350-432 SR

1/12/82 OR 4,310,222

United States Patent [19]

Ikemori

[11] 4,310,222

[45] * Jan. 12, 1982

[54] RETRO-FOCUS TYPE WIDE ANGLE LENS

[75] Inventor: **Keiji Ikemori**, Yokohama, Japan

[73] Assignee: **Canon Kabushiki Kaisha**, Kanagawa, Japan

[*] Notice: The portion of the term of this patent subsequent to Sep. 5, 1995, has been disclaimed.

[21] Appl. No.: **31,613**

[22] Filed: **Apr. 18, 1979**

Related U.S. Application Data

[63] Continuation-in-part of Ser. No. 845,579, Oct. 26, 1977, abandoned.

[30] **Foreign Application Priority Data**

Oct. 29, 1976	[JP]	Japan	51-130334
Apr. 21, 1978	[JP]	Japan	53-47511

[51] **Int. Cl.**^{3} **G02B 13/04**; G02B 9/64

[52] **U.S. Cl.** **350/432**; 350/458

[58] **Field of Search** 350/432, 458

[56] **References Cited**

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3,966,306	6/1976	Okudaira	350/214
4,111,558	9/1978	Ikemori	350/214
4,116,536	9/1978	Moscovich	350/214

Primary Examiner—Conrad J. Clark

Attorney, Agent, or Firm—Toren, McGeady & Stanger

[57] ABSTRACT

The present invention relates to a retro-focus type wide angle lens which is compact despite its remarkably large field of view and well compensated for various aberrations.

This lens system consists of the first divergent lens group and the second convergent lens group in sequence from the side of the object, whereby the first divergent group consists of a plural number of meniscus lenses convex to the object in such a manner that the distortion is compensated for and a compact lens system is realized by forming the object side surface of the substantially zero first order power lens in the meniscus lenses non spherical. The meniscus lens with non-spherical surface is formed from plastic material, resulting in an inexpensive and light retro-focus type wide angle lens.

Further, the second convergent lens group is divided into two lens groups with a diaphragm as boundary, whereby in the object side lens group a meniscus lens concave to the object and a biconvex lens are arranged in sequence from the diaphragm to the object side so as to form an air lens having a divergent effect between both lenses, while in the image plane side lens group a lens concave to the image is arranged so as to eliminate the astigmatism and the spherical aberration.

19 Claims, 47 Drawing Figures

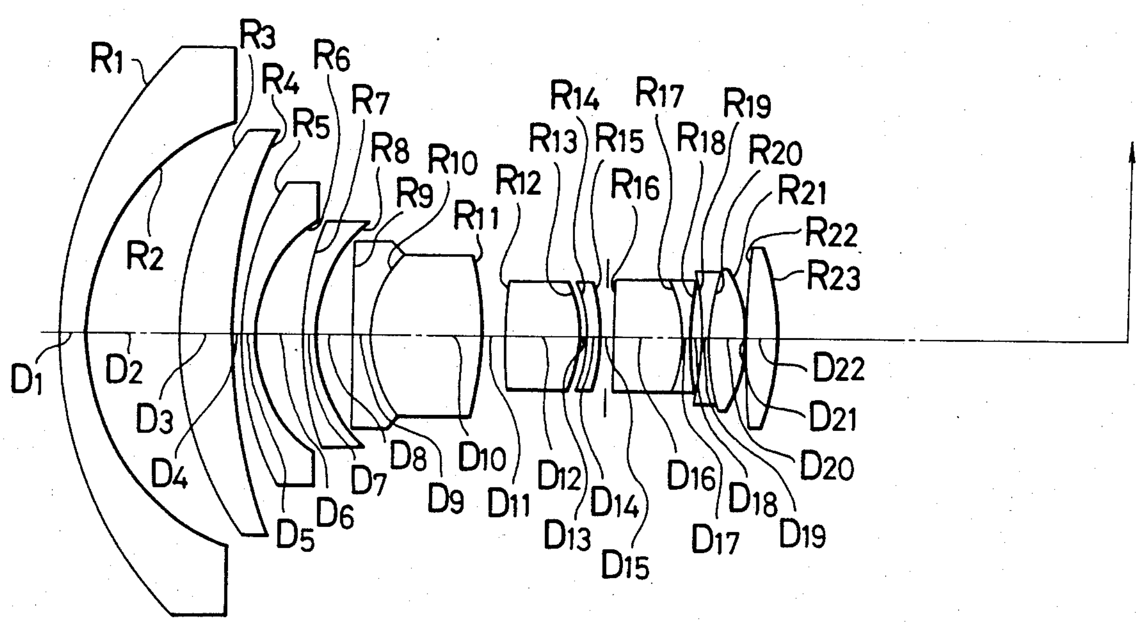

FIG.1

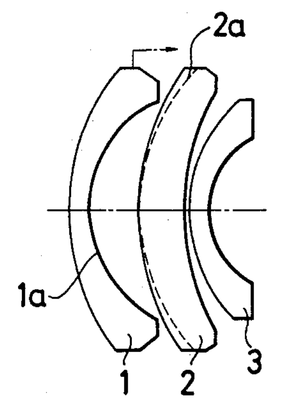
2a
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FIG.2

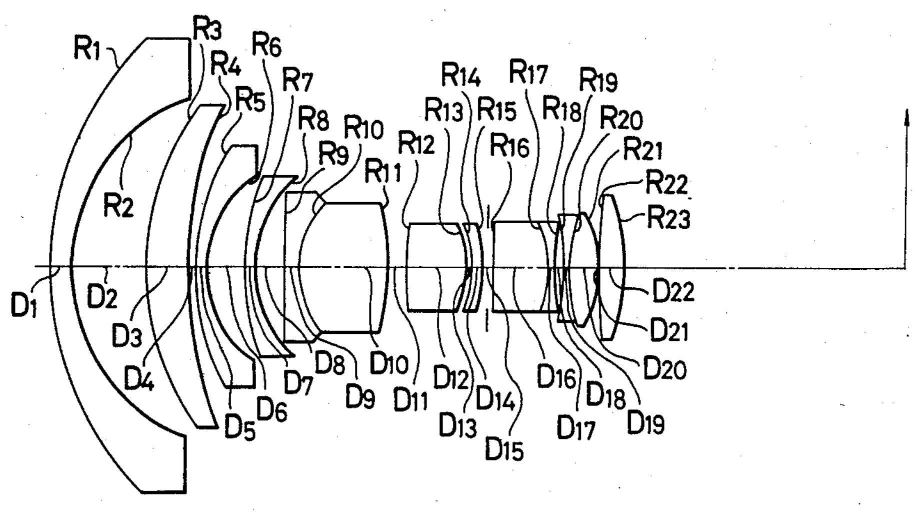
R1
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FIG.3A

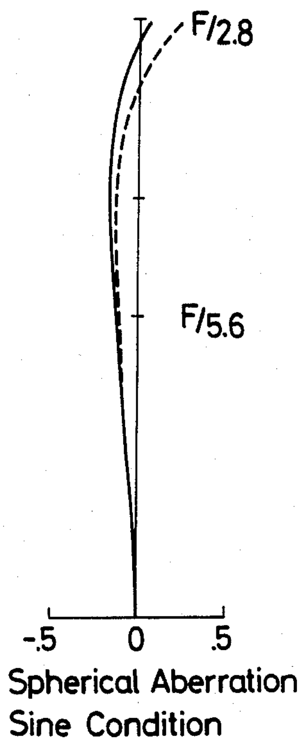

FIG.3B

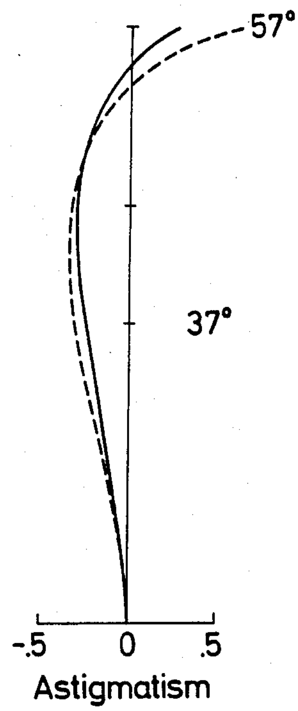

FIG.3C

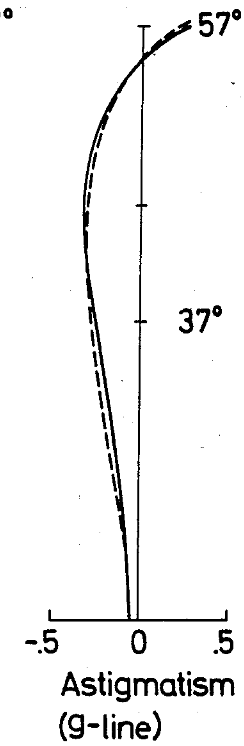

FIG.3D

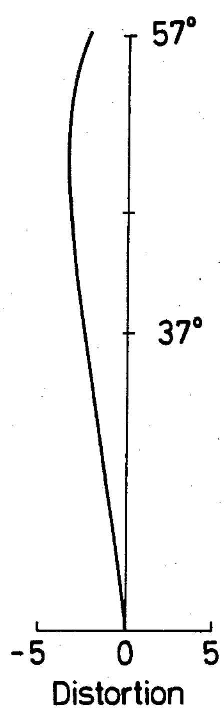

FIG.3E

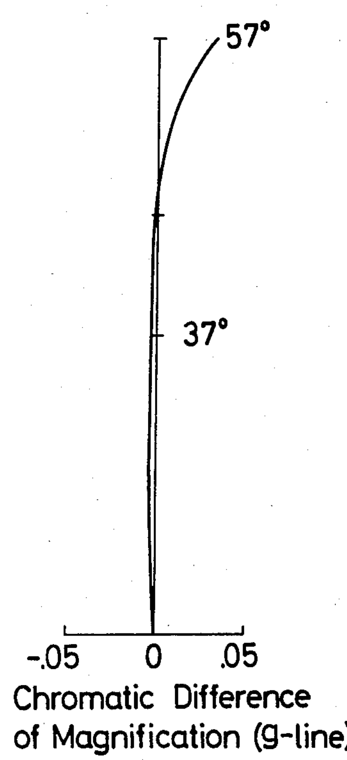

FIG.4

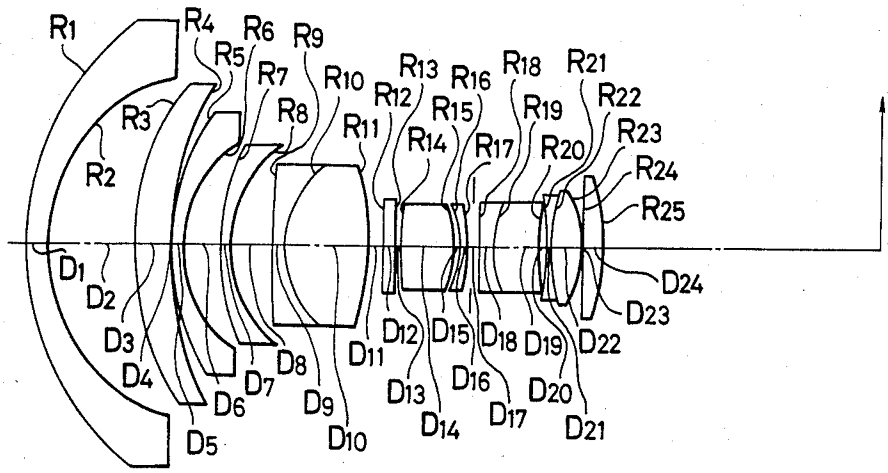
R1
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FIG.6

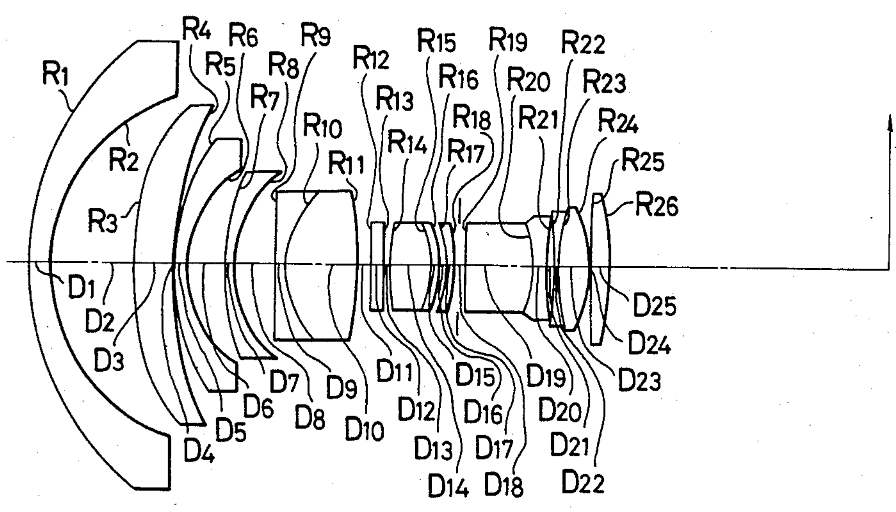
R1
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FIG.5A

