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(54) Benævnelse: **SYSTEM, APPARAT OG KØRETØJ TIL REGISTRERING AF PANORAMABILLEDER**

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DESCRIPTION

[0001] The present invention relates to a system, a device, and vehicle for recording panoramic images.

[0002] A panoramic image is an image with an elongated field of view (FOV). Normally, an optical camera records an image with a limited field of view as defined by the photosensitive component and lens system of the camera. In order to obtain a image of a wider format, one has to use different additional lenses, such as a fisheye lens, or one has to combine multiple images to provide the impression of one large image. The latter process requires stitching of the images. Normally, the multiple images have a slight overlap in their field of view such that an interpolation process can be used to determine the image properties in the overlapping region.

[0003] A drawback of combining multiple images is that it is prone to parallax errors. These errors originate from the fact that the multiple images are not recorded from the same position. A solution to this problem is to use rotatable cameras which are mounted on a stand. By making sure that the entrance pupil of the camera remains substantially at the same position, albeit rotated, one can reduce parallax errors to an acceptable degree.

[0004] Using a single camera to record a plurality of images that are later combined into a single panoramic image limits the applicability of the technique to the recording of static environments only. Moreover, such technique is not suitable for recording movies as this would require the camera to rotate at impractical speeds. Moreover, such system is not suitable for applications in which the camera itself is moving. Examples of such applications are the recording of panoramic images for navigational systems or derivatives thereof such as Google Street View.

[0005] A solution to this problem has been disclosed in US 2002/0089765 A1. The system described therein uses a reflective pyramid in which the reflective sidewalls are under a 45° angle with respect to the base of the pyramid. Cameras are positioned relative to each of the sidewalls such that each camera appears to record an image from a virtual reference point inside the pyramid. In other words, the images recorded by these cameras are identical to the images that would have been recorded by a virtual optical camera positioned at the reference point. Here, reference point corresponds to the position of the entrance pupil of the virtual camera. Using a pyramid with four sidewalls therefore results in four images from four different orientations which can later on be combined into one panoramic image. Moreover, the images making up the larger panoramic image, the so called partial images, appear to have been recorded at substantially the same position of the entrance pupil, thereby reducing or eliminating parallax errors.

[0006] A recent trend or desire is to obtain panoramic images with very high resolution, for instance for making detailed measurements in those images. Furthermore, to be able to derive

useful information from these images, they need to be metrically correct. These desires can only be partially met by the abovementioned system. Given an optical camera with a predefined resolution one can increase the resolution of the panoramic image by increasing the number of cameras used. This allows a camera to use its full resolution for a relatively small field of view.

[0007] A solution to this problem is presented in EP 0 982 946 A1. This system resembles that of US 2002/0089765 A1 with the exception that it describes how different pyramids may be stacked in the vertical direction.

[0008] A drawback of the abovementioned system is that it is difficult to stitch the various partial images that are capture by the cameras. To ensure proper stitching, an overlapping region in adjacent partial images is preferred. By using cameras with overlapping FOVs, as disclosed in EP 0 982 946 A1, such overlap can be realized. Unfortunately, the regions of overlap correspond to physical boundaries of the system, such as edges of mirrors or lenses. These boundaries introduce unwanted deformations in the partial images, thereby deteriorating the stitching process.

[0009] It is therefore an object of the present invention to provide a solution to the abovementioned problem such that high resolution parallax error free panoramic images can be recorded.

[0010] According to a first aspect of the invention, this object is at least partially achieved with a system for recording panoramic images as defined in claim 1.

[0011] The system of the present invention comprises a device for recording panoramic images, wherein the panoramic images are formed using a plurality of partial images. The device comprises a frame and a plurality of optical pairs, each optical pair comprising a light directing element and an optical camera having an entrance pupil. The light directing element of each optical pair is arranged at a point on a respective parabola, perpendicular to a tangent thereof. The respective parabola has an axis of symmetry and a focus point. The axis of symmetry runs through the vertex and focus point of the parabola.

[0012] The light directing element and optical camera of each optical pair are connected to the housing in such a manner that the optical camera records an image obtained via the light directing element as if it were positioned with its entrance pupil at the respective focus point. Hence, each optical pair is assigned a respective focus point and the optical camera appears to have its entrance pupil positioned at the respective focus point.

[0013] Each optical pair defines a field of view (FOV) representing a segment of an environment of the device from which light can be captured via directing thereof by the light directing element onto an entrance pupil of the respective optical camera.

[0014] The respective focus points of the plurality of optical pairs substantially overlap each

other. This allows a parallax error free or error reduced panoramic image. The wording substantially is used here because for some of the plurality of optical pairs, a slight offset between focus points is desired as will be described later.

[0015] The axes of symmetry of the respective parabolas of at least two optical pairs of the plurality of optical pairs are substantially parallel. FOVs defined by these at least two optical pairs are adjacent in a direction parallel to the substantially parallel axes of symmetry.

[0016] For instance, if the axes of symmetry extend along a vertical direction, the FOVs defined by the at least two optical pairs are arranged one above the other. The FOVs defined by the at least two optical pairs can be arranged in a stacked manner in the direction parallel to the substantially parallel axes of symmetry.

[0017] Alternatively or additionally, the FOVs defined by the at least two optical pairs can overlap in the direction parallel to the substantially parallel axes of symmetry for forming an overlapping region in the form of a ribbon that extends in a circumferential direction with respect to the substantially parallel axes of symmetry. The ribbon generally has a curved shape but is not restricted thereto. The ribbon facilitates the stitching process as will be elucidated later on.

[0018] The positioning of the light directing elements is determined by the mathematical concept of a parabola. Because the relevant optical camera is positioned such that it appears to be recording images at the corresponding focus point, its position is also determined by the parabola, albeit indirectly. The respective focus points of optical pairs corresponding to adjacent FOVs are preferably slightly offset relative to each other for allowing a slight overlap between the adjacent FOVs to improve stitching of the plurality of partial images into the panoramic image. The skilled person is aware of various techniques with which the information from overlapping FOVs can be used to obtain a reduced or error free transition between the partial images. This technique is particularly useful for reducing artifacts caused by the mechanical construction of the device. For instance, some parts of the frame may block incident light. Mostly, these elements cause disturbances near the edges of the FOV. Similarly, imperfections in the light direction elements, for instance at the edges thereof, may be a further cause for artifacts.

[0019] The parabola has the attracting feature that light incident parallel to the axis of symmetry are directed towards the focus point of the parabola. Consequently, the optical axis of every camera for which the corresponding light directing element is placed on the same parabola is parallel to the axis of symmetry. This allows for a very compact configuration as most cameras are elongated along their optical axes. Aligning these axes allows the cameras to be placed in close proximity to each other.

[0020] The system according to the invention further comprises a controller to individually and independently trigger each optical camera to record a partial image. A motion calculator is employed to calculate a distance travelled by the system in a movement direction. A

processing unit to calculate a timing difference between optical cameras based on the relative offset of their focus points in the direction of movement.

[0021] The controller is arranged to trigger the optical cameras using the calculated timing difference in a manner such that the optical cameras record partial images as if their entrance pupils were at substantially the same position in the direction of movement at the time of recording the partial image. For instance, if two optical cameras are used of which, in a direction of movement, the corresponding focus points are separated by a distance D, the triggering of the camera in the rear will trail the triggering of the camera in the front by D/v seconds, wherein v represents the velocity of the system. This ensures that the camera in the rear records an image at the same position with reference to the environment as the camera in front.

[0022] The present invention provides an improved stitching process whereby the deteriorating effects of physical boundaries in the optical system are alleviated by a combination of an intentional shift of the focus points of the cameras from their ideal position and a suitable triggering to compensate for the parallax errors introduced by the intentional shift.

[0023] At least the device for recording panoramic images is mounted on a moveable vehicle, wherein the respective focus points of the plurality of optical pairs are positioned along a substantially straight line that corresponds to a default direction of movement of said moveable vehicle. In this manner, parallax errors can be removed substantially entirely. Other components of the system for recording panoramic images may also be mounted on the vehicle. Alternatively, parts of the system are mounted on the vehicle while other parts are not. Wireless technology may be used for communication between the different parts of the system. In a preferred embodiment, the system is entirely mounted on the vehicle.

[0024] If the device is moving along the straight line and the individual cameras are properly triggered, it can be achieved that at the time of recording an image, the virtual entrance pupils of the respective cameras, i.e. the respective focus points, are at the same position.

[0025] It is also advantageous if the optical axes of the optical cameras of said at least two optical pairs are substantially parallel. Preferably, the parabolas of the at least two optical pairs are substantially overlapping.

[0026] Herein, the wording substantially is used to indicate that small deviations with respect to the ideal mathematical shape of a parabola are not excluded from the scope of the present invention. For instance, the skilled person will appreciate that by not placing the light directing element exactly at a point on the parabola, the optical axis of the optical camera will not be exactly parallel to the axis of symmetry. Moreover, for some applications, small deviations will be acceptable or desirable.

[0027] The axes of symmetry of the respective parabolas are preferably substantially parallel to a common axis of symmetry. It is further advantageous if the curvature of the parabolas is

substantially equal whereby the plurality of respective parabolas substantially defines a paraboloid.

[0028] It is further advantageous if the device has a conical or pyramid shape and/or is elongated in the direction of the common axis of symmetry. In addition, in some embodiments it is possible to divide the plurality of optical pairs into at least two groups, wherein each group is arranged for recording a circumferential ribbon of adjacent partial images around a longitudinal axis of the conical or pyramid shape, or the common axis of symmetry, albeit at a different longitudinal position.

[0029] The skilled person will understand that, given the fact that a slight offset must exist for the focus points to improve the stitching process, the combination of parabolas will not amount to a perfect mathematical ideal paraboloid.

