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(54) **Title:** 5 PIECES CAMERA LENS

(57) **Abstract:** An image pickup lens system is provided. The image pickup lens system includes a first lens, a second lens, a third lens, a fourth lens and a fifth lens, which are sequentially arranged from an object side. The first lens is configured such that the convex surface thereof is oriented toward the object side. The second lens is configured such that the concave surface thereof is oriented toward an image side. The third lens is configured such that the convex surface thereof is oriented toward the image side. The fourth lens is configured such that one or more surfaces thereof are made aspherical and that the image-side surface thereof is made concave in the vicinity of an optical axis. The fifth lens is configured such that both surfaces thereof are made spherical, or that one surface thereof is made aspherical and the remaining surface thereof is made spherical or planar.

5 PIECES CAMERA LENS

【Technical Field】

The present invention relates to an image pickup lens system which can be mounted to a mobile device and, more particularly, to a high-pixel image pickup lens system having five lenses, which can be mounted to a mobile device having five or more million pixels.

【Background Art】

Recently, with the popularization of personal computers in ordinary homes, digital still cameras (hereinafter, referred to as 'digital cameras') which enable image information to be input to such personal computers have become rapidly popularized. Furthermore, with the increasing functionality of mobile phones, a mobile phone, which has been equipped with a camera having a small-sized image pickup module, has also become rapidly popularized. In addition, a small-sized information terminal, such as a Personal Digital Assistant (PDA), to which such an image pickup module has been mounted, has been popularized.

In each of the above-described devices, an image pickup element, such as a Charge Coupled Device (CCD) or a Complementary Metal Oxide Semiconductor (CMOS), is used to realize an image pickup function. This image pickup element is made to be very small. For this reason, in an image pickup device using such an image pickup element such as a CCD, it is required that the main body of the device and a lens system mounted to the main body be made small and light. Furthermore, recently, an image pickup element, having a large number of pixels, has been developed to realize high-quality images. Accordingly, in a lens system as well, high-resolution and high-contrast performance is required.

As described above, the image pickup element is made small and has a large number of pixels. Accordingly, a high-resolution and compact image pickup lens is required, particularly for the image pickup lens system of a digital camera. Meanwhile, in a conventional image pickup lens system for a small-sized information terminal, such as a camera-equipped mobile phone, it is required to reduce the cost and size thereof. However, in the camera-equipped mobile phone, the recent trend is toward increasing the number of pixels of the image pickup element.

Generally, a lens system having three lenses is used for an image pickup element having three million pixels, and a lens system having four lenses is used for an image pickup element having five or more million pixels. In this case, an optical system is designed by actively taking advantage of aspherical lenses. A mobile optical system using three lenses and a mobile optical system using four lenses are respectively disclosed in Korean Pat. No. 843467 (Samsung Electro-Mechanics Co., Ltd.) and in Korean Pat. No. 843470 (Samsung Electro-Mechanics Co., Ltd.).

FIG. 1 shows an example of a conventional lens system having four lenses. The conventional lens system includes a first lens L1 having a positive power, a second lens L2 having a negative power, a third lens L3 having a positive power, a fourth lens L4 having a negative power, and an IR filter 1.

However, the conventional lens system having four lenses is problematic in that the sensitivity of the fourth lens L4, which is designed by actively taking advantage of the aspherical surfaces, is excessively increased, and thus assembling efficiency and productivity are lowered.

Accordingly, in order to overcome the difficulties of manufacturing, which are caused by actively taking advantage of the aspherical surfaces, there is a continuing demand for new lens systems that can alleviate the sensitivity in the conventional lens system.

【Disclosure】

【Technical Problem】

Accordingly, an object of the present invention is to provide a high-pixel lens system having five lenses.

Another object of the present invention is to provide a new lens system, which not only enables the realization of a high pixel lens system having five lenses, but also enables a reduction in the total length thereof.

A further object of the present invention is to provide a new lens system, which not only enables the realization of a high pixel lens system having five lenses, but also enables the coating of an IR filter.

【Technical Solution】

In order to accomplish the above objects, the present invention provides an image pickup lens system, comprising a first lens, a second lens, a third lens, a fourth lens and a fifth lens, which are sequentially arranged from an object side, wherein: the first lens is a lens having a positive power, and is configured such that the convex surface thereof is oriented toward the object side; the second lens is a meniscus having a negative power, and is configured such that the concave surface thereof is oriented toward an image side; the third lens is a meniscus having a positive power, and is configured such that the convex surface thereof is oriented toward the image side; the fourth lens is a lens having a negative power, and is configured such that one or more surfaces thereof are made aspherical and such that the image-side surface thereof is made concave in the vicinity of an optical axis; the fifth lens is a lens having a positive or negative power, and is configured such that both surfaces thereof are made spherical, or such that one surface thereof is made aspherical and the remaining surface thereof is made spherical or planar.

In the present invention, in order to enable a decreased Total Track Length (TTL) and ensure a high Modulation Transfer Function (MTF) that can be applied to high pixels ranging from five million to eight million by decreasing the spherical aberration and the axial chromatic aberration, it is preferred that the first and second lenses be configured to satisfy the following conditions (1) and (2) for the Abbe numbers thereof. In order to favorably correct the coma and astigmatic aberrations of the entire lens system by correcting the aberrations that are generated by the first to third lenses and to correct a distortion, it is preferred that the fourth lens be configured to satisfy the following condition (3). The conditions are:

$$\upsilon d1 > 50 \quad (1)$$

$$20 < \upsilon d2 < 40 \quad (2)$$

$$\upsilon d4 > 50 \quad (3)$$

where $\upsilon d1$, $\upsilon d2$ and $\upsilon d4$ are respective Abbe numbers of the first, second and fourth lenses.

