(12) UK Patent Application (19) GB (11) 2 254 934 (13) A

(43) Date of A publication 21.10.1992

(21) Application No 9207162.0

(22) Date of filing 01.04.1992

(30) Priority data
(31) 4111624 (32) 10.04.1991 (33) DE

(71) Applicant
Messerschmitt-Bölkow-Blohm GmbH

(Incorporated in the Federal Republic of Germany)

Postfach 80 11 09, D-8000 Munich 80,
Federal Republic of Germany

(72) Inventor
Heinz Staudinger

(74) Agent and/or Address for Service
Mewburn Ellis
2 Cursitor Street, London, EC4A 1BQ,
United Kingdom

(51) INT CL5
G02B 6/28

(52) UK CL (Edition K)
G2J JGEC JG9

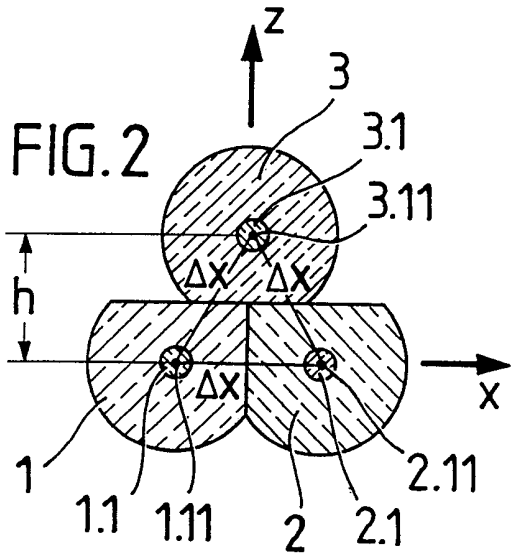
(56) Documents cited
GB 2220765 A GB 2119121 A GB 2015190 A
EP 0352957 A2 EP 0051727 A US 4950318 A

(58) Field of search
UK CL (Edition K) G2J JGEC
INT CL5 G02B

(54) Fibre optic 3x3 coupler

(57) Fibre cores 1.1, 2.1, 3.1 of joined optical fibres 1, 2, 3 of a 3x3 ground coupler are spatially arranged through the entire coupling region, i.e. in each plane which extends perpendicularly to the common joining line, at the points of an equilateral triangle. This is achieved by having the first and second fibres 1, 2 of equal circular curvature and arranged in a common plane x, and the third fibre 3 of elliptical curvature arranged in a plane z perpendicular to that of the first and second fibres 1, 2.