[0030] In addition, it is advantageous if the light direction elements of each optical pair in the same group have substantially the same longitudinal position and if the optical cameras of each optical pair in the same group have substantially the same longitudinal position.

[0031] The previous embodiments, in which a light directing element was used in combination with an optical camera, can be combined with an optical camera arranged substantially at one of the focus points. Preferably, this optical camera has an optical axis substantially parallel to one of the axis of symmetry of a previously mentioned parabola. When this camera is combined with the configuration of the groups of cameras, a device is obtained with which a semi-sphere or similar shape around the device can be captured at high resolution.

[0032] For each optical pair the distance between the respective focus point and the corresponding point on the parabola is preferably equal to the distance between the corresponding point and the entrance pupil of the respective optical camera. This ensures that the optical camera operates as a virtual camera with its entrance pupil at the respective focus point. Here, the optical axis of the virtual camera crosses the corresponding point on the parabola.

[0033] The light direction element could for instance be an optical reflective element, such as a mirror, or a combination of mirrors. In a further embodiment, each of a plurality of the optical pairs comprise a mirror that is part of an integrally formed curved mirror. Hence, instead of a plurality of discrete mirrors, a single integrally formed mirror can be used. Such mirror would reduce the artifacts normally attributed with the edges of the mirrors. When different groups of optical pairs are used, it is advantageous if the mirrors of each group are part of a respective integrally formed curved mirror.

[0034] Instead of or in addition to the reflective element, the light direction element could be a refractive element, such as a prism or a ray bender.

[0035] The skilled person is aware of various technologies in which to implement the various

components of the present invention. Here, the wording optical camera is used to indicate any element, device or system that is capable of recording an optical image by using a light sensitive component such as a charge coupled device (CCD) or light sensitive film.

[0036] Due to the compact nature of the device according to the present invention, it becomes feasible to realize at least one of the light direction elements and/or optical cameras in Micro Electro Mechanical Systems (MEMS) technology.

[0037] According to second and third aspect, the present invention also provides a moveable vehicle and a device for recording panoramic images as defined in claim 17 and 18, respectively. In a preferred embodiment, the moveable vehicle is a motorized vehicle, such as a car.

[0038] Next, the invention will be described in more detail using the appended figures, in which:

Figure 1 illustrates an embodiment of a device for recording panoramic images according to the present invention;

Figure 2 depicts a schematic side view of the embodiment in figure 1;

Figures 3A-3E explain the arrangement of the optical mirrors and cameras of the embodiment in figure 1;

Figures 4A-4C present a three-dimensional representation of the segments covered by the optical cameras described in conjunction with figures 3A-3E;

Figures 5A-5B illustrate the principle of overlapping fields of view to facilitate the stitching process; and

Figure 6 illustrates an example of overlapping fields of view according to the invention to facilitate the stitching process.

[0039] Figure 1 illustrates an embodiment of a device for recording panoramic images according to the present invention. This embodiment comprises 2 groups of optical pairs. The first group comprises six optical cameras 1 and six associated optical mirrors 1'. Similarly, the second group comprises six optical cameras 2 and six associated optical mirrors 2'. In figure 1, a separate optical camera 6 is arranged in between optical mirrors 1'.

[0040] The field of view (FOV) indicates a segment of an environment of the device from which light can be captured via directing thereof by the optical mirrors 1', 2' onto an entrance pupil of the optical cameras 1, 2. For instance, segments 3 and 4 represent the FOV corresponding to one of the optical cameras of the first and second group, respectively. Segment 5 corresponds to the optical camera that is arranged within optical mirrors 1'. Light incident on this camera is

not reflected by an optical mirror.

[0041] It is clear from figure 1 that each optical camera 1, 2 captures only a relatively small segment of the environment of the device. Hence, such segment is photographed using a relatively high resolution. This allows a high resolution panoramic image to be obtained.

[0042] Figure 2 depicts a schematic side view of the embodiment in figure 1. Here, only a single optical camera 1, 2 per group is illustrated. Moreover, mirrors 1', 2' are indicated by a straight line. The dotted lines indicate a two-dimensional representation of the FOV that corresponds to each optical camera 1, 2, and 6.

[0043] In figure 2, a parabola P is illustrated according to which optical mirrors 1', 2' are placed. Moreover, a single optical camera 6, corresponding to segment 5, is placed with its entrance pupil at the focus point of parabola P.

[0044] Next, the arrangement of optical cameras 1, 2 and optical mirrors 1', 2' is explained using figures 3A-3E. Here, figures 4A-4C present a three-dimensional representation of the segments covered by the optical cameras described in conjunction with figures 3A-3E.

[0045] Firstly, figure 3A shows that single optical camera 6 is arranged with its entrance pupil at focus point 7 of parabola P. Also illustrated in figure 3A is axis of symmetry I for parabola P, which coincides with the optical axis of optical camera 6.

[0046] Figure 3B shows the orientation of a virtual camera 8, having its entrance pupil at focus point 7, which would allow segment 3 to be captured. Here, point 10 illustrates where optical axis 9 intersects parabola P.

[0047] Figure 3C illustrates optical camera 1 which is arranged such that the distance between the entrance pupil of optical camera 1 and point 10 equals the distance between point 10 and focus point 7. The orientation of optical mirror 1' is such that segment 3 is covered. Moreover, actual optical camera 1 and virtual camera 8 are each other mirror images with respect to optical mirror 1'. Consequently, the light captured by optical camera 1 equals that which would have been captured by virtual camera 8. Moreover, the apparent position of the entrance pupil of optical camera 1 is focus point 7. Hence, images taken by optical cameras 1 and 6 appear to have been taken from the same point, i.e. focus point 7. At this point, it should be noted that in this explanation, the offset between the various focus points is not included. This will be elucidated with reference to figures 5A and 5B.

[0048] Figure 3D illustrates a virtual optical camera 11 that is positioned to cover segment 4. Optical axis 12 of camera 11 intersects parabola P at point 13. Figure 3E shows the arrangement of actual optical camera 2 and optical mirror 2'. Again the distance between the entrance pupil of optical camera 2 and point 13 equals that of the distance between point 13 and focus point 7. The orientation of optical mirror 2' is such that segment 4 is covered. Optical camera 2 and virtual optical camera 11 are each other mirror images with respect to optical

mirror 2'.

[0049] Optical cameras 1, 2 both have their optical axis parallel to axis of symmetry I depicted in figure 3A. Also, referring back to figure 1, it is apparent that every optical camera has its optical axis parallel to axis of symmetry. This also allows a close stacking of optical cameras. Furthermore, the focus points corresponding to the various parabolas used for arranging the optical cameras and optical mirrors in correspondence with the method disclosed in figures 3A-3E are substantially overlapping. In reality a small offset must be employed to improve the stitching process as will be described later on.

[0050] The respective parabolas corresponding to the optical pairs in figure 1 define a paraboloid having a single focus point that corresponds substantially to the focus points of the individual parabolas. Although preferred, the present invention does not exclude the possibility that different parabolas are used for different optical pairs. For instance, one optical pair could be placed in accordance with a parabola having a larger curvature than other optical pairs, albeit having substantially the same focus point.

[0051] Figures 5A-5B illustrate the principle of overlapping fields of view to facilitate the stitching process.

[0052] When stitching the partial images that are recorded by the optical cameras, distortion may occur near the edges of the light direction elements and/or parts of the frame may block incident light in particular near the region of overlap. To prevent these deteriorating effects or to reduce their effect in the final panoramic image, it is advantageous to ensure a certain overlap between neighboring FOVs. The information contained in the overlap can be used to at least reduce the impact of the distortions.

[0053] Figure 5A illustrates, in a top view, how the overlap can be achieved. By introducing an offset between the focus points 20, 21 corresponding to neighboring FOVs, an overlap 14 occurs near the edges of the segment. Here, point 20 represents the overlapping focus points corresponding to the optical pairs with respect to the remaining three segments. This is illustrated in more detail in figure 5B. Here, dots 16, 15 illustrate the actual position of optical camera 17 and the corresponding virtual camera 18, respectively, with respect to the positions based on overlapping focus points coinciding with focus point 7. In this example, the position of optical mirror 19 has not changed compared to the position corresponding to overlapping focus points.

[0054] In figure 5B, dot 15 represents the position of the entrance pupil of virtual camera 18 which would result in the desired overlap. If required, optical camera 17 can be chosen such that it has a larger angle of view. Dot 16 corresponds to the position of the actual optical camera 17. At this position, the light that would be captured by virtual camera 18 at the position indicated by dot 15, corresponds to that captured by optical camera 17.

[0055] Although this positioning produces the desired overlap it introduces parallax errors

because the partial images are not taken from the same position. To solve this problem in the specific case where the device is moving in a direction indicated by arrow A, optical camera 17 is triggered to record an image when the position of its apparent entrance pupil 15, or at least a component thereof in the direction of movement, is the same as that of the other cameras at the time of recording the image. In a system comprising a plurality of cameras, this would involve the individual triggering of each camera such that the position of the entrance pupil of the virtual camera, or at least a component thereof in the direction of movement, would be the same for each camera at the time of recording an image by that camera.

[0056] Figure 6 presents a different arrangement of focus points corresponding to the respective optical pairs. Compared to figure 5A, it is apparent that these focus points all lie on a straight line that corresponds with a direction of movement indicated by arrow A. Here, focus points (36, 37, 38, 39) correspond respectively to fields of view (30, 31+35, 32+34, 33), where "+" indicates that these fields of view correspond to an identical focus point. By individually triggering the various optical cameras, such that at the time of recording an image the virtual entrance pupil of each optical camera (i.e. the corresponding focus point) is at the same position, parallax errors can be completely eliminated. This is contrary to figure 5B, where a small shift perpendicular to the direction of movement remains.

