for insertion or receiving of an optical fiber. For example, the hollow passage may have a circular, elliptical or rectangular cross-sectional shape, and the slit-like passage, a U-shaped cross-section.

Preferably, the pipe and rod have a circular or elliptical sectional contour; the hollow passage has a circular or elliptical cross section; and the slit-like axial passage has a U-shaped cross section. The hollow or slit-like axial passage for optical fiber insertion preferably has a smooth inside surface and extends smoothly toward its both ends in the longitudinal direction.

The wall thickness of the pipe or rod having an optical fiber insertion passage, which varies depending upon the material of which it is made, should be such that plastic deformation is generated in the passage when forces are applied to facing peripheral surfaces of the pipe or rod by the process of this invention. Specifically, the pipe or rod may have an average wall thickness (defined as a value obtained by subtracting the diameter of the contour, taken as circular, of the passage from the diameter of the contour, taken as circular, of the outside circumference) of about 0.1 mm to 2.5 mm. The pipe, in its section taken at right angled to its axial direction, may have a hollow passage having an average diameter of about 0.2 mm to about 4.8 mm, and the rod may have a slit width of, for example, about 0.03 mm to about 3 mm. The pipe and the rod may have a length of about 1 to about 100 mm.

The aforesaid average diameter means the diameter of the contour of the passage which is taken as a circular contour.

Since, according to the process of this invention, an optical fiber is first inserted into the hollow or slit-like passage of the pipe or rod described above, the passage can be formed to such a shape and size that the optical fiber can be inserted into it with ample allowance for subsequent deformation. This can minimize the occurrence of an accidental breakage to the delicate optical fiber during insertion.

Preferably, the average diameter of the hollow passage of the pipe or the maximum width of the slit of the slit-like passage of the rod is about 1.001 to 60 times the diameter of the optical fiber to be inserted into the passage.

In accordance with the invention, a force is then applied to the pipe or rod in which the optical

fiber is inserted. The force should be applied at least partly to peripheral surface portions of the pipe or rod wrapping the optical fiber which face each other in the meridian direction in a cross-section of the optical fiber or in a direction parallel to it. Alternatively, forces directed toward the central part of the pipe or rod should be applied at least partly to the peripheral surface of the pipe or rod in at least three sites of the peripheral surface of the pipe or rod in a section of the optical fiber taken perpendicularly to its longitudinal direction.

The first process of the invention will be described, and then the second process.

It should be understood that in the first process, the meridian direction in the cross-section of the optical fiber is a phantom line passing through the center of the cross-section of the optical fiber. Accordingly, when a force is applied to the pipe or rod in the meridian direction in the cross-section of the optical fiber, two substantially opposite forces of substantially the same magnitude are applied to the pipe or rod at two sites of its peripheral surface which are directed at substantially 180° to each other with respect to the axis of the optical fiber. When a force is applied to the pipe or rod in a direction parallel to the axis of the fiber, two quite oppositely directed forces of substantially the same magnitude are applied to the pipe or rod at two sites of its peripheral surface which are directed at substantially 180° to each other with respect to a direction not passing through the axis of the fiber but being parallel to the direction passing through the center of the section. Application of forces in the manner described above is crucial in the first process of this invention.

When forces are applied by the first process of this invention to the pipe or rod in which the optical fiber is inserted, the hollow or slit-like passage is deformed inwardly thereof in the directions in which the forces are applied, and the optical fiber inserted in the passage is held tightly. Deformation of the passage should be carried out at least until two facing inner surface portions of the passage in the meridian direction of the optical fiber make zonal contact with the outside surface of the optical fiber. The deformation may be continued further until facing inner surface portions of the passage in a direction parallel to the meridian direction make contact with each other.

In the second process of this invention, forces to be exerted to at least three sites should substantially be equal to each other.

The three or more sites on the peripheral surface of the pipe or rod on which such forces are exerted are substantially symmetrical to each other with respect to the axis of the pipe or rod in a section taken at right angles to the longitudinal direction of the pipe or rod. In one specific exam-

ple of such a relation, a polygon formed by connecting the three or more sites is a regular polygon. For example, sites forming a regular triangle are symmetrical with each other with respect to a 120° rotating axis, and four sites forming a square are symmetrical to each other with respect to a 90° rotating axis. It will be understood that likewise, sites forming a regular polygon with n sides are symmetrical to each other with respect to a $(360/n)$ degree rotating axis.

It can also be said that four or more even-numbered sites forming a polygon having even-numbered sides and a 180° rotating axis of symmetry, such as a rectangle and a hexagon, are also axially symmetrical.

When forces are exerted by the second process of this invention as described above on the pipe or rod having an optical fiber inserted in its passage, the hollow or slit-like passage is deformed inwardly thereof in the directions in which the forces are applied, and finally the inserted optical fiber is held tightly. Deformation of the passage is carried out at least until inside surface portions of the passage facing the optical fiber make zonal contact with the outside surface of the optical fiber. It can further be continued until the inside surface of the passage makes at least partial contact with itself.

In the first and second processes, the forces applied may be adjusted from about 10 to 8000 N/mm² (1 to 800 Kg/mm²) of that area of the peripheral surface of the pipe or rod which finally undergoes load, preferably about 100 to 5000 N/mm² (10 to 500 kg/mm²), and more preferably 500 to 3000 N/mm² (50 to 300 kg/mm²).

The forces are exerted partly over the axial length of the peripheral surface of the pipe or rod which wraps and faces the optical fiber. In other words, the peripheral surface of the pipe or rod is deformed partly over the axial length, over a central portion, by applying a force to its peripheral surface only at a central portion of its axial length.

According to the above method of deformation of only the central part or portion of the pipe or rod, the optical fiber can be positioned nearly at the central part between the non-deformed end portions of the pipe or rod (the central part of the passage in an axial section). Furthermore, according to the above method of applying a force to only a part of the pipe or rod the force can be intermittently exerted on the pipe or rod. In this case, therefore, a non-deformed site can be left which relaxes strain generated in the pipe or rod upon deformation. When the pipe or rod is relatively long, it is desirable to apply forces intermittently as stated above.

Forces upon at least a part of the peripheral surface of the pipe or rod can be exerted on the

pipe or rod either simultaneously or separately at different times. Specifically, the forces can be applied to the peripheral surface of the pipe or rod by bringing those sites of the pipe or rod to which forces are to be applied into contact with the pressing surfaces of a force exerting device either simultaneously or gradually, for example first at the central part of the pipe or rod and then gradually toward its end portions. Forces to be applied to the peripheral surface of the pipe or rod at least partly are preferably controlled such that a force upon the central part of its peripheral surface is exerted earlier than forces upon both end portions of the peripheral surface. As a result of this control, strain generated in the pipe or rod upon deformation can be directed from its central part toward its end portions, and the breaking of the optical fiber can be prevented. Hence, the process of the invention can be carried out advantageously.

In the process of this invention, that part of the optical fiber which projects slightly from one end portion of the pipe or rod before or after holding the optical fiber tightly by applying forces may be melted under heat to form a convex surface in that part of the optical fiber, for example a curved surface in the form of a convex lens, an ellipse or a sphere, at the end portion of the pipe or rod. This convex surface is like that of a liquid which is formed at the end of a capillary. The formation of the convex surface has the advantage that light can be transmitted or received effectively from the end portion of the optical fiber without polishing.

The first process can be easily performed by using a first pressing device or member having two pressing surfaces at least one of which is movable in the direction of an optical fiber or in a direction parallel to it. The first pressing device is adapted to apply forces at least partly to facing peripheral surface portions of a termination member, i.e. a pipe or rod, having a passage for insertion of the optical fiber therein in the axial direction of the optical fiber or a direction parallel to it and wrapping at least a part of the peripheral surface of the optical fiber along the axis of the optical fiber.

The second process can be easily performed by using a second pressing device or member having at least three pressing surfaces at least one of which is movable in a direction passing through the central part of an optical fiber. The second pressing device is adapted to apply forces at least partly to the peripheral surface of a termination member, i.e. a pipe or rod, having a passage for insertion of the optical fiber therein in the direction passing through the central part of the optical fiber and wrapping at least a part of the peripheral surface of the optical fiber along the axis of the optical fiber.

The first and second pressing devices will be described below.

The first pressing device has two pressing surfaces at least one of which is movable in such a manner that the two surfaces can approach one another.

The two pressing surfaces are movable so as to approach one another on a common phantom axis. These pressing surfaces have such a surface shape as to generate oppositely directed forces of substantially the same magnitude on facing peripheral surface portions of the pipe or rod when pressing these peripheral surface portions. For example, two flat pressing surfaces substantially normal with respect to the phantom axis, or two pressing surfaces having a narrow groove along the axis of the pipe or rod in flat surface shapes may be used as the pressing surfaces of the first pressing device. Investigations have shown that an especially preferred pressing surface is constructed such that the central portion, taken in the axial direction of the optical fiber, of that part of the pressing surface which is to make contact finally with the termination member can exert a force on the termination member earlier than the end portions of that part. In such an especially preferred pressing surface, the central portion of the part to be finally contacted with the termination member is gently curved, for example slightly bulged as compared with its end portions in a direction in which the pressing surface abuts against the termination member.

Thus, according to this invention, there is provided a first press-bonding apparatus for producing the first optical fiber termination comprising an optical fiber and a termination member having a passage for insertion of the optical fiber therein and wrapping at least a part of the peripheral surface of the optical fiber along the axis of the optical fiber, said apparatus comprising a pressing member having two pressing surfaces at least one of which is movable in the meridian direction of the optical fiber or a direction parallel thereto, said pressing member being capable of applying forces at least partly to facing peripheral surface portions of the termination member in said meridian direction or said parallel direction, each of the two pressing surfaces of the pressing member which are to abut against the termination member being constructed such that the central portion, taken in the axial direction of the optical fiber, of that part of each pressing surface which is to make contact finally with the termination member can apply a force to the termination member earlier than the end portions of that part.

As stated above, the second pressing device has at least three pressing surfaces at least one of which can move in a direction passing through the central part of the optical fiber.

The three or more pressing surfaces in the second pressing device can move toward the central part of the optical fiber so as to approach each other. Furthermore, they have such a surface shape that when they press the peripheral surface of the pipe or rod, forces of quite the same magnitude are generated on the peripheral surface. For example, at least three pressing surfaces having flat shapes substantially perpendicular to a phantom axis passing through the central part of the optical fiber, or at least three pressing surfaces having narrow grooves lying along the axial direction of the pipe or rod in a flat surface may be used as the pressing surfaces of the second pressing device. Investigations have shown that an especially preferred pressing surface is constructed such that the central portion, taken in the axial direction of the optical fiber, of that part of the pressing surface which is to make contact finally with the termination member can exert a force on the termination member earlier than the end portions of that part. In such a preferred pressing surface, the central portion of that part which is to make contact finally with the termination member is gently curved, for example slightly bulged as compared with its end portions in a direction in which the pressing surface abuts against the termination member.

