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(54) OPTICAL SYSTEM FOR MIXING THE LIGHT EMITTED BY A PLURALITY OF LIGHT SOURCES

OPTISCHES SYSTEM ZUM MISCHEN DES VON MEHREREN LICHTQUELLEN ABGEGEBENEN LICHTS

SYSTÈME OPTIQUE POUR MÉLANGER LA LUMIÈRE ÉMISE PAR UNE PLURALITÉ DE SOURCES DE LUMIÈRE

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Description

TECHNICAL FIELD

[0001] The present invention relates to an optical system for mixing the light emitted by a plurality of light sources.

[0002] In particular, the present invention finds advantageous, though non-exclusive, application in mixing of the light emitted by a plurality of light sources constituted by LEDs, to which the ensuing description will make explicit reference without this implying any loss of generality.

BACKGROUND ART

[0003] Currently existing on the market are electronic components that integrate a plurality of LEDs, which are able to emit respective light radiation of different colours. For example, very widespread on the market are electronic components that integrate three LEDs, which are arranged at the vertices of a triangle and are able to emit light in the three fundamental colours, i.e., red, green and blue. Given that a LED source can be considered as a Lambertian point source with a wide angle of emission, the integration of three LEDs in a single component substantially enables approximation, from the optical standpoint, of the three light sources with a single Lambertian point source.

[0004] Likewise known are electronic lighting devices of the type comprising a plurality of LEDs integrated in a single electronic component and an optical system for mixing the light emitted by said LEDs, said optical system being designed so as to exploit the single-point-source approximation.

[0005] An optical system of the above sort is normally constituted by a single body made of transparent material having an index of refraction higher than that of the air. Said body has an optical axis, an inlet window perpendicular to the optical axis for collecting the light to be mixed, and an outlet window for supplying mixed light, which is also perpendicular to the optical axis and is designed to be set with the optical axis in a centred position between the LEDs in such a way that the latter will all face the inlet window. The inlet window normally has a central portion of surface shaped like a single convergent lens, which is coaxial to the optical axis and is set with its own focus in a position substantially centred between the LEDs for collecting rays of light emitted with small angles with respect to the optical axis, and a portion of lateral surface that surrounds the convergent lens for collecting rays of light emitted with large angles with respect to the optical axis. The body has a lateral outer surface, the curvature of which is such as to intercept and reflect, by total internal reflection, the rays of light collected by the inlet window in such a way that they will be conveyed in directions slightly divergent with respect to the optical axis. Said divergence enables the rays of light collected to be mixed together in an efficient way.

[0006] However, the efficiency of the optical systems mentioned above drops drastically in the case of use of discrete LED components, which can hence no longer be considered as a single point source even if they are mounted close to one another according to a regular arrangement. The use of discrete LEDs is necessary when it is desired not to be tied down to the format of the integrated components with a number of LEDs that are commercially, i.e., when it is desired to use a different number of LEDs with different combinations of basic colours in order to create new colours or different tones of one and the same basic colour. Said need is increasingly felt in various contexts, such as architecture, theatrical shows, and lighting techniques in general.

[0007] A known solution to said problem is that of appropriately sizing, and in particular oversizing, the optical system so as to be able to fit within the single-point-source approximation. Unfortunately, to obtain an efficiency equal to the one that is obtained with LEDs integrated in a single electronic component, it is necessary to increase the dimensions of the optical system, and this is particularly disagreeable from the aesthetic and functional standpoint in the contexts of use mentioned above.

DISCLOSURE OF THE INVENTION

[0008] The aim of the present invention is to provide an optical system for mixing the light emitted by a number of discrete LED components that will be free from the drawbacks described above and, at the same time, will be easy and inexpensive to produce.

[0009] Provided according to the present invention is an optical system for mixing the light emitted by a plurality of light sources according to the annexed claims.

BRIEF DESCRIPTION OF THE DRAWINGS

[0010] The present invention will now be described with reference to the annexed drawings, which illustrate a non-limiting example of embodiment thereof, and in which:

- Figure 1 illustrates, according to a view in longitudinal section, an electronic lighting device comprising a plurality of LEDs and the optical system made according to the teachings of the present invention;
- Figure 2 illustrates in greater detail a portion of the optical system of Figure 1;
- Figure 3 illustrates, according to a view in elevation from beneath, the optical system made according to the present invention;
- Figure 4 illustrates, according to an axonometric view, a component of the optical system of Figure 1; and
- Figure 5 is a schematic illustration of the operation of the optical system of Figure 1 in the presence of light emitted by the LEDs.

BEST MODE FOR CARRYING OUT THE INVENTION

[0011] In Figure 1, the reference number 1 designates as a whole an electronic lighting device comprising four LEDs 2, only two of which are visible in Figure 1, of the type made on respective discrete electronic components and mounted on a substantially plane support 3 so as to be centred on the vertices of a square (Figure 2), a control unit (not illustrated) for controlling electrical supply of the LEDs 2, and an optical system 4 made according to the present invention positioned above the LEDs 2 for collecting and mixing the light emitted by the LEDs 2 themselves. The support 3 on which the LEDs 2 are mounted is constituted, for example, by a printed-circuit board made on which are the electrical connections between the LEDs 2 and the control unit. The LEDs 2 are designed to emit respective light radiation of different colours, chosen as desired according to the colour and the tone of colour of the light that it is desired to obtain at output from the optical system 4.

[0012] The optical system 4 comprises an optical mixer body 5, which is made of a transparent material, and in particular polymethyl methacrylate (known by the acronym PMMA), and presents an axial symmetry with respect to a longitudinal axis 6, an inlet window 7, which is perpendicular to the axis 6 and through which the light to be mixed emitted by the LEDs 2 is collected, and an outlet window 8, which is perpendicular to the axis 6 and from which mixed light exits.

[0013] The mixer body 5 is designed to be mounted on the support 3 with the axis 6 perpendicular thereto at the centroid of the square in which the LEDs 2 are arranged in such a way that these are set facing the inlet window 7. In particular, the mixer body 5 comprises four longitudinal portions 9 contiguous to one another, each of which is associated to a respective one of the LEDs 2, extends between the inlet window 7 and the outlet window 8 and has a respective optical axis 10 substantially parallel to the axis 6 and a respective focus 11 lying on the optical axis 10 in a position corresponding to the inlet window 7. The optical axes 10 are set at equal distances apart from the axis 6 so that each focus 11 will be centred on the corresponding LED 2 to enable the light emitted by the LED 2 to be collected and conveyed, towards the outlet window 8, by the respective longitudinal portion 9. In other words, the optical axes 10 are arranged in such a way that each vertex of the square in which the LEDs 2 are arranged will lie substantially on a respective optical axis 10. Visible in Figure 1 are only two of the four longitudinal portions 9, i.e., those associated to the two visible LEDs 2.

[0014] As will be explained better hereinafter, the light collected by the longitudinal portions 9 propagates within the mixer body 5 from the inlet window 7 to the outlet window 8 according to rays that are slightly divergent with respect to the optical axes 10, hence undergoing a process of optical mixing. In order to improve mixing of the light at output from the optical system 4, the outlet window 8 of the mixer body 5 is constituted by a layer of small lenses (not illustrated) of a known type designed to increase the divergence of the rays of outgoing light.