[0057] It should be apparent to the skilled person in the art, that various other types of offset are possible to generate the desired overlap.

[0058] The present invention is particularly well suited for applications in which the panoramic images should be metrically correct. In such systems it is important to detect deformations of the optical system such that these deformations can be corrected or accounted for. Such detecting of deformations can be made part of a calibration of the system.

[0059] Several options may be used by which the system can be calibrated. As a first option, fiducials may be placed on reflective components, such that they appear in parts of the partial image that are not used in the final panoramic image. For instance, fiducials may appear in the overlapping regions.

[0060] As a second option, fiducials may be placed on reflective components, such that they appear in parts of the partial image that are used in the final panoramic image. In this case, the fiducials could be realized with special paint that is only visible when applying special light, such as infrared light. An infrared light source, such as a light emitting diode, can be part of the system for illuminating the fiducials during calibration.

[0061] As a third option, auxiliary light sources can be placed on known positions with respect to the reflective components. By capturing the light from these auxiliary light sources using the cameras, information can be obtained about the reflective components.

[0062] It should further be apparent to the skilled person that the present invention is not limited to recording still images only. The recording of moving images, for the construction of a

high-resolution panoramic movie, also falls within the scope of the invention.

[0063] Although the present invention has been described using embodiments thereof, it is not limited thereto. Various modifications to these embodiments are possible without departing from the scope of protection that is defined by the appended claims.

REFERENCES CITED IN THE DESCRIPTION

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PATENTKRAV

1. System til registrering af panoramabilleder, omfattende:

Et apparat til registrering af panoramabilleder, hvilke panoramabilleder dannes ved anvendelse af en flerhed af delbilleder, hvilket apparat omfatter:

En ramme;

en flerhed af optiske par, hvorved hvert optisk par omfatter et lysretningsstyrende element (1', 2') og et optisk kamera (1, 2) med en indgangspupil,

hvorved det lysretningsstyrende element i hvert optisk par er arrangeret i et punkt på en respektiv parabol (P), vinkelret på en tangent derfor, hvilken respektiv parabol omfatter en symmetriakse (I) og et fokuspunkt (7), hvorved det lysretningsstyrende element og det optiske kamera i hvert optisk par er forbundet til rammen på en sådan måde, at det optiske kamera registrerer et billede, der opnås via det lysretningsstyrende element, som om det var positioneret med sin indgangspupil i det respektive fokuspunkt;

hvorved hvert optisk par definerer et synsfelt (FOV), som repræsenterer et segment (3, 4, 5) af apparatets omgivelser, hvorfra lys kan indfanges via styring af det, med det lysretningsstyrende element, mod det respektive optiske kameras indgangspupil;

hvorved symmetriakserne for de respektive paraboler i mindst to optiske par blandt flerheden af optiske par i det væsentlige er parallelle, og hvorved FOV's, som defineres af de mindst to optiske par, grænser op til hinanden i en retning, som er parallel med de hovedsageligt parallelle symmetriakser;

hvorved de respektive fokuspunkter for parabolerne, og som er knyttet til flerheden af optiske par, i det væsentlige overlapper hinanden, hvorved respektive fokuspunkter for parabolerne, der er knyttet til de optiske par, svarer til tilgrænsende FOV's, som er lidt forskudt i forhold til hinanden med henblik på at tillade lidt overlapning mellem de tilgrænsende

FOV's for at forbedre sammenføjning af flerheden af delbilleder til panoramabilledet;

kendetegnet ved, at

i det mindste apparatet til registrering af panoramabilleder er monteret på et bevægeligt køretøj, hvorved de respektive fokuspunkter, som er knyttet til parabolerne, der svarer til flerheden af optiske par, er positioneret langs en i det væsentlige ret linje, som svarer til en default-bevægelsesretning for det bevægelige køretøj, hvilket system ydermere omfatter:

en controller, der er konfigureret til individuelt og uafhængigt at trigge hvert optisk kamera til at registrere et delbillede;

en bevægelseskalkulator, som er konfigureret til at beregne en distance, som gennemløbes af systemet i bevægelsesretningen;

en behandlingsenhed, der er konfigureret til at beregne en timing-forskel mellem optiske kameraer på basis af den relative forskydning af deres fokuspunkter i bevægelsesretningen;

hvorved controlleren er indrettet til at trigge de optiske kameraer ved anvendelse af timing-forskellen på en sådan måde, at de optiske kameraer registrerer delbilleder, som om kameraernes indgangspupiller var i stort set samme position i bevægelsesretningen på tidspunktet for registrering af delbilledet.

2. System ifølge krav 1, hvorved de optiske akser for de mindst to optiske par i det væsentlige er parallelle, og hvorved parabolerne i de mindst to optiske par med fordel i det væsentlige overlapper hinanden.

3. System ifølge et hvilket som helst af de foregående krav, hvorved symmetriakserne for de respektive paraboler i det væsentlige er parallelle med en fælles symmetriakse, hvilken flerhed af respektive paraboler fortrinsvis definerer en paraboloide.

4. System ifølge krav 3, hvorved apparatet er konisk formet og er langstrakt i retning af den fælles symmetriakse, og hvorved flerheden af optiske par kan

opdeles i mindst to grupper, hvorved hver gruppe er indrettet til at registrere et periferibånd af tilgrænsende delbilleder rundt om den fælles symmetriakse i en forskellig position i længderetningen, hvorved, fortrinsvis, lysstyringselementerne i hvert optisk par i samme gruppe har stort set samme position, og hvorved de optiske kameraer i hvert optisk par i samme gruppe har stort set samme position i længderetningen.

5. System ifølge et hvilket som helst af de foregående krav, ydermere omfattende et optisk kamera, der er arrangeret i det væsentlige i et af fokuspunkterne.

6. System ifølge et hvilket som helst af de foregående krav, hvorved, for hvert optisk par, afstanden mellem de respektive fokuspunkter og det tilsvarende punkt på parabolen er lig med afstanden mellem det tilsvarende punkt og indgangspupillen i det respektive optiske kamera.

7. System ifølge et af de foregående krav, hvorved lysstyringselementet er et optisk reflekterende element, fortrinsvis et spejl, hvorved hvert optisk par fortrinsvis omfatter et spejl, som er del af et integreret dannet krumt spejl.

8. System ifølge krav 4, hvorved lysretningsstyringselementerne er spejle, og spejlene i hver gruppe er del af et respektivt, integreret dannet, krumt spejl.

9. System ifølge et hvilket som helst af kravene 1-6, hvorved lysretningsstyringselementet er et refraktivt element, fortrinsvis en prisme eller et stråleafbøjningselement.

10. System ifølge et hvilket som helst af de foregående krav, hvorved mindst eet af lysretningsstyringselementerne og/eller de optiske kameraer er realiseret i Micro Electro Mechanical Systems (MEMS) teknologi.

11. Apparat ifølge et hvilket som helst af de foregående krav,
hvorved FOV's, som er defineret af mindst to optiske par, er arrangeret stablet i retningen, der er parallel med de i det væsentlige parallelle symmetriakser.

12. Apparat ifølge et hvilket som helst af de foregående krav, hvorved FOV's, som er defineret af mindst to optiske par, overlapper langs retningen, der er parallel med de hovedsageligt parallelle symmetriakser, med henblik på dannelse af et overlappende område i form af et bånd, der strækker sig i en periferiretning i forhold til de hovedsageligt parallelle symmetriakser.

13. Et bevægeligt køretøj, der er udstyret med systemet ifølge et hvilket som helst af de foregående krav, hvilket bevægelige køretøj fortrinsvis er et motorkøretøj, mere fortrinsvis en bil.

