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(73) Patent holder(s) Diostech Co., Ltd.
 151-21 Buk-ri, Namsa-myeon, Yongin-si, Gyeonggi-do, South Korea

(72) Inventor(s) Kim Moon Hyeon
 151-21 Buk-ri, Namsa-myeon, Cheoin-gu, Yongin-si, Gyeonggi-do, South Korea

Lee Jeong Hwan
 151-21 Buk-ri, Namsa-myeon, Cheoin-gu, Yongin-si, Gyeonggi-do, South Korea

(74) Representative Nate Patent Corporation

(56) Prior art search of patent literature

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Examiner(s): Kyeong Cheon Soo

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(54) Compact superwide angle optical system

(57) Summary

The present invention relates to a compact superwide angle optical system characterized including a first lens (L1) having a negative refractive power from the object side and a second lens (L2) having a positive or negative refractive power, a first lens group having negative refractive power as a whole; a second lens group comprising a third lens L3 having a positive refractive power; including a fourth lens (L4) having a positive refractive power from the object side and a fifth lens (L5) having a negative refractive power, a third lens group having positive refractive power as a whole; a diaphragm installed between the first lens group and the second lens group; the first lens group, the diaphragm, the second lens group, and the third lens group are arranged in order from the object side.

According to the present invention, it is possible to implement a superwide angle lens having a higher resolution performance while having a brighter F-number than the prior art. In addition, it is possible to implement a short optical system with a super wide angle and to secure a sufficient back focal length.

Representative

Diagram 1a

Scope of Patent Claims

Claim 1.

Including a first lens (L1) having a negative refractive power from the object side and a second lens (L2) having a positive or negative refractive power, the 1st lens group having negative refractive power as a whole;

The 2nd lens group consisting of a third lens (L3) having positive refractive power;

Including a fourth lens (L4) having a positive refractive power and a fifth lens (L5) having a negative refractive power from the object side, the 3rd lens group having a positive refractive power as a whole;

Including the diaphragm installed between the first lens group and the second lens group;

In the optical system arranged in the order of the 1st lens group, the diaphragm, the 2nd lens group, and the 3rd lens group from the object side,

The first lens group and the second lens group are compact superwide angle optical systems, characterized in that they satisfy the following conditions

$$0.4 < \phi_{12} / \phi_t < 0.8$$

ϕ_{12} : The reciprocal of the total focal length of the first lens group and the second lens group

ϕ_t : The reciprocal of the total focal length of the entire lens

Claim 2.

According to Claim 1,

All lens surfaces of the first lens group are aspheric, characterized in the compact superwide angle optical system

Claim 3.

According to Claim 1,

The first lens (L1) of the first lens group has a meniscus shape in which the object side is convex, characterized in the compact superwide angle optical system

Claim 4.

Deleted

Claim 5.

According to Claim 1,

The third lens group is a compact superwide angle optical system, characterized in that it satisfies the following conditions

$$0.1 < \phi_3 / \phi_t < 0.35$$

ϕ_3 : The reciprocal of the total focal length of the 3rd lens group

ϕ_t : The reciprocal of the total focal length of the entire lens

Claim 6.

According to Claim 1,

The third lens group is a compact superwide angle optical system, characterized in that it satisfies the following conditions

$$1.5 < V_4/V_5 < 3$$

V_4 : The dispersion value of the fourth lens (L4)

V_5 : The dispersion value of the fifth lens (L5)

Claim 7.

According to Claim 1,

When the distance from the first surface of the first lens to the image sensor in the optical system is TTL and the diagonal size of the image sensor is 2Y,

A compact superwide angle optical system characterized by having a relationship of

$$TTL / 2Y < 2.0$$

Specifications

Detailed Description of the Invention

Purpose of Invention

Technology to which the invention belongs and prior art in the field

The present invention is relevant to a surveillance camera capable of monitoring a wide area, particularly to a compact superwide angle optical system mounted on a vehicle.

In recent years, as the demand for optical systems used in vehicles has rapidly increased, corresponding technical requirements have also increased.

In general, a superwide angle optical system having an angle of view of about 140 to 160 degrees is used in surveillance cameras for vehicles, and the following conditions are the basic requirements for such a vehicle optical system.

