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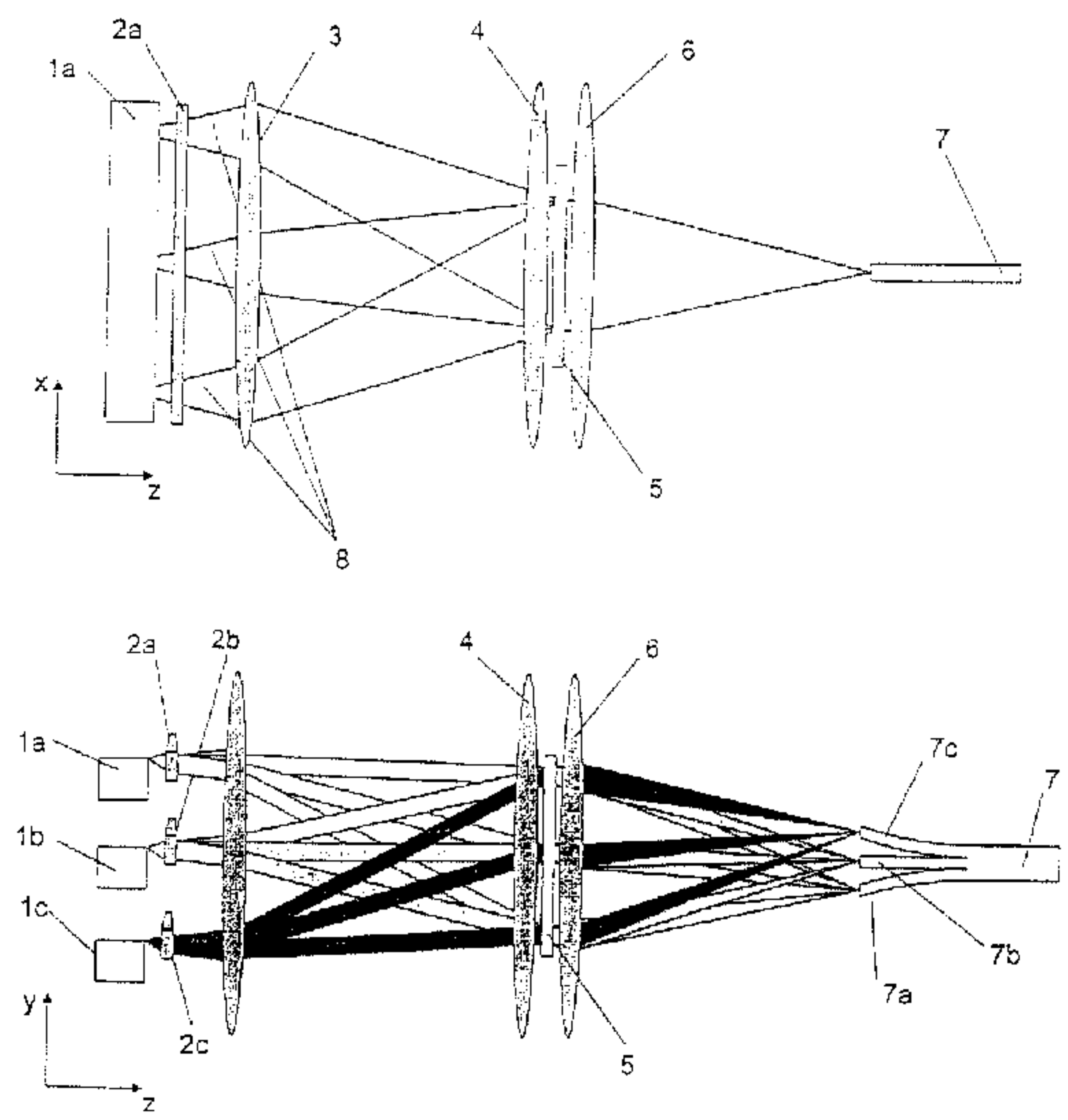
(54) Titre : DISPOSITIF OPTIQUE POUR RENDRE SYMETRIQUES LES RAYONNEMENTS DE RESEAUX BIDIMENSIONNELS DE DIODES LASER