[0015] The optical system 4 further comprises a reflector device 12 set in a position corresponding to the inlet window 7 of the mixer body 5 and set between the LEDs 2 for separating the LEDs 2 optically from one another in such a way that all the light emitted by each LED 2 will be collected by the respective longitudinal portion 9. In particular, the reflector device 12 comprises four concave reflecting surfaces 13 arranged according to an axial symmetry with respect to the axis 6 and associated, each, to a respective LED 2, and hence to a respective longitudinal portion 9. The curvature and arrangement of each reflecting surface 13 are such that a part of light that the corresponding LED 2 emits laterally towards the longitudinal portions 9 associated to the other LEDs 2 and that, in the absence of the reflecting surface 13 itself, would be collected by said longitudinal portions 9, is, instead, reflected in such a way as to be collected by the longitudinal portion 9 associated to said LED 2, as will be explained better hereinafter.

[0016] The mixer body 5 comprises a pin 14, which projects from the surface of the inlet window 7 sharing the axis 6 and is designed to engage a blind hole 15 made axially in the reflector device 12 for connecting the latter, fixedly and coaxially, to the mixer body 5.

[0017] With reference to Figure 2, which illustrates in greater detail a portion of the cross-sectional view of Figure 1, and to Figure 3, which illustrates the optical system 4 according to a view from the inlet window 7 orthogonal to the axis 6, the inlet window 7 comprises four subwindows 16, each of which is associated to a respective longitudinal portion 9. Each subwindow 16 has a surface made on which is an aspherical convergent lens 17, which has a focus coinciding with the focus 11 of the corresponding longitudinal portion 9, and a plurality of Fresnel halfrings (Figure 2), hereinafter referred to as a whole and for reasons of simplicity as Fresnel lens 18, operating as a convergent lens. The Fresnel lens 18 is coaxial and confocal to the lens 17 and is set between the latter and the pin 14 so as to surround the lens 17 partially. The surface of each subwindow 16 further comprises a portion of lateral surface 19 obtained substantially by rotation, through a quarter of a full circle about the corresponding optical axis 10, of a first broken line 20 (Figure 2) comprising a plurality of segments (not illustrated) forming, in a plane passing through the optical axis 10, respective angles with respect to the optical axis 10 itself. In addition, each reflecting surface 13 is set with its own concavity facing the portion of lateral surface 19 of the respective longitudinal portion 9 in such a way that the corresponding LEDs 2 will be substantially positioned between the reflecting surface 13 and the portion of lateral surface 19 (Figure 2).

[0018] With reference to Figure 2, each longitudinal portion 9 has a lateral surface 21 of separation between the transparent medium of the mixer body 5 and the sur-

rounding air, the lateral surface of which is designated by 21, extends between the subwindow 16 and the outlet window 8 and is obtained substantially by rotation, of a quarter of a full circle about the corresponding optical axis 10, of a second broken line 22 comprising a plurality of segments (not illustrated) forming, in a plane passing through the optical axis 10, respective angles with respect to the optical axis 10 itself.

[0019] With reference to Figure 2 and to Figure 4, which illustrates just the reflector device 12 according to an axonometric view, the curvature of each reflecting surface 13 is obtained by rotation, through half of a full circle about the corresponding optical axis 10, of a generatrix 23 defined in a plane (not illustrated) passing through the optical axis 10. In other words, the reflecting surface 13 has a semicircular cross section along any plane orthogonal to the axis 6. The generatrix 23 comprises a first curve 24, which is defined by a respective second-degree polynomial function, and a second curve 25, which has one end coinciding with one end of the curve 24 and is constituted by a succession of six curves (not illustrated) radiused to one another and defined by respective mathematical functions. To be precise, the two end curves of the succession of curves are defined by respective sixth-degree polynomial functions, the two central curves of the succession of curves are defined by respective root functions, and the remaining two curves, which are positioned, each, between a respective end curve and the central curves, are defined by respective eighth-degree polynomial functions.

[0020] The curves 24 and 25 are not radiused to one another. Following the mechanism of generation by rotation described above, the curve 24 generates a first portion 26 of the reflecting surface 13 set with an edge 26a of its own contiguous to the corresponding Fresnel lens 18 (Figure 2), and the curve 25 generates a second portion 27 of the reflecting surface 13 set with an edge 27a of its own contiguous to the corresponding LED 2.

[0021] Operation of the optical system 4 is described hereinafter with particular reference to Figure 5, which illustrates one of the longitudinal portions 9 and the corresponding reflecting surface 13 of the view of Figure 1, where, however, the section filling lines have been removed for reasons of greater clarity.

[0022] The light emitted by each LED 2 can be considered as being made up of multiple light beams that have different orientations with respect to the optical axis 10 of the longitudinal portion 9 associated to said LED 2 and that are hence collected from different portions by the respective subwindow 16 and are then conveyed, during their propagation within the longitudinal portion 9, towards the outlet window 8 in directions slightly divergent from the optical axis 10, i.e., in directions forming with the optical axis 10 angles smaller than or equal to 10°. Said divergence causes the light beams collected by the various longitudinal portions 9 to mix with one another during their propagation towards the outlet window 8.

[0023] In particular, a first one of said light beams, designated by 28, emitted centrally with respect to the corresponding optical axis 10, and in particular a conical beam 28 sharing the optical axis 10 and having its vertex substantially on the corresponding focus 11, is collected by the lens 7 and is then conveyed towards the outlet window 8 in said divergent directions. Another beam 29 emitted laterally with respect to the optical axis 10 and substantially oriented towards the other subwindows 16, and in particular oriented towards the pin 14, is intercepted by the first portion 26 of the reflecting surface 13 and is then reflected on, and collected by, the Fresnel lens 18, which conveys the beam 29 collected towards the outlet window 8 in said divergent directions. A further beam 30, emitted laterally with respect to the optical axis 10 and oriented in the direction of recession from the other LEDs 2, i.e., towards the lateral surface 21, is collected directly, i.e., without any intermediate reflections, by the portion of lateral surface 19. A fourth beam 31, emitted laterally with respect to the optical axis 10 in such a way as to be substantially oriented towards the other subwindows 16, and in particular oriented specularly, with respect to the optical axis 10, to a part of the beam 30, is, instead, intercepted by the second portion 27 of the reflecting surface 13 and is then reflected on, and collected by, the portion of lateral surface 19. The set of the beams 29 and 31 constitutes a beam emitted specularly, with respect to the optical axis 10, to the beam 30. The lateral surface 21 is designed to reflect, via total internal reflection, the beams 30 and 31 collected by the portion of lateral surface 19 so that they converge in said divergent directions.

