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(54) **WIDE-ANGLE LENS ASSEMBLY**

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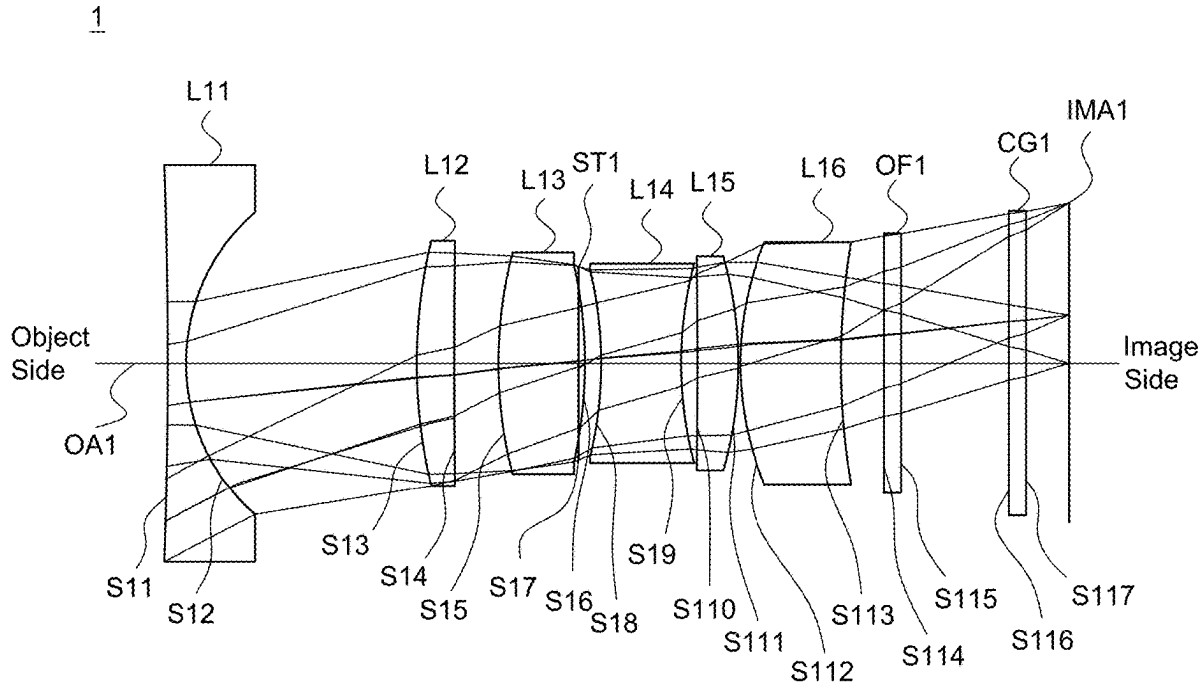
(57) **ABSTRACT**

A wide-angle lens assembly includes a first lens, a second lens, a third lens, a fourth lens, a fifth lens, and a sixth lens. The first lens is with negative refractive power. The second lens is with refractive power. The third lens is with positive refractive power. The fourth lens is with negative refractive power and includes a concave surface facing an image side. The fifth lens is with refractive power and includes a convex surface facing the image side. The sixth lens is with refractive power and includes a convex surface facing an object side. The first lens, the second lens, the third lens, the fourth lens, the fifth lens, and the sixth lens are arranged in order from the object side to the image side along an optical axis.



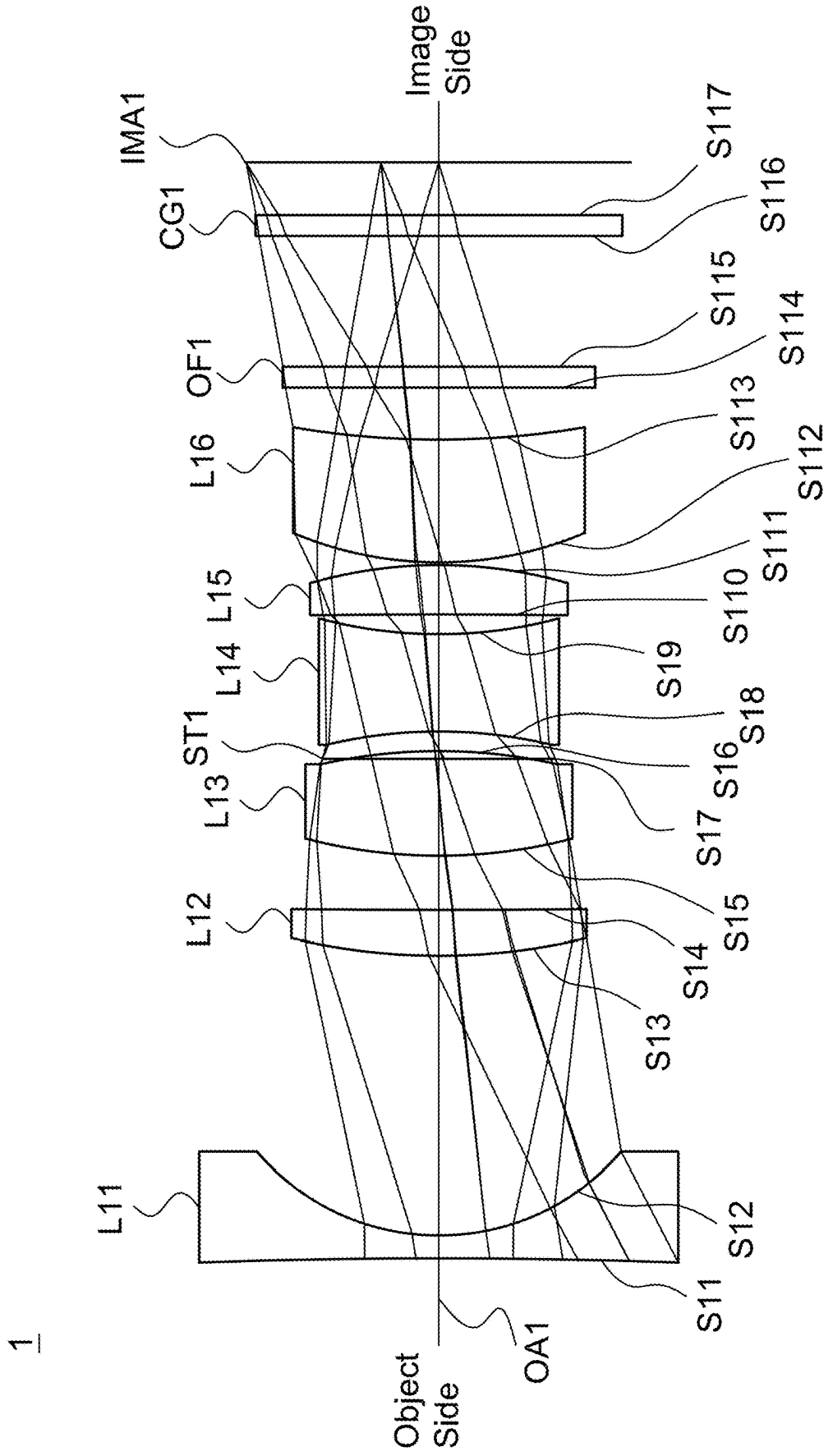

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Image Side
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IMA1
CG1
OF1
ST1
L11
L12
L13
L14
L15
L16
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S13
S14
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S18
S19
S110
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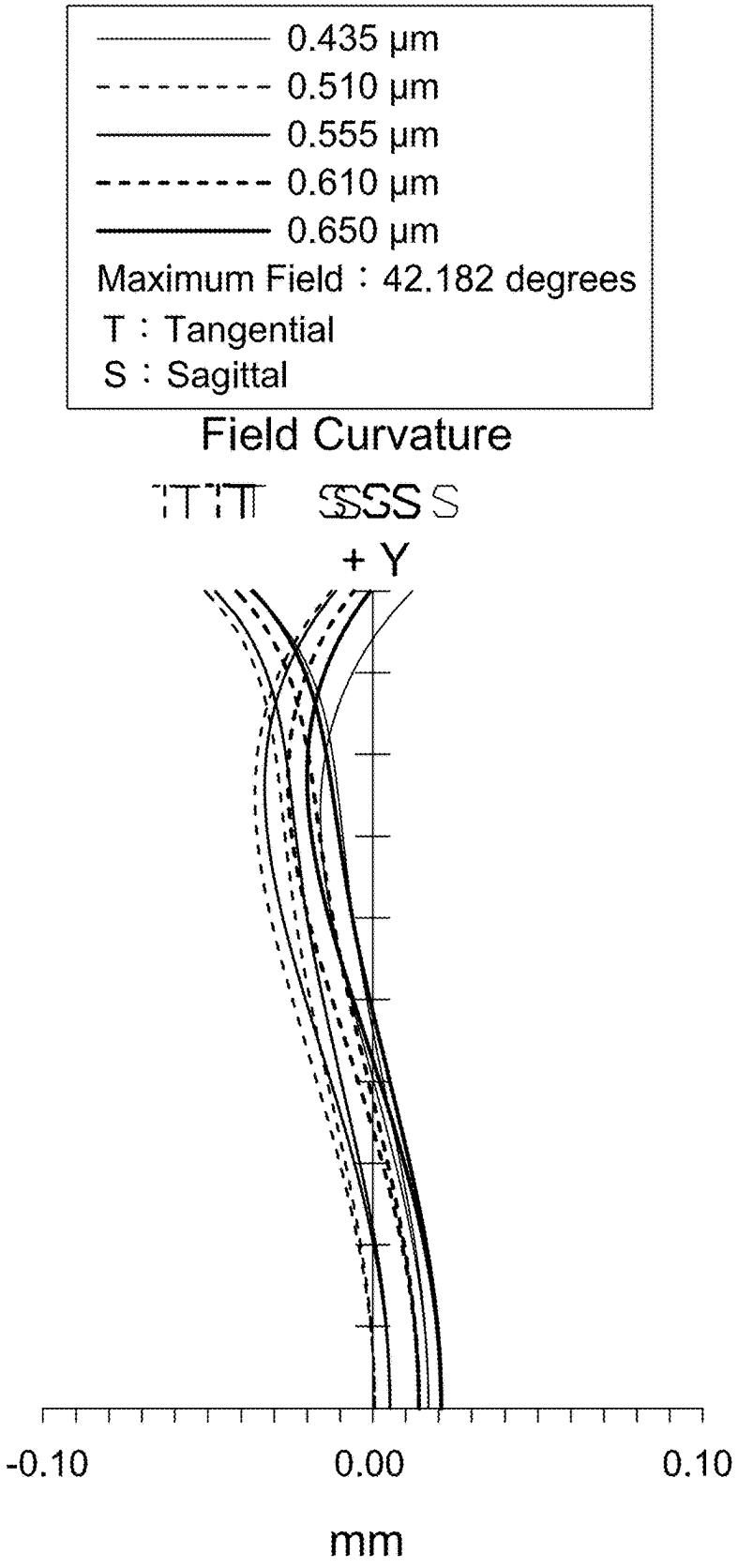
S112
S113
S114
S115
S116
S117

Fig. 1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0.510 μm
0.555 μm
0.610 μm
0.650 μm
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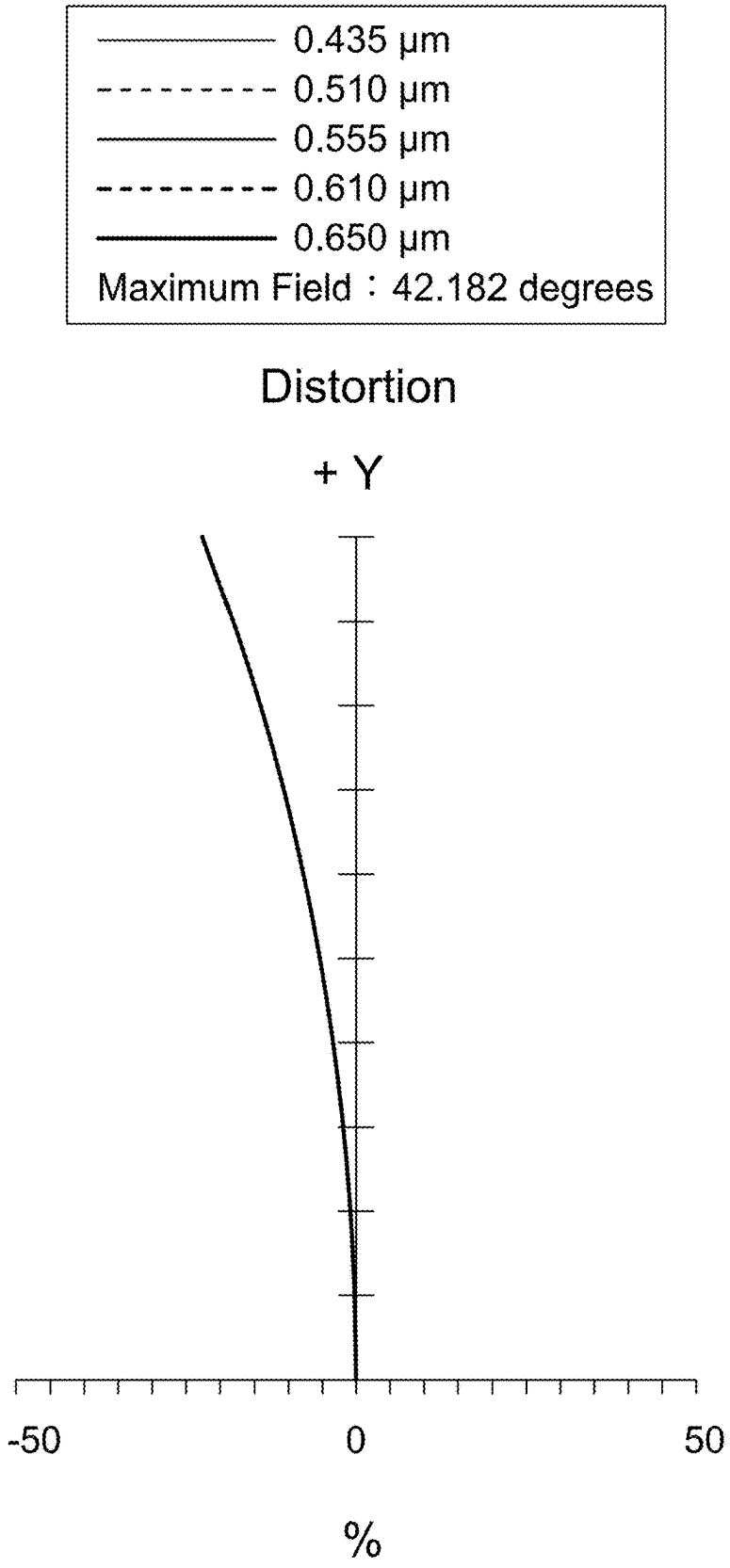
S : Sagittal
Field Curvature
+ Y
-0.10
0.00
0.10
mm