FIG. 2



GB 2 254 934 A

FIG. 1a

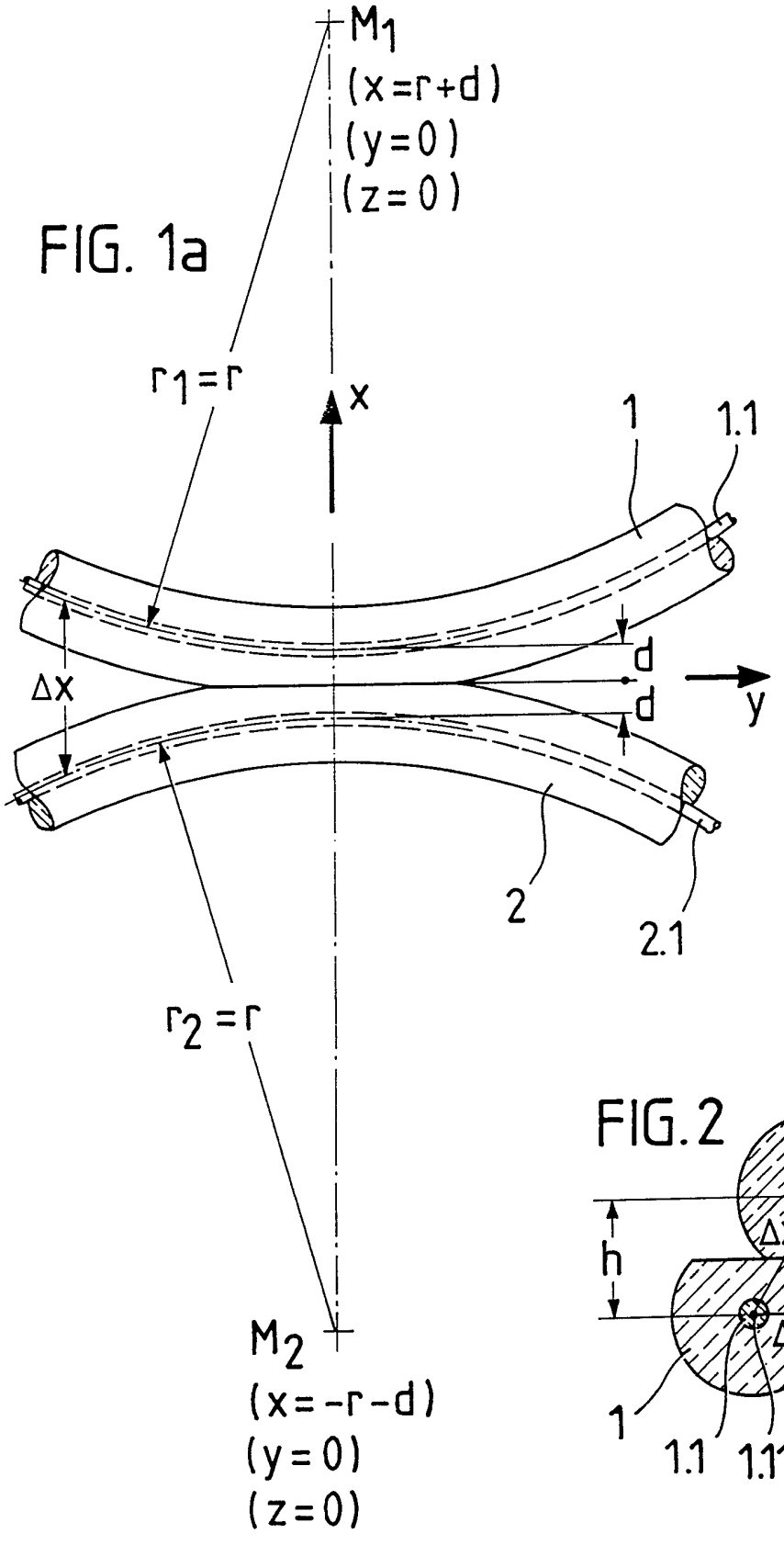


FIG. 1b

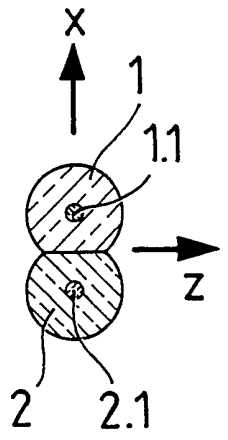
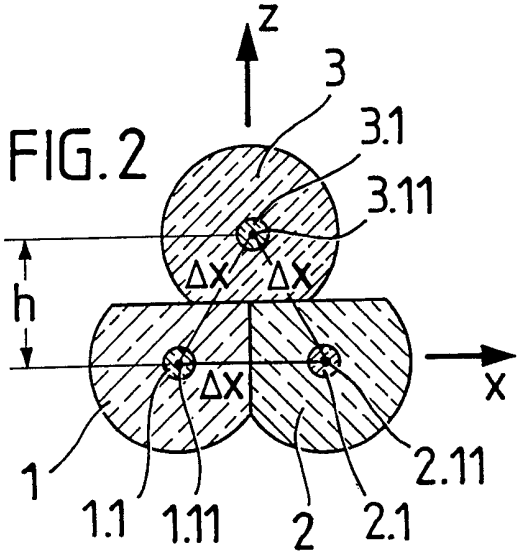


FIG. 2



FIBRE OPTIC 3x3 COUPLER

This invention relates to an optical fibre 3x3-coupler and to a process for its manufacture.

EP 0 074 789 and US 4 755 021 disclose 2x2- or 4x4-couplers in which the optical fibres are ground down singlesidedly, virtually to the fibre core, and joined by their ground surfaces. The coupling properties of couplers of this type are substantially determined by the distance between cores and the so-called coupling length within which light waves can pass from one fibre core to the other. Even joining of two optical fibres requires considerable precision, as the core diameters of monomode optical fibres are in the region of 10 µ and the distance between the cores in the coupling range has to be approximately 1 - 5 µ. It is then a precondition that the two fibre cores extend as much as possible in parallel along the coupling path. According to EP 0 074 789, this is achieved in that the two optical fibres are each circularly bent and in their intersecting area their curves are planed down virtually to the fibre core. The two fibres are then joined along their ground surfaces.

