

PATENT REQUEST: STANDARD PATENT/PATENT OF ADDITION

I/We, being the person(s) identified below as the Applicant, request the grant of a patent to the person identified below as the Nominated Person, for an invention described in the accompanying standard complete specification.

Full application details follow.

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[54] Invention Title: PROCESS FOR THE PRODUCTION OF AN OPTICAL COUPLER FOR POLYMERIC OPTICAL FIBERS

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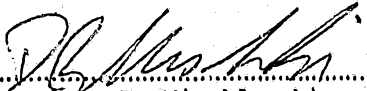
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BASIC CONVENTION APPLICATION(S) DETAILS

[31] Application Number	[33] Country	Country Code	[32] Date of Application
P40 38 018.1	Germany	DE	29th November 1990

Drawing number recommended to accompany the abstract

By ~~my~~^{XX} Your Patent Attorneys,
WATERMARK PATENT & TRADEMARK ATTORNEYS


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D. B. Mischlewski

...27th November 1991.....
(Date)

Registered Patent Attorney

AUSTRALIA

Patents Act 1990

NOTICE OF ENTITLEMENT

(To be filed before acceptance)

We, **HOECHST AG** of, D-6230 Frankfurt am Main 80, Federal Republic of Germany
being the applicant in respect of Application No. **88244/91** state the following:-

The Person nominated for the grant of the patent:

has entitlement from the actual inventor(s): **by assignment**

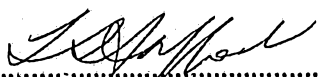
The person nominated for the grant of the patent:

is the applicant of the basic application(s) listed on the patent request form

The basic application listed on the request form:

is the first application made in a Convention country in respect of the invention

By our Patent Attorneys,
WATERMARK PATENT & TRADEMARK ATTORNEYS


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DBM/KJS:JJC [PAT 88244/91]

1st July, 1993

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(Date)



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(12) PATENT ABRIDGMENT (11) Document No. AU-B-88244/91
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- (54) Title
PROCESS FOR THE PRODUCTION OF AN OPTICAL COUPLER FOR POLYMERIC OPTICAL FIBERS
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- (56) Prior Art Documents
US 5146520
US 4919851
- (57) Claim

1. A process for the production of an optical coupler for polymeric optical fibers by arranging and bundling fibers in the same direction and connecting them, which comprises warming the fibers to a temperature of from 50 to 250°C for a period of from 0.2 to 3 hours and subsequently welding the fibers with the aid of ultrasound.
3. A process for the production of an optical coupler for polymeric optical fibers, which comprises inserting a connector bar which comprises a material which has the same refractive index as the core material of the fibers into a plastic tube and centering the connector in the middle, inserting from 2 to 10⁵ polymeric optical fibers into the tube and bringing them into contact with the connector, and welding the plastic tube, the connector bar and the fiber bundle to one another under the action of ultrasound.

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Regulation 3.2(2)

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ORIGINAL
COMPLETE SPECIFICATION
STANDARD PATENT

Application Number:

Lodged:

Invention Title:

PROCESS FOR THE PRODUCTION OF AN OPTICAL COUPLER FOR
POLYMERIC OPTICAL FIBERS

The following statement is a full description of this invention, including the
best method of performing it known to :- us

Description

Process for the production of an optical coupler for polymeric optical fibers

5 In passive optical fiber networks, couplers serve as optical components for apportioning the light signals from incoming optical fibers to outgoing optical fibers. Such couplers comprise a transparent body which is connected to optical fibers on the light inlet side and on the light outlet side. In addition to couplers formed by bonding or melting transparent moldings together with optical fibers, couplers are also known in whose produc-
10 tion optical fiber bundles are twisted and stretched at the twist point (cf. Agarwal, Fiber Integr. Optics 6 (1), 27-53, 1987).
15

The production of assembled couplers of this type is complex and expensive; furthermore, the transmission attenuation of such known couplers is difficult to reproduce, so the output varies by more than 2 dB between the various output fibers.
20