[0024] Further variants not illustrated of the optical system 4 according to the present invention comprise a number of longitudinal portions 9 different from four to adapt to electronic devices comprising a number of LEDs 2 different from four, provided that said LEDs 2 are arranged at the vertices of a regular polygon, for example, an equilateral triangle, or else a pentagon. In these cases, the portion of lateral surface 19 of each subwindow 16 and the lateral surface 21 of each longitudinal portion 9 are obtained by rotation of a submultiple of a full circle, said submultiple depending upon the number of the LEDs 2, for example, one third of a full circle in the case of three LEDs 2 or one fifth of a full circle in the case of five LEDs 2. In other words, each longitudinal portion 9 must be sized in such a way that each of said optical axes 10 passes through a respective vertex of said regular polygon.

[0025] The main advantage of the optical system 4 described above, as compared to the optical systems known at the current state of the art and suitable for being applied on three LEDs integrated in just one electronic component, is to supply, at the outlet window 8, a concentrated light spot, which is optimally mixed, albeit presenting external dimensions comparable to those of known optical systems, thanks to the particular division of the mixer body 5 into the multiple longitudinal portions 9 associated to the respective LEDs 2 and appropriately

shaped in a position corresponding to the inlet window 7 and the lateral surface 21.

[0026] Another advantage is that an efficiency is obtained, in terms of ratio between the amount of light emitted by the LEDs 2 and the amount of mixed light supplied by the outlet window 8 given the same external dimensions, that is very high, up to 75%, thanks to the particular reflector device 12 set between the LEDs 2, which recovers a part of the light emitted laterally by each LED 2 that would be lost and/or collected in an inefficient way by the longitudinal portions 9 associated to the other LEDs 2 producing, in particular, undesirable patches of colour in the light spot supplied at the outlet window 8.

[0027] Finally, the optical system 4 according to the present invention enables maximum freedom in the choice and control of the LED components 2 in order to obtain the desired colour and/or light intensity at the outlet window 8. For example, it enables choice of the combination of colours of the LEDs 2 on the basis of the commercial availability of discrete components, which is much wider than that of integrated components, or else, it enables a lighting device to be provided, which is able to control as desired the brightness and the tone of the light spot at output by appropriately controlling the electrical supply of the LEDs 2, or else, it enables use of a number of LEDs 2 all of the same colour to obtain a light spot of that colour but having a much higher light intensity.

[0028] According to further aspects, there is provided an optical system 4 according to the following points.

1. An optical system for mixing the light emitted by a plurality of light sources (2); the optical system (4) comprising an optical mixer body (5), which is made of transparent material and has an inlet window (7) for collecting the light emitted by the light sources (2), an outlet window (8) for supplying mixed light, and a longitudinal axis (6) transverse to the inlet and outlet windows (7, 8); the optical system (4) being characterized in that the mixer body (5) comprises a plurality of longitudinal portions (9) contiguous to one another, each of which is associated to a respective one of said light sources (2), extends between the inlet window (7) and the outlet window (8), has a respective optical axis (10) parallel to the longitudinal axis (6) and a respective focus (11) lying on the optical axis (10) in a position corresponding to the inlet window (7); the optical system (4) being designed to be positioned with each focus (11) centred on the respective light source (2) so that the light emitted thereby will be collected and conveyed, towards the outlet window (8), by the respective longitudinal portion (9).

2. The optical system according to point 1, wherein said light sources (2) are centred on respective vertices of a regular polygon; said optical axes (10) being set at equal distances apart from said longitudinal axis (6) in such a way that each vertex of said polygon will lie substantially on a respective optical axis (10).

3. The optical system according to point 2, wherein said plurality of light sources comprises four light sources (2) centred on the vertices of a square.

4. The optical system according to one of the preceding points, wherein each of said light sources is a LED (2).

Claims

1. An optical system for mixing the light emitted by a plurality of light sources (2); the optical system (4) comprising an optical mixer body (5), which is made of transparent material and has an inlet window (7) for collecting the light emitted by the light sources (2), an outlet window (8) for supplying mixed light, and a longitudinal axis (6) transverse to the inlet and outlet windows (7, 8); the optical system (4) being **characterized in that** the mixer body (5) comprises a plurality of longitudinal portions (9) contiguous to one another, each of which is associated to a respective one of said light sources (2), extends between the inlet window (7) and the outlet window (8), has a respective optical axis (10) parallel to the longitudinal axis (6) and a respective focus (11) lying on the optical axis (10) in a position corresponding to the inlet window (7); the optical system (4) being designed to be positioned with each focus (11) centred on the respective light source (2) so that the light emitted thereby will be collected and conveyed, towards the outlet window (8), by the respective longitudinal portion (9).

2. The optical system according to Claim 1, wherein said inlet window (7) comprises a plurality of subwindows (16), each of which is associated to a respective one of said longitudinal portions (9); each of said light sources (2) being designed to emit a respective first light beam (31) oriented towards the subwindows (16) of the other longitudinal portions (9); the optical system (4) comprising reflector means (12), which are arranged in a position corresponding to said inlet window (7) so as to be set between the light sources (2) and are designed to reflect the first light beam (31) of each light source (2) in such a way that said first light beam (31) will be collected by the subwindow (16) corresponding to said light source (2).

3. The optical system according to Claim 2, wherein each of said light sources (2) is designed to emit a respective second light beam (28) sharing said optical axis (10) of the respective said longitudinal portion (9); each of said subwindows (16) comprising a respective first lens (17), which is confocal to said focus (11) of the respective longitudinal portion (9) and is designed to collect the second light beam (28) for conveying it towards said outlet window (8).

4. The optical system according to Claim 2 or Claim 3, wherein each of said light sources (2) is designed to emit a respective third light beam (30) oriented in a direction of recession from the other light sources (2); each of said subwindows (16) presenting a respective portion of lateral surface (19), which is obtained by partial rotation, about said optical axis (10) of the respective longitudinal portion (9), of a first broken line (20) defined in a plane passing through the optical axis (10) and is designed to collect directly the third light beam (30) of the corresponding light source (2).

5. The optical system according to Claim 4, wherein said reflector means (12) are designed to reflect said second light beam (28) of each light source (2) in such a way that the second light beam (28) itself will be collected by the portion of lateral surface (19) of the subwindow (16) corresponding to said light source (2).

6. The optical system according to Claim 5, wherein each of said longitudinal portions (9) comprises a respective lateral surface (21), which extends between said inlet window (7) and said outlet window (8), is obtained by partial rotation, about said optical axis (10) of the longitudinal portion (9), of a second broken line (22) defined in a plane passing through the optical axis (10), and is designed to reflect, via total internal reflection, the light beams (30, 31) collected by said portion of lateral surface (19) of the respective subwindow (16) in such a way as to convey said light beams (30, 31) towards the outlet window (8).

7. The optical system according to any one of Claims 2 to 6, wherein each of said light sources (2) is designed to emit a fourth light beam (29) oriented towards the subwindows (16) of the other longitudinal portions (9); each of said subwindows (16) comprising a respective second lens (18), which comprises a plurality of Fresnel halfrings and is confocal to said focus (11) of the respective longitudinal portion (9); said reflector means (12) being designed to reflect the fourth light beam (29) of each light source (2) towards the second lens (18) corresponding to said light source (2); the second lens (18) being designed to collect the fourth light beam (29) for conveying it towards said outlet window (8).

