

Description

BACKGROUND OF THE INVENTION

1. Technical Field

This invention relates to connectors for physically and optically connecting optical fibers to one another, and to coupling components each forming a part of such a connector or for coupling an optical fiber to another device.

2. Background Art

A known type of optical fiber connectors is termed expanded beam connectors, examples of which are described in European Patent Application Publication No. 100,921 and U.S. Patent No. 4,183,618. In such connectors the light beam emitted from a fiber end is expanded and collimated by a lens and directed at a component which receives the collimated, larger diameter beam and focusses it onto the end of another fiber. Because the beam is of relatively large diameter where it is transferred from one component to another, the task of alignment is reduced as compared to aligning the tiny light-conductive cores of two fibers. Thus, the optical loss in the connector may be reduced. However, even if the expanded beam principle is adopted, it is still important, for reduction of light loss in the connector, that the two components, namely the transmitting and receiving components, be accurately aligned so that the maximum possible amount of light emitted by one fiber end is focussed onto the other fiber end. The task of such alignment may be regarded as having two interrelated aspects, namely the need to gain parallelism of the axes of the transmitting and receiving components and the need to gain coincidence of the axes (i.e. the reduction to zero of the distance between the parallel axes). The former may be regarded as concerning control of the tilt of the axes and the latter may be regarded as concerning the lateral positioning of the axes.

The term parallel, or parallelism, has a dictionary definition of "continuously equidistant" and the distance is a finite value other than zero. As used herein in relation to axes it is intended to cover also the case in which the distance is zero.

U.S. Patent No. 4,421,383 describes an optical fiber connector for optically coupling two optical fibers together. The connector comprises two similar coupling components. One of said coupling components may be regarded as a device to which the other component couples an optical fiber. The device includes a cylindrical alignment surface and a forward plano surface. The coupling component includes lens means including a lens having forward and rearward surfaces and a circumferential surface extending between the forward and rearward surfaces. The forward surface of the lens has a convex portion, for refracting radiation, and an annular plano portion radially outwardly of the convex portion. The plane of the plano portion is perpendicular to a datum axis. The lens means has a cylindrical outer surface coaxial with the datum axis. There

are means for securing an optical fiber to the lens with the end of the fiber in contact with the rearward surface of the lens. Light emitted from the fiber is transmitted by the convex surface portion in a collimated beam of a width greater than the width of the fiber and with the axis of the collimated beam parallel to said datum axis. There is a sleeve member disposed about the cylindrical outer surface of the lens means.

The connector described in 4,421,383 has the disadvantage that the sleeve member, termed therein a union, has to perform many roles. It has to assist in the gaining of parallelism of the axes of the transmitting and receiving components. This it does by virtue of its elasticity and the line contacts between its lips and the rings on the lens means, i.e. the connectors as therein termed. The elasticity of the union draws the plano faces of the lens means into contact with one another. The sleeve member, i.e. the union, is solely responsible for the other aspect of alignment, i.e. the lateral positioning of the axes. The elasticity of the union and the line contacts of the lips and rings are disadvantageous to the accurate lateral positioning of the axes relative to one another. The sleeve member in U.S. 4,421,383 also has to perform the task of physically coupling the two conductors and hence may be subjected to tensile stress. Evidently, the connector described in U.S. 4,421,383 has disadvantages in that the axes of the two halves of the connector are not fixedly located laterally and hence signal loss may occur when the axes are laterally displaced as may occur when the union flexes. Also, the parallelism of the axes may be destroyed upon flexing of the union, which would allow the plano forward faces of the lens means to move out of parallelism.

Disclosure of the Invention

The present invention is defined in the claims and overcomes the disadvantages of the prior art by providing the sleeve member with first and second coaxial cylindrical surfaces. The first cylindrical surface of the sleeve member is an internal surface arranged to engage the cylindrical outer surface of the lens means. The axial length of the region of contact of the cylindrical outer surface of the lens means and the first cylindrical surface of the sleeve member is short. The cooperation of the sleeve member with the lens means locates said datum axis laterally within said sleeve member and the shortness of the axial length of contact of the surfaces allows small freedom of the datum axis to tilt relative to the sleeve member. Thus, the sleeve member does not influence the critically important parallelism of the axes, because the lens means can tilt, relative to the sleeve member, to achieve the optimum angular orientation (i.e. tilt) of the datum axis.

In a coupling embodying the present invention, parts of the optical aspect of the coupling are given some freedom for movement relative to those parts which perform the physical coupling of the conductors. In this way the optical parts

can, by mutual cooperation between themselves, in some of the alignment characteristics without constraint imposed by the rugged physical coupling parts, which constraint could adversely affect the gaining of those alignment characteristics. Because of the partial independence of the lenses to gain some aspects of alignment independently of the physical coupling components, tolerances in the manufacture of the physical coupling may be relaxed, with resultant economies in manufacturing costs.

This is achieved by letting the physical coupling parts participate in the location of the axes of the lenses laterally of the axes, but giving the lenses freedom to tilt relative to the physical coupling parts. Also, the lenses cooperate with one another so that parallelism of the axes of the lenses is gained by this cooperation relatively independently of the physical coupling components. Parallelism of the axes of the lenses is achieved by providing lenses each of which has forward and rearward surfaces and a circumferential surface extending between the forward and rearward surfaces. The forward surface includes a convex surface portion and radially outwardly thereof an annular plano surface portion the plane of which constitutes a datum plane. Spacer means, preferably in the form of three hard spheres having identical diameters, are placed between the annular plano surfaces of the two lenses and the lenses are resiliently biased towards one another. This achieves parallelism of the datum planes and parallelism of the datum axes, as herein defined. This parallelism can be achieved because the lenses have a small freedom to tilt relative to the physical coupling parts.

The term "datum axis" as herein used is defined as a) in the case of the convex surface being aspheric, the aspheric axis, b) in the case of the convex surface being spheric and the rearward surface having a plano operative portion, the line passing through the center of curvature of the spheric surface and perpendicular to the plane of the plano portion of the rearward surface, or c) in the case of the convex surface being spheric and the rearward surface having a curved operative portion, the line passing through the centers of curvature of the spheric surface portion of the forward surface and of the curved operative portion of the rearward surface.

In one embodiment of the present invention in the form of a connector, the lateral positioning of the datum axes, so that they are coincident, is achieved in a simple and effective manner by coaxial cooperating surfaces. The lens, or a ring member provided around the lens, has a cylindrical surface coaxial with the datum axis of the lens. This cylindrical surface cooperates with a cylindrical internal surface on a sleeve member which is part of the physical coupling. The sleeve member has an external cylindrical surface which is coaxial with its cylindrical internal surface. The two external cylindrical surfaces, one on each of the two sleeve members, cooperate with internal cylindrical surfaces of a single intermediary

member. The two internal cylindrical surfaces of the intermediary member are coaxial with one another. Thus, the axes of the cylindrical internal surfaces of the two sleeve members are coaxial in a complete coupling.