First, it must be a bright lens. As a wide-angle lens for a vehicle has the characteristic of photographing an object regardless of the surrounding environment, a bright lens is required in order to photograph an object even in a low light amount.

Second, as it must be installed in an appropriate location without compromising the aesthetics of the vehicle, a size as small as possible is necessary.

Third, it must have high resolution performance.

Regarding such a superwide angle lens, Japanese Laid-Open Patent Publication No. 2006-11093 and Japanese Laid-Open Patent Publication No. 2005-321742 also disclosed such.

However, although the optical system of No. 2006-11093 has good resolving performance, there is a problem in that the brightness is not sufficient as the F-number, which is a measure of lens brightness, is only about 2.46.

Also, if calculated based on the disclosed embodiment, as the optical length (the distance from the first surface of the first lens to the image surface) is about 5.3 times larger than the diagonal size of the image sensor, since the overall size of the optical system is quite large, miniaturization of the optical system is limited.

Although the optical system disclosed in No. 2005-321742 is composed of only three lenses and is simple, the F-number is 2.96, which is not only very dark, but also has poor resolution performance. Furthermore, the size of the optical system is still on the large side, with the optical length being 4.3 times larger than the diagonal size of the image sensor.

Technical task to be achieved by the invention

The present invention is meant to solve such problems, and its purpose is to provide a superwide angle optical system that drastically improves the lens brightness and resolution performance compared to conventional methods and significantly reduces the overall size.

Composition of the invention

The present invention, in order to achieve the above purpose, provides a compact superwide angle optical system characterized including a first lens (L1) having a negative refractive power from the object side and a second lens (L2) having a positive or negative refractive power, a first lens group having negative refractive power as a whole; a second lens group having a third lens (L3) having positive refractive power; a third lens group having a positive refractive power as a whole, including a fourth lens L4 having a positive refractive power and a fifth lens L5 having a negative refractive power from the object side; including a diaphragm installed between the first lens group and the second lens group; the first lens group, the diaphragm, the second lens group and the third lens group are arranged in order from the object side.

From now on, proper embodiments of the present invention will be described with reference to the diagrams.

As the lens optical system according to the embodiments of the present invention is commonly shown in Diagram 1a, Diagram 2a, and Diagram 3a showing lens configurations according to the first, second, and third embodiments, respectively, arranged in the order of the first lens group, the second lens group, and the third lens group from the object side, each lens group has a structure including one or more lenses. Also, a diaphragm (not shown) is installed between the first lens group and the second lens group.

The first lens group, the second lens group, and the third lens group are distributed to have negative, positive, and positive refractive power, respectively, and in order to have a superwide angle, it has a structure in which the strong positive refractive power of the second lens group is complemented by the arrangement of the first lens group and the third lens group.

Looking at the specifics, the first lens group has a negative refractive power as a whole, and it includes a first lens (L1) having negative refractive power from the object side and a second lens (L2) having positive or negative refractive power.

As such, the first lens group in front of the aperture has a strong negative refractive power, making it possible to construct a superwide angle system, and even if the total length of the optical system is shortened, a sufficient margin for the back focal length (the distance from the last lens surface to the image sensor) can be secured, making it easier to configure and design equipment.

In particular, a meniscus-shaped lens having a convex object side is used as the first lens (L1) so as to be suitable for incident light in the superwide angle areas.

In addition, in order to increase lens brightness and resolution, all four lens surfaces of the first and second lenses are made of aspherical surfaces.

The second lens group is composed of a third lens (L3) having a positive refractive power.

In particular, in each embodiment of the present invention, in order to implement a superwide angle system, the refractive powers of the first lens group and the second lens group are designed to satisfy Conditional Expression 1 below.

<Conditional Expression 1>

$$0.4 < \phi_{12} / \phi_t < 0.8$$

ϕ_{12} : The reciprocal of the total focal length of the first lens group and the second lens group.

ϕ_t : The reciprocal of the total focal length of the entire lens.

Conditional Expression 1 is about the relationship between the total focal length of the first lens group and the second lens group, and if the upper limit is exceeded, the power burden increases and aberration correction becomes difficult, and if it is less than the lower limit, it becomes difficult to have a superwide angle.