Couplers in which fiber bundles comprising polymeric optical fibers are melted by means of a shrinkable sleeve (DE-A-37 37 930) or optical fibers which are attached to the end face of a cylindrical mixing zone (R.D. Codd, SAE/IEEE, International Congress of Transportation Electronics, 1984) are likewise known.
25

A further process for the production of optical couplers is described in DE-A-40 13 307, which was not published before the date of filing of this application. Here, the
30 optical fibers are bundled using a plastic tube, and this tube is enveloped by a shrinkable plastic sleeve in a subsequent step. At elevated temperature, the fibers melt with the plastic tube as a consequence of the pressure

and the heating action of the shrinkable sleeve. In this case, the heating is effected by means of electrical resistance heating, the welding times being on average 0.5 to 1 hour.

- 5 The essential disadvantage of the known production processes is the complex and time-consuming series of process steps, as a result of which only relatively expensive unit-by-unit production is possible.

10 The object was to find a process which allows mechanically stable couplers to be produced simply and inexpensively and in a relatively short time. It should be possible to carry out such a process with monitoring, so that it is possible to produce couplers having low output attenuation and little variation between the outputs of the output fibers.

15 The present invention achieves this object. It relates to a process for the production of a coupler from polymeric optical fibers in which the fibers are welded to one another over the length of the mixing zone.

20 For the process according to the invention, from two to 10^5 , preferably from 2 to 1000, polymeric optical fibers are ordered in the same direction, if desired twisted with one another and bundled. The fibers are warmed to a temperature of from 50 to 250°C for a period of from 0.2 to 3 hours and then welded to one another with the aid of ultrasound. The ultrasound method is not a nondestructive welding method. Welding without prior warming of the plastic parts to be welded would result in the destruction thereof, in particular in the case of hard, brittle materials. Only after prior warming to a defined temperature at which the fiber material still experiences no change enables nondestructive melting of the optical fibers to one another.

30 In the process according to the invention, the polymeric

optical fibers are kept at a temperature of from 50 to 250°C, preferably at from 130 to 150°C, for from 0.2 to 3 hours, preferably for from 5 to 30 minutes, and subsequently welded to one another in an ultrasound welding unit at a frequency in the range from 10 to 60 kHz, preferably at from 20 to 40 kHz. The pressure used in the unit is, in the process according to the invention, in the range from 1 to 10 bar, preferably in the range from 2 to 4 bar. The welding times are from 0.1 to 3 seconds, preferably from 0.1 to 1.5 seconds. The hold times are in the range from 0.1 to 10 seconds, preferably from 0.1 to 5 seconds. The hold time is in this case taken to mean the time after welding in which the sonotrode (1) still surrounds the fibers which lie in, respectively on, the sonotrode operating area (4), under pressure.

The hold times correspond at least to the welding times, but are preferably selected to be somewhat longer than the latter. Since the fiber material is warmed under pressure and additional friction forces occur due to the action of ultrasound (interface friction, internal friction of the macromolecules), the stresses which occur can still be compensated in this way.

The vibration amplitudes of the sonotrodes⁽¹⁾ in the process according to the invention are in a range from 10 to 65 μm , preferably from 20 to 50 μm , and are generally material-specific.

The duration of the prewarming time depends on the temperature. In the case of relatively short prewarming times, elevated temperatures are preferably used. The temperatures used in each case are furthermore dependent on the fiber materials and are chosen to be lower in the case of relatively sensitive materials, which could experience decomposition or destruction in the upper temperature range, than in the case of more robust materials.

In a preferred case, the fibers are dried, before

prewarming, for from 5 to 30 hours in vacuo at temperatures in the range from 40 to 100°C. The principal purpose of this predrying is to remove any residual monomer still present and any traces of moisture, which can accumulate in the fibers, in particular in the case of relatively long storage periods, and thus to prevent any bubble formation which may occur. In the case of freshly spun fibers, this predrying can be omitted.

By acoustically irradiating the joint zone on both sides, it is possible to further shorten the welding times, which results in very homogeneous weldings.