The cylindrical region of contact between the cylindrical surface of the lens, or the ring member around the lens, and the cylindrical internal surface of the sleeve member locates the lens, or lens and ring member, relative to the sleeve member laterally of the datum axis, by virtue of the contact. However, the axial extent of the cylindrical region of contact is short so as to allow the lens, or lens and ring member, to tilt by a small amount within the sleeve member, i.e., the datum axis has small freedom to tilt relative to the axes of the cylindrical surface of the sleeve member. In this way, an effective lateral location with freedom to tilt is achieved in a simple and effective manner.

The physical coupling is completed by two collar nuts, one cooperating with each of the sleeve members, and both threadedly engaged with the intermediary member. In this way, the two coupling components, including lens, sleeve member and collar nut, associated with the ends of conductors to be joined, are identical and can be joined by the intermediary member. This avoids problems encountered when non-identical, e.g. male and female, components are used, such as occur when it happens that two male or two female components have to be connected.

The resilient bias of the two lenses towards one another is achieved in a simple, convenient and economical manner by resilient O-rings acting between the sleeve member and the lens of each coupling component.

The association of a ring member with the lens has advantages in that the required cylindrical surface is more economically formable as part of a molding process forming the ring member, than it is to form it on the lens itself.

Conveniently, the spacer means in the form of hard spheres, between the annular plano surfaces of the lenses, are carried in a cage. In order to avoid adverse influence by the cage on the alignment of the lenses, the cage is formed from thin flexible plastic material as a continuous annulus with lobes carrying the spheres. The construction is such that while the spheres are constrained against movement relative to one another radially and circumferentially of the axis, the forces the cage exerts on the lenses through the spheres are negligible.

For best performance of the connector, the end of a fiber has to be accurately positioned relative to the convex surface of the lens. This accurate positioning, having been determined using test apparatus, is maintained by transparent cement having a refractive index corresponding to that of the lens.

Brief Description of the Drawings

A preferred embodiment of the present invention will now be described, by way of example,

with reference being made to the accompanying drawings in which:

Fig. 1 is an elevational view, partially broken away for the sake of understanding, of an optical fiber connector embodying the present invention;

Fig. 2 is a view similar to Fig. 1, but with parts of the connector spaced away from one another prior to effecting the connection of the optical fibers;

Fig. 3 is a perspective view of spacer means included in the connector illustrated in Figs. 1 and 2;

Fig. 4 is a partial section taken on line 4-4 in Fig. 2 showing keys and keyways; and

Fig. 5 is an enlarged section of a portion of the connector illustrated in Fig. 1.

Best Mode of Carrying out the Invention

The embodiment of the invention now to be described is a connector for coupling two optical fibers to one another. It comprises two similar coupling components and an intermediary member. For the purposes of understanding the invention in its broadest form, one of the coupling components may be regarded as a device to which an optical fiber is to be connected by the other coupling component.

Illustrated in Fig. 1 of the drawings is a connector 11 optically coupling two optic fiber conductors 13a, 13b. Each conductor 13a, 13b, comprises an optic fiber 15a, 15b surrounded by a buffer 17a, 17b in turn surrounded by a sheath 19a, 19b, in known manner. End portions of the fibers 15a, 15b are bared for connection.

The connector 11 comprises two identical coupling components 21a, 21b and an intermediary member 23. As the coupling components are identical a description of one will suffice.

The coupling component 21a includes lens means including a lens 25 formed of a refractive material, in the present embodiment, glass, and having a rearward surface, which is substantially plano in at least an operative central region 27, and a forward surface 29. The forward surface 29 has a convex surface portion 31 which in the present embodiment is spheric. In other embodiments the portion 31 is aspheric. Radially outwardly of the portion 31 a plano annular portion 33 to which the rearward plano surface region 27 is substantially parallel. The term "radially outwardly" is intended to describe distance from the axis and not relative positions along the axis. The plane of the plano annular portion 33 is termed the datum plane. A datum axis 34 in the present embodiment, in accordance with the definition given above, is the line passing through the center of curvature of the spheric surface and perpendicular to the plane of the plano central region 27 of the rearward surface. The datum axis and datum plane are perpendicular. A circumferential surface 35 extends between the forward and rearward surfaces and, in the present embodiment, is of generally circular cylindrical shape having an axis approximately coaxial with the datum axis 34. Abutting the rearward plano

surface region 27 of the lens 25 is a tubular element 37 formed, in the present embodiment, of glass transparent to ultraviolet light, and having an axial bore 39 in which is disposed a bared end portion of the fiber 15a. For the purpose of illustration, the bore 39 is shown with a diameter much greater than that of the fiber. This is not the case in reality. For example, the bore may have a 0.017 cm diameter and the fiber may have a 0.012 cm diameter. The end of the fiber is in contact with the lens. The end portion of the fiber, the tubular element 37 and the lens are bonded together by cement 40 having a refractive index matching that of the glass of the lens. The location of the end of the fiber relative to the convex surface portion 31 is such that light emitted from the fiber end is transmitted from the convex surface portion in a collimated beam having a diameter larger than that of the fiber and having its axis parallel to the datum axis. The technique for achieving this important condition involves moving the location of the end of the fiber, in contact with the lens, until a test apparatus shows that light emitted by the fiber end is transmitted by the convex surface portion as a collimated beam with the axis of the beam parallel to the datum axis. When this condition is achieved, ultraviolet light is applied to the uncured cement around the fiber end, the cement being of a type curable by ultraviolet light.

The forward surface of the lens has an anti-reflection coating.

The lens means also includes ring member 41 which is fixedly disposed around the circumferential surface of the lens and is secured to the lens so that relative movement of the ring member and the lens is prevented. The ring member is formed of plastics material and is molded in situ onto the lens. The ring member 41 has an outer surface 43 of circular cylindrical shape, the orientation of the axis of which is coaxial with the datum axis. Thus, whatever may be the shape of the circumferential surface 35 of the lens, the ring member 41 provides a surface, the surface 43, for the lens means which is cylindrical and coaxial with the datum axis.

The lens means, consisting of the lens 25 and the ring member 41, is disposed radially within a sleeve-like end portion 45 of a tubular member 47. The portion 45 has a circular cylindrical inner surface 49 which is in mating surface to surface engagement with the surface 43 of the ring member over a cylindrical region of short axial length. Movement of the ring member 41 out of the end portion 45 of the tubular member (to the right as seen in Fig. 1), is prevented by inwardly directed resiliently mounted teeth 51 on the tubular member.

The end portion 45 of the tubular member 47 has a circular cylindrical external surface 53 coaxial with its inner surface 49.