The third lens group has a positive refractive power as a whole, and it is configured to include a fourth lens (L4) having positive refractive power and a fifth lens (L5) having negative refractive power from the object side.

As the superwide angle lens system must have strong refractive power by default, in each embodiment of the present invention, the third lens group serves to share the burden of the strong positive refractive power of the second lens group. The third lens group has slightly weaker positive refractive power than the second lens group.

In addition, the positive refractive power of the third lens group closest to the image side has the effect of reducing the chief ray angle (CRA) of the chief ray incident on the image plane.

In each embodiment of the present invention, the third lens group must be designed to satisfy Conditional Expression 2 below in relation to power.

<Conditional Expression 2>

$$0.1 < \phi_3 / \phi_t < 0.35$$

ϕ_3 : The reciprocal of the total focal length of the third lens group.

ϕ_t : The reciprocal of the total focal length of the entire lens.

If the upper limit is exceeded in Conditional Expression 2, aberration correction becomes difficult due to power burden, and if the value is smaller than the lower limit, it becomes difficult to configure an ultra-wide angle with a short length.

In addition, in the third lens group, the lens group itself is composed of a telephoto type to help shorten the overall length, and even with a bright F-number, the effect of aberration correction is large, and it plays a decisive role in enabling a bright F-number.

In addition, in order to have high resolving power, the third lens group must satisfy the following Conditional Expression 3 related to chromatic aberration correction.

<Conditional Expression 3>

$$1.5 < V_4 / V_5 < 3$$

V_4 : The dispersion value of the fourth lens.

V_5 : The dispersion value of the fifth lens.

Meanwhile, Table 1 below shows calculated values for performance values and conditional expressions for design specifications of three embodiments that satisfy the configuration of the lens described above.

[Table 1]

	Embodiment 1	Embodiment 2	Embodiment 3
FNO	1.7916	1.7916	1.8200
Angle of view	144	148	154
TTL/2Y	1.9189	1.9750	1.9415
Image height - Y	1	1	1
Total length of the lens	0.97760	0.97730	0.96280
$\phi 12 / \phi t$ - Conditional Expression 1	0.62729	0.70657	0.61669
$\phi 3 / \phi t$ - Conditional Expression 2	0.22170	0.15353	0.20317
V4/V5 - Conditional Expression 3	2.18726	2.18726	2.18726

All of the three embodiments shown in Table 1 assume a lens system in which the image height Y value is 1 (in other words, the image diagonal size is 2). Here, TTL/2Y is the total length of the lens divided by the diagonal size of the image, and represents information on the total length of the lens.

From Table 1, it can be seen that the F-number, which is a measure of lens brightness, is only 1.79 and 1.82 in each embodiment of the present invention. Therefore, according to the embodiment of the present invention, a much brighter superwide angle optical system can be implemented, and according to experiments, an F-number in the range of 1.65 to 1.85 can be easily obtained.

Also, the values of TTL/2Y related to the size of the optical system are all less than 2, and therefore, according to the embodiment of the invention, it can be shown that the optical electric field can be configured to be less than twice the diagonal size of the image sensor. Here, TTL is the distance from the first surface of the lens to the image sensor, and 2Y is the diagonal size of the image sensor.

The data for each embodiment provided to calculate the values in Table 1 are as follows, and the specific configuration of the superwide angle optical system according to each embodiment is as shown in Diagram 1a, Diagram 2a, and Diagram 3a.

Here, the R value is the radius of curvature of the lens, the D value is the thickness and air gap of the lens, Nd is the refractive index at the d-line (587.56nm) of the lens material, and vd is the Abbe number of the lens material. Aperture represents a value that is half of the aperture that blocks light at the position where it blocks light.

In addition, the aspheric surface coefficient shown in each embodiment is a coefficient applied to the following relational expression related to the aspherical surface shape.

Here, Z is the distance from the apex of the lens in the direction of the optical axis, h is the distance in the direction perpendicular to the optical axis, C is the reciprocal of the radius of curvature at the apex of the lens, K is the Conic constant, and A4, A6, A8, A10, and A12 are aspheric coefficients, respectively.