Thus, there is provided a second press-bonding apparatus for producing the second optical fiber termination comprising an optical fiber and a termination member having a passage for insertion of the optical fiber therein and wrapping at least a part of the peripheral surface of the optical fiber along the axis of the optical fiber, said apparatus comprising a pressing member having at least three pressing surfaces at least one of which is movable in a direction passing through the central part of the optical fiber, said pressing member being capable of applying forces at least partly to the peripheral surface of the termination member in said direction passing through the central part of the optical fiber, each of said at least three pressing surfaces being constructed such that the central portion, taken in the axial direction of the optical fiber, of that part of each pressing surface which is to make contact finally with the termination member can exert a force on the termination member earlier than the end portions of that part.

It will be understood therefore that by using the first process and the first press-bonding apparatus, there is provided the first optical fiber termination of this invention comprising at least one optical fiber and a termination member wrapping at least a part of the peripheral surface of the optical fiber in the axial direction of the optical fiber, wherein in its section taken at right angles to the axis of the optical fiber, the termination member holds the

optical fiber tightly at its inside surface portions which face the optical fiber in the meridian direction of the optical fiber, and at least one of said inside surface portions of the termination member has at least a minute space between it and the peripheral surface of the optical fiber in the equatorial direction.

The first optical fiber termination of this invention is characterized by the structure of its section perpendicular to the axis of the optical fiber. In this cross-section, the inside surface portions of the termination member facing the optical fiber are in intimate tight fitting contact with the optical fiber in a meridian direction of the optical fiber, and in the equatorial direction (the direction passing through the center of the optical fiber), at least one of the inner surface portions of the termination member has at least a minute space between it and the peripheral surface of the optical fiber. In other words, in a cross section of the first optical fiber termination of this invention, the termination member has two surface portions in intimate contact with the optical fiber in a first direction passing through the center of the optical fiber and remaining surface portions not in contact with the optical fiber in a second perpendicular to direction the aforesaid direction. The first termination in accordance with this invention has a space in one radial direction and can be said to be characteristic in that the optical fiber is strongly and elastically wrapped by the wrapping material owing to the spring action of the inside surface portions of the termination member defining the space.

The number, size and shape of such spaces present in the direction perpendicular to surfaces in contact vary depending upon the material and type of the termination member, the shape of the passage in the termination member, and the degree of deformation of the passage. For example, the optical fiber termination of this invention may have two spaces of a substantially similar shape at opposite positions in the equatorial direction. One of the spaces may have a sectional area about 0.001 to about 150 times, preferably about 0.001 to about 75 times, more preferably about 0.1 to about 10 times, that of the optical fiber.

It will be likewise understood that according to this invention, by using the second process and the second press-bonding apparatus, there can be provided the second optical fiber termination of this invention comprising at least one optical fiber and a termination member wrapping at least a part of the peripheral surface of the optical fiber in the axial direction of the optical fiber, wherein its cross section taken perpendicular to the axis of the optical fiber, the termination member holds the optical fiber tightly in at least three sites of its inner circumferential surface facing the optical fiber.

A second termination in accordance with the invention is thus characterized by the structure of its cross section taken perpendicular to the axis of the optical fiber. In the aforesaid section, the inner circumferential surface of the termination member which faces the optical fiber is in intimate and tight contact with the optical fiber in at least three sites. In addition such a termination is also characterized by the fact that it has a plurality of pressed sites on its peripheral surface, and in its, cross-section taken perpendicular to the axis of the optical fiber, at least three minute spaces exist between the inner circumferential surface of the termination member and the peripheral surface of the optical fiber.

The number, size and shape of such spaces vary depending upon the material and type of the termination member, the shape of the axial passage in the termination member, the history of pressing, or the degree of deformation of the passage. For example, the second termination of this invention in the aforesaid section may have three spaces of a substantially similar shape at positions spaced from each other by an angle of about 120° or four spaces of a substantially similar shape at positions spaced from each other by an angle of about 90°. Each space may have a cross-sectional area not more than about 100 times, preferably not more than about 75 times, more preferably not more than about 10 times, that of the optical fiber.

The optical fiber terminations of this invention have termination members or wrapping materials which have various outside shapes or traces of pressing sites reflecting the surface structures of the pressing surfaces of the press-bonding apparatus. For example, the outside surface of a pressed site which faces the inner surface of the wrapping material which tightly holds the optical fiber is substantially flat at least partly along the axis of the optical fiber. Alternatively, it may consist of two substantially flat surfaces extending along the axial direction of the optical fiber and a raised surface located between the two flat surfaces and extending in the axial direction of the optical fiber.

The wrapping material tightly holds the optical fiber at the central part of the wrapping material along the axis of the optical fiber and releases the optical fiber from tight holding at both end portions of the wrapping material.

The wrapping material has an approximate length of, about 1 to about 100 mm in the axial direction of the optical fiber, and tightly holds the optical fiber over a length of about 1 to about 50 mm in the axial direction of the optical fiber.

In a termination of this invention, the distance between two ends radially facing each other may, for example, be about 0.25 mm to about 5 mm in cross-section taken perpendicular angles to the fiber axis. In another termination of this invention,

the maximum distance between two points where a phantom axis passing through the center of the optical fiber crosses the peripheral surface of the wrapping material in a section taken perpendicular to the axis of the optical fiber may, for example, be about 0.25 mm to about 5 mm.

In the present invention, the optical fiber is made of, for example, quartz, multi-component glass, or a synthetic polymer. Any optical fiber may be used irrespective of the material from which it is made. Optical fibers made of the multi-component glass are disclosed, for example, in Japanese Patent Publication No. 29524/1976 and Japanese Laid-Open Patent Publication No. 3352/1978, 3354/1978 and 60240/1978, and optical fibers made of synthetic polymers are disclosed, for example, in Japanese Laid-Open Patent Publication No. 103504/1980.

The optical fiber preferably used in this invention is composed of a core and a cladding and is substantially circular in a section taken at right angles to the fiber axis. It may have an outside diameter of, for example, about 50 to about 1,000 micrometers, preferably about 100 to about 600 micrometers.

The optical fiber termination of this invention may have the termination member or wrapping material in at least one end portion, and the optical fiber has a con-vex surface in the aforesaid at least one end portion. The con-vex surface is effective for efficient transmission and receiving of light by its lens effect.

Specific embodiments of the present invention will be described in greater detail with reference to the accompanying drawings.

Figures 1 and 2 respectively show an example of a pipe and a rod having an optical fiber insertion passage which is used in the first and second processes of this invention. Figure 1 shows a pipe 1 having a circular outer cross-sectional shape having one passage 2 with a circular section for insertion of an optical fiber. Figure 2 shows a rod 1' of a circular outer cross-sectional shape having one slit-like passage 2' with a U-shaped cross section. Other examples of the pipe and rod used in the processes of this invention will be easily understood from these examples taken in conjunction with the foregoing description.

Figure 3a shows an optical fiber 3 as it is inserted into the hollow passage 2 of the pipe 1 shown in Figure 1. The hollow passage 2 is shown to have a space between its inside surface and the peripheral surface of the optical fiber 3. Figure 3b is a schematic view showing the manner of applying a force to the pipe 1 in the state shown in Figure 3a in accordance with the first process of this invention. Figures 3c, 3d and 3e show the cross section of the first optical fiber termination of

this invention in various stages during the performance of the process of this invention. With reference to Figures 3a, 3b, 3c, 3d and 3e, the first process of this invention will be specifically described.

The pipe 1 having the optical fiber 3 inserted in the hollow passage 2 (Figure 3a) undergoes forces F and F' of quite the same magnitude directed in opposite directions in the meridian direction passing through the center of the optical fiber 3 (Figure 3b). Upon application of the forces F and F' sufficient to deform the pipe 1 plastically, the pipe 1 begins to be deformed, and as shown in Figure 3c, the inner surface 21 of the passage 2 comes into contact with the peripheral surface of the optical fiber 3 in the meridian direction of the optical fiber 3. As the application of forces is continued, its deformation proceeds as shown in Figures 3d and 3e, and the space formed in the equatorial direction between the inner surface 21 of the passage 2 and the peripheral surface 31 of the optical fiber 3 becomes smaller than that shown in Figure 3c. In the states shown in Figures 3c, 3d and 3e, the forces F and F' are applied by two substantially flat pressing surfaces (not shown), and the outside surface of the deformed pipe 1 in the meridian direction is substantially flat.

Figure 4a schematically illustrates pressing surfaces respectively having substantially flat lateral surface portions P_1 and P'_1 and centrally located curved surface portion P_2 and P'_2 extending tangentially of the pipe as they are in contact with the pipe 1 in the state shown in Figure 1. It will be seen that in this case, forces F and F' are first applied to the pipe 1 as forces f_1 and f_2 at sites t_1 and t_2 of contact between the pressing surfaces and the pipe 1 in a direction parallel to the meridian direction of the optical fiber. When the two pressing surfaces P_1 and P'_1 further move toward each other from the state shown in Figure 4a, the pipe 1 begins to be deformed, and in the same way as shown in Figure 3c, the inner surface of the passage 2 and the outside surface 31 of the optical fiber 3 contact in the meridian direction of the optical fiber 3. Finally, as shown in Figure 4b, there is obtained the first optical fiber termination of this invention provided in the meridian direction with an outside surface having flat portions 11 and a raised portion 12, which reflect the surface structure of the pressing surfaces $P_1(P'_1)$ and $P_2(P'_2)$, leaving minutes spaces in the equatorial direction.

The groove in the pressing surfaces shown in Figure 4a is semi-circular in its section taken at right angles to the axial direction, but may be in other shapes, for example, a shallow semicircular shape, a U-shape or a polygonal shape such as a triangular shape. The width of the groove in a direction at right angles to the axial direction (the

width of an open portion) is preferably larger than the diameter of the optical fiber.

Figure 5a illustrates the manner of applying forces to the pipe 1 in the state shown in Figure 3a from three directions spaced from each other by an angle of 120° in accordance with the second process of this invention. Figures 5b, 5c and 5d illustrate the section of the second optical fiber termination of this invention in a direction at right angles to the axial direction at various stages of performing the second process of this invention. The second process will now be specifically described with reference to Figures 5a, 5b, 5c and 5d.