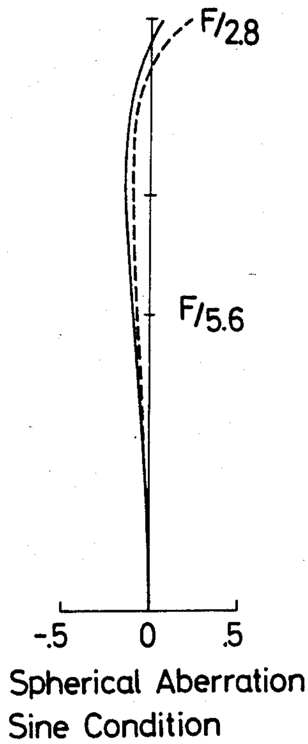

FIG.5B

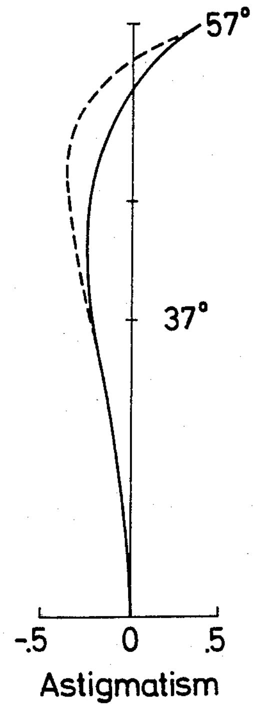

FIG.5C

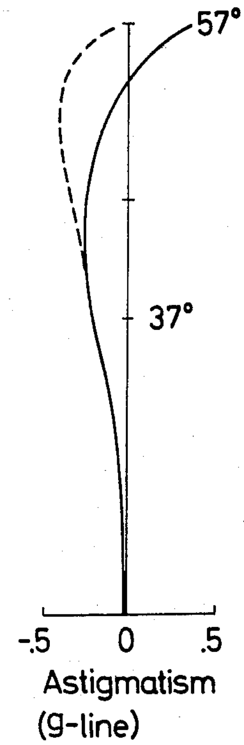

FIG.5D

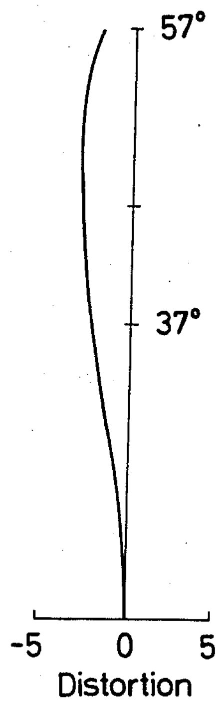

FIG.5E

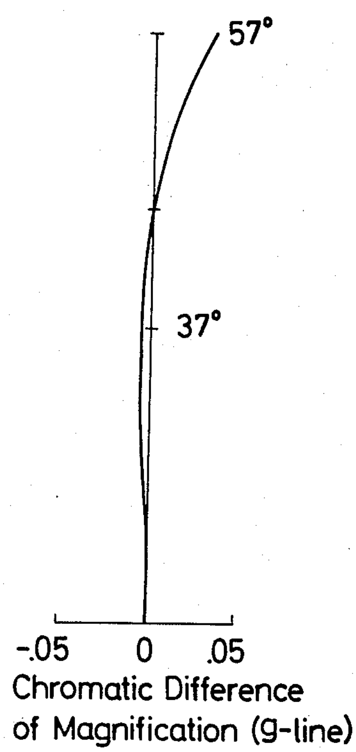

FIG.7A

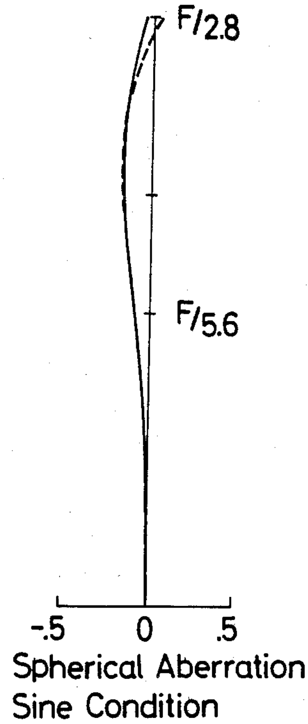

FIG.7B

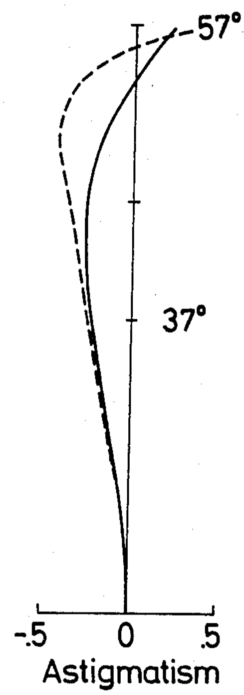

FIG.7C

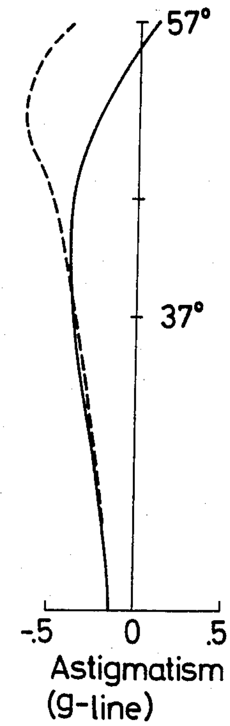

FIG.7D

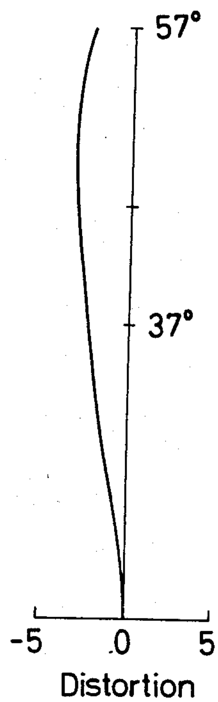

FIG.7E

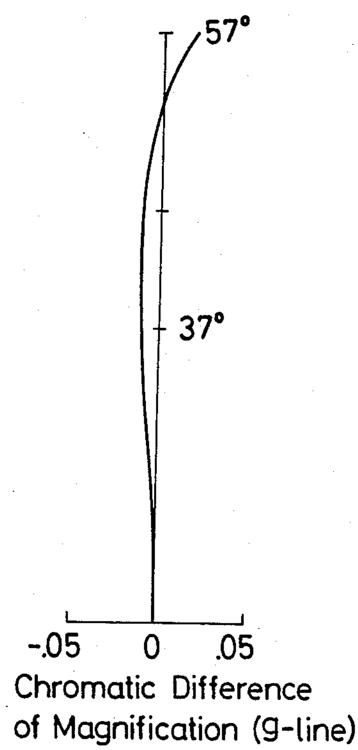

FIG.8

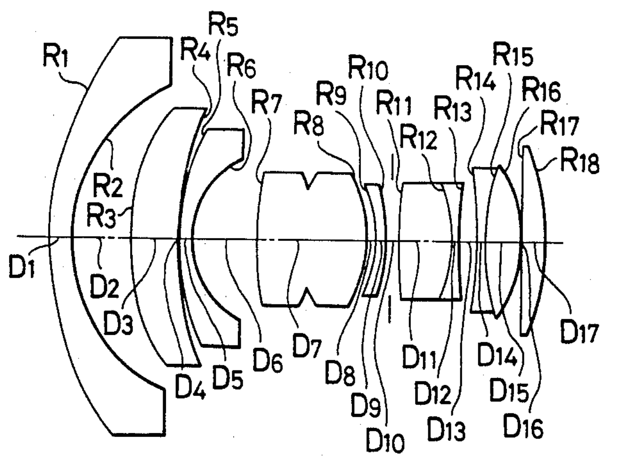
R1
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FIG.10

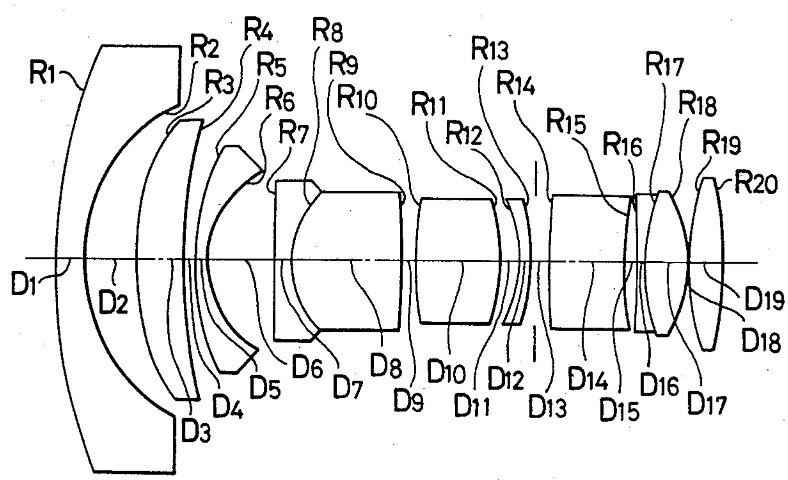
R1
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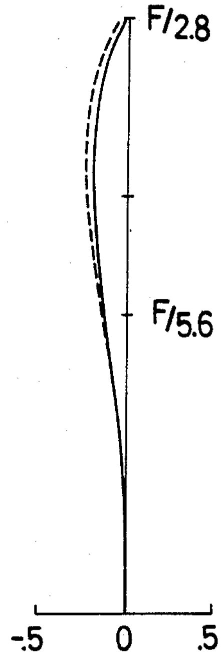
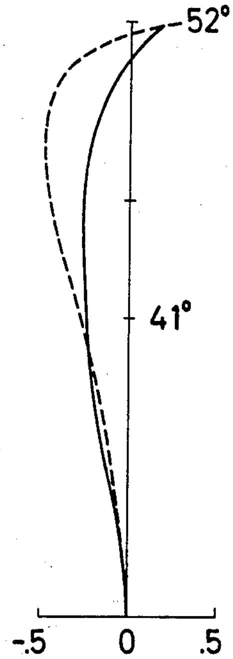
FIG.9A



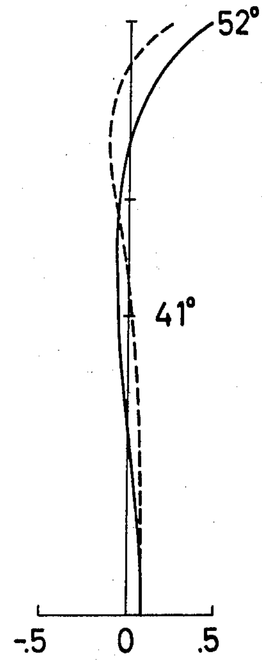
Spherical Aberration
Sine Condition

FIG.9B



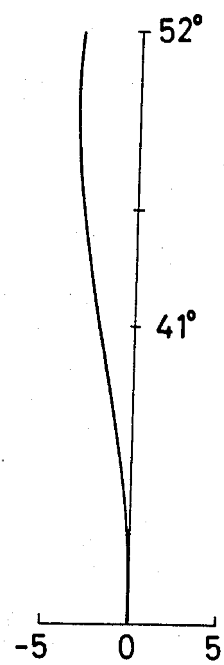
Astigmatism

FIG.9C



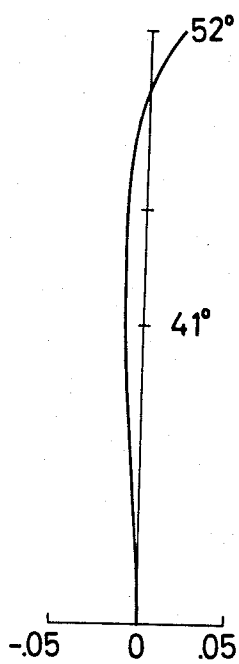
Astigmatism
(g-line)

FIG.9D



Distortion

FIG.9E



Chromatic Difference
of Magnification (g-line)