According to an embodiment of the present invention, in order to ensure a higher resolution, it is preferred that the first and second lenses be configured to satisfy the following condition (4) for the difference between the Abbe numbers thereof. It is preferred that the second lens be configured to satisfy the following condition (5) for the curvature thereof. The conditions are:

$$\upsilon d1 - \upsilon d2 > 15.0 \quad (4)$$

$$(R21+R22)/(R21-R22) > -0.7 \quad (5)$$

where $\upsilon d1$ and $\upsilon d2$ are respective Abbe numbers of the first and second lenses, R21 is the object-side curvature of the second lens, and R22 is the image-side curvature of the second lens.

In the present invention, in order to decrease the chromatic aberration of the image pickup lens system, it is preferred that the fifth lens be configured to satisfy the following condition (6) for the Abbe number thereof. The condition is:

$$\upsilon d5 < 50 \quad (6)$$

where $\upsilon d5$ is an Abbe number of the fifth lens.

The image pickup lens system according to the present invention is described in detail below.

In the present invention, the first lens is a lens having a positive power, and is configured such that the convex surface thereof is oriented toward the object side. In order to limit an increase in the spherical aberration or an increase in the side of the lens system and to construct a highly compact optical system, it is preferred that the first lens be configured to satisfy the following condition (7). The condition is:

$$0 < f1/F < 0.8 \qquad (7)$$

where F denotes the focal length of the entire optical system, and f1 is the focal length of the first lens. In the case where the value f1/F of the first lens is greater than 0.8, it is difficult to realize such a compact optical system.

In the present invention, the second lens is a meniscus having a negative power, and is configured such that the concave surface thereof is oriented toward the image side. In order to increase the resolution of the entire lens system by decreasing the axial chromatic aberration, it is preferred that the second lens have an Abbe number that is smaller than that of the first lens by fifteen or more, preferably by twenty or more, as in the above-described condition (4).

In the present invention, the third lens is a meniscus having a positive power, and is configured such that the convex surface thereof is oriented toward the image side, the object-side surface is made spherical, and the image-side surface thereof is made aspherical. In order to decrease the axial chromatic aberration, it is preferred that the third lens be configured to satisfy the following condition (8) for the Abbe numbers thereof.

$$\upsilon d3 - \upsilon d2 > 15.0 \qquad (8)$$

where $\upsilon d2$ and $\upsilon d3$ are respective Abbe numbers of the second and third lenses.

Furthermore, the power of the third lens is determined to satisfy the following condition (9). The reason for this is to favorably correct the spherical aberration or the coma aberration and realize a compact optical system. The condition is:

$$0.5 < f3/F < 20 \qquad (9)$$

In the present invention, the fourth lens may be configured such that one or more surfaces thereof (preferably both) are made aspherical, and the image-side surface thereof is made concave in the vicinity of the optical axis thereof. Accordingly, the coma and astigmatic aberrations of the entire lens system can be favorably corrected and, in addition, the distortion can be favorably corrected.

In the present invention, the fifth lens may have a positive or negative power. In order to distribute the increased sensitivity of the fourth lens, the fifth lens may be configured such that both surfaces thereof are made spherical, or may be configured such that one surface thereof is made aspherical and the remaining surface thereof is made spherical or planar. Accordingly, the sensitivity attributable to an aspherical surface can be lowered and, in addition, a core can be easily manufactured.

According to a preferred embodiment of the present invention, in order to decrease the sensitivity that affects 0.3 ~ 0.5 F, it is preferred that the fifth lens be configured such that object-side surface is made aspherical and such that the image-side surface is made planar.

In the case where the image-side surface of the fifth lens is made spherical or planar, an IR filter may be directly applied to the lens so as to decrease the total length of the image pickup lens system. According to a preferred embodiment of the present invention, in the case where the image-side surface of the fifth lens is made planar, an IR filter may be disposed to be in contact with the image-side surface.

According to an embodiment of the present invention, in order to decrease the chromatic aberration of the image pickup lens system, it is preferred that the fifth lens be configured to satisfy the following condition. More preferably, the Abbe number of the fifth lens is smaller than that of the fourth lens by twenty or more. The condition is:

$$\upsilon d5 < 50 \qquad (10)$$

where $\upsilon d5$ is an Abbe number of the fifth lens.

According to an embodiment of the present invention, the image pickup lens system may employ a separate filter. Alternatively, an IR filter layer may be applied to the image-side surface of the fifth lens so as to remove infrared light. In this case, a high-pixel image pickup lens system can be realized using the fifth lens and, in addition, the space that is necessary for the IR filter can be reduced. Accordingly, the image pickup lens system has a total length identical to that of a lens system having four lenses.

In the present invention, in order to prevent the total length from being increased, it is preferred that the image pickup lens system be configured to satisfy the following condition (11) for the focal length and the total length.

$$TL/f < 1.7 \quad (11)$$

where TL denotes the total length between an iris diaphragm and an image pickup surface. When this condition is satisfied, a further smaller optical system can be achieved.