A pipe 1 having an optical fiber 3 inserted in its hollow passage 2 undergoes forces F_1 , F'_1 and F''_1 of the same magnitude directed toward the central part of the optical fiber 3 from three sites of its peripheral surface (Figure 5a). Upon the application of forces F_1 , F'_1 and F''_1 which are large enough to deform the pipe 1 plastically, the pipe 1 begins to be deformed, and as shown in Figure 5b, the inner surface 21 of the passage 2 makes contact with the peripheral surface 31 of the optical fiber 3 at those parts of the inner surface 21 on which the forces are exerted. As the application of the forces continues, the deformation of the pipe proceeds to the state shown in Figure 5c and further to the state shown in Figure 5d, and the spaces formed between the peripheral surface 31 of the optical fiber 3 and the three sites of the inner surface 21 of the pipe passage which are spaced from each other by 120° become smaller than in the state shown in Figure 5b. The states shown in Figures 5b, 5c and 5d are produced by applying the forces F_1 , F'_1 and F''_1 by three substantially flat pressing surfaces, and the pressed sites of the outside surface of the deformed pipe 1 are substantially flat.

Figure 6a schematically shows substantially flat pressing surfaces P_1 , P_2 , P_3 and P_4 which are brought into contact with the pipe 1 in the state shown in Figure 3a in accordance with the second process of the present invention. It will be appreciated that in this case, the four forces are first applied to the pipe 1 from the contacting sites between the pressing surfaces and the pipe 1 toward the center of the optical fiber in four directions which are spaced from each other by 90° .

When the four pressing surfaces P_1 , P_2 , P_3 and P_4 move in the direction in which they approach each other further from the state shown in Figure 6a, the pipe 1 begins to be deformed, and in the same way as shown in Figure 5b, the inner surface 21 of the passage 2 comes into contact with the outside surface 31 of the optical fiber 3 in the meridian and equatorial directions of the optical fiber 3. Finally, as shown in Figure 6b, there is obtained the second optical fiber termination of this

invention having an outside surface with four flat pressed portions 11 and four raised portions 12 both extending in the axial direction and reflecting the surface structures of the four pressing surfaces P_1 , P_2 , P_3 and P_4 , leaving minute spaces between the pipe and the fiber in the two directions in which the forces have been applied.

Figure 7a shows four pressing members P_1 , P_2 , P_3 and P_4 each having an angled pressing surface P, P' which are in contact with the pipe 1 in the state shown in Figure 3a in accordance with the second process of this invention. In this case, a set of the pressing members P_1 and P_2 and a set of the pressing members P_3 and P_4 move in opposite directions relative to each other. Hence, the forces directed toward the center of the optical fiber are balanced between the vector component from the pressing member P_1 and the vector component from vector component from the pressing member P_4 and between the vector component from the pressing member P_2 and the vector component from the pressing member P_3 .

When the pressing members further move in such directions that the pressing members P_1 and P_2 approach the pressing members P_3 and P_4 , the pipe 1 begins to be deformed, and as shown in Figure 7b, for example, the inner surface 21 of the passage 2 is collapsed complexly as a whole. It will be easily understood that the product shows the pressed parts illustrated in Figure 7b.

Figure 8 shows the pressing of the pipe 1 in the state shown in Figure 3a by eight pressing surfaces of pressing members.

From Figures 5 to 8 and the foregoing description, one will be able to understand fully that an optical fiber is held tightly by pressing a pipe or rod having the optical fiber inserted in it with forces applied at three or more sites in accordance with the second process of this invention.

Figure 9a schematically shows pressing surfaces P_1 and P_1' having a gentle con-vox surface in the axial direction of the pipe 1 which is in contact with the central part of the pipe 1 in its axial direction. When the pressing surfaces P_1 and P_1' approach each other further from the state shown in Figure 9a, the pipe 1 and the passage 2 begin to be deformed at the central part of the pipe 1 in the axial direction and the deformation gradually proceeds towards the ends of the pipe.

It will be understood from the embodiment shown in Figures 9a and 9b that the forces on the central part, taken axially of the pipe or rod, of the peripheral surface of the pipe or rod in its axial direction are exerted earlier than the forces on the end portions of its peripheral surface. Such application forces may also be effected on a pipe or rod of the type shown in Figure 10 which has a larger outside diameter at its center than at its both end

portions.

Figure 11 and 13 show one example of the first press-bonding apparatus that can be used in this invention to press the pipe or rod constituting the wrapping material on an optical fiber. The apparatus is portable and manually-operated. A pair of handles 72 and 72' are connected pivotably to levers 73 and 73' by pins 81 and 81'. The levers 73 and 73' and the handles 72 and 72' connected by the pins 81 and 81' form a pair of arms. The handles 72 and 72' are connected to each other pivotably by a pin 80, and the levers 73 and 73' are connected to each other by a lever supporting member 74 and pins 82 and 82'. The levers 73 and 73' can pivot respectively on the pins 82 and 82'. As shown in Figure 12, the levers 73 and 73' may also be pivotably connected by providing linking portions 84 and 84' in the levers 73 and 73' and connecting them by a pin 85 at the linking portions instead of using the lever supporting member 74.

It will be appreciated therefore that an arm 71 comprised of the lever 73 and the handle 72 and an arm 71' comprised of the lever 73' and the handle 72' constitute a pair of arms.

A pressing member 75 is pivotably connected to one end of the lever 73 and one end of the lever 73' by pins 83 and 83' respectively. The pressing member 75 is comprised of base portions 90 and 90', pressing portions 91 and 91' fixed respectively to the base portions 90 and 90' and having pressing surfaces 92 and 92', and a guide member 93 cf. also Fig. 13. The member 93 has an opening 94 for supplying a pipe or rod having an optical fiber inserted in it between the pressing surfaces 92 and 92'. The guide member 93 may, for example, be a cylinder, in which case the pressing portions 91 and 91' may, for example, be pistons slidable longitudinally within the passage of the cylinder. The cylinder 93 may define the relative movement of the pistons 91 and 91' only on a common axis in slidable relation to both of the pistons 91 and 91', or in fixed relation to one of the pistons 91 and 91' and slidable relation to the other.

Figure 13 shows the opening 94 of Figure 11 in an enlarged perspective view. It will be understood from Figure 13 that the pressing surfaces 92 and 92' respectively have grooves 95 and 95', and the pipe or rod having the optical fiber inserted in it can be very easily positioned between the pressing surfaces 92 and 92' within the opening 94.

The press-bonding apparatus shown in Figure 11 can be operated by positioning the pipe or rod having the optical fiber inserted in it between the pressing surfaces 92 and 92' in the opening 94 and causing the handles to approach each other by, for example, grasping it. Approaching of the handles 72 and 72' to each other produces a pivoting motion. The pivoting motion is transmitted to the

levers 73 and 73' through the pins 81 and 81'. The levers 73 and 73' then pivot on the pins 82 and 82' and transmit their pivoting motion to the pressing member 75 through the pins 83 and 83' to cause the pressing surfaces 92 and 92' to approach each other. Consequently, the pipe or rod positioned between the pressing surfaces 92 and 92' is pressed by the pressing surfaces 92 and 92' in the meridian direction or a direction parallel to it in that section of the optical fiber in the pipe or rod which is taken at right angles to the fiber axis to produce the first optical fiber termination of this invention.

It will be understood that the first optical fiber termination of this invention having the cross-sectional shape shown in Figure 6b is obtained by using the first press-bonding apparatus of this invention having pressing surfaces 92 and 92' with the grooves 95 and 95'.

Figure 14 shows one example of a second portable manually-operated press-bonding apparatus which can be used in this invention to press the pipe or rod constituting the wrapping material on an optical fiber. Figures 15, 16, and 17 shows the component parts of the apparatus of Figure 14 in the disassembled state.

Figure 15 shows a pressing mechanism 173 formed as a unit with one handle 172 in a top plan view. The pressing mechanism 173 has guide grooves 175 receiving pressing members 174 and defining their moving direction. In the embodiment shown in Figure 15, four guide grooves 175 exist. It is sufficient, however, that at least three guide grooves 175 exist symmetrically with respect to a rotating axis.

Figure 16 shows a cam mechanism 176 formed as a unit with the other handle 172' in a top plan view. The cam mechanism 176 is provided with eccentric cams 177.

In Figure 15, the pressing members 174 are held within the guide grooves 175 to the wall of the pressing mechanism 173 by a spring, and adapted to return to predetermined positions after holding the optical fiber tightly.

The pressing mechanism 173 of Figure 15 and the cam mechanism 176 of Figure 16 are combined in the state shown in Figure 14, and the back of the cam mechanism 176 is covered with a closure member 180 having an opening 178 for insertion of the wrapping material on the optical fiber. Surface grooves 179 provided in the component parts are arranged in position and pins 181 are inserted into the grooves 179 to build the second press-bonding device or tool shown in Figure 14. The tool shown in Figure 14 is provided with a spring 182. According to the tool shown in Figure 14, the wrapping material having the optical fiber inserted in it is inserted into the pressing mechanism 173 and the cam mechanism 176

through the opening 178, and then the handles 172 and 172' are grasped so as to cause them to approach. As a result, the rotating motion of the cam mechanism 176 is converted to a motion tending in a direction in which the pressing members 174 approach each other in the guide grooves 175, and the wrapping material is pressed by pressing surfaces 174' of the pressing members 174 to give the second optical fiber termination of this invention.

In the optical fiber terminations of this invention, the optical fibers are held tightly by the termination member e.g. the pipe or rod by very simple means. Since in the optical fiber terminations of this invention, the optical fibers are protected accurately from forces which may be applied in the axial direction of the fibers and in a direction at right angles to the fiber axis, the application of optical fibers in various uses can be greatly extended. One example of application is illustrated in Figure 18 which shows the first or second optical fiber termination of this invention incorporated in an optical connector plug.

With reference to Figure 18, an optical connector plug 50 is provided with a ferrule 51 and a holder 52. The ferrule 51 is fabricated in a stepped hollow cylindrical shape and includes a large-diameter hole portion 51a adapted to receive the holder 52 in tight fit and a small-diameter hole portion 51b for insertion of the optical fiber termination of the invention. It also has at its end portion a hole 54 for insertion of an optical fiber 3. The optical fiber termination of this invention composed of the optical fiber 3 and the wrapping material 1 is fitted in the small-diameter hole portion 51b at a portion A where the optical fiber is tightly held by the wrapping material. That part of the optical fiber 3 which projects slightly from one end of the wrapping material 1 is inserted in the hole 54 of the end portion 53 of the ferrule 51.

The holder 52 has a nearly hollow-cylindrical shape and includes a large-diameter hole portion 52a for insertion of an optical fiber cable 33 (composed of the optical fiber 3 and a flexible coating 34 thereon) and a small-diameter hole portion 52b for receiving the end portion 10a of the wrapping material and fixing it there. The small-diameter hole portion 52b is of a stepped structure, and fixes the end portion 10a of the wrapping material by a step 52c.