(54) Title: OPTICAL ARRANGEMENT FOR SYMMETRIZING THE RADIATION OF TWO-DIMENSIONAL ARRAYS OF LASER DIODES



(57) Abrégé/Abstract:
The invention relates to an optical arrangement for symmetrizing the radiation of a plurality of laser diodes that are arranged adjacently to each other and on top of each other, in a fixed manner relative to each other. The output radiation of each laser diode is unsymmetrical in relation to a first direction (the y axis) and a second direction (the x axis) which are perpendicular in relation to each other. The inventive optical arrangement is particularly for use for symmetrizing the radiation of laser diode bars that are stacked on top of each other, forming a laser diode stack. A plurality of microcylindrical lens units (2a, 2b, 2c) with sufficient isoplanacy are arranged in such a way that they are tilted about the optical axis (the z axis) of the designated linear array of laser diodes, collimate the output beam bundles of the individual laser diodes of the designated linear array of laser diodes in direction y, deviating said output beam bundles to different degrees and separating them as they do so. The bundles (8) output from the laser diodes that are arranged on top of each other in direction y coincide at a set distance. A directional element (3) is mounted downstream of the microcylindrical lens unit (2a, 2b, 2c). This directional element diverts the beam bundle (8) of the individual laser diodes that are arranged adjacently to each other in direction x with different angles of deflection respectively, so that the central points of the individual beam bundles (8) coincide at a set distance. A redirecting element (5) is located at a distance behind the directional element (3) and compensates the different angles of deflection of the beam bundles (8) introduced by the directional element (3) in the plane xz.

Abstract

Optical arrangement for symmetrizing the beams of a plurality of laser diodes arranged next to one another and above one another in a fixed allocation whose respective output beam is asymmetrical with respect to a first direction (y axis) and a second direction (x axis) that are perpendicular to one another, in particular for symmetrizing the beams from laser diode bars stacked above one another into a laser diode stack, with a plurality of microcylinder lens optics (2a, 2b, 2c) with sufficient isoplanacy being arranged in an inclined manner around the optical axis (z axis) of the assigned linear array of laser diodes, which optics collimate the exit beams of the individual laser diodes of the assigned linear array of laser diodes in the y direction and deflect them to different degrees, thus separating them, and the beams (8) emitting from the laser diodes arranged above one another in the y direction converging at a predetermined distance, and with a direction element (3) being arranged downstream of the microcylinder lens optics (2a, 2b, 2c), which direction element deflects in the x direction the beam (8) of the individual laser diodes arranged next to one another in the x direction in such a way that the central points of the individual beams (8) converge at a predetermined distance and with a redirection element (5) being arranged at a distance behind the direction element (3), which redirection element recompensates for the different deflection angles of the beam (8) in the x-z plane.

Optical Arrangement for Symmetrizing the Radiation of Two-Dimensional Arrays of Laser Diodes

The invention relates to an optical arrangement for symmetrizing the beams from laser diodes in accordance with the preamble of the primary claim.

For the production of high-power laser diode arrangements, a multitude of laser diodes are arranged next to one another in a fixed allocation relative to so-called laser diode bars. Such bars achieve optical output up to approximately 40W and comprise individual emitters arranged in a row with typical dimensions of the radiating surface from 50µm x 1 µm to 200µm x 1µm, with the linear arrangement of these emitters always occurring in the direction of their greatest expansion. In order to achieve even greater outputs, such laser diode bars are stacked on top of one another in the direction of the small extension of the emitters into laser diode stacks. The emission of these stacks is extremely asymmetrical and has a low radiance due to the non-radiating regions between the individual emitters of a bar and among the bars as compared to the individual emitters.

In order to achieve a symmetrical bundle with the greatest possible radiance as is needed, for example, for material processing or for pumping of solid state lasers, optical systems are necessary that, on the one hand, cause a symmetrizing of the beams as well as a fading-out of the non-radiating regions for the purpose of maintaining the radiance.

Arrangements for symmetrizing laser diode stacks are known, for example, for connection to optical fibers and/or focusing in a focal spot. Here, depending on the requirements with regard to symmetrizing and radiance, different concepts are prior art.

The coupling of a stack is described in DE 195 00 513 C1. Here, it is disadvantageous that the minimum distance between the individual bars is three times the thickness of the collimation lenses, which may obstruct the integration of as great as possible a number of bars for a given height.

While an arrangement according to DE 195 44 488 does allow a scaling to very high outputs by using many bars, the radiance achieved is at least one order of magnitude less than the fiber-coupled laser diode bars, such as those according to DE 44 38 368.

Moreover, an optical arrangement of multiple laser diodes arranged next to one another in a fixed allocation for symmetrizing of beams is known (DE 196 45 150 A1). The symmetrizing arrangement here comprises a cylinder lens rotated around the optical axis, a directional lens for deflecting the radiation beams of the individual laser diodes, a redirection lens for compensating the deflection of the directional lens, and a subsequent collimation lens.