FIG.11A

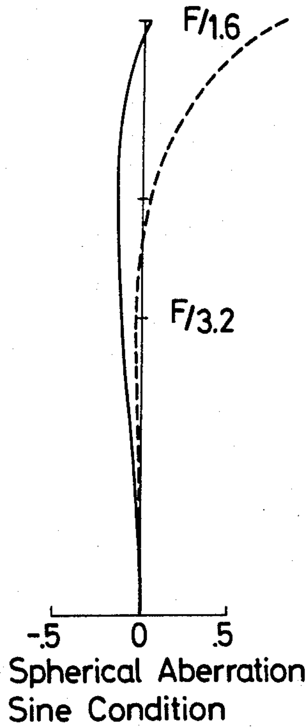


FIG.11B

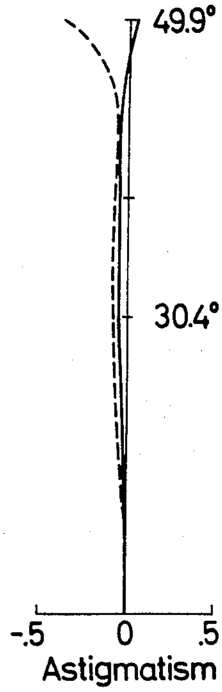


FIG.11C

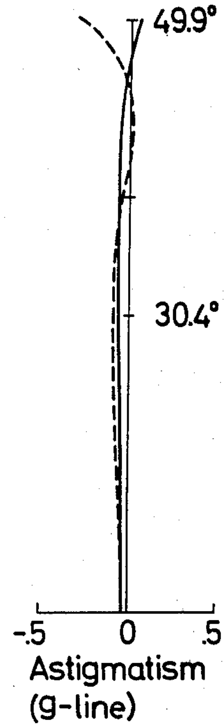


FIG.11D

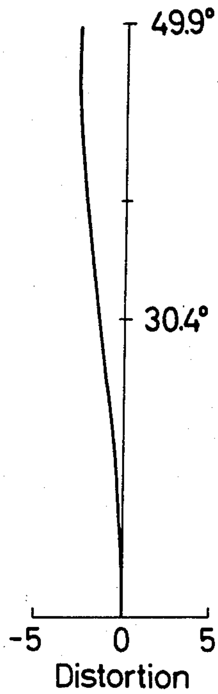


FIG.11E

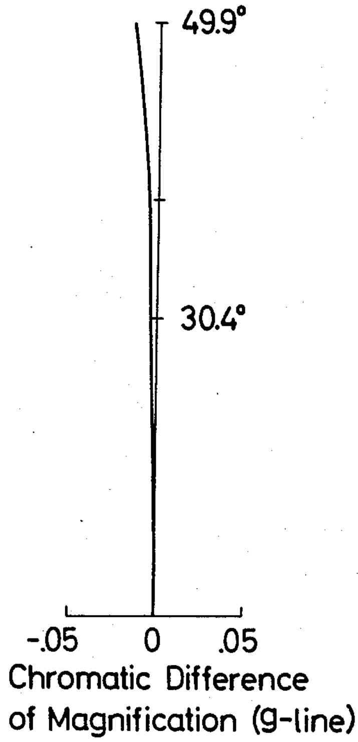


FIG.12

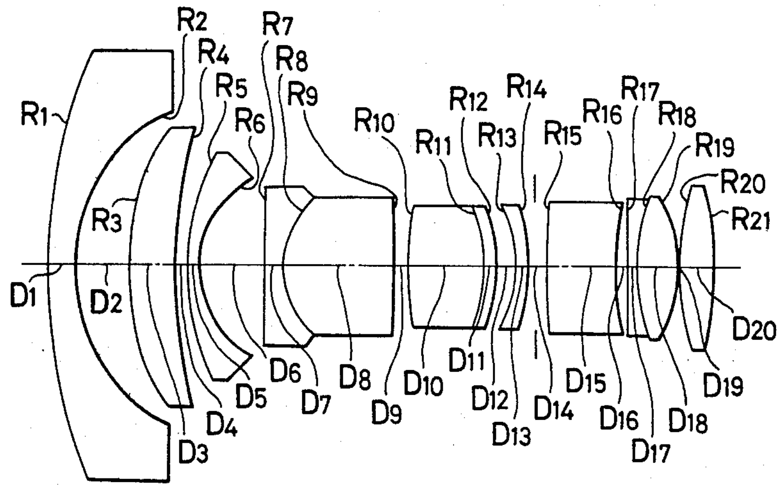

R1
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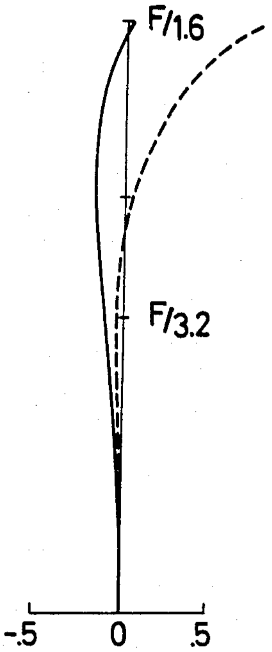
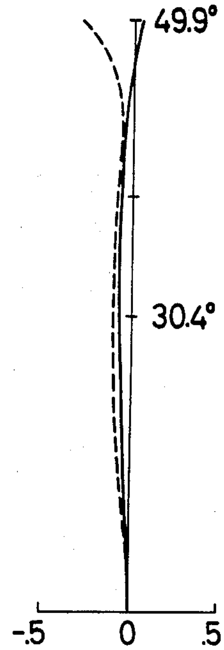
FIG.13A



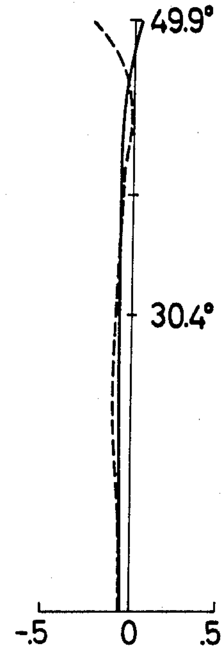
Spherical Aberration
Sine Condition

FIG.13B



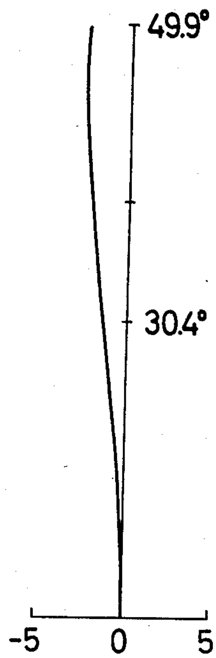
Astigmatism

FIG.13C



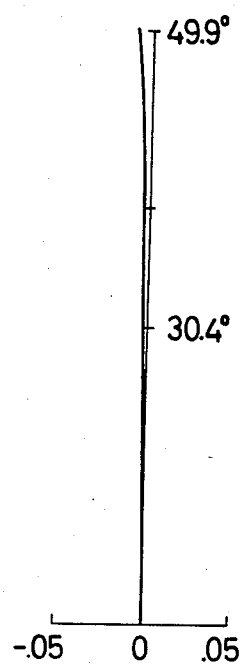
Astigmatism
(g-line)

FIG.13D

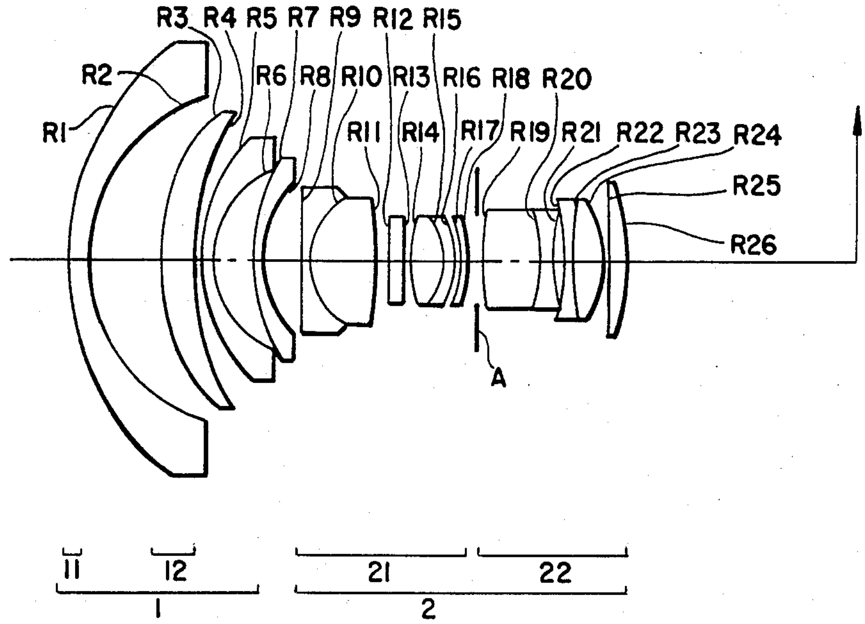


Distortion

FIG.13E



Chromatic Difference
of Magnification (g-line)


R3 R4 R5 R7 R9 R12 R15
R2
R6 R8 R10 R13 R16 R18 R20
R1
R11 R14 R17 R19 R21 R22 R23 R24
R25
R26
A
11
12
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22
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FIG. 14

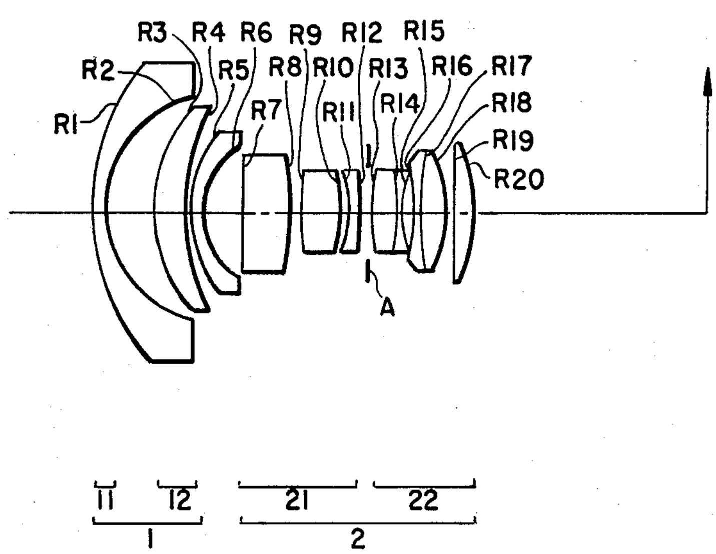
R3 R4 R6 R9 R12 R15
R2
R5 R8 R10 R13 R16 R17
R1
R7 R11 R14
R18
R19
R20
A
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FIG. 16

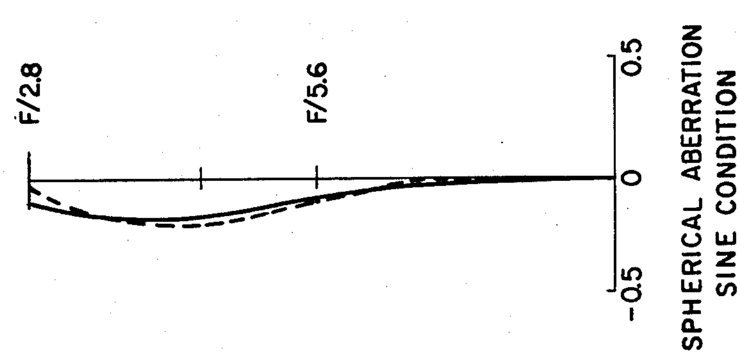


FIG. 15A

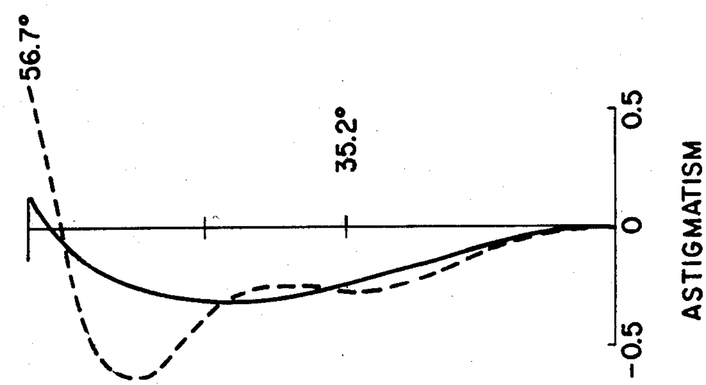


FIG. 15B

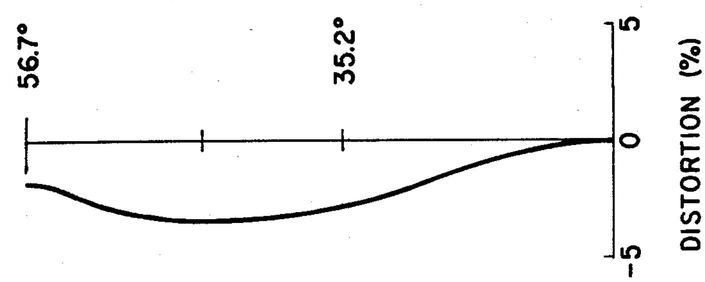


FIG. 15C

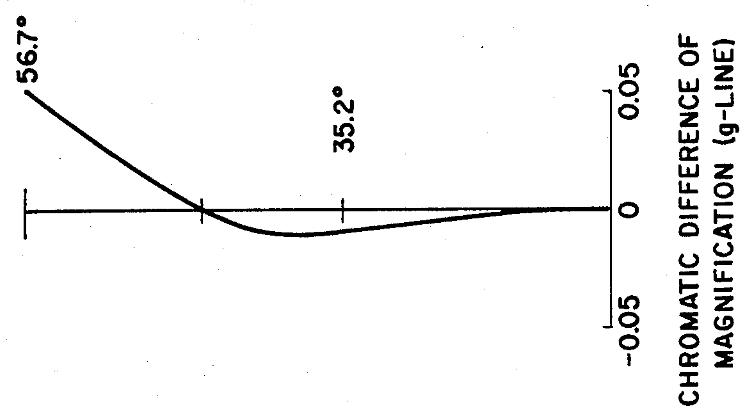
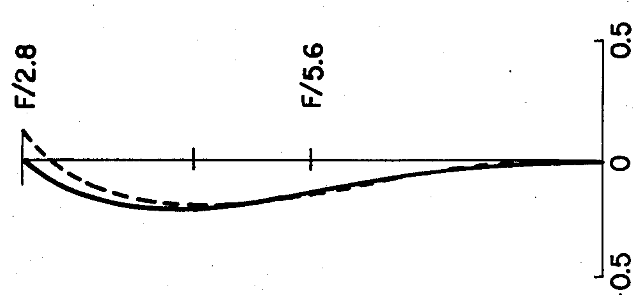
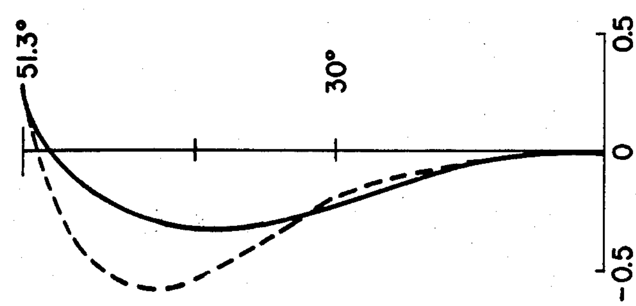


FIG. 15D



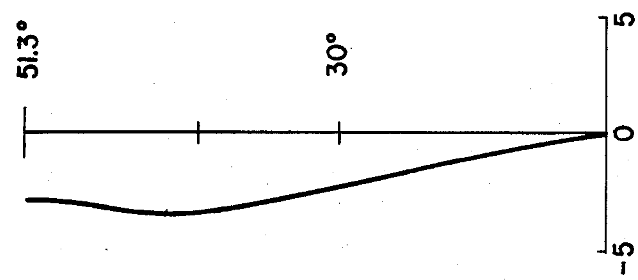
SPHERICAL ABERRATION
SINE CONDITION

FIG. 17A



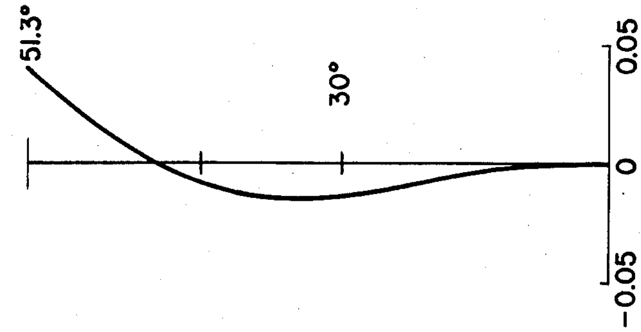
ASTIGMATISM

FIG. 17B



DISTORTION (%)

FIG. 17C



CHROMATIC DIFFERENCE OF
MAGNIFICATION (g-LINE)

FIG. 17D

RETRO-FOCUS TYPE WIDE ANGLE LENS

CROSS REFERENCE TO RELATED APPLICATION:

This application is a continuation-in-part of our co-pending application Ser. No. 845,579 filed on Oct. 26, 1977 and now abandoned.