End portion 55 of the tubular member 47 remote from its end portion 45, is formed to allow physical connection between the tubular member 47 and the sheath 19a or 19b of the conductor. In

the present embodiment the physical connection is achieved by mastic 57, but it may also be achieved in other ways, for example, by a resilient or split collar compressible or deformable by a nut threadedly engaged with the tubular member.

The tubular member 47 has a forwardly facing annular recess 59 the bottom of which is formed by a forwardly facing annular shoulder 61. Disposed in the recess 59 is an O-ring 63 of resilient material. A rearwardly facing annular surface 65 on the ring member 41 faces the O-ring 63.

Each coupling component 21a, 21b also includes a collar nut 67 having a forwardly facing annular surface 69 engageable with a rearwardly facing annular surface 71 on the tubular member 47. The collar nut 67 has internal threads 73.

The two coupling components 21a, 21b are physically connected by the intermediary member 23 which has inner cylindrical surfaces 75 for mating telescopic engagement with the external surfaces 53 of the tubular members 47. The intermediary member 23 also has external threads 77 for cooperation with the internal threads 73 of the collar nuts 67.

The coupling components 21a, 21b can be drawn towards one another by rotation of the collar nuts 67 relative to the intermediary member 23 when the threads 73 and 77 are engaged with one another.

The outer surface 43 of the ring member 41 has a keyway 79 and the inner surface 49 of the tubular member 47 has a key 83 extending into the keyway 79, see Fig. 4. The external surface 53 of the tubular member 47 has a keyway 85 and the inner surface 75 of the intermediary member 23 has a key 89 extending into the keyway 85. The keys and keyways are axially extensive allowing relative axial movement of the ring member, tubular member and intermediary member, but are so formed as to prevent relative rotational movement about the datum axis, of the ring member, tubular member and intermediary member. Thus, the angular orientation of the fibers relative to one another is controlled once they have been cemented to their respective lens members.

The plano annular portions 33 of the forward surfaces of the lenses are held apart in parallel, spaced relationship (i.e., the datum planes are held parallel) by spacer means including three spheres 91 of incompressible material, in the present example, steel, having substantially identical diameters. The spheres 91 are retained in a cage 93 formed of thin flexible plastic material, and are in mutually spaced disposition about the datum axis. In the present embodiment they are at 120° to one another. The cage 93 includes a continuous annulus 96 and three lobes 95 extending radially inwards from, and integral with, the annulus. The external diameter of the annulus is such that the cage fits with minimal play within one of the cylindrical surfaces 75 of the intermediary member 23. The cage is located axially within the intermediary member 23 by abutting against an annular rib 94. The cage resists movement of the spheres radially relative to the datum axis and

circumferentially about the datum axis. However, the cage imposes minimal opposition to movement of the spheres axially, with respect to the remainder of the coupling, out of their positions when the cage is unflexed. The minimization of the axially directed forces applied by the cage on the spheres minimizes any influence the cage might have on one or the other (or both asymmetrically) of the lens means.

As described above, appropriate rotation of the collar nuts 67 draws the lens means towards one another. The approach of the lens means towards one another is terminated when the forward surfaces of the lenses contact all spheres. Further rotation of the collar nuts causes compression of the O-rings 63. Compression of the O-rings is limited by engagement of annular shoulders 97 on the tubular member 47 with end surfaces 99 of the intermediary member. Any further rotation of the collar nuts 67 after engagement of the shoulders 97 with the surfaces 99 serves to put the threads 73 and 77 under stress thereby locking the collar nuts 67 with the intermediary member 23 so that the connector does not unintentionally come apart.

The intermediary member 23 is, for the purpose of illustration, shown with an enlarged central portion 101. This central portion may take any convenient form such as a flange for mounting on a panel or for connection to flanges of other similar connectors. Also, it may be provided with a tool-engaging surface, such as a hexagonal surface for cooperation with a wrench, for example, for holding the intermediary member against rotation as the collar nuts 67 are tightened onto it.

It is stated above that the axial extent of the cylindrical region of contact of the outer surface 43 of the ring member 41 with the inner surface 49 of the tubular member is short. As an example, the aforesaid axial extent may be 0.050 to 0.075 cm in an embodiment in which the thickness of each lens is 0.5 cm, and the diameter of the cylindrical outer surface 43 of the ring member is 1 cm. The axial extent of the region of contact is short in order to minimize any influence which the tubular member might exert, through such contact, which might tend to destroy parallelism of the datum axes. The region of contact, with small axial extent, might be likened to a gimbal. Thus, the short axial extent of the region of contact allows small freedom of the datum axis to tilt relative to the sleeve member. The region of contact is, however, fully adequate for the lateral positioning of the datum axis to be determined by the tubular member.

The use of the steel spheres 91, often termed micro-spheres, to maintain the parallelism of the datum planes, with the lens means being resiliently biased towards one another by the compressed O-rings 63, has advantages because they are readily available with high accuracy of diameter at economical price.

The intermediary member and tubular members are molded from rigid plastics material.

The ring member 41 allows the creation of a desired cylindrical surface coaxial with the datum axis by molding techniques and does not require

the creation on the lens of a circumferential surface which both is accurately cylindrical and has an axis coaxial with the datum axis.

It will have been realized that parallelism of the datum planes is achieved by the spheres 91, the plano annular surface portions 33 and the resilient O-rings 63. Coincidence of the parallel datum axes is achieved by making the circular cylindrical surfaces 43, 49, 53, 75 coaxial.

In the embodiment described above, the cage 93 for the spheres 91 is an element separate from the intermediary member. However, the cage may be molded integrally with the intermediary member 23 and in such case the rib 94 would be omitted.

The invention has been described above in an embodiment which is a connector for optically coupling two optic fibers. A coupling component in accordance with the present invention may be used for optically coupling an optic fiber to another device, such as a terminal device, as well as to another fiber. In such an embodiment of the present invention in which a single coupling component, such as is described above, is used for coupling a fiber to another device, the coupling component would be physically connectible to the other device which would have a plano surface corresponding in function to the plano annular surface 33. Spacer means, such as spheres 91 and cage 93, would be interposed between the plano annular surface 33 of the coupling component and the corresponding plano surface of the device. The device would have a cylindrical surface, coaxial with a datum axis of the device, for direct or indirect cooperation with a cylindrical surface on the coupling component, such as surface 53. Preferably, the light source or receiver of the device would be mounted in the device in a manner similar to that in which the lens 25 and its ring member 41 is mounted in the tubular member as described above.

In the embodiment particularly described above with reference to the drawings, the two coupling components are both male and there is an intermediary member which is female at both ends. In another connector embodying the present invention, one coupling component may be male and the other may be female. In this case there need be no intermediary member. In order to achieve the necessary coaxial relationship of the two components in the assembled condition, the tubular member of the female would have a circular cylindrical internal surface, coaxial with the datum axis, which would extend forwardly and mate with the circular cylindrical external surface of the tubular member of the male component.