Fig. 2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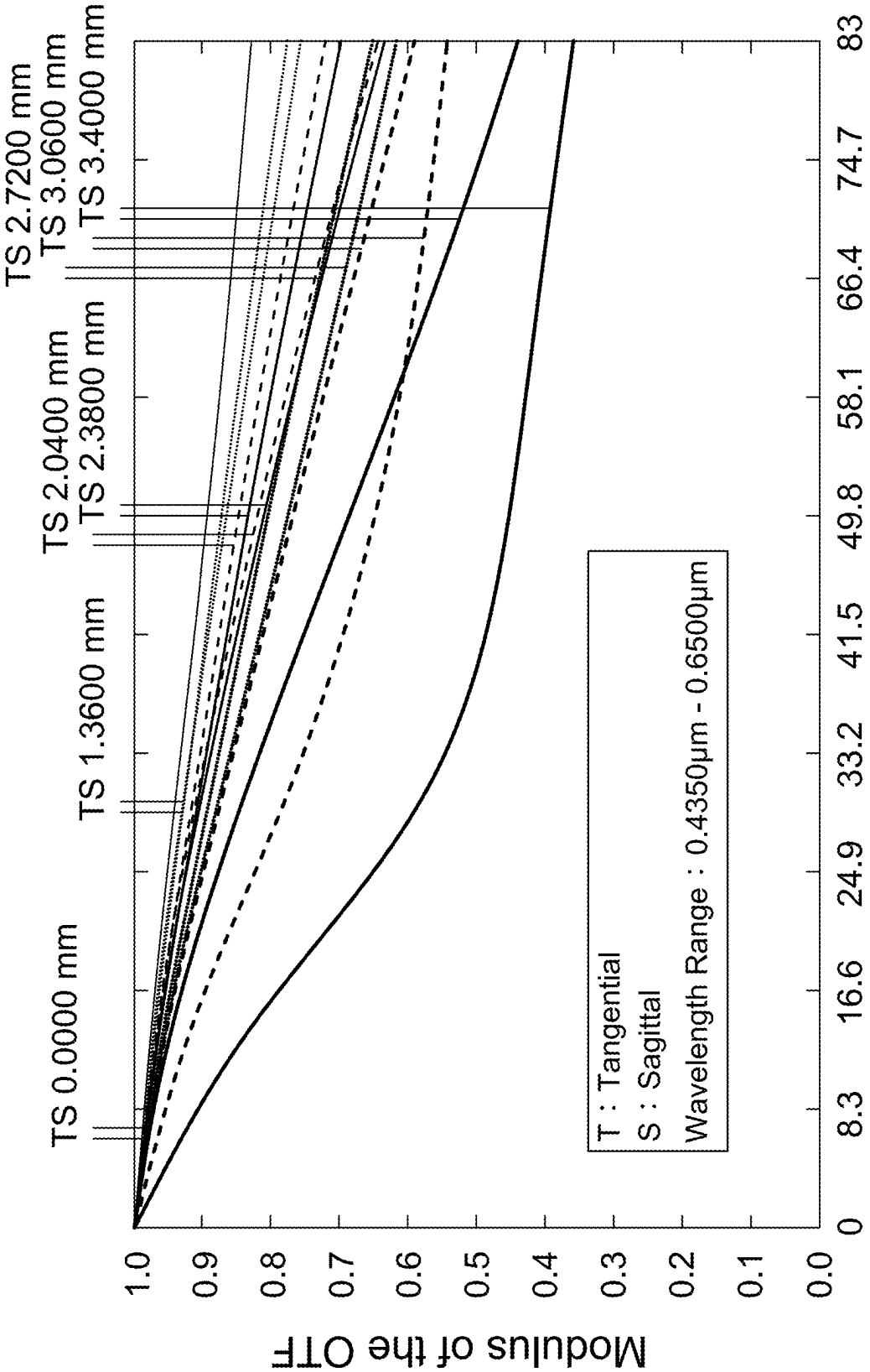
0.510 µm
0.555 µm
0.610 µm
0.650 µm
Maximum Field : 42.182 degrees
Distortion
+ Y
-50
0
50
%

Fig. 3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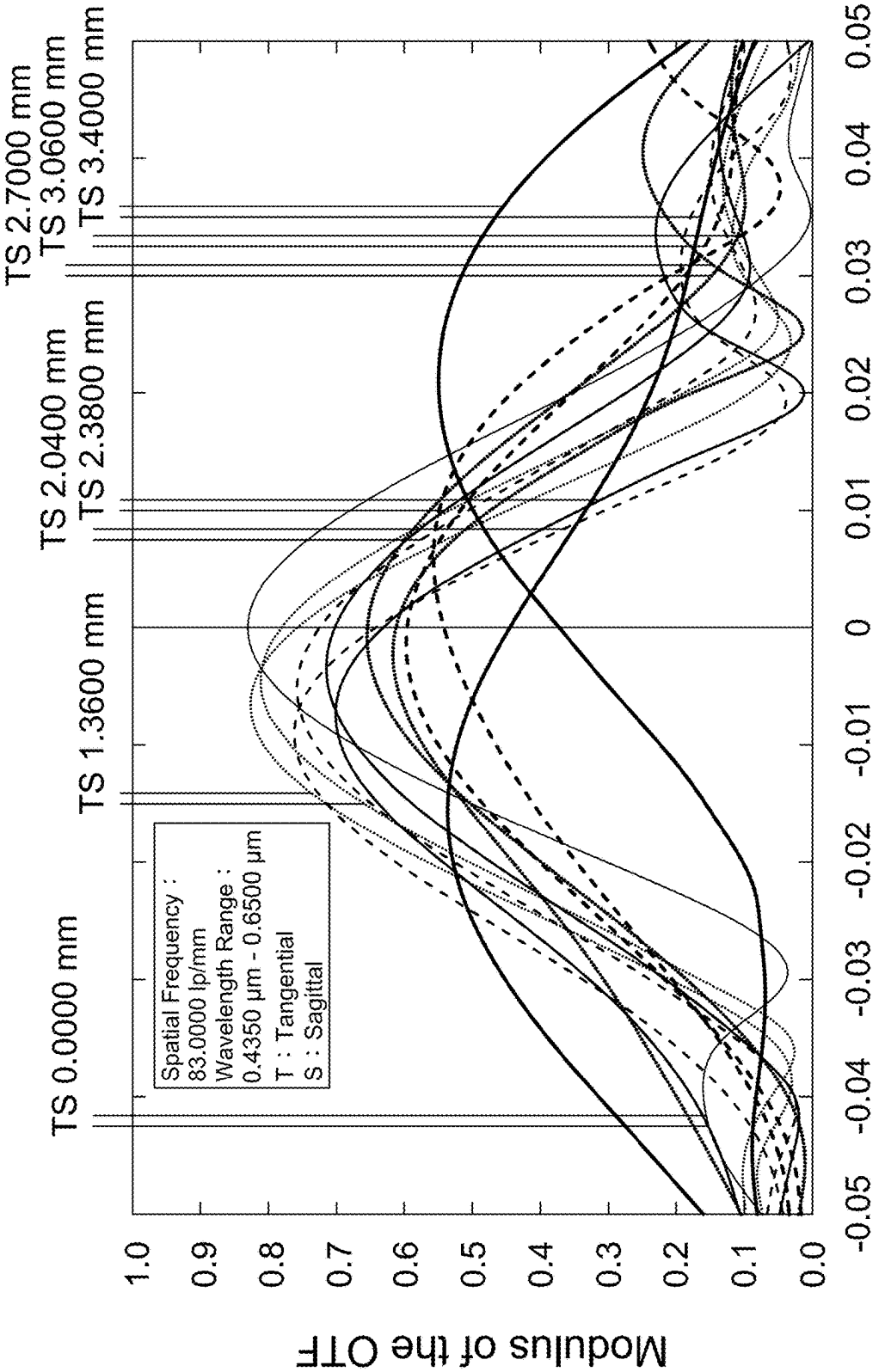
TS 1.3600 mm
TS 2.0400 mm
TS 2.3800 mm
TS 2.7200 mm
TS 3.0600 mm
TS 3.4000 mm
T : Tangential
S : Sagittal
Wavelength Range : 0.4350µm - 0.6500µm
Modulus of the OTF
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
0
8.3
16.6
24.9
33.2
41.5
49.8
58.1
66.4
74.7
83
Spatial Frequency (lp/mm)

Fig. 4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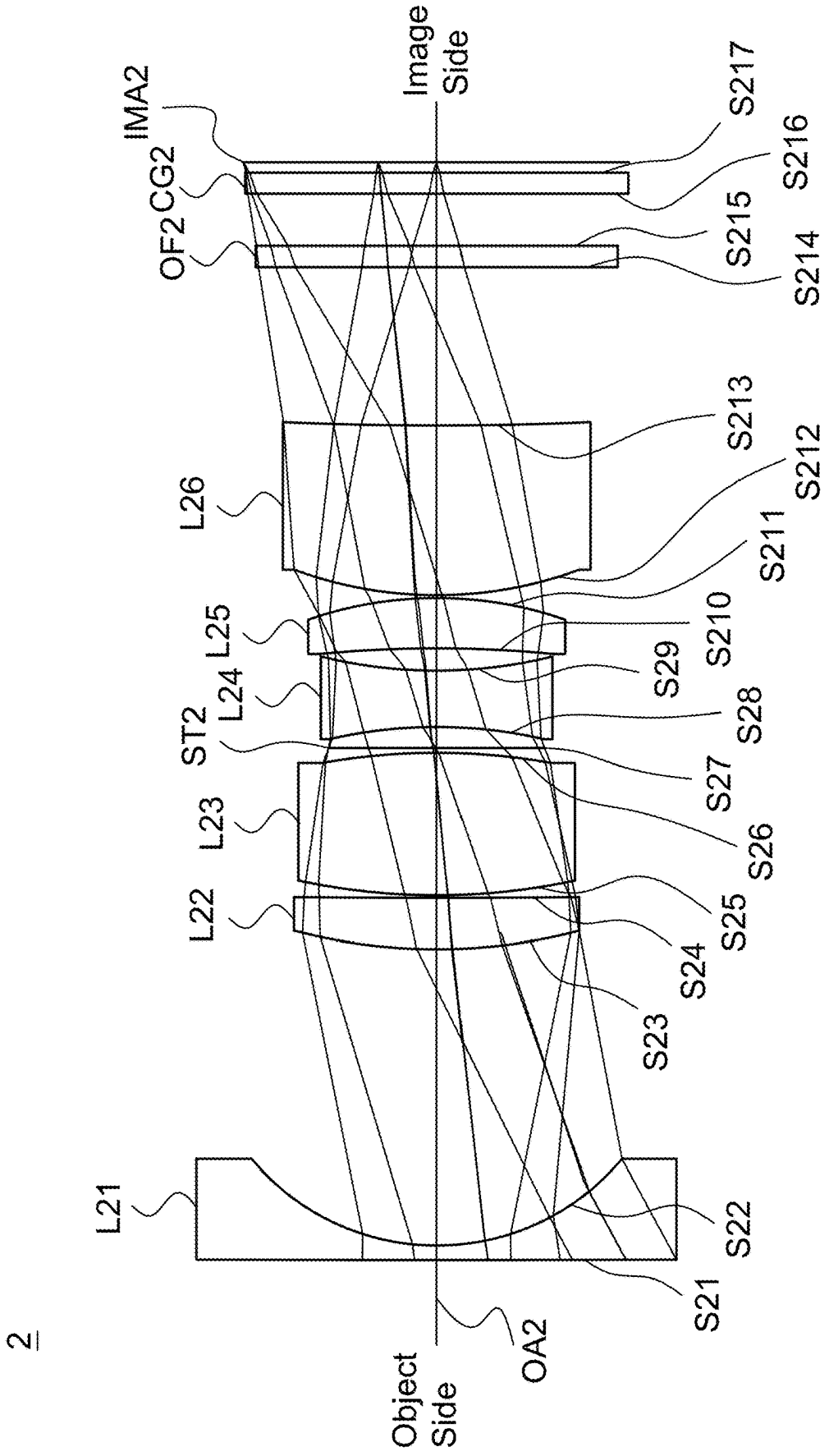
TS 2.7000 mm
TS 3.0600 mm
TS 3.4000 mm
Spatial Frequency :
83.0000 lp/mm
Wavelength Range :
0.4350 µm - 0.6500 µm
T : Tangential
S : Sagittal
Modulus of the OTF
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
-0.05
-0.04
-0.03
-0.02
-0.01
0
0.01
0.02
0.03
0.04
0.05
Focus Shift (mm)