The object of the invention is to create an optical arrangement for symmetrizing the beam of a scaleable number of laser diode bars that comprises micro-optic components that are comparably simple to produce, is accessible to a cost-effective miniaturization, and with which the losses in radiance accompanying the symmetrizing are as small as possible. In particular, an improvement of the radiance should be attained as compared to fiber-coupled laser diode bars.

This object is attained according to the invention using the characterizing features of the primary claim in connection with the features of the preamble.

Preferred exemplary embodiments are the object of subclaims 2 to 5.

Using a microcylinder lens that is assigned to each individual bar and inclined to its optical axis (z-axis), the beams emitted by the individual emitter of each bar in the direction of the stack of the laser diode bars is collimated, differently deflected, and thus separated. This deflection occurs such that the centers of the beams of individual emitters of different bars lying above one another impact a redirection element at the same height in this direction at a predetermined distance. A direction element located downstream from the microcylinder lenses causes a deflection of the beams of the individual emitters of a bar in the direction of the linear arrangement of the individual emitter such that the beam centers of the emitters of one bar occur at a predetermined distance on the redirection element in this direction. Moreover, the direction element deflects the beam centers of the individual bars in the direction of the stack such that all centers in the stack direction also fall on the redirection element. The redirection element deflects the emission beams originating from the individual emitters such that the deflection angles produced by the direction element are compensated again. A projection lens adjacent to the redirection element projects the beams of each bar in a focal spot, located at a predetermined distance. These focal spots are coupled into the face surfaces positioned there of the spread fibers of an optical fiber bundle. This bundle causes the focal spots, which were originally arranged one above the other in the direction of the stacking of the bars, to be rearranged into the desired symmetrical total focal spot.

By means of the multiple use of the direction and redirection element and the projection lens for all bars, the arrangement thus described allows a simple and cost-effective symmetrizing of the radiation from laser diode stacks while maintaining the radiance of the individual emitters to the greatest extent possible.

An exemplary embodiment is shown in the drawings and is explained in greater detail in the description below. Shown are:

Fig. 1 the optical arrangement for symmetrizing the beams of a two-dimensional array of laser diodes using a fiber bundle and

Fig. 2 The optical arrangement for symmetrizing the beams of a two-dimensional array of laser diodes using additional deflecting elements.

In the optical arrangement shown in Fig. 1, 1a, 1b, 1c indicate three laser diode bars stacked in the y direction, where the limitation to three bars 1a, 1b, 1c is solely for the purpose of an improved depiction. Each of these bars 1a, 1b, 1c comprises a plurality of individual emitters arranged in the x direction; for the sake of simplicity, only the two outer emitters and the center emitter are shown here. The divergence of the beams of each emitter is relatively large in the y-z plane (fast axis), the half angle of beam spread is 30° or greater. In the x-z plane (slow axis), on the other hand, the divergence of the beams of each emitter is comparatively low. Here, the half angle of beam spread is typically approximately 6°. The total extension of the bars 1a, 1b, 1c in the slow axis is typically 10 mm. The stack distance of the bars 1a, 1b, 1c from one another is in the range of approximately 0.1 to several millimeters.

A microcylinder lens 2a, 2b, 2c is assigned downstream of each of the individual bars 1a, 1b, 1c. In the path of the beams, a direction element 3 and a lens 4, a redirection element 5 and another lens 6 as well as optical fibers 7a, 7b, 7c joined into an optical cable bundle 7 follow in the sequence.

The microcylinder lenses 2a, 2b, 2c, which are inclined relative to the z axis, collimate the beams of the individual emitters of different bars 1a, 1b, 1c arranged one above the other and deflect the beam of the individual emitters, indicated in the drawings by 8, on the same height to the redirection element 5 such that the beams 8 of the emitter of a bar 1a, 1b, 1c are separated. Preferably, gradient optical cylinder lenses or multi-component cylinder lenses with sufficient isoplanacy are used as microcylinder lenses 2a, 2b, 2c. Typical focal lengths of the microcylinder lenses 2a, 2b, 2c lie in the range of 100 μm to approximately 1 mm.

The direction element 3 causes a deflection of the individual beams 8 of the emitters in the slow axis and a similar deflection of the beams of all emitters of each individual bar in the fast axis such that the beams 8 of the emitters of a bar 1a, 1b, 1c meet at the same x position and the central points of the beams of each bar meet at the same y position on the redirection element 5.

