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(54) **IMAGE PICKUP OPTICAL LENS ASSEMBLY**

8,189,273 B2 * 5/2012 Noda 359/766
8,233,224 B2 * 7/2012 Chen 359/764
8,358,474 B2 * 1/2013 Kwon 359/764

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(Continued)

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FOREIGN PATENT DOCUMENTS

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JP 2003131136 A 5/2003
JP 2003161879 A 6/2003

(Continued)

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OTHER PUBLICATIONS

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Related U.S. Patent Documents

(Continued)

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(30) **Foreign Application Priority Data**

(57) **ABSTRACT**

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G02B 9/60 (2006.01)
G02B 13/00 (2006.01)

(52) **U.S. Cl.**
CPC **G02B 13/0045** (2013.01)

(58) **Field of Classification Search**
CPC G02B 13/0045
USPC 359/763, 764, 766
See application file for complete search history.

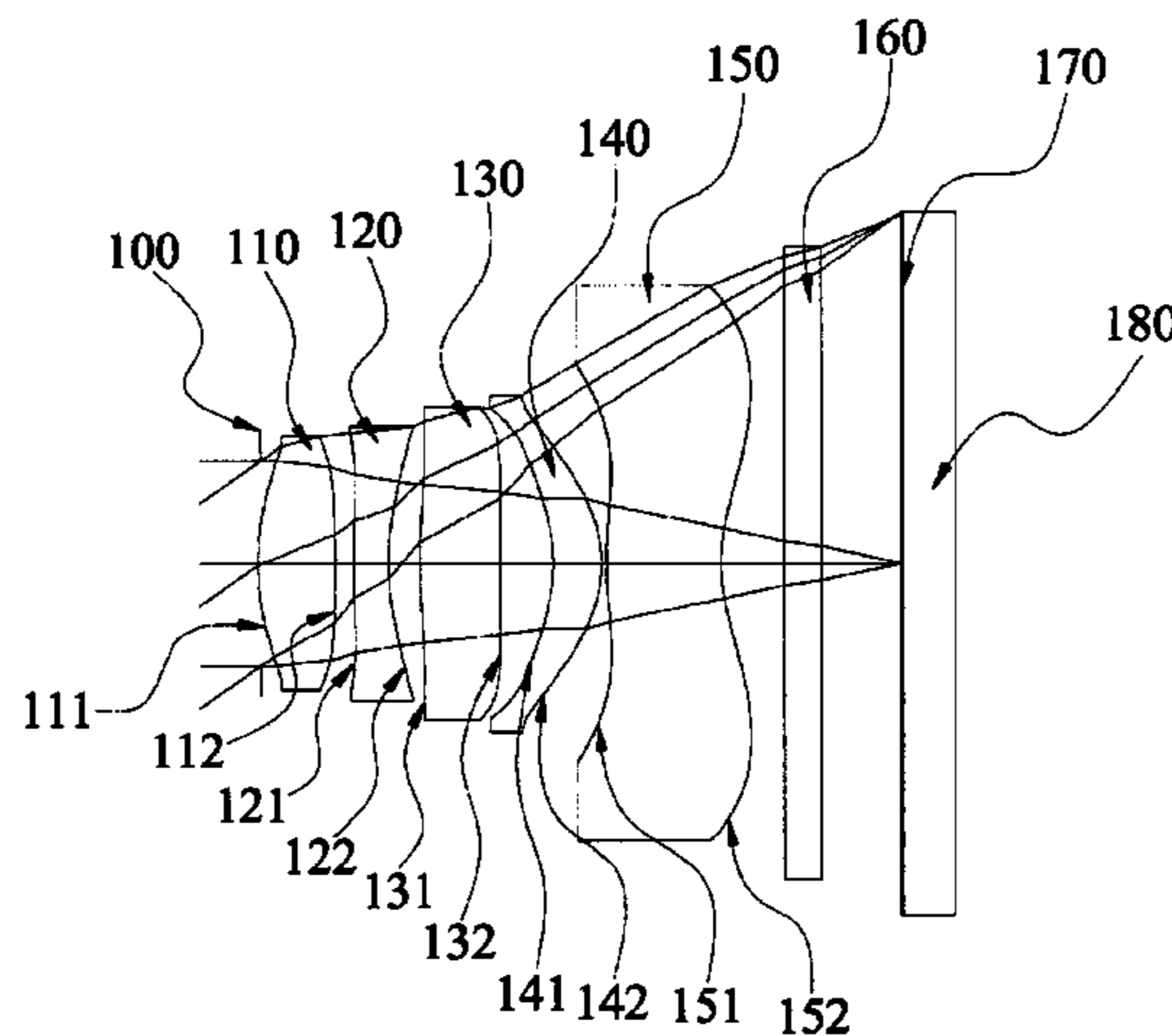
An image pickup optical lens assembly, sequentially arranged from an object side to an image side along an optical axis, comprising: the first lens element with positive refractive power having a convex object-side surface, the second lens element with negative refractive power, the third lens element with refractive power, the fourth lens element with positive or negative refractive power having a concave object-side surface and a convex image-side surface with both being aspheric, and the fifth lens element with positive or negative refractive power having a convex object-side surface and a concave image-side surface with both being aspheric. Additionally, the image pickup optical lens assembly satisfies conditions related to the reduction of the total length and the sensitivity of the image pickup optical lens assembly for compact cameras and mobile phones with camera functionalities.

(56) **References Cited**

U.S. PATENT DOCUMENTS

7,826,151 B2 11/2010 Tsai
7,864,454 B1 * 1/2011 Tang et al. 359/764

42 Claims, 33 Drawing Sheets



US RE45,765 E

Page 2

(56)

References Cited

U.S. PATENT DOCUMENTS

8,411,376	B2 *	4/2013	Kubota	359/764
8,503,111	B2 *	8/2013	Kwon	359/764
2003/0117722	A1	6/2003	Chen		
2004/0196571	A1	10/2004	Shinohara		
2009/0122423	A1 *	5/2009	Park et al.	359/764
2010/0134904	A1 *	6/2010	Tsai	359/764
2010/0253829	A1	10/2010	Shinohara		
2010/0254029	A1	10/2010	Shinohara		

FOREIGN PATENT DOCUMENTS

JP	2003185917	A	7/2003
JP	2005266771	A	9/2005
JP	2006293042	A	10/2006

JP	2007298572	11/2007
JP	2011085733	4/2011
KR	2010000132	A 1/2010
KR	1020100001525	1/2012
TW	M313246	6/2007
TW	M313781	6/2007
TW	M332199	5/2008
TW	201022714	6/2010
TW	201038966	11/2010

OTHER PUBLICATIONS

English abstract for JP2007298572; published Nov. 15, 2007 and retrieved Mar. 3, 2015.

English abstract for KR1020100001525; published Jan. 17, 2012 and retrieved Mar. 3, 2015.

