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(54) **Optical multiplexer**

(57) An optical multiplexer is formed by branching, light-conductive tracks (5, 6, 7, 8) which are embedded in the surface of a solid body. Successive branches (3, 4) are formed in a light-conductive central track (2), branch tracks (5 to 8) opening into the central track (2) at each branch (3, 4) on both sides and at the same angle. The angle is preferably approximately 1.5 degrees to minimise disturbing effect between the branch tracks connected to each branch.

The device may also be used in reverse as an optical branching device.

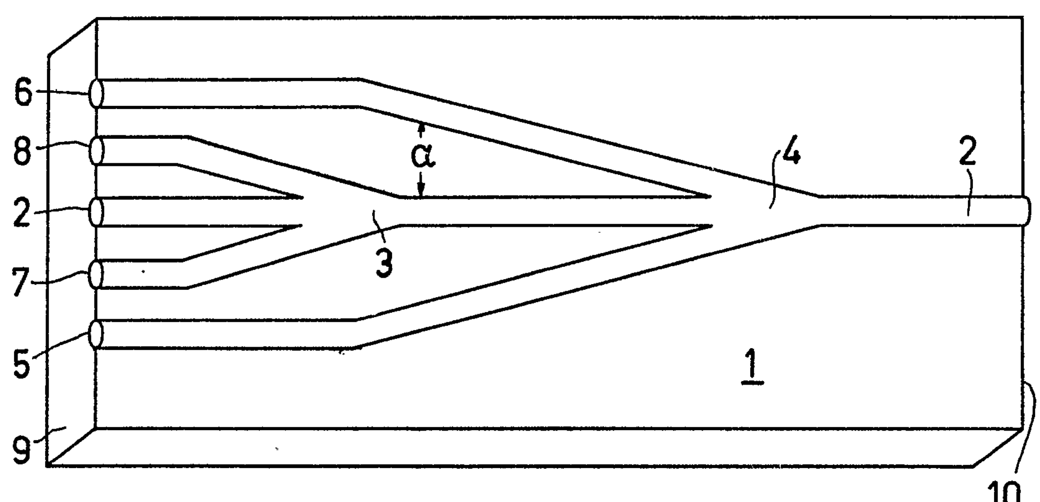

FIG.1

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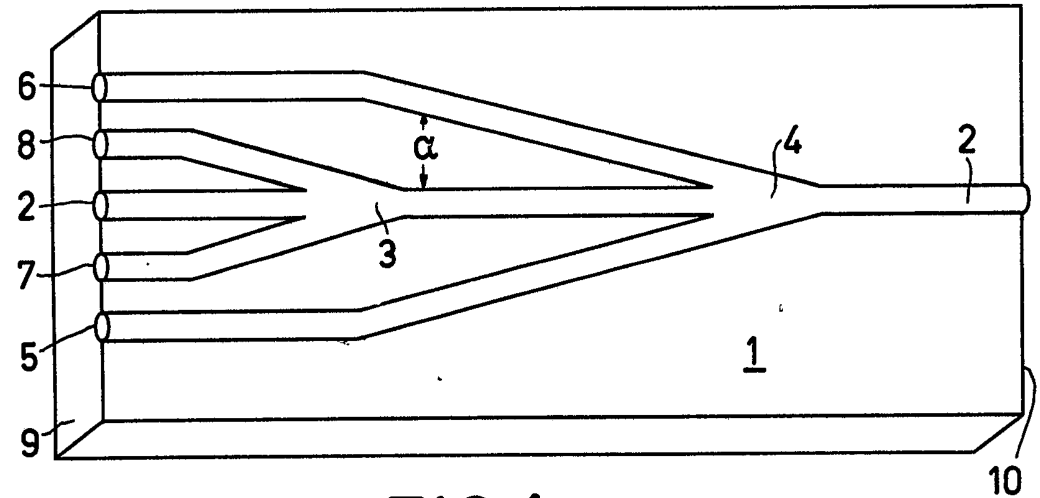