In the embodiments specifically described above, there are surfaces which are described as cylindrical internal surfaces. Those skilled in the art of molding plastic parts will readily recognize that the forming of such surfaces may be difficult. They will recognize that the effect of such surfaces may be created by a plurality of flat sur-

faces, tangential to the cylindrical surface desired. Accordingly, reference in the preceding description and ensuing claims to cylindrical surfaces is to be understood as including slightly conical (draft) surfaces, interrupted cylindrical surfaces and theoretical cylindrical surfaces defined by a plurality of other, e.g. flat, surfaces tangential to the theoretical cylindrical surface.

Industrial Applicability

The present invention finds application in connecting optical fibers to one another for transmission of optical signals from one to the other with low loss, and also for connecting an optical fiber to another device such as a transmitter or receiver for transmitting or receiving an optical signal into or from an optical fiber.

Claims

1. A coupling component for use in coupling an optical fiber to a device having a substantially cylindrical alignment surface (75) and a forward plane surface, said component comprising lens means (25, 41) including a lens (25) having forward and rearward surfaces (29, 27); said forward surface (29) of said lens (25) having a convex portion (31) and an annular plane portion (33) radially outwardly of the convex portion (31); means defining a datum axis (34), the plane of said annular plane portion (33) being perpendicular to said datum axis (34); said lens means (25, 41) having a substantially cylindrical outer surface (43) coaxial with said datum axis (34); means (40) for securing an optical fiber (15) to the lens (25) with the end of the fiber (15) in contact with said rearward surface (27) of the lens (25) such that light emitted from the fiber (15) is transmitted by the convex surface portion (31) in a collimated beam of a width greater than the width of the fiber (15) and with the axis of the collimated beam parallel to or colinear with said datum axis (34); and a sleeve member (45) disposed about the substantially cylindrical outer surface (43) of said lens means (25, 41), characterized in that the sleeve member (45) has first and second coaxial substantially cylindrical surfaces (49, 53), the first substantially cylindrical surface (49) of said sleeve member (45) being an internal surface and arranged to engage said substantially cylindrical outer surface (43) of said lens means (25, 41), the axial length of the region of contact of the substantially cylindrical outer surface (43) of said lens means (25, 41) and the first substantially cylindrical surface (49) of said sleeve member (45) being short, whereby the cooperation of the sleeve member (45) with the lens means (25, 41) locates said datum axis (34) laterally within said sleeve member (45) while allowing small freedom of the datum axis (34) to tilt relative to the sleeve member (45), the second substantially cylindrical surface (53) of the sleeve member (45) being for cooperation with the substantially cylindrical alignment surface (75) of the device.

2. A coupling component as claimed in claim 1,

the creation on the lens of a circumferential surface which both is accurately cylindrical and has an axis coaxial with the datum axis.

It will have been realized that parallelism of the datum planes is achieved by the spheres 91, the plano annular surface portions 33 and the resilient O-rings 63. Coincidence of the parallel datum axes is achieved by making the circular cylindrical surfaces 43, 49, 53, 75 coaxial.

In the embodiment described above, the cage 93 for the spheres 91 is an element separate from the intermediary member. However, the cage may be molded integrally with the intermediary member 23 and in such case the rib 94 would be omitted.

The invention has been described above in an embodiment which is a connector for optically coupling two optic fibers. A coupling component in accordance with the present invention may be used for optically coupling an optic fiber to another device, such as a terminal device, as well as to another fiber. In such an embodiment of the present invention in which a single coupling component, such as is described above, is used for coupling a fiber to another device, the coupling component would be physically connectible to the other device which would have a plano surface corresponding in function to the plano annular surface 33. Spacer means, such as spheres 91 and cage 93, would be interposed between the plano annular surface 33 of the coupling component and the corresponding plano surface of the device. The device would have a cylindrical surface, coaxial with a datum axis of the device, for direct or indirect cooperation with a cylindrical surface on the coupling component, such as surface 53. Preferably, the light source or receiver of the device would be mounted in the device in a manner similar to that in which the lens 25 and its ring member 41 is mounted in the tubular member as described above.

In the embodiment particularly described above with reference to the drawings, the two coupling components are both male and there is an intermediary member which is female at both ends. In another connector embodying the present invention, one coupling component may be male and the other may be female. In this case there need be no intermediary member. In order to achieve the necessary coaxial relationship of the two components in the assembled condition, the tubular member of the female would have a circular cylindrical internal surface, coaxial with the datum axis, which would extend forwardly and mate with the circular cylindrical external surface of the tubular member of the male component.

In the embodiments specifically described above, there are surfaces which are described as cylindrical internal surfaces. Those skilled in the art of molding plastic parts will readily recognize that the forming of such surfaces may be difficult. They will recognize that the effect of such surfaces may be created by a plurality of flat sur-

faces, tangential to the cylindrical surface desired. Accordingly, reference in the preceding description and ensuing claims to cylindrical surfaces is to be understood as including slightly conical (draft) surfaces, interrupted cylindrical surfaces and theoretical cylindrical surfaces defined by a plurality of other, e.g. flat, surfaces tangential to the theoretical cylindrical surface.

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The present invention finds application in connecting optical fibers to one another for transmission of optical signals from one to the other with low loss, and also for connecting an optical fiber to another device such as a transmitter or receiver for transmitting or receiving an optical signal into or from an optical fiber.

Claims

1. A coupling component for use in coupling an optical fiber to a device having a substantially cylindrical alignment surface (75) and a forward plane surface, said component comprising lens means (25, 41) including a lens (25) having forward and rearward surfaces (29, 27); said forward surface (29) of said lens (25) having a convex portion (31) and an annular plane portion (33) radially outwardly of the convex portion (31); means defining a datum axis (34), the plane of said annular plane portion (33) being perpendicular to said datum axis (34); said lens means (25, 41) having a substantially cylindrical outer surface (43) coaxial with said datum axis (34); means (40) for securing an optical fiber (15) to the lens (25) with the end of the fiber (15) in contact with said rearward surface (27) of the lens (25) such that light emitted from the fiber (15) is transmitted by the convex surface portion (31) in a collimated beam of a width greater than the width of the fiber (15) and with the axis of the collimated beam parallel to or colinear with said datum axis (34); and a sleeve member (45) disposed about the substantially cylindrical outer surface (43) of said lens means (25, 41), characterized in that the sleeve member (45) has first and second coaxial substantially cylindrical surfaces (49, 53), the first substantially cylindrical surface (49) of said sleeve member (45) being an internal surface and arranged to engage said substantially cylindrical outer surface (43) of said lens means (25, 41), the axial length of the region of contact of the substantially cylindrical outer surface (43) of said lens means (25, 41) and the first substantially cylindrical surface (49) of said sleeve member (45) being short, whereby the cooperation of the sleeve member (45) with the lens means (25, 41) locates said datum axis (34) laterally within said sleeve member (45) while allowing small freedom of the datum axis (34) to tilt relative to the sleeve member (45), the second substantially cylindrical surface (53) of the sleeve member (45) being for cooperation with the substantially cylindrical alignment surface (75) of the device.