The optical connector plug 50 of Figure 18 may be built by removing the flexible coating 34 from one end portion of the optical fiber cable 33 over a predetermined length, putting the large-diameter hole portion 52a of the holder 52 over the cable 33 in the manner shown in Figure 18, putting a pipe or rod (i.e., a wrapping material) having a fiber insertion passage over the uncovered optical

fiber 3, advancing the wrapping material until it abuts against the step 52c of the small-diameter hole portion 52b of the holder 52, thereafter pressing a portion having a length A of the wrapping material 1 by the process of this invention to hold the optical fiber tightly by the wrapping material, mounting a collar 55, a washer 56 and a cushion 57 on the holder 52, then applying the ferrule 51 until its large-diameter hole portion 51a is received tightly by the holder 52 and its small-diameter hole portion receives the wrapping material in tight fit, and finally polishing that end portion of the uncovered optical fiber which slightly projects from the nozzle 54 to form it into a mirror surface.

In another embodiment of the optical connector plug using the optical fiber termination of this invention, the end portion of the optical connector plug is formed, for example, as shown in Figure 19. In the embodiment of Figure 19, the end portion of the optical fiber 3 is processed into a spherical shape. The processing can be easily carried out by melting the end portion of the optical fiber. An optical fiber made from a multi-component glass can be very easily processed in this manner. An optical fiber termination of this invention having a spherical fiber end can advantageously minimize signal losses by the lens action of the spherical end.

Claims

1. An optical fiber termination composed of an optical fiber (3) and a termination member (1) of pre-determined length having an axial passage (2) in which the fiber is received; wherein the termination member is a monolithic structure formed from plastically deformable material initially of cylindrical shape prior to deformation, an end portion of the fiber is received in the passage to thereby surround an outer peripheral surface (31) of the fiber for said predetermined length and the termination member is plastically deformed progressively along a central portion of the pre-determined length to make tight fitting contact with the fiber directly without additional bonding means only over the central portion, the end portions of the termination member remaining substantially non-deformed and the outer peripheral surface of said optical fiber being substantially free of tight fitting contact with the end portions of the termination member, the fiber being crimped snugly by the central portion of the termination member so that inner curved surfaces (21) of the passage (3) make the tight fitting contact with outer peripheral surface portions of the fiber along the central portion of the termination member with the contacted pe-

ripheral outer surface portions of the optical fiber being disposed substantially symmetrical to one another with respect to the longitudinal axis of the optical fiber and being separated from one another by minute spaces which are also disposed symmetrical to one another with respect to the longitudinal axis of the optical fiber.

2. An optical fiber termination according to claim 1, wherein the deformed termination member contacts two separate peripheral outer surface portions of the end portion of the optical fiber which are disposed substantially symmetrical to each other with respect to the fiber axis, the mid-points of said contacted surface portions being about 180 degrees apart, said contact occurring along a meridian of a cross-section of the optical fiber, said contacted surface portions being separated by two spaces between the termination member and optical fiber located at opposite sides of the optical fiber in the equatorial direction of said cross-section of the optical fiber.
3. An optical fiber termination according to claim 1, wherein the deformed termination member contacts as least three separate peripheral outer surface portion of the end portion of the optical fiber, said contacted surface portions being substantially symmetrical to each other with respect to the fiber axis, the mid-points of said contacted surface portions being separated from the mid-points of adjacent contacted surface portions by substantially the same angular displacement about the fiber axis, said contacted surface portions being separated from each other by at least three spaces between the termination member and the optical fiber, said spaces being disposed substantially symmetrical to each other with respect to the fiber axis and separated by the same angular displacement as the mid-points of adjacent contacted surface portions.
4. An optical fiber termination according to claim 2, wherein said termination member has outer peripheral surface portions corresponding to the contacted surface portions of said optical fiber which are substantially flat in cross-section.
5. An optical fiber termination according to claim 4 wherein each of said flat outer surface portions of the termination member also has a raised central region which extends axially along at least the central portion of the length of said termination member.



fiber 3, advancing the wrapping material until it abuts against the step 52c of the small-diameter hole portion 52b of the holder 52, thereafter pressing a portion having a length A of the wrapping material 1 by the process of this invention to hold the optical fiber tightly by the wrapping material, mounting a collar 55, a washer 56 and a cushion 57 on the holder 52, then applying the ferrule 51 until its large-diameter hole portion 51a is received tightly by the holder 52 and its small-diameter portion receives the wrapping material in tight fit, and finally polishing that end portion of the uncovered optical fiber which slightly projects from the nozzle 54 to form it into a mirror surface.

In another embodiment of the optical connector plug using the optical fiber termination of this invention, the end portion of the optical connector plug is formed, for example, as shown in Figure 19. In the embodiment of Figure 19, the end portion of the optical fiber 3 is processed into a spherical shape. The processing can be easily carried out by melting the end portion of the optical fiber. An optical fiber made from a multi-component glass can be very easily processed in this manner. An optical fiber termination of this invention having a spherical fiber end can advantageously minimize signal losses by the lens action of the spherical end.

Claims

1. An optical fiber termination composed of an optical fiber (3) and a termination member (1) of pre-determined length having an axial passage (2) in which the fiber is received; wherein the termination member is a monolithic structure formed from plastically deformable material initially of cylindrical shape prior to deformation, an end portion of the fiber is received in the passage to thereby surround an outer peripheral surface (31) of the fiber for said predetermined length and the termination member is plastically deformed progressively along a central portion of the pre-determined length to make tight fitting contact with the fiber directly without additional bonding means only over the central portion, the end portions of the termination member remaining substantially non-deformed and the outer peripheral surface of said optical fiber being substantially free of tight fitting contact with the end portions of the termination member, the fiber being crimped snugly by the central portion of the termination member so that inner curved surfaces (21) of the passage (3) make the tight fitting contact with outer peripheral surface portions of the fiber along the central portion of the termination member with the contacted pe-

ripheral outer surface portions of the optical fiber being disposed substantially symmetrical to one another with respect to the longitudinal axis of the optical fiber and being separated from one another by minute spaces which are also disposed symmetrical to one another with respect to the longitudinal axis of the optical fiber.

2. An optical fiber termination according to claim 1, wherein the deformed termination member contacts two separate peripheral outer surface portions of the end portion of the optical fiber which are disposed substantially symmetrical to each other with respect to the fiber axis, the mid-points of said contacted surface portions being about 180 degrees apart, said contact occurring along a meridian of a cross-section of the optical fiber, said contacted surface portions being separated by two spaces between the termination member and optical fiber located at opposite sides of the optical fiber in the equatorial direction of said cross-section of the optical fiber.
3. An optical fiber termination according to claim 1, wherein the deformed termination member contacts as least three separate peripheral outer surface portion of the end portion of the optical fiber, said contacted surface portions being substantially symmetrical to each other with respect to the fiber axis, the mid-points of said contacted surface portions being separated from the mid-points of adjacent contacted surface portions by substantially the same angular displacement about the fiber axis, said contacted surface portions being separated from each other by at least three spaces between the termination member and the optical fiber, said spaces being disposed substantially symmetrical to each other with respect to the fiber axis and separated by the same angular displacement as the mid-points of adjacent contacted surface portions.
4. An optical fiber termination according to claim 2, wherein said termination member has outer peripheral surface portions corresponding to the contacted surface portions of said optical fiber which are substantially flat in cross-section.
5. An optical fiber termination according to claim 4 wherein each of said flat outer surface portions of the termination member also has a raised central region which extends axially along at least the central portion of the length of said termination member.



6. An optical fiber termination according to claim 3, wherein said termination member has an outer peripheral surface which is deformed inwardly at at least three locations corresponding to the contacted peripheral surface portions of said optical fiber, said inwardly deformed locations having the same symmetrical alignment about the fiber axis as said contacted surface portions.
7. An optical fiber termination according to claim 6, wherein said inwardly deformed locations extend along the central portion of the termination member.
8. An optical fiber termination according to claim 7, wherein said inwardly deformed locations are substantially L-shaped in cross-section.
9. An optical fiber termination according to claim 8, wherein said L-shaped locations extend as L-shaped grooves in the outer peripheral surface of the termination member along the central portion of the termination member.
10. An optical fiber termination according to claim 1, 2 or 3 wherein said termination member has an outer peripheral surface with n flat surfaces in cross-section (where $n > 1$) which are symmetrical to each other about the optical fiber axis with respect to a $360/n$ degree rotating axis.
11. An optical fiber termination according to any one of claims 1 to 10 wherein said central portion of the termination member is deformed progressively with the maximum deformation at the mid-point of the termination member length.
12. An optical fiber termination according to Claim 11 wherein said termination member has an outer diameter which at least initially is larger at the mid-point of the termination member length than at either end.
13. An optical fiber termination according to any one of Claims 1 to 12 wherein said plastically deformable material is a metal selected from the group of copper, zinc, lead, aluminium or alloys containing these metals, and wherein said optical fiber is made from quartz or multi-component glass and has a core and a cladding.
14. An optical fiber termination according to any one of Claim 1 to 12, wherein said plastically deformable material is a synthetic resin, and said optical fiber is made from quartz or multi-component glass and has a core and a cladding.
15. An optical fiber termination according to any one of Claims 1 to 14, wherein said end portion of the optical fiber has an end face formed as a curved surface.
16. A process for terminating an end portion of an optical fiber (3) with a termination member (1) of monolithic structure of predetermined length formed from a plastically deformable material having a substantially cylindrical shape initially prior to deformation with an axial passage (2), said process comprising the steps of:
 - inserting the end portion of said optical fiber through the axial passage of the termination member so as to surround an outer peripheral surface (31) of the optical fiber for a predetermined distance from its end and
 - applying force against the outer periphery of said termination member at at least two separate peripheral locations disposed substantially symmetrically to each other with respect to the fiber axis, in a manner such that said force plastically deforms said termination member toward said optical fiber progressively only along a central portion of the predetermined distance so as to establish direct tight fitting contact between the central portion of the termination member and the fiber without additional bonding means while end portions of the termination member are substantially free of tight fitting contact with the fiber; wherein the deformation of said termination member crimps the fiber snugly with the central portion so that inner curved surfaces of the passage make the tight fitting contact with peripheral outer surface portions of said optical fiber along the central portion, said contacted peripheral outer surface portions of the optical fiber being disposed substantially symmetrical to each other with respect to the axis of the optical fiber and being separated from each other by minute spaces between the deformed termination member and the optical fiber, said spaces being disposed substantially symmetrically to each other with respect to the longitudinal axis of the fiber.
17. A process according to claim 16, wherein said force is applied to each location so as to deform the termination member into contact with two separate peripheral outer surface portions of the end portion of the optical fiber which are disposed substantially symmetrical to each other with respect to the fiber axis, the



mid-points of said contacted surface portions being about 160 degrees apart, said contact occurring along a meridian of a cross-section of the optical fiber, said contacted surface portions being separated by two spaces between the termination member and optical fiber located at opposite sides of the optical fiber in the equatorial direction of said cross-section of the optical fiber.

