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(54) **Title**: PROJECTION LENS APPARATUS

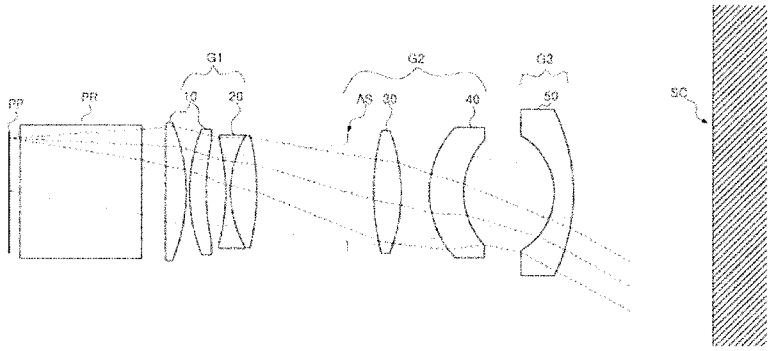

FIG. 3

(57) **Abstract**: A projection lens apparatus for enlarging an image of a pixelized panel on a screen includes a first lens group, a second lens group, and a third lens group. The first lens group has a positive power and includes a telecentric lens for telecentrically adjusting a beam emitting from the panel, and an achromatic lens for calibrating a chromatic aberration of the beam which has passed through the telecentric lens. The second lens group has a positive power and includes an aperture stop for adjusting an amount of beams introduced from the first lens group, a first lens having a convex lens shape to have a positive power and configured to adjust power of the beam introduced through the aperture stop, and a second lens having a meniscus shape concavely curved toward the screen to reduce a size of the beam introduced from the first lens. The third lens group calibrates a distortion of the beam introduced from the second lens group, using a non-spherical lens having a meniscus shape convexly curved toward the screen so as to have a negative power.

WO 2012/127323 A2

PROJECTION LENS APPARATUS

Field of the invention

The present invention relates to a projection lens apparatus, and more particularly to a projection lens apparatus adapted to enlarge an image of a pixelized panel to form the enlarged image on a screen.

Background of the Invention

FIG. 1 illustrates a conventional projection lens apparatus. The conventional projection lens apparatus for enlarging an image of a pixelized panel PP to form the enlarged image on a screen SC includes: a first lens group G10 including a telecentric lens 110 configured to telecentrically adjust a beam emitting from the panel PP using two lenses, and an achromatic lens 120 having a shape convexly curved toward the panel PP so as to have a positive power and configured to calibrate a chromatic aberration of the beam which has passed through the telecentric lens 110, the first lens group G10 being configured to have a positive power; a second lens group G20 including an aperture stop AS configured to adjust an amount of beams introduced from the first lens group G10, a first lens 130 having a convex lens shape so as to have a

positive power and configured to adjust power of the beam introduced through the aperture stop AS, and a second lens 140 having a concave lens shape so as to have a negative power such that the beam introduced from the first lens 130 has a large angle of view, the second lens group G20 being configured to have a negative power; and a third lens group G30 configured to calibrate a distortion of the beam introduced from the second lens group G20, using a non-spherical lens 150 having a meniscus shape convexly curved toward the screen SC so as to have a negative power.

However, in the conventional projection lens apparatus, as illustrated in FIG. 2, since the second lens 140 of the second lens group G20 is a concave lens having a negative power to achieve a large angle of view, a beam passing through the second lens 140 spreads out at a wide angle with respect to a central axis thereof. (That is, the size of the beam is enlarged). Accordingly, the non-spherical lens 50 of the third lens group G30 needs to have an effective diameter corresponding to the large angle of view, i.e. a large diameter.

Summary Of The Invention

Accordingly, the present invention has been made to solve the above-mentioned problems occurring in the prior art, and an object of the present invention is to provide a projection lens apparatus adapted to reduce a diameter of a lens closest to a screen, i.e. the non-spherical lens of the third lens group of the conventional projection lens apparatus.

In order to accomplish this object, there is provided a projection lens apparatus for enlarging an image of a pixelized panel to form the enlarged image on a screen, including: a first lens group including a telecentric lens configured to telecentrically adjust a beam emitting from the panel, and an achromatic lens configured to calibrate a chromatic aberration of the beam which has passed through the telecentric lens, the first lens group being configured to have a positive power; a second lens group including an aperture stop configured to adjust an amount of beams introduced from the first lens group, a first lens having a convex lens shape so as to have a positive power and configured to adjust power of the beam introduced through the aperture stop, and a second lens having a meniscus shape concavely curved toward the screen to reduce a size of the beam introduced from the first lens, the second lens group being configured to have a positive power; and a third lens group configured to calibrate a distortion of

the beam introduced from the second lens group, using a non-spherical lens having a meniscus shape convexly curved toward the screen so as to have a negative power.