<First Embodiment>

surface #		R value	D value	Nd	Vd	aperture
1	Sphere	infinity	infinity			Refract
2	Asphere	6.82734	0.22838	1.48749	70.41	Refract
3	Asphere	0.63740	0.42632			Refract
4	Asphere	1.02110	0.33029	1.75520	27.58	Refract
STOP	Asphere	0.72063	0.18040			Refract
5	Sphere	3.04576	0.68443	1.66545	52.89	Refract
6	Sphere	-0.85153	0.22222			Refract
7	Sphere	2.18748	0.65976	1.62041	60.32	Refract
8	Sphere	-0.78481	0.22222	1.75520	27.58	Refract
9	Sphere	-6.64433	0.68981			Refract
10	Sphere	infinity	0.13330	1.48749	70.41	Refract
11	Sphere	infinity	0.00000			Refract
12	Sphere	infinity	6.8578			Refract
image	Sphere	infinity	0.00000			Refract

surface #	K	A4	A6	A8	A12
1	-1.20026284482E+03	7.63796583252E-02	1.25182873514E-02	-4.58422870472E-02	1.83093516517E-02
2	-3.8488823603E-01	-2.53313683398E-01	1.64874858119E+00	-1.99742632111E+00	6.09713082258E+00
3	1.49308936502E+00	-0.54541784439E-01	-1.06162023218E-01	-5.64348120037E+00	1.82932933631E+00
STOP	1.40193115991E+00	1.07613085028E-02	-2.97436939940E+00	9.10894505990E+00	-7.62235731333E-01

<Second Embodiment>

surface #		R value	D value	N d	V d		aperture
	Sphere	infinity	infinity			Refract	
1	Asphere	13.77396	0.22272	1.48749	70.4058	Refract	
2	Asphere	0.82951	0.87803			Refract	0.82738
3	Asphere	1.07795	0.22272	1.75581	27.5795	Refract	
stop	Asphere	0.83905	0.13382			Refract	
5	Sphere	2.74741	0.52268	1.69058	49.8164	Refract	
6	Sphere	-1.03624	0.02261			Refract	0.87253
7	Sphere	2.27528	0.75106	1.82041	60.3236	Refract	
8	Sphere	-0.78811	0.22272	1.75581	27.5795	Refract	
9	Sphere	-24.92379	0.08895			Refract	
10	Sphere	infinity	0.18327	1.48749	70.4058	Refract	
11	Sphere	infinity	0.00000			Refract	
12	Sphere	infinity	0.76731			Refract	
image	Sphere	infinity	0.00000			Refract	1

surface #	K	A4	A6	A8	A10
1	-1.15477114592E+03	9.77554682466E+08	4.29475123404E+02	-2.84857303097E+02	5.73144282638E+03
2	6.09313892306E+01	-2.7338257413E+01	8.6087617516E+01	-2.83212346620E+00	2.67320925799E+00
3	1.58396099746E+00	-8.43300072497E+01	-9.41087659933E+01	3.93880714737E+02	-2.43328583469E+00
STOP	1.42355707821E+00	-8.68985337709E+01	-2.33021597948E+00	1.18593762404E+01	-4.41666657225E+01

<Third Embodiment>

surface #		R value	D value	N d	V d		aperture
	Sphere	infinity	infinity			Refract	
1	Asphere	19.98700	0.36535	1.48749	70.4058	Refract	
2	Asphere	0.93628	0.77790	1.68623	31.0344	Refract	0.82738
3	Asphere	1.37622	0.25734	1.68623	31.0344	Refract	
stop	Asphere	1.81803	0.22418			Refract	
5	Sphere	-6.49935	0.45732	1.74367	44.8504	Refract	
6	Sphere	-0.02750	0.02742			Refract	0.87253
7	Sphere	1.58226	0.97482	1.82041	60.3236	Refract	
8	Sphere	-0.97506	0.22418	1.75581	27.5795	Refract	
9	Sphere	12.43753	0.08897			Refract	
10	Sphere	infinity	0.18327	1.48749	70.4058	Refract	
11	Sphere	infinity	0.00000			Refract	
12	Sphere	infinity	0.43226			Refract	
image	Sphere	infinity	0.00000			Refract	1

surface #	K	A4	A6	A8	A10
1	-5.23155272564E+05	-4.63948981733E+02	6.93622608746E+02	-2.83736356778E+02	4.4352733685E+03
2	6.53099152263E+01	1.16740790455E+01	1.19689056324E+01	2.54233312070E+01	4.27000320085E+01
3	3.34967727877E+00	-3.37063578512E+01	-1.99280038227E+00	3.68450905956E+00	-1.43168032471E+01
STOP	8.38127355687E+00	-2.95318593373E+02	-1.95338650871E+00	7.46765564861E+00	-2.13455273997E+01