8. The optical system according to any one of Claims 2 to 7, wherein said reflector means (12) comprise a plurality of concave reflecting surfaces (13), each of which is associated to a respective one of said longitudinal portions (9) and has a semicircular cross section in any plane orthogonal to said longitudinal axis (6).

9. The optical system according to any one of Claims 5 to 8, wherein said reflector means (12) comprise a plurality of concave reflecting surfaces (13), each of which is associated to a respective one of said longitudinal portions (9) and is positioned with its concavity facing said portion of lateral surface (19) of the subwindow (16) corresponding to said longitudinal portion (9).

10. The optical system according to any one of Claims 5 to 9, wherein each said reflecting surface (13) comprises a first portion of surface (27), which is obtained by rotation, through half of a full circle about said optical axis (10) of the respective longitudinal portion (9), of a first curve (25) defined in a plane passing through the optical axis (10), and is designed to intercept and reflect said first light beam (31) of the respective source in such a way that the first light beam (31) itself will be collected by said portion of lateral surface (19) of the subwindow (16) corresponding to said longitudinal portion (9).

11. The optical system according to Claim 10, wherein said first curve (25) comprises a succession of a preset number of third curve radiused to one another and defined by respective mathematical functions; at least one of said third curves being defined by a polynomial function of a degree higher than three.

12. The optical system according to Claim 7, wherein said reflector means (12) comprise a plurality of concave reflecting surfaces (13), each of which is associated to a respective one of said longitudinal portions (9); each reflecting surface (13) comprising a second portion of surface (26), which is obtained by rotation, through half of a full circle about said optical axis (10) of the respective longitudinal portion (9), of a second curve (24) defined in a plane passing through the optical axis (10), and is designed to intercept said fourth light beam (29) of the respective light source (2) to reflect it onto said second lens (18) corresponding to said longitudinal portion (9); said second curve (24) being defined by a second-degree polynomial function.

13. The optical system according to one of the preceding claims, wherein said light sources (2) are centred on respective vertices of a regular polygon; said optical axes (10) being set at equal distances apart from said longitudinal axis (6) in such a way that each vertex of said polygon will lie substantially on a respective optical axis (10).

14. The optical system according to one of the preceding claims, wherein each of said light sources (2) is designed to emit a light radiation of a respective colour.

15. The optical system according to one of the preceding

claims, wherein said light emitted by each said light source (2) comprises a respective plurality of light beams (28-31), and the respective said longitudinal portion (9) is designed to collect said light beams (28-31) and convey them towards the outlet window (8) in respective directions forming, with said respective optical axis (10), angles smaller than or equal to 10° in such a way that the plurality of light beams (28-31) collected by the various longitudinal portions (9) mix together during their propagation towards the outlet window (8).

Patentansprüche

1. Ein optisches System zum Mischen von Licht, das durch eine Vielzahl von Lichtquellen (2) emittiert wird, wobei das optische System (4) einen optischen Mischkörper (5) aufweist, der aus einem transparenten Material hergestellt ist und der ein Einlassfenster (7) zum Sammeln des Lichtes, das durch die Lichtquellen (2) emittiert wird, ein Auslassfenster (8) zum Liefern des gemischten Lichtes, und eine Längsachse (6) aufweist, die quer zu den Einlass- und Auslassfenstern (7, 8) verläuft; das optische System (4) ist **dadurch gekennzeichnet, dass** der Mischkörper (5) eine Vielzahl von Längsteilen (9) aufweist, die fortlaufend zueinander sind, wobei jeder der Längsteile mit einer entsprechenden der Lichtquellen (2) assoziiert ist, sich zwischen dem Einlassfenster (7) und dem Auslassfenster (8) erstreckt, eine jeweilige optische Achse (10) besitzt, die parallel zur Längsachse (6) ist und einen jeweiligen Fokus (11) aufweist, der auf der optischen Achse (10) liegt, und zwar in einer Position entsprechend dem Einlassfenster (7); das optische System (4) ist aufgebaut, um so positioniert zu werden, dass jeder Fokus (11) auf die jeweilige Lichtquelle (2) fokussiert ist, so dass das hierdurch emittierte Licht gesammelt und zu dem Auslassfenster (8) geleitet wird, und zwar durch den jeweiligen Längsteil (9).

2. Optisches System nach Anspruch 1, wobei das Einlassfenster (7) eine Vielzahl von Unterfenstern (16) aufweist, die jeweils mit einem jeweiligen der Längsteile (9) assoziiert sind, wobei jede der Lichtquellen (2) so aufgebaut ist, dass sie einen jeweiligen ersten Lichtstrahl (31) emittiert, der zu den Unterfenstern (16) der anderen Längsteile (9) gerichtet ist; wobei das optische System (4) ferner Reflektormittel (12) aufweist, die in einer Position entsprechend dem Einlassfenster (7) angeordnet sind, um zwischen die Lichtquellen (2) platziert zu werden und die so aufgebaut sind, dass sie den ersten Lichtstrahl (31) jeder Lichtquelle (2) in einer solchen Art und Weise reflektieren, das der erste Lichtstrahl (31) durch das Unterfenster (16), das der Lichtquelle (2) entspricht, gesammelt wird.

3. Optisches System nach Anspruch 2, wobei jede der Lichtquellen (2) so aufgebaut ist, dass sie einen jeweiligen zweiten Lichtstrahl (28), der die optische Achse (10) des entsprechenden Längsteils (9) teilt, emittiert, wobei jedes der Unterfenster (16) eine jeweilige erste Linse (17) aufweist, die konfokal zum Fokus (11) des jeweiligen Längsteils (9) ist, und die so aufgebaut ist, dass sie den zweiten Lichtstrahl (28) aufnimmt, um ihn zu dem Auslassfenster (8) weiterzuleiten.

4. Optisches System nach Anspruch 2 oder 3, wobei jede der Lichtquellen (2) so aufgebaut ist, dass sie einen jeweiligen dritten Lichtstrahl (30) emittiert, der in einer Richtung weg von den anderen Lichtquellen (2) gerichtet ist, wobei jedes der Unterfenster (16) einen jeweiligen Abschnitt einer seitlichen Oberfläche (19) besitzt, der erhalten wird durch partielle Rotation, um die optische Achse (10) des jeweiligen Längsteils (9) einer ersten unterbrochenen Linie (20), die in einer Ebene definiert ist, die durch die optische Achse (10) hindurchgeht, und wobei die Fläche aufgebaut ist, um den dritten Lichtstrahl (30) der entsprechenden Lichtquelle (2) direkt aufzunehmen.

5. Optisches System nach Anspruch 4, wobei die Reflektormittel (12) aufgebaut sind, um den zweiten Lichtstrahl (28) jeder Lichtquelle (2) in einer solchen Art und Weise zu reflektieren, dass der zweite Lichtstrahl (28) selbst durch den Teil der seitlichen Oberfläche (19) des Unterfensters (16) gesammelt wird, der der Lichtquelle (2) entspricht.