[Advantageous Effects]

The image pickup lens system according to the present invention is an optical system that is basically constructed using five lenses, and can be applied to five or more million pixels so as to overcome limitations on the aberration correction and the resolution of a conventional image pickup lens system having three or four lenses. Both surfaces of the fifth lens are made spherical or one surface of the fifth lens is made aspherical, so that the image pickup lens system according to the present invention can reduce the sensitivity compared with the conventional image pickup lens system using a lens, both surfaces of which are made aspherical, thus easily achieving the high performance that is obtained by using five lenses while maintaining the sensitivity that is obtained by using four lenses.

[Description of Drawings]

FIG. 1 is a sectional view of a conventional lens system having four lenses;

FIG. 2 is a sectional view of an image pickup lens system having five lenses, according to a first embodiment of the present invention;

FIG. 3 is a sectional view of an image pickup lens system having five lenses, according to a second embodiment of the present invention;

FIG. 4 is a view showing the aberration of an image pickup lens system according to a comparison embodiment of the present invention;

FIG. 5 is a view showing the aberration of the image pickup lens system according to the first embodiment of the present invention; and

FIG. 6 is a view showing the coma aberration of the image pickup lens system according to the first embodiment of the present invention.

[Best Mode]

Embodiments of an image pickup lens system having five lenses according to the present invention are described in detail with reference to the accompanying drawings below.

First Embodiment

FIG. 2 shows an image pickup lens system having five lenses according to a first embodiment of the present invention, in which a fifth lens has a negative refractive index. The image pickup lens system 100 according to the present embodiment includes an iris diaphragm 'a,' a first lens 1, a second lens 2, a third lens 3, and a fourth lens 4, a fifth lens 5, and an IR filter 6, which are sequentially arranged in the direction toward the image side of an image plane from an object side. The first lens 1 is a lens having a positive power, and is configured such that the convex surface thereof is located close to the iris diaphragm 'a' and oriented toward the object side. The second lens 2 is a meniscus having a negative power and is configured such that the concave surface thereof is oriented toward the image side. The third lens 3 is a meniscus having a positive power, and is configured such that the convex surface thereof is oriented toward the image side, such that the object-side surface thereof is made spherical, and such that the image-side surface thereof is made aspherical. The fourth lens 4 is a lens having a negative power, and is configured such that both the object-side and image-side surfaces thereof are made aspherical, and such that the image-side surface thereof is made concave in the vicinity of the optical axis. The fifth lens 5 is a lens having a negative power, and is configured such that the object-side surface thereof is made aspherical and such that the image-side surface thereof is made planar. The IR filter 6 is disposed between the fifth lens and the image plane.

The overall optical system data of the image pickup lens system 100 according to the present embodiment are given as follows.

Focal length f: 4.56 ㎜

The focal length f1 of the first lens: 2.83 ㎜

The focal length f5 of the fifth lens: -29.79 ㎜

The length TL from the iris diaphragm to the image plane: 5.56 ㎜

Table 1

plane number	Curvature radius	Thickness, Length	Refractive index	Abbe number	Reference
1*	1.6601	0.65	1.53113	55.7	First lens
2*	-13.2206	0.045			
3*	7.1386	0.39	1.6320	23	Second lens
4*	2.0848	0.806			
5*	-1.4775	0.640	1.53113	55.7	Third lens
6*	-0.9848	0.132			
7*	7.9467	0.695	1.53113	55.7	Fourth lens
8*	1.8860	0.234			
9*	-17.35778	0.47	1.5825	30	Fifth lens

10	Infinity	0.02			
11		0.30	1.516798	64	IR filter
12		1.1919			

In Table 1, the symbol * denotes an aspherical surface. In the first embodiment, the image-side surface of the third lens, both surfaces of the fourth lens, and the object-side surface of the fifth lens are made aspherical, and the image-side surface of the fifth lens is made planar.

Aspherical coefficients are given by the following Table 2.

Table 2

plane number	K	A	B	C	D	E	F
1*	0	-.790259E-02	0.695305E-03	-.641785E-01	-.281384E-01		
2*	0	0.533786E-01	-.161483E+00	0.718674E-01	-.256523E-01		
3*	0	0.551581E-01	-.139180E+00	0.404200E-01	0.285450E-01		
4*	0	0.345958E-01	0.970684E-02	-.387918E-01	0.539476E-01		
5*	0	0.418074E-02	-.688593E-01	0.187317E+00	-.796562E-01	-.564576E-01	0.318356E-01

6*	-0.834612	0.160237E+00	-.977244E-01	0.112251E+00	-.354298E-01	-.548611E-02	0.360871E-02
7*	-279.903910	-.331440E-01	0.293187E-01	-.120509E-01	0.195201E-02	-.892733E-04	-.264686E-05
8*	-13.933706	-.721021E-01	0.266824E-01	-.799427E-02	0.135934E-02	-.152336E-03	0.756017E-05
9*	0	0.135220E-02	-.449481E-03	0.765106E-04	-.511123E-05		

An aspherical equation is given as follows.

$$Z = \frac{Ch^2}{1+\{1-(1+K)C^2h^2\}^{1/2}} + Ah^4 + Bh^6 + Ch^8 + Dh^{10} + Eh^{12} + Fh^{14}$$

$$C = 1/R, \quad h^2 = X^2 + Y^2$$

FIG. 3 shows an image pickup lens system according to a second embodiment of the present invention.