On the other hand, Diagram 1b, Diagram 2b, and Diagram 3b show aberration diagrams of superwide angle optical systems according to the first, second, and third embodiments, respectively, and through this, it can be confirmed that spherical aberration, astigmatism, and distortion aberration are normal in each embodiment.

In the astigmatism diagram, *tan* represents the astigmatism curve in the direction in which the object and the optical axis are parallel, and *sag* represents the astigmatism curve in the direction perpendicular to the object and the optical axis.

Effects of the invention

According to the embodiment of the present invention, as the first lens group having a strong negative refractive power is located in front of the diaphragm, it is possible to implement an optical system with a superwide angle and short overall length and to secure a sufficient back focal length.

Specifically, it is possible to miniaturize the optical system by configuring the optical electric field to be less than twice the diagonal size of the image sensor.

In addition, the first lens group is composed of two lenses, a first lens and a second lens, and by configuring all four lens surfaces with aspherical surfaces, it is possible to implement a lens having a high resolution performance while having a bright F-number.

In particular, according to the present invention, the F-number, which is the brightness of the lens, reaches about 1.65 to 1.85 so that a superwide angle optical system that is much brighter than before can be implemented.

In addition, the third lens group with positive refractive power located at the uppermost side is composed of a fourth lens with positive refractive power and a fifth lens with negative refractive power, and in particular, as it is configured as a telephoto type, the optical length can be further shortened, and in this case, as the effect of aberration correction is increased, a bright F-number can be realized.

Brief Description of the Diagrams

Diagram 1a and Diagram 1b are diagrams showing a configuration diagram and an aberration diagram of an optical system according to the first embodiment of the present invention, respectively.

Diagram 2a and Diagram 2b are diagrams showing a configuration diagram and an aberration diagram of an optical system according to the second embodiment of the present invention, respectively.

Diagram 3a and Diagram 3b are diagrams showing a configuration diagram and an aberration diagram of an optical system according to the third embodiment of the present invention, respectively.