In the process according to the invention, the fibers to be welded can comprise, in the region to be welded, either core and cladding material or only core material. If the optical cladding has already been removed, it is expedient, after the welding process, to surround the mixing zone again with optical cladding. One possibility is to pull a shrinkable sleeve over this region. In order to adopt the function of optical cladding, this sleeve must have a lower refractive index than the fibers.

A shrinkable sleeve which is suitable for the process according to the invention comprises, for example, a polyolefin, polyvinyl chloride, polyvinylidene chloride, polytetrafluoroethylene, polychloroprene, vinylidene fluoride-hexafluoropropylene copolymer, silicone rubber, polyester, fluorinated ethylene-propylene copolymer or a polyfluoroalkoxy copolymer.

In another preferred embodiment, a coating, preferably having a lower refractive index than the core material and thus likewise being suitable as optical cladding for the mixing zone, can subsequently be applied to the mixing zone for protection thereof.

In a further embodiment, the polymeric optical fibers⁽²⁾ can be surrounded over the length of the mixing zone with a

(3)
plastic tube⁽³⁾ (Fig. 1), over which a shrinkable sleeve
may, if desired, be pushed after the welding process. The
plastic tube⁽³⁾ has the task of melting with the fibers
during the welding process, surrounding the fibers
uniformly and filling any cavities which may occur
between the fibers, which makes it possible to further
reduce the attenuation of couplers produced in this way.
In this way, it is possible to achieve a very good match
of the fiber bundle over the entire area to the mixing
zone. Surface losses do not occur.

The tube gives the mixing zone high mechanical stability
and furthermore protects the latter against climatic
effects.

It is appropriate to select the material of the plastic
tube so that its refractive index is, for the abovementioned
reasons, below that of the core material of the
fibers, so that it additionally takes on the function of
the optical cladding. Suitable materials for plastic
tubes⁽³⁾ of this type are all highly transparent polymers
whose refractive index is lower than the refractive index
of the fiber core, for example polymethyl methacrylate
(PMMA), polycarbonate (PC), poly-4-methylpentene or
fluorine-containing polymers.

In a further embodiment, it is possible to weld from 2 to
 10^5 fibers⁽⁶⁾ directly to a so-called mixing connector *)
(ultrasound weld pressing, Figs. 2 and 3). The mixing
connector here comprises a material which has the same
refractive index as the core material of the fibers, and
preferably comprises the same material. Examples of
frequently used core materials are polymethyl methacrylate
and polycarbonate. *) or connector bar (5)

To produce a coupler of this type, the mixing connector (5)
is inserted into a plastic tube⁽³⁾ and centered in the
middle of the tube. The fibers⁽⁶⁾ to be welded to the mixing
connector are bundled and likewise inserted into the tube

and positioned against the connector. The action of ultrasound and pressure causes the fibers to melt with the mixing zone. This process offers the advantage that the fibers need not be freed from the cladding material before the welding process, and that no plug-in connections, which make a considerable contribution toward increasing the attenuation values, need be used in a coupler of this type.

The ultrasound welding process according to the invention is suitable for all polymeric optical fibers with and without optical cladding. The optical fibers preferably used for couplers for the transmission of optical data signals are those without optical cladding at the connection point, and those preferred for fiber bundles for illumination purposes are those with cladding.

The ultrasound welding technique makes it possible to use very short welding times, which, under optimum experimental conditions, can be reduced to well below one second. The process according to the invention makes it possible to produce, in a simple, inexpensive and time-saving manner, couplers having a mixing zone with a very homogeneous structure.

Example 1

The optical cladding of seven plastic optical fibers made of polycarbonate and having a length of 0.4 m and a diameter of 1 mm each was removed in a 3 cm zone using petroleum ether. A PMMA tube ($n_k = 1.49$) was subsequently pushed over this zone. The refractive index of the fibers was $n_k = 1.58$. The PMMA tube had an internal diameter of 3 mm, a wall thickness of 1 mm and a length of 3 cm.

The seven fibers were welded homogeneously to the PMMA tube in a commercially available ultrasound welding unit, known in polymer and ceramics processing, through exposure to ultrasound at a frequency of 20 kHz.