2. A coupling component as claimed in claim 1,



characterized in that said lens means (25, 41) further includes a ring member (41) disposed about the circumferential surface of, and secured to, the lens (25), the said substantially cylindrical outer surface (43) of the lens means (25, 41) being a surface of the ring member (41).

3. A coupling component as claimed in claim 1 or 2, wherein the substantially cylindrical alignment surface (75) of said device is an internal substantially cylindrical surface (75) of an externally threaded (77) tubular portion (23) of the device; said coupling component being characterized in that the second coaxial substantially cylindrical surface (53) of the sleeve member (45) is an external substantially cylindrical surface; and that said coupling component further includes means (67) for securing the sleeve member (45) to said another device including a collar nut (67) cooperating with the sleeve member (45) and the externally threaded tubular portion (23).

4. A coupling component as claimed in any one of the preceding claims, characterized in that the sleeve member (45) has a forwardly facing annular shoulder (61), and that the lens means (25, 41) has a rearwardly facing annular shoulder (65) facing the annular shoulder (61) of the sleeve member (45), and that said coupling component further includes biasing means (63) for biasing the lens means (25, 41) forwardly relative to the sleeve member (45), including an O-ring (63) of resilient material disposed between the annular shoulders.

5. A coupling component as claimed in claim 1, 2, 3 or 4 characterized by further including three spheres (91) of incompressible material for location against the annular plane portion (33) of the forward surface of the lens (25) in mutually spaced disposition about the datum axis (34) and for cooperation with the forward plane surface (33) of said device.

6. A coupling component as claimed in claim 5, characterized by further including a cage (93) for said spheres (91), said cage (93) restraining the spheres (91) against movement radially and circumferentially of said datum axis (34) but imposing minimal restraint against movement parallel to said datum axis (34).

7. A connector for coupling two optical fibers including two coupling components (21) each as claimed in claim 1, 2 or 3 one of said components (21) constituting said device having a substantially cylindrical alignment surface and a forward plane surface, the forward plane surface being the annular plane portion (33) of the forward surface of the lens (25) of said component constituting said device, the substantially cylindrical alignment surface of said device being the second substantially cylindrical surface (49) of the sleeve member (45) of the coupling component constituting said device, characterized by an intermediary member (23) of tubular form having aligned substantially cylindrical surfaces (75) for cooperation with the second substantially cylindrical surfaces (53) of the sleeve members

(45) of the two coupling components, by connecting means (67, 77, 73) for connecting the sleeve members (45) to the intermediary member (23), by biasing means (63) for biasing the lens (25) of each component forwardly relative to its associated sleeve member (45) and by spacer means (91) for maintaining the planes of the annular plane portions (33) of the two lenses (25) parallel and spaced when the lens means (25, 41) are biased towards one another by the biasing means (63).

8. A connector as claimed in claim 7, characterized in that the spacer means (91, 93) includes three spheres of incompressible material disposed about the datum axis (34) to engage the annular plane portions (33) of the forward surfaces of the lenses (25).

9. A connector as claimed in claim 8, characterized in that the spacer means (91, 93) also includes a cage (93) for retaining said spheres (91) and opposing movement of the spheres (91) relative to one another and to the intermediary member (23) radially of the datum axes (34) and circumferentially of the datum axes (34), but imposing minimal opposition to movement relative to one another parallel to the datum axes (34).

10. A connector for coupling two optical fibers, the connector including two coupling components (21) and an intermediary member (23) of tubular form for connecting the two coupling components (21); each of said coupling components (21) including a lens (25) having forward and rearward surfaces (29, 27) and a circumferential surface between the forward and rearward surfaces, the forward surface (29) having a convex surface portion (31) and an annular plane portion (33) radially outwardly of the convex surface portion (31); and means defining a datum axis (34), the plane of said annular plane portion (33) being perpendicular to said datum axis (34) and constituting a datum plane; means (37, 40) for securing an optical fiber (15) to the rearward surface (27) of the lens (25) such that light emitted from the fiber (15) is transmitted by the convex surface portion (31) in a collimated beam of a width greater than the width of the fiber (15) and with its axis parallel to or colinear with said datum axis (34); characterized in that each coupling component (21) further includes a ring member (41) disposed about the circumferential surface of, and secured to, the lens (15) and having a substantially circular cylindrical outer surface (43) coaxial with the datum axis (34); a sleeve member (45) disposed about the substantially circular cylindrical outer surface (43) of the ring member (41) and having an inner substantially circular cylindrical surface (49) in contact with said substantially circular cylindrical outer surface (43) in a substantially cylindrical region of short axial length; biasing means (63) for biasing the lens (25) and ring member (41) forwardly relative to the sleeve member (45); connecting means (67, 73) for cooperation with said intermediary member (23) for connecting the component (21) to the intermediary member (23), in that said



intermediary member (23) has cooperating means (77) for cooperating with each of the connecting means (67, 73) of the two coupling components (21), and in that said intermediary member (23) further includes: spacer means (91, 93) for maintaining the two datum planes parallel and spaced when said lenses (25) are biased towards one another by said biasing means (63), said spacer means (91, 93) including three spheres (91) of incompressible material and a cage (93) for retaining said spheres (91) and opposing movement of the spheres (91) relative to one another and to the intermediary member (23) radially of said datum axes (34) and circumferentially of said datum axes, but imposing minimal opposition to movement relative to one another parallel to said datum axes (34), the cooperation of the intermediary member (23) with the two coupling components (21) and the contact between the sleeve members (45) and the ring members (41) serving to prevent movement of the two datum axes (34) relative to one another radially of the datum axes (34), the short axial length of the said substantially cylindrical region of contact of the said inner circular substantially cylindrical surface (49) of the sleeve member (45) with the substantially circular cylindrical outer surface (43) of the ring member (41) of each coupling component (21) allowing the lens (25) small freedom to tilt relative to the sleeve member (45).