Second Embodiment

FIG. 3 shows a case where both surfaces of the fifth lens of the image pickup lens system are made spherical. The image pickup lens system 100 according to the present embodiment includes an iris diaphragm 'a,' a first lens 1, a second lens 2, a third lens 3, and a fourth lens 4, a fifth lens 5, and an IR filter 6, which are sequentially arranged in the direction toward the image side of an image plane from an object side. The first lens 1 is a lens having a positive power, and is configured such that the convex surface thereof is located close to the iris diaphragm 'a' and oriented toward the object side. The second lens 2 is a meniscus having a negative power, and is configured such that the concave surface thereof is oriented toward the image side. The third lens 3 is a meniscus having a positive power, and is configured such that the convex surface thereof is oriented toward the image side, such that the object-side surface thereof is made spherical, and such that the image-side surface thereof is made aspherical. The fourth lens 4 is a lens having a negative power, and is configured such that both the object-side and image-side surfaces thereof are made aspherical, and such that the image-side surface thereof is made concave in the vicinity of the optical axis. The fifth lens 5 is a lens having a negative power and is configured such that both the object-side and image-side surfaces thereof are made spherical. The IR filter 6 is disposed between the fifth lens and the image plane.

The overall optical system data of the image pickup lens system 100 according to the present embodiment are given as follows.

Focal length f: 4.53 ㎜

The focal length f1 of the first lens: 2.83 ㎜

The focal length f5 of the fifth lens: -23.88 ㎜

The length TL from the iris diaphragm to the image plane: 5.40 ㎜

Table 3

plane number	Curvature radius	Thickness, Length	Refractive index	Abbe number	Reference
1*	1.6601	0.65	1.53113	55.7	First lens
2*	-13.2206	0.045			
3*	7.1386	0.39	1.6320	23	Second lens
4*	2.0848	0.806			
5*	-1.4775	0.640	1.53113	55.7	Third lens
6*	-0.9848	0.132			
7*	7.9467	0.695	1.53113	55.7	Fourth lens
8*	1.8860	0.234			
9	-12.00	0.47	1.84666	23.7	Fifth lens
10	-30.00	0.02			
11		0.30	1.516798	64	IR filter
12		1.0540			

In Table 3, the symbol * denotes an aspherical surface. In the second embodiment, the image-side surface of the third lens and both surfaces of the fourth lens are made aspherical, and both surfaces of the fifth lens are made spherical. Aspherical coefficients are given by the following Table 4.

Table 4

plane number	K	A	B	C	D	E	F
1*	0	-.790259E-02	0.695305E-03	-.641785E-01	-.281384E-01		
2*	0	0.533786E-01	-.161483E+00	0.718674E-01	-.256523E-01		

3*	0	0.551581E-01	-.139180E+00	0.404200E-01	0.285450E-01		
4*	0	0.345958E-01	0.970684E-02	-.387918E-01	0.539476E-01		
5*	0	0.418074E-02	-.688593E-01	0.187317E+00	-.796562E-01	-.564576E-01	0.318356E-01
6*	-0.834612	0.160237E+00	-.977244E-01	0.112251E+00	-.354298E-01	-.548611E-02	0.360871E-02
7*	-279.903910	-.331440E-01	0.293187E-01	-.120509E-01	0.195201E-02	-.892733E-04	-.264686E-05
8*	-13.933706	-.721021E-01	0.266824E-01	-.799427E-02	0.135934E-02	-.152336E-03	0.756017E-05

FIG. 5 is a view showing the aberration of the lens system according to the first embodiment of the present invention.

Here, it should be noted that Z denotes the sag amount, C denotes the curvature of a lens surface at the optical axis, K denotes the conic coefficient, A, B, C, D, E and F denote fourth-order to fourteenth-order aspherical coefficients, and the relationship between the curvature C and the curvature radius R is given by C = 1/R.

Comparison Embodiment

Conditions in the comparison embodiment are the same as those in the first embodiment except that the Abbe number of the second lens is changed to 55.7. In this state, the aberration of a lens system according to the comparison embodiment is measured and is shown in FIG. 4.

【CLAIMS】

【Claim 1】

An image pickup lens system, comprising a first lens, a second lens, a third lens, a fourth lens and a fifth lens, which are sequentially arranged from an object side, wherein:

the first lens is a lens having a positive power, and is configured such that a convex surface thereof is oriented toward the object side;

the second lens is a meniscus having a negative power, and is configured such that a concave surface thereof is oriented toward an image side;

the third lens is a meniscus having a positive power, and is configured such that a convex surface thereof is oriented toward the image side;

the fourth lens is a lens having a negative power, and is configured such that one or more surfaces thereof are made aspherical and such that an image-side surface thereof is made concave in a vicinity of an optical axis;

the fifth lens is a lens having a positive or negative power, and is configured such that both surfaces thereof are made spherical, or such that one surface thereof is made aspherical and a remaining surface thereof is made spherical or planar.

【Claim 2】

The image pickup lens system according to claim 1, wherein the image pickup lens system is configured to satisfy conditions (1), (2) and (3), wherein the conditions (1), (2) and(3) are:

$$\upsilon d1 > 50 \quad (1)$$

$$20 < \upsilon d2 < 40 \quad (2)$$

$$\upsilon d4 > 50 \quad (3)$$

where $\upsilon d1$, $\upsilon d2$ and $\upsilon d4$ are respective Abbe numbers of the first, second and fourth lenses.

【Claim 3】

The image pickup lens system according to claim 2, wherein the image pickup lens system is configured to satisfy conditions (4) and (5), wherein the conditions (4) and (5) are:

$$\upsilon d1 - \upsilon d2 > 15.0 \quad (4)$$

$$(R21+R22)/(R21-R22) > -0.7 \quad (5)$$

where $\upsilon d1$ and $\upsilon d2$ are respective Abbe numbers of the first and second lenses, R21 is an object-side curvature of the second lens, and R22 is an image-side curvature of the second lens.