6. Optisches System nach Anspruch 5, wobei jeder der Längsteile (9) eine jeweilige seitliche Oberfläche (21) aufweist, die sich zwischen dem Einlassfenster (7) und dem Auslassfenster (8) erstreckt, und die erhalten wird durch partielle Rotation, um die optische Achse (10) des Längsteils (9) einer zweiten unterbrochenen Linie (22), die in einer Ebene definiert wird, die durch die optische Achse (10) hindurchgeht, und die aufgebaut ist zum Reflektieren über vollständige interne Reflektion der Lichtstrahlen (30, 31), die durch den Teil der seitlichen Oberfläche (19) des jeweiligen Unterfensters (16) gesammelt wird, und zwar in einer solchen Art und Weise, dass die Lichtstrahlen (30, 31) zu dem Auslassfenster (8) geleitet werden.

7. Optisches System nach einem der Ansprüche 2 bis 6, wobei jede der Lichtquellen (2) so aufgebaut ist, dass sie einen vierten Lichtstrahl (29) emittiert, der zu den Unterfenstern (16) der anderen Längsteile (9) gerichtet sind, wobei jedes der Unterfenster (16) eine jeweilige zweite Linse (18) aufweist, die eine Vielzahl von Fresnel-Halbringen aufweist, und die konfokal zum Fokus (11) des jeweiligen Längsteils

(9) ist, wobei die Reflektormittel (12) so aufgebaut sind, dass sie den vierten Lichtstrahl (29) jeder Lichtquelle (2) zu den zweiten Linsen (18) der jeweiligen Lichtquelle (2) reflektieren, wobei die zweiten Linsen (18) so aufgebaut sind, dass sie den vierten Lichtstrahl (29) aufnehmen, um ihn zu dem Auslassfenster (8) zu leiten.

8. Optisches System nach einem der Ansprüche 2 bis 7, wobei die Reflektormittel (12) eine Vielzahl von konkaven reflektierenden Oberflächen (13) aufweisen, die jeweils mit einem entsprechenden der Längsteile (9) assoziiert ist, und die jeweils einen halbkreisförmigen Querschnitt in einer Ebene senkrecht zur Längsachse (6) aufweisen.

9. Optisches System nach einem der Ansprüche 5 bis 8, wobei die Reflektormittel (12) eine Vielzahl von konkaven reflektierenden Oberflächen (13) aufweisen, die jeweils mit einem jeweiligen der Längsteile (9) assoziiert sind, und die so positioniert sind, dass der konkave Bereich zu dem Teil der seitlichen Oberfläche (19) des Unterfensters (16) des jeweiligen Längsteils (9) weist.

10. Optisches System nach einem der Ansprüche 5 bis 9, wobei jede der reflektierenden Oberflächen (13) einen ersten Oberflächenteil (27) aufweist, der erhalten wird durch eine Rotation um die Hälfte eines Vollkreises um die optische Achse (10) des jeweiligen Längsteils (9) einer ersten Kurve (25), die in einer Ebene definiert ist, die durch die optische Achse (10) hindurchgeht, und die so aufgebaut ist, dass sie den ersten Lichtstrahl (31) der jeweiligen Quelle in einer solchen Art und Weise abfängt und reflektiert, dass der erste Lichtstrahl (31) selbst durch den Teil der seitlichen Oberfläche (19) des Unterfensters (16) des jeweiligen Längsteils (9) gesammelt wird.

11. Optisches System nach Anspruch 10, wobei die erste Kurve (25) eine Abfolge einer vorbestimmten Anzahl von dritten Kurven, die zueinander einen Radius bilden und die durch jeweilige mathematische Funktionen gebildet sind, aufweist, wobei wenigstens eine der dritten Kurven definiert ist durch eine polynomische Funktion eines Grades höher als 3.

12. Optisches System nach Anspruch 7, wobei die Reflektormittel (12) eine Vielzahl von konkaven reflektierenden Oberflächen (13) aufweisen, die jeweils mit einem jeweiligen der Längsteile (9) assoziiert sind, wobei jede reflektierende Oberfläche (13) einen zweiten Oberflächenteil (16) aufweist, der erhalten wird durch Rotation um die Hälfte eines Vollkreises um die optische Achse (10) des jeweiligen Längsteils (9) einer zweiten Kurve (24), die in einer Ebene definiert ist, die durch die optische Achse (10) hindurchgeht und die aufgebaut ist, um den vierten Lichtstrahl (29) der entsprechenden Lichtquelle (2) abzufangen und ihn auf die zweite Linse (18) des jeweiligen Längsteils (9) zu reflektieren, wobei die zweite Kurve (24) als eine polynomische Funktion des zweiten Grades definiert ist.

13. Optisches System nach einem der vorhergehenden Ansprüche, wobei die Lichtquellen (2) auf jeweiligen Eckpunkten eines regulären Polygons zentriert sind, wobei die optischen Achsen (10) mit gleichem Abstand zu der Längsachse (6) liegen, und zwar in einer solchen Art und Weise, dass jeder Eckpunkt des Polygons im Wesentlichen auf einer jeweiligen optischen Achse (10) liegt.

14. Optisches System nach einem der vorhergehenden Ansprüche, wobei jede der Lichtquellen (2) aufgebaut ist, um eine Lichtstrahlung einer jeweiligen Farbe zu emittieren.

15. Optisches System nach einem der vorhergehenden Ansprüche, wobei das Licht, das jede der Lichtquellen (2) emittiert wird, eine entsprechende Vielzahl von Lichtstrahlen (28 bis 31) aufweist, und wobei der jeweilige Längsteil (9) so aufgebaut ist, dass er die Lichtstrahlen (28 bis 31) aufnimmt und sie zu dem Auslassfenster (8) in jeweilige Richtungen leitet, die mit den jeweiligen optischen Achsen (10) Winkel bilden, die kleiner gleich 10 Grad sind, und zwar in einer solchen Art und Weise, dass die Vielzahl von Lichtstrahlen (28 bis 31), die durch die unterschiedlichen Längsteile (9) gesammelt werden, sich während ihrer Fortpflanzung zu dem Auslassfenster (8) vermischen.

Revendications

1. Système optique destiné à mélanger la lumière émise par une pluralité de sources de lumière (2) ; le système optique (4), comprenant un corps mélangeur optique (5), qui est réalisé en un matériau transparent et présente une fenêtre d'entrée (7) destinée à collecter la lumière émise par les sources de lumière (2), une fenêtre de sortie (8) destinée à distribuer la lumière mélangée, et un axe longitudinal (6) transversal aux fenêtres d'entrée et de sortie (7, 8) ; le système optique (4) étant **caractérisé en ce que** le corps mélangeur (5) comprend une pluralité de parties longitudinales (9) contiguës les unes aux autres, dont chacune est associée à une source de lumière respective parmi lesdites sources de lumière (2), s'étend entre la fenêtre d'entrée (7) et la fenêtre de sortie (8), comporte un axe optique (10) respectif parallèle à l'axe longitudinal (6) et un foyer (11) respectif se trouvant sur l'axe optique (10) dans une position correspondant à la fenêtre d'entrée (7) ; le système optique (4) étant conçu pour être positionné

avec chaque foyer (11) centré sur la source de lumière (2) respective de sorte que la lumière émise par cette dernière, soit collectée et acheminée, vers la fenêtre de sortie (8), par la partie longitudinale (9) respective.