Fig. 5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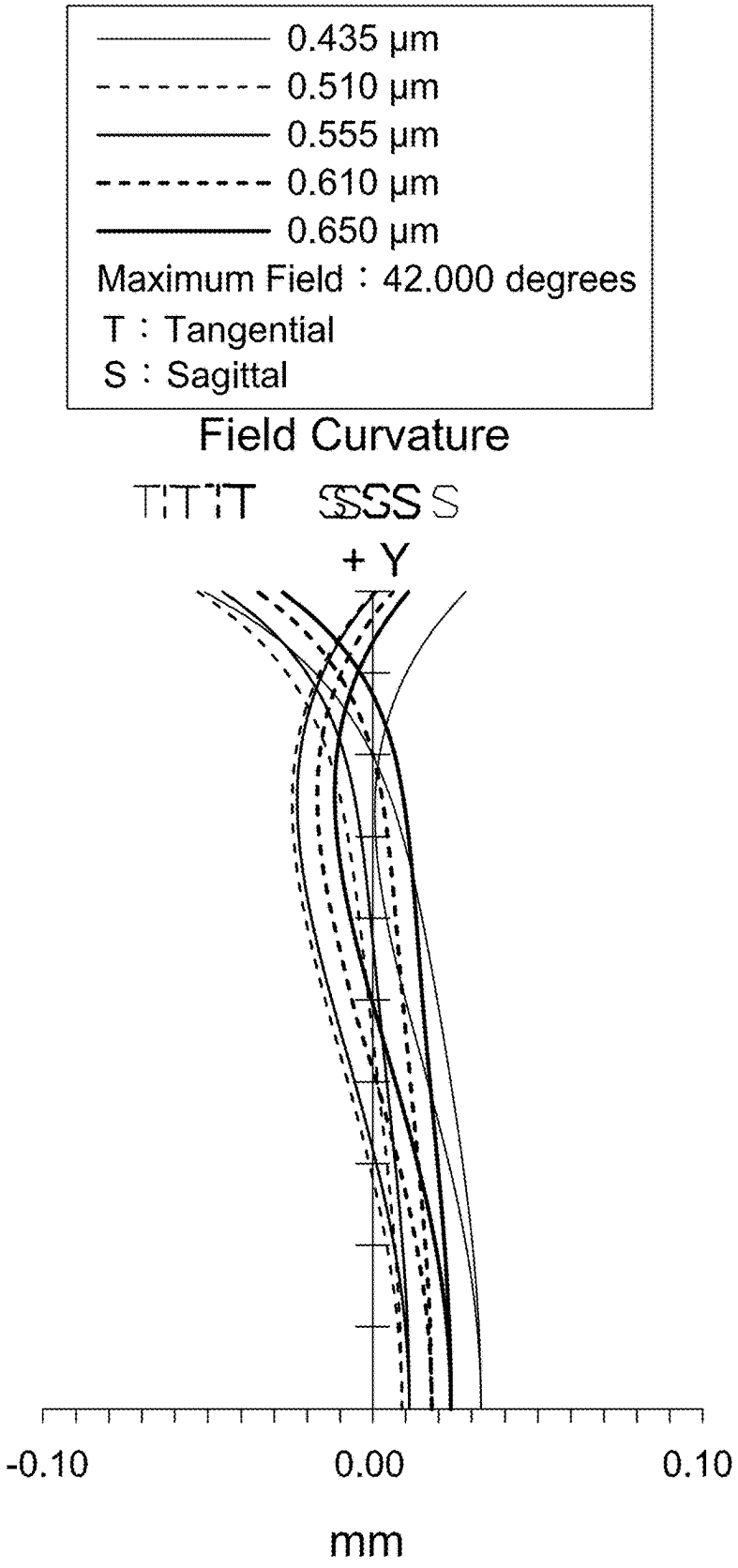
IMA2
CG2
OF2
L21
L22
L23
ST2
L24
L25
L26
S21
S22
S23
S24
S25
S26
S27
S28
S29
S210
S211
S212
S213
S214
S215
S216
S217

Fig. 6


0.435 μm
0.510 μm
0.555 μm
0.610 μm
0.650 μm
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T : Tangential
S : Sagittal
Field Curvature
+ Y
-0.10
0.00
0.10
mm

Fig. 7

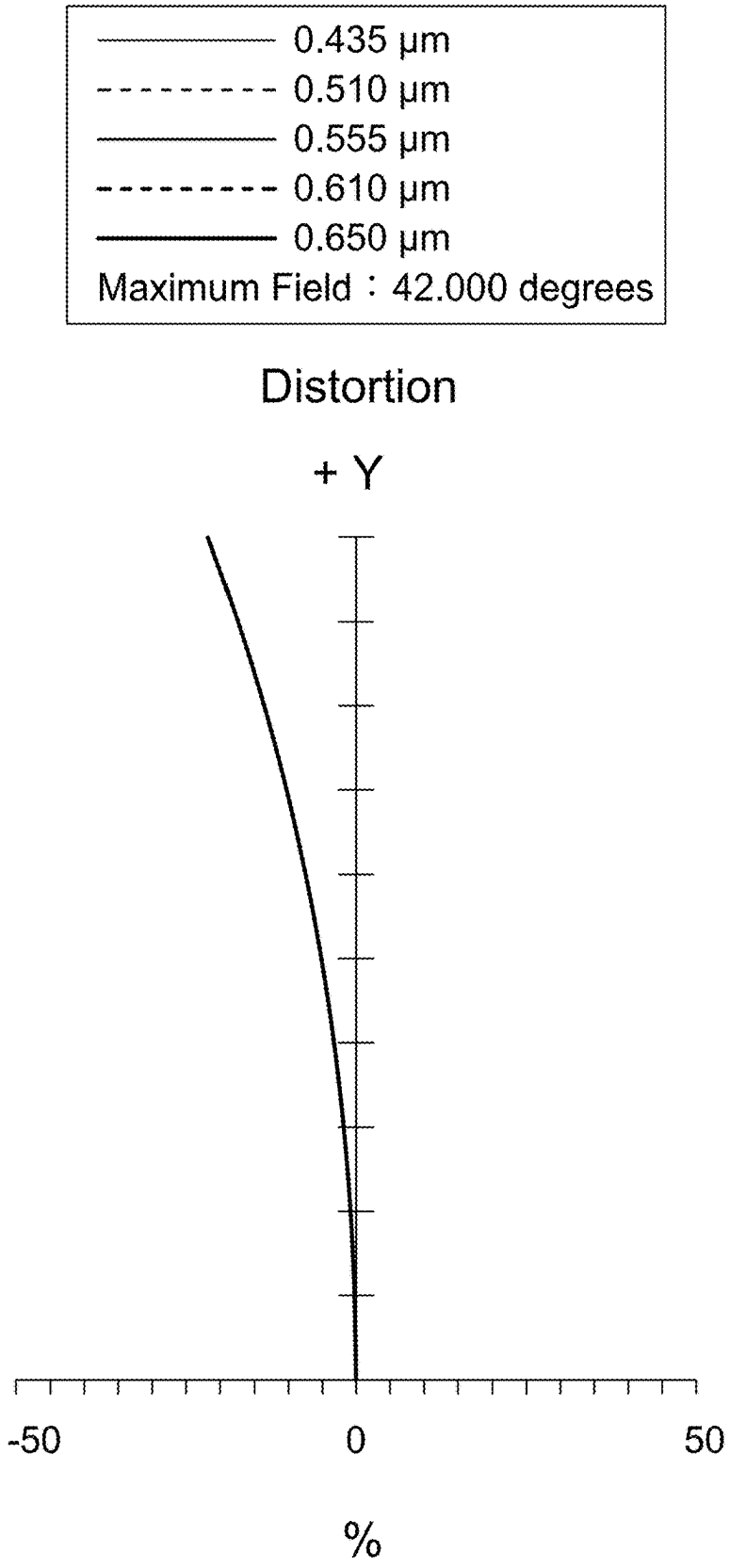
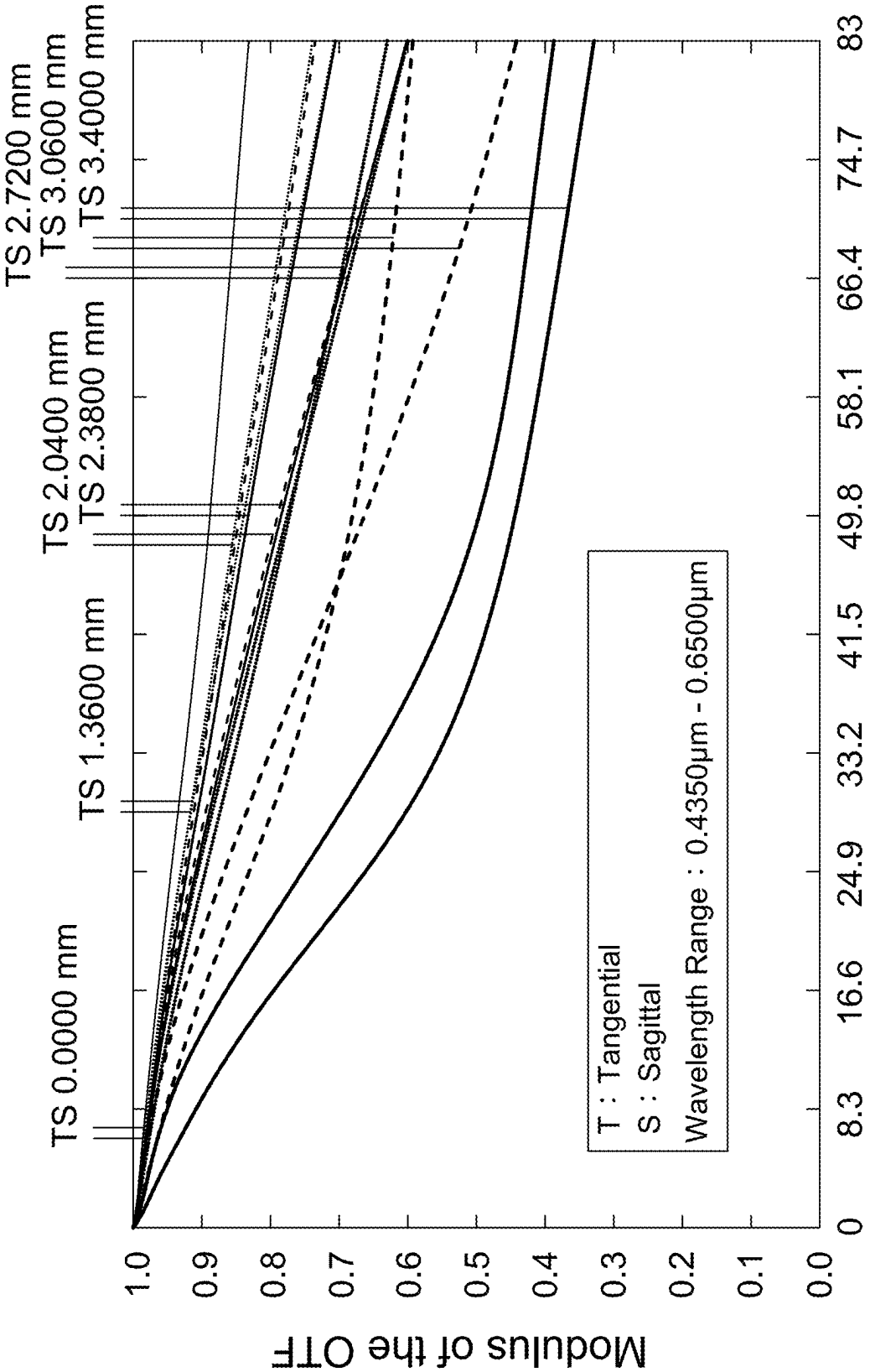

0.435 µm
0.510 µm
0.555 µm
0.610 µm
0.650 µm
Maximum Field : 42.000 degrees
Distortion
+ Y
-50
0
50
%

Fig. 8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TS 2.7200 mm
TS 3.0600 mm
TS 3.4000 mm
T : Tangential
S : Sagittal
Wavelength Range : 0.4350µm - 0.6500µm
Modulus of the OTF
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
0
8.3
16.6
24.9
33.2
41.5
49.8
58.1
66.4
74.7
83
Spatial Frequency (lp/mm)

