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Mukai et al.

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[54] METHOD OF PRODUCING BRANCHED PHOTON-CONDUCTIVE FIBER BUNDLES

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[52] **U.S. Cl.** **156/180;** 156/296; 350/320
[51] **Int. Cl.** **D04h 3/08**
[58] **Field of Search** ..... 156/180, 296; 350/96 B, 350/320; 29/419 G

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Primary Examiner—C. W. Lanham
Assistant Examiner—D. C. Reiley, III
Attorney, Agent, or Firm—Littlepage, Quaintance, Murphy & Dobyns

[57] **ABSTRACT**

A guide plate formed with a plurality of holes for guiding the fiber filaments has a first photon-conductive fiber filament of relatively large size passed through a relatively large-sized center hole of the guide plate and several second photon-conductive fiber filaments of relatively small size passed through relatively small holes concentrically surrounding the center hole such that the second filaments will be delivered out through the respective holes toward the first filament so that they are arranged around and concentric with the first filament and then bonded together.

5 Claims, 7 Drawing Figures

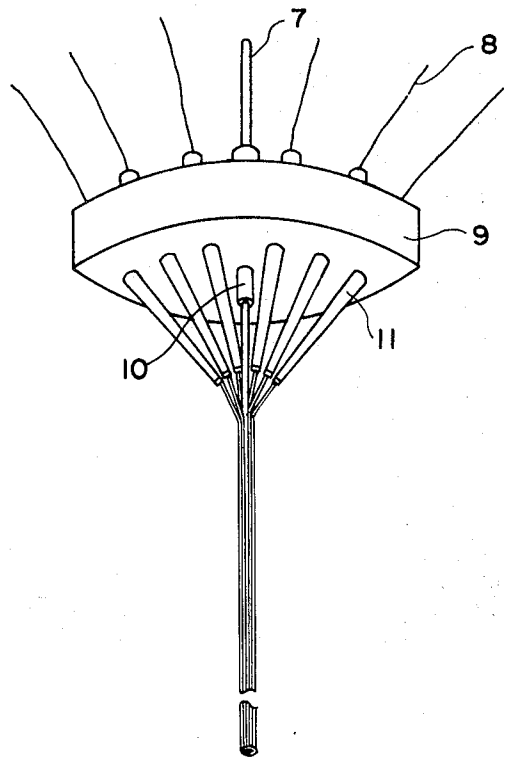


FIG 1

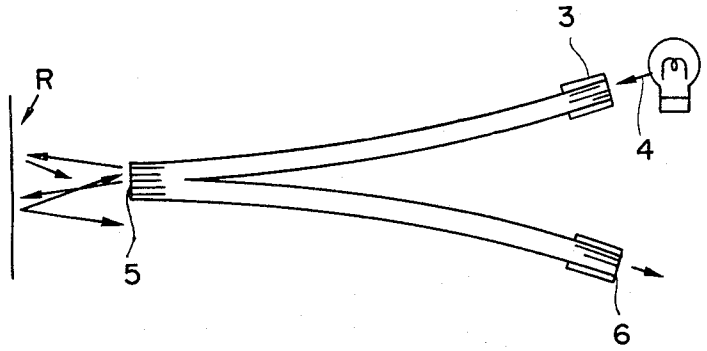
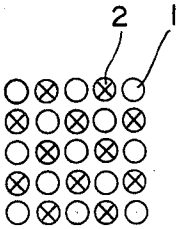