Patentansprüche

1. Kupplungselement zum Verbinden eines optischen Wellenleiters mit einer Vorrichtung, die eine im wesentlichen zylindrische Zentrierfläche (75) und eine vordere plane Fläche aufweist, mit einer Linseneinrichtung (25, 41), deren Linse (25) eine vordere und eine hintere Fläche (29, 27) besitzt, wobei die vordere Fläche (29) der Linse (25) einen konvexen Bereich (31) und einen radial außerhalb des konvexen Bereichs (31) liegenden ringförmigen planen Bereich (33) aufweist, mit Mitteln, die eine Bezugsachse (34) bilden, zu der die Ebene des ringförmigen planen Bereichs (33) senkrecht verläuft, wobei die Linseneinrichtung (25, 41) eine im wesentlichen zylindrische, koaxial mit der Bezugsachse (34) verlaufende Außenfläche (43) besitzt, mit Mitteln (40), mit denen ein optischer Wellenleiter (15) so an der Linse (25) befestigt werden kann, daß das Ende des Wellenleiters (15) mit der hinteren Fläche (27) der Linse (25) derart in Berührung steht, daß von dem Wellenleiter (15) abgegebenes Licht über den konvexen Flächenbereich (31) in einem kollimierten Strahlenbündel übertragen wird, dessen Durchmesser größer ist als der des Wellenleiters (15) und dessen Achse parallel oder kollinear mit der Bezugsachse (34) verläuft, und mit einer Hülse (45), die um die im wesentlichen zylindrische Außenfläche (43) der Linseneinrichtung (25, 41) herum angeordnet ist, dadurch gekennzeichnet, daß die Hülse (45) eine erste und eine zweite im wesentlichen zylindrische Fläche (49, 53) aufweist, die koaxial zueinander verlaufen und von denen die erste im wesent-

lichen zylindrische Fläche (49) eine Innenfläche bildet und so angeordnet ist, daß sie mit der im wesentlichen zylindrischen Außenfläche (43) der Linseneinrichtung (25, 41) in Eingriff steht, wobei sich die im wesentlichen zylindrische Außenfläche (43) der Linseneinrichtung (25, 41) und die erste im wesentlichen zylindrische Fläche (49) der Hülse (45) in einem Bereich von geringer axialer Länge berühren, derart, daß durch das Zusammenwirken von Hülse (45) und Linseneinrichtung (25, 41) die Bezugsachse (34) seitlich innerhalb der Hülse (45) festgelegt ist, während die Bezugsachse (34) gleichzeitig ein geringes Maß an Spielraum besitzt, so daß sie relativ zu der Hülse (45) eine Kippbewegung ausführen kann, wobei die zweite im wesentlichen zylindrische Fläche (53) der Hülse (45) für ein Zusammenwirken mit der im wesentlichen zylindrischen Zentrierfläche (75) der Vorrichtung vorgesehen ist.

2. Kupplungselement nach Anspruch 1, dadurch gekennzeichnet, daß die Linseneinrichtung (25, 41) außerdem ein Ringelement (41) aufweist, das um die Umfangsfläche der Linse (25) herum angeordnet und an ihr befestigt ist, wobei die im wesentlichen zylindrische Außenfläche (43) der Linseneinrichtung (25, 41) eine Fläche des Ringelements (41) bildet.

3. Kupplungselement nach Anspruch 1 oder 2, bei dem die im wesentlichen zylindrische Zentrierfläche (75) der Vorrichtung eine im wesentlichen zylindrische Innenfläche (75) eines mit einem Außengewinde (77) versehenen rohrförmigen Teils (23) der Vorrichtung ist, dadurch gekennzeichnet, daß die zweite koaxial verlaufende, im wesentlichen zylindrische Fläche (53) der Hülse (45) eine im wesentlichen zylindrische Außenfläche ist und daß das Kupplungselement außerdem Mittel (67) zur Befestigung der Hülse (45) an der anderen Vorrichtung enthält, die eine Achsmutter (67) umfassen, die mit der Hülse (45) und dem ein Außengewinde aufweisenden rohrförmigen Teil (23) zusammenwirkt.

4. Kupplungselement nach einem der vorhergehenden Ansprüche, dadurch gekennzeichnet, daß die Hülse (45) einen nach vorne weisenden ringförmigen Ansatz (61) besitzt und daß die Linseneinrichtung (25, 41) einen nach hinten weisenden ringförmigen Ansatz (65) besitzt, der dem ringförmigen Ansatz (61) der Hülse (45) zugewandt ist, und daß das Kupplungselement außerdem Vorspannmittel (63) aufweist, mit denen die Linseneinrichtung (25, 41) nach vorne zur Hülse (45) hin vorgespannt ist und zu denen ein zwischen den ringförmigen Ansätzen liegender O-Ring (63) aus elastischem Material gehört.

5. Kupplungselement nach Anspruch 1, 2, 3 oder 4, dadurch gekennzeichnet, daß es drei Kugeln (91) aus nicht zusammendrückbarem Material enthält, die im Abstand voneinander um die Bezugsachse (34) herum angeordnet sind und an dem ringförmigen planen Bereich (33) der vorderen Fläche der Linse (25) anliegen und mit der vorderen planen Fläche (33) der Vorrichtung zusammenwirken.

6. Kupplungselement nach Anspruch 5, dadurch gekennzeichnet, daß es einen Käfig (93) für die



Kugeln (91) aufweist, der die Kugeln (91) an einer Bewegung in radialer Richtung und um die Bezugsebene (34) herum hindert, jedoch ihre Bewegung parallel zur Bezugsachse (34) nur geringfügig einschränkt.

7. Verbinder zum Verbinden zweier optischer Wellenleiter, mit zwei Kupplungselementen (21) gemäß Anspruch 1, 2 oder 3, von denen eines (21) die Vorrichtung mit einer im wesentlichen zylindrischen Zentrierfläche und einer vorderen planen Fläche bildet, die der ringförmige plane Bereich (33) der vorderen Fläche der Linse (25) des die Vorrichtung bildenden Elements ist, wobei die im wesentlichen zylindrische Zentrierfläche der Vorrichtung die zweite im wesentlichen zylindrische Fläche (49) der Hülse (45) des die Vorrichtung bildenden Kupplungselements ist, gekennzeichnet durch ein rohrförmiges Zwischenglied (23) mit zueinander ausgerichteten, im wesentlichen zylindrischen Flächen (75), die mit den zweiten im wesentlichen zylindrischen Flächen (53) der Hülsen (45) der beiden Kupplungselemente zusammenwirken, weiterhin gekennzeichnet durch Mittel (67, 77, 73) zum Verbinden der Hülsen (45) mit dem Zwischenglied (23), durch Vorspannmittel (63), mit denen die Linse (25) eines jeden Elements in Vorwärtsrichtung relativ zu der ihm zugeordneten Hülse (45) vorgespannt ist, und durch Abstandsmittel (91), durch welche die Ebenen der ringförmigen planen Bereiche (33) der beiden Linsen (25) parallel und im Abstand zueinander gehalten werden, wenn die Linseneinrichtungen (25, 41) durch die Vorspannmittel (63) zueinander hin vorgespannt sind.

8. Verbinder nach Anspruch 7, dadurch gekennzeichnet, daß die Abstandsmittel (91, 93) aus drei Kugeln aus nicht zusammendrückbarem Material bestehen, die so um die Bezugsachse (34) herum angeordnet sind, daß sie an den ringförmigen planen Bereichen (33) der vorderen Flächen der Linsen (25) angreifen.