BACKGROUND OF THE INVENTION

The present invention relates to a retro-focus type ultra wide angle lens which is well compensated for various aberrations by the use of a non-spherical optical system.

Until now various kinds of retro-focus type wide angle lenses have been known. In the retro-focus type lens system it is desirable to have a sufficiently long back focus, while the compensation of the distortion, the astigmatism or the coma is difficult because of the non-symmetry of the lens system. It is remarkably difficult to compensate for both the distortion and the astigmatism at the same time. Consequently, the larger the field of view is, the higher the number of the lenses is increased in order to compensate various aberrations.

It is well known to introduce a non-spherical surface in order to compensate distortion without complicating the lens system. Because the non-spherical surface influences other aberrations, however, care should be taken in designing the non-spherical surface. In order to compensate the distortion well it is desirable that the non-spherical surface is provided at the position in the lens system at which the distance between the optical axis and the off-axial principal ray with the maximum field of view is as large as possible.

The reason is as follows. Hereby, let ν represent the number of respective lens surfaces, $\overline{h\nu}$ the height of the position on the νth surface at which the on-axial (paraxial) ray crosses the surface, $h\nu$ the height of the position on the νth surface at which the principal ray (a ray from the object point to the center of the diaphragm) crosses the surface.

I (Spherical aberration with the third grade aberration coefficient)$=\Sigma I\nu$,
II (Coma)$=\Sigma II\nu$,
III (Astigmatism)$=\Sigma III\nu$,
V (Distortion)$=\Sigma V\nu$

The amount which the non-spherical element contributes to respective aberration is proportional to $h^4\nu$ with reference to $I\nu$, to $h^3\nu\overline{h\nu}$ with reference to $II\nu$, to $h^2\nu\overline{h\nu}^2$ with reference to $III\nu$ and to $h\nu\overline{h\nu}^3$ ($h\nu\overline{h\nu}^5$ in fifth order distortions) with reference to $V\nu$.

As is understood from the above, the surface with large $\overline{h\nu}$ but small $h\nu$ should be formed non-spherically in order to compensate the distortion V by using a non-spherical surface, keeping the influence or other aberrations as small as possible.

Further, even in the range of the higher orders than the fifth, the distortion is proportional to the height $\overline{h\nu}$, so that it is effective to form the surface with the large $h\nu$ non-spherical in order to compensate the distortion.

An example of a retro-focus type wide angle lens in which the distortion is compensated with a non-spherical surface while the astigmatism to be increased as the result is suppressed is disclosed in the U.S. Pat. No. 3,832,035. In case of this example any optical surface in the front divergent lens system is made non-spherical in order to eliminate the distortion, while the astigmatism is compensated by limiting the sum of the thickness at the center of a determined number of lenses.

However, generally in case of the retro-focus type wide angle lenses, as is explained above, the larger the field is, the greater the number of the lenses is increased in order to compensate for various aberrations so that the realization of a compact wide angle lens is desired, for which conventionally no particular consideration has been paid.

When a lens having a non-spherical surface is used in a lens system, more labor and time are required for grinding the lens surface to a non-spherical form than for grinding the lens to a spherical form and thus the manufacturing cost of the lens system will be very high. However, if the lens having a non-spherical surface is made of plastic, the manufacturing cost will be markedly lowered, because the plastic lens can be formed by molds and only several accurate molds make possible a mass production in a short period of time.

However, a plastic lens has the following two defects. First, plastic shows a larger degree of thermal expansion and contraction than glass, and changes in the thickness of the plastic lens produce adverse effects on the total focal length and the back focus of the whole lens system. Secondly, the plastic lens made by molding has a poor surface accuracy as compared with a glass lens. This induces deterioration of the aberration.

A lens system using a plastic lens having a non-spherical surface is disclosed in British Pat. No. 1,388,723, but it has been impossible to provide a high-performance lens system using a plastic lens due to the above-mentioned defects.

SUMMARY OF THE INVENTION

A purpose of the present invention is to offer a retro-focus type wide angle lens in which the distortion is compensated despite its remarkably large field of view, while other aberrations are also well compensated.

Another purpose of the present invention is to offer a cheap and light retro-focus type wide angle lens, while the distortion and other aberrations are well compensated.

In the retro-focus type according to the present invention, the above object is achieved by effectively arranging a plastic lens containing a non-spherical surface.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 shows an embodiment of the first divergent lens group of the retro-focus type ultra wide angle lens of the present invention.

FIG. 2 shows a section of the first embodiment of the lens in accordance with the present invention.

FIGS. 3A to 3E show the respective aberrations of the first embodiment.

FIG. 4 shows a section of the second embodiment of the lens in accordance with the present invention.

FIGS. 5A to 5E show respective aberrations of the second embodiment.

FIG. 6 shows a section of the third embodiment of the lens in accordance with the present invention.

FIGS. 7A to 7E show respective aberrations of the third embodiment.

FIG. 8 shows a section of the fourth embodiment of the lens in accordance with the present invention.

FIGS. 9A to 9E show respective aberrations of the fourth embodiment.

FIG. 10 shows a section of the fifth embodiment of the lens in accordance with the present invention.

FIGS. 11A to 11E show respective aberrations of the fifth embodiment.

FIG. 12 shows a section of the sixth embodiment of the lens in accordance with the present invention.

FIGS. 13A to 13E show respective aberrations of the sixth embodiment.

FIG. 14 shows a section of the seventh embodiment of the lens in accordance with the present invention.

FIGS. 15A to 15D show the respective aberrations of the seventh embodiment.

FIG. 16 shows a section of the eighth embodiment of the lens in accordance with the present invention.

FIGS. 17A to 17D show respective aberrations of the eighth embodiment.

DETAILED DESCRIPTION OF THE INVENTION

The retro-focus type wide angle lens in accordance with the present invention is divided into a first divergent lens group and a second convergent lens group in sequence from the object side. In the embodiments to be explained later the first divergent lens group is separated from the second convergent lens group at a position at which the height of the paraxially traced light beam on the optical axis is 1.4 with an incident height of 1.0.

In order to well compensate the distortion, which is the purpose of the present invention, it is recommended to provide the non-spherical surface at the position at which the distance between the optical axis and the principal ray with the maximum angle of field is as large as possible. When using wide angle lenses among the so-called photographic objective lenses whose back focus is longer than 1.7 times of the effective total length, it is recommended to provide the distortion compensating non-spherical surface in the first divergent lens group in which a surface with maximum $\overline{h\nu}$ but small $h\nu$ exists. Further, espeically when the field of view, is remarkably large in a retro-focus type wide angle lens having a non-spherical surface, it is possible to decrease the diameter of the front lens greatly by shortening the air gaps in the first divergent lens group. In consequence, the second purpose of the present invention can be achieved by means of the following two measures. Namely, in order to realize a compact wide angle lens, it is essential that immediately in front of the lens with a non-spherical surface a negative meniscus lens having a surface convex to the object should be provided and the radius of curvature of the lens surface facing the non-spherical surface of the meniscus lens should be smaller than the radius of paraxial curvature of the non-spherical lens.

Secondly, a conventional non-spherical lens such as the retro-focus type wide angle lens disclosed in U.S. Pat. No. 3,832,035 has paraxially a considerable divergent effect, while in accordance with the present invention a substantially almost afocal (substantially zero first order power) lens is used to the one to be provided with a non-spherical surface. Thus, the divergent effect of each concave lens in accordance with the present invention is weaker even if the number of the concave meniscus lenses in the first divergent lens group in accordance with the present invention is equal to that of the conventional first divergent lens group where the divergent effect in the first divergent lens group is chosen equal to that in the conventional first divergent lens. This enables the reduction of the air gaps in the first divergent lens group, or the reduction of the number of lenses and further the reduction of the diameter of the front lens. Further, the higher order aberrations take place lens often, which serves to the improvement of the efficiency. Namely, the fact that the non-spherical lens of the barrel distortion compensation is paraxially almost afocal includes many optically important factors for the realization of the lens system, the improvement of the efficiency, the realization of a large field of view and so on.

In the retro-focus type ultra wide angle lens group of the present invention, each number of the first divergent lens group consists of meniscus lenses convex to the object, namely the 1-1th divergent lens group whose at least one meniscus lens has a negative refractive index, the 1-2th lens group having at least one meniscus lens with an absolute value of the paraxial focal length twenty five times or more as large as the composed focal length of the lens system and the 1–3th divergent lens group having more than one meniscus lenses with a negative refractive index in sequence from the side of the object. The meniscus lens arranged in the 1-2th lens group is the one nearly afocal, whereby the surface nearest to the object, of the 1-2th lens group is non-spherical and represented as follows:

$$X = R\left\{1 - \left(1 - \frac{H^2}{R^2}\right)^{\frac{1}{2}}\right\} + V$$

$$V = AH^2 + BH^4 + CH^6 + DH^8 + EH^{10}$$

Under the following difinitions:

R: Paraxial radius of curvature

H: Coordinate perpendicular to the optical axis

X: Coordinate in alignment with the optical axis, the direction along which the light beam advances is supposed positive while the summit of the plane is supposed the origin

A–E: non-spherical coefficient

and under the condition $B>0$, V is increased along as $H(0<H<R)$ increases. In other words, the non-spherical surface is so shaped that the more distant it is from the optical axis toward the circumference of the lens, the greater the displacement of the non-spherical surface from the spherical surface, namely the more the polished the surface is. Further the radius of curvature of the surface facing the above non-spherical surface, of the 1-1th divergent lens group is smaller than the paraxial radius of curvature R of the non-spherical surface.

Further, the second convergent lens group consists of the 2-1st convergent lens group and the 2-2nd convergent lens group in sequence from the side of the object so as to include the diaphragm between them. In the 2-1st convergent lens group at least one negative meniscus lens whose concave surface is facing the object is arranged immediately in front of the side of the diaphragm that faces the object, while a biconvex lens is provided at the side of the negative meniscus lens facing the object. The air lens formed between the negative meniscus lens and the biconvex lens has a divergent effect. Further, the 2-2nd convergent lens group has at least one divergent surface concave to the image plane.

Further, it is desired that the distance between the diaphragm and the surface at the side of the image plane, of the biconvex lens in the afore mentioned 2-1st convergent lens should be 0.15 times or more but 0.85

times or less as large as the effective focal length of the wide angle lens.

It is possible that by constituting the first divergent lens group only with the meniscus lenses convex to the object no remarkably large light incident angle or light exiting out angle is involved when the light beam outside of the axis reaching the circumference of the picture plane and having a particularly large incident angle to the first surface penetrates the lens group, which is connected with the reduction of the diameter of the lens and the reasonable compensation of aberration.

The non-spherical surface of the nearly afocal meniscus lens provided in the **1-2**th lens group is so shaped that the closer it is to the circumference of the lens, the greater is the displacement of the non-spherical surface from the spherical surface. This means that the lens with non-spherical surface is almost afocal near the optical axis while the convergence is increased toward the circumference of the picture plane, which is quite effective for a reasonable compensation of the barrel distortion to be remarkably emphasized toward the circumference of the picture plane.

First, it is essential to keep the distortion of the third aberration coefficient as small as possible, for which at least B should be greater than zero.

FIG. **1** shows an embodiment of the first divergent lens group in accordance with the present invention, whereby each of the **1-1**th divergent lens group **1**, the **1-2**th lens group **2** and the **1-3**th divergent lens group **3** consists of only the lens. The non-spherical surface **2***a* is shown with a dotted line, whereby the radius curvature of the lens plane **1***a* opposed the non-spherical surface **2***a* is smaller than that of the surface **2***a*. With this shape of the non-spherical surface, the air gap between the image side **1***a* of the negative meniscus lens **1** and the non-spherical surface **2***a* is increased toward the circumference of the lens, as compared with the ordinary spherical lens. This means that the lens **1** can be brought closer to the non-spherical lens **2**, which allows the reduction of the total lens length and of the diameter of the front lens.

In the present invention, the non-spherical lens to be provided in the **1-2**th lens group so as to compensate the barrel distortion should paraxially be nearly afocal, whereby as a standard the focal length of the non-spherical lens is twenty-five or more times as large as that of the total lens system. The paraxial refracting power of this non-spherical lens is of weak convergence in the first embodiment, of weak divergence in the second and third embodiment, of weak convergence in the fourth embodiment and of considerably weak convergence in the fifth and the sixth embodiments. Consequently, the non-spherical lens in the **1-2**th lens group of the present invention has paraxially little refracting power, whereby the more distant it is from the optical axis toward the circumference of the lens, the more convergence, practically takes place thanks to the effect of the non-spherical surface.

Further, a negative meniscus lens convex to the object is located at the object side of the non-spherical lens so that at first a light beam with a remarkably large incident angle out of the optical axis is at first refracted by means of the negative meniscus lens, in such a manner that the angle between the light beam and the optical axis is decreased, and enters into the non-spherical lens. Thus, it never happens that the chromatic difference of magnification (g-line) should become extremely larger near the largest picture angle.

Hereby, the barrel distortion is compensated by means of the introduction of a non-spherical surface. However, it can not always be said that aberrations other than the distortion are never adversely influenced, whereby the astigmatism is worst influenced in such a manner that the amount is proportional to the compensation amount of the distortion. Thus, if within the range of the above mentioned conditions the distortion is compensated in the state in which the compensation amount of the distortion is small, the deterioration of the astigmatism is permissible. However, in order to further increase the picture angle while keeping the compactness, it is necessary to compensate the barrel distortion by increasing the amount of deviation of the non-spherical surface as stated above, whereby the compensation of the astigmatism becomes insufficient at the same time. For example in the present embodiment, the astigmatism is no longer permissible when the picture angle is larger than 99.8°. Further, in order to obtain a smaller F value (for example F1:2.8 or more as in case of the present embodiment) while keeping a good image forming ability at the circumference of the picture plane, the afore mentioned conditions are also needed for the second convergent lens group.