DRAWINGS

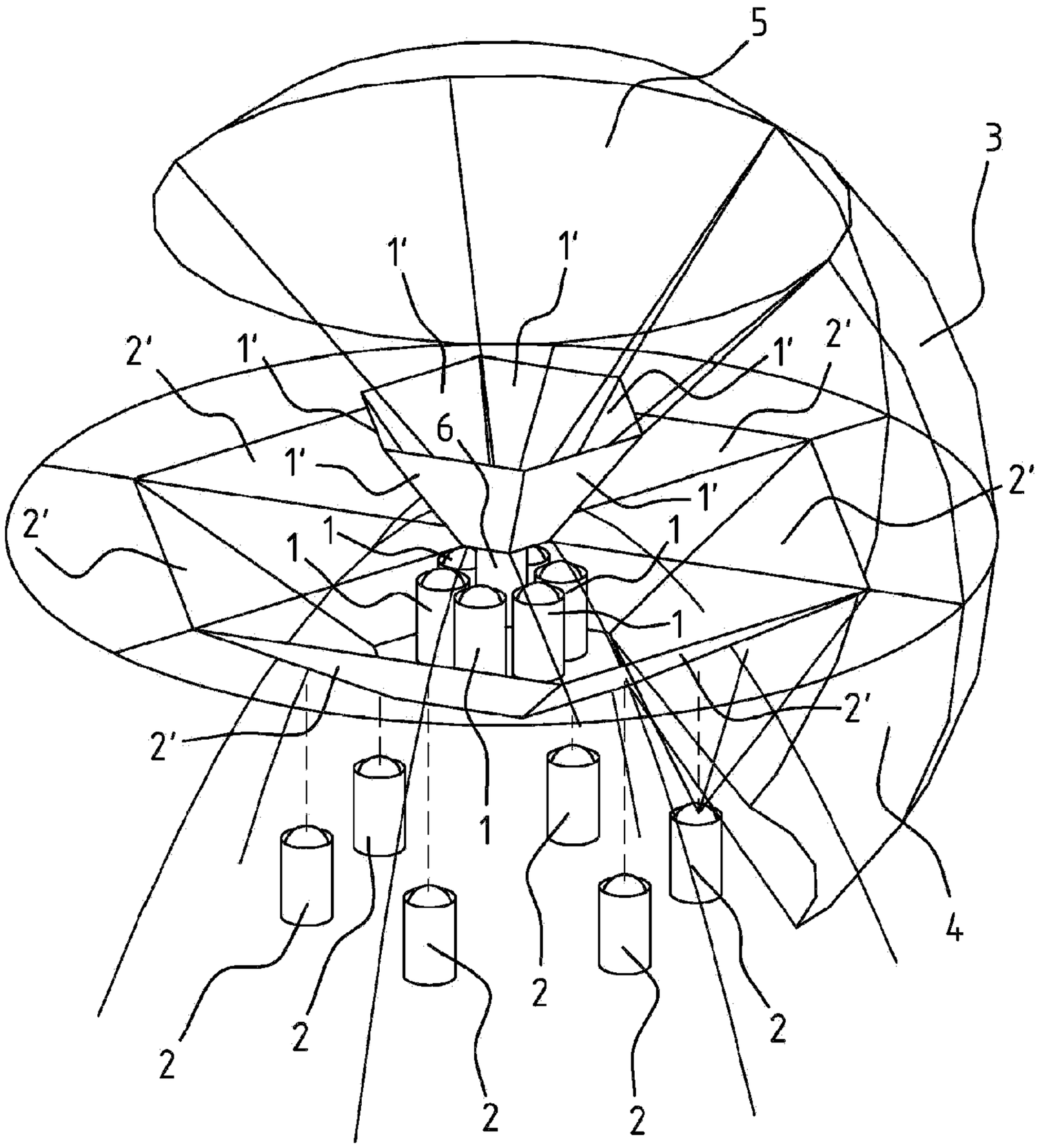


FIG. 1

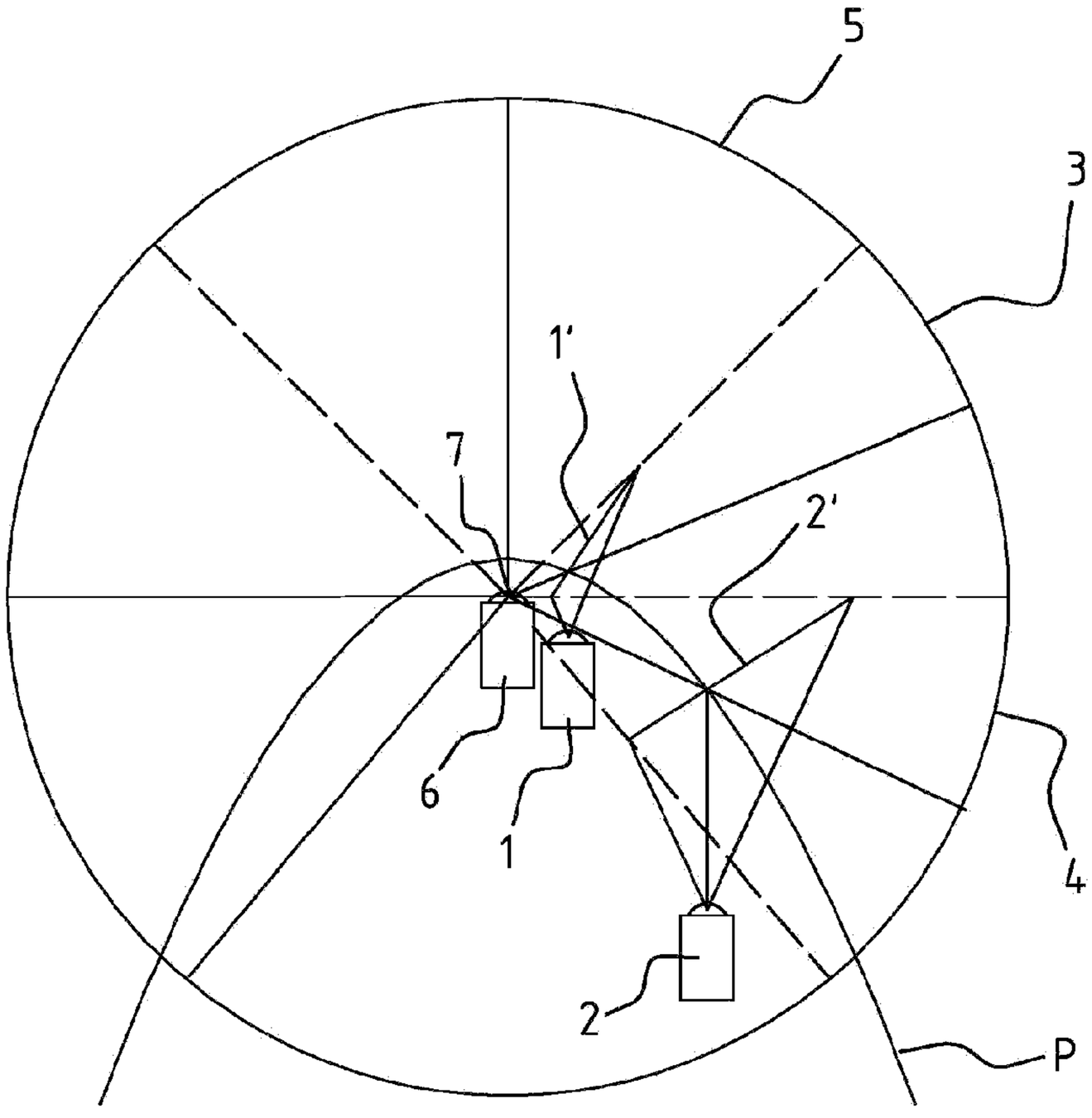


FIG. 2

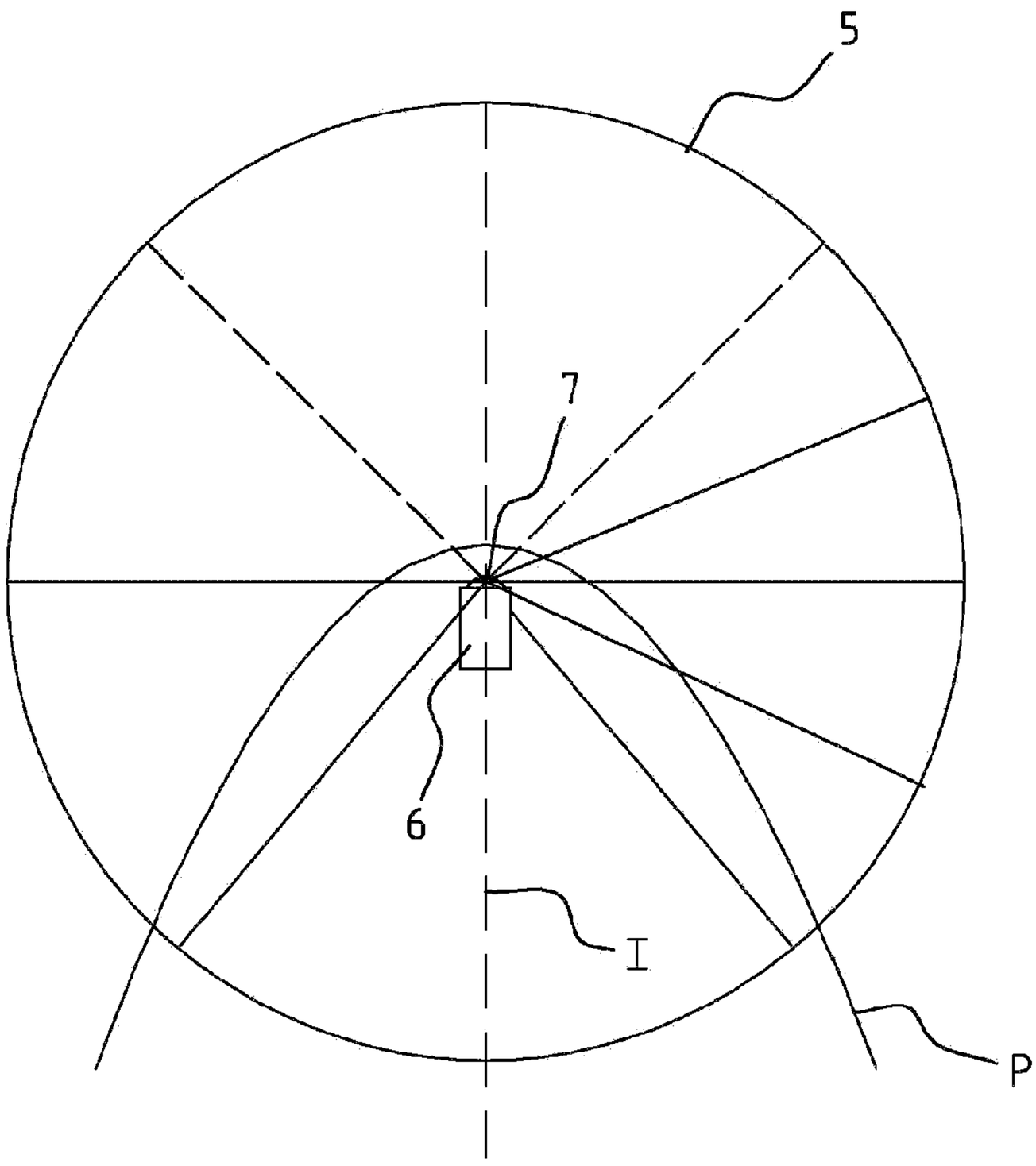