* cited by examiner

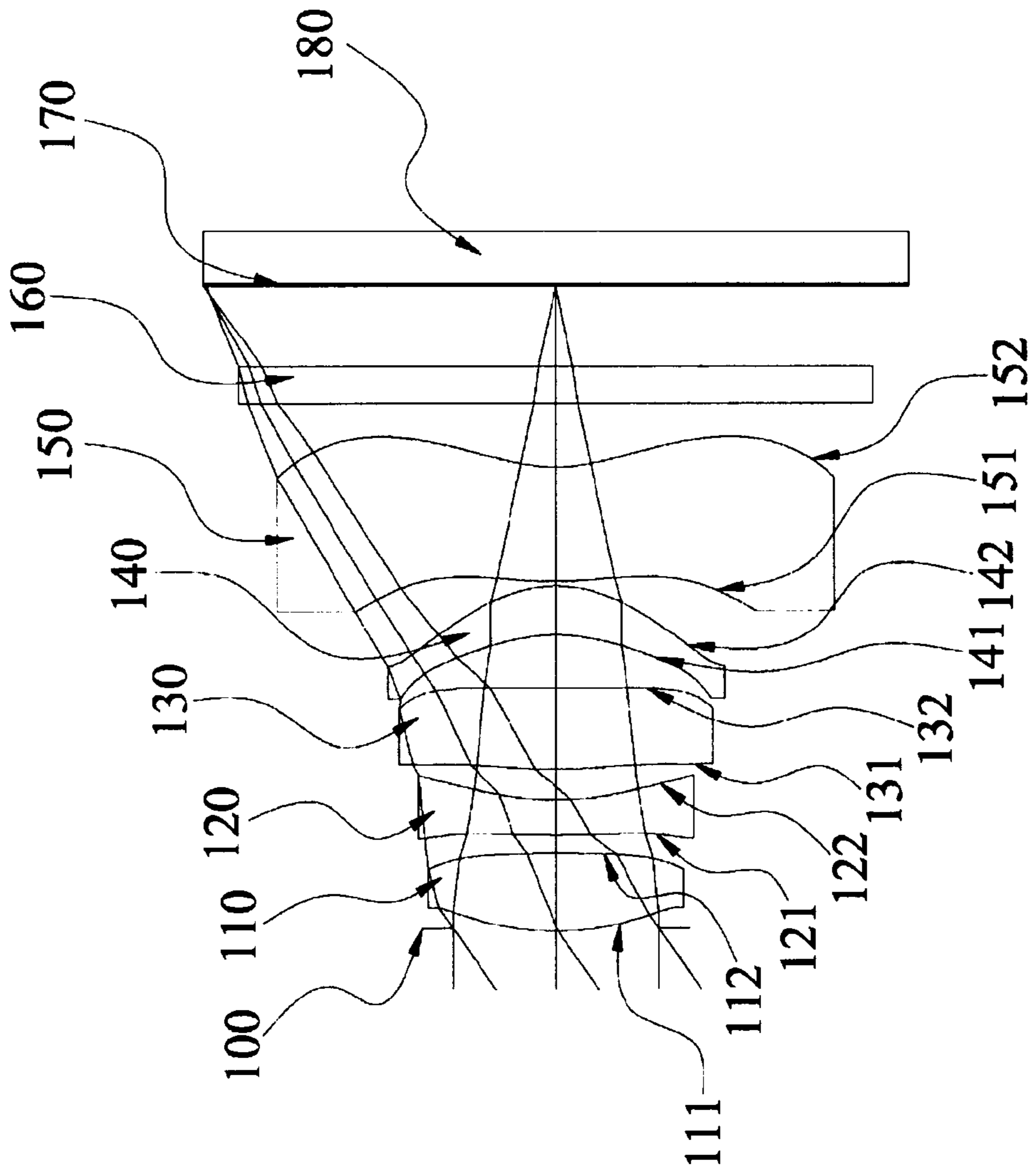


FIG. 1A

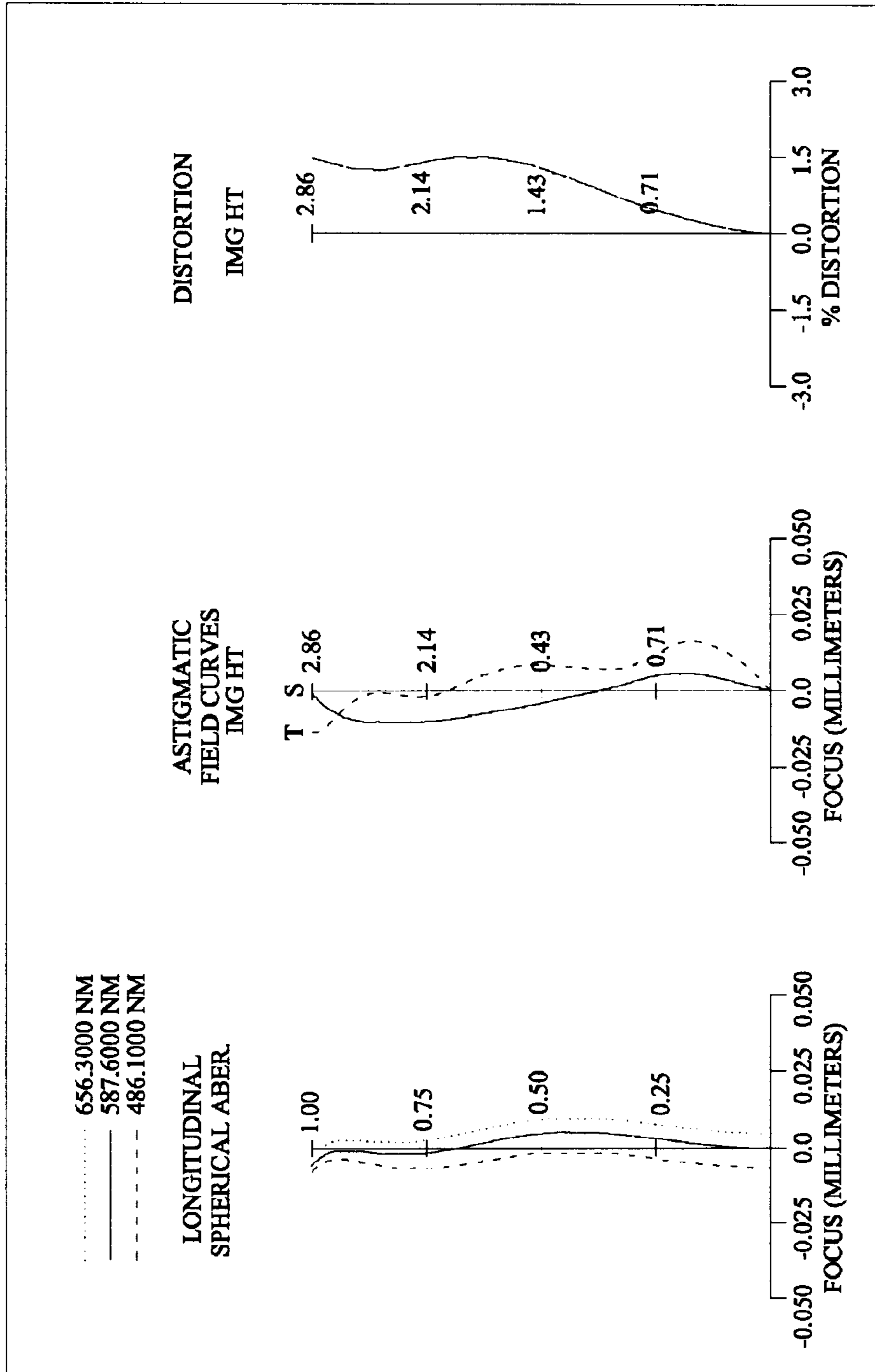


FIG. 1B

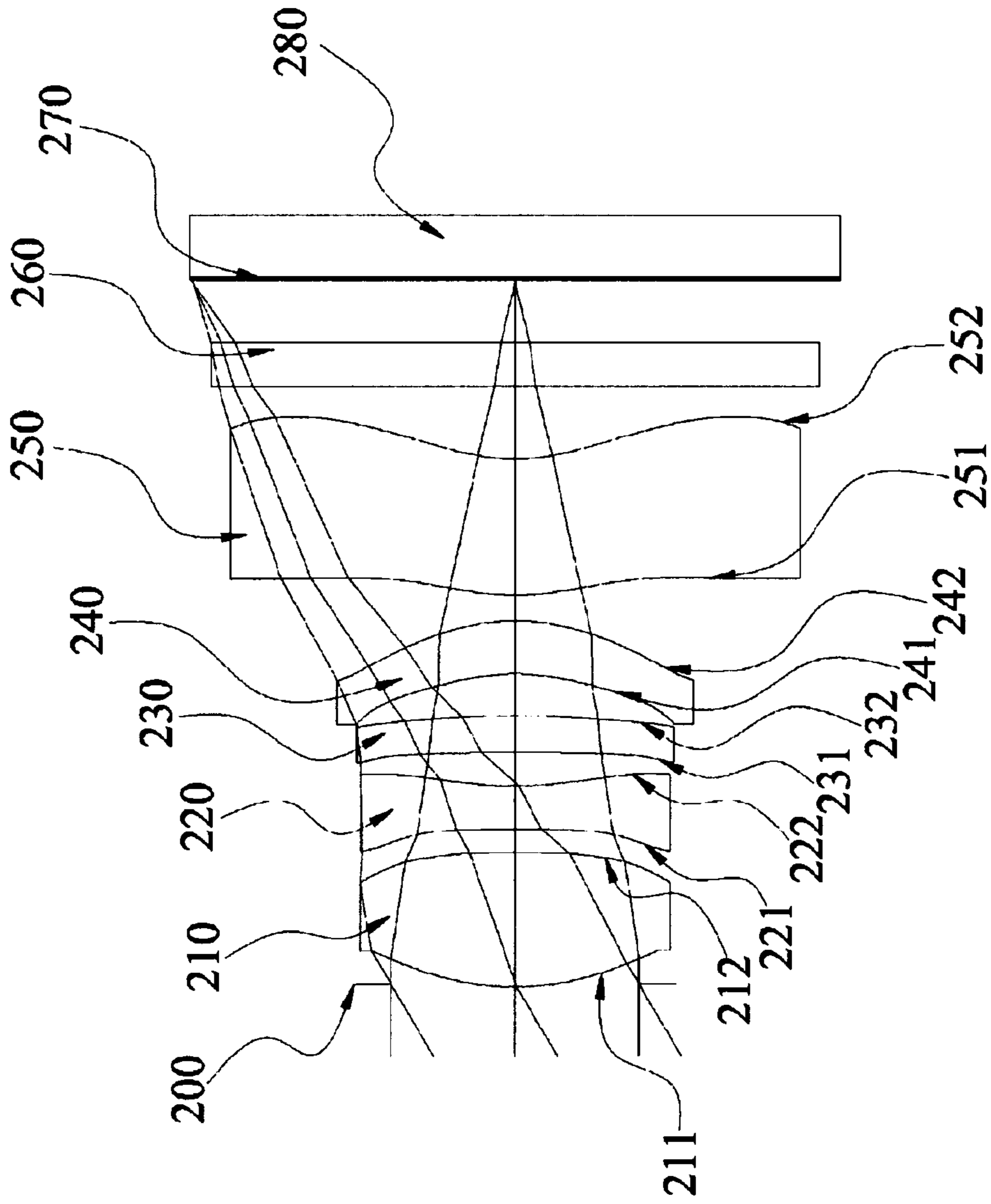


FIG. 2A

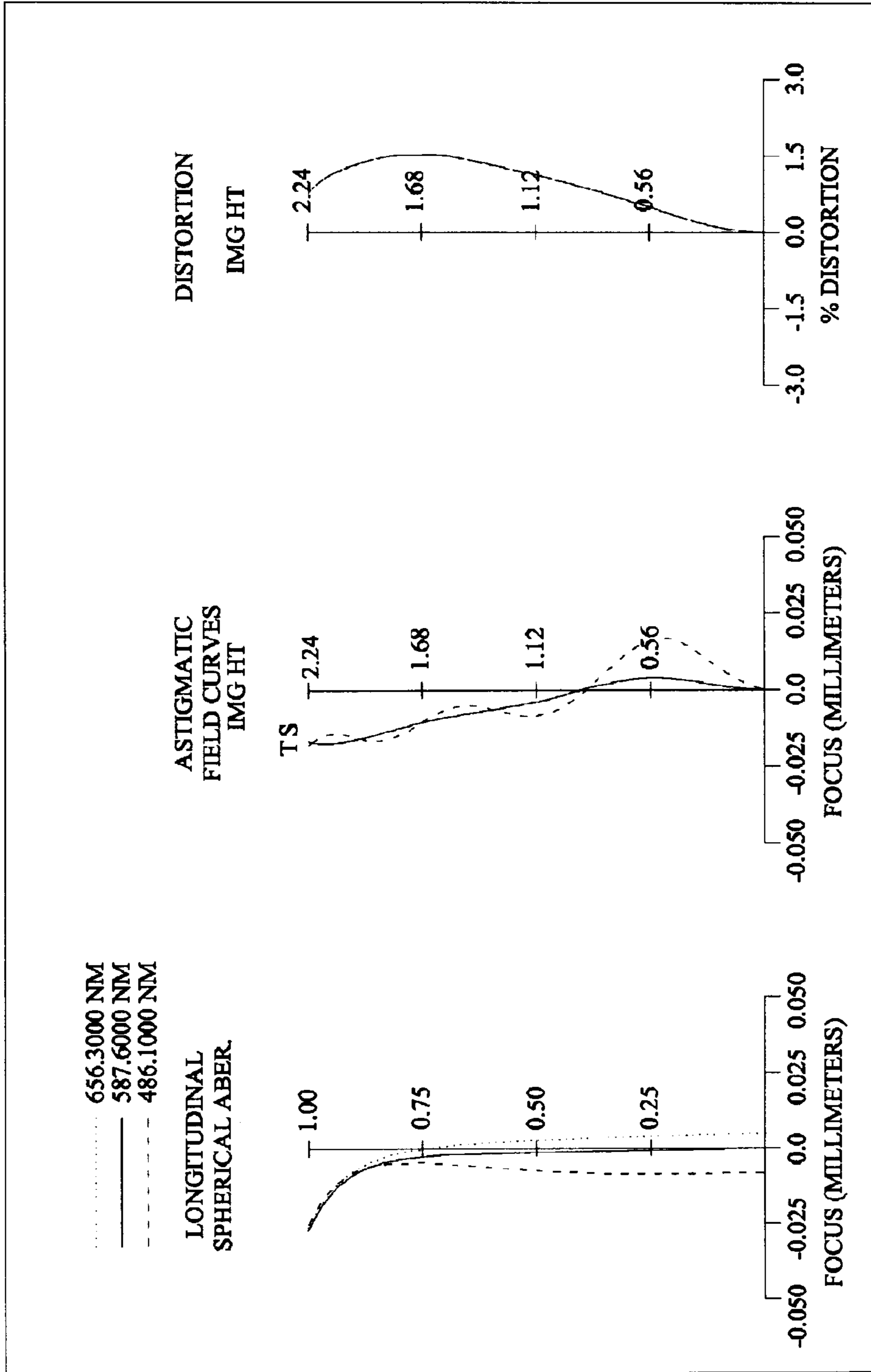


FIG. 2B

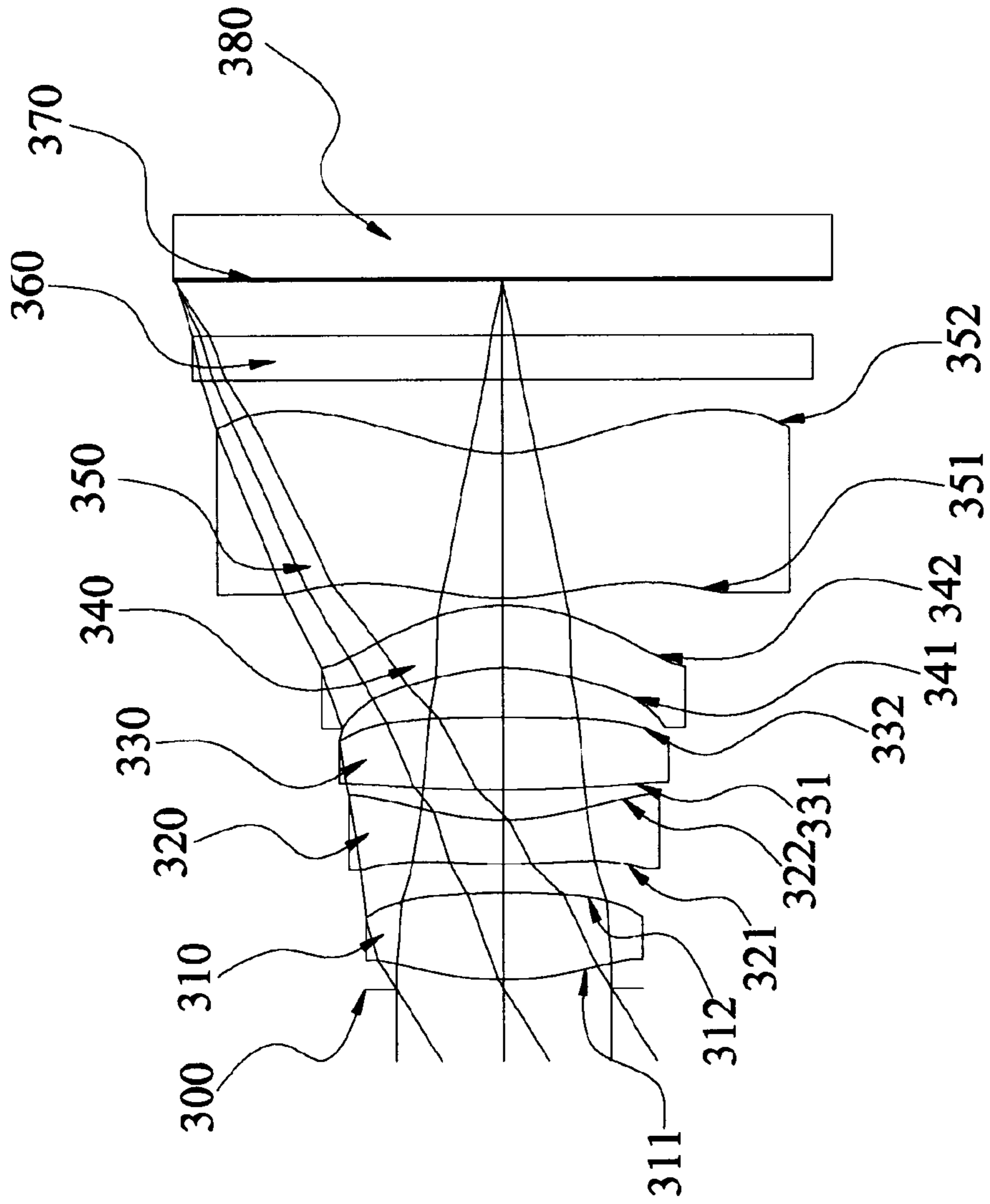


FIG. 3A