Namely, the second convergent lens group consists of the **2-1**st convergent lens group and the **2-2**nd convergent lens group in sequence from the object side so as to include the diaphragm between them. Immediately in front of the diaphragm in the **2-1**st convergent lens group at least one negative meniscus lens having a surface concave to the object is provided, while a biconvex lens is provided an the object side of this negative meniscus lens in such a manner that a divergent air lens is formed between the negative meniscus lens and the biconvex lens. When the negative meniscus lens consists of a plural number of lenses, the biconvex lens and the last meniscus lens at the object side may be cemented to each other. In this case, the cemented surfaces form a divergent surface with no air gap. The **2-2**nd convergent lens group includes at least one divergent surface concave to the object, whereby this divergent surface may be either exposed to the air or cemented to another surface.

By providing a divergent air lens or a divergent surface exercising an excessive spherical aberration respectively in the **2-1**st and the **2-2**nd convergent lens group, the balance of the spherical aberration in the total lens system can be kept by means of the amount of the spherical aberrations whose respective divergence is small. This enables the reduction of the spherical aberration, namely the realization of a higher efficiency.

In the same way, as in case of the afore mentioned aberrations, the astigmatism is proportional to $h\nu^2\overline{h\nu}^2$ while the distortion is almost proportional to $h\nu\overline{h\nu}^3$.

Thus, in accordance with the present invention, the afore mentioned negative meniscus lens in the **2-1**st convergent lens group is arranged between the diaphragm and the object side surface of the biconvex lens and a little closer to the diaphragm, whereby the object side surface of the biconvex is between 0.15 f and 0.85 f from the diaphragm. Hereby, f is the focal length of the total lens system. Thus, this concave meniscus lens is large in $h\nu(+)$ and small in $\overline{h\nu}(-)$ to some extent so that practically no barrel distortion takes place while the astigmatism is emphasized. Further by forming this concave lens as a meniscus lens concave to the object, the light beam out of the optical axis is incident on the lens at a considerably large angle so that astigmatism is not emphasized on the light beam near the center while the greater the distance of the beam from the optical axis, the more emphasized the astigmatism is.

Thus, when the above mentioned negative meniscus lens is within 0.15 f from the diaphragm, $\overline{h\nu}$ is nearly 0 so that practically no astigmatism takes place while when it is beyond 0,85 f from the diaphragm, the astigmatism is emphasized already from the neighborhood of the central intermediate picture angle, whereby a large barrel distortion also takes place in such a manner that a reasonable compensation of the aberration as a whole is no longer possible. Further in case of the conventional retro-focus type ultra wide angle lens, there is a general tendency that the astigmatism for the light beam (for example g-line) with a wave length shorter than the standard wave length is extremely suppressed between the intermediate angle and the maximum angle of field. However, this tendency can also reasonably compensate, by arranging a negative meniscus lens in the above mentioned **2-1st** convergent lens group at a proper position within the range of the above mentioned numerical figures as in case of the present invention.

The **2-2nd** convergent lens group is arranged behind the diaphragm so that, as is shown in the tables to be explained later, both $h\nu$ and $\overline{h\nu}$ have positive values whereby the value of $h\nu$ is large while that for $\overline{h\nu}$ is small. Thus the divergent surfaces in this lens group emphasize astigmatism and cause pincushion distortion, whereby the amount is larger in the astigmatism than in the distortion.

Thus, even if the astigmatism is allowed to be emphasized, practically no barrel distortion takes place so that a largely emphasized astigmatism may be produced even from the neighborhood of the central light beam.

Further, apart from the above mentioned effects, the divergent surfaces in the 2-2nd convergent lens group keep the necessary amount of the back focus so that it is necessary to keep the divergent effect to some extent, whereby it is desirable that the effect should be born by more than two surfaces particularly if the field of view and the diaphragm aperture are large.

Further, because the astigmatism is produced largely from the intermediate angle of field, the lenses must be concave to the object within a range in which the higher order aberrations are rarely produced. This has the effect of extending the back focus. Therefore, the shortage of the compensation of the astigmatism caused by the compensation of the barrel distortion by increasing the amount of deviation of the non-spherical surface in the first divergent lens group is in the second convergent lens group compensated by providing a negative meniscus lens in the **2-1st** convergent lens group near the maximum angle of field and by the divergent surfaces concave to the object in the **2-2nd** convergent lens group from an area near the center of an area near the intermediate angle of field. Further, because there is a portion having a divergent effect respectively in the **2-1st** and the **2-2nd** convergent lens groups, the spherical aberration can be removeably balanced for the whole lens system in which the respective spherical aberrations are small so that it is possible to realize a large diaphragm aperture.

Below the embodiments of the present invention will be explained. FIG. **2** shows a section of the first embodiment of the lens system in accordance with the present invention, whereby a negative meniscus lens (**R1, R2**) convex an the object side, a paraxial almost afocal non-spherical positive meniscus lens (**R3, R4**) convex at the object side and two negative meniscus lenses (**R5–R8**) convex at the object side are provided in sequence from the object side in such a manner that the first divergent lens group consists of the surfaces **R1** to **R8**. Behind the first divergent lens group, a cemented lens convex on both surfaces (**R9–R11**), a lens convex on both surfaces (**R12, R13**), a negative meniscus lens (**R14, R15**) convex on the image side, a diaphragm, two cemented negative meniscus lens (**R16–R18**) with a concave divergent surface on the image plane side and a convex surface on the object side, a positive meniscus lens (**R19–R21**) having a cemented concave divergent plane (**R20**) on the image side and a convex surface on the image plane side and a lens convex on both surfaces (**R22, R23**) are arranged in sequence from the object side, whereby the second convergent lens group consists of the surfaces **R9–R23**. FIG. **3** shows the respective aberrations of the first embodiment. Below the data for the first embodiment are given. Hereby the values for $h\nu$ and $h\nu$ are those when the focal distance is 1.

The first embodiment:

f (focal distance) = 14.2; F No. = 1:2.8
bf (back focal distance) = 36.6
Angle of field = 114°

Lens Group	Plane	Focal Distance
The first divergent lens group	R1–R8	−1.06f
The second convergent lens group		
The 2-1st convergent lens group	R9–R15	2.67f
The 2-2nd convergent lens group	R16–R23	2.37f

Radius of Curvature		Thickness · Distance		Refractive Index (nd)		Abbe Number (νd)		$h\nu$	$\overline{h\nu}$
R 1	44.344	D 1	3	n 1	1.6968	ν 1	55.5	1.000	−1.942
R 2	25.494	D 2	10.63					0.972	−1.764
R 3	56.952	D 3	6.14	n 2	1.6031	ν 2	60.7	1.088	−1.208
R 4	58.976	D 4	1					1.085	−0.958
R 5	32.455	D 5	1.5	n 3	1.6968	ν 3	55.5	1.096	−0.903
R 6	15.699	D 6	5.45					1.084	−0.837
R 7	34.226	D 7	1.5	n 4	1.7725	ν 4	49.7	1.275	−0.632
R 8	16.356	D 8	4.18					1.280	−0.588
R 9	202.88	D 9	2	n 5	1.6968	ν 5	55.5	1.559	−0.487
R10	12.66	D10	12.71	n 6	1.60342	ν 6	38	1.631	−0.457
R11	−41.964	D11	2.187					2.213	−0.280
R12	56.099	D12	8.88	n 7	1.51742	ν 7	52.3	2.304	−0.223
R13	−13.786	D13	0.738					2.423	−0.056
R14	−12.664	D14	1.2	n 8	1.7725	ν 8	49.7	2.371	−0.034
R15	−26.477	D15	1.7					2.421	−0.014
R16	140.256	D16	7.98	n 9	1.69895	ν 9	30.1	2.427	0.035
R17	−14.608	D17	1	n10	1.62606	ν10	39.1	2.386	0.170

-continued

	Radius of Curvature		Thickness · Distance		Refractive Index (nd)		Abbe Number (νd)	hν	$\overline{h\nu}$
R18	55.637	D18	0.846					2.373	0.187
R19	−55.153	D19	1	n11	1.84666	ν11	23.9	2.378	0.212
R20	27.603	D20	4.24	n12	1.48749	ν12	70.1	2.401	0.230
R21	−15.512	D21	0.15					2.612	0.333
R22	111.951	D22	3.41	n13	1.60311	ν13	60.7	2.610	0.337
R23	−32.396							2.563	0.388

In the above table, **R3** is a non-spherical surface, while the non-spherical coefficients are as follows:

A=0

$B=9.660\times10^{-6}$

$C=2.605\times10^{-9}$

$D=1.106\times10^{-11}$

$E=2.260\times10^{-14}$

R	SA	CM	AS	PT	DS
	Third Order Aberration Coefficients				
1	0.0080	0.0094	0.0109	0.1322	0.0131
2	−0.1108	0.0381	−10.0131	−0.2300	0.0836
3	0.2215	−0.1780	0.2682	0.0943	−0.1264
4	−0.0281	−0.0380	−0.0515	−0.0910	−0.1933
5	0.0933	0.0580	0.0361	0.1806	0.1349
6	−1.3530	0.2046	−0.0309	−0.3735	0.0611
7	0.6407	0.1692	0.0447	0.1818	0.0598
8	−5.0722	0.4171	−0.0343	−0.3804	0.0341
9	1.1410	0.3318	0.0965	0.0289	0.0364
10	−2.6949	0.3425	−0.0435	−0.0387	0.0104
11	−0.0104	0.0309	−0.0917	0.1280	−0.1075
12	1.5006	0.4068	0.1103	0.0867	0.0534
13	34.0270	−4.7817	0.6719	0.3531	−0.1440
14	−43.2239	5.5665	−0.7168	−0.4914	0.1556
15	1.1038	−0.3691	0.1234	0.2350	−0.1198
16	0.0192	0.0272	0.0383	0.0418	0.1132
17	2.7195	−0.0855	0.0026	0.0257	−0.0008
18	−0.2276	−0.1557	−0.1066	−0.0988	−0.1405
19	−0.0609	0.0430	−0.0303	−0.1187	0.1051
20	−6.0295	−1.4431	−0.3454	−0.6776	−0.0988
21	9.8725	−0.2382	0.0057	0.3016	−0.0074
22	0.0007	0.0014	0.0027	0.0479	0.0968
23	10.1839	−0.3229	0.0102	0.1658	−0.0055
1-23	2.7204	0.0343	−0.0424	0.1138	0.1668

In the above table: SA=Spherical aberrations; CM=Coma; AS=Astigmatism; PT=Petzval's sum and DS=Distortion.

FIG. 4 shows the second embodiment of the lens system in accordance with the present invention, whereby what is different from the lens construction in the first embodiment is that the non-spherical almost afocal lens in the first divergent lens group has a negative refractive power in paraxial value. The second embodiment in **FIG. 3** and the third embodiment in **FIG. 4** are shown in the state in which a filter is provided in the lens system, whereby this filter has nothing to do with the present invention. **FIG. 5** shows the respective aberrations of the second embodiment. Below the data for the second embodiment will be given.

The second embodiment:

f=14.2

bf=36.3

F No.=1:2.8

Angle of field=114°

Lens Group	Plane	Focal Distance
The first divergent lens group		
The second convergent lens group		
The 2-1st convergent lens group	R9–R17	3.24f
The 2-2nd convergent lens group	R18–R25	2.24f

	Radius of Curvature		Thickness · Distance		Refractive Index (nd)		Abbe Number (νd)	hν	$\overline{h\nu}$
R 1	38.794	D 1	3.1	n 1	1.72	ν 1	50.2	1.000	−2.087
R 2	24.997	D 2	12.41					0.967	−1.891
R 3	58.28	D 3	5.02	n 2	1.6031	ν 2	60.7	1.082	−1.217
R 4	46.009	D 4	0.15					1.076	−1.007
R 5	33.022	D 5	1.7	n 3	1.6968	ν 3	55.5	1.078	−0.999
R 6	17.647	D 6	5.39					1.067	−0.925
R 7	32.787	D 7	1.3	n 4	1.7725	ν 4	49.7	1.237	−0.718
R 8	17.218	D 8	6.32					1.239	−0.678
R 9	266.96	D 9	1.5	n 5	1.6968	ν 5	55.5	1.606	−0.521
R10	13.984	D10	12.08	n 6	1.60342	ν 6	38	1.653	−0.498
R11	−43.016	D11	2.2					2.142	−0.326
R12	∞	D12	1.8	n 7	1.51633	ν 7	64.1	2.219	−0.266
R13	∞	D13	0.8					2.260	−0.233
R14	74.564	D14	7.84	n 8	1.51118	ν 8	51	2.288	−0.211
R15	−14.201	D15	0.94					2.387	−0.062
R16	12.614	D16	0.9	n 9	1.7725	ν 9	49.7	2.324	−0.033
R17	−26.958	D17	1.7					2.363	−0.018
R18	129.909	D18	2.	n10	1.64769	ν10	33.8	2.376	0.033
R19	12.278	D19	6.9	n11	1.69895	ν11	30.1	2.371	0.068
R20	50.377	D20	0.83					2.315	0.187
R21	−80.749	D21	0.8	n12	1.84666	ν12	23.9	2.330	0.213
R22	28.151	D22	4.4	n13	1.48749	ν13	70.1	2.348	0.228
R23	−15.466	D23	0.15					2.563	0.337
R24	493.467	D24	2.85	n14	1.7725	ν14	49.7	2.562	0.341
R25	−33.952							2.542	0.382

In the above table, R3 is a non-spherical surface, whereby the non-spherical coefficients are as follows.