18. A process according to claim 16 wherein said force is applied against the outer periphery of said termination member at at least three separate peripheral locations disposed substantially symmetrical to each other with respect to the fiber axis so as to deform the termination member into contact with at least three separate peripheral outer surface portions of the end portion of the optical fiber, said contacted surface portions being substantially symmetrical to each other with respect to the fiber axis, the mid-points of each of said contacted surface portions being separated from the mid-points of adjacent contact surface portions by substantially the same angular displacement about the fiber axis, said contacted surface portions being separated from each other by at least three spaces between the termination member and the optical fiber, said spaces being separated by the same angular displacement as the mid-points of adjacent contact surface portions.

19. A process according to claim 18, wherein said force applied to the termination member deforms its outer peripheral surface inwardly at at least the three locations corresponding to the contacted peripheral surface portions of said optical fiber, said inwardly deformed locations having the same symmetrical alignment about the fiber axis as said contact surface portions.

20. A process according to any one of claims 16 to 19, wherein the force is applied to deform said central portions progressively with the maximum deformation of the mid-point of the termination member length.

21. A process according to any one of claims 16 to 20 and further comprising the step of forming the end face of said end portion of the optical fiber into a curved surface such as a convex surface.

22. A process according to any one of claims 17 to 21 wherein said force applied to said termination member substantially flattens outer peripheral surface portions of said member in

cross-section in correspondence with the contacted surface portions of said optical fiber.

23. A Process according to claim 22, wherein said force forms a raised central region on each of said flat outer surface portions of the termination member, said raised central regions extending axially along the central portion of the length of said termination member.

24. A process according to claim 16 wherein n forces are applied to said termination member to deform its outer peripheral surface at n peripheral locations (where $n > 1$) which are symmetrical to each other about the optical fiber axis with respect to a $360/n$ degree rotating axis.

25. A process according to claim 24, wherein said deformed locations are substantially L-shaped in cross-section.

26. A manually-operable portable press bonding apparatus for terminating an end portion of an optical fiber (3) with a termination member (1) of monolithic structure of predetermined length formed of plastically deformable material initially having a substantially cylindrical shape prior to deformation with an axial passage (2) through which the end portion of the optical fiber is inserted, said apparatus comprising a pressing member (75) adapted to receive said termination member with the inserted end portion of said optical fiber, said pressing member having at least two pressing surfaces (92 92') at least one of which is movable, said pressing surfaces being disposed substantially symmetrical to each other with respect to the axis of the optical fiber wherein said pressing surfaces are capable of applying force against the outer periphery of said termination member at at least said two separate peripheral locations in a manner so as to plastically deform the termination member progressively only over a central portion of the termination member so as to make tight fitting contact between the fiber and said central portion, the end portions of the termination member remaining substantially non-deformed and the outer peripheral surface of the fiber being substantially free of tight fitting contact with the end portions of the termination member, the central portion of the termination member being crimped to the fiber snugly to make direct contact between curved surfaces of the passage and at least two separate peripheral portions of said optical fiber without additional bonding means such that the peripheral surface portions of said optical fiber



are disposed substantially symmetrical to each other with respect to the fiber axis and are separated from one another by minute spaces thereby achieving the tight fitting contact between the central portion of said plastically deformed termination member and said peripheral outer surface portions of the optical fiber.

27. Apparatus according to claim 26, wherein the pressing member has two pressing surfaces which apply force against the outer periphery of the central portion of the termination member so that when deformed, the termination member contacts two separate peripheral outer surface portions of the end portion of the optical fiber which are disposed substantially symmetrical to each other with respect to the fiber axis, the mid-points of said contacted surface portions being about 180 degrees apart, said contact occurring along a meridian direction of a cross-section of the optical fiber, said contacted surface portions being separated by two spaces between the termination member and the optical fiber located at opposite sides of the optical fiber in the equatorial direction of said cross-section of the optical fiber.

28. Apparatus according to claim 26, wherein the pressing member has at least three pressing surfaces which apply force against the outer periphery of the central portion of the termination member so that when deformed, the termination member contacts at least three separate peripheral outer surface portions of the end portion of the optical fiber which are substantially symmetrical to each other with respect to the fiber axis, the mid-point of each of said contacted surface portions being separated from the mid-points of adjacent contacted surface portions by substantially the same angular displacement about the fiber axis, said contacted surface portions being separated from each other by at least three spaces between the termination member and the optical fiber, said spaces being separated by the same angular displacement as the mid-points of adjacent contacted surface portions.

29. Apparatus according to claim 26, 27 or 28, wherein said pressing surfaces have a convex shape axially of the termination member so that said central portion is deformed progressively with a maximum deformation of the mid-point of the termination member length.

30. Apparatus according to claim 26, 27, 28, or 29 wherein said pressing surfaces are substan-

tially flat in cross-section relative to the termination member so that said termination member will have outer peripheral surface portions corresponding to the contacted surface portions of said optical fiber which are substantially flat in cross-section.

31. Apparatus according to claim 30 wherein said pressing surfaces are further shaped so that each of said flat outer surface portions of the termination member will have a raised central region which extends axially along at least the central portion of the length of said termination member.

32. Apparatus according to claim 28 wherein said pressing surfaces have a shape so that the outer peripheral surface of the termination member will be deformed inwardly at at least three locations corresponding to the contacted peripheral surface portions of said optical fiber, said inwardly deformed locations having the same symmetrical alignment about the fiber axis as said contacted surface portions.

33. Apparatus according to claim 26, wherein said pressing member has n pressing surfaces which apply force to said termination member to deform its outer peripheral surface at n peripheral locations (where $n > 1$) which are symmetrical to each other about the optical fiber axis with respect to a $360/n$ -degree rotating axis.

34. Apparatus according to claim 33 wherein said pressing surfaces are shaped so that said inwardly deformed locations are substantially L-shaped in cross-section.

Patentansprüche

1. Lichtleitfaseranschluß, umfassend eine Lichtleitfaser (3) und ein Anschlußteil (1) mit einer vorbestimmten Länge, welches einen axialen Durchgang (2) hat, in welchem die Faser aufgenommen ist; bei dem das Anschlußteil einen monolithischen Aufbau hat, welcher von einem plastisch verformbaren Material mit einer anfänglichen zylindrischen Gestalt vor der Verformung gebildet wird, ein Endteil der Faser in dem Durchgang aufgenommen ist, um hierdurch eine äußere Umfangsfläche (31) der Faser über das vorbestimmte Längsstück hinweg zu umgeben, und das Anschlußteil progressiv plastisch entlang eines Mittelteils des vorbestimmten Längsstückes derart verformbar ist, daß ein festsitzender Kontakt mit der Faser direkt ohne ein zusätzliches Bindemittel nur



über den Mittelteil hinweg hergestellt wird, die Endteile des Anschlußteils im wesentlichen unverformt bleiben und die äußere Umfangsfläche der Lichtleitfaser im wesentlichen frei von einem feststehenden Kontakt mit den Endteilen des Anschlußteiles ist, die Faser eng sitzend durch das Mittelteil des Anschlußteils derart gepreßt ist, daß die inneren, gekrümmten Flächen (21) des Durchgangs (3) den feststehenden Kontakt mit den äußeren Umfangsflächenteilen der Faser entlang des Mittelteils des Anschlußteils herstellen, wobei die kontaktierten, äußeren Umfangsflächenteile der Lichtleitfaser im wesentlichen symmetrisch zueinander bezüglich der Längsachse der Lichtleitfaser angeordnet sind und voneinander durch sehr kleine Zwischenräume getrennt sind, welche ebenfalls symmetrisch zueinander bezüglich der Längsachse der Lichtleitfaser angeordnet sind.

2. Lichtleitfaseranschluß nach Anspruch 1, bei dem das verformte Anschlußteil zwei gesonderte, äußere Umfangsflächenteile des Endteils der Lichtleitfaser kontaktiert, welche im wesentlichen symmetrisch zueinander bezüglich der Faserachse angeordnet sind, die Mittelpunkte der kontaktierten Flächenteile etwa in einem Winkelabstand von 180° angeordnet sind, der Kontakt entlang einer meridianen Linie eines Querschnitts der Lichtleitfaser auftritt, und die kontaktierten Flächenteile durch zwei Zwischenräume zwischen dem Anschlußteil und der Lichtleitfaser getrennt sind, welche auf gegenüberliegenden Seiten der Lichtleitfaser in Äquatorialrichtung des Querschnitts der Lichtleitfaser liegen.

3. Lichtleitfaseranschluß nach Anspruch 1, bei dem das verformte Anschlußteil wenigstens drei gesonderte, äußere Umfangsflächenteile des Endteils der Lichtleitfaser kontaktiert, die kontaktierten Flächenteile im wesentlichen symmetrisch zueinander bezüglich der Faserachse sind, die Mittelpunkte der kontaktierten Flächenteile von den Mittelpunkten benachbarter, kontaktierter Flächenteile im wesentlichen um den gleichen Winkelabstand um die Faserachse getrennt sind, die kontaktierten Flächenteile voneinander durch wenigstens drei Zwischenräume zwischen dem Anschlußteil und der Lichtleitfaser getrennt sind, die Räume im wesentlichen symmetrisch zueinander bezüglich der Faserachse angeordnet sind und um den gleichen Winkelabstand wie die Mittelpunkte benachbarter kontaktierter Flächenteile getrennt sind.

4. Lichtleitfaseranschluß nach Anspruch 2, bei dem das Anschlußteil äußere Umfangsflächenteile hat, welche den kontaktierten Flächenteilen der Lichtleitfaser entsprechen, welche im Querschnitt im wesentlichen eben ausgelegt sind.

5. Lichtleitfaseranschluß nach Anspruch 4, bei dem jedes der ebenen, äußeren Flächenteile des Anschlußteiles auch einen erhabenen Mittelbereich hat, welcher sich axial entlang wenigstens des Mittelteils der Längserstreckung des Anschlußteiles erstreckt.

6. Lichtleitfaseranschluß nach Anspruch 3, bei dem das Anschlußteil eine äußere Umfangsfläche hat, welche an wenigstens drei Stellen nach innen verformt ist, welche den kontaktierten Umfangsflächenteilen der Lichtleitfaser zugeordnet sind, und die nach innen verformten Stellen die gleiche symmetrische Ausrichtung um die Faserachse wie die kontaktierten Flächenteile haben.

7. Lichtleitfaseranschluß nach Anspruch 6, bei dem die nach innen verformten Stellen entlang des Mittelteils des Anschlußteils verlaufen.