FIG.1

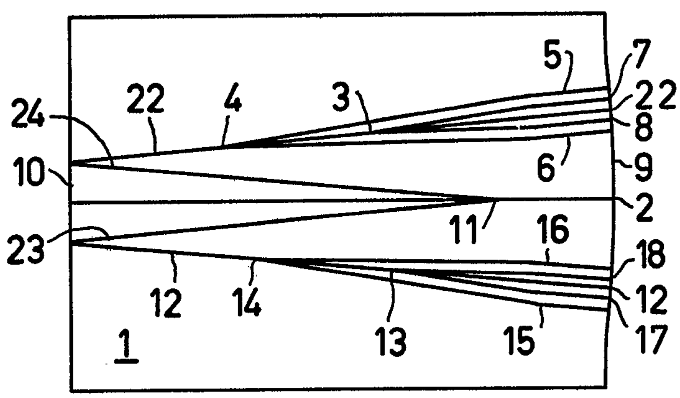

FIG.2

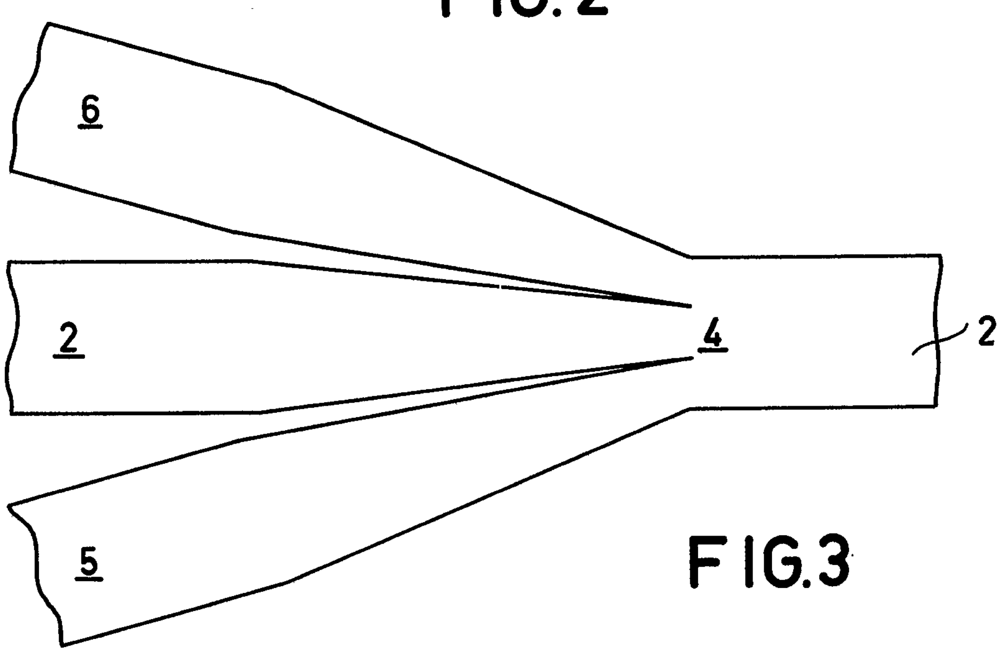

FIG.3

SPECIFICATION
Optical multiplexer

The invention relates to an optical multiplexer which is formed by branching, light-conductive tracks which are embedded in the surface of a solid body. Such tracks embedded in the surface of solid bodies are used to form integrated optical components which perform a variety of tasks in the communication technique.

For an integrated optical connector (DE-OS 23 49 012) types of branching are known whereby radiation can be distributed. When acting in the opposite direction, radiation can also be recombined in such a branch. For multiplexing, however, such a type of branching is not suitable, notably because unequal coupling conditions exist for different tracks at the branching location.

It is an object of the invention to enable the provision of an integrated optical multiplexer in which substantially equal and as small as possible coupling losses at all branching locations are obtained.

The invention provides an optical multiplexer as set forth in the opening paragraph characterised in that there is provided a light-conductive central track on which successive branches are formed, a branch track opening into the central track at each branch on both sides and at the same angle.

In a particularly attractive embodiment, the angles at which the branch tracks open into the central track are approximately 1.5°.

Embodiments of the invention will now be described, by way of example with reference to the accompanying drawing, in which:—

Figure 1 is a three-dimensional view of a five-channel multiplexer,

Figure 2 is a plan view of an eleven-channel multiplexer, and

Figure 3 is a sectional view of one version of a branch.