Description of symbols for main parts of the diagrams

L1: First lens L2: Second lens

L3: Third lens L4: Fourth lens

L5: Fifth lens LF: Filter

Diagrams

Diagram 1a

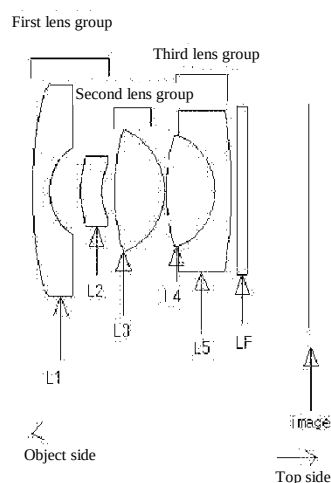


Diagram 1b

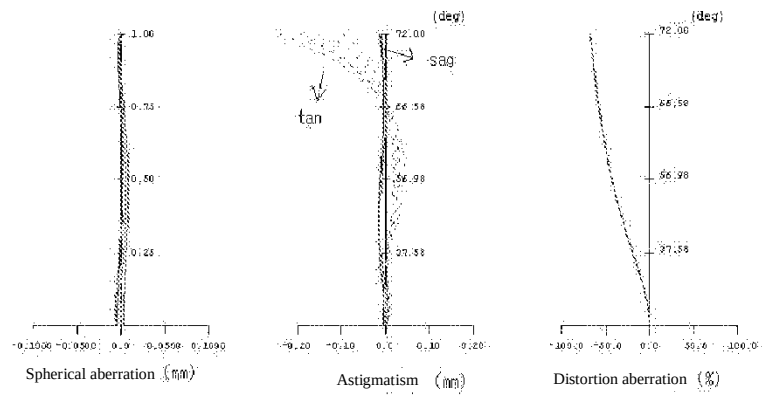


Diagram 2a

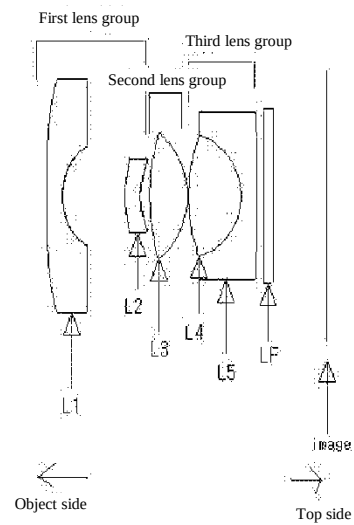


Diagram 2b

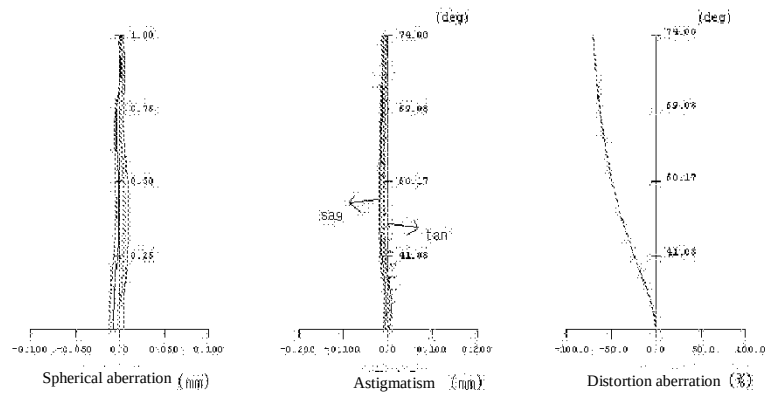


Diagram 3a

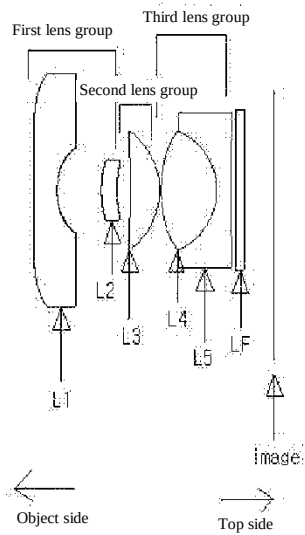
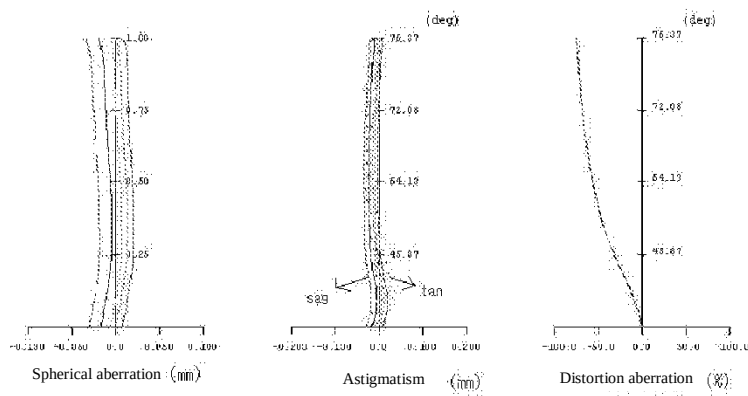


Diagram 3b





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I, Jacqueline Yorke, hereby certify that the document “#86405_EX1008_KR100677055B1” is, to the best of my knowledge and belief, a true and accurate translation from Korean into English.

I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true. Further, I hereby declare that these statements were made with the knowledge that willful false statements and the like are punishable by fine or imprisonment, or both, under 18 U.S.C. § 1001.

A handwritten signature in black ink, appearing to read 'J Yorke', written over a horizontal line.

Jacqueline Yorke

Sworn to before me this
January 13, 2023

A handwritten signature in black ink, appearing to read 'WJP', written over a horizontal line.

Signature, Notary Public



Stamp, Notary Public

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