2. Système optique selon la revendication 1, dans lequel ladite fenêtre d'entrée (7) comprend une pluralité de sous-fenêtres (16), dont chacune est associée à une partie longitudinale respective parmi lesdites parties longitudinales (9) ; chacune desdites sources de lumière (2) étant conçue pour émettre un premier faisceau lumineux (31) respectif orienté vers les sous-fenêtres (16) des autres parties longitudinales (9) ; le système optique (4) comprenant des moyen réflecteurs (12), qui sont agencés dans une position correspondant à ladite fenêtre d'entrée (7) de manière à être placés entre les sources de lumière (2) et sont conçus pour réfléchir le premier faisceau lumineux (31) de chaque source de lumière (2) de telle sorte que ledit premier faisceau lumineux (31) soit collecté par la sous-fenêtre (16) correspondant à ladite source de lumière (2).

3. Système optique selon la revendication 2, dans lequel chacune desdites sources de lumière (2) est conçue pour émettre un deuxième faisceau lumineux (28) respectif partageant ledit axe optique (10) de ladite partie longitudinale (9) respective ; chacune desdites sous-fenêtres (16) comprenant une première lentille (17) respective, qui est confocale audit foyer (11) de la partie longitudinale (9) respective et est conçue pour collecter le deuxième faisceau lumineux (28) pour l'acheminer vers ladite fenêtre de sortie (8).

4. Système optique selon la revendication 2 ou 3, dans lequel chacune desdites sources de lumière (2) est conçue pour émettre un troisième faisceau lumineux (30) respectif orienté dans une direction de retrait par rapport aux autres sources de lumière (2) ; chacune desdites sous-fenêtres (16) présentant une partie respective de surface latérale (19), qui est obtenue par une rotation partielle, autour dudit axe optique (10) de la partie longitudinale (9) respective, d'une première ligne brisée (20) définie dans un plan passant à travers l'axe optique (10) et est conçue pour collecter directement le troisième faisceau de lumière (30) de la source de lumière correspondante (2).

5. Système optique selon la revendication 4, dans lequel lesdits moyens réflecteurs (12) sont conçus pour réfléchir ledit deuxième faisceau lumineux (28) de chaque source de lumière (2) de telle sorte que le deuxième faisceau lumineux (28) lui-même soit collecté par la partie de surface latérale (19) de la sous-fenêtre (16) correspondant à ladite source de lumière (2).

6. Système optique selon la revendication 5, dans lequel chacune desdites parties longitudinales (9) comprend une surface latérale (21) respective, qui s'étend entre ladite fenêtre d'entrée (7) et ladite fenêtre de sortie (8), est obtenue par une rotation partielle, autour dudit axe optique (10) de la partie longitudinale (9), d'une deuxième ligne brisée (22) définie dans un plan passant à travers l'axe optique (10), et est conçue pour réfléchir, par une réflexion interne totale, les faisceaux lumineux (30, 31) collectés par ladite partie de surface latérale (19) de la sous-fenêtre (16) respective de manière à acheminer lesdits faisceaux lumineux (30, 31) vers la fenêtre de sortie (8).

7. Système optique selon l'une quelconque des revendications 2 à 6, dans lequel chacune desdites sources de lumière (2) est conçue pour émettre un quatrième faisceau lumineux (29) orienté vers les sous-fenêtres (16) des autres parties longitudinales (9) ; chacune desdites sous-fenêtres (16) comprenant une deuxième lentille (18) respective qui comprend une pluralité de demi-anneaux de Fresnel et est confocale audit foyer (11) de la partie longitudinale (9) respective ; lesdits moyens réflecteurs (12) étant conçus pour réfléchir le quatrième faisceau lumineux (29) de chaque source de lumière (2) vers la deuxième lentille (18) correspondant à ladite source de lumière (2) ; la deuxième lentille (18) étant conçue pour collecter le quatrième faisceau lumineux (29) pour l'acheminer vers ladite fenêtre de sortie (8).

8. Système optique selon l'une quelconque des revendications 2 à 7, dans lequel lesdits moyens réflecteurs (12) comprennent une pluralité de surfaces réfléchissantes concaves (13), dont chacune est associée à une partie longitudinale respective parmi lesdites parties longitudinales (9) et présente une section transversale semi-circulaire dans tout plan orthogonal audit axe longitudinal (6).

9. Système optique selon l'une quelconque des revendications 5 à 8, dans lequel lesdits moyens réflecteurs (12) comprennent une pluralité de surfaces réfléchissantes concaves (13), dont chacune est associée à une partie longitudinale respective parmi lesdites parties longitudinales (9) et est positionnée avec sa concavité opposée à ladite partie de surface latérale (19) de la sous-fenêtre (16) correspondant à ladite partie longitudinale (9).

10. Système optique selon l'une quelconque des revendications 5 à 9, dans lequel chacune desdites surfaces réfléchissantes (13) comprend une première partie de surface (27), qui est obtenue par la rotation, par la moitié d'un cercle entier autour dudit axe op-

tique (10) de la partie longitudinale (9) respective, d'une première courbe (25) définie dans un plan passant à travers l'axe optique (10), et est conçue pour intercepter et réfléchir ledit premier faisceau lumineux (31) de la source respective de telle sorte que le premier faisceau lumineux (31) lui-même soit collecté par ladite partie de surface latérale (19) de la sous-fenêtre (16) correspondant à ladite partie longitudinale (9).