FIG 2



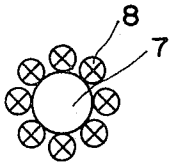


FIG 3a

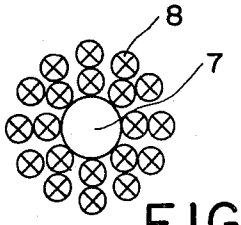


FIG 3b

FIG 4a

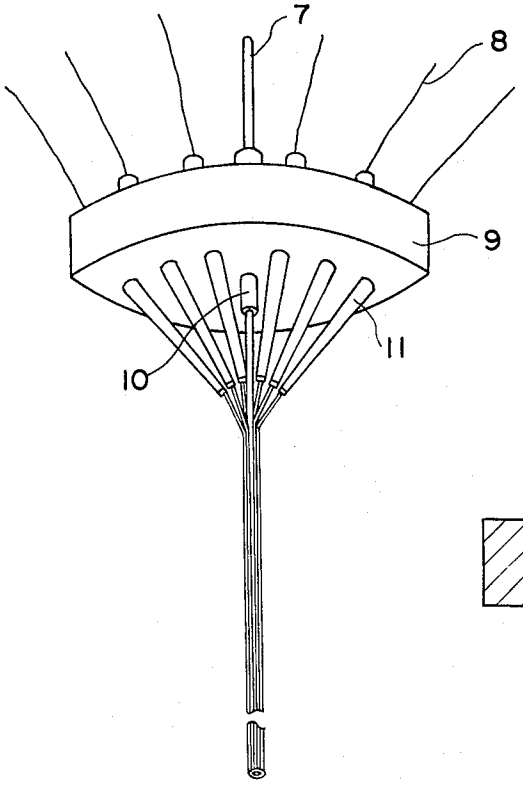


FIG 4b

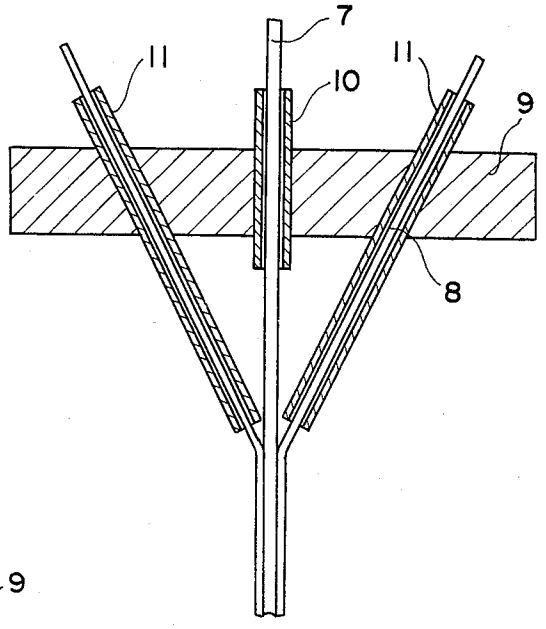
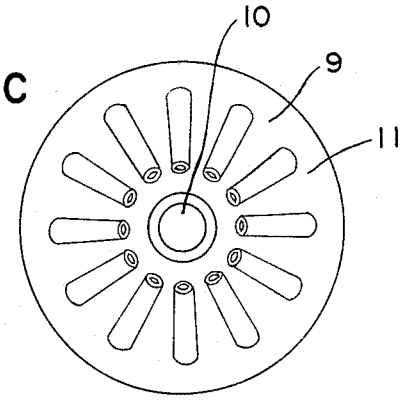


FIG 4c



METHOD OF PRODUCING BRANCHED PHOTON-CONDUCTIVE FIBER BUNDLES

FIELD OF THE INVENTION

This invention relates to a photon-conductive fiber bundle of the type used for light pens, the bundle being composed of two types of fiber filaments which differ in diameter, the filament of relatively large diameter being surrounded by the filaments of relatively small diameter. The invention also relates to a method of and an apparatus for producing such fiber bundles.

BACKGROUND OF THE INVENTION

A photon-conductive fiber bundle composed of photon-conductive fibers such as plastic or glass fibers which are bundled together at one end and branched or ramified at the other end is used, for example, as a light pen designed to serve as a light entrance terminal for a photoelectric circuit or for other purposes. It is desirable that the arangement of the fibers constituting the branched end and the combined end on the reflection side is such that the light receiving fibers and the light projecting fibers are positioned contiguously adjacent to each other.

If the fibers associated with reception of light and the fibers associated with the projection of light are correctly arranged uniform reception of light can be achieved even if some fibers should have a certain inclination relative to the reflector face, and hence there can be obtained as a whole a satisfactory performance of a high sensitivity detection end.

It is, however, very difficult to produce a combined end having a structure such as previously described, and particularly, when the diameter of such combined end is extremely small, for example, less than 0.5 mm. The light transmitting capacity of the fibers is lessened since the fiber size is reduced and hence, a certain limitation is necessarily imposed on the number of fiber filaments composing the end.

In case of composing a 0.3 mm diameter combined end from fibers with a size of say 30μm, the number of such fibers usable for constructing the end must be limited to about 90. It therefore becomes an absolute requirement that the respective fibers be correctly positioned adjacent to each other in a prescribed geometrical pattern. If disorder should be caused even in part of the fiber arrangement, the working performance of the photon-conductive fiber bundle is markedly lowered. In order to avoid this, highly skilled producing techniques are required, and it is necessary to carry out the manufacture at a conscious sacrifice of yield and therefore, the manufacturing cost is inevitably elevated.