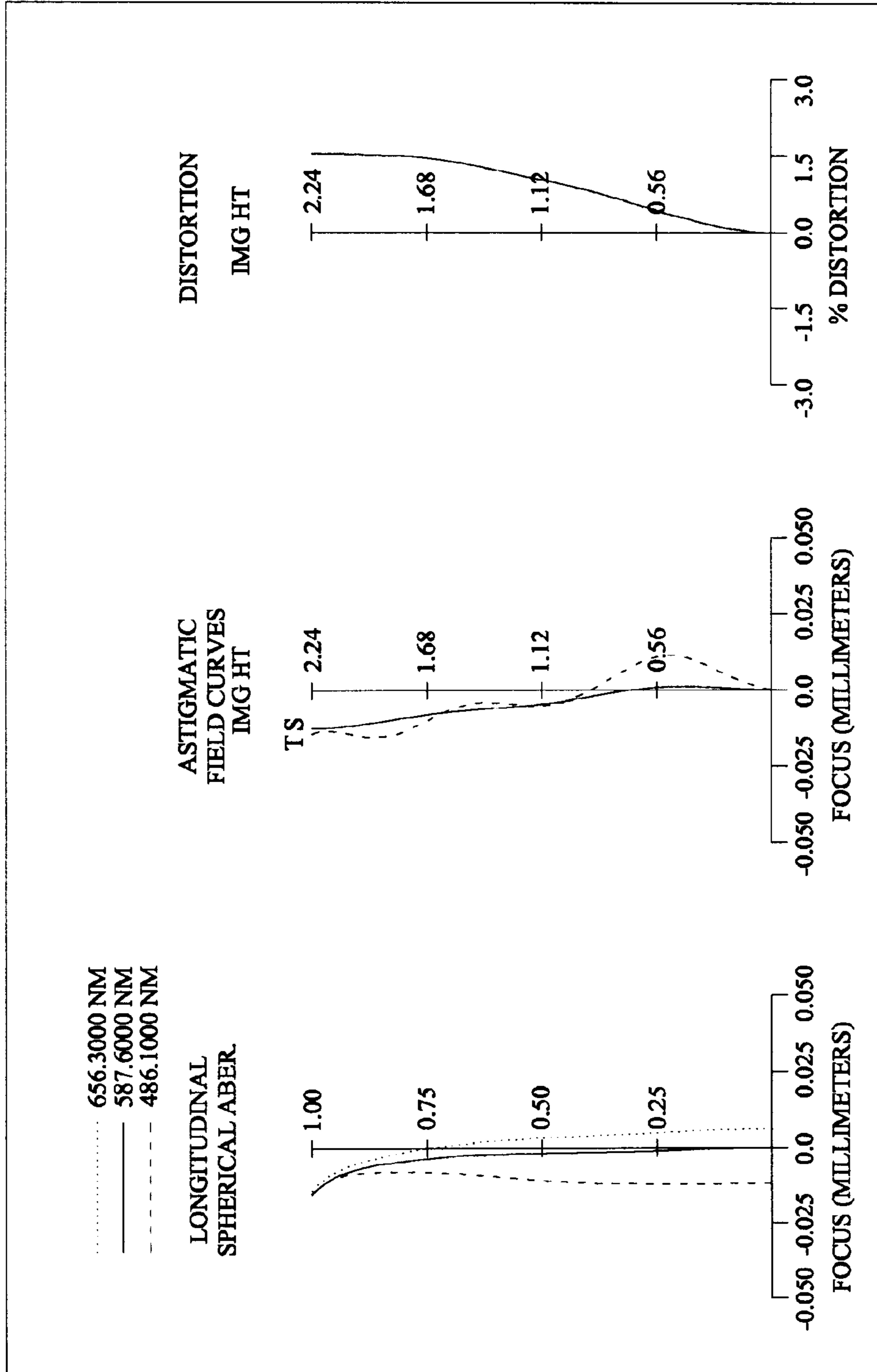


FIG. 3B

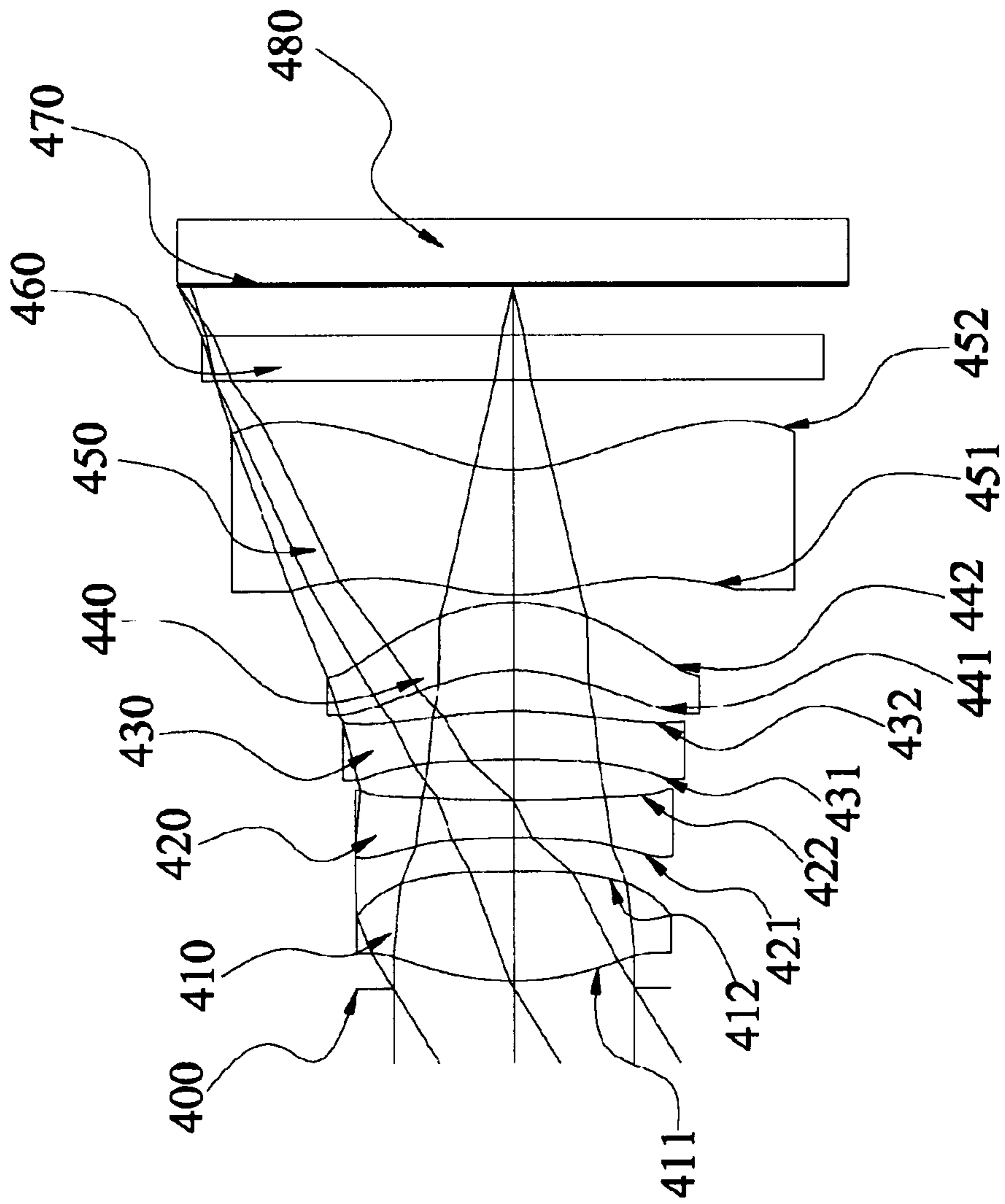


FIG. 4A

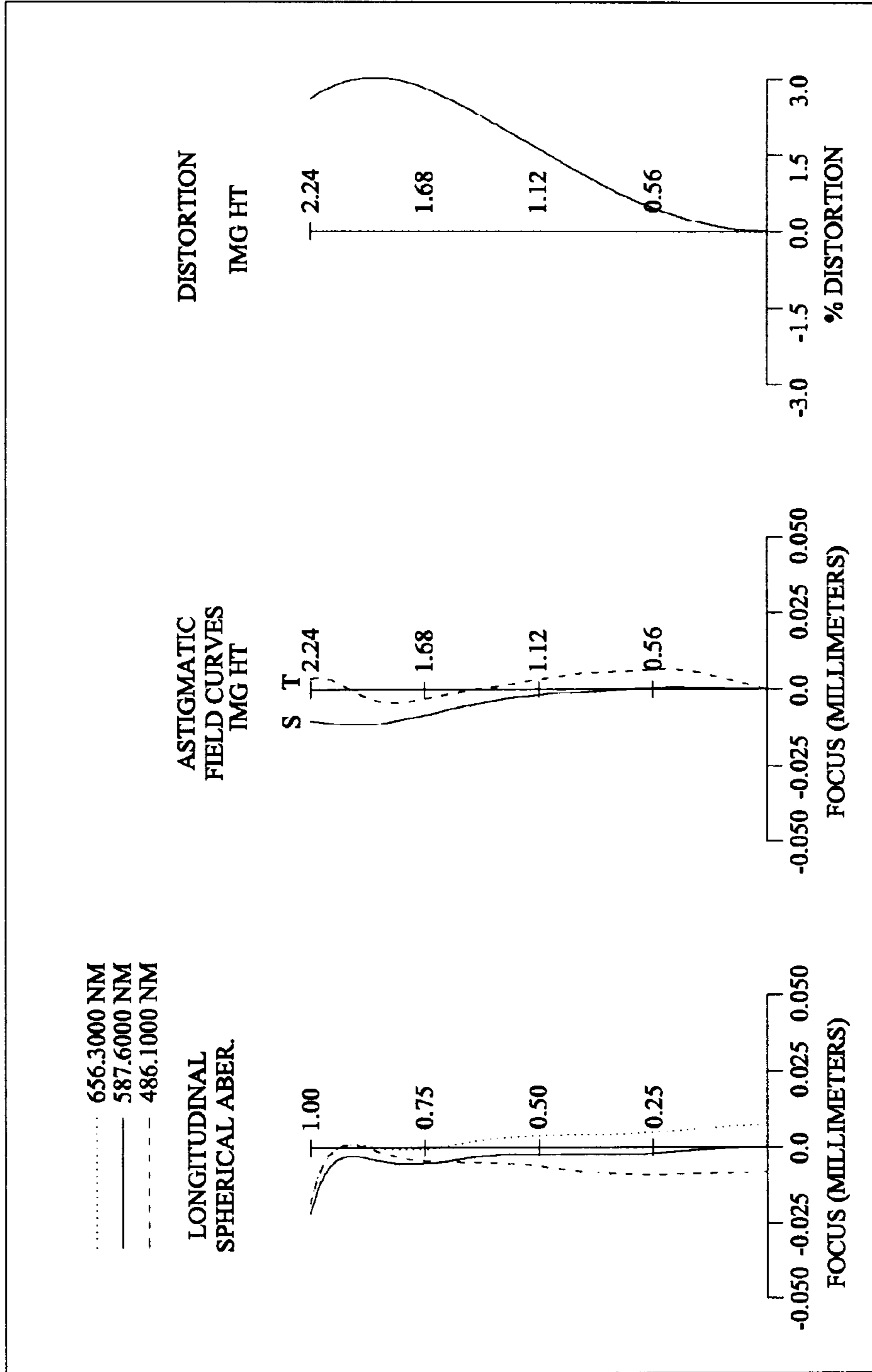


FIG. 4B

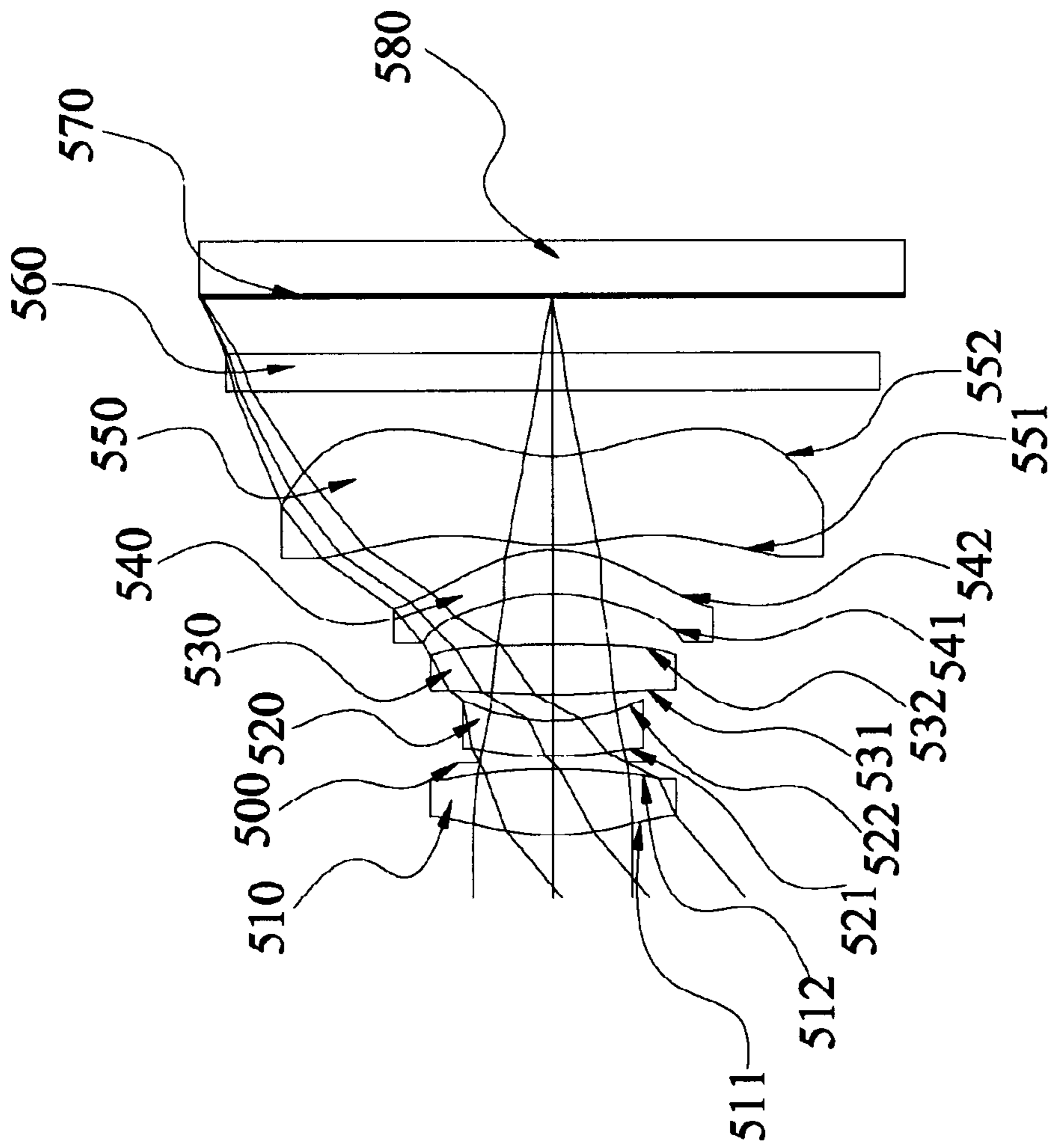


FIG. 5A

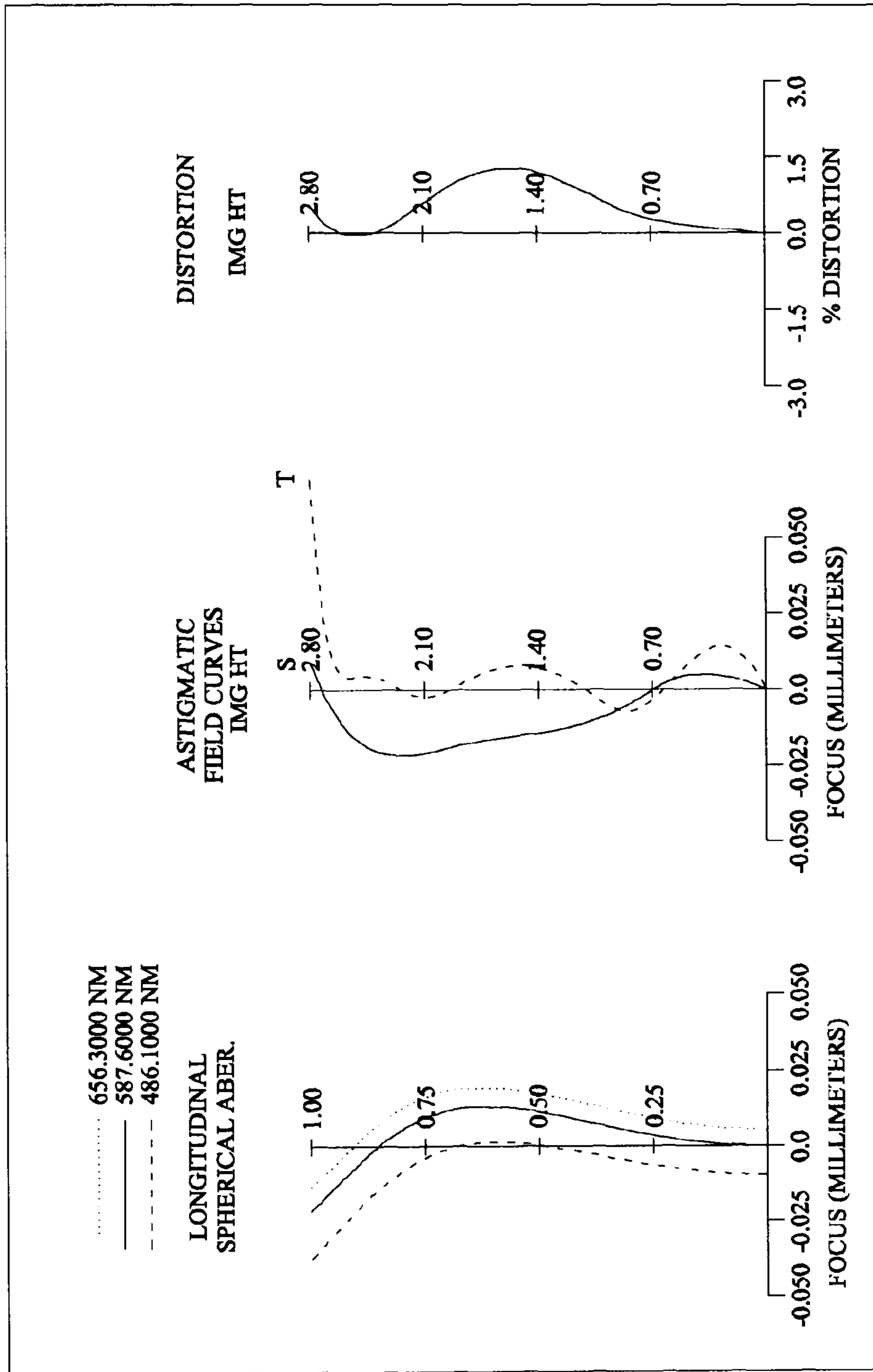


FIG. 5B