To manufacture a 4x4-coupler, two pairs of optical fibres of this type, which are joined via their ground surfaces, are again circularly bent and again planed down in the intersecting area of the curvature virtually to the two adjacently extending fibre cores, in which respect this ground surface now extends perpendicularly to the first. Thereafter, the two pairs of optical fibres, which are provided with a lateral ground surface, are joined via their ground surfaces, thus producing a coupler having a cross-sectional shape like a four leaf clover.

Analogous application of this manufacturing process to a 3x3-coupler has not been possible in the past, as with three circularly bent fibres the optical fibre cores are located

equidistantly only in the centre of the coupling area. To the left and right of this centre, the distances between the optical fibre cores are displaced in a non-linear manner, resulting in asymmetry of coupling between the three optical fibres. Therefore, 3x3-couplers are usually manufactured by a different process, namely by drilling and subsequent melting together whilst simultaneously drawing the three optical fibres. However, melting processes of this type are insufficiently reproducible.

It is an object of the present invention to provide a 3x3-coupler and a process for its manufacture, which is reproducible and offers even coupling over all three optical fibres.

According to the invention an optical fibre 3x3-coupler having 3 optical fibres joined along a coupling path has the cores of the optical fibres positioned within the coupling path, in each plane arranged perpendicularly to the coupling path, at the points of an equilateral triangle.

The invention will now be described in more detail, based on an exemplary embodiment, which is partially schematically illustrated in the figures, in which:

Fig. 1a is a side view of two optical fibres joined via ground surfaces;

Fig. 1b is a cross-section through the centre of the arrangement shown in Fig. 1a; and

Fig. 2 is a cross-section through a 3x3 ground coupler in accordance with the invention.

The inventive ground coupler is manufactured as follows:

First of all, two of the three optical fibres 1 and 2 which are to be joined are circularly bent by known methods (for

example according to EP 0 074 789) with a bending radius of $r_1 = r_2 = r$, and ground flat in the intersecting region of their curvatures and close to their respective fibre cores 1.1 or 2.1. The two optical fibres 1, 2 are then glued together along their ground surfaces, resulting in a geometry as in Fig. 1a. In the illustrated coordinates system, the curvature centre M1 of the first fibre core 1.1 has the coordinates x = r + d, y = o and z = o. Correspondingly, the curvature centre M_2 of the second fibre core 2.1 has the coordinates x = -r-d, y = o and z = o. At any distance from the coordinates centre, the two fibre cores are at a distance Δx:

$$\Delta x = 2 \left(r+d^{(\pm)} \times \sqrt{r^2-y^2}\right)$$

A section through the arrangement of Fig. 1a perpendicularly to the y-coordinates in the region of the coordinates origin is shown in Fig. 1b. The connection of the two fibres along their common ground surfaces must be such that the two curvature planes coincide in a common plane, i.e. the centres of the fibre cores are permanently in the x-y plane.

When connecting a 2x2-coupler produced as above with a third optical fibre in order to produce a 3x3-coupler, the distance of the core 3.1 of the third fibre from the x-y plane in the region of the coupling length should always be such that together with the fibre cores 1.1 and 2.1 it produces an equilateral triangle, i.e. the three cores 3.1, 2.1, 1.1 should always be equidistant. The height h of an equilateral triangle with sides Δx may be expressed as:

$$h = \Delta x \times \sqrt{3}/2.$$

As the requirement for an equilateral triangle between the centre points 1.11, 2.11 and 3.11 of the three fibre cores 1.1, 2.1 and 3.1 applies to all planes (or sections) parallel to the x-z-plane in the coupling region of the 3x3-coupler, the following applies:

$$z = h = \sqrt{3}/2 \times \Delta x.$$

If the above formula is used in this equation, the result is

$$z = \sqrt{3} \quad (r+d \ ^{(+)}\sqrt{r^2-y^2})$$

After transformation, the result is:

$$[z - \sqrt{3} \ (r+d)] \ ^2/3yr^2 + y^2/r^2 = 1$$

This formula describes an ellipse with semi-axes $a = \sqrt{3} \times r$ and $b = r$ as well as a centre M_3 with coordinates $x = y = o$ and $z = (r+d) \sqrt{3}$. Consequently the third optical fibre 3 should be curved according to the above elliptical formula and again ground in the intersecting region of the curvature to near the fibre core. The fibres 1 and 2, which have already been joined into a 2x2-coupler, are now ground flat in the region of the mutual joint perpendicularly to their first common ground surface until the entire distance h conforms to the above formula (Fig. 3). When joining the ground optical fibre 3 with the further ground optical fibres 1 and 2, it should be noted that the centre 3.11 of the fibre core 3.1 is positioned centrally between the two fibre cores 1.1 and 2.1, as seen from the z-direction, i.e. substantially in the plane of the joined first ground surfaces of the first and second optical fibre.