By warming the joint parts (optical fiber bundle/PMMA tube) to a temperature from 130 to 150°C, it was possible to weld these parts to one another in a nondestructive manner. In order to avoid bubble formation, the fibers used were dried, before warming, at 80°C for 24 hours in vacuo.

The ultrasound welding unit had a generator output of 2 kW. The sonotrode vibration amplitude (peak-peak) was in the range from 30 to 50 μ m. The unit pressure was from 2 to 4 bar.

The welding time was 0.3 second, at a hold time of 3 seconds.

Equally good results were also achieved at higher ultrasound frequencies (from 30 to 40 kHz) using prewarmed joint parts. In order to achieve good welding over the mixing zone, a PMMA tube, into which the fibers are subsequently inserted, was placed in the sonotrode operating area(4). Figure 1 illustrates this tool arrangement.

The 7 $\times$ 7 star coupler produced in the transmission mixer had an excess loss of 2.4 dB, with the output varying between random output fibers by a maximum of 1.6 dB.

Example 2

In order to avoid the insulation process (as in Example 1), the arrangement to be welded was modified somewhat. Firstly, seven polycarbonate fibers (diameter 1 mm) in each case were bundled by means of a shrinkable sleeve in such a manner that 1 cm of fibers was not covered by the shrinkable sleeve on one side and 8 cm of fibers were not covered on the opposite side of the shrinkable sleeve. The shrinkable sleeve had a length of 40 mm.

A polycarbonate connector bar (diameter 2.9 mm, length 30 mm) whose ends were polished was then pushed into a

5 PMMA tube (internal diameter 3 mm, wall thickness 1 mm) having a length of 50 mm. A fiber bundle comprising 7 individual fibers in each case was then inserted into each end of the tube so that the polycarbonate bar was centered. This arrangement was likewise welded by means of ultrasound analogously to Example 1.

10 The action of pressure and ultrasound caused good melting between the fiber bundle and the connector bar. A good match over the whole area was furthermore produced between the mixing zone and the fiber bundle.

The insertion attenuation, averaged over all inlet and outlet channels, was 11.5 dB, giving an excess loss of about 3.1 dB. The difference between the outlet fibers was 2 dB.

~~XXXXXXXXXXXX~~
~~Patent claims~~

THE CLAIMS DEFINING THE INVENTION ARE AS FOLLOWS:

1. A process for the production of an optical coupler for polymeric optical fibers by arranging and bundling fibers in the same direction and connecting them, which comprises warming the fibers to a temperature of from 50 to 250°C for a period of from 0.2 to 3 hours and subsequently welding the fibers with the aid of ultrasound.
2. The process as claimed in claim 1, wherein the fibers only comprise core material over the region to be welded.
3. A process for the production of an optical coupler for polymeric optical fibers, which comprises inserting a connector bar which comprises a material which has the same refractive index as the core material of the fibers into a plastic tube and centering the connector in the middle, inserting from 2 to 10⁵ polymeric optical fibers into the tube and bringing them into contact with the connector, and welding the plastic tube, the connector bar and the fiber bundle to one another under the action of ultrasound.
4. The process as claimed in claim 3, wherein the fibers are heated, before the welding operation, to a temperature within the range from 50 to 250°C for from 0.2 to 3 hours.
5. The process as claimed in claim 1 or 3, wherein a plastic tube which melts with the fibers during the welding operation to form a unit is pushed over the fibers.
6. The process as claimed in claim 5, wherein the plastic tube has a lower refractive index than the core material of the polymeric optical fibers.

7. The process as claimed in claim 5, wherein the plastic tube comprises a polymethyl methacrylate, a polycarbonate, a poly-4-methylpentene or a fluorinated polymer.

5 8. The process as claimed in claim 5, wherein the plastic tube is enveloped with a shrinkable sleeve after the welding process.

9. The process as claimed in claim 1 or 3, wherein the welding process is carried out at a pressure in the range from 1 to 10 bar, preferably in the range from 2 to 4 bar.