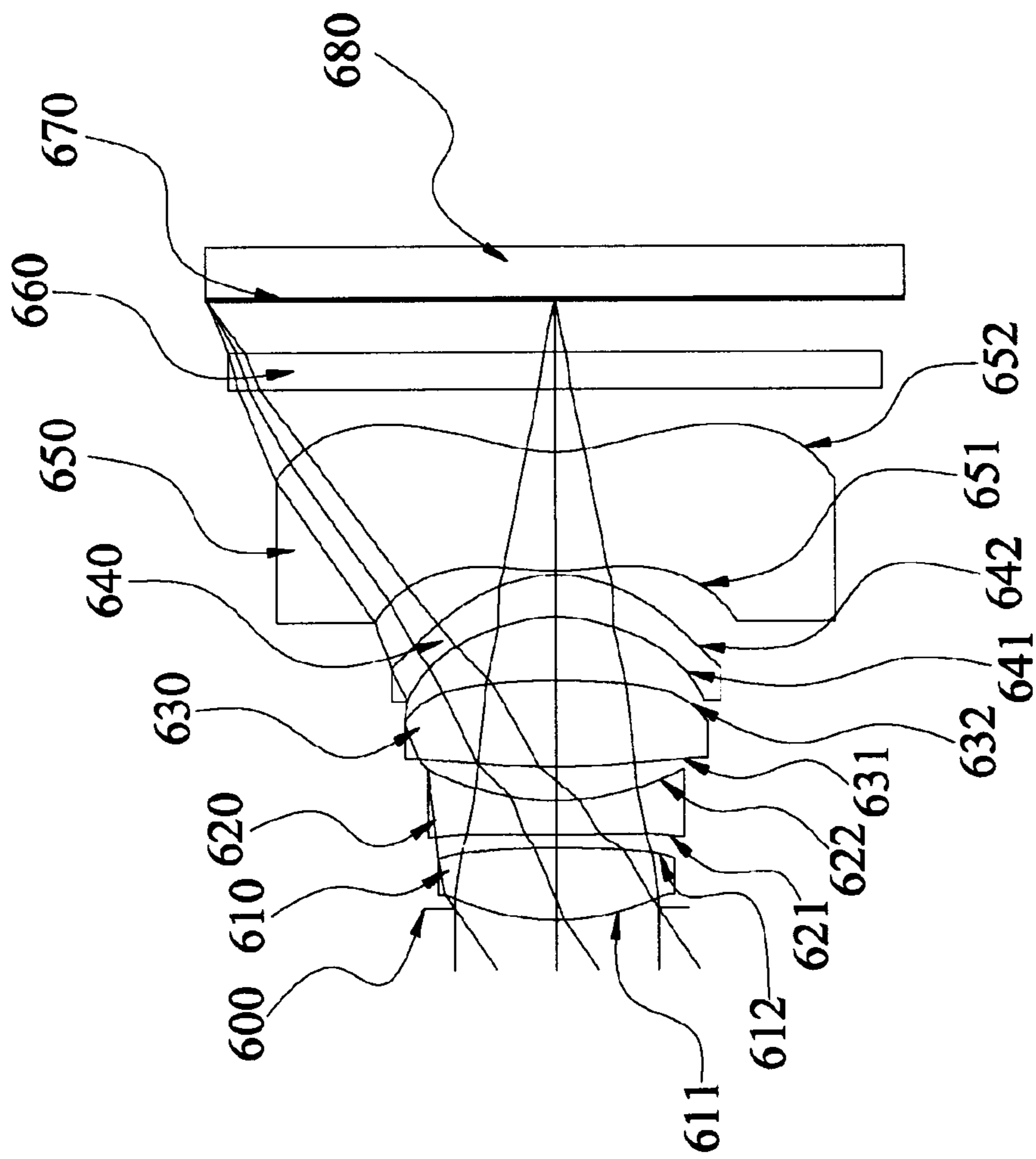


FIG. 6A

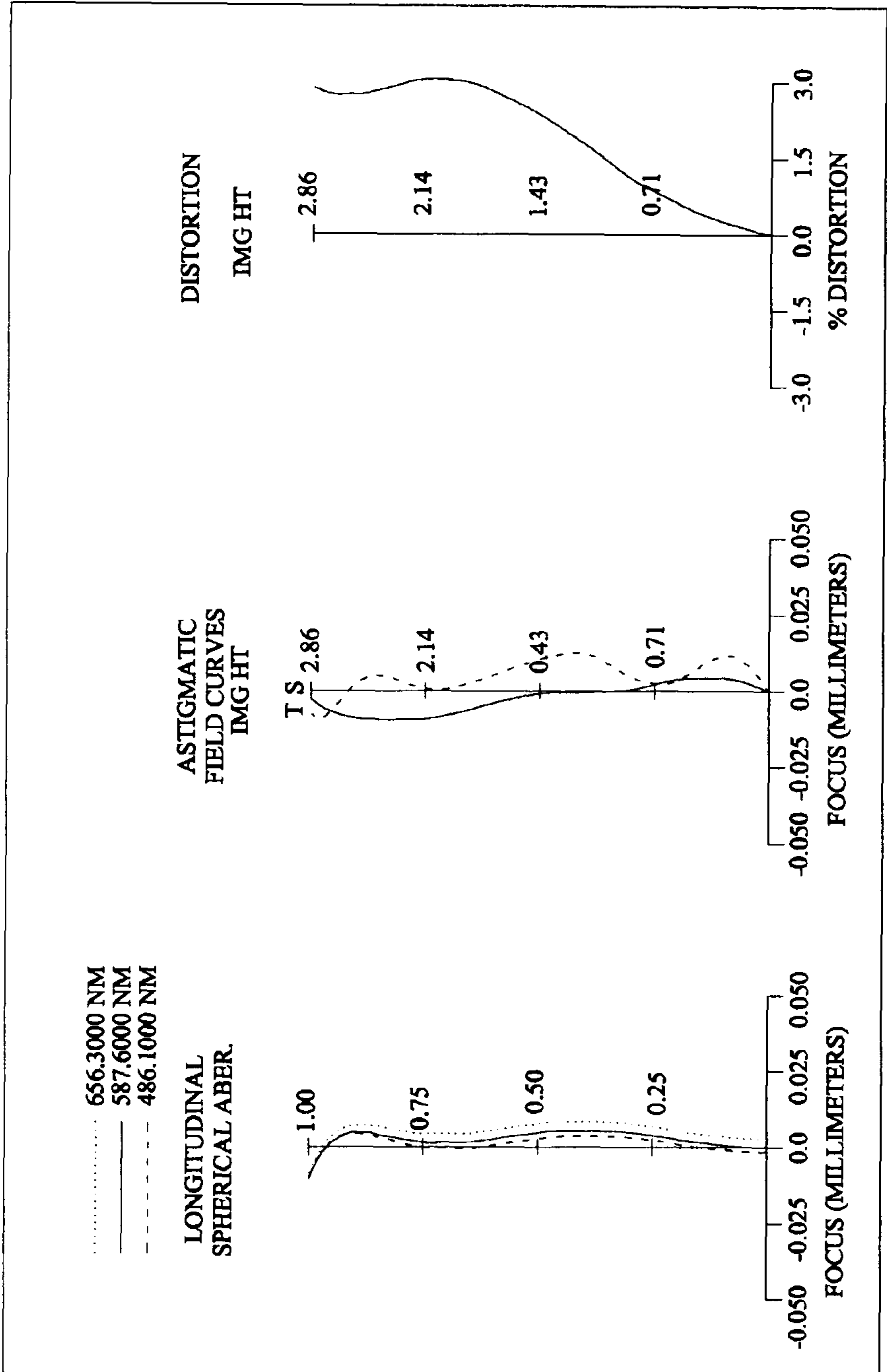


FIG. 6B

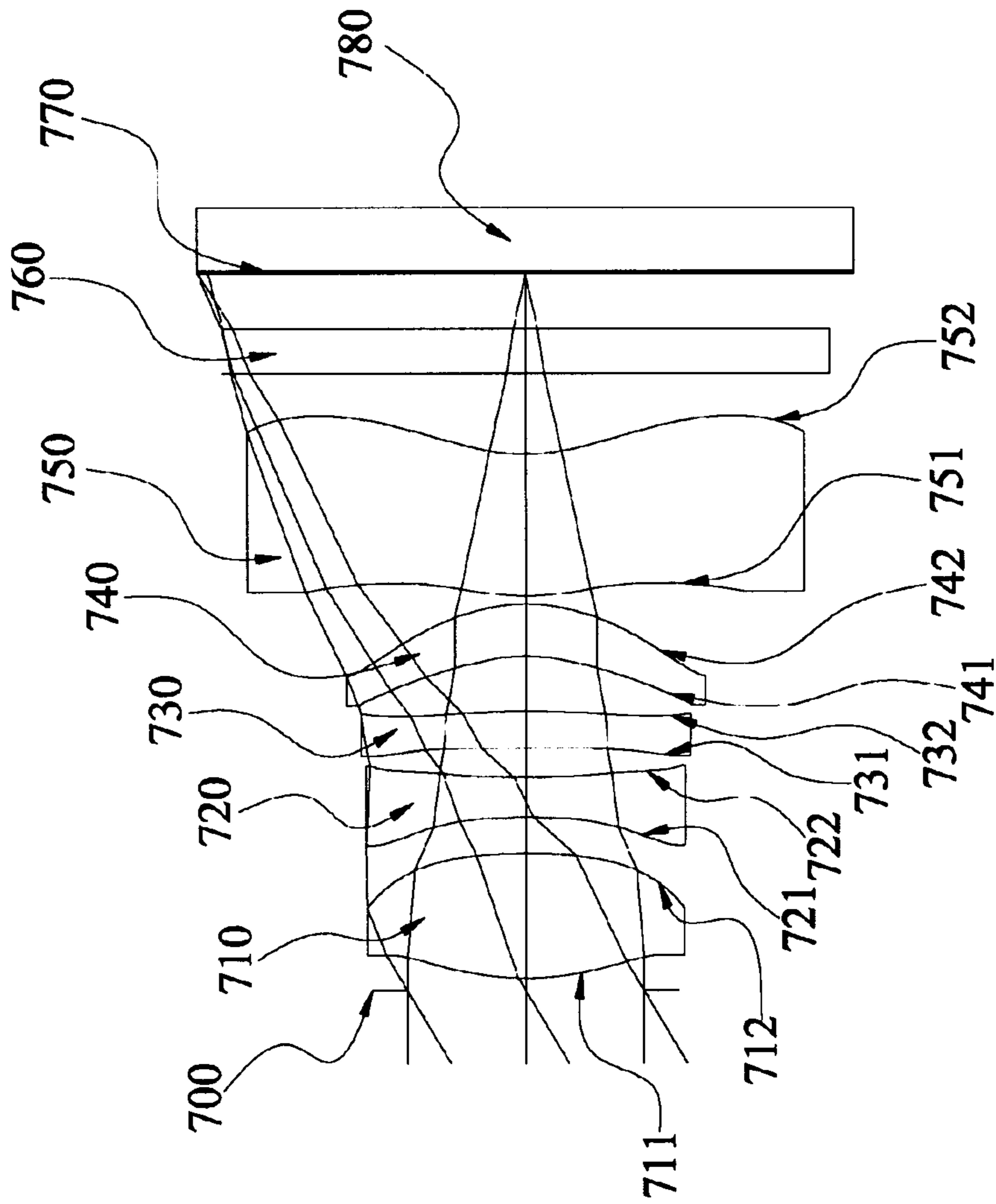


FIG. 7A

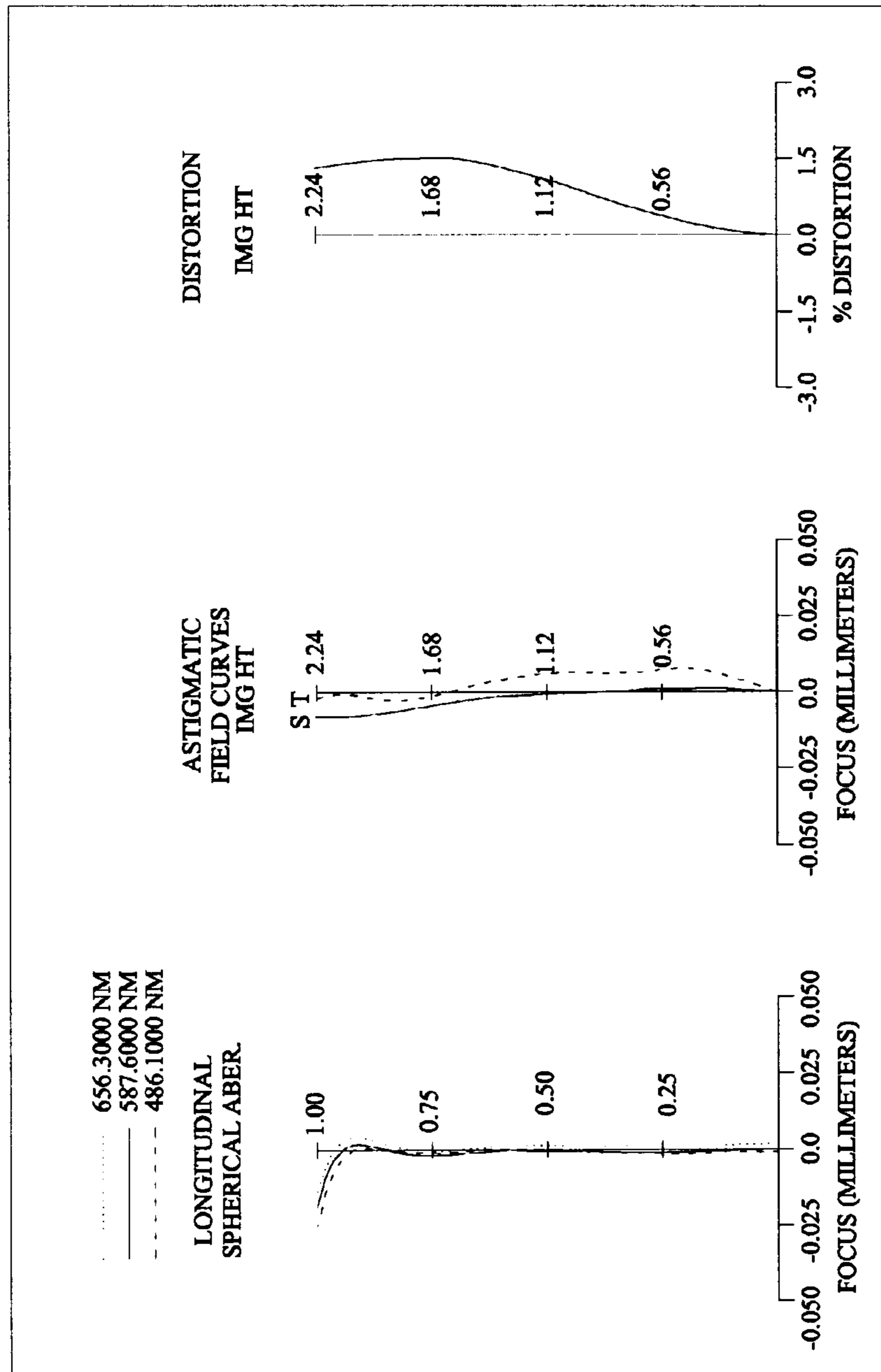


FIG. 7B

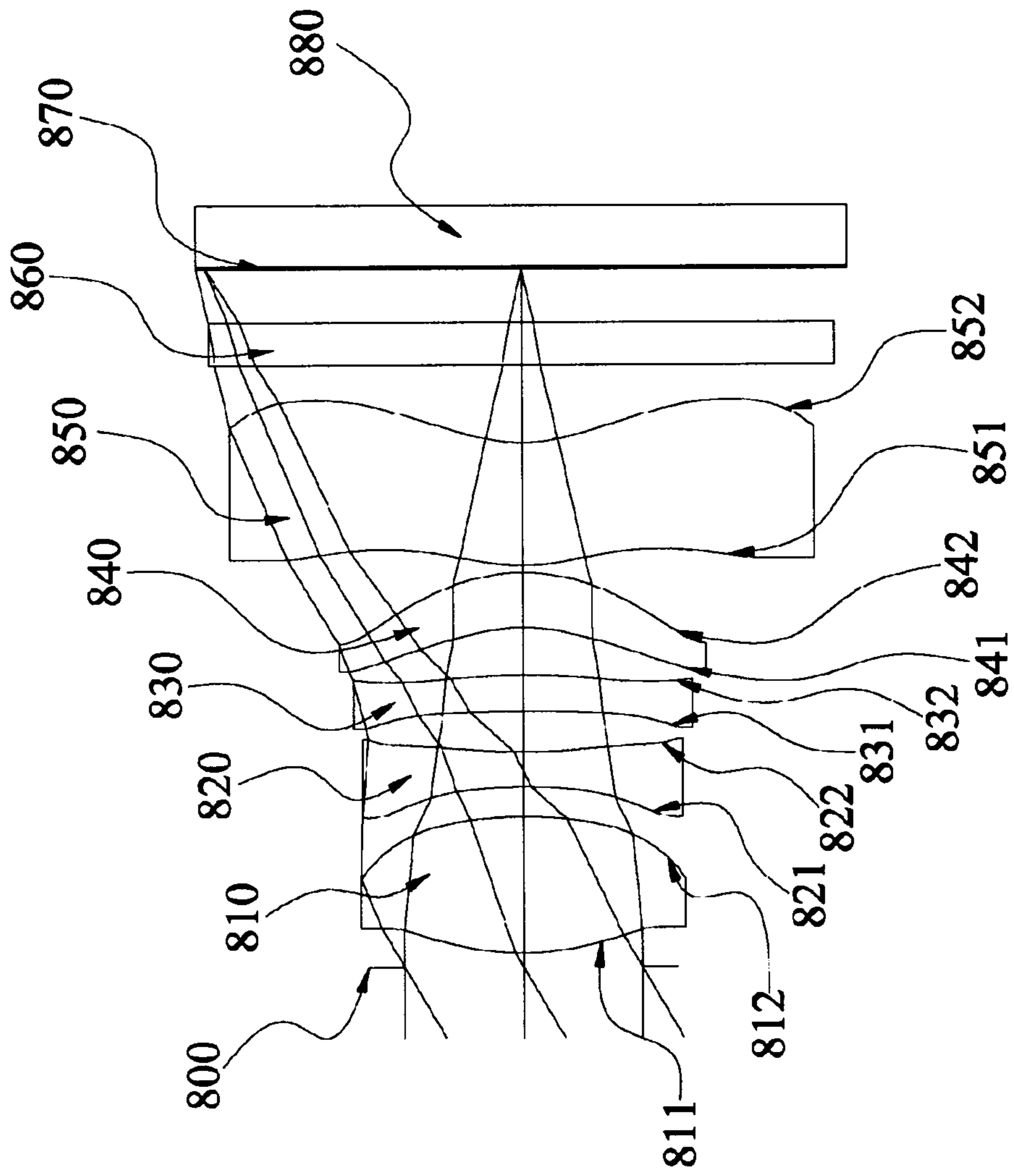


FIG. 8A

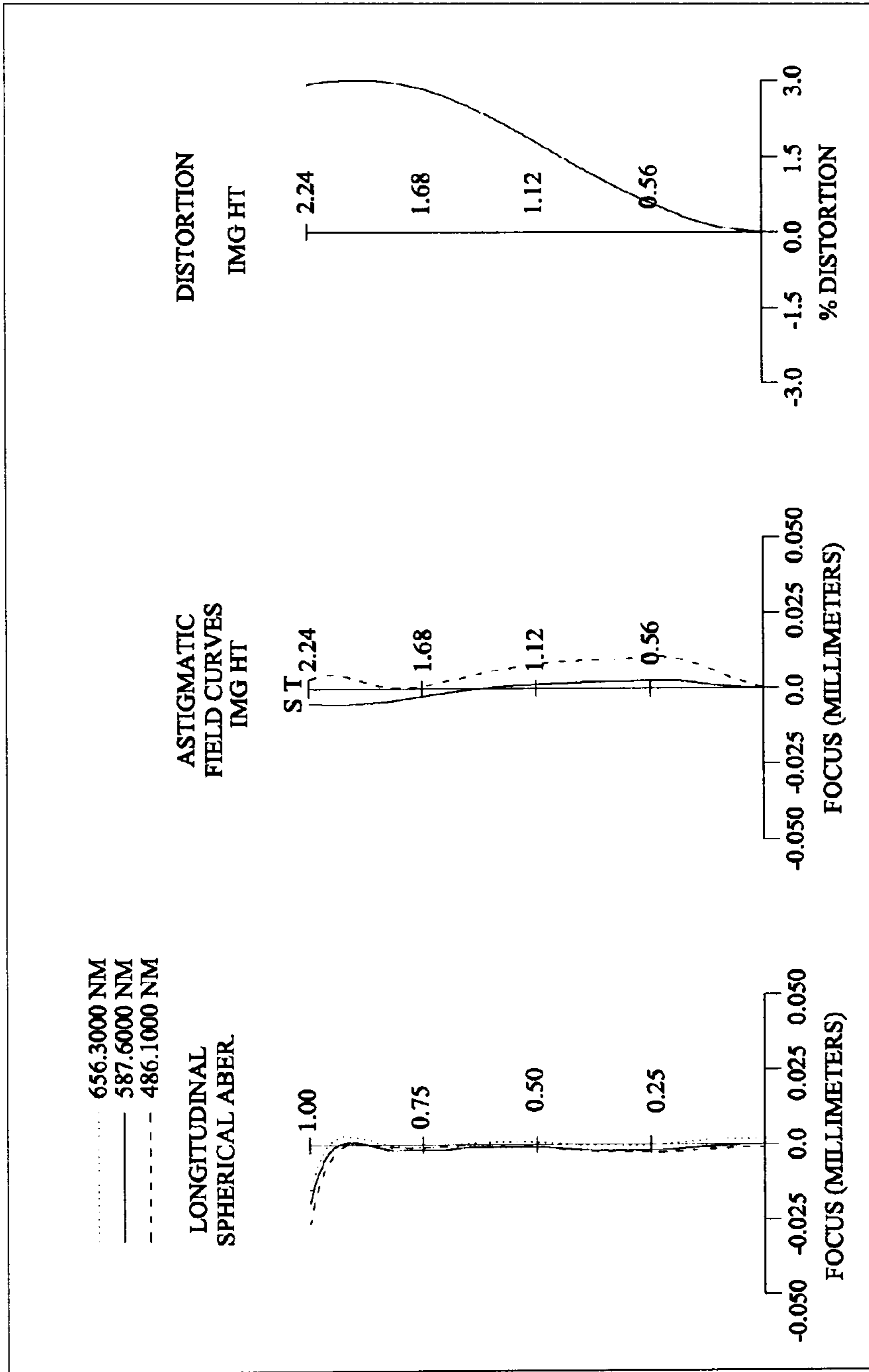