When an effective focusing distance of the first lens group is F1 and an effective focusing distance of the entire projection lens apparatus is F0, F1/F0 is set to be larger than 1.3 and smaller than 2.4.

When an effective focusing distance of the second lens group is F2, an effective focusing distance of the entire projection lens apparatus is F0, an effective focusing distance of the second lens is FL2, and an effective focusing distance of the first lens is FL1, F2/F0 is set to be larger than 1.5 and smaller than 2.2 and |FL2/FL1| is set to be larger than 1.

When an effective focusing distance of the third lens group is F3 and an effective focusing distance of the entire projection lens apparatus is F0, |F3/F0| is larger than 1.5 and smaller than 2.1.

A positive power of the first lens is the largest of positive powers of all the lenses so that a power of a beam is adjusted.

According to the present invention, since the second lens of the second lens group has a meniscus shape concavely curved toward the screen to reduce a size of a beam and the second lens group has a positive power, a lens closest to the screen, i.e. the non-spherical lens of the

third lens group can become smaller. Thus, a thickness of the entire projection system can be reduced.

Brief Description Of The Drawings

The above and other objects, features and advantages of the present invention will be more apparent from the following detailed description taken in conjunction with the accompanying drawings, in which:

FIG. 1 is a view illustrating a conventional projection lens apparatus;

FIG. 2 is a view illustrating a feature of a second lens of FIG. 1;

FIG. 3 is a view illustrating a projection lens apparatus according to an embodiment of the present invention;

FIG. 4 is a view illustrating a projection lens apparatus according to another embodiment of the present invention; and

FIG. 5 is a view illustrating a feature of a second lens of the projection lens according to the embodiment of the present invention.

Detailed Description Of The Preferred Embodiments

Hereinafter, preferred embodiments of the present invention will be described in detail with reference to the accompanying drawings. A detailed description of known functions and configurations incorporated herein will be omitted when it may make the subject matter of the present invention rather unclear.

As illustrated in FIG. 3 to 5, a projection lens apparatus for enlarging an image of a pixelized panel PP to form the enlarged image on a screeen SC according to the present invention includes: a first lens group G1 including a telecentric lens 10 configured to telecentrically adjust a beam emitting from the panel PP, and an achromatic lens 20 configured to calibrate a chromatic aberration of the beam which has passed through the telecentric lens 10, the first lens group G1 being configured to have a positive power; a second lens group G2 including an aperture stop AS configured to adjust an amount of beams introduced from the first lens group G1, a first lens 30 having a convex lens shape so as to have a positive power and configured to adjust power of the beam introduced through the aperture stop AS, and a second lens 40 having a meniscus shape concavely curved toward the screen SC to reduce a size of the beam introduced from the first lens 30, the second lens group G2 being configured to have a positive power; and a

third lens group G3 configured to calibrate a distortion of the beam introduced from the second lens group G2, using a non-spherical lens 50 having a meniscus shape convexly curved toward the screen SC so as to have a negative power.

Here, when an effective focusing distance of the first lens group G1 is F1 and an effective focusing distance of the entire projection lens apparatus is F0, F1/F0 is set to be larger than 1.3 and smaller than 2.4.

When an effective focusing distance of the second lens group G2 is F2, an effective focusing distance of the entire projection lens apparatus is F0, an effective focusing distance of the second lens 40 is FL2, and an effective focusing distance of the first lens 30 is FL1, F2/F0 is set to be larger than 1.5 and smaller than 2.2 and |FL2/FL1| is set to be larger than 1.

When an effective focusing distance of the third lens group G3 is F3 and an effective focusing distance of the entire projection lens apparatus is F0, |F3/F0| is larger than 1.5 and smaller than 2.1.

Meanwhile, a positive power of the first lens 30 is the largest of positive powers of all the lenses (the telecentric lens 10, the achromatic lens 20, the first lens 30, the second lens 40, and the non-spherical lens 50) so that a power of a beam is adjusted.

The first lens group G1 can be moved forward or rearward to adjust a focus of the entire projection lens

apparatus.