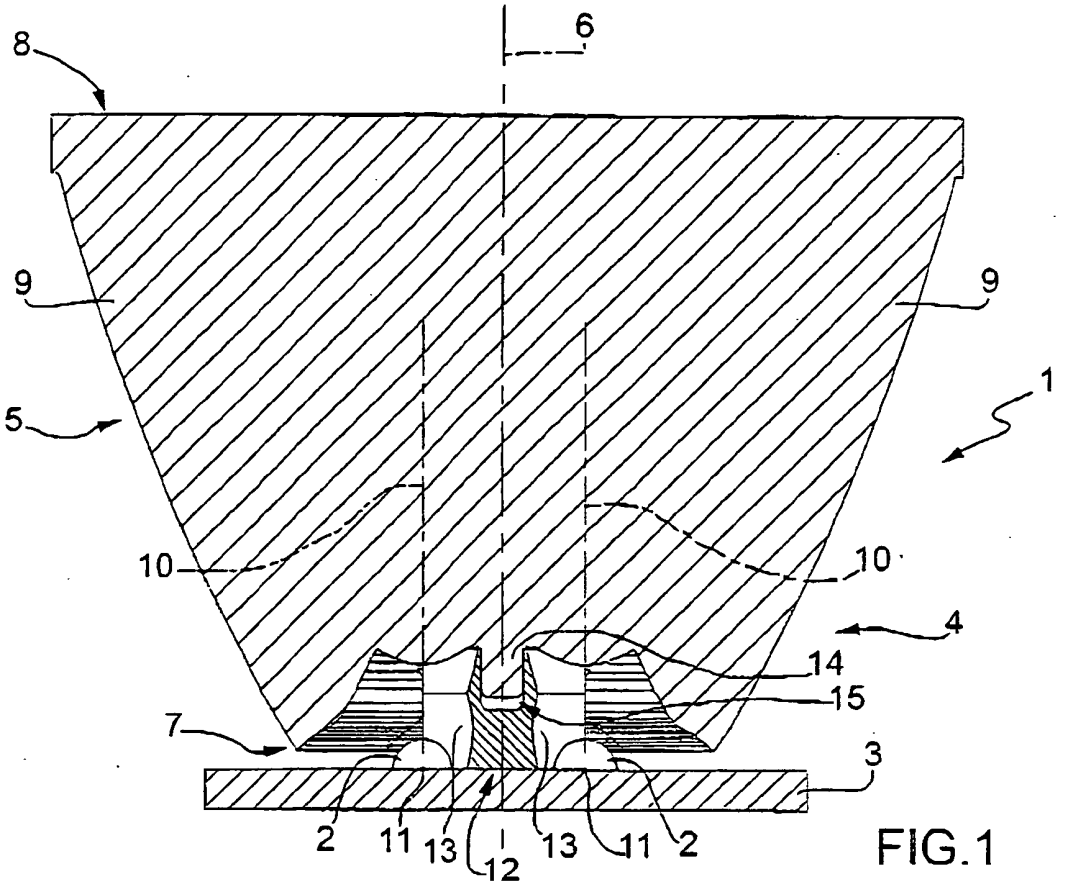
11. Système optique selon la revendication 10, dans lequel ladite première courbe (25) comprend une série d'un nombre prédéfini de troisièmes courbes arrondies les unes envers les autres et définies par des fonctions mathématiques respectives ; au moins l'une desdites troisièmes courbes étant définie par une fonction polynomiale de degré supérieur à trois.

12. Système optique selon la revendication 7, dans lequel lesdits moyens réflecteurs (12) comprennent une pluralité de surfaces réfléchissantes concaves (13), dont chacune est associée à une partie longitudinale respective parmi lesdites parties longitudinales (9) ; chaque surface réfléchissante (13) comprenant une deuxième partie de surface (26), qui est obtenue par la rotation, par la moitié d'un cercle entier autour dudit axe optique (10) de la partie longitudinale (9) respective, d'une deuxième courbe (24) définie dans un plan passant à travers l'axe optique (10), et est conçue pour intercepter ledit quatrième faisceau lumineux (29) de la source de lumière (2) respective afin de le réfléchir sur ladite deuxième lentille (18) correspondant à ladite partie longitudinale (9) ; ladite deuxième courbe (24) étant définie par une fonction polynomiale du second degré.

13. Système optique selon l'une des revendications précédentes, dans lequel lesdites sources de lumière (2) sont centrées sur des sommets respectifs d'un polygone régulier ; lesdits axes optiques (10) étant définis à des distances égales par rapport audit axe longitudinal (6) de telle sorte que chaque sommet dudit polygone soit situé essentiellement sur un axe optique (10) respectif.

14. Système optique selon l'une des revendications précédentes, dans lequel chacune desdites sources de lumière (2) est conçue pour émettre un rayonnement lumineux d'une couleur respective.

15. Système optique selon l'une des revendications précédentes, dans lequel ladite lumière émise par chacune desdites sources de lumière (2) comprend une pluralité respective de faisceaux lumineux (28-31), et ladite partie longitudinale (9) respective est conçue pour collecter lesdits faisceaux lumineux (28-31) et les acheminer vers la fenêtre de sortie (8) dans des directions respectives formant, avec ledit axe optique (10) respectif, des angles inférieurs ou égaux à 10° de telle sorte que la pluralité de faisceaux lumineux (28-31) collectés par les diverses parties longitudinales (9) se mélangent les uns avec les autres pendant leur propagation vers la fenêtre de sortie (8).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6
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FIG.1

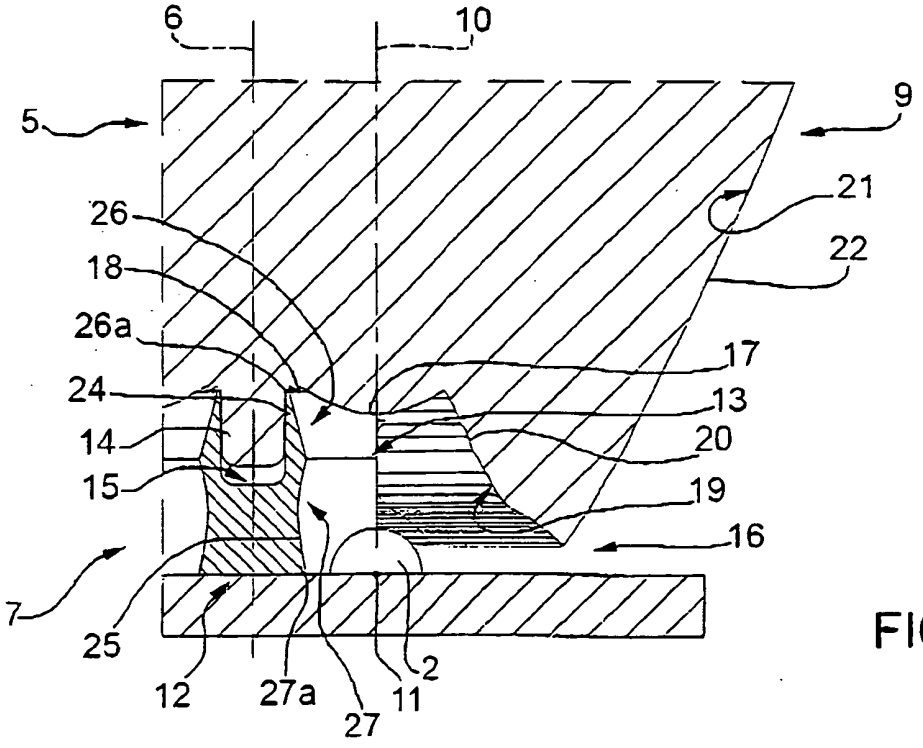
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FIG.2