Fig. 9

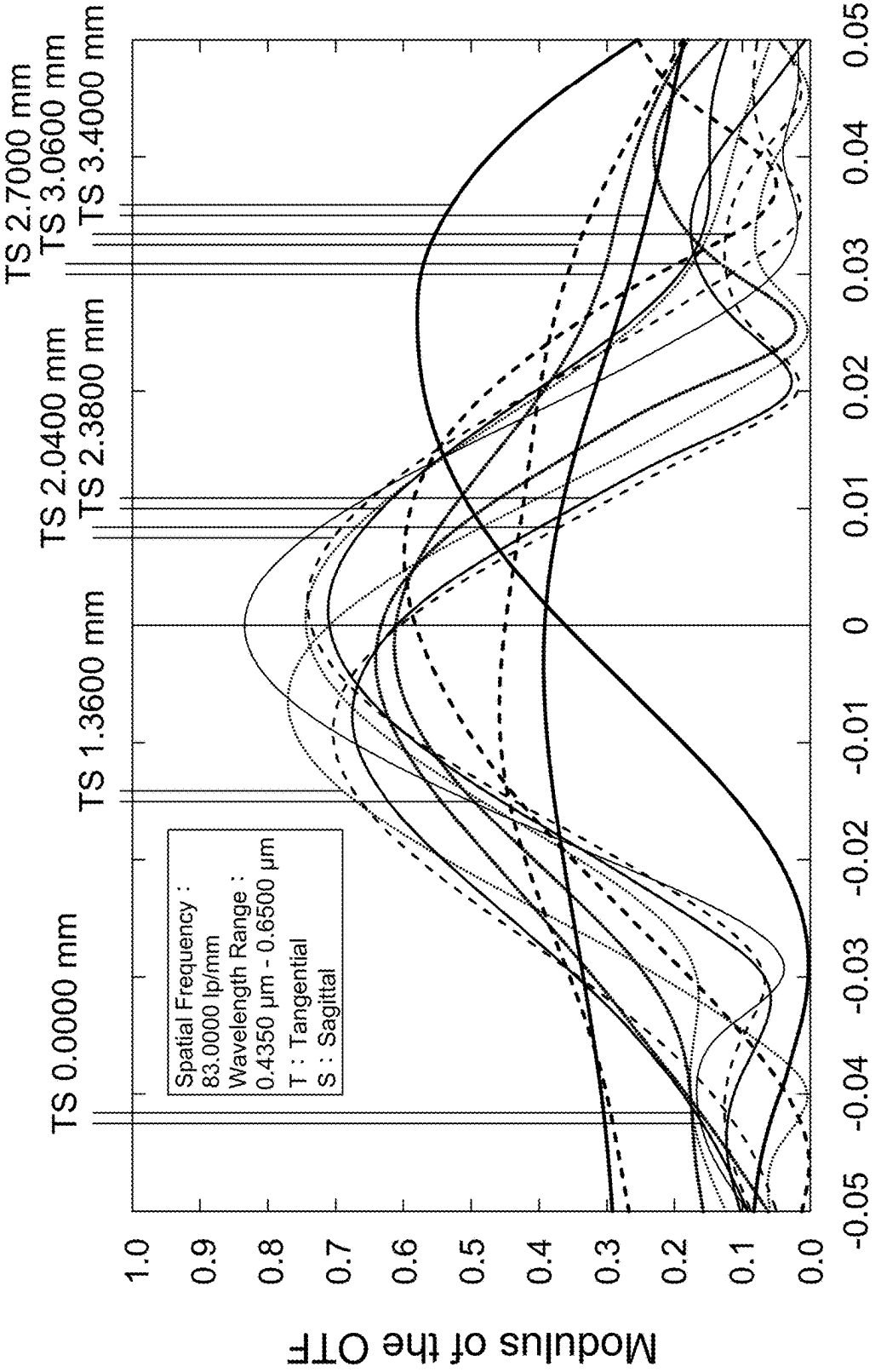
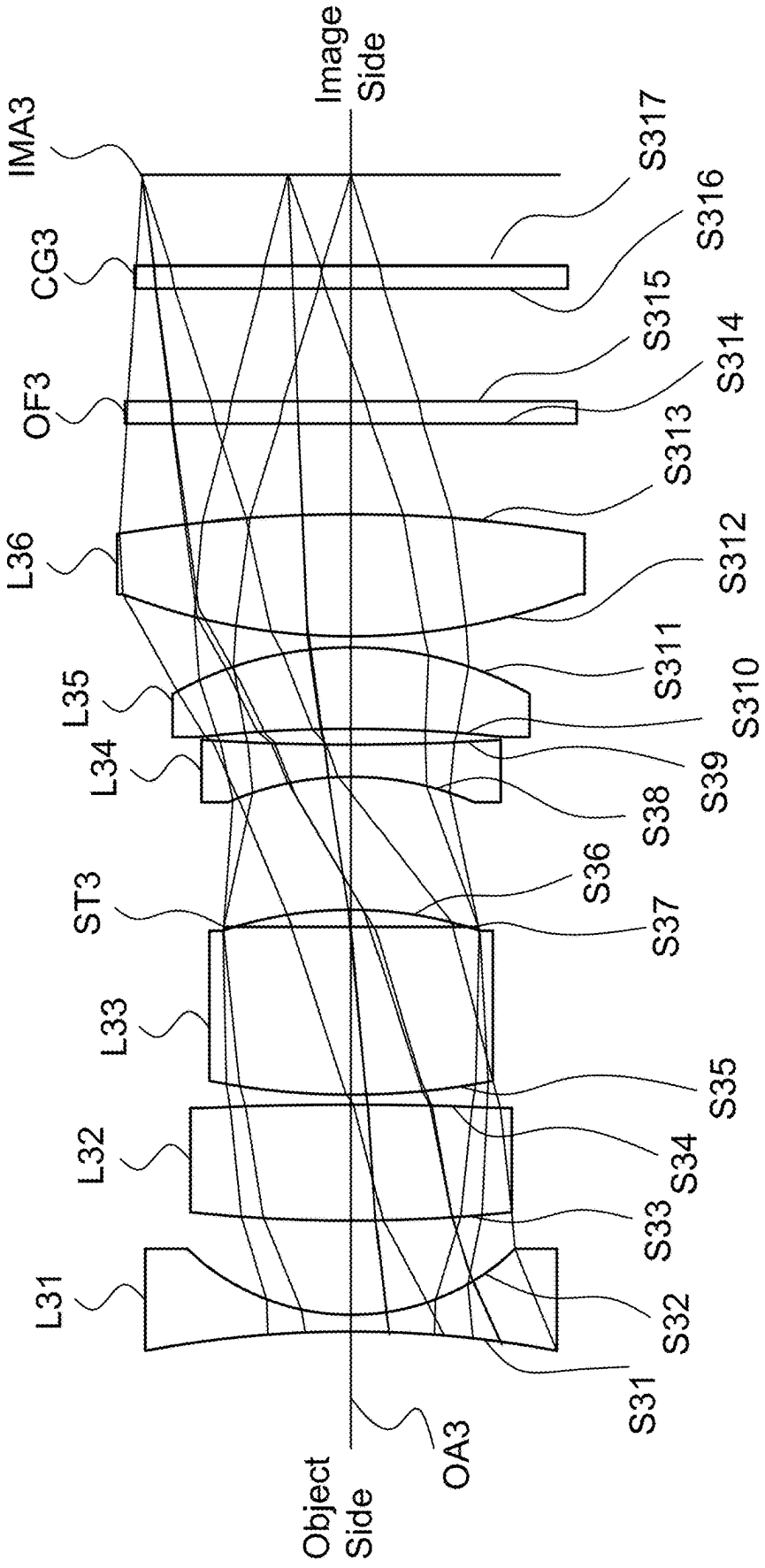

TS 0.0000 mm
TS 1.3600 mm
TS 2.0400 mm
TS 2.3800 mm
TS 2.7000 mm
TS 3.0600 mm
TS 3.4000 mm
Spatial Frequency :
83.0000 lp/mm
Wavelength Range :
0.4350 µm - 0.6500 µm
T : Tangential
S : Sagittal
Modulus of the OTF
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
-0.05
-0.04
-0.03
-0.02
-0.01
0
0.01
0.02
0.03
0.04
0.05
Focus Shift (mm)

Fig. 10


3
Object Side
Image Side
OA3
IMA3
CG3
OF3
L36
L35
L34
ST3
L33
L32
L31
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S32
S33
S34
S35
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S38
S39
S310
S311
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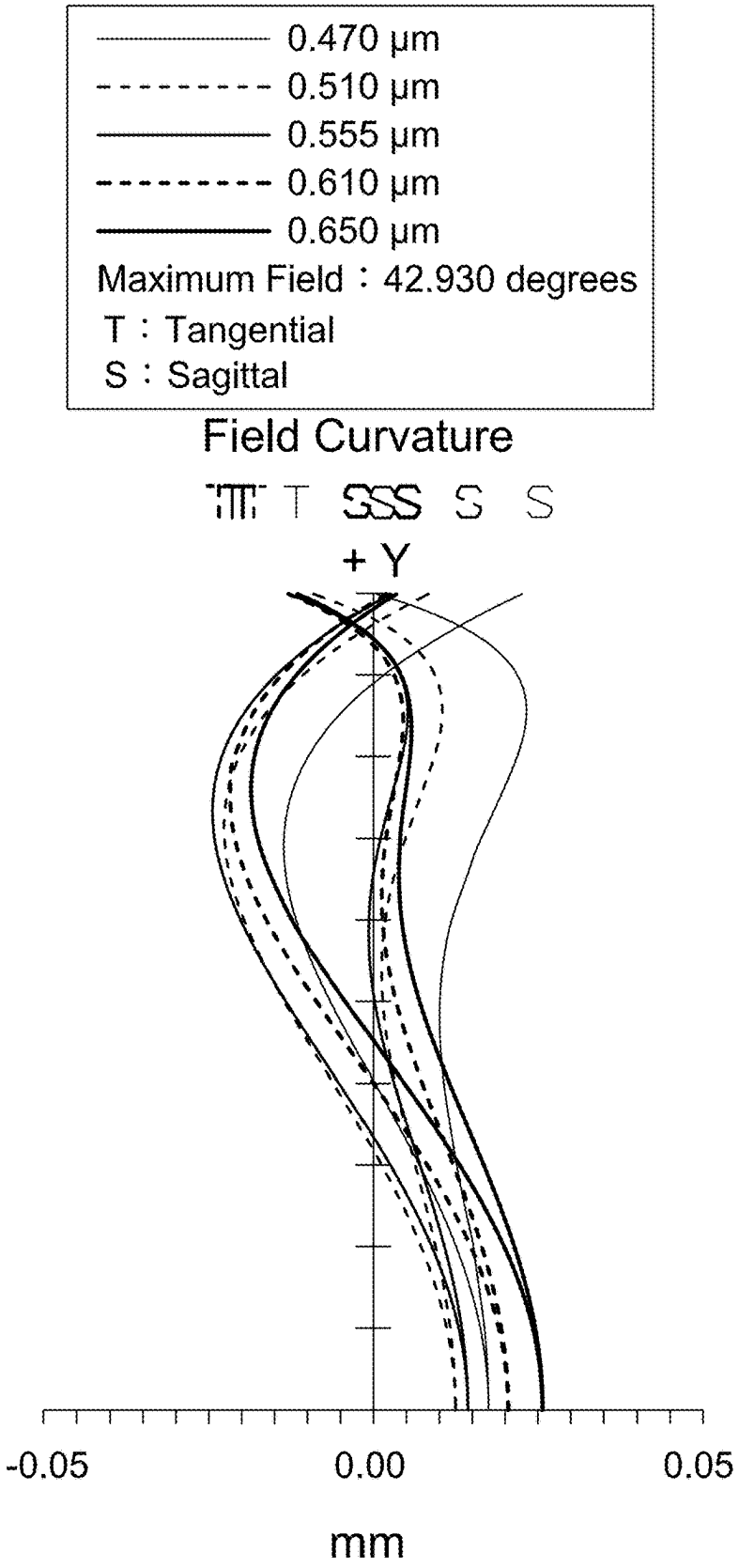
S313
S314
S315
S316
S317

Fig. 11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0.510 µm
0.555 µm
0.610 µm
0.650 µm
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T：Tangential
S：Sagittal
Field Curvature
T T S S
+ Y
-0.05
0.00
0.05
mm