In more detail, the telecentric lens 10 functions to telecentrically adjust a beam emitting from the panel PP using at least one lens. For example, as illustrated in FIG. 3, a beam emitting from the panel PP can be telecentrically adjusted using two lenses, or as illustrated in FIG. 4, a beam emitting from the panel PP can be telecentrically adjusted using one lens. Then, at least one of the lens or the lenses should be a positive power. Here, the telecentric adjustment of a beam refers to transmission of light almost perpendicular to the panel PP to the screen SC. Meanwhile, the telecentric lens 10 pertains to a well-known technology, and a detailed description thereof will be omitted.

The achromatic lens 20 is disposed parallel to the telecentric lens 10 such that a beam emitting from the telecentric lens 10 is introduced therethrough, and is a combined lens system configured to calibrate a chromatic aberration of a lens. That is, several lenses having different components are combined to offset chromatic aberrations of the lenses. For example, the achromatic lens 20 according to the present invention is a lens (usually, called a doublet) where two lenses are combined, may have a meniscus shape convexly curved toward the screen SC as in FIG. 3 or have a meniscus shape concavely curved toward the screen as in FIG. 4 according to a condition of

the telecentric lens 10. Meanwhile, the first lens group G1 should have a positive power.

The aperture stop AS of the second lens group G2 is disposed furthest from the screen SC, and is disposed at a central portion of the entire projection lens apparatus in a suitable way.

The first lens 30 of the second lens group G2 is adapted to adjust a power of the entire projection system, and is a convex lens to have a positive power. Then, the first lens 30 is disposed between the aperture stop AS and the second lens 40.

The second lens 40 of the second lens group G2 has a meniscus shape concavely curved toward the screen SC, and is disposed closest to the screen SC of the second lens group G2. Here, a meniscus shape refers to a lens (i.e. a crescent-shaped lens) whose two lens surfaces have a same direction, in which case as in FIG. 5, light gathers (light is introduced through a convex surface) while an introduced beam is passing through the second lens 40 such that an exiting beam becomes smaller than the introduced beam. Accordingly, since the non-spherical lens 50 of the third lens group G3 through which a beam exiting from the second lens 40 is introduced may be manufactured to correspond to the reduced size of the beam, its diameter may be made smaller. Meanwhile, the second lens 40 may be a positive or negative power, but the second lens group G2 should have

a positive power.

The non-spherical lens 50 of the third lens group G3 has a meniscus shape convexly curved toward the screen SC, and is disposed closest to the screen SC of all the elements of the projection lens apparatus. The third lens group G3 typically includes at least one non-spherical lens.

The projection lens apparatus according to the present invention has an angle of view of 50 degrees or more.

Meanwhile, the prisms of FIGS. 1, 3, and 4 pertain to a well-known technology, and help share an illumination optical system and a pixelized panel PP.

According to the present invention, since the second lens of the second lens group has a meniscus shape concavely curved toward the screen to reduce a size of a beam and the second lens group has a positive power, a lens closest to the screen, i.e. the non-spherical lens of the third lens group can become smaller. Thus, a thickness of the entire projection system can be reduced.

Although a preferred embodiment of the present invention has been described for illustrative purposes, those skilled in the art will appreciate that various modifications, additions and substitutions are possible, without departing from the scope and spirit of the invention as disclosed in the accompanying claims.

What Is Claimed Is:

1. A projection lens apparatus for enlarging an image of a pixelized panel to form the enlarged image on a screen, comprising:

a first lens group including a telecentric lens configured to telecentrically adjust a beam emitting from the panel, and an achromatic lens configured to calibrate a chromatic aberration of the beam which has passed through the telecentric lens, the first lens group being configured to have a positive power;

a second lens group including an aperture stop configured to adjust an amount of beams introduced from the first lens group, a first lens having a convex lens shape so as to have a positive power and configured to adjust power of the beam introduced through the aperture stop, and a second lens having a meniscus shape concavely curved toward the screen to reduce a size of the beam introduced from the first lens, the second lens group being configured to have a positive power; and

a third lens group configured to calibrate a distortion of the beam introduced from the second lens group, using a non-spherical lens having a meniscus shape convexly curved toward the screen so as to have a negative power.

2. The projection lens apparatus as claimed in claim 1, wherein when an effective focusing distance of the first lens group is F1 and an effective focusing distance of the entire projection lens apparatus is F0, F1/F0 is set to be larger than 1.3 and smaller than 2.4.