$A=0$
$B=9.556\times10^{-6}$
$C=2.591\times10^{-9}$
$D=-1.015\times10^{-11}$
$E=2.128\times10^{-14}$

R	SA	CM	AS	PT	DS
1	0.0121	0.0076	0.0048	0.1540	0.1000
2	−0.1006	0.0447	−0.0199	−0.2391	0.1153
3	0.2082	−0.1774	0.2678	0.0921	−0.1087
4	−0.0512	−0.0457	−0.0409	−0.1167	−0.1409
5	0.0999	0.0522	0.0272	0.1775	0.1070
6	−0.9275	0.1422	−0.0218	−0.3322	0.0543
7	0.5331	0.1258	0.0297	0.1898	0.0518
8	−3.4887	0.3912	−0.0438	−0.3614	0.0454
9	0.7537	0.2687	0.0958	0.0219	0.0420
10	−2.0363	0.2743	−0.0369	−0.0350	0.0097
11	−0.0134	0.0313	−0.0731	0.1249	−0.1209
12	0.1541	0.1212	0.0953	0.0000	0.0750
13	−0.1569	−0.1234	−0.0971	0.0000	−0.0764
14	0.7556	0.2833	0.1062	0.0647	0.0641
15	28.8193	−4.3449	0.6550	0.3401	−0.1500
16	−38.7408	5.1916	−0.6957	−0.4933	0.1593
17	0.7093	−0.2688	0.1018	0.2308	−0.1261
18	0.0440	0.0502	0.0573	0.0432	0.1148
19	2.2778	0.2796	0.0343	0.0212	0.0068
20	−0.6391	−0.3529	−0.1948	−0.1166	−0.1719
21	0.0043	−0.0119	0.0327	−0.0810	0.1320
22	−5.3722	−1.3352	−0.3318	−0.0663	−0.0989
23	9.2513	−0.2384	0.0061	0.3023	−0.0079
24	−0.0002	0.0025	−0.0232	0.0126	0.0961
25	10.2818	−0.4098	0.0163	0.1832	−0.0079
1-25	2.3777	−0.0416	−0.0484	0.1172	0.1641

FIG. 6 shows the third embodiment of the lens system in accordance with the present invention, whereby the **2-1st** convergent lens group is a little different from that of the afore mentioned second embodiment in such a manner that the **2-1st** convergent lens group consists of a cemented lens (**R9–R12**) convex on both surfaces, a filter (**R12, R13**), a lens **R14–R16**) having a cemented divergent surface convex on the object side, convex on both surfaces, and a negative meniscus lens (**R17, R18**) convex on the image plane side in sequence from the object side. FIG. 7 shows the respective aberrations of the third embodiment. The data for the third embodiment are given below.

The third embodiment:

f=14.2
bf=36.3
F No.=1:2.8
Angle of field=114°

Lens Group	Plane	Focal Distance
The first divergent lens group	R1-R8	−1.15f
The second convergent lens group		
The 2-1st convergent lens group	R9-R18	3.19f
The 2-2nd convergent lens group	R19-R26	2.30f

	Radius of Curvature		Thickness · Distance		Refractive Index (nd)		Abbe Number (νd)	hν	$\overline{h\nu}$
R 1	41.022	D 1	3.1	n 1	1.6968	ν 1	55.5	1.000	−2.036
R 2	25.486	D 2	11.61					0.969	−1.845
R 3	59.586	D 3	5.8	n 2	1.60311	ν 2	60.7	1.079	−1.216
R 4	53.247	D 4	0.15					1.074	−0.975
R 5	31.755	D 5	1.7	n 3	1.6968	ν 3	55.5	1.076	−0.967
R 6	16.408	D 6	5.63					1.063	−0.890
R 7	32.689	D 7	1.3	n 4	1.7725	ν 4	49.7	1.245	−0.672
R 8	16.569	D 8	5.98					1.247	−0.632
R 9	327.3	D 9	1.5	n 5	1.6968	ν 5	55.5	1.612	−0.481
R10	13.739	D10	10.42	n 6	1.60342	ν 6	38	1.662	−0.457
R11	−62.67	D11	2.2					2.110	−0.307
R12	∞	D12	1.8	n 7	1.51633	ν 7	64.1	2.217	−0.249
R13	∞	D13	0.8					2.274	−0.218
R14	50.943	D14	6.24	n 8	1.51118	ν 8	51	2.313	−0.198
R15	−12.241	D15	1.	n 9	1.6968	ν 9	55.5	2.418	−0.082
R16	−14.812	D16	1.14					2.454	−0.066
R17	−13.815	D17	0.9	n10	1.7725	ν10	49.7	2.393	−0.032
R18	−26.056	D18	1.7					2.434	−0.017
R19	122.96	D19	9.74	n11	1.69895	ν11	30.1	2.448	0.032
R20	−17.987	D20	2.15	n12	1.59551	ν12	39.2	2.415	0.195
R21	56.343	D21	0.68					2.389	0.232
R22	−160.37	D22	0.8	n13	1.92286	ν13	21.3	2.393	0.252
R23	28.576	D23	4.77	n14	1.48749	ν14	70.1	2.401	0.265
R24	−17.792	D24	0.15					2.581	0.379
R25	219.82	D25	2.75	n15	1.7725	ν15	49.7	2.578	0.382
R26	−42.458							2.541	0.419

In the above table, **R3** is the non-spherical surface, while the non-spherical coefficients are as follows:

$A=0$
$B=9.452\times10^{-6}$
$C=2.539\times10^{-9}$
$D=-1.049\times10^{-11}$
$E=2.118\times10^{-14}$

R	SA	CM	AS	PT	DS
1	0.0102	0.0085	0.0071	0.1429	0.1255
2	−0.0982	0.0376	−0.0144	−0.2301	0.0937
3	0.2045	−0.1737	0.2649	0.0901	−0.1036
4	−0.0338	−0.0405	−0.0486	−0.1009	−0.1794
5	0.0950	0.0531	0.0297	0.1847	0.1199
6	−1.0724	0.1705	−0.0271	−0.3574	0.0611
7	0.5632	0.1462	0.0379	0.1904	0.0593
8	−4.0525	0.3829	−0.0361	−0.3757	0.0389
9	0.8368	0.3018	0.1089	0.0179	0.0457
10	−2.2738	0.2614	−0.0300	−0.0356	0.0075
11	−0.0296	−0.0617	−0.1287	0.0857	−0.0895
12	0.4177	0.2247	0.1209	0.0000	0.0650
13	−0.4286	−0.2305	−0.1240	0.0000	−0.0667
14	2.2290	0.5276	0.1248	0.0948	0.0520
15	−5.4887	0.7668	−0.1071	−0.0844	0.0267
16	25.7670	−4.0431	0.6344	0.3960	−0.1616
17	28.3388	4.0296	−0.5729	−0.4506	0.1455
18	0.8953	−0.3084	0.1062	0.2389	−0.1189
19	0.0574	0.0591	0.0609	0.0477	0.1119

-continued-

R	SA	CM	AS	PT	DS
20	2.2028	−0.0950	0.0041	0.0303	−0.0014
21	−0.2145	−0.1517	−0.1072	−0.0946	−0.1427
22	0.0002	−0.0007	0.0022	−0.0427	0.1236
23	−4.5965	−1.2485	−0.3391	−0.0760	−0.1127
24	7.6797	−0.1772	0.0040	0.2631	−0.0061
25	−0.0004	0.0042	−0.032	0.0283	0.0894
26	7.8002	−0.3682	0.0173	0.1466	−0.0077
1-26	2.1310	0.0749	−0.0501	0.1094	0.1754

FIG. **8** shows the fourth embodiment of the lens system in accordance with the present invention, whereby a negative meniscus lens (**R1, R2**) convex at the side of the object, an almost afocal meniscus lens (**R3, R4**) having a non-spherical surface (**R3**) and a surface convex at the object side, and a negative meniscus lens (**R5, R6**) convex at the object side are arranged in sequence from the object side, in such a manner that the first divergent lens group consists of the surfaces **R1–R6**. Behind this first divergent lens group, a lens (**R7, R8**) convex on both sides, a negative meniscus lens (**R9, R10**) concave at the object side, a diaphragm, a positive meniscus (**R11–R13**) having a divergent cemented surface concave at the image plane side, a positive meniscus lens (**R14–R16**) having a divergent cemented surface (**R15**) concave on the image side, convex at the image and a lens (**R17–R18**) convex at both surfaces are arranged in sequence from the object side. FIG. **9** shows the respective aberrations of the fourth embodiment. Below the data for the fourth embodiment will be given.

The fourth embodiment:

f=17.34

bf=36.61

F No.=1:2.8

Angle of field=104°

Lens Group	Plane	Focal Distance
The first divergent lens group	R1-R6	−0.93f
The second convergent lens group		
The 2-1st convergent lens group	R7-R10	2.46f
The 2-2nd convergent lens group	R11-R18	1.54f

	Radius of Curvature		Thickness · Distance		Refractive Index (nd)		Abbe Number (νd)	hν	$\overline{h\nu}$
R 1	36.562	D 1	2.5	n 1	1.6968	1	55.5	1.000	−1.133
R 2	18.877	D 2	6.76					0.972	−1.016
R 3	36.009	D 3	5.31	n 2	1.60311	2	60.7	1.086	−0.734
R 4	36.	D 4	0.16					1.081	−0.555
R 5	26.936	D 5	1.5	n 3	1.6968	3	55.7	1.084	−0.548
R 6	10.237	D 6	7.52					1.074	−0.496
R 7	40.279	D 7	12.62	n 4	1.60342	4	38.	1.539	−0.306
R 8	−15.661	D 8	1.116					1.844	−0.072
R 9	−13.1	D 9	1.	n 5	1.7725	5	49.6	1.808	−0.036
R10	−27.485	D10	1.7					1.849	−0.019
R11	87.301	D11	5.967	n 6	1.69895	6	30.1	1.887	0.034
R12	−16.511	D12	1.	n 7	1.59551	7	39.2	1.913	0.142
R13	123.783	D13	1.788					1.910	0.160
R14	−56.858	D14	1.	n 8	1.92286	8	21.3	1.918	0.215
R15	27.983	D15	4.	n 9	1.48749	9	70.1	1.936	0.233
R16	−15.574	D16	0.15					2.113	0.334
R17	1652.078	D17	2.65	n10	1.7725	10	49.6	2.113	0.338
R18	−29.01							2.110	0.379

In the above table, R3 is the non-spherical surface, while the non-spherical coefficients are as follows:

$A=0$

$B=2.530\times10^{-5}$

$C=1.505\times10^{-8}$

$D=-2.012\times10^{-11}$

$E=2.102\times10^{-13}$

R	SA	CM	AS	PT	DS
1	0.0258	0.0252	0.0245	0.1948	0.2139
2	−0.5546	0.0980	−0.0173	−0.3773	0.0697
3	1.1018	−0.4995	0.4491	0.1812	−0.1703
4	−0.2133	−0.1337	−0.0838	−0.1812	−0.1661
5	0.3795	0.1625	0.0696	0.2644	0.1430
6	−10.2347	1.4266	−0.1988	−0.6958	0.1247
7	3.7520	0.6590	0.1157	0.1620	0.0488
8	10.2507	−2.5376	0.6282	0.4168	−0.2587
9	−15.2953	3.1676	−0.6560	−0.5770	0.2553
10	0.0258	−0.0181	0.0127	0.2750	−0.2024
11	0.3772	0.2689	0.1918	0.0817	0.1950
12	1.5692	−0.1331	0.0112	0.0400	−0.0043
13	−0.0247	−0.0396	−0.0636	−0.0523	−0.1860
14	−0.0446	0.0407	−0.0372	−0.1464	0.1678
15	−5.7631	−1.7107	−0.5078	−0.0943	−0.1787
16	6.1583	−0.2606	0.0110	0.3650	−0.0159
17	−0.0000	−0.0000	−0.0000	0.0045	0.1534
18	10.7117	−0.3221	0.0096	0.2605	−0.0081
1-18	2.2218	0.1934	−0.0409	0.1218	0.1810

FIG. **10** shows the fifth embodiment of the lens system in accordance with the present invention, whereby the lens system consists of a negative meniscus lens (**R1, R2**) convex on the object side, a non-spherical positive meniscus lens of substantially zero first order power (**R3, R4**) and a negative meniscus lens (**R5, R6**) convex on the object side in sequence from the object side in such a manner that the first divergent lens group consists of the surfaces **R1–R6**. Behind the first divergent lens, a cemented lens (**R7–R9**) convex on both planes, a lens (**R10, R11**) convex on both surfaces, a negative meniscus lens (**R12, R13**) concave on the object side, a diaphragm, a negative meniscus lens (**R14, R15**) having a divergent surface concave on the image side and a convex surface on the object side, a positive meniscus lens (**R16–R18**) having a cemented divergent plane concave at the image side and a convex surface on the image side and a lens (**R19, R20**) convex on both sides and arranged in sequence from the object side in such a manner that the second convergent lens group consists of the surfaces **R7–R20**.

FIG. **11** shows the respective aberrations of the fifth embodiment. Below the data for the fifth embodiment will be given.