SUMMARY OF THE INVENTION

An object of the present invention is to provide a branched type photon-conductive fiber bundle which requires no complicated manufacturing steps and which can produce a working effect equal to or higher than that obtainable from a fiber bundle in which the light receiving fibers and the light entering fibers are arranged alternately in contiguously adjacent relation.

Another object of the present invention is to provide a branched type photon-conductive fiber bundle in which the core of the bundle is composed of either a light receiving type fiber filament or a light projecting type fiber filament, the core being surrounded by the fibers of the other type. More specifically, a fiber filament with a comparatively large diameter is placed in the center and the fibers with a comparatively small diameter are arranged concentrically around the center fiber filament and bonded together.

A further object of the present invention is to provide a branched type photon-conductive fiber bundle in which a fiber filament with a comparatively large diameter is positioned in the center of the bundle and a plurality of fibers with a comparatively small diameter are placed around the central filament in multiple layers and bonded together.

Still another object of the present invention is to provide a fiber bundling guide used in producing a fiber bundle of the type described above, the fiber bundling guide having a construction such that a large-diameter guide pipe for passing a comparatively thick fiber filament is provided in the center of the guide and a plurality of small-diameter guide pipes for passing the comparatively thin fiber filaments are provided concentrically around the center guide pipe.

While the above-mentioned objects can be accomplished by use of various combinations in configuration and construction of the respective parts constituting the present invention, a preferred embodiment thereof is described in detail hereinbelow for illustrative purposes with reference to the accompanying drawings. It is to be understood therefore, that various changes and modifications in details of the construction shown herein are embraced within the scope of the invention as defined in the appended claims.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a diagram illustrating the operating principle of a branched or bifurcated type photon-conductive fiber bundle.

FIG. 2 is an enlarged diagrammatic view showing the combined end of a conventional high sensitivity fiber bundle.

FIGS. 3*a* and 3*b* diagrammatically show the examples of the combined end of a bifurcated type photon-conductive fiber bundle according to the present invention, where 3*a* shows an example in which the small-diameter fibers are arranged in a single layer around a large-diameter fiber, and 3*b* shows an example where the small-diameter fibers are arranged in double layers around the central large-diameter fiber.

FIGS. 4*a*, 4*b* and 4*c* show a fiber bundling guide used in practicing the present invention, where 4*a* is a perspective view, 4*b* is an enlarged central vertical sectional view, and 4*c* is a bottom view.

DESCRIPTION OF THE PREFERRED EMBODIMENT

As illustrated in FIG. 1, a bifurcated or branched photon-conductive fiber bundle is composed of photon-conductive fibers such as plastic or glass fibers which are bundled together at one end 5 and branched at the other end. Such a fiber bundle is used, for example, in a light pen designed to serve as a light entrance terminal for a photoelectric circuit or other similar purpose. It is desirable that the arrangement of the fibers constituting the combined end 5 is such that the light receiving fibers 1 and the light projecting fibers 2 are positioned alternately adjacent to each other to present a geometrical pattern as shown in FIG. 2.

In such an arrangement, light 4 which has entered from one end 3 of the divergent ends of the ramified

fiber bundle projects out of the combined end **5**. The light is reflected off a reflective surface R, the reflected light being again received at the combined end **5** and passed to the other divergent end **6** of the fiber bundle. If the fibers **1** associated with the reception of light and the fibers **2** associated with the projection of light are correctly arranged alternately as shown in FIG. **2**, uniform reception of light can be achieved even if some fibers should have a certain inclination relative to the reflective surface R. As previously indicated, it is particularly difficult to produce a combined end having a structure such as that described when the diameter of such a combined end is extremely small.

FIGS. **3***a* and **3***b* show examples of the combined end of a bifurcated photon-conductive fiber bundle produced by using the fiber bundling guide according to this invention. FIG. **3***a* shows an example where the small-diameter fiber filaments **8** are arranged in a row around a single piece of large-diameter fiber filament **7**, and FIG. **3***b* shows an example where the small-diameter fiber filaments **8** are arranged in multiple layers around the central filament **7**.