【Claim 4】

The image pickup lens system according to claim 1, wherein the fifth lens is configured to satisfy a condition (6) for an Abbe number thereof, wherein the condition (6) is:

$$\upsilon d5 < 50 \qquad (6)$$

where $\upsilon d5$ is an Abbe number of the fifth lens.

【Claim 5】

The image pickup lens system according to claim 4, further comprising:

an IR filter applied to an image-side surface of the fifth lens, or an IR filter lens formed between the fifth lens and an image plane.

【Claim 6】

An image pickup lens system, comprising an iris diaphragm, a first lens, a second lens, a third lens, a fourth lens and a fifth lens, which are sequentially arranged from an object side, wherein:

the first lens is a positive lens having a positive power;

the second lens is a negative lens having a negative power;

the third lens is a positive lens having a positive power, and is configured such that at least one surface thereof is made aspherical;

the fourth lens is a negative lens having a positive power; and

the fifth lens is a negative lens having a negative power:

wherein the system is configured to satisfy conditions as follows:

$(R21+R22)/(R21-R22) > -0.7$ (7)

$\upsilon d1 - \upsilon d2 > 15.0$ (8)

$\upsilon d3 - \upsilon d2 > 15.0$ (9)

$\upsilon d5 < 50$ (10)

where R21 is an object-side curvature of the second lens, R22 is an image-side curvature of the second lens, and υd1, υd2, υd3 and υd5 are respective Abbe numbers of the first, second, third and fifth lenses for d-line.

【Claim 7】

An image pickup lens system, comprising a first lens, a second lens, a third lens, a fourth lens and a fifth lens, which are sequentially arranged from an object side, wherein:

the first lens is a positive lens having a positive power;

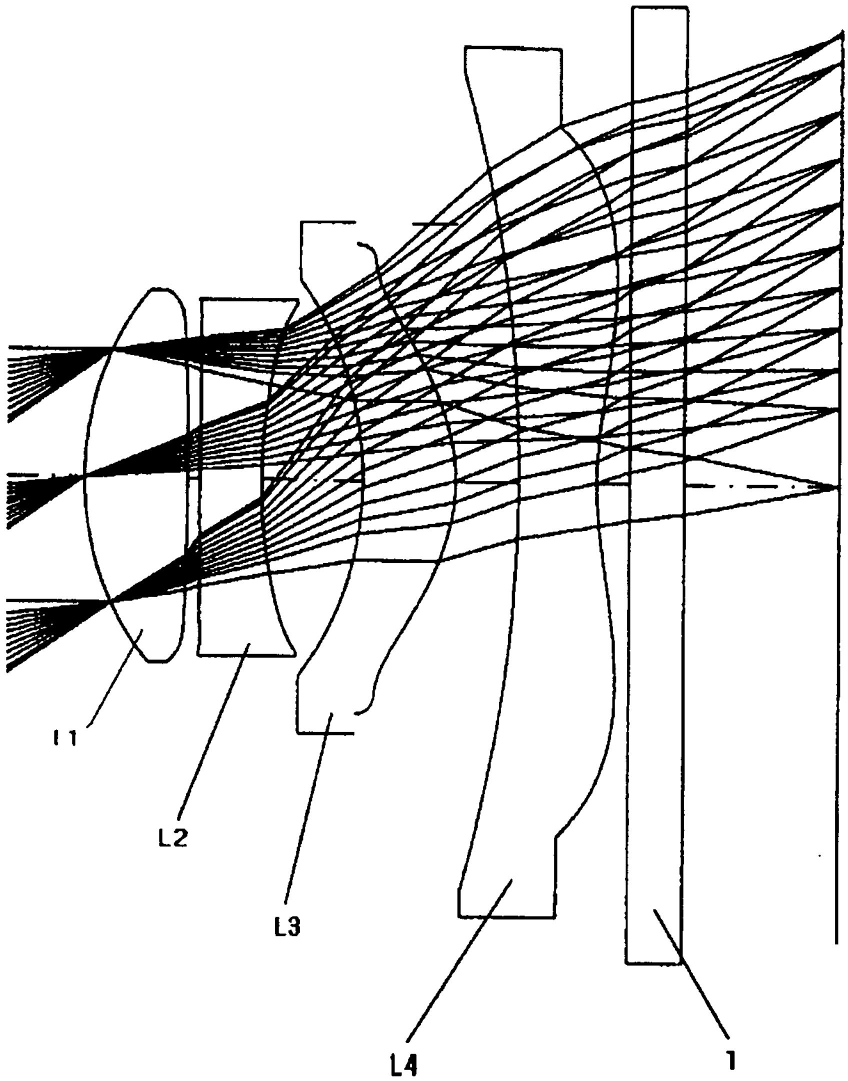
the second lens is a negative lens having a negative power;

the third lens is a positive lens having a positive power, and is configured such that at least one surface thereof is made aspherical; and