9. Verbinder nach Anspruch 8, dadurch gekennzeichnet, daß die Abstandsmittel (91, 93) einen Käfig (93) besitzen, durch den die Kugeln (91) in ihrer Lage gehalten und an einer Bewegung relativ zueinander und zu dem Zwischenglied (23) radial zu den Bezugsachsen (34) und um die Bezugsachsen (34) herum gehindert werden, während ihre Bewegung relativ zueinander parallel zu den Bezugsachsen (34) nur minimal eingeschränkt ist.

10. Verbinder zum Verbinden zweier optischer Wellenleiter, mit zwei Kupplungselementen (21) und einem rohrförmigen Zwischenglied (23) zum Verbinden der beiden Kupplungselemente (21), von denen jedes (21) eine Linse (25) mit einer vorderen und einer hinteren Fläche (29, 27) und einer zwischen der vorderen und hinteren Fläche liegenden Umfangsfläche besitzt, wobei die vordere Fläche (29) einen konvexen Flächenbereich (31) und einen radial außerhalb des konvexen Flächenbereichs (31) befindlichen ringförmigen planen Flächenbereich (33) aufweist, und mit Mitteln, die eine Bezugsachse (34) bilden, wobei

die Ebene des ringförmigen planen Bereichs (33) senkrecht zu der Bezugsachse (34) verläuft und eine Bezugsebene bildet, mit Mitteln (37, 40), mit denen ein optischer Wellenleiter (15) an der hinteren Fläche (27) der Linse (25) so befestigt werden kann, daß von dem Wellenleiter (15) abgegebenes Licht über den konvexen Flächenbereich (31) in einem kollimierten Strahlenbündel übertragen wird, das einen größeren Durchmesser besitzt als der Wellenleiter (15) und dessen Achse parallel oder kollinear mit der Bezugsachse (34) verläuft, dadurch gekennzeichnet, daß jedes Kupplungselement (21) außerdem ein Ringelement (41) enthält, das um die Umfangsfläche der Linse (15) herum angeordnet und an dieser befestigt ist und eine im wesentlichen kreisförmige zylindrische Außenfläche (43) hat, die coaxial mit der Bezugsachse (34) verläuft, sowie eine Hülse (45), die um die im wesentlichen kreisförmige zylindrische Außenfläche (43) des Ringelements (41) herum angeordnet ist und eine im wesentlichen kreisförmige zylindrische Innenfläche (49) besitzt, die über einen im wesentlichen zylindrischen Bereich von geringer axialer Länge mit der im wesentlichen kreisförmigen zylindrischen Außenfläche (43) in Berührung steht, Vorspannmittel (63), mit denen die Linse (25) und das Ringelement (41) in Vorwärtsrichtung relativ zu der Hülse (45) vorgespannt sind, und Verbindungsmittel (67, 73); die im Zusammenwirken mit dem Zwischenglied (23) das Element (21) mit dem Zwischenglied (23) verbinden, daß das Zwischenglied (23) Mittel (77) aufweist, durch die es mit jedem der Verbindungsmittel (67, 73) der beiden Kupplungselemente (21) zusammenwirkt, und daß das Zwischenglied (23) weiterhin folgende Elemente aufweist: Abstandsmittel (91, 93), die die beiden Bezugsebenen parallel und im Abstand zueinander halten, wenn die Linsen (25) durch die Vorspannmittel (63) zueinander hin vorgespannt sind, und die drei Kugeln (91) aus nicht zusammendrückbarem Material sowie einen Käfig (93) umfassen, der die Kugeln (91) in ihrer Position hält und an einer Bewegung relativ zueinander und zu dem Zwischenglied (23) radial zu den Bezugsachsen (34) und um die Bezugsachsen herum hindert, jedoch ihre Bewegung relativ zueinander parallel zu den Bezugsachsen (34) nur geringfügig einschränkt, wobei das Zusammenwirken des Zwischenglieds (23) mit den beiden Kupplungselementen (21) und der Kontakt zwischen den Hülsen (45) und den Ringelementen (41) eine Bewegung der beiden Bezugsachsen (34) relativ zueinander in radialer Richtung verhindert und die geringe axiale Länge des im wesentlichen zylindrischen Kontaktbereichs der kreisförmigen im wesentlichen zylindrischen Innenfläche (49) der Hülse (45) mit der im wesentlichen kreisförmigen zylindrischen Außenfläche (43) des Ringelements (41) eines jeden Kupplungselements (21) der Linse (25) ein geringes Maß an Spielraum gewährt, so daß sie relativ zu der Hülse (45) eine Kippbewegung ausführen kann.



Revendications

Elément de couplage utilisable pour relier une fibre optique à un dispositif présentant une surface de guidage (75) pratiquement cylindrique et une surface avant plane, ledit élément comprenant une optique (25, 41) présentant une lentille (25) munie d'une surface arrière (27), et d'une surface avant (29) qui comporte, d'une part une zone convexe définissant un axe de référence (34) avec la surface arrière et, d'autre part une zone annulaire plane (33) entourant la zone convexe (31) et dont le plan est orthogonal à l'axe de référence (34) et une surface périphérique cylindrique (43) pratiquement coaxiale à l'axe (34), des moyens (40) pour fixer en contact l'extrémité d'une fibre optique (15) à la surface arrière (27) de la lentille (25) de manière que la lumière émise par la fibre (15) soit transmise par la zone convexe (31) sous la forme d'un pinceau collimaté dont la section droite est plus importante que celle de la fibre (15) et dont l'axe est confondu avec l'axe de référence (34) et un manchon (45) entourant la surface périphérique (43) de l'optique (25, 41), l'élément de couplage étant caractérisé en ce que le manchon (45) présente d'une part, une première surface (49) pratiquement cylindrique, intérieure et agencée pour coopérer avec la surface périphérique (43) de l'optique (25, 41) selon une région de contact dont la longueur suivant l'axe de référence (34) est petite afin que la coopération entre le manchon (45) et l'optique (25, 41) localise latéralement l'axe de référence (34) à l'intérieur du manchon (45) tout en permettant un léger basculement de l'axe de référence (34) par rapport au manchon (45) et d'autre part, une seconde surface (53) pratiquement cylindrique et coaxiale à ladite première surface et agencée pour coopérer avec la surface de guidage (75) du dispositif.

2. Elément de couplage conforme à la revendication 1, caractérisé en ce que l'optique (25, 41) présente une monture annulaire (41) solidaire de la lentille (25), entourant la surface périphérique de cette dernière et définissant ladite surface extérieure périphérique (43) pratiquement cylindrique de l'optique (25, 41).