Fig. 12

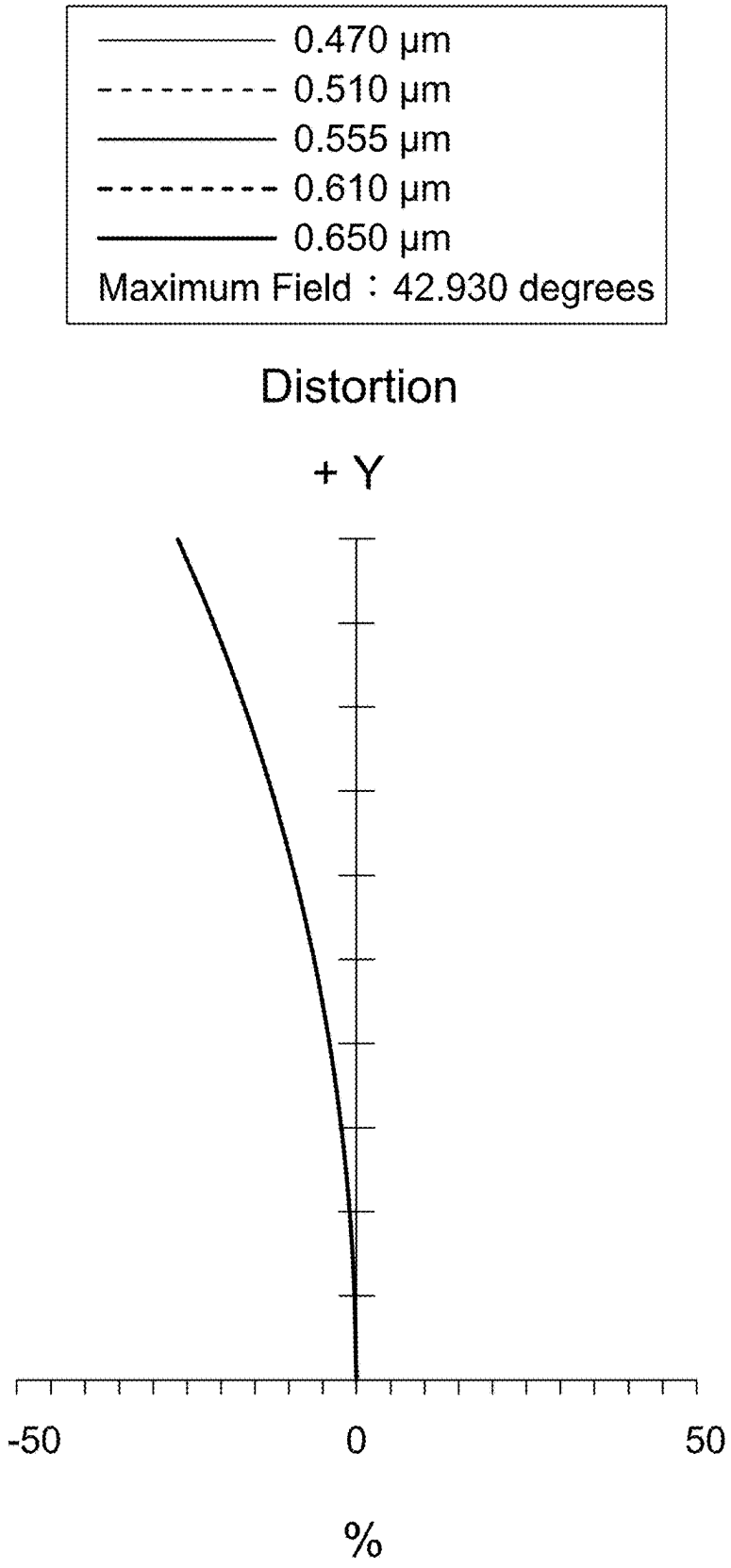
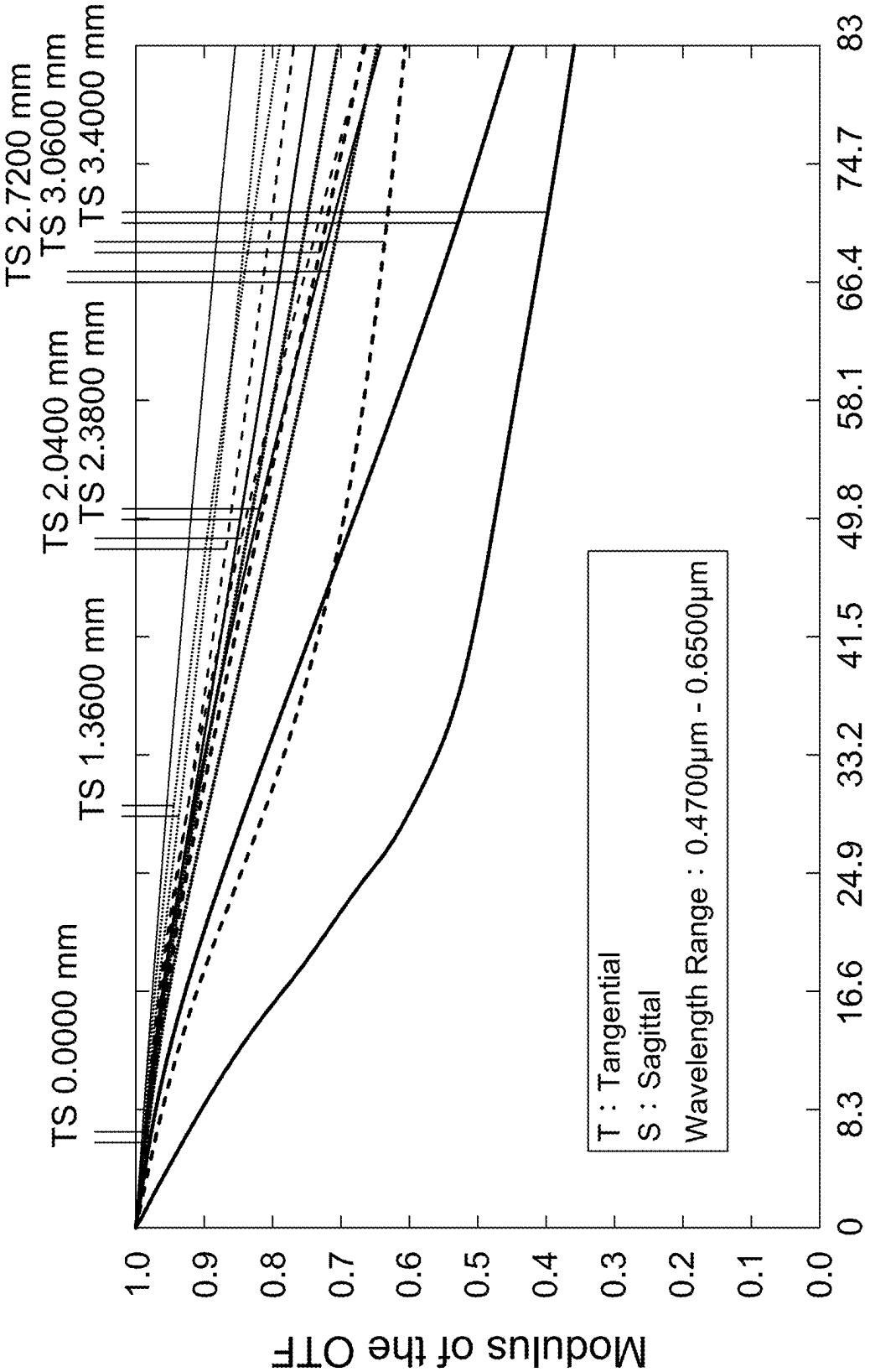

0.470 µm
0.510 µm
0.555 µm
0.610 µm
0.650 µm
Maximum Field : 42.930 degrees
Distortion
+ Y
-50
0
50
%

Fig. 13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TS 2.7200 mm
TS 3.0600 mm
TS 3.4000 mm
T : Tangential
S : Sagittal
Wavelength Range : 0.4700µm - 0.6500µm
Modulus of the OTF
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
0
8.3
16.6
24.9
33.2
41.5
49.8
58.1
66.4
74.7
83
Spatial Frequency (lp/mm)

Fig. 14

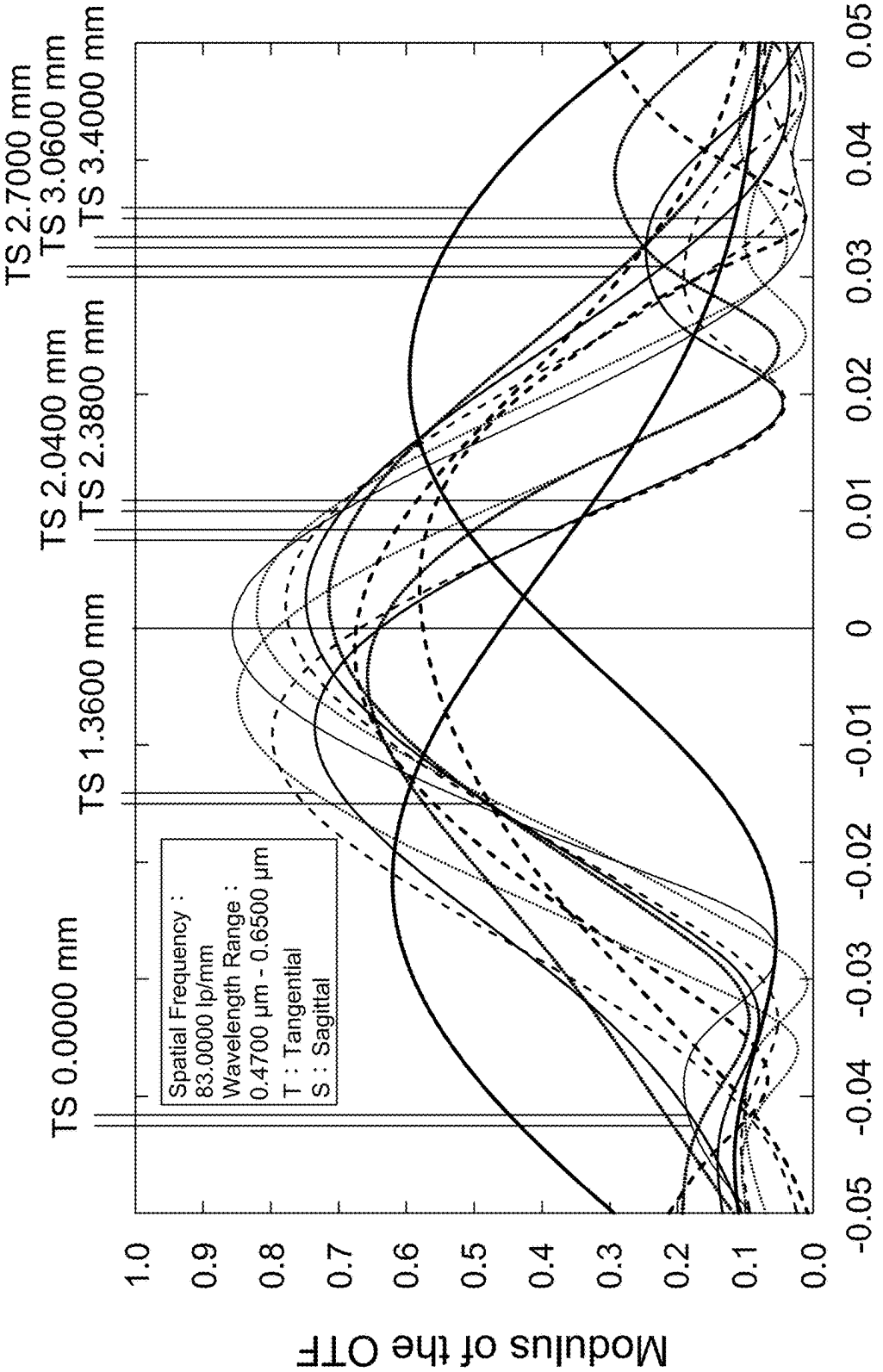
TS 0.0000 mm
TS 1.3600 mm
TS 2.0400 mm
TS 2.3800 mm
TS 2.7000 mm
TS 3.0600 mm
TS 3.4000 mm
Spatial Frequency :
83.0000 lp/mm
Wavelength Range :
0.4700 µm - 0.6500 µm
T : Tangential
S : Sagittal
Modulus of the OTF
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
-0.05
-0.04
-0.03
-0.02
-0.01
0
0.01
0.02
0.03
0.04
0.05
Focus Shift (mm)

Fig. 15

WIDE-ANGLE LENS ASSEMBLY

BACKGROUND OF THE INVENTION

Field of the Invention

[0001] The present invention relates to a wide-angle lens assembly.

Description of the Related Art

[0002] The current development trend of a wide-angle lens assembly is toward large field of view. Additionally, the wide-angle lens assembly is developed to have high resolution in accordance with different application requirements. However, the known wide-angle lens assembly can't satisfy such requirements. Therefore, the wide-angle lens assembly needs a new structure in order to meet the requirements of large field of view and high resolution at the same time.

BRIEF SUMMARY OF THE INVENTION

[0003] The invention provides a wide-angle lens assembly to solve the above problems. The wide-angle lens assembly of the invention is provided with characteristics of an increased field of view, an increased resolution, and still has a good optical performance.