CLAIMS

1. An optical fibre 3x3-coupler having 3 optical fibres joined along a coupling path, the cores of the optical fibres being positioned within the coupling path, in each plane arranged perpendicularly to the coupling path, at the points of an equilateral triangle.

2. An optical fibres 3x3-coupler as claimed in claim 1, wherein a first and a second optical fibre have circular curvatures in the same plane and of the same radii r, in which respect the circle centres have the coordinates

$$M_1 = \begin{pmatrix} x = r + d \\ y = o \end{pmatrix} \text{ and}$$

$$M_2 = \begin{pmatrix} x = -r - d \\ y = o \end{pmatrix}$$

where d is the minimum distance of the optical fibres in the intersecting point of the curvature, and

a third optical fibre, which is joined to the first and second optical fibres, has an elliptical curvature with the semi-axes a = r 3 and b = r as well as a centre point

$$M_3 = \begin{pmatrix} x = y = o \\ z = (r+d) \times 3 \end{pmatrix},$$

the curvature plane of the third fibre being oriented perpendicularly to that of the first and second optical fibre, with all three fibres being joined via straight ground surfaces.

3. A method of manufacture of an optical fibre 3x3-coupler as claimed in claim 1 or 2, wherein:

a) a first and a second optical fibre are circularly bent at an equal bending radius, and the fibre casing of each is ground plane in the intersecting region of

their curvature to near the fibre core;

b) the first and the second optical fibre are joined along their ground surfaces, and their fibre casing is again ground plane to near the fibre core in a plane which is equidistant to the two fibre cores;

c) a third optical fibre is elliptically curved, and the fibre casing thereof is ground plane in the intersecting region of the curvature to near the fibre core; and

d) the third optical fibre is joined along its ground surface to the free ground surfaces of the joined first and second optical fibres so that the three fibre cores, in each plane arranged perpendicularly to the common joining line is positioned at the points of an equilateral triangle.

4. An optical fibre 3x3-coupler substantially as hereinbefore described with reference to and as illustrated in Fig. 3 of the accompanying drawings.

Patents Act 1977

Examiner's report to the Comptroller under Section 17 (The Search Report)

Application number
9207162.0

Relevant Technical fields

(i) UK Cl (Edition K) G2J (JGEC)

(ii) Int CL (Edition 5) G02B

Search Examiner
MR C J ROSS

Databases (see over)

(i) UK Patent Office

(ii)

Date of Search
9 JULY 1992

Documents considered relevant following a search in respect of claims 1-4

Category (see over)	Identity of document and relevant passages	Relevant to claim(s)
X	GB 2220765 A (STC) see especially Figure 2	1 at least
X	GB 2119121 A (W.E.C.) see especially Figure 5	1 at least
X	GB 2015190 A (TRW) see especially Figure 8	1 at least
X	EP 0352957 A2 (CORNING) see especially Figure 14	1 at least
X	EP 0051727 (FELTEN) see especially Figure 4	1 at least
X	US 4950318 (ANDREW CORPN)	1 at least

Category	Identity of document and relevant passages	Relevant to claim(s)

Categories of documents

X: Document indicating lack of novelty or of inventive step.

Y: Document indicating lack of inventive step if combined with one or more other documents of the same category.

A: Document indicating technological background and/or state of the art.

P: Document published on or after the declared priority date but before the filing date of the present application.

E: Patent document published on or after, but with priority date earlier than, the filing date of the present application.

&: Member of the same patent family, corresponding document.

Databases: The UK Patent Office database comprises classified collections of GB, EP, WO and US patent specifications as outlined periodically in the Official Journal (Patents). The on-line databases considered for search are also listed periodically in the Official Journal (Patents).

Published 1992 at The Patent Office, Concept House, Cardiff Road, Newport, Gwent NP9 1RH. Further copies may be obtained from Sales Branch, Unit 6, Nine Mile Point, Cwmfelinfach, Cross Keys, Newport, NP1 7HZ. Printed by Multiplex techniques ltd, St Mary Cray, Kent.