The fifth embodiment:

f=5.52

bf=17.2
F No.=1:1.6
Angle of field=99.8°

Lens Group	Plane	Focal Distance
The first divergent lens group	R1–R6	−1.976f
The second convergent lens group		
The 2-1st convergent lens group	R7–R13	7.22f
The 2-2nd convergent lens group	R14–R20	2.735f

	Radius of Curvature		Thickness · Distance		Refractive Index (nd)		Abbe Number (νd)	hν	$\overline{h\nu}$
R 1	49.0189	D 1	2.3	n 1	1.6968	ν 1	55.5	1.000	−2.561
R 2	15.0921	D 2	4.48					0.981	−2.266
R 3	47.2056	D 3	4	n 2	1.60311	ν 2	60.7	1.120	−1.761
R 4	47.2056	D 4	1					1.162	−1.423
R 5	21.34	D 5	1	n 3	1.6968	ν 3	55.5	1.193	−1.305
R 6	3.3649	D 6	5.685					1.189	−1.211
R 7	514.905	D 7	1.5	n 4	1.6968	ν 4	55.5	1.710	−0.876
R 8	7.745	D 8	9.46	n 5	1.60342	ν 5	38	1.789	−0.823
R 9	−139.463	D 9	1.3					2.444	−0.526
R10	33.6069	D10	7.295	n 6	1.60342	ν 6	38	2.574	−0.458
R11	−16.1228	D11	1.6					2.820	−0.182
R12	−10.9129	D12	1	n 7	1.7725	ν 7	49.6	2.738	−0.073
R13	−18.1377	D13	1.7					2.819	−0.038
R14	131.723	D14	6.376	n 8	1.59551	ν 8	39.2	2.857	0.070
R15	35.387	D15	0.927					2.894	0.325
R16	−489.874	D16	0.7	n 9	1.92286	ν 9	21.3	2.948	0.389
R17	16.7027	D17	3.684	n10	1.48749	ν10	70.1	2.971	0.414
R18	−11.9649	D18	0.15					3.321	0.614
R19	23.5946	D19	2.925	n11	1.7725	ν11	49.6	3.322	0.622
R20	−31.1173							3.152	0.680

In the above table, **R3** is the non-spherical surface, while the non-spherical coefficients are as follows:

$A=0$; $B=1.111\times 10^{-4}$; $C=-1.823\times 10^{-7}$
$D=-6.583\times 10^{-11}$; $E=6.906\times 10^{-12}$

R	SA	CM	AS	PT	DS
1	0.0003	0.0021	0.0137	0.0462	0.3794
2	−0.0547	0.0212	−0.0082	−0.1502	0.0614
3	0.1556	−0.2037	0.3768	0.0439	−0.4535
4	−0.0154	−0.0239	−0.0371	−0.0439	−0.1257
5	0.0525	0.0336	0.0215	0.1062	0.0818
6	−1.0302	0.3781	−0.1387	−0.2709	0.1503
7	0.1574	0.0949	0.0572	0.0044	0.0371
8	−0.8444	0.2106	−0.0525	−0.0244	0.0192
9	−0.1613	−0.1096	−0.0745	0.0148	−0.0405
10	1.0751	0.2363	0.0519	0.0618	0.0250
11	1.7616	−0.6133	0.2135	0.1288	−0.1191
12	−4.0727	1.0006	−0.2458	−0.2204	0.1145
13	0.1926	−0.0956	0.0475	0.1326	−0.0895
14	0.0173	0.0254	0.0372	0.0156	0.0775
15	−0.5191	−0.2904	−0.1624	−0.0582	−0.1234
16	0.0551	0.0723	0.0947	−0.0054	0.1170
17	−3.8327	−1.1101	−0.3215	−0.0503	−0.1077
18	2.3896	−0.0379	0.0006	0.1511	−0.0024

-continued

R	SA	CM	AS	PT	DS
19	0.4639	0.2594	0.1450	0.1019	0.1381
20	6.2774	0.0779	0.0009	0.0773	0.0009
1-20	2.0679	−0.0720	0.0199	0.0611	0.1405

FIG. **12** shows the sixth embodiment of the lens system in accordance with the present invention, whereby what is different from the lens composition of the aforementioned fifth embodiment is that the negative meniscus lens concave on the object side, provided in the 2-1st divergent lens group consists of two lenses while the negative meniscus lens (**R11, R12**) provided on the object side is cemented with a lens (**R10, R11**) convex on both surfaces so as to form a cemented surface (**R11**). This surface (**R11**) serves as divergent surface with no air gap. FIG. **13** shows the respective aberrations of the sixth embodiment. Below the data for the sixth embodiment will be given.

The sixth embodiment:

f=5.52
bf=17.4
F No.=1:1.6
Angle of field=99.8°.

Lens Group	Plane	Focal Distance
The first divergent lens group	R1–R6	−1.991f
The second convergent lens group		
The 2-1st convergent lens group	R7–R14	7.343f
The 2-2nd convergent lens group	R15–R21	2.738f

	Radius of Curvature		Thickness · Distance		Refractive Index (nd)		Abbe Number (νd)	hν	$\overline{h\nu}$
R 1	47.3142	D 1	2.3	n 1	1.6968	ν 1	55.5	1.000	−2.582
R 2	14.9039	D 2	4.613					0.980	−2.285
R 3	46.113	D 3	4	n 2	1.60311	ν 2	60.7	1.123	−1.767
R 4	46.113	D 4	1					1.164	−1.429
R 5	21.4146	D 5	1	n 3	1.6968	ν 3	55.5	1.196	−1.312
R 6	8.4483	D 6	5.667					1.192	−1.218
R 7	577.663	D 7	1.5	n 4	1.6968	ν 4	55.5	1.707	−0.883
R 8	7.603	D 8	9.482	n 5	1.60342	ν 5	38	1.786	−0.830
R 9	−220.61	D 9	1.3					2.442	−0.535
R10	30.088	D10	6.54	n 6	1.60342	ν 6	38	2.577	−0.468
R11	−13.4264	D11	1	n 7	1.6968	ν 7	55.5	2.791	−0.221
R12	−16.0569	D12	1.672					2.834	−0.186
R13	−10.9266	D13	1	n 8	1.7725	ν 8	49.6	2.748	−0.073

-continued

Radius of Curvature		Thickness · Distance		Refractive Index (nd)		Abbe Number (νd)		hν	$\overline{h\nu}$
R14	−18.0916	D14	1.7					2.829	−0.038
R15	131.185	D15	5.98	n 9	1.59551	ν 9	39.2	2.867	0.070
R16	35.313	D16	0.92					2.903	0.308
R17	−488.534	D17	0.7	n10	1.92286	ν10	21.3	2.957	0.371
R18	16.7051	D18	3.605	n11	1.48749	ν11	70.1	2.980	0.396
R19	−11.9702	D19	0.15					3.323	0.589
R20	23.5131	D20	2.961	n12	1.7725	ν12	49.6	3.324	0.597
R21	−31.1174							3.152	0.658

In the above table, R3 is the non-spherical surface, while the non-spherical coefficients are as follows.

$A=0$

$B=1.099\times10^{-4}$

$C=-1.747\times10^{-7}$

$D=-1.411\times10^{-11}$

$E=6.880\times10^{-12}$

R	SA	CM	AS	PT	DS
1	0.0003	0.0023	0.0137	0.0479	0.3695
2	−0.0559	0.0236	−0.0100	−0.1520	0.0685
3	0.1563	−0.2041	0.3767	0.0450	−0.4578
4	−0.0159	−0.0241	−0.0364	−0.0450	−0.1228
5	0.0525	0.0333	0.0211	0.1058	0.0806
6	−1.0096	0.3703	−0.1358	−0.2683	0.1482
7	0.1524	0.0932	0.0570	0.0039	0.0373
8	−0.8737	0.2243	−0.0576	−0.0249	0.0211
9	−0.2175	−0.1256	−0.0725	0.0094	−0.0364
10	1.3089	0.2467	0.0465	0.0690	0.0217
11	−0.1687	0.0523	−0.0162	−0.0141	0.0094
12	1.8761	−0.6500	0.2252	0.1411	−0.1269
13	−4.0906	1.0001	−0.2445	−0.2201	0.1136
14	0.1975	−0.0971	0.0477	0.1329	−0.0888
15	0.0177	0.0257	0.0373	0.0157	0.0769
16	−0.5277	−0.2902	−0.1595	−0.0583	−0.1198
17	0.0559	0.0725	0.0940	−0.0054	0.1148
18	−3.8777	−1.0947	−0.3090	−0.0502	−0.1014
19	2.3744	−0.0562	0.0013	0.1511	−0.0036
20	0.4762	0.2613	0.1434	0.1023	0.1348
21	6.2774	0.0322	0.0001	0.0773	0.0003
1-21	2.1083	−0.1038	0.0227	0.0630	0.1394

The data in the aforementioned embodiments in accordance with the present invention form a principal part of the present invention. That is, the focal distances of the 12 lens groups (lens groups each including a non-spherical surface in the embodiments) of the aforementioned first divergent lens groups and the distance (L) between the diaphragm and the image side surface of the lens convex on both surfaces provided immediately in front of the object side surface of the negative meniscus lens concave on the object side, in the **2-1st** convergent lens group are given in Table 1.

TABLE 1

	Focal distance of the 12th lens group	L
The 1st embodiment	90.5f	0.179f
The 2nd embodiment	−30.2f	0.172f
The 3rd embodiment	−89.1f	0.256f
The 4th embodiment	−62.3f	0.157f
The 5th embodiment	444.79f	0.58f
The 6th embodiment	424.44f	0.774f

Table 2 shows the arrangements of the divergent parts provided on both sides of the diaphragm in the second convergent lens group for realizing a large aperture of the lens system, whereby the arrangement from the first to the sixth embodiment are given in the table. In Table 2, I shows the spherical aberration coefficients of the third order in the divergent parts.

TABLE 2

	The 2-1st convergent lens group		The 2-2nd convergent lens group	
	Divergent part	I	Divergent part	I
Embodiment 1	R13 + R14	−9.197	R18 + R20	−6.257
Embodiment 2	R15 + R16	−9.921	R20 + R22	−6.011
Embodiment 3	R15 + R16 + R17	−8.061	R21 + R23	−4.811
Embodiment 4	R8 + R9	−5.045	R13 + R15	−5.788
Embodiment 5	R11 + R12	−2.3111	R15 + R17	−4.3519
Embodiment 6	R11 + R12 + R13	−2.382	R16 + R18	−4.409

Further according to the present invention, the meniscus lens element having a non-spherical surface of the **1-2st** lens group may be made of a plastic material. This can provide a light-weight retro-focus type wide angle lens at a low manufacturing cost. As described hereinbefore, a plastic lens is susceptible to large thermal expansion and contraction, which produces adverse effects on the total focal length of the lens system and the back focus. Further, a plastic lens prepared by foaming has a poor surface accuracy, and tends to deteriorate the aberration.

In the retro-focus type wide angle lens according to the present invention, a non-spherical plastic lens having substantially a zero-first order-power is arranged immediately after the image surface side of a negative meniscus lens positioned closest to the object and having its convex surface toward the object. Thus, the non-spherical surface of the plastic lens is arranged opposing to the negative meniscus lens. Since the non-spherical plastic lens has substantially zero-first order-power, the adverse effects on the lens system caused by the thermal deformation of the plastic lens are relieved. Also the adverse effects are relieved by the fact that plastics generally show larger changes in refractive index due to changes in the temperatures than optical glass.

By the arrangement of the non-spherical surface immediately after the image surface of the negative meniscus lens positioned closest to the object, the effective diameter of the non-spherical lens can be increased. Therefore, the width of a light flux on and outside the axis, incident on the non-spherical surface is very small relative to the effective diameter of the non-spherical lens so that the effects on the aberration due to the deviation of the non-spherical surface of the plastic lens from an ideal surface are minimized.

Further, the divergency of the **1-1th** divergent lens group of retro-focus type according to the present invention is not so strong, so that thus the width of the light beam on the optical axis, incident on the first surface and the width of the light beam incident on the non-spherical surface do not vary appreciably. Further, in the non-spherical lens, the width of the light beam on the optical axis does not change substantially, and the effect of changes in the thickness on the total focal distance and the back focus are very small. For example, when the thickness of the non-spherical lens in the eighth Embodiment set forth hereinafter changes 0.5 mm, the total focal distance changes only 0.02 mm and the back focus changes only 0.001 mm. The same thing can be said about the changes in the total focal length and the back focus due to the changes in the refractive index.

Still further, as the width of the light beam on and outside the optical axis is very small relative to the effective diameter of the non-spherical lens, it can be said that the effect on the aberration by the changes on the non-spherical surface is minimal. For this reason, it is possible to use a plastic lens, which generally has poor surface accuracy as compared with a glass lens, but can be easily formed, thereby making it possible to remarkably reduce the manufacturing cost.

As plastics have a very small specific gravity as compared with glass, the use of a plastic lens for a lens having a large effective diameter is very effective to reduce the weight of the whole lens system.

As the plastic material, acrylic plastics are preferable, because the chromatic aberration on axis is paraxially afocal and thus does not occur, but in the marginal portion the chromatic aberration due to magnification takes place because this portion has converging power. For this reason, a material having dispersion as low as possible is preferred and the acrylic plastics are most preferable.

In the embodiments set forth hereinafter, the **1-1th** divergent lens group is composed of a negative meniscus lens having its convex surface on the object side, the **1-2th** lens group is composed of a plastic meniscus lens having its non-spherical surface on the object side, and the **1-3th** divergent lens group is composed of one or more negative meniscus lenses and has its convex surface on the object side.

In order to relieve the adverse effects caused by the plastic lens, the absolute value of the paraxial focal length of the non-spherical plastic lens is made more than 50 times larger than the effective total length of the retro-focus type wide angle lens, and the distance from the surface on the image side of the both convex lenses in the **2-1st** convergent lens group to the diaphragm is limited to a range from 0.15 time to 0.35 times of the total focal length. However, the angle of field is designed to be not less than 102.7°.

Seventh Embodiment:

In FIG. **14** showing a cross sectional view a retrofocus wide angle type lens according to the present invention, **R1–R8** surfaces form the first divergent lens group, **R9–R26** surfaces form the second convergent lens group, **R3** surface is non-spherical, and **R3** and **R4** surfaces are surfaces of the plastic lens. **R1–R2** surfaces correspond to the **1-1th** meniscus lens, **R3–R4** surfaces correspond to the **1-2th** meniscus lens, **R9–R18** correspond to the **2-1st** convergent lens group, and **R19–R26** surfaces correspond to the **2-2nd** convergent lens group. A is a diaphragm.