[0004] The wide-angle lens assembly in accordance with an exemplary embodiment of the invention includes a first lens, a second lens, a third lens, a fourth lens, a fifth lens, and a sixth lens. The first lens is with negative refractive power. The second lens is with refractive power. The third lens is with positive refractive power. The fourth lens is with negative refractive power and includes a concave surface facing an image side. The fifth lens is with refractive power and includes a convex surface facing the image side. The sixth lens is with refractive power and includes a convex surface facing an object side. The first lens, the second lens, the third lens, the fourth lens, the fifth lens, and the sixth lens are arranged in order from the object side to the image side along an optical axis. The wide-angle lens assembly satisfies at least one of the following conditions: $1.03 \leq BFL/f \leq 1.22$; $0.44 \leq |f/R31| \leq 0.57$; $0.5 \leq R52/R61 \leq 1.3$; 17.2 degrees/mm $\leq FOV/f \leq$ 17.5 degrees/mm; 45 degrees $\leq FOV/Fno \leq$ 47 degrees; 2.58 mm $\leq f/Fno \leq$ 2.72 mm; wherein f is an effective focal length of the wide-angle lens assembly, R**31** is a radius of curvature of an object side surface of the third lens, R**52** is a radius of curvature of an image side surface of the fifth lens, R**61** is a radius of curvature of an object side surface of the sixth lens, BFL is an interval from an image side surface of the sixth lens to an image plane along the optical axis, FOV is a maximum field of view of the wide-angle lens assembly, and Fno is a F-number of the wide-angle lens assembly.

[0005] In another exemplary embodiment, the second lens is with positive refractive power; the fifth lens is with positive refractive power; and the sixth lens is with positive refractive power.

[0006] In yet another exemplary embodiment, the first lens includes a concave surface facing the image side; the second lens includes a convex surface facing the object side; the third lens is a biconvex lens and includes a convex surface facing the object side and another convex surface facing the image side; the fourth lens is a biconcave lens and further includes another concave surface facing the object side; and the fifth lens is a meniscus lens and further includes a concave surface facing the objet side.

[0007] In another exemplary embodiment, the second lens is a meniscus lens and further includes a concave surface facing the image side; and the sixth lens is a meniscus lens and further includes a concave surface facing the image side.

[0008] In yet another exemplary embodiment, the first lens is a meniscus lens and further includes a convex surface facing the object side.

[0009] In another exemplary embodiment, the first lens is a biconcave lens and further includes another concave surface facing the object side.

[0010] In yet another exemplary embodiment, the second lens is a biconvex lens and further includes another convex surface facing the image side; and the sixth lens is a biconvex lens and further includes another convex surface facing the image side.

[0011] In another exemplary embodiment, the wide-angle lens assembly further includes a stop disposed between the third lens and the fourth lens.

[0012] In yet another exemplary embodiment, the wide-angle lens assembly satisfies at least one of following conditions: $2 \leq Vd1/Vd2 \leq 3$; $3.4 \leq TTL/BFL \leq 4.2$; $2.2 \leq |R21/R12| \leq 6.3$; $1.35 \leq f1/f4 \leq 2.05$; wherein Vd**1** is an Abbe number of the first lens, Vd**2** is an Abbe number of the second lens, TTL is an interval from an object side surface of the first lens to the image plane along the optical axis, BFL is the interval from the image side surface of the sixth lens to the image plane along the optical axis, R**12** is a radius of curvature of an image side surface of the first lens, R**21** is a radius of curvature of an object side surface of the second lens, f**1** is an effective focal length of the first lens, and f**4** is an effective focal length of the fourth lens.

[0013] A detailed description is given in the following embodiments with reference to the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

[0014] The invention can be more fully understood by reading the subsequent detailed description and examples with references made to the accompanying drawings, wherein:

[0015] FIGS. **1**, **6**, and **11** are lens layout and optical path diagrams of wide-angle lens assemblies in accordance with a first, second, and third embodiments of the invention, respectively;

[0016] FIGS. **2**, **3**, **4**, and **5** depict a field curvature diagram, a distortion diagram, a modulation transfer function diagram, and a through focus modulation transfer function diagram of the wide-angle lens assembly in accordance with the first embodiment of the invention, respectively;

[0017] FIGS. **7**, **8**, **9**, and **10** depict a field curvature diagram, a distortion diagram, a modulation transfer function diagram, and a through focus modulation transfer function diagram of the wide-angle lens assembly in accordance with the second embodiment of the invention, respectively; and

[0018] FIGS. **12**, **13**, **14**, and **15** depict a field curvature diagram, a distortion diagram, a modulation transfer function diagram, and a through focus modulation transfer function diagram of the wide-angle lens assembly in accordance with the third embodiment of the invention, respectively.

DETAILED DESCRIPTION OF THE INVENTION

[0019] The following description is made for the purpose of illustrating the general principles of the invention and should not be taken in a limiting sense. The scope of the invention is best determined by reference to the appended claims.

[0020] The present invention provides a wide-angle lens assembly including a first lens, a second lens, a third lens, a fourth lens, a fifth lens, and a sixth lens. The first lens is with negative refractive power. The second lens is with refractive power. The third lens is with positive refractive power. The fourth lens is with negative refractive power and includes a concave surface facing an image side. The fifth lens is with refractive power and includes a convex surface facing the image side. The sixth lens is with refractive power and includes a convex surface facing an object side. The first lens, the second lens, the third lens, the fourth lens, the fifth lens, and the sixth lens are arranged in order from the object side to the image side along an optical axis. The wide-angle lens assembly satisfies at least one of the following conditions: 1.03≤BFL/f≤1.22; 0.44≤|f/**R31**|≤0.57; 0.5≤**R52**/**R61**≤1.3; 17.2 degrees/mm≤FOV/f≤17.5 degrees/mm; 45 degrees≤FOV/Fno≤47 degrees; 2.58 mm≤f/Fno≤2.72 mm; wherein f is an effective focal length of the wide-angle lens assembly, **R31** is a radius of curvature of an object side surface of the third lens, **R52** is a radius of curvature of an image side surface of the fifth lens, **R61** is a radius of curvature of an object side surface of the sixth lens, BFL is an interval from an image side surface of the sixth lens to an image plane along the optical axis, FOV is a maximum field of view of the wide-angle lens assembly, and Fno is a F-number of the wide-angle lens assembly. A wide-angle lens assembly of the present invention is a preferred embodiment of the present invention when the wide-angle lens assembly satisfies the above features and at least one of the above conditions.

[0021] Referring to Table 1, Table 3, and Table 5, wherein Table 1, Table 3, and Table 5 show optical specification in accordance with a first, second, and third embodiments of the invention, respectively.

[0022] FIGS. **1**, **6**, and **11** are lens layout and optical path diagrams of wide-angle lens assemblies in accordance with a first, second, and third embodiments of the invention, respectively. The first lenses **L11**, **L21**, **L31** are with negative refractive power, wherein the image side surfaces **S12**, **S22**, **S32** are concave surfaces and both of the object side surfaces **S11**, **S21**, **S31** and image side surfaces **S12**, **S22**, **S32** are spherical surfaces.

[0023] The second lenses **L12**, **L22**, **L32** are with positive refractive power, wherein the object side surfaces **S13**, **S23**, **S33** are convex surfaces and both of the object side surfaces **S13**, **S23**, **S33** and image side surfaces **S14**, **S24**, **S34** are spherical surfaces.

[0024] The third lenses **L13**, **L23**, **L33** are biconvex lenses with positive refractive power, wherein the object side surfaces **S15**, **S25**, **S35** are convex surfaces, the image side surfaces **S16**, **S26**, **S36** are convex surfaces, and both of the object side surfaces **S15**, **S25**, **S35** and image side surfaces **S16**, **S26**, **S36** are spherical surfaces.

[0025] The fourth lenses **L14**, **L24**, **L34** are biconcave lenses with negative refractive power, wherein the object side surfaces **S18**, **S28**, **S38** are concave surfaces, the image side surfaces **S19**, **S29**, **S39** are concave surfaces, and both of the object side surfaces **S18**, **S28**, **S38** and image side surfaces **S19**, **S29**, **S39** are spherical surfaces.

[0026] The fifth lenses **L15**, **L25**, **L35** are meniscus lenses with positive refractive power, wherein the object side surfaces **S110**, **S210**, **S310** are concave surfaces, the image side surfaces **S111**, **S211**, **S311** are convex surfaces, and both of the object side surfaces **S110**, **S210**, **S310** and image side surfaces **S111**, **S211**, **S311** are spherical surfaces.

[0027] The sixth lenses **L16**, **L26**, **L36** are with positive refractive power, wherein the object side surfaces **S112**, **S212**, **S312** are convex surfaces and both of the object side surfaces **S112**, **S212**, **S312** and image side surfaces **S113**, **S213**, **S313** are spherical surfaces.

[0028] In addition, the wide-angle lens assemblies 1, 2, and 3 satisfy at least one of the following conditions (1)-(10):

$$2 \le Vd1/Vd2 \le 3; \tag{1}$$

$$3.4 \le TTL/BFL \le 4.2; \tag{2}$$

$$1.03 \le BFL/f \le 1.22; \tag{3}$$

$$0.44 \le |f/R31| \le 0.57; \tag{4}$$

$$0.5 \le R52/R61 \le 1.3; \tag{5}$$

$$2.2 \le |R21/R12| \le 6.3; \tag{6}$$

$$1.35 \le f1/f4 \le 2.05; \tag{7}$$

$$17.2 \text{ degrees/mm} \le FOV/f \le 17.5 \text{ degrees/mm}; \tag{8}$$

$$45 \text{ degrees} \le FOV/Fno \le 47 \text{ degrees}; \tag{9}$$

$$2.58 \text{ mm} \le f/Fno \le 2.72 \text{ mm}; \tag{10}$$

[0029] wherein: f is an effective focal length of the wide-angle lens assemblies 1, 2, 3 for the first to third embodiments; f**1** is an effective focal length of the first lenses **L11**, **L21**, **L31** for the first to third embodiments; f**4** is an effective focal length of the fourth lenses **L14**, **L24**, **L34** for the first to third embodiments; **R12** is a radius of curvature of the image side surfaces **S12**, **S22**, **S32** of the first lenses **L11**, **L21**, **L31** for the first to third embodiments; **R21** is a radius of curvature of the object side surfaces **S13**, **S23**, **S33** of the second lenses **L12**, **L22**, **L32** for the first to third embodiments; **R31** is a radius of curvature of the object side surfaces **S15**, **S25**, **S35** of the third lenses **L13**, **L23**, **L33** for the first to third embodiments; **R52** is a radius of curvature of the image side surfaces **S111**, **S211**, **S311** of the fifth lenses **L15**, **L25**, **L35** for the first to third embodiments; **R61** is a radius of curvature of the object side surfaces **S112**, **S212**, **S312** of the sixth lenses **L16**, **L26**, **L36** for the first to third embodiments; TTL is an interval from the object side surfaces **S11**, **S21**, **S31** of the first lenses **L11**, **L21**, **L31** to the image planes IMA**1**, IMA**2**, IMA**3** along the optical axes OA**1**, OA**2**, OA**3** for the first to third embodiments; BFL is an interval from the image side surfaces **S113**, **S213**, **S313** of the sixth lenses **L16**, **L26**, **L36** to the image planes IMA**1**, IMA**2**, IMA**3** along the optical axes OA**1**, OA**2**, OA**3** for the first to third embodiments; Vd**1** is an Abbe number of the first lenses **L11**, **L21**, **L31** for the first to third embodiments; Vd**2** is an Abbe number of the second lenses **L12**, **L22**, **L32** for the first to third embodiments; FOV is a maximum field of view of the wide-angle lens assemblies 1, 2, 3 for the first to third embodiments; and Fno is a F-number of the wide-

angle lens assemblies 1, 2, 3 for the first to third embodiments. With the lens assemblies 1, 2, and 3 satisfying at least one of the above conditions (1)-(10), the field of view can be effectively increased, the resolution can be effectively increased, and the aberration can be effectively corrected.

[0030] When the condition (1): 2≤Vd**1**/Vd**2**≤3 is satisfied, the chromatic aberration can be corrected effectively and resolution can be increased effectively. When the condition (2): 3.4≤TTL/BFL≤4.2 is satisfied, the back focal length can be controlled effectively to improve production yield. When the conditions (3), (4), and (5): 1.03≤BFL/f≤1.22, 0.44≤|f/R**31**|≤0.57, and 0.5≤R**52**/R**61**≤1.3 are satisfied, the field curvature can be decreased effectively and resolution can be increased effectively. When the condition (6): 2.2≤|R**21**/R**12**|≤6.3 is satisfied, the resolution can be increased effectively. When the condition (7): 1.35≤f**1**/f**4**≤2.05 is satisfied, the light collection ability can be increased effectively. When the conditions (8), (9), and (10): 17.2 degrees/mm≤FOV/f≤17.5 degrees/mm, 45 degrees≤FOV/Fno≤47 degrees, and 2.58 mm≤f/Fno≤2.72 mm are satisfied, the diameter of the wide-angle lens assembly can be increased effectively and the brightness of the image can be increased effectively.

[0031] A detailed description of a wide-angle lens assembly in accordance with a first embodiment of the invention is as follows. Referring to FIG. **1**, the wide-angle lens assembly **1** includes a first lens L**11**, a second lens L**12**, a third lens L**13**, a stop ST**1**, a fourth lens L**14**, a fifth lens L**15**, a sixth lens L**16**, an optical filter OF**1**, and a cover glass CG**1**, all of which are arranged in order from an object side to an image side along an optical axis OA**1**. In operation, the light from the object side is imaged on an image plane IMA**1**. According to the foregoing, wherein: the first lens L**11** is a biconcave lens, wherein the object side surface S**11** is a concave surface; the second lens L**12** is a meniscus lens, wherein the image side surface S**14** is a concave surface; the sixth lens L**16** is a meniscus lens, wherein the image side surface S**113** is a concave surface; both of the object side surface S**114** and image side surface S**115** of the optical filter OF**1** are plane surfaces; both of the object side surface S**116** and image side surface S**117** of the cover glass CG**1** are plane surfaces; and with the above design of the lenses, stop ST**1**, and at least one of the conditions (1)-(10) satisfied, the wide-angle lens assembly 1 can have an effective increased field of view, an effective increased resolution, and an effective corrected aberration. The wide-angle lens assembly 1 of the present invention can meet the basic operation requirements when it only satisfies condition (3), condition (4), condition (5), condition (8), condition (9), or condition (10), and the refractive surface shape characteristics of the independent claim.