FIG. 3A

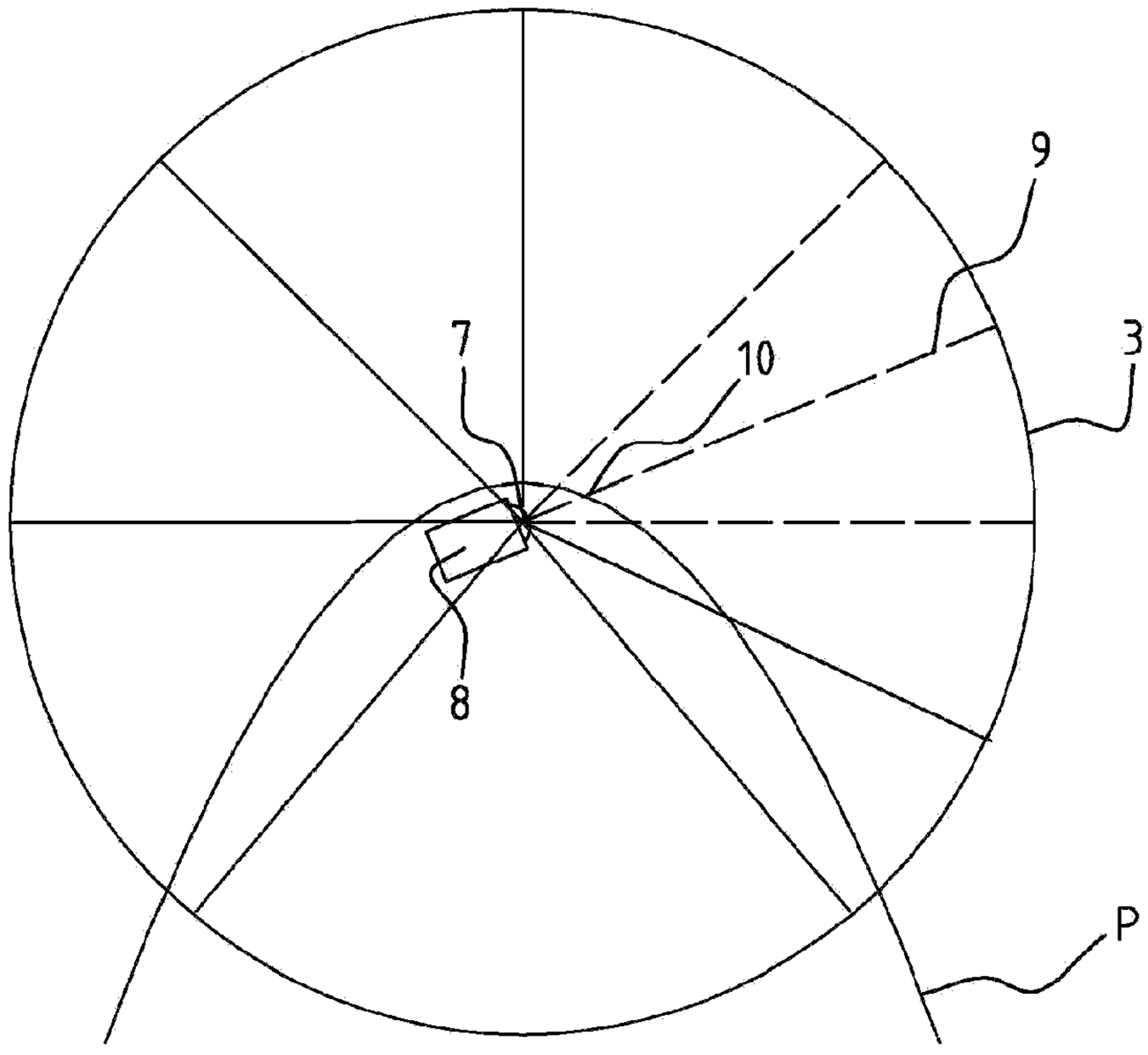


FIG. 3B

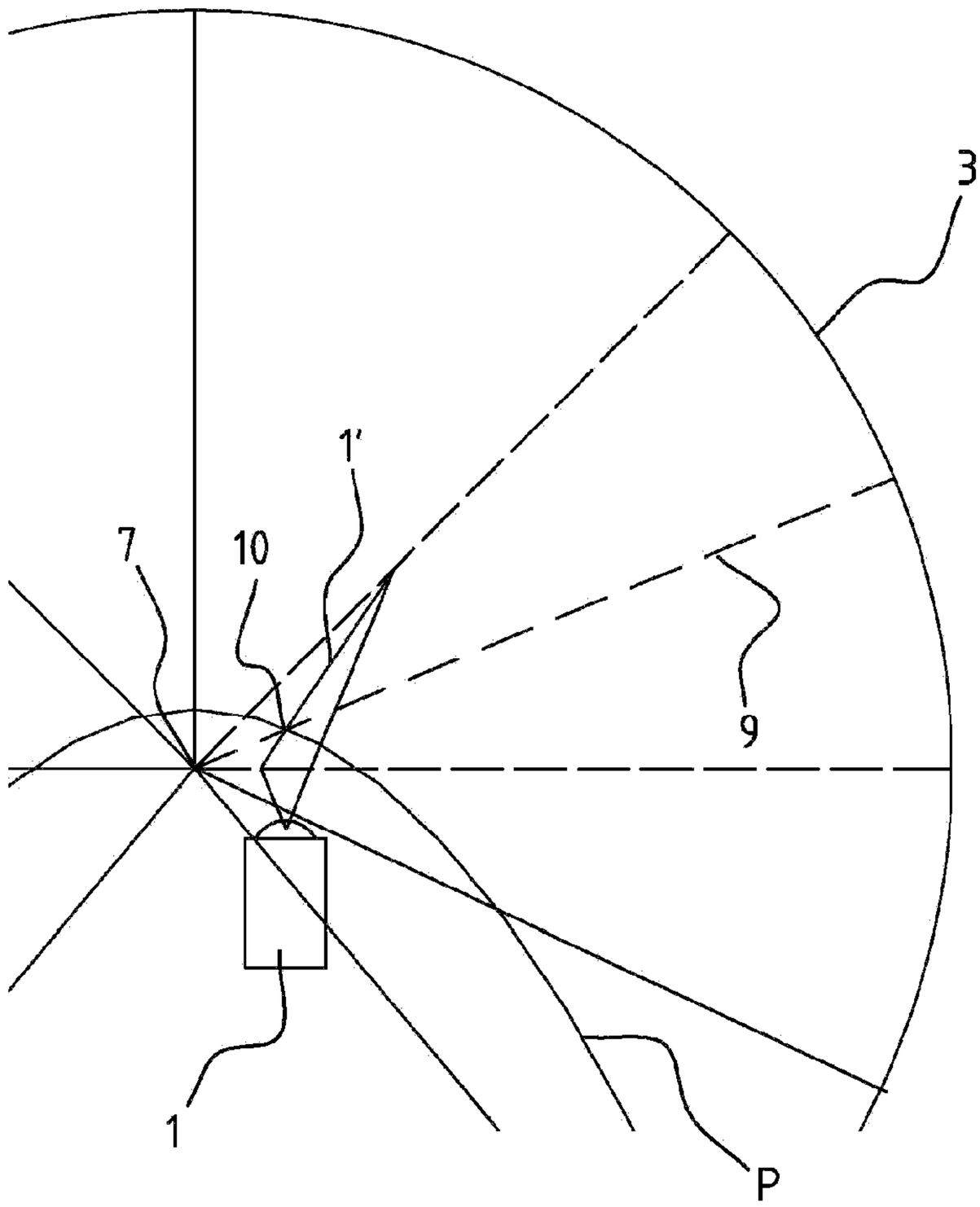


FIG. 3C