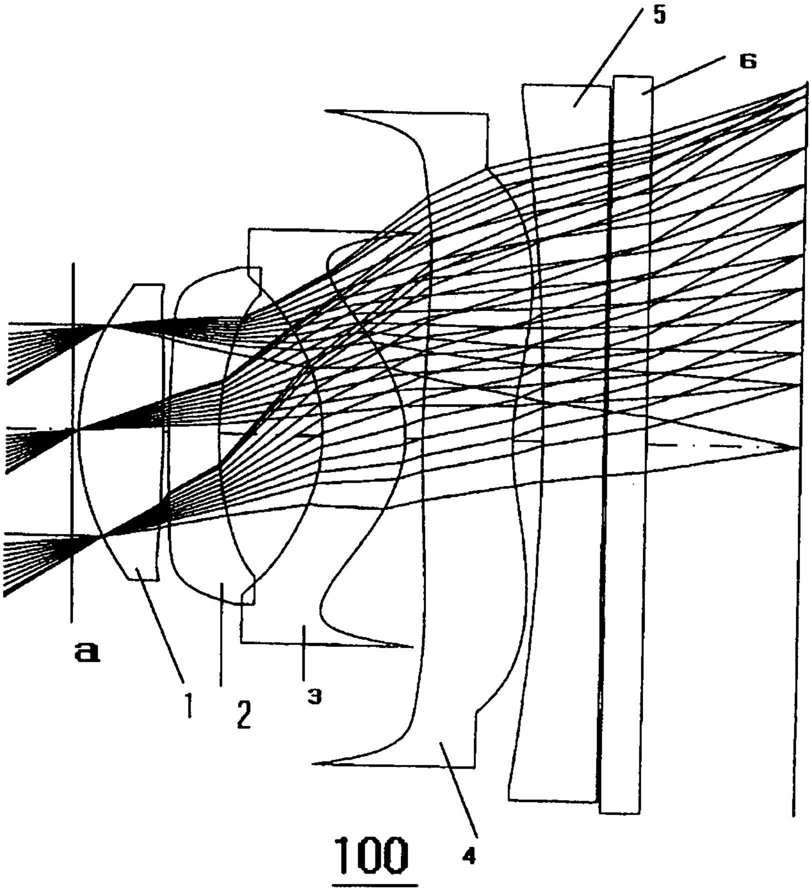
the fourth lens is a negative lens having a positive power; and the fifth lens is a positive or negative lens having a positive or negative power, and is configured such that both surfaces thereof are made spherical, or such that one surface thereof is made aspherical and a remaining surface thereof is made spherical or planar.