8. Lichtleitfaseranschluß nach Anspruch 7, bei dem die nach innen verformten Stellen im Querschnitt im wesentlichen L-förmig ausgebildet sind.

9. Lichtleitfaseranschluß nach Anspruch 8, bei dem die L-förmigen Stellen als L-förmige Ausnehmungen in der äußeren Umfangsfläche des Anschlußteiles entlang des Mittelteils des Anschlußteiles verlaufen.

10. Lichtleitfaseranschluß nach Anspruch 1, 2 oder 3, bei dem das Anschlußteil eine äußere Umfangsfläche mit n ebenen Flächen im Querschnitt hat (wobei $n > 1$), welche symmetrisch zueinander um die Lichtleitfaserachse bezüglich einer $360/n$ Grad Rotationsachse angeordnet sind.

11. Lichtleitfaseranschluß nach einem der Ansprüche 1 bis 10, bei dem das Mittelteil des Anschlußteiles progressiv verformt ist, wobei die maximale Verformung am Mittelpunkt der Anschlußteillängserstreckung vorhanden ist.

12. Lichtleitfaseranschluß nach Anspruch 11, bei dem das Anschlußteil einen Außendurchmesser hat, welcher wenigstens zu Beginn größer als der Mittelpunkt der Anschlußteillängserstreckung am jeweiligen Ende ist.



13. Lichtleitfaseranschluß nach einem der Ansprüche 1 bis 12, bei dem das plastisch verformbare Material ein Metall ist, welches aus der Gruppe gewählt ist, die Kupfer, Zink, Blei, Aluminium oder diese Metalle enthaltende Legierungen umfaßt, und bei dem die Lichtleitfaser aus Quarz oder einem Vielkomponentenglas hergestellt ist und einen Kern und einen Mantel hat.

14. Lichtleitfaseranschluß nach einem der Ansprüche 1 bis 12, bei dem das plastisch verformbare Material ein Kunstharz ist, und die Lichtleitfaser aus Quarz oder einem Vielkomponentenglas hergestellt ist und einen Kern und einen Mantel hat.

15. Lichtleitfaseranschluß nach einem der Ansprüche 1 bis 14, bei dem das Endteil der Lichtleitfaser eine Endfläche hat, welche als eine gekrümmte Fläche ausgebildet ist.

16. Verfahren zum Anschließen eines Endteils einer Lichtleitfaser (3) an einem Anschlußteil (1) mit einer monolithischen Konstruktion und einer vorbestimmten Längserstreckung, welches aus einem plastisch verformbaren Material hergestellt ist, welches zu Beginn vor der Verformung eine im wesentlichen zylindrische Gestalt mit einem axialen Durchgang (2) hat, wobei das Verfahren die folgenden Schritte aufweist:

Einführen des Endteils der Lichtleitfaser durch den axialen Durchgang des Anschlußteiles derart, daß eine äußere Umfangsfläche (31) der Lichtleitfaser über einen vorbestimmten Abstand von ihrem Ende umgeben ist, und

Aufbringen einer Kraft gegen den äußeren Umfang des Anschlußteiles an wenigstens zwei gesonderten Umfangsstellen, welche im wesentlichen symmetrisch zueinander bezüglich der Faserachse derart angeordnet sind, daß die Kraft das Anschlußteil in Richtung auf die Lichtleitfaser progressiv nur entlang eines Mittelteils mit einer vorbestimmten Strecke derart verformt, daß ein direkter, festsitzender Kontakt zwischen dem Mittelteil des Anschlußteiles und der Faser ohne zusätzliche Bindemittel hergestellt wird, während die Endteile des Anschlußteiles im wesentlichen frei von einem festsitzenden Kontakt mit der Faser sind, bei dem die Verformung des Anschlußteiles die Faser eng anliegend an dem Mittelteil derart preßt, daß die inneren, gekrümmten Flächen des Durchgangs den festsitzenden Kontakt mit den äußeren Umfangsflächenteilen der Lichtleitfaser entlang des Mittelteils herstellen, die kontaktierten, äußeren Umfangsflächenteile der Lichtleit-

faser im wesentlichen symmetrisch zueinander bezüglich der Achse der Lichtleitfaser angeordnet sind und voneinander durch sehr kleine Zwischenräume zwischen dem verformten Anschlußteil und der Lichtleitfaser getrennt sind, und bei dem die Zwischenräume im wesentlichen symmetrisch zueinander bezüglich der Längsachse der Faser angeordnet sind.

17. Verfahren nach Anspruch 16, bei dem die Kraft auf jede Stelle derart aufgebracht wird, daß das Anschlußteil in Kontakt mit den beiden, gesonderten, äußeren Umfangsflächenteilen des Endteils der Lichtleitfaser verformt wird, welche im wesentlichen symmetrisch zueinander bezüglich der Faserachse angeordnet sind, die Mittelpunkte der kontaktierten Flächenteile einen Winkelabstand von etwa 180 Grad haben, der Kontakt entlang einer Meridianlinie eines Querschnitts der Lichtleitfaser auftritt, und die kontaktierten Flächenteile durch zwei Zwischenräume zwischen dem Anschlußteil und der Lichtleitfaser getrennt sind, welche auf gegenüberliegenden Seiten der Lichtleitfaser in Äquatorialrichtung des Querschnitts der Lichtleitfaser liegen.

18. Verfahren nach Anspruch 16, bei dem die Kraft gegen den äußeren Umfang des Anschlußteiles an wenigstens drei, gesonderten Umfangsstellen aufgebracht wird, die im wesentlichen symmetrisch zueinander bezüglich der Faserachse angeordnet sind, so daß das Anschlußteil in Kontakt mit wenigstens drei, gesonderten äußeren Umfangsflächenteilen des Endteils der Lichtleitfaser verformt wird, die kontaktierten Flächenteile im wesentlichen symmetrisch zueinander bezüglich der Faserachse sind, die Mittelpunkte jedes kontaktierten Flächenteils von den Mittelpunkten benachbarter kontaktierter Flächenteile im wesentlichen um den gleichen Winkelabstand um die Faserachse getrennt sind, die kontaktierten Flächenteile voneinander durch wenigstens drei Zwischenräume zwischen dem Anschlußteil und der Lichtleitfaser getrennt sind, und die Zwischenräume um den gleichen Winkelabstand wie die Mittelpunkte benachbarter Kontaktflächenteile getrennt sind.

19. Verfahren nach Anspruch 18, bei dem die auf das Anschlußteil aufgebrachte Kraft die äußere Umfangsfläche an wenigstens drei Stellen nach innen verformt, welche den kontaktierten Umfangsflächenteilen der Lichtleitfaser zugeordnet sind, und die nach innen verformten Stellen die gleiche symmetrische Ausrichtung um die Faserachse wie die Kontaktflächenteile



haben.

20. Verfahren nach einem der Ansprüche 16 bis 19, bei dem die Kraft aufgebracht wird, um die Mittelteile progressiv derart zu verformen, daß die maximale Verformung am Mittelpunkt der Anschlußteillängserstreckung auftritt.

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21. Verfahren nach einem der Ansprüche 16 bis 20, welches ferner den Schritt aufweist, gemäß dem die Endfläche des Endteils der Lichtleitfaser in Form einer gekrümmten Fläche ausgebildet ist, welche als eine konvexe Fläche ausgelegt ist.

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22. Verfahren nach einem der Ansprüche 17 bis 21, bei dem die auf das Anschlußteil aufgebrachte Kraft im wesentlichen die äußeren Umfangsteile des Teils im Querschnitt unter Zuordnung zu den kontaktierten Flächenteilen der Lichtleitfaser flach macht.

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23. Verfahren nach Anspruch 22, bei dem die Kraft einen erhabenen Mittelbereich auf jedem der ebenen, äußeren Flächenteile des Anschlußteiles bildet, und die erhabenen Mittelbereiche axial entlang des Mittelteils der Längserstreckung des Anschlußteils verlaufen.

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24. Verfahren nach Anspruch 16, bei dem n Kräfte auf das Anschlußteil aufgebracht werden, um die äußere Umfangsfläche an n Umfangsstellen (wobei $n > 1$) zu verformen, welche symmetrisch zueinander um die Lichtleitfaserachse bezüglich einer $360/n$ Grad Rotationsachse angeordnet sind.

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25. Verfahren nach Anspruch 24, bei dem die verformten Stellen im Querschnitt im wesentlichen L-förmig sind.

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26. Manuell-bedienbare, transportable Druckverbindungseinrichtung zum Anschließen eines Endteils einer Lichtleitfaser (3) an einem Anschlußteil (1) mit monolithischem Aufbau und vorbestimmter Länge, welches aus einem plastisch verformbaren Material ausgebildet ist, das zu Beginn eine im wesentlichen zylindrische Gestalt vor der Verformung und einen axialen Durchgang (2) hat, durch welchen das Endteil der Lichtleitfaser eingeführt wird, die Einrichtung ein Druckteil (75) hat, welches derart ausgelegt ist, daß es das Anschlußteil mit dem eingeführten Endteil der Lichtleitfaser aufnimmt, das Druckteil wenigstens zwei Druckflächen (92, 92') hat, von denen wenigstens eine beweglich ist, die Druckflächen im wesentlichen symmetrisch zueinander bezüglich der

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Achse der Lichtleitfaser angeordnet sind, bei der die Druckflächen die Fähigkeit haben, eine Kraft gegen den äußeren Umfang des Anschlußteiles an wenigstens zwei gesonderten Umfangsstellen derart aufzubringen, daß das Anschlußteil plastisch progressiv nur auf einem Mittelteil des Anschlußteiles derart verformt wird, daß ein festsitzender Kontakt zwischen der Faser und dem Mittelteil hergestellt wird, die Endteile des Anschlußteiles im wesentlichen unverformt bleiben und die äußere Umfangsfläche der Faser im wesentlichen frei von einem festsitzenden Kontakt mit den Endteilen des Anschlußteiles ist, das Mittelteil des Anschlußteiles engsitzend gegen die Faser gepreßt ist, um einen direkten Kontakt zwischen den gekrümmten Flächen des Durchgangs und wenigstens zwei gesonderten Umfangsstellen der Lichtleitfaser ohne zusätzliches Bindemittel derart herzustellen, daß die Umfangsflächenteile der Lichtleitfaser im wesentlichen symmetrisch zueinander bezüglich der Faserachse angeordnet sind und voneinander durch kleine Zwischenräume getrennt sind, wodurch ein festsitzender Kontakt zwischen dem Mittelteil des plastisch verformten Anschlußteils und den äußeren Umfangsflächenteilen der Lichtleitfaser hergestellt wird.