According to the fiber bundle obtained, when a light beam projecting from a small-diameter fiber filament **8** disposed around the central filament is reflected on the face of a reflector, R, the reflected light beam inevitably enters into the central large-diameter filament because every small-diameter filament is positioned either in contact with or in close proximity to the central filament **7**. With the combined end shown in FIGS. **3***a* and **3***b* there can be obtained substantially the same effect or sensitivity as obtainable with the combined end having a structure as shown in FIG. **2**.

A fiber bundle having a combined end such as shown in FIGS. **3***a* and **3***b* is easily assembled using a fiber guide plate or bundling guide as shown in FIGS. **4***a*, **4***b* and **4***c*. In the guide plate **9** are formed a central guide pipe **10** extending axially through the center of the plate and a plurality of guide pipes **11** equidistantly encircling the central guide pipe **10** and extending through the plate with an inclination of a certain angle toward the axis of the central guide pipe **10**. A fiber filament **7** with a comparatively large diameter, such as for example 100μm is inserted into the central guide pipe **10** from one end thereof and extended out from the other end. The fiber filaments **8** with a comparatively small diameter, such as for example 13μm are inserted into the respective surrounding guide pipes **11** from one end and extended out from the other end. These fiber filaments **7** and **8** are bundled together such that the filaments with a small diameter will be arranged in order around the large-diameter filament **7**, and then the filaments **7** and **8** are bonded together with epoxy resin or other suitable synthetic resin adhesive.

In producing a bifurcated photon-conductive fiber bundle by using the fiber bundling guide **9**, it is desirable to apply suitable coating on the inner face of each guide pipe so as to provide pertinent slidability to the respective fiber filaments and to protect the fiber surfaces. Preferably, the large- and small-diameter fiber filaments are arranged parallel to each other at and near the combined end thereof. A suitable coating is silicone.

Further, there is no need of arranging the fibers composing the ramified bundle in an alternate geometrical pattern as shown in FIG. **2**, and hence the producing process is greatly simplified. The combined end area (scanning face in the light pen or like) of the bifurcated photon-conductive fiber bundle according to the present invention is extremely small so that such a fiber bundle proves most effective when used as a light pen which is employed in applications where the inclinations of the scanning face and the reflection face often differ. As described above, the branched photon-conductive fiber bundle according to the present invention demonstrates substantially as excellent an operating performance as obtained in the conventional high sensitivity fiber bundles such as shown in FIG. **2**, and yet it can be produced by merely using a very simple apparatus.

What is claimed is:

1. A method for producing a bifurcated photon-conductive fiber bundle by combining a first photon-conductive fiber filament and second photon-conductive fiber filaments, the first fiber filament having a larger diameter than any of the second fiber filaments, the method comprising the following steps:

a. passing said first fiber filament through a larger diametered hole formed in the center of a fiber bundling guide plate,

b. converging said second fiber filaments onto said first fiber filament by passing said second fiber filaments respectively through a plurality of smaller diametered holes in said guide plate, the smaller diametered holes being arranged around the larger diametered holes and being inclined toward the first fiber filament,

c. concentrically arranging said second fiber filaments to said first fiber filament, and,

d. bonding the filaments together.

2. The method of claim **1** further comprising the step of coating the inside surface of the respective holes in said guide plate with a suitable material for protecting and giving proper slidability to the surfaces of the fiber filaments.

3. A method of producing a bifurcated photon-conductive fiber bundle by combining a first photon-conductive fiber filament and second photon-conductive fiber filaments having respective different diameter, according to the following steps:

a. passing said first photon-conductive fiber filament of a comparatively large diameter through a central hole formed in the center of a fiber bundling guide plate, and

b. passing said second photon-conductive fiber filaments respectively through a plurality of smaller holes provided in said guide plate concentrically around said central hole,

c. converging said second photon-conductive fiber filaments into said first photon-conductive fiber filament,

d. concentrically arranging said second fiber filament to said first fiber filament, and

e. bonding the filaments together.

4. The method as claimed in claim **3**, of inserting said first and second fiber filaments into respective holes provided on said guide plate, wherein the insides of each hole are provided with a proper coating so as to protect the surfaces of the first fiber filament and second fiber filaments as well as to give a proper slidability to each fiber filament.

5. The method according to claim **3** wherein another portion of said second photoconductive fiber filaments are joined together without said first photoconductive fiber filament thereby forming the bifurcated portion of the photon-conductive fiber bundle.

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