3. Elément de couplage conforme à l'une quelconque des revendications 1 ou 2, dans lequel la surface de guidage (75) pratiquement cylindrique du dispositif est constituée par la surface intérieure pratiquement cylindrique (75) d'une portion tubulaire (23) filetée (77) extérieurement du dispositif; élément caractérisé en ce que la seconde surface (53) pratiquement cylindrique du manchon (45) est une surface extérieure pratiquement cylindrique et en ce qu'il comprend aussi un organe (67) qui permet de fixer le manchon (45) au dispositif et qui comporte un écrou coopérant avec l'organe et le filetage extérieur (77) de la portion tubulaire (23).

4. Elément de couplage conforme à l'une quelconque des revendications précédentes, caractérisé en ce que le manchon (45) présente un épaulement annulaire (61) dirigé vers l'avant, en ce que l'optique (25, 41) présente un épaulement

annulaire (65) dirigé vers l'arrière et situé en regard de l'épaulement annulaire (61) du manchon (45), et en ce que l'élément comprend, en plus, des moyens de sollicitation (63) qui sollicitent l'optique (25, 41) vers l'avant par rapport au manchon (45), et qui sont constitués par au moins un joint (63) torique en matériau élastique situés entre lesdits épaulements.

5. Elément de couplage conforme à l'une quelconque des revendications 1 à 4, caractérisé en ce qu'il comprend trois sphères (91) en matériau incompressible agencées pour venir coopérer avec la zone annulaire plane (33) de la surface avant de la lentille (25) et disposées de manière espacée autour de l'axe de référence (34).

6. Elément de couplage conforme à la revendication 5, caractérisé en ce que les sphères (91) sont maintenues en position radiale et angulaire par rapport à l'axe de référence (34) par une cage (93) qui n'impose que des contraintes minimales suivant la direction parallèle à l'axe de référence (34).

7. Connecteur pour relier deux fibres optiques terminées chacune par un élément de couplage conforme à l'une quelconque des revendications 1 à 3, l'un des éléments (21) constituant le dispositif présentant une surface de guidage pratiquement cylindrique et surface avant plane, la surface avant plane étant délimitée par la zone annulaire (33) plane de la surface avant de la lentille (25) de l'élément constituant le dispositif, la surface de guidage pratiquement cylindrique étant formée par la seconde surface (49) pratiquement cylindrique du manchon (45) de l'élément de couplage constituant le dispositif connecteur caractérisé en ce qu'il comprend un composant intermédiaire (23) de forme tubulaire présentant des surfaces de guidage (75) pratiquement cylindriques destinées à coopérer avec la seconde surface (53) pratiquement cylindrique des manchons (45) des deux éléments de couplage, des moyens (67, 77, 73) pour relier les manchons (45) au composant intermédiaire (23), des moyens de sollicitation (63) pour solliciter la lentille (25) de chaque élément vers la face avant de son manchon (45) respectif et des moyens de séparation (91) pour maintenir les plans des zones annulaires planes (33) des lentilles (25) espacés et parallèles entre eux lorsque les optiques (25, 41) sont sollicitées l'une vers l'autre par les moyens de sollicitation (63).

8. Connecteur conforme à la revendication 8, caractérisé en ce que les moyens de séparation (91, 93) comportent trois sphères en matériau incompressible, disposées autour de l'axe de référence (34) de manière à venir au contact des zones annulaires planes (33) des surfaces avant des lentilles (25).

9. Connecteur conforme à la revendication 8, caractérisé en ce que les moyens de séparation (91, 93) comprennent une cage (93) pour retenir les sphères (91) et empêcher le déplacement des sphères (91), les unes par rapport aux autres et par rapport au composant intermédiaire (23), radialement et angulairement par rapport à l'axe



de référence (34) tout en imposant des contraintes minimales vis-à-vis du déplacement des sphères suivant une direction parallèle à l'axe de référence (34).

10. Connecteur de liaison de deux fibres optiques, comprenant deux éléments de couplage (2) et un composant intermédiaire (23) de forme tubulaire pour relier les deux éléments de couplage (21); chaque élément de couplage comprenant une lentille (25) munie d'une surface arrière (27), d'une surface avant (29) qui comporte, d'une part, une zone convexe définissant avec la surface arrière, un axe de référence (34) et, d'autre part, une zone annulaire plane (33) qui entoure la zone convexe et dont le plan forme un plan de référence et est perpendiculaire à l'axe de référence (34), et d'une surface périphérique reliant entre elles les surfaces avant et arrière; des moyens (37, 40) pour fixer l'extrémité d'une fibre optique (15) à la surface arrière (27) de la lentille (25) de manière que la lumière émise par la fibre (15) soit transmise par la zone convexe (31) sous la forme d'un pinceau collimaté dont la section droite est plus importante que celle de la fibre (15) et dont l'axe est confondu avec l'axe de référence (34), connecteur caractérisé en ce que chaque élément de couplage (21) comprend une monture annulaire (41) disposée autour de la surface périphérique, solidaire de celle-ci et présentant une surface extérieure périphérique (43) pratiquement cylindrique et coaxiale avec l'axe de référence (34); un manchon (45) disposé autour de la surface extérieure périphérique (43) pratiquement cylindrique et munie d'une surface intérieure (49) pratiquement cylindrique en contact avec cette surface extérieure périphérique par une région de contact dont la longueur suivant l'axe de référence (34)

est petite, des moyens de sollicitation (63) pour solliciter les lentilles (25) et les montures (41) vers l'avant par rapport aux manchons (45), des moyens de liaisons (67, 73) coopérant avec le composant intermédiaire (23), en ce que le composant intermédiaire (23) présente des moyens de liaison (77) coopérant avec les moyens de liaison (67, 73) des deux éléments de couplage (21), et en ce que le composant intermédiaire (23) comprend des moyens de séparation (91, 93) qui maintiennent les deux plans de référence parallèles et espacés lorsque les lentilles (25) sont sollicitées l'une vers l'autre par les moyens de sollicitation (63), et qui sont constitués notamment de trois sphères (91) en matériau incompressible et d'une cage (93) retenant les sphères (91) et empêchant le déplacement des sphères (91) les unes par rapport aux autres et par rapport au composant intermédiaire, angulairement et radialement par rapport aux axes de référence (34) tout en imposant des contraintes minimales au déplacement suivant une direction parallèle aux axes de références (34); la coopération entre les deux éléments de couplage (21) et le composant intermédiaire (23) ainsi que le contact entre les manchons (45) et les surfaces périphériques (43) des montures annulaires (41) permettent d'éviter le déplacement des deux axes de référence (34) l'un par rapport à l'autre, et la petite longueur axiale de la région de contact entre la surface extérieure périphérique (43) pratiquement cylindrique des montures (41) et la surface intérieure pratiquement cylindrique (49) du manchon (45) de chaque élément de couplage (21) fournit un petit degré de liberté à la lentille (25), ce qui permet un basculement relatif de cette lentille par rapport au manchon (45).