27. Einrichtung nach Anspruch 26, bei der das Druckteil zwei Druckflächen hat, welche eine Kraft auf den äußeren Umfang des Mittelteils des Anschlußteiles derart ausüben, daß bei der Verformung das Anschlußteil zwei gesonderte, äußere Umfangsflächenteile des Endteils der Lichtleitfaser berührt, welche im wesentlichen symmetrisch zueinander bezüglich der Faserachse angeordnet sind, die Mittelpunkte der kontaktierten Flächenteile in einem Winkelabstand um etwa 180 Grad angeordnet sind, der Kontakt entlang einer Meridianrichtung eines Querschnitts der Lichtleitfaser auftritt, und die kontaktierten Flächenteile durch zwei Zwischenräume zwischen dem Anschlußteil und der Lichtleitfaser getrennt sind, die auf gegenüberliegenden Seiten der Lichtleitfaser in Äquatorialrichtung des Querschnitts der Lichtleitfaser liegen.

28. Einrichtung nach Anspruch 26, bei der das Druckteil wenigstens drei Druckflächen hat, welche die Kraft gegen den äußeren Umfang des Mittelteils des Anschlußteiles derart aufbringen, daß bei der Verformung das Anschlußteil wenigstens drei, gesonderte, äußere Umfangsflächenteile des Endteils der Lichtleitfaser berührt, die im wesentlichen symmetrisch zueinander bezüglich der Faserachse liegen, der



Mittelpunkt jedes kontaktierten Flächenteils von den Mittelpunkten benachbarter, kontaktierter Flächenteile um im wesentlichen den gleichen Winkelabstand um die Faserachse getrennt ist, die kontaktierten Flächenteile voneinander durch wenigstens drei Zwischenräume zwischen dem Anschlußteil und der Lichtleitfaser getrennt sind, und die Zwischenräume um denselben Winkelabstand wie die Mittelpunkte benachbarter kontaktierter Flächenteile getrennt sind.

29. Einrichtung nach Anspruch 26, 27 oder 28, bei der die Druckflächen eine konvexe Gestalt in Achsrichtung des Anschlußteiles derart haben, daß das Mittelteil progressiv mit einer maximalen Verformung am Mittelpunkt der Anschlußteillängserstreckung verformt wird.
30. Einrichtung nach Anspruch 26, 27, 28 oder 29, bei der die Druckflächen im wesentlichen im Querschnitt eben relativ zu dem Anschlußteil derart sind, daß das Anschlußteil äußere Umfangsflächenteile hat, die den kontaktierten Flächenteilen der Lichtleitfaser zugeordnet sind, die im wesentlichen im Querschnitt ausgelegt sind.
31. Einrichtung nach Anspruch 30, bei der die Druckflächen ferner derart geformt sind, daß jedes ebene, äußere Flächenteil des Anschlußteiles einen erhabenen Mittelbereich hat, welcher in axialer Richtung entlang wenigstens des Mittelteils der Längserstreckung des Anschlußteiles verläuft.
32. Einrichtung nach Anspruch 28, bei der die Druckflächen eine derartige Gestalt haben, daß die äußere Umfangsfläche des Anschlußteiles nach innen an wenigstens drei Stellen verformt wird, die den kontaktierten Umfangsflächenteilen der Lichtleitfaser zugeordnet sind, und bei der die nach innen verformten Stellen die gleiche symmetrische Ausrichtung um die Faserachse wie die kontaktierten Flächenteile haben.
33. Einrichtung nach Anspruch 26, bei der das Druckteil n Druckflächen hat, welche die Kraft auf das Anschlußteil aufbringen, um die äußere Umfangsfläche an n-Umfangsstellen (wobei $n > 1$) zu verformen, welche symmetrisch zueinander um die Lichtleitfaserachse bezüglich einer 360 n/Grad Reaktionsachse angeordnet sind.
34. Einrichtung nach Anspruch 33, bei der die Druckflächen derart geformt sind, daß die nach innen verformten Stellen im wesentlichen L-

förmig im Querschnitt sind.

Revendications

1. Une terminaison pour fibres optiques composée d'une fibre optique (3) et d'un organe de terminaison (1) d'une longueur prédéterminée ayant un passage axial (2) pour recevoir la fibre; dans laquelle l'organe de terminaison est une structure monolithique formée d'un matériau déformable plastiquement et initialement d'une forme cylindrique avant sa déformation, et dans lequel une partie d'extrémité de la fibre est reçue dans le passage afin d'entourer une surface périphérique externe (31) de la fibre sur ladite longueur prédéterminée, l'organe de terminaison étant déformé progressivement et plastiquement le long d'une partie centrale de la longueur prédéterminée afin de venir en contact en adaptation serrée avec la fibre directement sans moyens de liaison supplémentaires et uniquement sur la partie centrale, les parties d'extrémité de l'organe de terminaison restant sensiblement sans déformation et la référence périphérique externe de ladite fibre optique étant sensiblement sans contact à adaptation serrée avec les parties d'extrémité de l'organe de terminaison, la fibre étant sertie avec un ajustage à frottement doux par la partie centrale de l'organe de terminaison de sorte que des surfaces incurvées internes (21) du passage (3) réalisent les contacts par ajustage serrée avec des parties de surface périphérique externe de la fibre le long de la partie centrale de l'organe de terminaison, les parties de surface périphériques externes qui sont en contact avec la fibre optique étant disposées sensiblement symétriquement l'une par rapport à l'autre par rapport à l'axe longitudinal des fibres optiques et étant séparées l'une de l'autre par des intervalles minimaux qui sont également disposés symétriquement l'un par rapport à l'autre par rapport à l'axe longitudinal de la fibre optique.
2. Une terminaison pour fibre optique selon la revendication 1, dans laquelle l'organe de terminaison, une fois déformé, vient en contact avec deux parties de surface externes périphériques différentes de la partie d'extrémité de la fibres optique, lesdites parties étant disposées sensiblement symétriquement l'une par rapport à l'autre par rapport à l'axe de la fibre, les parties centrales desdites parties de surface de contact étant séparées l'une de l'autre d'environ 180°, ledit contact se réalisant selon un méridien d'une section transversale de fibre optique, les parties de surface de contact étant



séparées par deux intervalles entre l'organe de terminaison et la fibre optique, les intervalles étant situés sur des côtés opposés de la fibre optique dans la direction équatoriale de ladite section latérale de fibre optique.

3. Une terminaison pour fibre optique selon la revendication 1, dans laquelle l'organe de terminaison, une fois déformé, vient en contact avec au moins trois parties de surface périphérique externe différentes de la partie d'extrémité de la fibre optique, lesdites parties de surface de contact étant sensiblement symétriques l'une par rapport à l'autre par rapport à l'axe de la fibre, les points centraux desdites parties de surface de contact étant séparés des points centraux de parties de surface de contact adjacentes de sensiblement la même séparation angulaire autour de l'axe de la fibre, lesdites parties de surface de contact étant séparées l'une de l'autre par au moins trois intervalles entre l'organe de terminaison et la fibre optique, lesdits intervalles étant disposés sensiblement symétriquement l'un par rapport à l'autre par rapport à l'axe de la fibre et étant séparés par la même séparation angulaire que les points centraux des parties de surface de contact adjacentes.
4. Une terminaison pour fibre optique selon la revendication 2, dans laquelle ledit organe de terminaison comporte des parties de surface périphérique externe qui correspondent aux parties de surface au contact de ladite fibre optique qui sont sensiblement planes en section transversale.
5. Une terminaison pour fibre optique selon la revendication 4, dans laquelle chacune desdites parties de surface externe plane de l'organe de terminaison comporte également une zone centrale surélevée qui s'étend axialement le long d'au moins la partie centrale de la longueur dudit organe de terminaison.
6. Une terminaison pour fibre optique selon la revendication 3, dans laquelle l'organe de terminaison comporte une surface périphérique externe qui est déformée vers l'intérieur en au moins trois positions correspondantes aux parties de surface périphérique au contact de ladite fibre optique, lesdites positions déformées vers l'intérieur ayant le même alignement symétrique autour de l'axe de la fibre que lesdites parties de surface de contact.
7. Une terminaison pour fibre optique selon la revendication 6, dans laquelle lesdites posi-

tions déformées vers l'intérieur s'étendent le long de la partie centrale de l'organe de terminaison.

8. Une terminaison pour fibre optique selon la revendication 7, dans laquelle lesdites positions déformées vers l'intérieur ont sensiblement la forme d'un L, en section transversale.
9. Une terminaison pour fibre optique selon la revendication 8, dans laquelle lesdites positions en forme de L s'étendent comme des rainures en forme de L dans la surface périphérique externe de l'organe de terminaison le long de la partie centrale de l'organe de terminaison.
10. Une terminaison pour fibre optique selon la revendication 1, 2 ou 3, dans laquelle ledit organe de terminaison comporte une surface périphérique externe ayant n surfaces qui sont planes en section transversale (avec $n > 1$) qui sont symétriques l'une par rapport à l'autre autour de l'axe de fibre optique par rapport à un axe de rotation de $360/n$ degrés.
11. Une terminaison pour fibre optique selon l'une quelconque des revendications 1 à 10, dans laquelle ladite partie centrale de l'organe de terminaison est déformée progressivement avec la déformation au point central de la longueur de l'organe de terminaison.
12. Une terminaison pour fibre optique selon la revendication 11, dans laquelle ledit organe de terminaison a un diamètre externe qui, au moins initialement, est plus important au point central de la longueur de l'organe de terminaison qu'à l'une quelconque de ses extrémités.
13. Une terminaison pour fibre optique selon l'une quelconque des revendications 1 à 12, dans laquelle ledit matériau déformable plastiquement est un métal sélectionné dans le groupe comprenant du cuivre, du zinc, du plomb, de l'aluminium ou des alliages qui contiennent des métaux, et dans lequel ladite fibre optique est réalisée en quartz ou en verre multi-composants et comporte un noyau et une gaine.
14. Une terminaison pour fibre optique selon l'une quelconque des revendications 1 à 12, dans laquelle ledit matériau déformable plastiquement est une résine synthétique, et ladite fibre optique est réalisée en quartz ou en verre multi-composants et comporte un noyau et une gaine.



15. Une terminaison pour fibre optique selon l'une quelconque des revendications 1 à 14, dans laquelle ladite part d'extrémité de la fibre optique comporte une face terminale en forme d'une surface incurvée.