[0032] Table 1 shows the optical specification of the wide-angle lens assembly 1 in FIG. **1**.

TABLE 1

Effective Focal Length = 4.85 mm F-number = 1.85
Total Lens Length = 21.00 mm Field of View = 84.36 degrees

Surface Number	Radius of Curvature (mm)	Thickness (mm)	Nd	Vd	Effective Focal Length (mm)	Remark
S11	−116.13	0.45	1.52	64.04	−7.52	L11
S12	4.03	5.35				
S13	10.06	0.88	2.00	25.46	10.45	L12
S14	215.68	1.05				
S15	8.71	2.01	1.59	60.47	7.64	L13
S16	−8.71	−0.15				
S17	∞	0.53				ST1
S18	−7.71	1.86	1.95	17.98	−3.81	L14
S19	7.71	0.37				
S110	−148.76	0.95	2.05	26.94	7.61	L15
S111	−7.66	0.05				
S112	6.12	2.35	1.73	54.67	13.19	L16
S113	14.05	1.00				
S114	∞	0.40	1.52	64.17		OF1
S115	∞	2.50				
S116	∞	0.40	1.52	64.17		CG1
S117	∞	1.02				

[0033] Table 2 shows the parameters and condition values for conditions (1)-(10) in accordance with the first embodiment of the invention. It can be seen from Table 2 that the wide-angle lens assembly 1 of the first embodiment satisfies the conditions (1)-(10).

TABLE 2

BFL	5.32 mm	Vd1/Vd2	2.52	TTL/BFL	3.95
BFL/f	1.10	|f/R31|	0.56	R52/R61	−1.25
|R21/R12|	2.49	f1/f4	1.97	FOV/f	17.39 degrees/mm
FOV/Fno	45.6 degrees	f/Fno	2.62 mm		

[0034] In addition, the wide-angle lens assembly 1 of the first embodiment can meet the requirements of optical performance as seen in FIGS. **2**-**5**. It can be seen from FIG. **2** that the field curvature of tangential direction and sagittal direction in the wide-angle lens assembly 1 of the first embodiment ranges from −0.06 mm to 0.03 mm. It can be

seen from FIG. **3** that the distortion in the wide-angle lens assembly 1 of the first embodiment ranges from −25% to 0%. It can be seen from FIG. **4** that the modulation transfer function of tangential direction and sagittal direction in the wide-angle lens assembly 1 of the first embodiment ranges from 0.36 to 1.0. It can be seen from FIG. **5** that the through focus modulation transfer function of tangential direction and sagittal direction in the wide-angle lens assembly 1 of the first embodiment ranges from 0.0 to 0.83 as focus shift ranges from −0.05 mm to 0.05 mm. It is obvious that the field curvature and the distortion of the wide-angle lens assembly 1 of the first embodiment can be corrected effectively, and the resolution and the depth of focus of the wide-angle lens assembly 1 of the first embodiment can meet the requirement. Therefore, the wide-angle lens assembly 1 of the first embodiment is capable of good optical performance.

[0035] A detailed description of a wide-angle lens assembly in accordance with a second embodiment of the invention is as follows. Referring to FIG. **6**, the wide-angle lens assembly 2 includes a first lens L**21**, a second lens L**22**, a third lens L**23**, a stop ST**2**, a fourth lens L**24**, a fifth lens L**25**, a sixth lens L**26**, an optical filter OF**2**, and a cover glass CG**2**, all of which are arranged in order from an object side to an image side along an optical axis OA**2**. In operation, the light from the object side is imaged on an image plane IMA**2**. According to the foregoing, wherein: the first lens L**21** is a meniscus lens, wherein the object side surface S**21** is a convex surface; the second lens L**22** is a meniscus lens, wherein the image side surface S**24** is a concave surface; the sixth lens L**26** is a meniscus lens, wherein the image side surface S**213** is a concave surface; both of the object side surface S**214** and image side surface S**215** of the optical filter OF**2** are plane surfaces; both of the object side surface S**216** and image side surface S**217** of the cover glass CG**2** are plane surfaces; and with the above design of the lenses, stop ST**2**, and at least one of the conditions (1)-(10) satisfied, the wide-angle lens assembly 2 can have an effective increased field of view, an effective increased resolution, and an effective corrected aberration. The wide-angle lens assembly 2 of the present invention can meet the basic operation requirements when it only satisfies condition (1) or condition (2), and the refractive surface shape characteristics of the independent claim.

[0036] Table 3 shows the optical specification of the wide-angle lens assembly 2 in FIG. **6**.

TABLE 3

Effective Focal Length = 4.83 mm F-number = 1.86
Total Lens Length = 21.00 mm Field of View = 84.00 degrees

Surface Number	Radius of Curvature (mm)	Thickness (mm)	Nd	Vd	Effective Focal Length (mm)	Remark
S21	796.09	0.30	1.52	64.14	−7.85	L21
S22	4.05	5.66				
S23	9.19	0.97	2.00	25.46	9.44	L22
S24	257.29	0.05				
S25	10.59	2.73	1.60	67.74	9.32	L23
S26	−10.59	0.09				
S27	∞	0.40				ST2
S28	−7.77	1.07	1.96	17.47	−3.88	L24
S29	7.77	0.43				
S210	−19.41	0.97	2.00	29.14	8.68	L25
S211	−6.18	0.05				
S212	6.69	3.24	1.73	54.67	10.02	L26
S213	61.20	3.03				
S214	∞	0.40	1.52	64.17		OF2
S215	∞	1.00				
S216	∞	0.40	1.52	64.17		CG2
S217	∞	0.20				

[0037] Table 4 shows the parameters and condition values for conditions (1)-(10) in accordance with the second embodiment of the invention. It can be seen from Table 4 that the wide-angle lens assembly 2 of the second embodiment satisfies the conditions (1)-(10).

TABLE 4

BFL	5.03 mm	Vd1/Vd2	2.52	TTL/BFL	4.17
BFL/f	1.04	|f/R31|	0.46	R52/R61	−0.92
|R21/R12|	2.27	f1/f4	2.02	FOV/f	17.39 degrees/mm
FOV/Fno	45.16 degrees	f/Fno	2.6 mm		

[0038] In addition, the wide-angle lens assembly 2 of the second embodiment can meet the requirements of optical performance as seen in FIGS. **7**-**10**. It can be seen from FIG. **7** that the field curvature of tangential direction and sagittal direction in the wide-angle lens assembly 2 of the second embodiment ranges from −0.06 mm to 0.04 mm. It can be seen from FIG. **8** that the distortion in the wide-angle lens assembly 2 of the second embodiment ranges from −25% to 0%. It can be seen from FIG. **9** that the modulation transfer function of tangential direction and sagittal direction in the wide-angle lens assembly 2 of the second embodiment ranges from 0.33 to 1.0. It can be seen from FIG. **10** that the through focus modulation transfer function of tangential

direction and sagittal direction in the wide-angle lens assembly 2 of the second embodiment ranges from 0.0 to 0.83 as focus shift ranges from −0.05 mm to 0.05 mm. It is obvious that the field curvature and the distortion of the wide-angle lens assembly 2 of the second embodiment can be corrected effectively, and the resolution and the depth of focus of the wide-angle lens assembly 2 of the second embodiment can meet the requirement. Therefore, the wide-angle lens assembly 2 of the second embodiment is capable of good optical performance.

[0039] A detailed description of a wide-angle lens assembly in accordance with a third embodiment of the invention is as follows. Referring to FIG. **11**, the wide-angle lens assembly 3 includes a first lens L**31**, a second lens L**32**, a third lens L**33**, a stop ST**3**, a fourth lens L**34**, a fifth lens L**35**, a sixth lens L**36**, an optical filter OF**3**, and a cover glass CG**3**, all of which are arranged in order from an object side to an image side along an optical axis OA**3**. In operation, the light from the object side is imaged on an image plane IMA**3**. According to the foregoing, wherein: the first lens L**31** is a biconcave lens, wherein the object side surface S**31** is a concave surface; the second lens L**32** is a biconvex lens, wherein the image side surface S**34** is a convex surface; the sixth lens L**36** is a biconvex lens, wherein the image side surface S**313** is a convex surface; both of the object side surface S**314** and image side surface S**315** of the optical filter OF**3** are plane surfaces; both of the object side surface S**316** and image side surface S**317** of the cover glass CG**3** are plane surfaces; and with the above design of the lenses, stop ST**3**, and at least one of the conditions (1)-(10) satisfied, the wide-angle lens assembly 3 can have an effective increased field of view, an effective increased resolution, and an effective corrected aberration. The wide-angle lens assembly 3 of the present invention can meet the basic operation requirements when it only satisfies condition (6) or condition (7), and the refractive surface shape characteristics of the independent claim.

[0040] Table 5 shows the optical specification of the wide-angle lens assembly 3 in FIG. **11**.

TABLE 5

Effective Focal Length = 4.96 mm F-number = 1.84
Total Lens Length = 20.49 mm Field of View = 85.86 degrees

Surface Number	Radius of Curvature (mm)	Thickness (mm)	Nd	Vd	Effective Focal Length (mm)	Remark
S31	−16.16	0.29	1.52	64.14	−5.68	L31
S32	3.61	1.67				
S33	22.44	2.06	2.00	25.46	15.51	L32
S34	−49.13	0.18				
S35	10.99	3.28	1.60	67.74	7.03	L33
S36	−6.03	−0.30				
S37	∞	2.69				ST3
S38	−4.46	0.54	1.96	17.47	−4.06	L34
S39	35.21	0.28				
S310	−20.69	1.46	2.00	29.14	6.95	L35
S311	−5.42	0.18				
S312	9.53	2.17	1.77	49.60	8.70	L36
S313	−20.76	1.60				
S314	∞	0.40	1.52	64.17		OF3
S315	∞	2.00				
S316	∞	0.40	1.52	64.17		CG3
S317	∞	1.61				

[0041] Table 6 shows the parameters and condition values for conditions (1)-(10) in accordance with the third embodiment of the invention. It can be seen from Table 6 that the wide-angle lens assembly 3 of the third embodiment satisfies the conditions (1)-(10).

TABLE 6

BFL	6.01 mm	Vd1/Vd2	2.52	TTL/BFL	3.41
BFL/f	1.21	|f/R31|	0.45	R52/R61	−0.57
|R21/R12|	6.21	f1/f4	1.40	FOV/f	17.31 degrees/mm
FOV/Fno	46.66 degrees	f/Fno	2.7 mm		

[0042] In addition, the wide-angle lens assembly 3 of the third embodiment can meet the requirements of optical performance as seen in FIGS. **12-15**. It can be seen from FIG. **12** that the field curvature of tangential direction and sagittal direction in the wide-angle lens assembly 3 of the third embodiment ranges from −0.025 mm to 0.03 mm. It can be seen from FIG. **13** that the distortion in the wide-angle lens assembly 3 of the third embodiment ranges from −30% to 0%. It can be seen from FIG. **14** that the modulation transfer function of tangential direction and sagittal direction in the wide-angle lens assembly 3 of the third embodiment ranges from 0.37 to 1.0. It can be seen from FIG. **15** that the through focus modulation transfer function of tangential direction and sagittal direction in the wide-angle lens assembly 3 of the third embodiment ranges from 0.01 to 0.85 as focus shift ranges from −0.05 mm to 0.05 mm. It is obvious that the field curvature and the distortion of the wide-angle lens assembly 3 of the third embodiment can be corrected effectively, and the resolution and the depth of focus of the wide-angle lens assembly 3 of the third embodiment can meet the requirement. Therefore, the wide-angle lens assembly 3 of the third embodiment is capable of good optical performance.

[0043] While the invention has been described by way of example and in terms of the preferred embodiment(s), it is to be understood that the invention is not limited thereto. On the contrary, it is intended to cover various modifications and similar arrangements and procedures, and the scope of the appended claims therefore should be accorded the broadest interpretation so as to encompass all such modifications and similar arrangements and procedures.