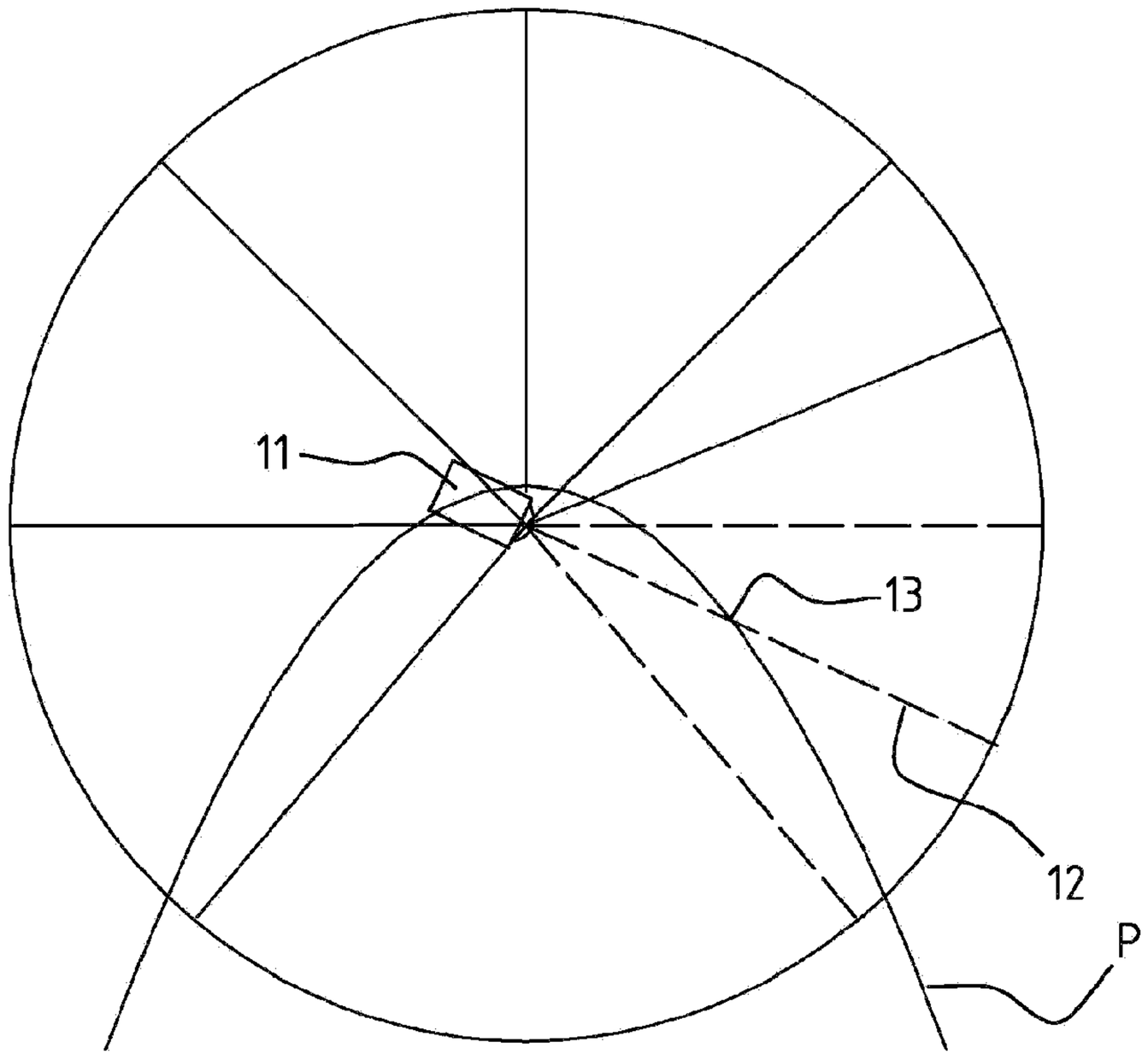


FIG. 3D

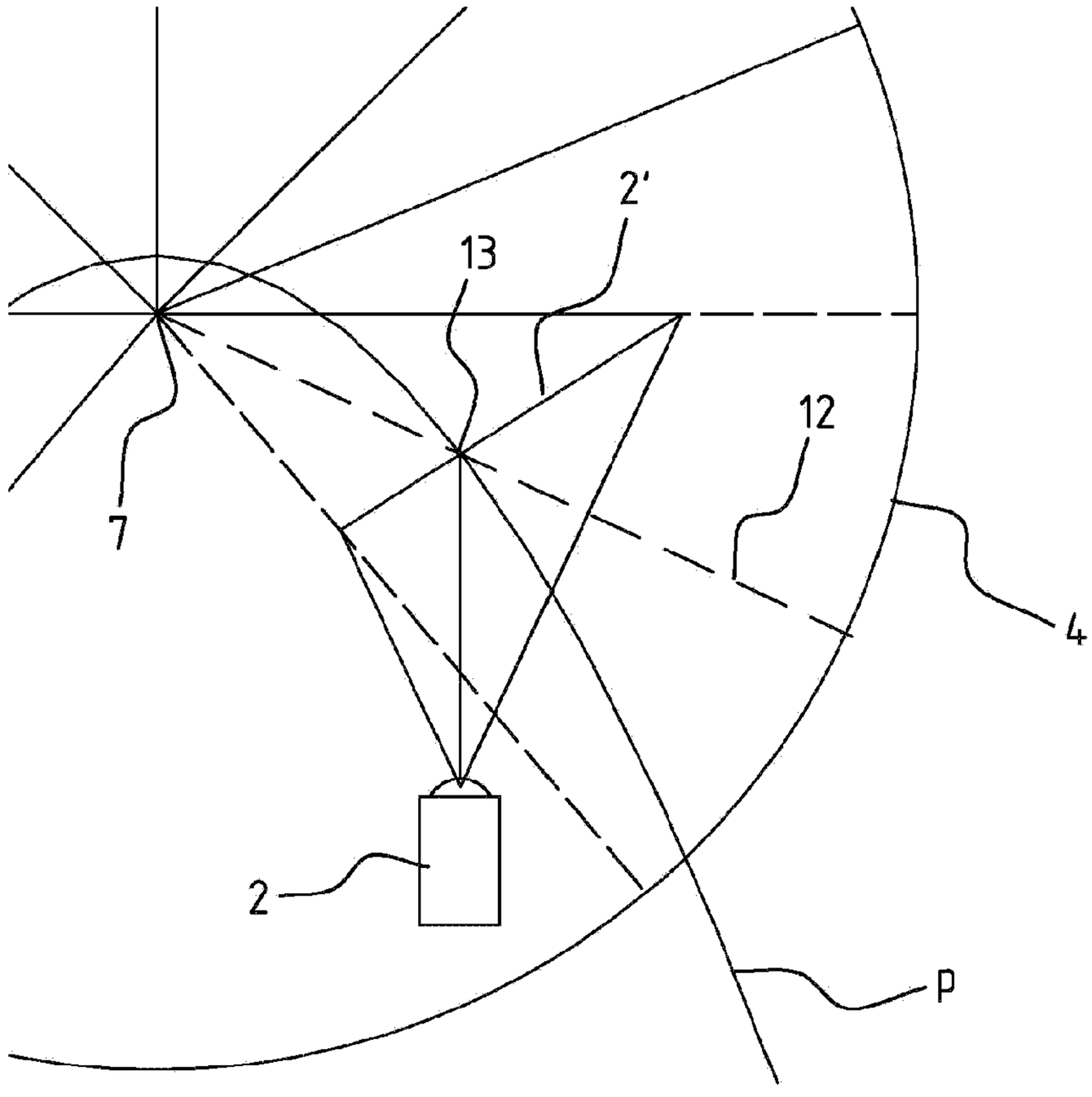


FIG. 3E

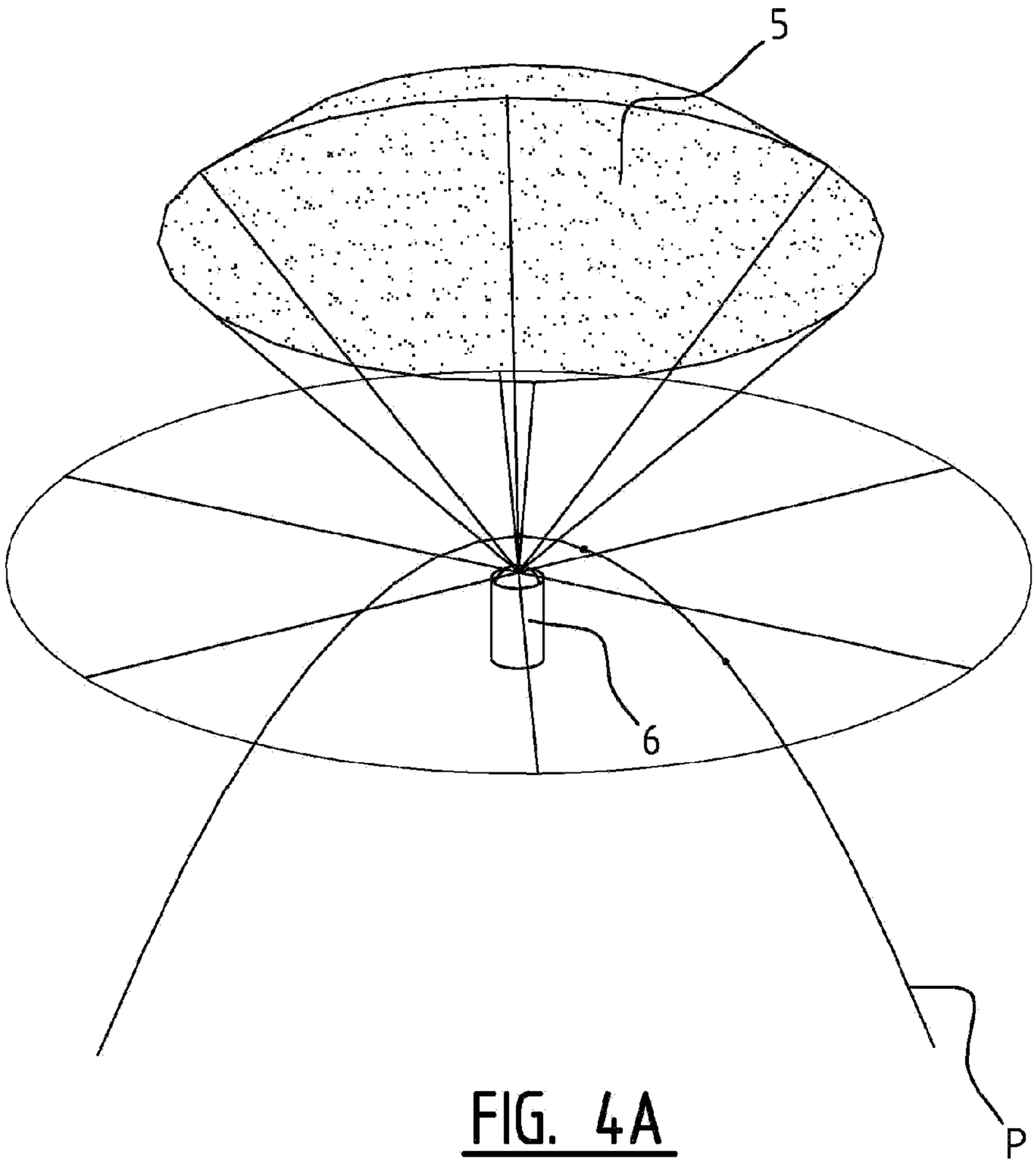