Plano-convex or biconvex lenses or doublets, preferably with a large field angle, with spherical or aspherical surfaces may be used as the direction element 3

Another possible implementation is combinations of these directional lenses 3 with prism arrays 9 according to Fig. 2, which cause a displacement of the beams 8 of the individual bars 1a, 1b, 1c on the redirection element 5 in the slow axis. Here, a prism 9a, 9b, 9c that deflects in the slow axis is assigned to each bar 1a, 1b, 1c. By means of the separation of the central points of the beams of the individual bars 1a, 1b, 1c on the redirection element 5 thus achieved, a position of the focal spots for each bar 1a, 1b, 1c in the y direction can be individually achieved, provided that the redirection element 5 is appropriately constructed, for example, the individual focal spots can also be positioned precisely on top of one another. Alternately, the combination of the direction lens 3 and the prism array 9 can be achieved by a dismantling of the direction lens 3 into several segments arranged in the slow axis displaced relative to one another. The focal lengths of the direction element 3 typically lie in the range of several mm to several 10 mm.

The redirection element 5 and the projection lens 4, 6 are located downstream of the direction element 3 (see Fig. 1). In the concrete implementation, the lens 4, whose focal length corresponds to the focal length of the director, follows first. This first lens 4 of the projection lens causes a collimation of the beam bundles of the individual emitters in the slow axis. This allows an almost aberration-free operation of the redirection element 5. The embodiment options for the first lens 4 of the projection lens correspond to the variants for the direction element 3.

The redirection element 5 comprises a number of elements stacked in the fast axis with a deflecting effect in the slow axis, for example, an array of blazed gratings, a stack of prisms, or a mirror array. After the redirection element 5, a collimated beam is obtained from each bar 1a, 1b, 1c with a right-angle or square cross-section. The beam direction of this collimated beam from the redirection element 5 in the fast axis is different for each bar 1a, 1b, 1c.

If a separation of the beams 8 of the individual bars 1a, 1b, 1c is attained on the redirection element 5 in the slow axis by means of a combination of the direction lens 3 and the prism arrays 9 as in Fig. 2, these different beam directions can be compensated by appropriate elements 10 in the vicinity of the redirection element 5 that deflect in the fast and slow axes. These elements 10 may be implemented using, for example, additional prisms in the vicinity of the redirection element 5, using an appropriate construction of the redirection element 5, for example, as an array of two-dimensional deflecting blazed grating, or a combination of these elements. Thus, after the redirection element 5, an extensively symmetrical, collimated beam with a high radiance is present. For applications in which a collimated beam with a right-angular cross-section is needed, the second lens 6 of the projection lens, which would otherwise follow here, may be omitted.

Conventionally, however, a focused exiting beam is needed. The subsequent lens 6 forms images of the individual emitters of the respective bar 1a, 1b, 1c into one common focal spot.

Shown in Fig. 1 are the focal planes of the optic fibers 7a, 7b, 7c assigned to the lens 6, into which the overlapping images of the emitters of each bar 1a, 1b, 1c are coupled. By combining the optic cables 7a, 7b, 7c into a fiber bundle 7, the desired symmetrical bundle cross-section with the greatest maintenance of radiance is attained.

If, as shown in Fig. 2, the variant of the combination of the director lens 3 and the redirector 5, each with a prism array 9 or 10, is realized, a common focal spot is achieved for all bars 1a, 1b, 1c in the focal plane of the lens 6. Thus, a spread fiber bundle for combining the focal spots of the individual bars 1a, 1b, 1c is not necessary in this implementation.

Claims

1. Optical arrangement for symmetrizing the beams of a plurality of laser diodes arranged next to one another and above one another in a fixed allocation, whose respective emitted beams are asymmetrical relative to a first direction (y axis) and a second direction (x axis) that run perpendicular to one another, in particular for symmetrizing the beams from laser diode bars stacked on top of one another to form a laser diode stack,

   characterized in that

   a plurality of microcylinder lens optics (2a, 2b, 2c) with sufficient isoplanacy are arranged in an inclined manner around the optical axis (z axis) of the assigned linear array of laser diodes, which collimate the exit beams of the individual laser diodes of the assigned linear array of laser diodes in the y direction and deflect them with different angles, thereby separating them,

   in that a direction element (3) is arranged downstream of the microcylinder lens optics (2a, 2b, 2c), which direction element deflects the beam (8) of the individual laser diodes arranged next to one another in the x direction in the deflection angles, which are each different in the x direction, in such a way that the central points of the individual beams (8) converge at a predetermined distance in the x direction and deflects the beam of each individual linear laser diode array in the y direction in such a way that this beam converges at a predetermined distance in the y direction, and

   in that, at a distance behind the direction element (3), a redirection element (5) is arranged which again compensates for the different angles of deflection of the beams (8) sent through the direction element (3) in the x-z plane.