What is claimed is:

1. A wide-angle lens assembly comprising:

a first lens which is with negative refractive power;

a second lens which is with refractive power;

a third lens which is with positive refractive power;

a fourth lens which is with negative refractive power and comprises a concave surface facing an image side;

a fifth lens which is with refractive power and comprises a convex surface facing the image side; and

a sixth lens which is with refractive power and comprises a convex surface facing an object side;

wherein the first lens, the second lens, the third lens, the fourth lens, the fifth lens, and the sixth lens are arranged in order from the object side to the image side along an optical axis;

wherein the wide-angle lens assembly satisfies at least one of following conditions:

$$1.03 \le BFL / f \le 1.22;$$

$$0.5 \le R52 / R61 \le 1.3;$$

$$17.2 \text{ degrees/mm} \le FOV / f \le 17.5 \text{ degrees/mm};$$

$$45 \text{ degrees} \le FOV / Fno \le 47 \text{ degrees};$$

$$2.58 \text{ mm} \le f / Fno \le 2.72 \text{ mm};$$

wherein f is an effective focal length of the wide-angle lens assembly, **R52** is a radius of curvature of an image side surface of the fifth lens, **R61** is a radius of curvature of an object side surface of the sixth lens, BFL is an interval from an image side surface of the sixth lens to an image plane along the optical axis, FOV is a maximum field of view of the wide-angle lens assembly, and Fno is a F-number of the wide-angle lens assembly.

2. The wide-angle lens assembly as claimed in claim **1**, wherein the wide-angle lens assembly satisfies at least one of following conditions:

$$2 \le Vd1 / Vd2 \le 3;$$

$$3.4 \le TTL / BFL \le 4.2;$$

$$2.2 \le |R21 / R12| \le 6.3;$$

$$1.35 \le f1 / f4 \le 2.05;$$

$$0.44 \le |f / R31| \le 0.57;$$

wherein Vd**1** is an Abbe number of the first lens, Vd**2** is an Abbe number of the second lens, TTL is an interval from an object side surface of the first lens to the image plane along the optical axis, BFL is the interval from the image side surface of the sixth lens to the image plane along the optical axis, **R12** is a radius of curvature of an image side surface of the first lens, **R21** is a radius of curvature of an object side surface of the second lens, f**1** is an effective focal length of the first lens, and f**4** is an effective focal length of the fourth lens, **R31** is a radius of curvature of an object side surface of the third lens, f is an effective focal length of the wide-angle lens assembly.

3. The wide-angle lens assembly as claimed in claim **1**, wherein:

the second lens is with positive refractive power;

the fifth lens is with positive refractive power; and

the sixth lens is with positive refractive power.

4. The wide-angle lens assembly as claimed in claim **3**, wherein the wide-angle lens assembly satisfies at least one of following conditions:

$$2 \le Vd1 / Vd2 \le 3;$$

$$3.4 \le TTL / BFL \le 4.2;$$

$$2.2 \le |R21 / R12| \le 6.3;$$

$$1.35 \le f1 / f4 \le 2.05;$$

$$0.44 \le |f / R31| \le 0.57;$$

wherein Vd**1** is an Abbe number of the first lens, Vd**2** is an Abbe number of the second lens, TTL is an interval from an object side surface of the first lens to the image plane along the optical axis, BFL is the interval from the image side surface of the sixth lens to the image plane along the optical axis, **R12** is a radius of curvature of an image side surface of the first lens, **R21** is a radius of curvature of an object side surface of the second lens, f**1** is an effective focal length of the first lens, and f**4** is an effective focal length of the fourth lens, **R31** is a radius of curvature of an object side surface of the third lens, f is an effective focal length of the wide-angle lens assembly.

5. The wide-angle lens assembly as claimed in claim **3**, wherein:

the first lens comprises a concave surface facing the image side;

the second lens comprises a convex surface facing the object side;

the third lens is a biconvex lens and comprises a convex surface facing the object side and another convex surface facing the image side;

the fourth lens is a biconcave lens and further comprises another concave surface facing the object side; and

the fifth lens is a meniscus lens and further comprises a concave surface facing the objet side.

6. The wide-angle lens assembly as claimed in claim **5**, wherein the wide-angle lens assembly satisfies at least one of following conditions:

$$2 \le Vd1/Vd2 \le 3;$$

$$3.4 \le TTL/BFL \le 4.2;$$

$$2.2 \le |R21/R12| \le 6.3;$$

$$1.35 \le f1/f4 \le 2.05;$$

$$0.44 \le |f/R31| \le 0.57;$$

wherein Vd**1** is an Abbe number of the first lens, Vd**2** is an Abbe number of the second lens, TTL is an interval from an object side **10** surface of the first lens to the image plane along the optical axis, BFL **11** is the interval from the image side surface of the sixth lens to the image plane along the optical axis, R**12** is a radius of curvature of an image side surface of the first lens, R**21** is a radius of curvature of an object side surface of the second lens, f**1** is an effective focal length of the first lens, and f**4** is an effective focal length of the fourth lens, R**31** is a radius of curvature of an object side surface of the third lens, f is an effective focal length of the wide-angle lens assembly.

7. The wide-angle lens assembly as claimed in claim **5**, wherein:

the second lens is a meniscus lens and further comprises a concave surface facing the image side; and

the sixth lens is a meniscus lens and further comprises a concave surface facing the image side.

8. The wide-angle lens assembly as claimed in claim **7**, wherein the wide-angle lens assembly satisfies at least one of following conditions:

$$2 \le Vd1/Vd2 \le 3;$$

$$3.4 \le TTL/BFL \le 4.2;$$

$$2.2 \le |R21/R12| \le 6.3;$$

$$1.35 \le f1/f4 \le 2.05;$$

$$0.44 \le |f/R31| \le 0.57;$$

wherein Vd**1** is an Abbe number of the first lens, Vd**2** is an Abbe number of the second lens, TTL is an interval from an object side surface of the first lens to the image plane along the optical axis, BFL is the interval from the image side surface of the sixth lens to the image plane along the optical axis, R**12** is a radius of curvature of an image side surface of the first lens, R**21** is a radius of curvature of an object side surface of the second lens, f**1** is an effective focal length of the first lens, and f**4** is an effective focal length of the fourth lens, R**31** is a radius of curvature of an object side surface of the third lens, f is an effective focal length of the wide-angle lens assembly.

9. The wide-angle lens assembly as claimed in claim **5**, wherein the first lens is a biconcave lens and further comprises another concave surface facing the object side.

10. The wide-angle lens assembly as claimed in claim **9**, wherein the wide-angle lens assembly satisfies at least one of following conditions:

$$2 \le Vd1/Vd2 \le 3;$$

$$3.4 \le TTL/BFL \le 4.2;$$

$$2.2 \le |R21/R12| \le 6.3;$$

$$1.35 \le f1/f4 \le 2.05;$$

$$0.44 \le |f/R31| \le 0.57;$$

wherein Vd**1** is an Abbe number of the first lens, Vd**2** is an Abbe number of the second lens, TTL is an interval from an object side surface of the first lens to the image plane along the optical axis, BFL is the interval from the image side surface of the sixth lens to the image plane along the optical axis, R**12** is a radius of curvature of an image side surface of the first lens, R**21** is a radius of curvature of an object side surface of the second lens, f**1** is an effective focal length of the first lens, and f**4** is an effective focal length of the fourth lens, R**31** is a radius of curvature of an object side surface of the third lens, f is an effective focal length of the wide-angle lens assembly.

11. The wide-angle lens assembly as claimed in claim **5**, wherein:

the second lens is a biconvex lens and further comprises another convex surface facing the image side; and

the sixth lens is a biconvex lens and further comprises another convex surface facing the image side.

12. The wide-angle lens assembly as claimed in claim **11**, wherein the wide-angle lens assembly satisfies at least one of following conditions:

$$2 \le Vd1/Vd2 \le 3;$$

$$3.4 \le TTL/BFL \le 4.2;$$

$$2.2 \le |R21/R12| \le 6.3;$$

$$1.35 \le f1/f4 \le 2.05;$$

$$0.44 \le |f/R31| \le 0.57;$$

wherein Vd**1** is an Abbe number of the first lens, Vd**2** is an Abbe number of the second lens, TTL is an interval from an object side surface of the first lens to the image plane along the optical axis, BFL is the interval from the image side surface of the sixth lens to the image plane along the optical axis, R**12** is a radius of curvature of an image side surface of the first lens, R**21** is a radius of curvature of an object side surface of the second lens, f**1** is an effective focal length of the first

lens, and f**4** is an effective focal length of the fourth lens, R**31** is a radius of curvature of an object side surface of the third lens, f is an effective focal length of the wide-angle lens assembly.

13. The wide-angle lens assembly as claimed in claim **7**, wherein the first lens is a meniscus lens and further comprises a convex surface facing the object side.

14. The wide-angle lens assembly as claimed in claim **13**, wherein the wide-angle lens assembly satisfies at least one of following conditions:

$$2 \le Vd1/Vd2 \le 3;$$

$$3.4 \le TTL/BFL \le 4.2;$$

$$2.2 \le |R21/R12| \le 6.3;$$

$$1.35 \le f1/f4 \le 2.05;$$

$$0.44 \le |f/R31| \le 0.57;$$

wherein Vd**1** is an Abbe number of the first lens, Vd**2** is an Abbe number of the second lens, TTL is an interval from an object side **10** surface of the first lens to the image plane along the optical axis, BFL **11** is the interval from the image side surface of the sixth lens to the **12** image plane along the optical axis, R**12** is a radius of curvature of an **13** image side surface of the first lens, R**21** is a radius of curvature of an object side surface of the second lens, f**1** is an effective focal length of the first lens, and f**4** is an effective focal length of the fourth lens, R**31** is a radius of curvature of an object side surface of the third lens, f is an effective focal length of the wide-angle lens assembly.

15. The wide-angle lens assembly as claimed in claim **1**, further comprising a stop disposed between the third lens and the fourth lens.

16. The wide-angle lens assembly as claimed in claim **15**, wherein the wide-angle lens assembly satisfies at least one of following conditions:

$$2 \le Vd1/Vd2 \le 3;$$

$$3.4 \le TTL/BFL \le 4.2;$$

$$2.2 \le |R21/R12| \le 6.3;$$

$$1.35 \le f1/f4 \le 2.05;$$

$$0.44 \le |f/R31| \le 0.57;$$

wherein Vd**1** is an Abbe number of the first lens, Vd**2** is an Abbe number of the second lens, TTL is an interval from an object side surface of the first lens to the image plane along the optical axis, BFL is the interval from the image side surface of the sixth lens to the image plane along the optical axis, R**12** is a radius of curvature of an image side surface of the first lens, R**21** is a radius of curvature of an object side surface of the second lens, f**1** is an effective focal length of the first lens, and f**4** is an effective focal length of the fourth lens, R**31** is a radius of curvature of an object side surface of the third lens, f is an effective focal length of the wide-angle lens assembly.

17. The wide-angle lens assembly as claimed in claim **1**, wherein:

the first lens is a meniscus lens or a biconcave lens;

when the first lens is the meniscus lens, then the sixth lens is also a meniscus lens; when the first lens is the biconcave lens, then a shape of an object side surface of the second lens is similar to a shape of an object side surface of the six lens, and a shape of an image side surface of the second lens is similar to a shape of an image side surface of the six lens.

18. A wide-angle lens assembly comprising:

a first lens which is with negative refractive power;

a second lens which is with refractive power;

a third lens which is with positive refractive power;

a fourth lens which is with negative refractive power and comprises a concave surface facing an image side;

a fifth lens which is with refractive power and comprises a convex surface facing the image side; and

a sixth lens which is with refractive power and comprises a convex surface facing an object side;

wherein the first lens, the second lens, the third lens, the fourth lens, the fifth lens, and the sixth lens are arranged in order from the object side to the image side along an optical axis;

wherein the first lens is a meniscus lens or a biconcave lens; when the first lens is the meniscus lens, then the sixth lens is also a meniscus lens; when the first lens is the biconcave lens, then a shape of an object side surface of the second lens is similar to a shape of an object side surface of the six lens, and a shape of an image side surface of the second lens is similar to a shape of an image side surface of the six lens.

19. The wide-angle lens assembly as claimed in claim **17**, wherein the wide-angle lens assembly satisfies at least one of following conditions:

$$2 \le Vd1/Vd2 \le 3;$$

$$3.4 \le TTL/BFL \le 4.2;$$

$$2.2 \le |R21/R12| \le 6.3;$$

$$1.35 \le f1/f4 \le 2.05;$$

$$0.44 \le |f/R31| \le 0.57;$$

$$1.03 \le BFL/f \le 1.22;$$

$$0.5 \le R52/R61 \le 1.3;$$

$$17.2 \text{ degrees/mm} \le FOV/f \le 17.5 \text{ degrees/mm};$$

$$45 \text{ degrees} \le FOV/Fno \le 47 \text{ degrees};$$

$$2.58 \text{ mm} \le f/Fno \le 2.72 \text{ mm};$$

wherein Vd**1** is an Abbe number of the first lens, Vd**2** is an Abbe number of the second lens, TTL is an interval from an object side surface of the first lens to the image plane along the optical axis, BFL is the interval from the image side surface of the sixth lens to the image plane along the optical axis, R**12** is a radius of curvature of an image side surface of the first lens, R**21** is a radius of curvature of an object side surface of the second lens, f**1** is an effective focal length of the first lens, and f**4** is an effective focal length of the fourth lens, R**31** is a radius of curvature of an object side

surface of the third lens, f is an effective focal length of the wide-angle lens assembly, R**52** is a radius of curvature of an image side surface of the fifth lens, R**61** is a radius of curvature of an object side surface of the sixth lens, BFL is an interval from an image side surface of the sixth lens to an image plane along the optical axis, FOV is a maximum field of view of the wide-angle lens assembly, and Fno is a F-number of the wide-angle lens assembly.

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