10 10. The process as claimed in claim 1 or 3, wherein the fibers are welded at a frequency in the range from 10 to 60 kHz, preferably in the range from 20 to 40 kHz.

15 11. The process as claimed in claim 1 or 3, wherein the welding time is in the range from 0.1 to 3 seconds, preferably in the range from 0.1 to 1.5 seconds, and the hold time is in the range from 0.1 to 10 seconds, preferably in the range from 0.1 to 5 seconds.

20 DATED this 27th day of November 1991.

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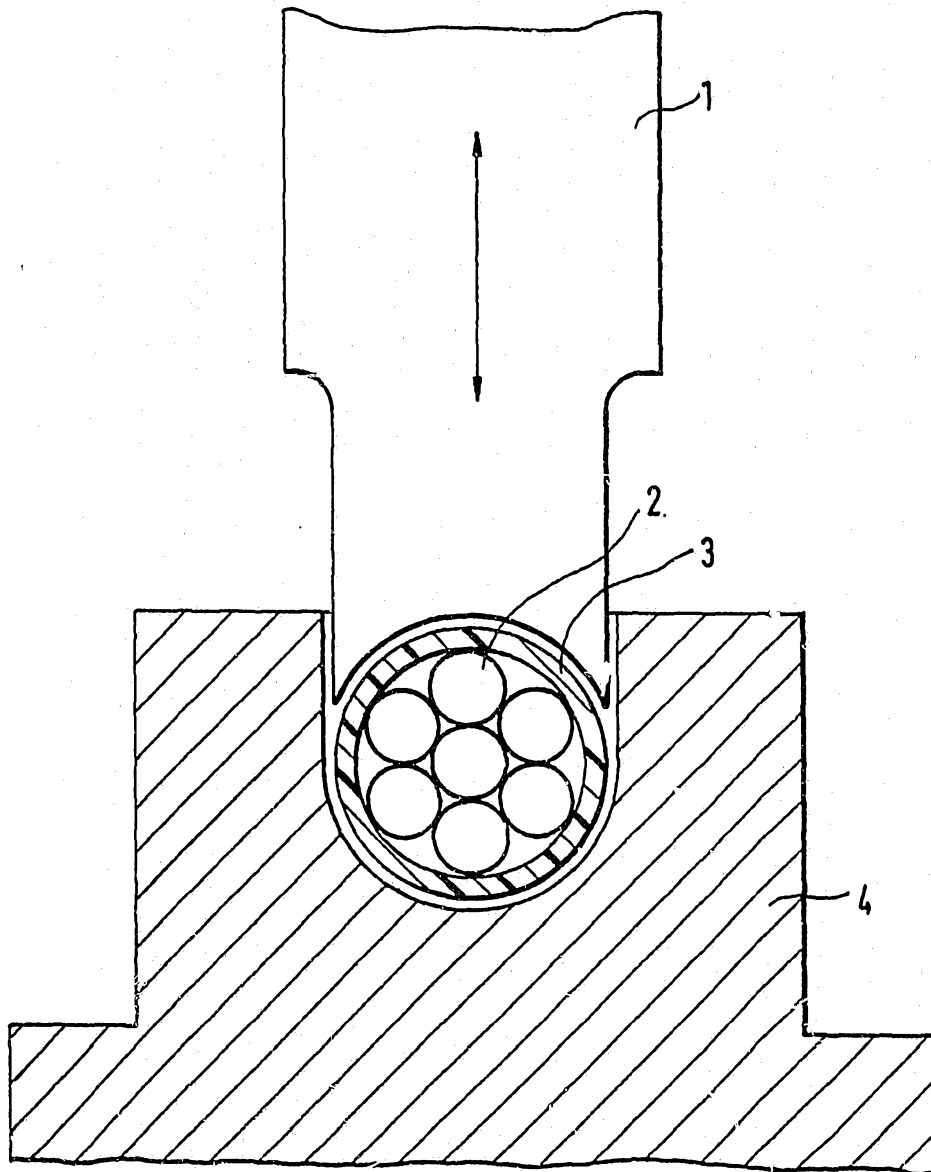


Fig. 1