16. Une méthode pour terminer une partie d'extrémité d'une fibre optique (3) au moyen d'un organe de terminaison (1) d'une structure monolithique et d'une longueur prédéterminée constitué d'un matériau plastiquement déformable et ayant initialement, avant sa déformation en une certaine longueur, une forme sensiblement cylindrique et ayant un passage axial (2), ledit procédé comprenant les étapes consistant à:

- insérer la partie d'extrémité de ladite fibre optique à travers le passage axial de l'organe de terminaison de sorte que le passage entoure une surface périphérique externe (31) de la fibre optique sur une distance prédéterminée à partir de son extrémité, et
- appliquer une force contre la périphérie externe dudit organe de terminaison à au moins deux positions périphériques séparées disposées sensiblement symétriquement l'une par rapport à l'autre par rapport à l'axe de la fibre de sorte que ladite force réalise une déformation plastique dudit organe de terminaison vers ladite fibre optique progressivement uniquement le long d'une partie centrale de ladite distance prédéterminée afin de réaliser un contact à ajustement serré direct entre la partie centrale de l'organe de terminaison et la fibre sans l'utilisation de moyens de liaison supplémentaires pendant que des parties d'extrémité de l'organe de terminaison ne présentent sensiblement aucun contact à ajustement serré avec la fibre;

dans lequel la déformation dudit organe de terminaison réalise un sertissage de la fibre à ajustage à contact doux avec la partie centrale de sorte que les surfaces incurvées vers l'intérieur du passage réalisent le contact à ajustement serré avec les parties de surface périphérique externe de ladite fibre optique le long de la partie centrale, lesdites parties de surface périphérique externe en contact avec la fibre optiques étant disposées sensiblement symétriquement l'une par rapport à l'autre par rapport à l'axe de la fibre optique et étant séparées l'une de l'autre par des intervalles minimaux entre l'organe de terminaison déformé et la fibre optique, lesdits intervalles étant disposés sensiblement symétriquement l'un

par rapport à l'autre par rapport à l'axe longitudinal de la fibre.

17. Un procédé selon la revendication 16, dans lequel ladite force est appliquée à chaque position afin de déformer l'organe de terminaison et de l'amener en contact avec deux parties de surface périphérique externe séparées de la partie d'extrémité de la fibre optique, lesdites positions étant disposées sensiblement symétriquement l'une par rapport à l'autre par rapport à l'axe de la fibre, les points centraux desdites parties de surface de contact étant séparés d'environ 180°, le contact se produisant le long d'un méridien d'une section transversale de fibre optique, lesdites parties de surface de contact étant séparées par deux intervalles entre l'organe de terminaison et la fibre optique, lesdits intervalles étant situés sur des côtés opposés de la fibre optique dans la direction équatoriale de ladite section transversale de fibre optique.

18. Un procédé selon la revendication 16, dans lequel ladite force est appliquée contre la périphérie externe dudit organe de terminaison en au moins trois positions périphériques séparées et disposées sensiblement symétriquement l'une par rapport à l'autre par rapport à l'axe de la fibre afin de déformer l'organe de terminaison et de l'amener en contact avec au moins trois parties de surface périphérique externe séparées de la partie d'extrémité de la fibre optique, lesdites parties de chacune desdites parties de surface de contact étant séparées des points centraux de parties de surface de contact adjacentes de sensiblement la même séparation angulaire autour de l'axe de fibre, lesdites parties de surface de contact étant séparées l'une de l'autre par au moins trois intervalles entre l'organe de terminaison et la fibre optique, lesdits intervalles étant séparés par la même séparation angulaire que les points centraux de parties de surface de contact adjacentes.

19. Un procédé selon la revendication 18, dans lequel ladite force appliquée à l'organe de terminaison réalise une déformation de sa surface périphérique vers l'intérieur à au moins trois positions correspondant aux parties de surface périphérique de contact avec ladite fibre optique, lesdites positions déformées vers l'intérieur ayant le même alignement symétrique autour de l'axe de fibre que les parties de surface de contact.



20. Un procédé selon l'une quelconque des revendications 16 à 19, dans lequel la force est appliquée afin de déformer lesdites parties centrales progressivement avec la déformation maximale au point central de la longueur de l'organe de terminaison. 5
21. Un procédé selon l'une quelconque des revendications 16 à 20, comprenant en outre l'étape de former la face d'extrémité de ladite partie d'extrémité de la fibre optique en une surface incurvée telle qu'une surface convexe. 10
22. Un procédé selon l'une quelconque des revendications 16 à 21, dans lequel ladite force appliquée audit organe de terminaison aplatit sensiblement des parties de surface périphérique externe dudit organe de terminaison, en section transversale, en correspondance avec des parties de surface au contact de ladite fibre optique. 15 20
23. Un procédé selon la revendication 22, dans lequel ladite force constitue une zone centrale surélevée sur chacune desdites parties de surface externe plane de l'organe de terminaison, lesdites zones centrales surélevées s'étendant axialement le long de la partie centrale de la longueur dudit organe de terminaison. 25 30
24. Un procédé selon la revendication 16, dans lequel on applique n forces audit organe de terminaison afin de déformer sa surface périphérique externe en n positions sur sa périphérie (où $n > 1$) qui sont symétriques l'une par rapport à l'autre autour de l'axe de la fibre optique par rapport à un axe de rotation de $360/n$ degrés. 35
25. Un procédé selon la revendication 24, dans lequel lesdites positions déformées ont une section transversale sensiblement en forme de L. 40
26. Un appareil de liaison par compression, portatif et à actionnement manuel, pour réaliser la terminaison d'une partie d'extrémité d'une fibre optique (3) au moyen d'un organe de terminaison (1) de structure monolithique et de longueur prédéterminée formé de matériau déformable plastiquement et ayant initialement, avant sa déformation, une forme sensiblement cylindrique et comportant un passage axial (2) à travers lequel la partie d'extrémité de la fibre optique est introduite, ledit appareil comprenant un organe d'application de pression (75) adapté pour recevoir ledit organe de terminaison avec la partie d'extrémité de ladite fibre 45 50 55
- optique introduite dans son passage, ledit organe d'application de pression ayant au moins deux surfaces d'application de pression (92, 92') dont au moins une est déplaçable, lesdites surfaces d'application de pression étant sensiblement symétriques l'une de l'autre par rapport à l'axe de la fibre optique, dans lequel lesdites surfaces d'application de pression sont capables d'appliquer une force contre la périphérie externe dudit organe de terminaison au moins auxdites deux positions périphériques séparées de telle manière que l'organe de terminaison subisse progressivement une déformation plastique uniquement sur une partie centrale de l'organe de terminaison de manière à faire un contact à ajustement serré entre la fibre et ladite partie centrale, les parties d'extrémité de l'organe de terminaison restant sensiblement sans déformation, et la surface périphérique externe de la fibre étant sensiblement sans contact à ajustement serré avec les parties d'extrémité de l'organe de terminaison, la partie centrale de l'organe de terminaison étant serti aux fibres avec un ajustement à contact doux afin de réaliser un contact direct entre des surfaces incurvées du passage et au moins deux parties périphériques séparées de ladite fibre optique sans moyens de liaison supplémentaires, de sorte que les parties de surface périphériques de ladite fibre sont exposées sensiblement symétriquement l'une de l'autre par rapport à l'axe de la fibre, et sont séparées l'une de l'autre par des intervalles minimaux réalisant ainsi le contact à ajustement serré entre la partie centrale dudit organe de terminaison déformé plastiquement et lesdites parties de surface périphérique externe de la fibre optique.
27. Un appareil selon la revendication 26, dans lequel l'organe d'application de pression comporte deux surfaces d'application de pression qui appliquent une force contre la périphérie externe de la partie centrale de l'organe de terminaison de sorte que, quand il est déformé, l'organe de terminaison vienne en contact avec deux parties de surface périphérique externe séparées de la partie d'extrémité de la fibre optique, lesdites parties de surface étant disposées sensiblement symétriquement l'une de l'autre par rapport à l'axe de la fibre, les points centraux desdites parties de surface de contact étant séparées d'environ 180° , ledit contact se réalisant le long d'une direction méridienne par rapport à une section transversale de la fibre optique, lesdites parties de surface de contact étant séparées par deux intervalles entre l'organe de terminaison et la



fibres optiques situées à des côtés opposés de la fibre optique dans la direction équatoriale de ladite section transversale de fibre optique.

28. Un appareil selon la revendication 26, dans lequel l'organe d'application de pression comporte au moins trois surfaces d'application de pression qui appliquent une force contre la périphérie externe de la partie centrale de l'organe de terminaison de sorte que, quand il est déformé, l'organe de terminaison vient en contact avec au moins trois parties de surface périphérique externe séparées de la partie d'extrémité de la fibre optique, lesdites parties de surface étant sensiblement symétriques l'une de l'autre par rapport à l'axe de la fibre, le point central de chacune desdites parties de surface de contact étant séparé des points centraux de parties de surface de contact adjacentes par sensiblement la même séparation angulaire autour de l'axe de la fibre, lesdites parties de surface de contact étant séparées l'une de l'autre par au moins trois intervalles entre l'organe de terminaison et la fibre optique, lesdits intervalles étant séparés par la même séparation angulaire que les points centraux des parties de surface de contact adjacentes.

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29. Un appareil selon la revendication 26, 27 ou 28, dans lequel lesdites surfaces d'application de pression ont une forme convexe dans le sens axial de l'organe de terminaison de sorte que ladite partie centrale se déforme progressivement avec une déformation maximale au point central de la longueur de l'organe de terminaison.

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30. Un appareil selon la revendication 26, 27, 28 ou 29, dans lequel lesdites surfaces d'application de pression sont sensiblement planes en section transversale relative à l'organe de terminaison, de sorte que ledit organe de terminaison reçoit des parties de surface périphérique externe, en correspondance avec les parties de surface au contact de ladite fibre optique, de forme sensiblement plane en section transversale.

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31. Un appareil selon la revendication 30, dans lequel lesdites surfaces d'application de pression sont conformées en outre de sorte que chacune desdites parties de surface externe plane de l'organe de terminaison reçoive une zone centrale surélevée qui s'étend axialement le long d'au moins la partie centrale de la longueur dudit organe de terminaison.

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32. Un appareil selon la revendication 28, dans lequel lesdites surfaces d'application de pression ont une forme telle que la surface périphérique externe de l'organe de terminaison sera déformée vers l'intérieur à au moins trois positions qui correspondent aux parties de surface périphérique au contact de ladite fibre optique, lesdites positions déformées vers l'intérieur ayant le même alignement symétrique autour de l'axe de la fibre optique que lesdites parties de surface de contact.

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33. Un appareil selon la revendication 26, dans lequel ledit organe d'application de pression comporte n surfaces d'application de pression qui sont susceptibles d'appliquer une force audit organe de terminaison afin de déformer sa surface périphérique externe en n positions périphériques (où $n > 1$) qui sont symétriques l'une par rapport à l'autre autour de l'axe de la fibre optique par rapport à un axe de rotation de $360/n$ degrés.

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34. Un appareil selon la revendication 33, dans lequel lesdites surfaces d'application de pression sont conformées de sorte que lesdites positions déformées vers l'intérieur ont sensiblement la forme d'un L, en section latérale.

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