2. Arrangement according to claim 1, characterized in that a projection lens (4, 6) is

assigned to the redirection element (5), which projection lens directs the beams (8) of all laser diodes lying next to one another in the x direction into one common focal spot each that is coupled into spread individual fibers (7a, 7b, 7c) of a fiber bundle (7) and, in this manner, unified into one common focal spot.

3. Arrangement according to one of claims 1 to 2, characterized in that each of the microcylinder lenses (2a, 2b, 2c) has a gradient optical microcylinder lens (GRIN), a spherical or aspherical microcylinder lens, a Fresnel lens, and/or a combination of the same.

4. Arrangement according to one of claims 1 to 3, characterized in that the direction element (3) is embodied as a doublet, biconvex, or planoconvex lens with spherical or aspherical surfaces.

5. Arrangement according to claim 1 or 3 to 4, characterized in that the direction element (3) has an optical element (9) assigned to it that evenly deflects the beams of the laser diodes arranged next to one another in the x direction in such a way that the beams of laser diodes arranged above one another in the y direction are separated from one another at a predetermined distance in the x direction.

6. Arrangement according to claim 5, characterized in that an array of blazed gratings, a prism stack, or a mirror stack serves as the deflecting element (9).

7. Arrangement according to claim 5, characterized in that the deflection function in the x direction is realized by sectioning the direction element and subsequently joining the sections such that they are displaced relative to one another in the x direction.

8. Arrangement according to one of claims 1 to 7, characterized in that an array of blazed gratings, a prism stack, or a mirror stack serves as the redirection element (5).

9. Arrangement according to one of claims 5 to 7, characterized in that an element (10) that deflects in the y direction is assigned to the redirection element (5) and deflects the beams (8) of the individual bars (1a, 1b, 1c) in the y direction in such a way that they leave the redirection element (5) parallel to the z axis.

10. Arrangement according to claim 9, characterized in that an array of blazed gratings, a prism stack, or a mirror stack serves as the deflecting element (10).

11. Arrangement according to claim 9, characterized in that the function of the redirection element (5) as well as that of the deflecting element (10) is realized by means of a diffractive element.

12. Arrangement according to one of claims 1 to 11, characterized in that a lens (4) is located upstream of the redirection element (5), which lens causes a collimation of the individual beams (8) in the x direction.

13. Arrangement according to claim 12, characterized in that the lens (4) located upstream of the redirection element (5) is embodied as a doublet, biconvex, or planoconvex lens with spherical or aspherical surfaces.

14. Arrangement according to one of claims 1 to 13, characterized in that a focusing lens (6) is arranged downstream of the redirection element (5) and focuses the beams (8) into one or more focus spots.

15. Arrangement according to claim 14, characterized in that the focusing lens (6) is embodied as an achromate, an achromate and a meniscus lens, a planoconvex lens, a planoconvex lens and a meniscus lens, or a biconvex lens with either a spherical or aspherical profile form.