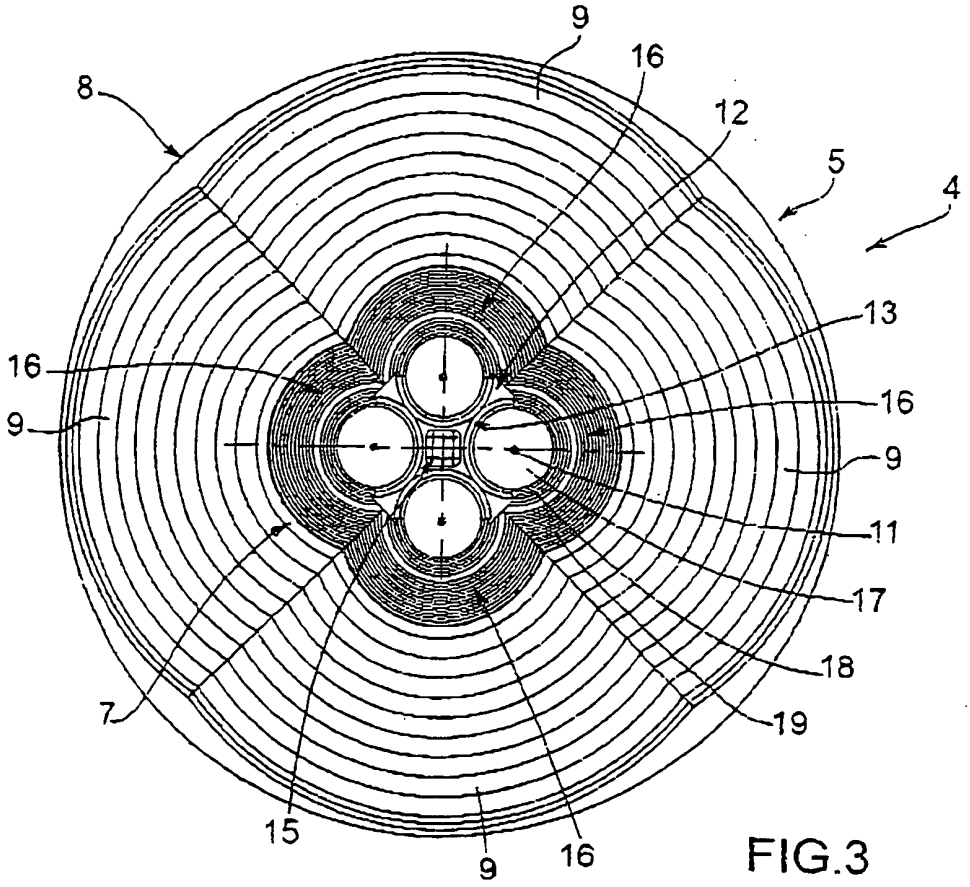
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FIG.3

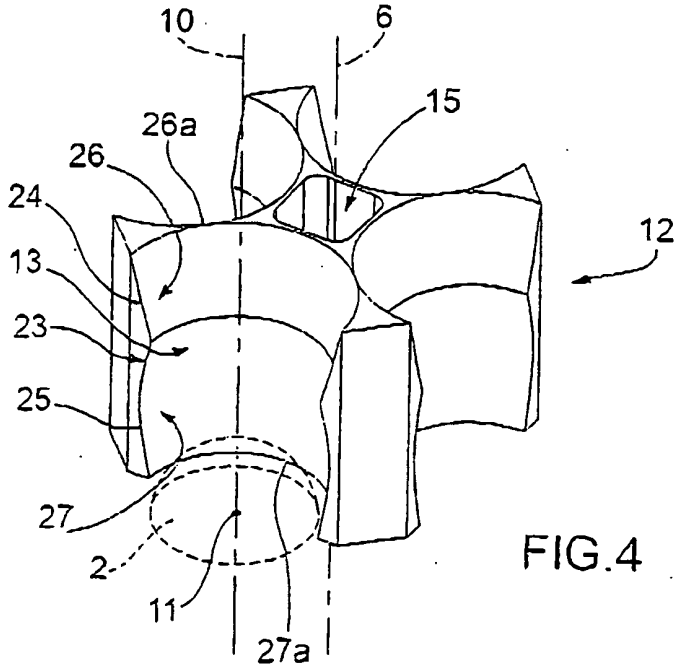
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FIG.4

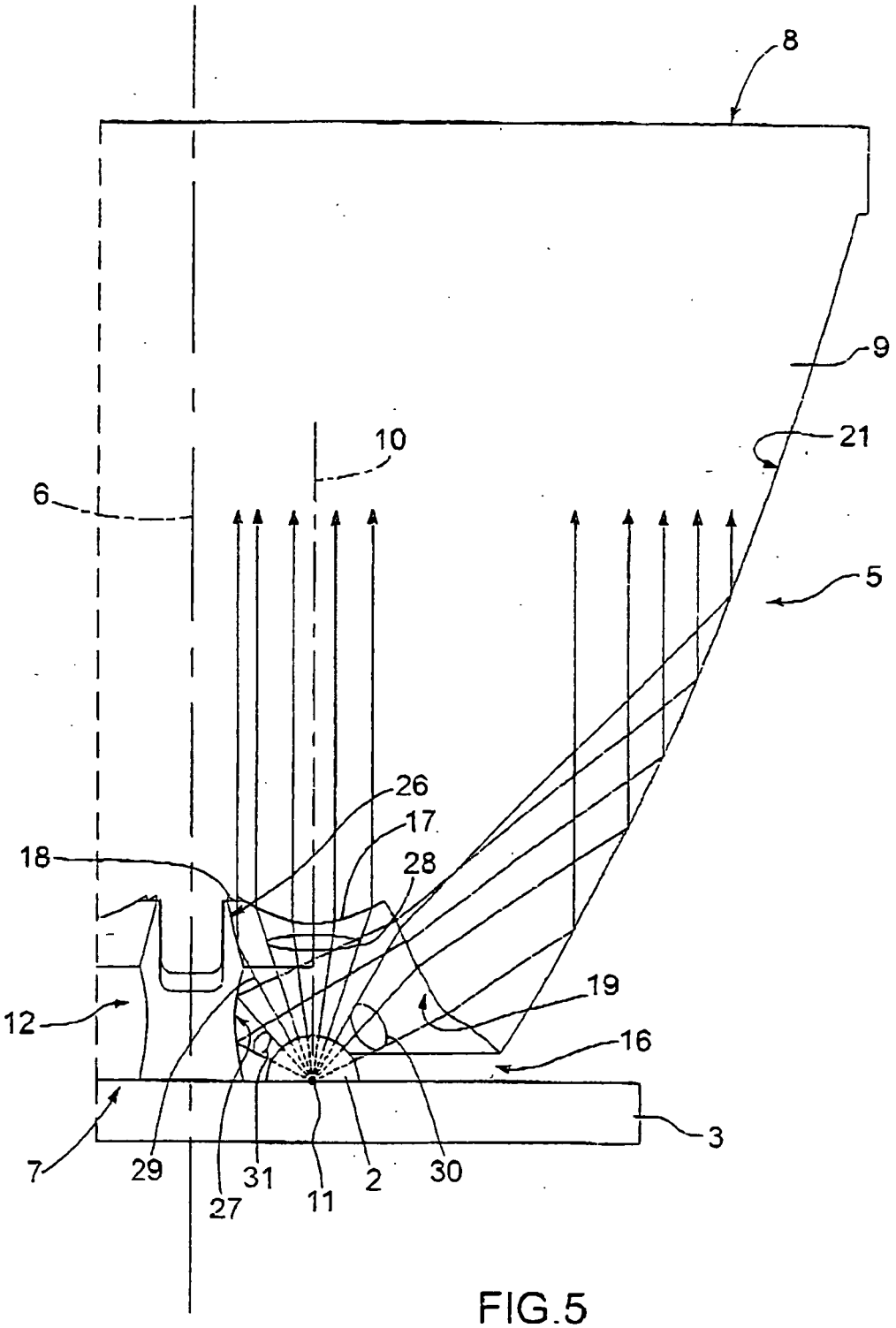

FIG.5