Radius of Curvature		Thickness & Distance			Refractive Index (nd)	Abbe Number (νd)	
R 1	42.889	D 1	3.1	N 1	1.6968	ν 1	55.5
R 2	26.161	D 2	11.55				
R 3	61.567	D 3	5.83	N 2	*1.493	ν 2	54.2
R 4	57.577	D 4	0.15				
R 5	30.956	D 5	1.7	N 3	1.6968	ν 3	55.5
R 6	16.443	D 6	5.75				
R 7	32.978	D 7	1.3	N 4	1.7725	ν 4	49.6
R 8	16.486	D 8	5.95				
R 9	357.247	D 9	1.5	N 5	1.6968	ν 5	55.5
R10	12.444	D10	10.4	N 6	1.60342	ν 6	38
R11	−55.993	D11	2.53				
R12	∞	D12	1.8	N 7	1.51633	ν 7	64.1
R13	∞	D13	0.7				
R14	49.441	D14	5.6	N 8	1.51742	ν 8	52.3
R15	−12.228	D15	1.5	N 9	1.6968	ν 9	55.5
R16	−14.588	D16	1.08				
R17	−13.862	D17	0.9	N10	1.7725	ν10	49.6
R18	−25.881	D18	1.7				
R19	136.4	D19	9.65	N11	1.68893	ν11	31.1
R20	−21.198	D20	1.9	N12	1.59551	ν12	39.2
R21	54.226	D21	0.69				
R22	−160.011	D22	0.8	N13	1.92286	ν13	21.3
R23	28.566	D23	5.53	N14	1.48749	ν14	70.1
R24	−17.829	D24	0.1				
R25	277.71	D25	2.63	N15	1.804	ν15	46.6
R26	−43.605						

In the above table, **R3** is the non-spherical surface, while the non-spherical coefficients are as follows:

$A=0$;

$B=1.07336\times10^{-5}$;

$C=5.38038\times10^{-9}$

$D=-1.98246\times10^{-11}$

$E=3.65339\times10^{-14}$

$f=14.2$;

F No.$=1:2.8$;

$bf=36.1$

Angle of field$=113.4°$

Paraxial Focal Distance of the non-spherical lens(R3, R4): -265 f

Distance on axis between the surface R and the diaphragm A: 0.30 f

FIG. **15** shows the aberrations of the lens shown in FIG. **14**, and the values of aberration coefficients are shown below.

	SA	CM	AS	PT	DS
R1	0.0089	0.0086	0.0082	0.1368	0.1395
R2	−0.0940	0.0341	−0.0124	−0.2243	0.0860
R3	0.1901	−0.1654	0.2515	0.0766	−0.1117
R4	−0.0262	−0.0344	−0.0453	−0.0819	−0.1672
R5	0.0987	0.0519	0.0272	0.1895	0.1139
R6	−1.0512	0.1666	−0.0264	−0.3568	0.0607
R7	0.5346	0.1458	0.0397	0.1888	0.0623
R8	−4.0937	0.3852	−0.0362	−0.3777	0.0389
R9	0.8115	0.2994	0.1105	0.0164	0.0468
R10	−2.8478	0.3591	−0.0452	−0.0394	0.0106
R11	−0.0106	−0.0362	−0.1236	0.0960	−0.0939
R12	0.3859	0.2145	0.1193	0.0000	0.0663
R13	−0.3955	−0.2199	−0.1222	0.0000	−0.0679
R14	2.2408	0.5310	0.1258	0.0985	0.0531
R15	−5.5306	0.7824	−0.1107	−0.0814	0.0271
R16	29.7855	−4.4844	0.6751	0.4022	−0.1622
R17	−31.3770	4.3542	−0.6042	−0.4492	0.1461
R18	1.3486	−0.4280	0.1358	0.2406	−0.1194
R19	0.0140	0.0210	0.0314	0.0427	0.1110
R20	1.2688	−0.0827	0.0053	0.0233	−0.0018
R21	−0.2020	−0.1453	−0.1045	−0.0983	−0.1459
R22	−0.0002	0.0007	−0.0021	−0.0428	0.1264
R23	−4.2175	−1.1740	−0.3268	−0.0761	−0.1121
R24	7.7045	−0.1320	0.0022	0.2626	−0.0045
R25	−0.0030	0.0116	−0.0454	0.0229	0.0872
R26	7.5725	−0.3468	0.0158	0.1460	−0.0074
Σ	2.1151	0.1171	−0.0569	0.1151	0.1820

In the above table: SA=Spherical aberrations; CM=Coma; AS=Astigmatism; PT=Petzval's sum and DS=Distortion.

Eighth Embodiment:

In FIG. **16** showing a still another embodiment retro-focus wide angle lens according to the present invention, **R1-R6** surfaces form the first divergent lens group, R7-**R20** surfaces the second convergent lens group, A is a diaphragm, **R3** surface is non-spherical, **R3-R4** surfaces are surfaces of a plastic lens, **R1-R2** surfaces correspond to the **1-1**th meniscus lens, **R3-R4** surfaces correspond to the **2-1**th meniscus lens, **R7-R12** surfaces correspond to the **2-1st** convergent lens group and, **R13-R20** surfaces correspond to the **2-2nd** convergent lens group.

f=17.3;

F No.=1:2.8;

bf=36.2;

Angle of field=102.7°

R3—non-spherical surface

A=0

$B=2.51989\times10^{-5}$

$C=2.25528\times10^{-8}$

$D=-2.51574\times10^{-11}$

$E=3.21205\times10^{-13}$

Radius of Curvature		Thickness · Distance		Refractive Index (nd)		Abbe Number (νd)	
R 1	35.43	D 1	2.5	N 1	1.6968	ν 1	55.5
R 2	17.531	D 2	6.8				
R 3	35.8	D 3	5.3	N 2	*1.493	ν 2	54.2
R 4	36.5	D 4	0.15				
R 5	21.591	D 5	1.5	N 3	1.6968	ν 3	55.5
R 6	10.2174	D 6	6.				
R 7	300.	D 7	8.	N 4	1.60342	ν 4	38.
R 8	−46.177	D 8	1.5				
R 9	124.799	D 9	7.	N 5	1.60342	ν 5	38.
R10	−14.3706	D10	1.1				
R11	−13.0615	D11	1.	N 6	1.6968	ν 6	55.5
R12	−36.637	D12	2.3				
R13	67.788	D13	3.7	N 7	1.6968	ν 7	30.1
R14	−129.82	D14	1.	N 8	1.66672	ν 8	48.3
R15	55.651	D15	1.2				
R16	−51.303	D16	1.	N 9	1.92286	ν 9	21.3
R17	29.3603	D17	4.5	N10	1.48749	ν10	70.1
R18	−15.9063	D18	0.15				
R19	−340.986	D19	3.2	N11	1.7725	11	49.6
R20	−23.448						

Paraxial focal distance of non-spherical lens (R3, R4): 62f

Distance on axis between the surface R and the diaphragm A: 0.19f

	SA	CM	AS	PT	DS
R1	0.0283	0.0253	0.0226	0.2009	0.1998
R2	−0.7201	0.1892	−0.0497	−0.4061	0.1198
R3	1.0013	−0.4385	0.3976	0.1599	−0.1848
R4	−0.2416	−0.1263	−0.0661	−0.1568	−0.1166
R5	0.7170	0.1523	0.0323	0.3297	0.0769
R6	−10.0498	1.6351	−0.2660	−0.6969	0.1566
R7	1.0832	0.4042	0.1508	0.0217	0.0644
R8	−0.0023	0.0164	−0.1163	0.1413	−0.1766
R9	0.4653	0.2698	0.1564	0.0522	0.1210
R10	21.5413	−4.4879	0.9350	0.4540	−0.2894
R11	−24.6732	4.6320	−0.8695	−0.5451	0.2655
R12	0.1360	−0.1005	0.0742	0.1943	−0.1984
R13	0.1278	0.1188	0.1105	0.1052	0.2005
R14	0.0040	−0.0033	0.0026	0.0015	−0.0034
R15	−0.2300	−0.1902	−0.1573	−0.1246	−0.2332
R16	−0.0146	0.0160	−0.0175	−0.1622	0.1966
R17	−5.2023	−1.5200	−0.4441	−0.0898	−0.1560
R18	4.1219	−0.3231	0.0253	0.3572	−0.0299
R19	0.0000	0.0002	0.0241	−0.0221	0.1671
R20	14.3171	−0.2084	0.0030	0.3223	−0.0047
Σ	2.4096	0.0612	−0.0518	0.1367	0.1753

FIG. **17** shows the aberrations of the lens shown in FIG. **16** and their numerical data are shown in the above mentioned table.

What is claimed is:

1. A retro-focus type wide angle lens for forming an image of an object at an image plane comprising:

a divergent lens group including:

two sets of sub-lens groups each consisting of at least one first meniscus lens having a negative refractive power and a surface convex on the object side; and

a lens group arranged between said two sets of sub-lens groups and comprising meniscus lens convex on the object side, the surface of the lens group closest to the object being non-spherical for distortion compensation; and

a convergent lens group on the image side against said divergent lens group including:

a front lens group including a diaphragm, a second negative meniscus lens concave on the object side, and a biconvex lens in sequence from the diaphragm to the object so as to form a divergent air lens between said second negative meniscus lens and said biconvex lens; and

a rear lens group having a plural number of lens surfaces and provided on the image side with reference to the diaphragm, at least one of said lens surfaces being concave on the image side.

2. A retro-focus type wide angle lens in accordance with claim **1**, wherein said non-spherical surface is so formed that the more distant it is from the optical axis of the lens system, the greater the deviation from an ideal spherical surface, the radius of the paraxial curvature being larger than the radius of curvature of the surface next to the non-spherical surface at the object side.

3. A retro-focus type wide angle lens in accordance with claim **2**, wherein the absolute value paraxial focal length of the lens having said non-spherical surface is larger than twenty-five times the effective total focal length of the wide angle lens.

4. A retro-focus type wide angle lens in accordance with claim **1**, wherein the distance between the diaphragm and the image side of the biconvex lens in said front lens group is larger than 0.15 times the effective focal length of the wide angle lens but smaller than 0.85 times said effective focal length.

5. A retro-focus type wide angle lens in accordance with claim **4**, wherein the front lens group consists, in sequence from the diaphragm to the object side of said negative meniscus lens said biconvex lens, and a further biconvex lens which consists of a negative lens and a positive lens cemented to each other.

6. A retro-focus type wide angle lens in accordance with claim **1**, wherein said rear lens group consists, in sequence from the diaphragm to the image side, of a meniscus lens consisting of two lenses cemented to each other, whereby the object side lens of said cemented meniscus lens is biconvex and the image side lens of said cemented meniscus lens is biconcave, and a further meniscus lens consisting of two further lenses cemented to each other, whereby the object side further lens is biconcave and the image side further lens is biconvex, and a biconvex lens.

7. A retro-focus type wide angle lens in accordance with claim 1, wherein said rear lens group consists, in sequence from the diaphragm to the image side, of a meniscus lens consisting of two meniscus lenses cemented to each other both being convex on the object side, a further meniscus lens consisting of two further lenses, whereby the further lens on the object side is biconvex and the further lens on the image side is biconvex, and a biconvex lens.

8. A retro-focus type wide angle lens in accordance with claim 1, wherein said rear lens group consists, in sequence from the diaphragm to the image side, of a negative meniscus lens being convex on the object side, a further negative meniscus lens consisting of two further lenses cemented to each other, whereby the further lens on the object side is biconcave and the lens on the image side is biconvex, and a biconvex lens.

9. A retro-focus type wide angle lens comprising:

a diaphragm; and

a front lens group on the object side of the diaphragm comprising:

a negative meniscus lens convex on the object side;

a meniscus lens of substantially zero first order power, having a convex non-spherical surface on the object side;

a negative meniscus lens group having at least one meniscus lens convex on the subject side;

a convergent lens group next to said negative meniscus lens group, including a lens pair which consists of a biconvex lens on the object side, and a negative meniscus lens concave on the object side and located on the image side in sequence form the object side immediately up to the diaphragm; and

a rear lens group on the image side of the diaphragm comprising:

a first meniscus lens concave on the image side;

a second positive meniscus lens convex on the image side and having a divergent cemented surface concave on the image side; and

a biconvex lens, in sequence from the object side.

10. A retro-focus type wide angle lens in accordance with claim 9, wherein said non-spherical surface has a deviation from a hypothetical spherical surface, which deviation increases toward the circumferential portions of the lens from the optical axis, while the radius of the paraxial curvature of the non-spherical surface is larger than the radius of curvature of the surface next to the non-spherical surface on the object side.

11. A retro-focus type wide angle lens in accordance with claim 9, wherein the distance between the diaphragm and the image side surface of said biconvex lens included in said convergent lens group in said front lens group is larger than 0.15 times the effective focal length of the wide angle lens but smaller than 0.85 times said effective focal length.

12. A retro-focus type wide angle lens in accordance with claim 9, wherein said convergent lens group in said front lens group consists of said lens pair, and further a biconvex lens consisting of a positive lens and a negative lens cemented to each other.

13. A retro-focus type wide angle lens in accordance with claim 9, wherein said first meniscus lens in said rear lens groups is a lens consisting of a biconvex lens on the object side and a biconcave lens on the image side cemented to each other.

14. A retro-focus type wide angle lens in accordance with claim 9, wherein said first meniscus lens in said rear lens group is a meniscus lens consisting of two meniscus lenses both having a convex surface on the object side, said two meniscus lenses being cemented to each other.

15. A retro-focus type wide angle lens in accordance with claim 1 or 9, wherein the meniscus lens having said non-spherical surface is formed from plastic material.

16. A retro-focus type wide angle lens in accordance with claim 15, wherein said non-spherical surface is so formed that the more distant it is from the optical axis of the lens system, the greater the deviation from the spherical, the radius of the paraxial curvature being larger than the radius of curvature of the surface next to the non-spherical surface on the object side.

17. A retro-focus type wide angle lens in accordance with claim 16, wherein the absolute value paraxial focal length of the lens having said non-spherical surface is larger than 50 times the effective total focal length of the wide angle lens.

18. A retro-focus type wide angle lens in accordance with claim 15, wherein the distance between the diaphragm and the image side surface of the biconvex lens in said front lens group is larger than 0.15 times the effective focal length of the wide angle lens but smaller than 0.35 times said effective focal length.

19. A retro-focus type wide angle lens in accordance with claim 15, wherein said rear lens group consists, in sequence from said diaphragm to the image side, of a meniscus lens consisting of two lenses cemented to each other, whereby the object side lens of said cemented meniscus lens is biconvex and the image side lens of said cemented meniscus lens is biconcave and a further meniscus lens consisting of two further lenses cemented to each other, whereby the object side further lens is biconcave and the image side further lens is biconvex, and a biconvex lens.

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