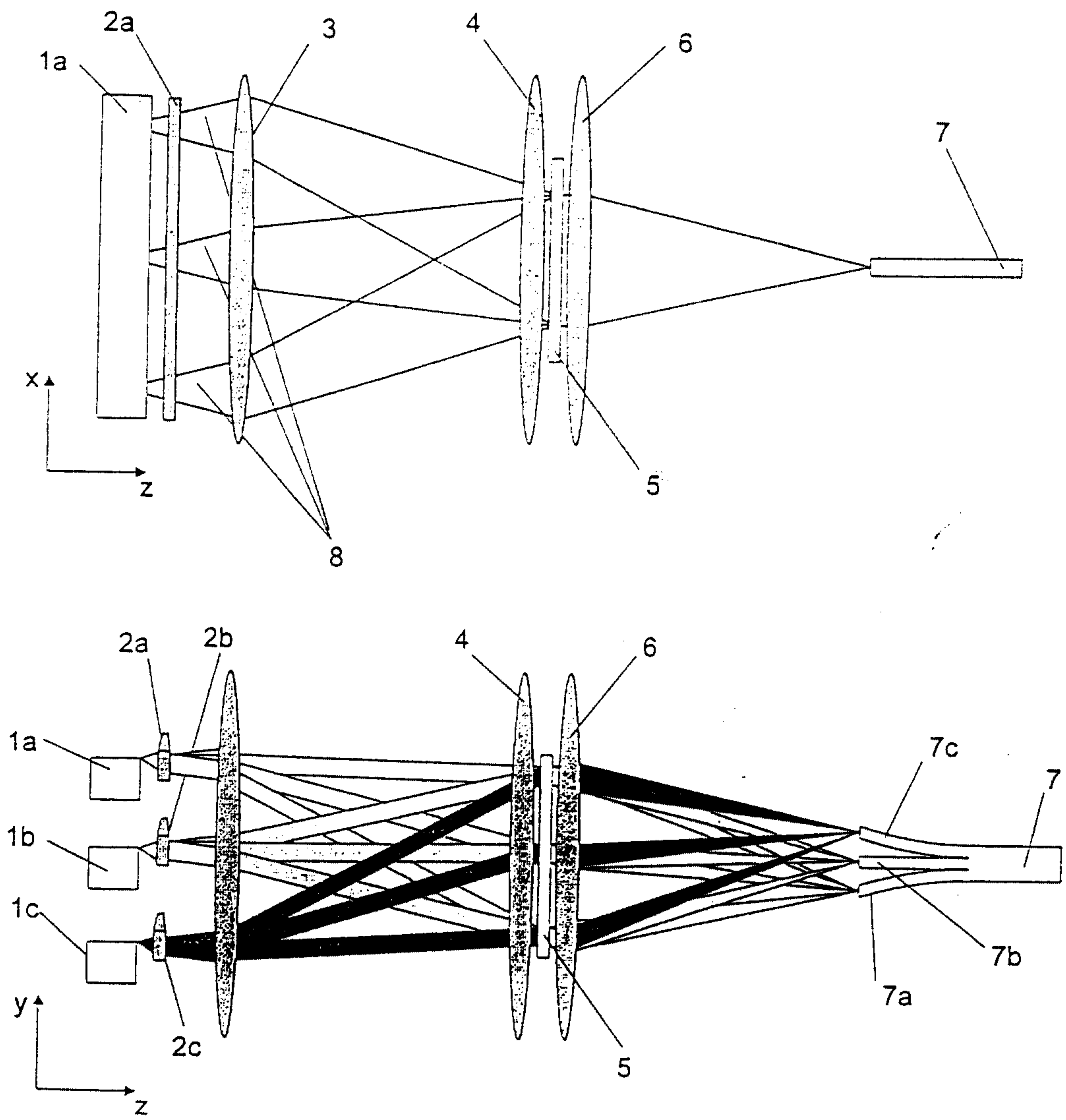


Fig. 1