FIG. 4A

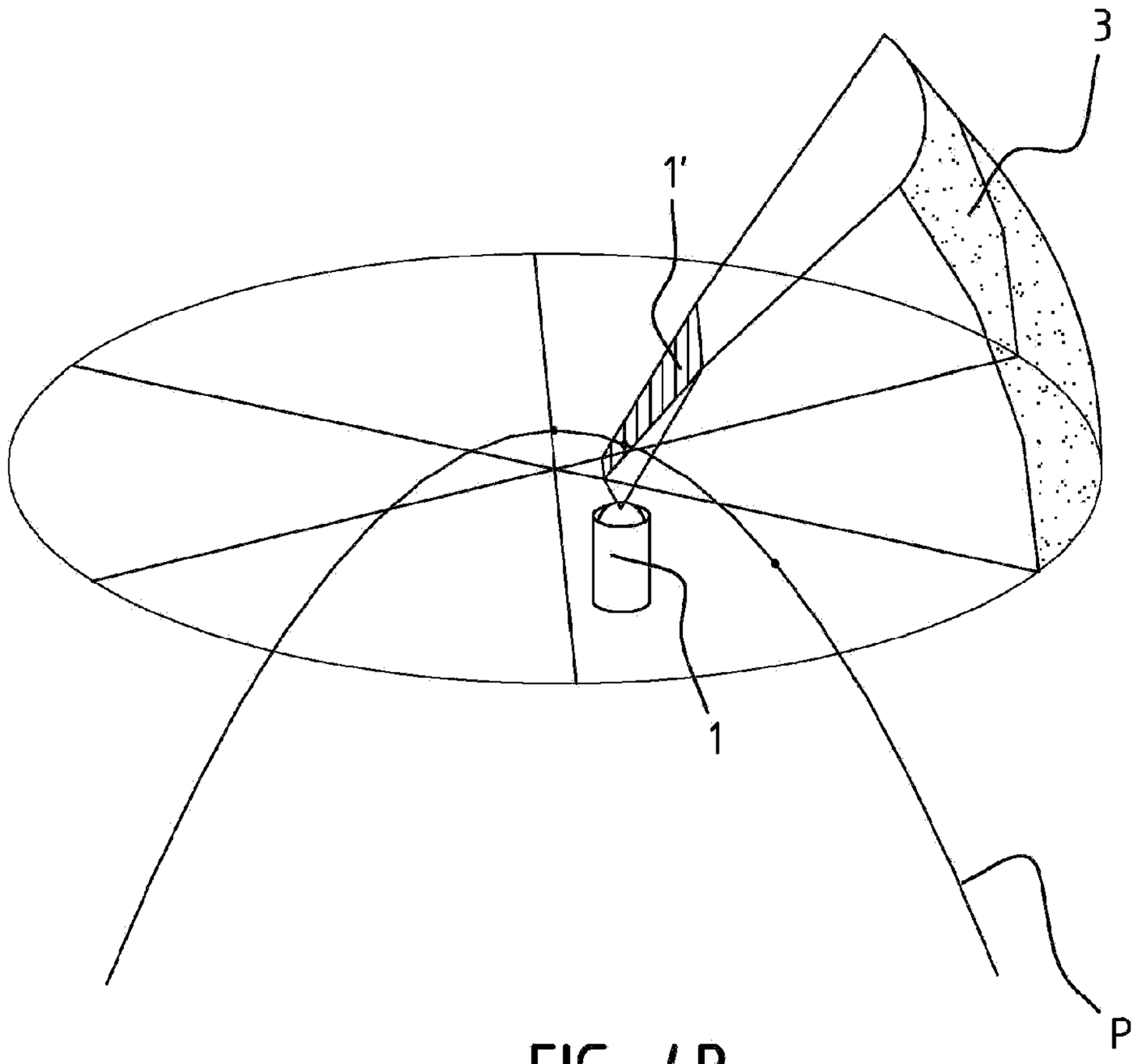


FIG. 4B

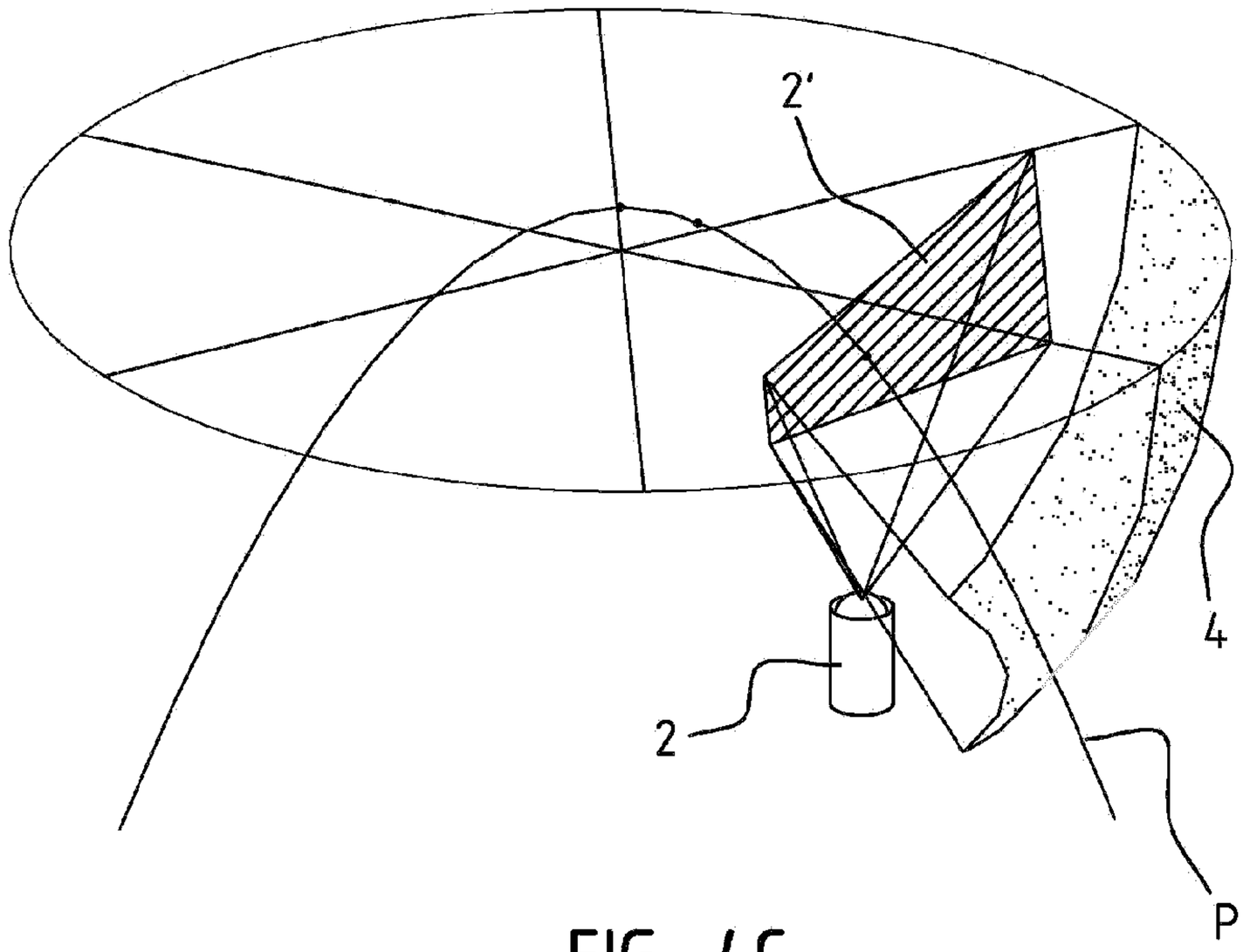


FIG. 4C