The optical multiplexer shown in Figure 1 comprises a rectilinear central track 2 which is embedded in a solid body 1 and which can be connected to an optical transmission system at both ends. On the central track 2 there are formed successive branches 3 and 4 from which end portions of branch tracks 7, 8 and 5, 6 open in pairs. The input sections of the branch tracks 5 to 8 which are connected to the end portions are directed parallel to the central track 2 and terminate, together with the central track, on a side 9 of the solid body 1.

Solid bodies for integrated optical elements are made of, for example, borosilicate glass having a comparatively small refractive index. Using a mask, metal ions are implanted along desired tracks, with the result that the refractive index in modified. Another known manufacturing method is disclosed, for example, in the report of the "First European Conference on Integrated Optics", London, 14/15 September 1981, for example, by D. Hoffmann and U. Langmann, pages 1 to 3, in which use is made of a solid body in the form of a substrate of $LiNbO_3$ in which the tracks are formed by titanium ion diffusion. Again masks are to be used for the formation of the track pattern in accordance with the invention.

In the multiplexer shown in Figure 1, the radiation from four optical channels can be applied to one of the branch tracks 5 to 8 on the side 9 of a solid body, the multiplex radiation then appearing at the exit of the central track 2 on the opposite side 10.

The properties of the multiplexer, notably the function of all connections, can be tested by measuring apparatus without interference from the radiation in branch tracks, said measuring apparatus being connected to the central track 2 which is prolonged as far as the two sides 9, 10. If desired, the straight portion of the central track 2 is also suitable for the inclusion of a fifth channel.

Angles of incidence α of approximately 1.5 degrees between the branch tracks 5 to 8 and the central track minimise, for example, disturbing effects of a branch track on the other branch track connected to the same branch.

Figure 2 shows a further version of a multiplexer which comprises a larger number of channels, the radiation path being folded by reflection on a side 10. Therein, tracks 23 and 24 open into the continuous central track 2 at the branch 11, said tracks being a continuation of the central tracks 12 and 22 after reflection. Thus, a particularly compact construction is obtained whereby the elongate device formed due to the acute angle of incidence α is distributed over a larger surface. In addition to ten channels 5, 6, 7, 8, 12, 15, 16, 17, 18, 22 to be connected to the side 9, a further central connection to the central track 2 is available. The branches of the tracks 12 and 22 are denoted by the reference numerals 3, 4, 13 and 14.

An attractive further branch is shown in Figure 3 in which all tracks 2, 5, 6 become narrower towards the further central track 2, so that their cross-section is reduced at the area of the branch 4. The common point of intersection of their optical axes is situated within the central track.

The wedge-like shape of the tracks reduces energy losses caused by modes which can propagate at the area of the branch due to an increased diameter of the track. Energy emerging at the area of the narrowed portion is partly captured again by modes which cannot propagate in but only outside this area. This is particularly advantageous for monomode systems.

When operating in the opposite direction, a multiplexer in accordance with the invention can also be used as a branching device.

CLAIMS

1. An optical multiplexer which is formed by branching, light-conductive tracks which are embedded in the surface of a solid body, characterised in that there is provided a light-conductive central track on which successive branches are formed, a branch track opening into the central track at each branch on both sides and at the same angle.

2. An optical multiplexer as claimed in Claim 1, characterised in that the branch tracks open into the central track at an angle of approximately 1.5 degrees.

3. An optical multiplexer as claimed in Claim 1 or 2, characterised in that the central track opens into oppositely situated sides of the solid body.

4. An optical multiplexer as claimed in Claim 3, characterised in that the central track is guided so as to extend zig-zag between reflective sides of the solid body.

5. An optical multiplexer as claimed in any of the preceding Claims, characterised in that the cross-section of the central track and/or the branch tracks is reduced at the area of the branch.

6. An optical multiplexer as claimed in any of the preceding Claims, characterised in that the branch tracks are directed to one side of the solid body parallel to the central track.

7. An optical multiplexer as claimed in any of the preceding Claims, characterised in that the solid body is made of borosilicate glass.

8. An optical multiplexer substantially as described herein with reference to Figure 1, Figure 2, Figures 1 and 3, or Figures 2 and 3 of the accompanying drawing.

9. An optical branching device substantially as described herein with reference to Figure 1, Figure 2, Figures 1 and 3, or Figures 2 and 3 of the accompanying drawing.

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