FIG. 8B

TABLE 1

(Embodiment 1)

 $f = 4.01 \text{ mm}$, $Fno = 2.40$, $HFOV = 35.1 \text{ deg.}$

Surface #	Object	Curvature	Radius	Thickness	Material	Index	Abbe #	Focal length
0	Object	Plano		Infinity				
1	Ape. Stop	Plano		-0.023				
2	Lens 1	2.15674 (ASP)		0.630	Plastic	1.544	55.9	3.39
3		-11.48250 (ASP)		0.150				
4	Lens 2	9.71690 (ASP)		0.280	Plastic	1.634	23.8	-4.71
5		2.25818 (ASP)		0.251				
6	Lens 3	4.84800 (ASP)		0.658	Plastic	1.544	55.9	10.32
7		33.71410 (ASP)		0.429				
8	Lens 4	-1.39134 (ASP)		0.399	Plastic	1.544	55.9	5.09
9		-1.01946 (ASP)		0.035				
10	Lens 5	3.01690 (ASP)		0.927	Plastic	1.544	55.9	-5.15
11		1.29504 (ASP)		0.520				
12	IR-filter	Plano		0.300	Glass	1.517	64.2	-
13		Plano		0.657				
14	Image	Plano		-				

Note: Reference wavelength is 587.6 nm. ASP stands for aspherical surfaces.