3. The projection lens apparatus as claimed in claim 1, wherein when an effective focusing distance of the second lens group is F2, an effective focusing distance of the entire projection lens apparatus is F0, an effective focusing distance of the second lens is FL2, and an effective focusing distance of the first lens is FL1, F2/F0 is set to be larger than 1.5 and smaller than 2.2 and |FL2/FL1| is set to be larger than 1.

4. The projection lens apparatus as claimed in claim 1, wherein when an effective focusing distance of the third lens group is F3 and an effective focusing distance of the entire projection lens apparatus is F0, |F3/F0| is larger than 1.5 and smaller than 2.1.

5. The projection lens apparatus as claimed in claim 1, wherein a positive power of the first lens is the largest of positive powers of all the lenses so that a power of a beam is adjusted.

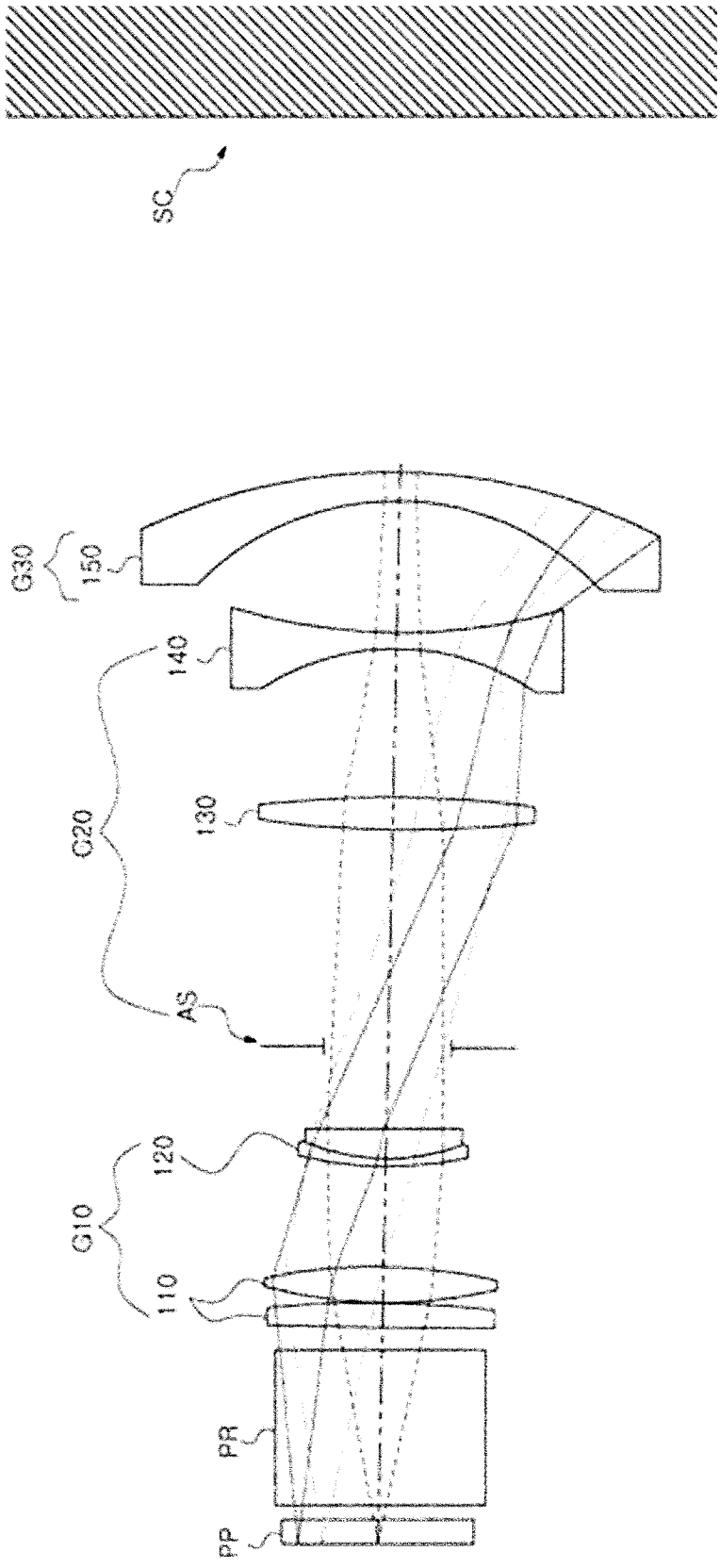

FIG. 1

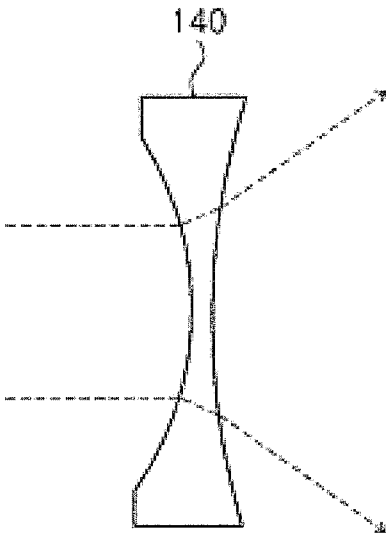

FIG. 2

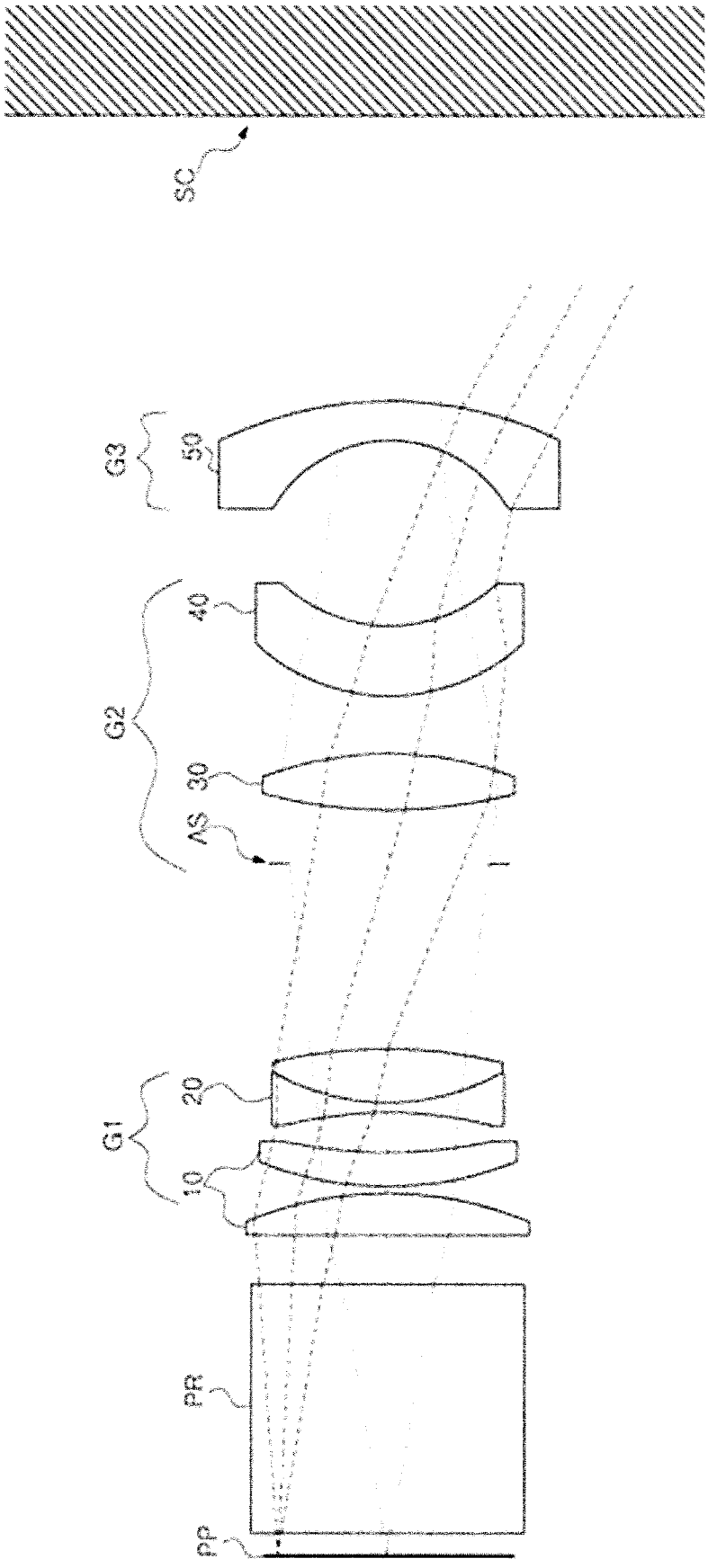

FIG. 3

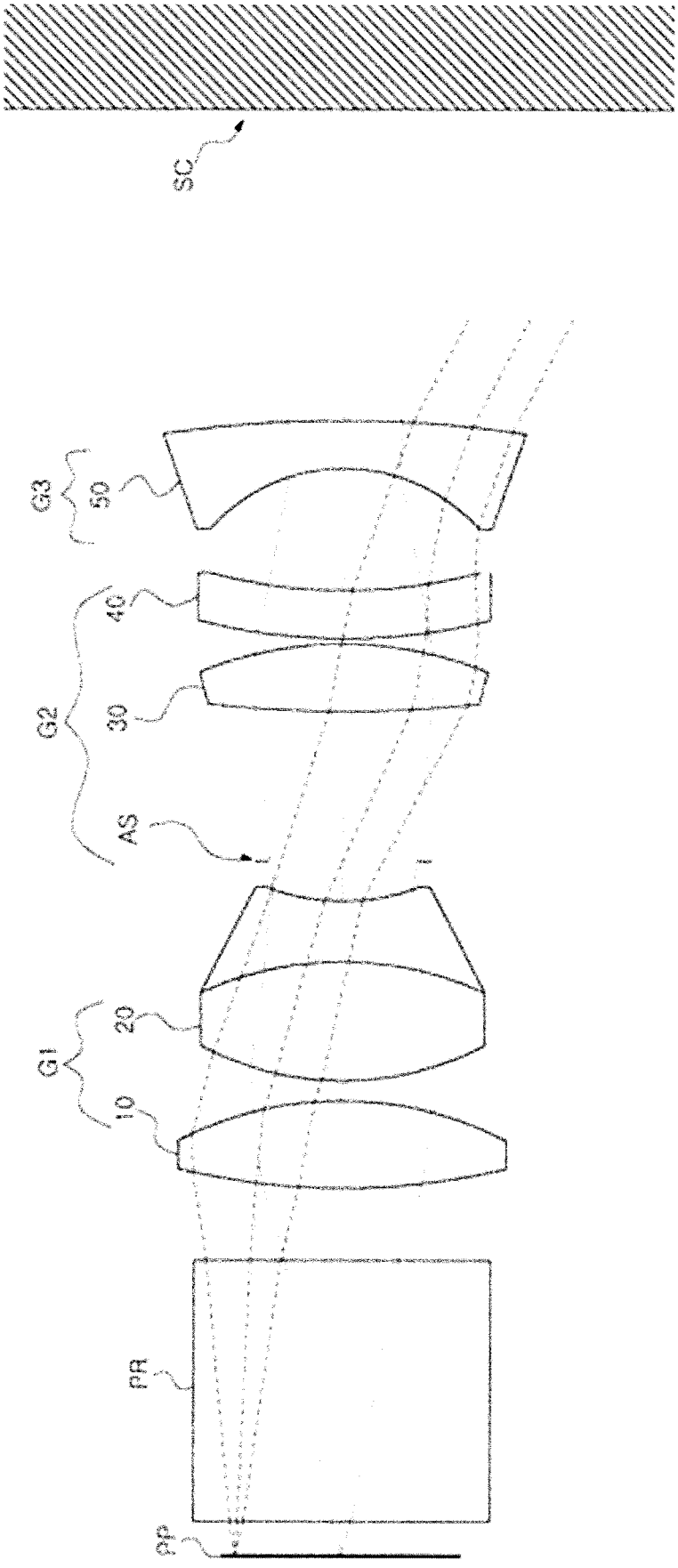

FIG. 4

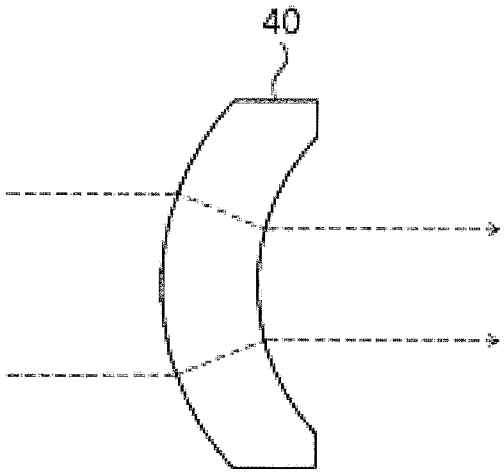

FIG. 5