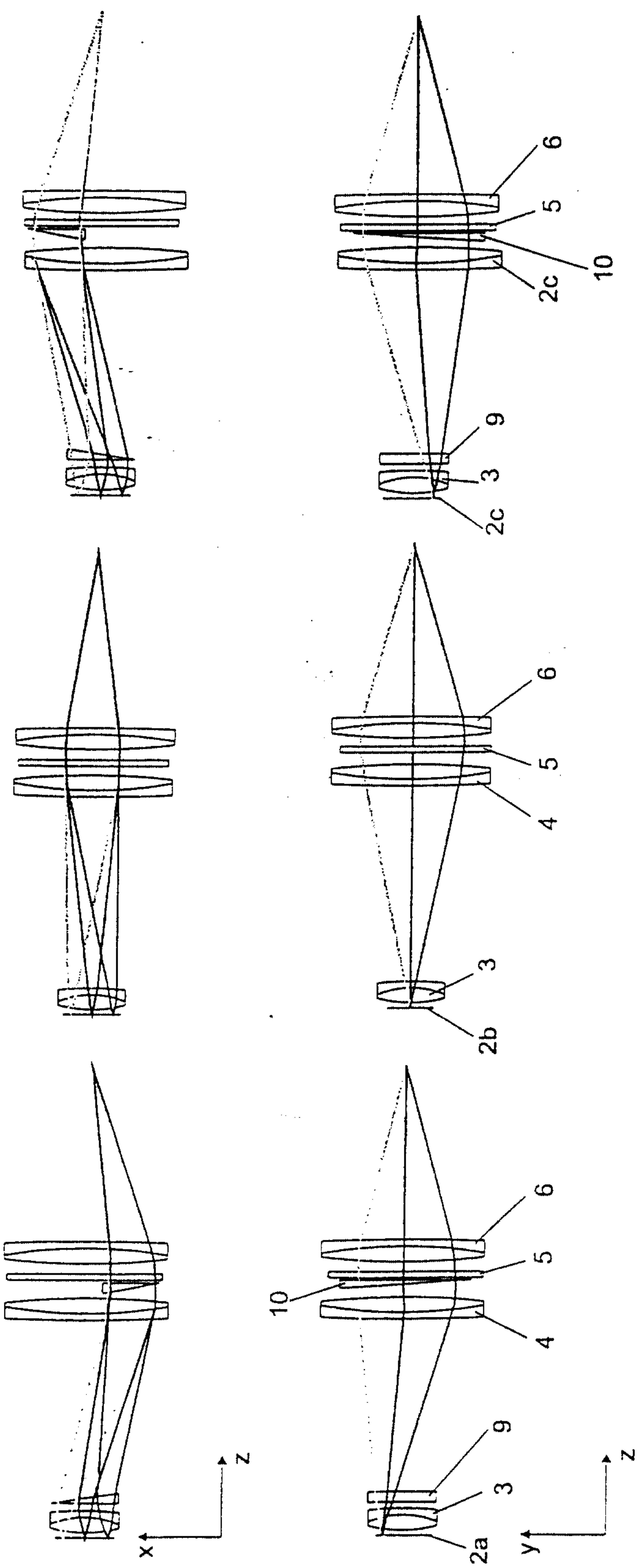
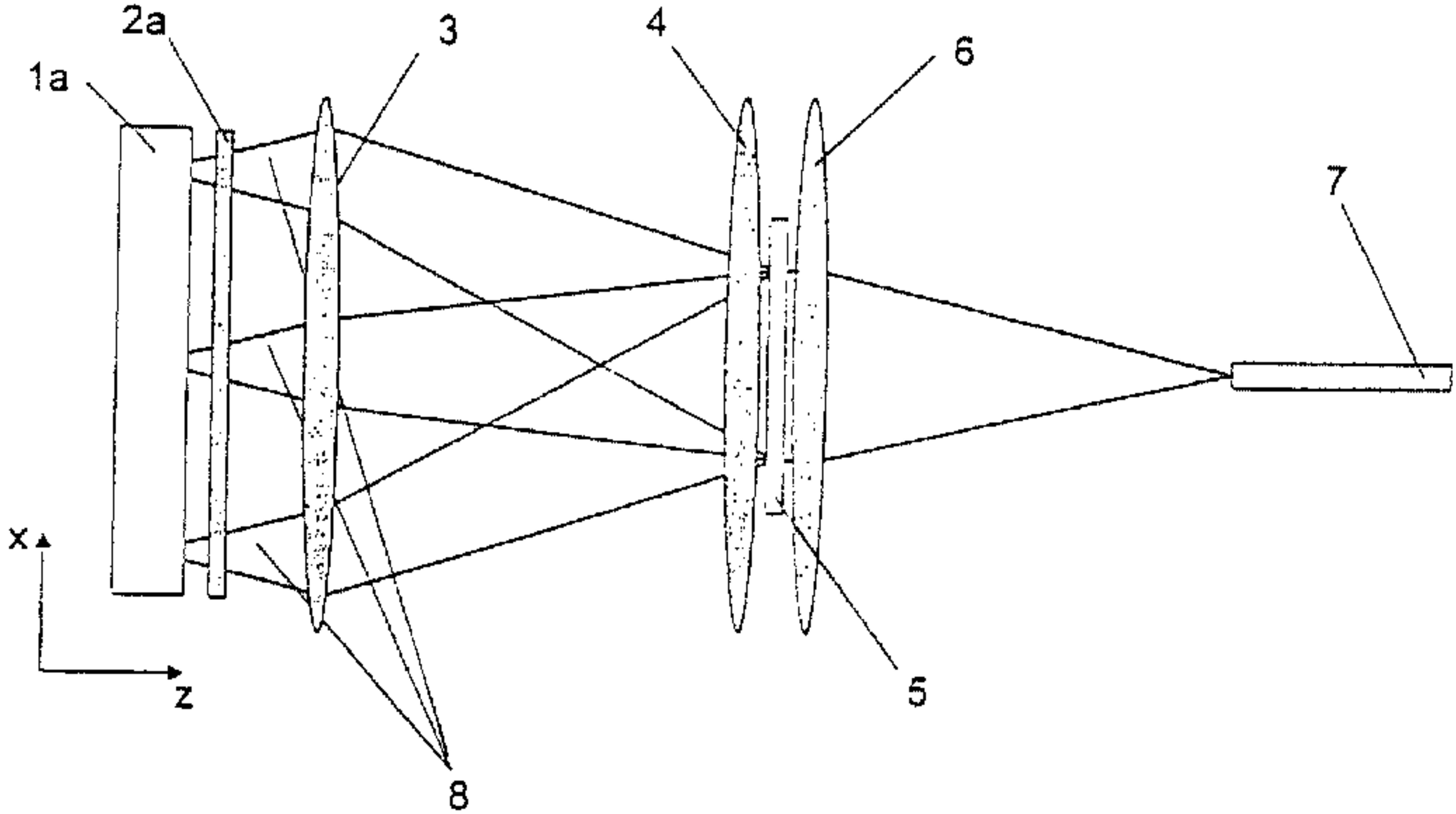