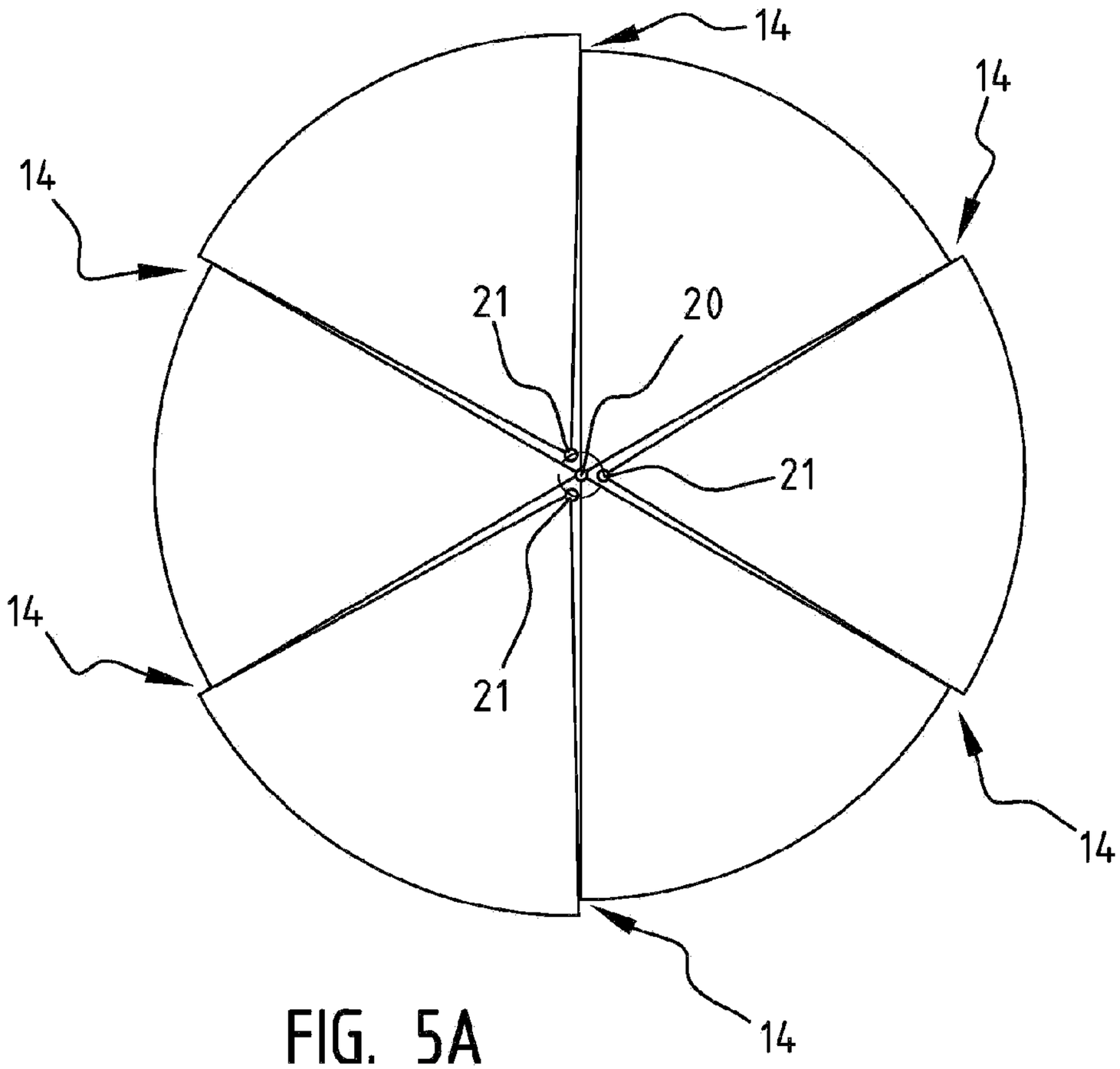


FIG. 5A

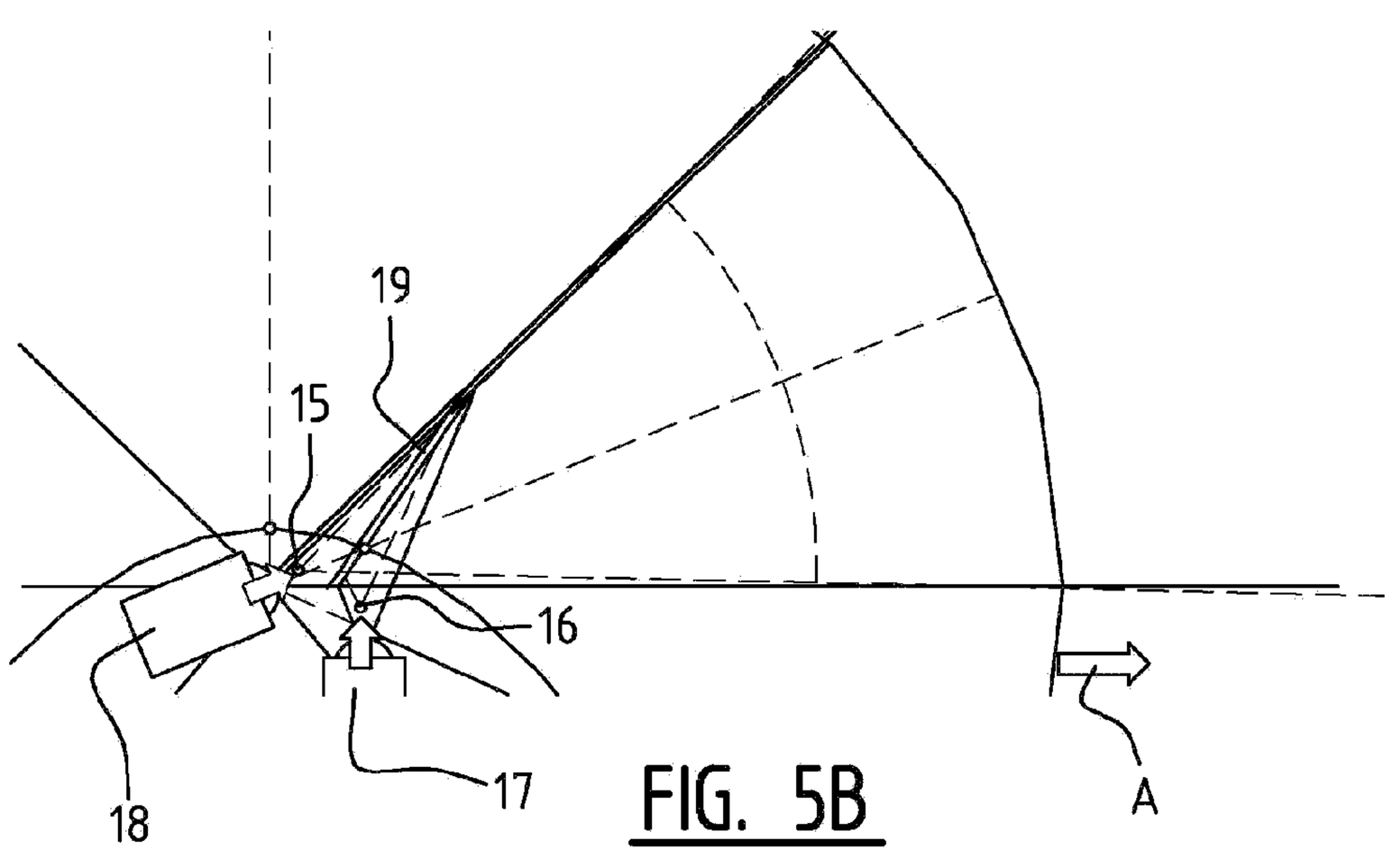


FIG. 5B

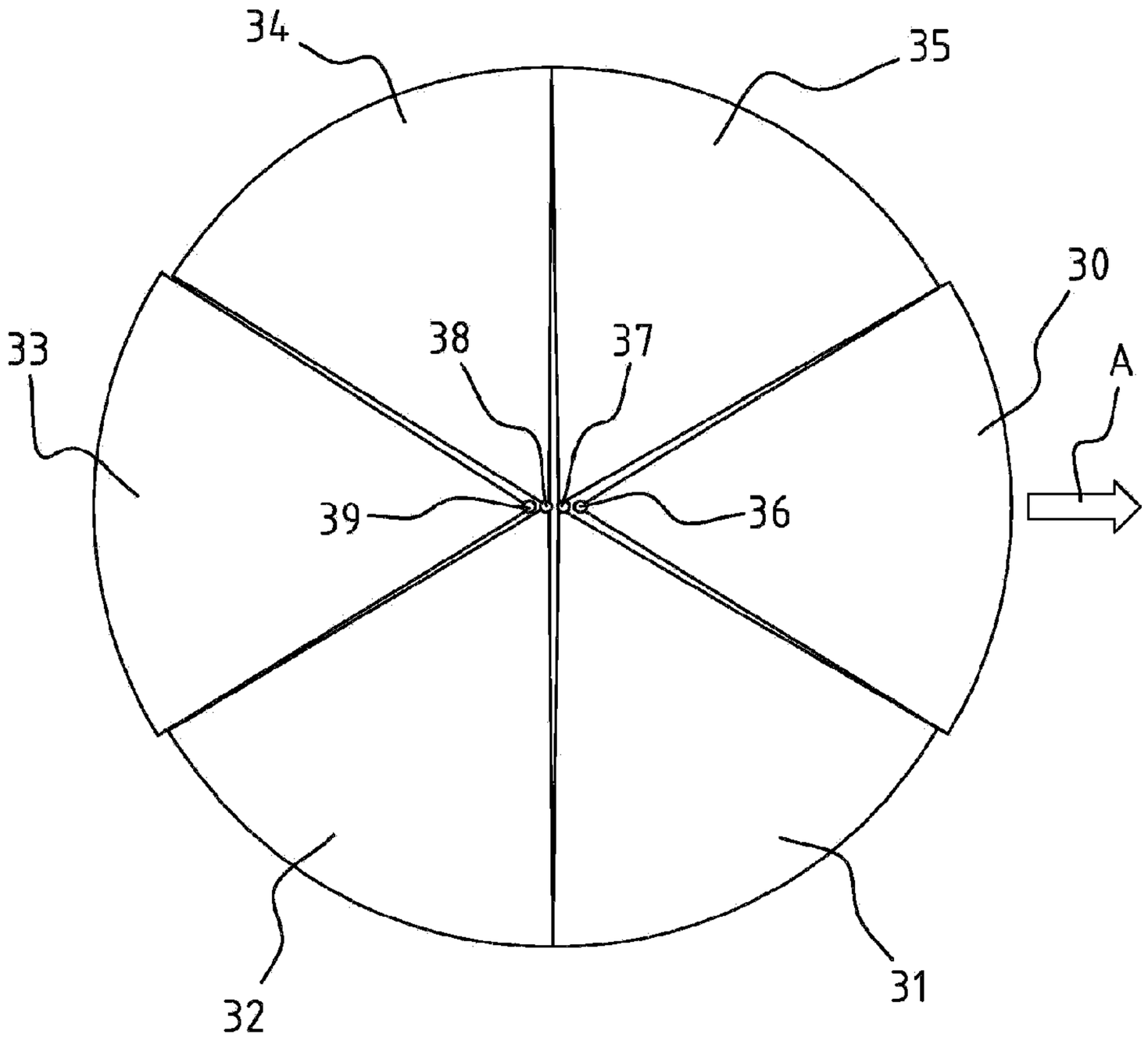


FIG. 6