【DRAWINGS】

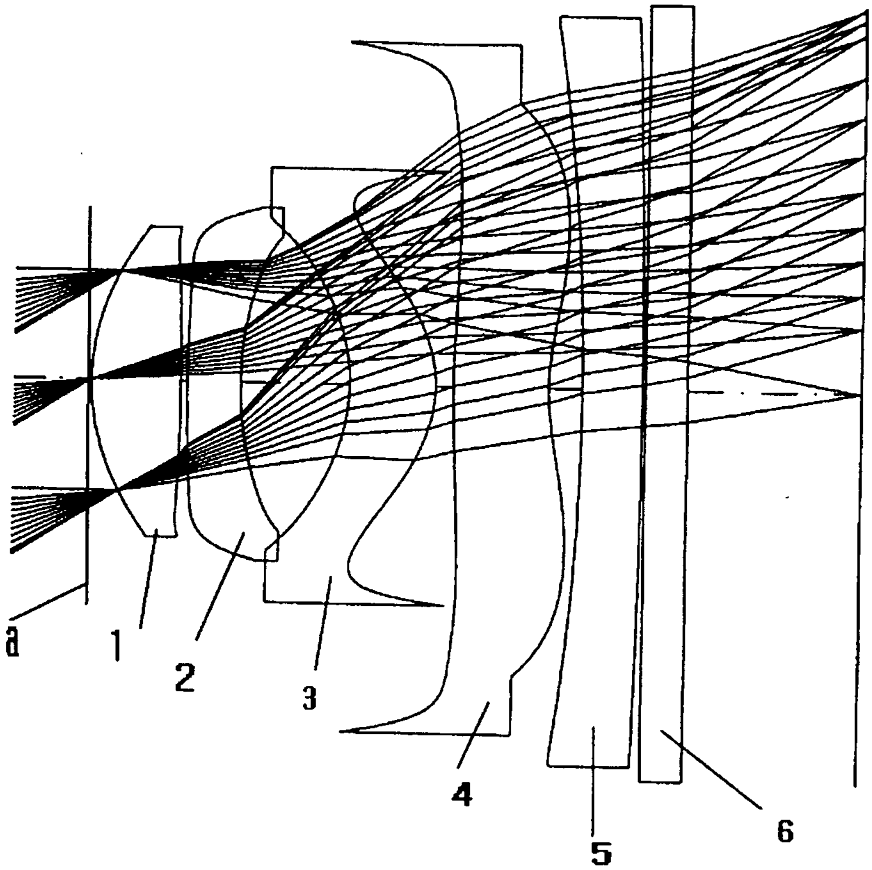
【Fig. 1】



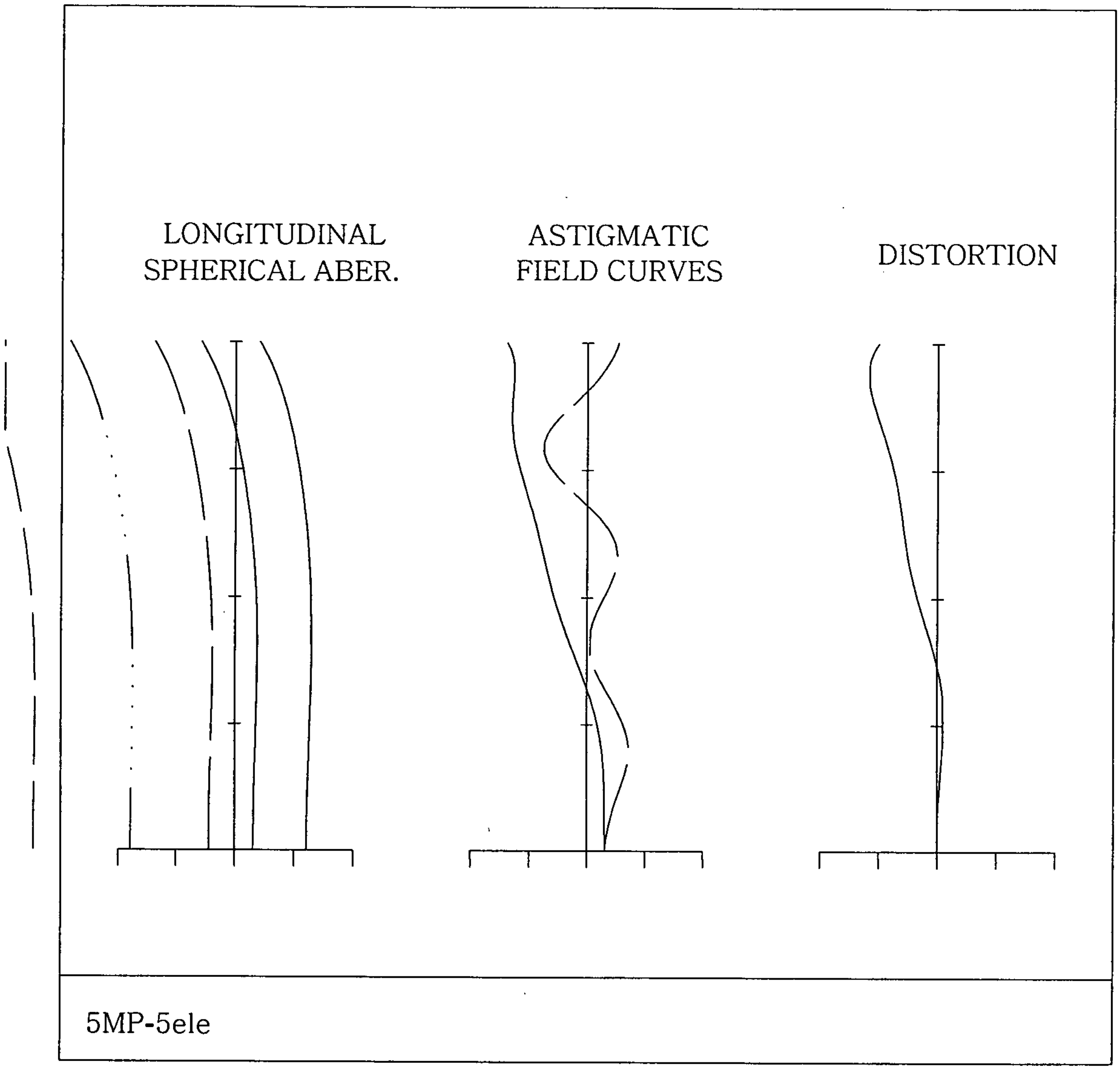
【Fig. 2】



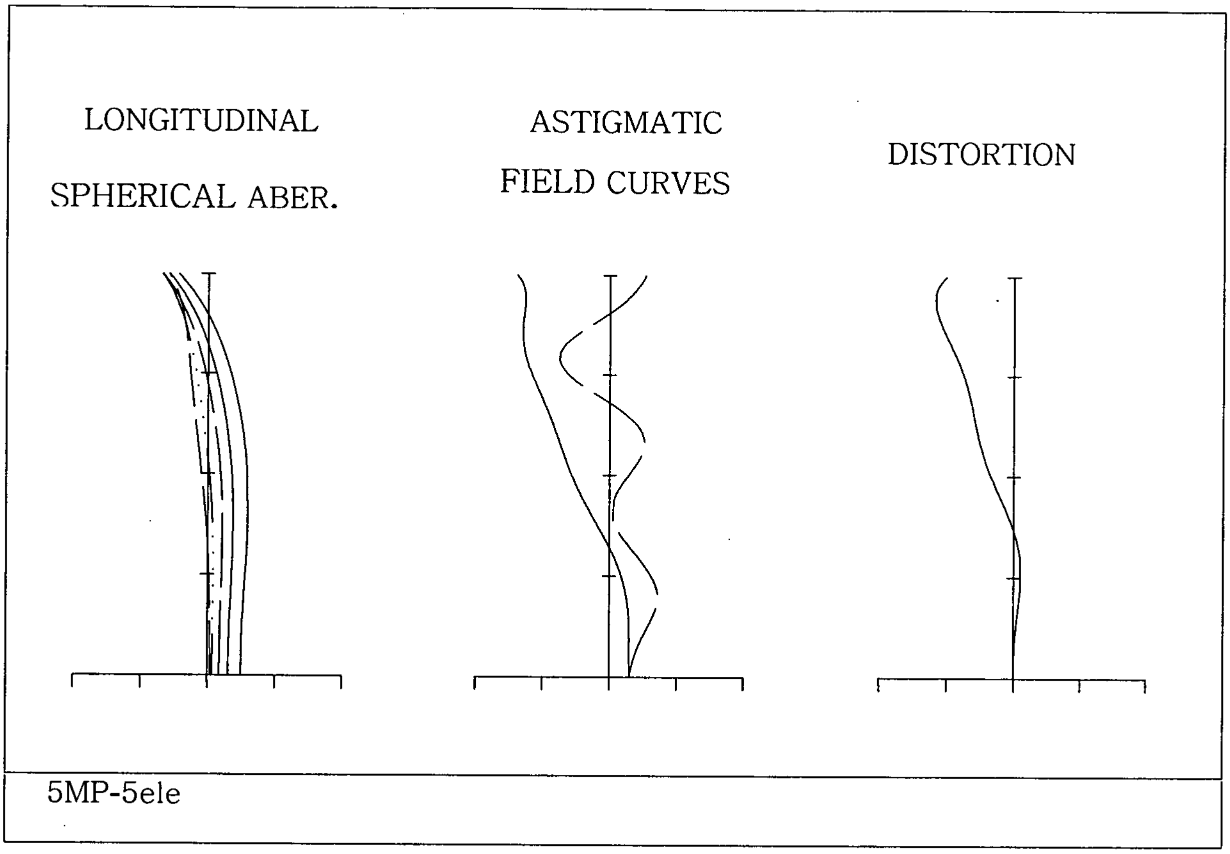
【Fig. 3】



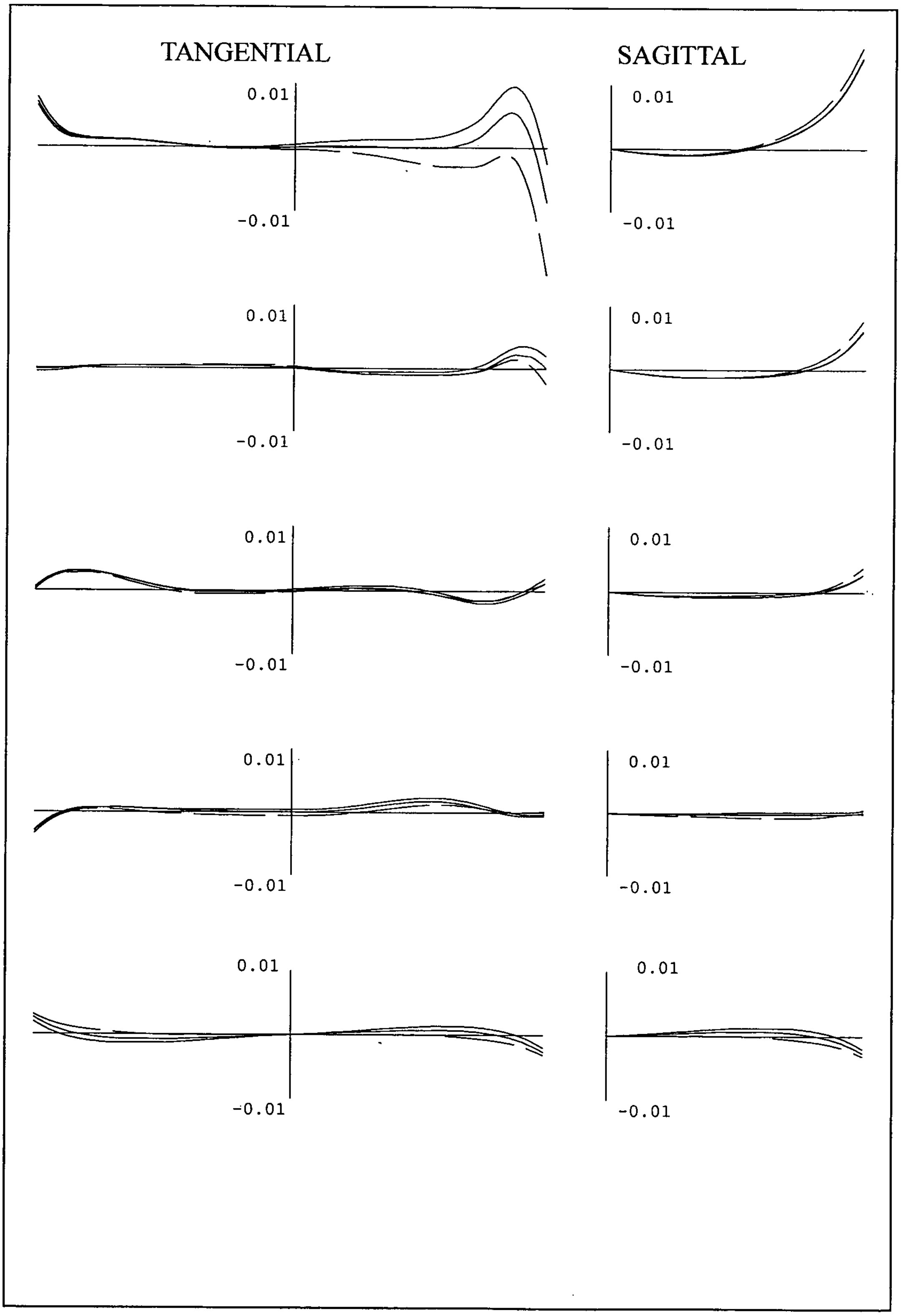
【Fig. 4】


LONGITUDINAL
SPHERICAL ABER.
ASTIGMATIC
FIELD CURVES
DISTORTION
5MP-5ele

【Fig. 5】


LONGITUDINAL
SPHERICAL ABER.
ASTIGMATIC
FIELD CURVES
DISTORTION
5MP-5ele

【Fig. 6】


TANGENTIAL
SAGITTAL
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-0.01
0.01
-0.01
0.01
-0.01
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-0.01
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-0.01
0.01
-0.01
0.01
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0.01
-0.01
0.01
-0.01
0.01
-0.01