Fig. 2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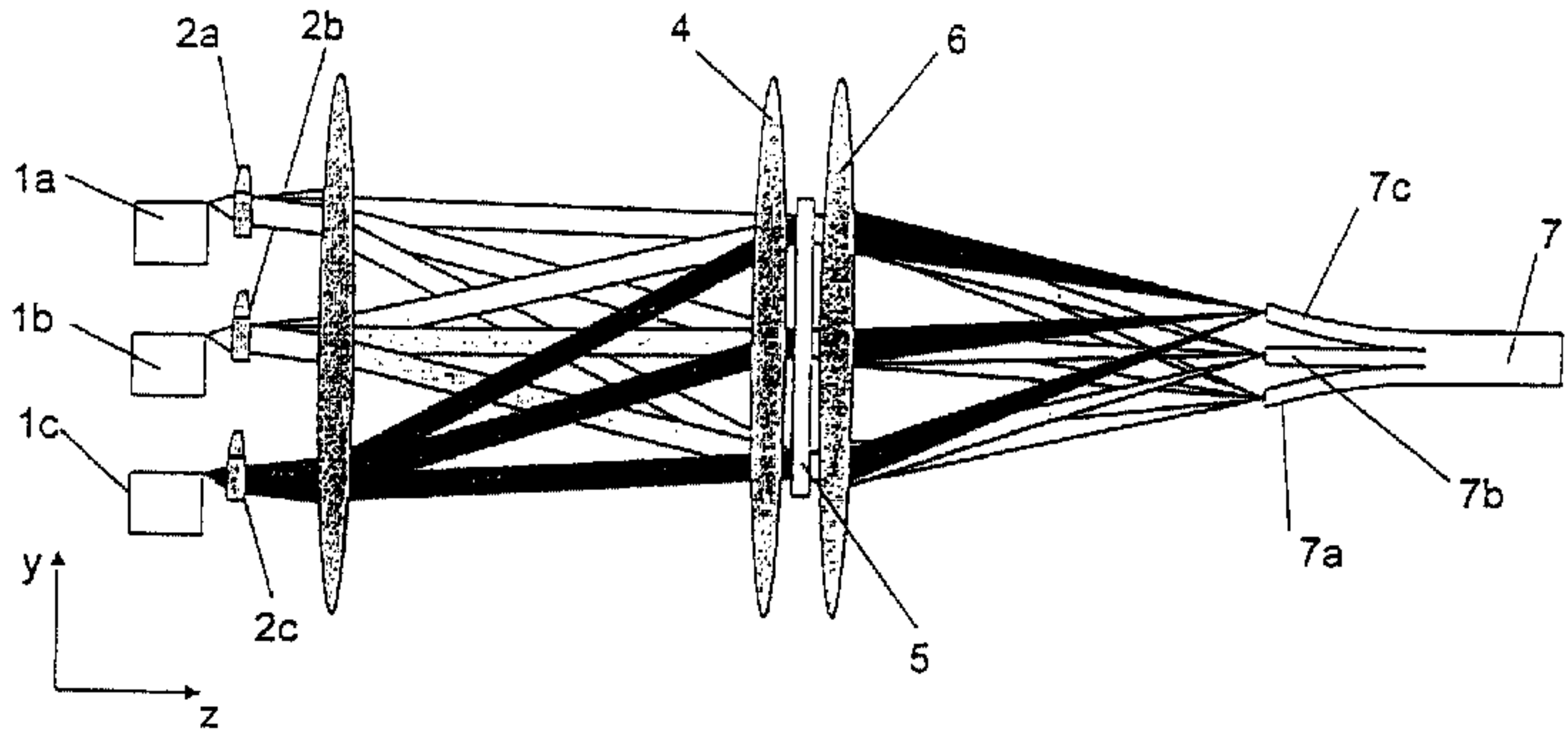
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