FIG. 9

TABLE 2
Aspheric Coefficients

Surface #	2	3	4	5	6
k =	-4.98855E-01	0.00000E+00	-1.00000E+00	-3.58034E+00	-1.48333E+01
A4 =	-1.58194E-03	8.80060E-03	-2.75722E-02	-2.82747E-02	-3.80357E-02
A6 =	-1.79464E-02	-1.07032E-01	-8.62949E-02	-2.95624E-02	-3.64878E-02
A8 =	3.30715E-03	5.27576E-02	4.41763E-02	4.69352E-02	1.96039E-02
A10 =	-2.03684E-02	-2.27092E-02	3.77873E-03	-2.83546E-02	3.60903E-03
A12 =				9.16626E-03	

Surface #	7	8	9	10	11
k =	-9.00000E+01	-6.20090E+00	-6.13804E-01	-3.36628E+01	-6.73062E+00
A4 =	-1.24657E-03	5.66559E-04	1.24523E-01	-1.11526E-01	-6.12357E-02
A6 =	-3.62336E-02	-2.63856E-02	-1.01477E-02	3.12663E-02	1.75208E-02
A8 =	5.03574E-03	1.13406E-02	-7.92596E-03	-9.07141E-03	-4.53679E-03
A10 =	-6.23058E-03	-6.25917E-03	1.12580E-02	1.54691E-03	6.27653E-04
A12 =		-4.19157E-03			-3.70128E-05

FIG. 10

TABLE 3

(Embodiment 2)

 $f = 3.77 \text{ mm}$, $Fno = 2.20$, $HFOV = 30.6 \text{ deg.}$

Surface #	Object	Curvature	Radius	Thickness	Material	Index	Abbc #	Focal length
0	Object	Plano		Infinity				
1	Ape. Stop	Plano		-0.020				
2	Lens 1	1.88342 (ASP)		0.930	Plastic	1.543	56.5	2.90
3		-7.91300 (ASP)		0.161				
4	Lens 2	-46.10400 (ASP)		0.300	Plastic	1.632	23.4	-4.29
5		2.89132 (ASP)		0.228				
6	Lens 3	-37.96360 (ASP)		0.258	Plastic	1.544	55.9	12.58
7		-5.81530 (ASP)		0.289				
8	Lens 4	-1.35959 (ASP)		0.364	Plastic	1.583	30.2	68.49
9		-1.44455 (ASP)		0.177				
10	Lens 5	1.70796 (ASP)		0.940	Plastic	1.530	55.8	-137.38
11		1.35067 (ASP)		0.500				
12	IR-filter	Plano		0.300	Glass	1.517	64.2	-
13		Plano		0.438				
14	Image	Plano		-				

Note: Reference wavelength is 587.6 nm. ASP stands for aspherical surfaces.

FIG. 11

TABLE 4
Aspheric Coefficients

Surface #	2	3	4	5	6
k =	8.23715E-02	0.00000E+00	-1.00000E+00	1.24588E-01	9.00000E+01
A4 =	-7.90248E-03	-4.40743E-02	-7.94602E-02	-1.65945E-02	-8.28016E-03
A6 =	-1.51210E-02	-1.43636E-01	-3.27388E-01	-2.47094E-01	-1.30832E-02
A8 =	-9.17877E-04	1.06978E-01	3.70724E-01	2.97271E-01	-1.14479E-02
A10 =	-1.36800E-02	-2.30420E-02	-9.34612E-02	-1.76076E-01	-2.09540E-03
A12 =				4.34405E-02	
Surface #	7	8	9	10	11
k =	-8.12620E+01	-4.96500E+00	-1.27739E-01	-8.15323E+00	-3.78227E+00
A4 =	-1.21740E-03	1.68662E-01	8.29330E-02	-1.22856E-01	-9.58062E-02
A6 =	8.62044E-05	-2.46093E-01	1.93705E-02	3.98932E-02	3.94513E-02
A8 =	3.21730E-04	1.23935E-01	-3.94773E-02	-1.67193E-03	-1.21770E-02
A10 =	-4.24924E-03	-2.23621E-02	2.43317E-02	-7.14556E-04	2.12461E-03
A12 =		-2.03702E-02			-1.62169E-04

FIG. 12

TABLE 5

(Embodiment 3)

 $f = 3.52$ mm, $Fno = 2.40$, $HFOV = 32.1$ deg.

Surface #	Curvature	Radius	Thickness	Material	Index	Abbe #	Focal length
0	Object	Plano	Infinity				
1	Apc. Stop	Plano	0.064				
2	Lens 1	2.20955 (ASP)	0.593	Plastic	1.544	55.9	3.19
3		-7.29880 (ASP)	0.199				
4	Lens 2	5.13600 (ASP)	0.300	Plastic	1.632	23.4	-5.03
5		1.91898 (ASP)	0.200				
6	Lens 3	9.22320 (ASP)	0.496	Plastic	1.544	55.9	10.91
7		-16.33060 (ASP)	0.338				
8	Lens 4	-1.37430 (ASP)	0.429	Plastic	1.530	55.8	15.96
9		-1.31008 (ASP)	0.050				
10	Lens 5	1.77171 (ASP)	0.990	Plastic	1.530	55.8	-24.90
11		1.25968 (ASP)	0.500				
12	IR-filter	Plano	0.300	Glass	1.517	64.2	-
13		Plano	0.383				
14	Image	Plano	-				

Note: Reference wavelength is 587.6 nm. ASP stands for aspherical surfaces.

FIG. 13

TABLE 6
Aspheric Coefficients

Surface #	2	3	4	5	6
k =	-8.52360E-01	0.00000E+00	-1.00000E+00	-2.19914E-01	4.80369E+01
A4 =	-1.01156E-02	-4.35501E-02	-7.35645E-02	-2.16332E-02	-3.56513E-04
A6 =	-4.85899E-02	-1.61319E-01	-2.98047E-01	-2.52919E-01	-2.39295E-03
A8 =	6.69010E-03	1.43170E-01	3.42065E-01	3.02772E-01	-2.13053E-02
A10 =	-4.63864E-02	-7.86642E-02	-1.08696E-01	-1.71146E-01	7.41909E-03
A12 =				3.28167E-02	
Surface #	7	8	9	10	11
k =	8.87499E+01	-6.47211E+00	-1.80746E-01	-8.28311E+00	-3.90265E+00
A4 =	-8.96216E-03	1.18861E-01	1.06044E-01	-1.36301E-01	-9.42095E-02
A6 =	-3.71158E-02	-2.20992E-01	1.83959E-02	4.00567E-02	3.68181E-02
A8 =	-2.81375E-03	1.10111E-01	-3.44444E-02	-2.63140E-03	-1.11522E-02
A10 =	-7.08123E-03	-4.05299E-02	2.61525E-02	-6.12120E-04	1.83469E-03
A12 =		-1.12690E-02			-1.35009E-04

FIG. 14

TABLE 7

(Embodiment 4)

 $f = 3.54 \text{ mm}$, $Fno = 2.20$, $HFOV = 31.7 \text{ deg.}$

Surface #	Curvature	Radius	Thickness	Material	Index	Abbe #	Focal length
0	Object	Plano	Infinity				
1	Apc. Stop	Plano	0.048				
2	Lens 1	1.81873 (ASP)	0.731	Plastic	1.530	55.8	2.76
3		-6.40120 (ASP)	0.224				
4	Lens 2	-6.15910 (ASP)	0.250	Plastic	1.650	21.4	-5.03
5		7.08570 (ASP)	0.272				
6	Lens 3	-7.48490 (ASP)	0.322	Plastic	1.514	56.8	9.49
7		-2.99465 (ASP)	0.272				
8	Lens 4	-1.01488 (ASP)	0.449	Plastic	1.530	55.8	-48.65
9		-1.21837 (ASP)	0.050				
10	Lens 5	1.40083 (ASP)	0.832	Plastic	1.530	55.8	-61.10
11		1.06650 (ASP)	0.600				
12	IR-filter	Plano	0.300	Glass	1.517	64.2	-
13		Plano	0.340				
14	Image	Plano	-				

Note: Reference wavelength is 587.6 nm. ASP stands for aspherical surfaces.

FIG. 15

TABLE 8
Aspheric Coefficients

Surface #	2	3	4	5	6
k =	-2.64334E-01	0.00000E+00	-1.00000E+00	4.14590E+00	4.13470E+01
A4 =	-9.96395E-03	-6.57258E-02	-5.43210E-02	3.53903E-03	-3.61395E-03
A6 =	-5.41647E-02	-1.35447E-01	-2.66473E-01	-2.28158E-01	-2.82055E-02
A8 =	5.45255E-02	8.81040E-02	3.63277E-01	3.17420E-01	-5.70074E-02
A10 =	-1.05745E-01	-4.73987E-02	-9.20171E-02	-1.60311E-01	5.64489E-02
A12 =				5.47620E-02	
Surface #	7	8	9	10	11
k =	-2.54895E+01	-6.83268E+00	-2.52431E-01	-8.32953E+00	-4.17332E+00
A4 =	7.81806E-03	4.57119E-02	9.54444E-02	-1.63990E-01	-9.15475E-02
A6 =	1.21156E-02	-1.26801E-01	-4.51877E-03	5.91247E-02	3.57689E-02
A8 =	3.18663E-02	1.26565E-01	-1.41436E-02	-8.46981E-03	-1.03157E-02
A10 =	-1.77047E-02	-3.14819E-02	2.65722E-02	8.84379E-05	1.58950E-03
A12 =		-1.10459E-03			-1.16459E-04

FIG. 16

TABLE 9
(Embodiment 5)

$f = 3.30 \text{ mm}$, $Fno = 2.60$, $HFOV = 40.2 \text{ deg.}$

Surface #	Object	Curvature	Radius	Thickness	Material	Index	Abbe #	Focal length
0	Object	Plano		Infinity				
1	Lens 1	2.10618 (ASP)		0.520	Plastic	1.544	55.9	2.78
2		-4.89900 (ASP)		0.050				
3	Ape. Stop	Plano		0.050				
4	Lens 2	3.56460 (ASP)		0.280	Plastic	1.634	23.8	-4.21
5		1.47993 (ASP)		0.210				
6	Lens 3	5.96510 (ASP)		0.397	Plastic	1.544	55.9	8.62
7		-21.41320 (ASP)		0.407				
8	Lens 4	-1.14085 (ASP)		0.345	Plastic	1.544	55.9	11.39
9		-1.06614 (ASP)		0.038				
10	Lens 5	1.59006 (ASP)		0.706	Plastic	1.544	55.9	-12.13
11		1.08087 (ASP)		0.520				
12	IR-filter	Plano		0.300	Glass	1.517	64.2	-
13		Plano		0.449				
14	Image	Plano		-				

Note: Reference wavelength is 587.6 nm. ASP stands for aspherical surfaces.

FIG. 17

TABLE 10
Aspheric Coefficients

Surface #	1	2	4	5	6
k =	-1.76388E+00	0.00000E+00	-1.00000E+00	-3.44800E+00	-4.12527E+01
A4 =	-2.03767E-02	3.07206E-02	3.06306E-03	1.04470E-02	-3.68235E-02
A6 =	-4.48760E-02	-5.62800E-02	1.00511E-01	1.44426E-01	-2.94992E-02
A8 =	1.50421E-02	-1.85544E-02	8.86414E-04	-3.17017E-02	1.32542E-01
A10 =	-2.81783E-02	1.16922E-02	-1.46352E-01	-1.31366E-01	-6.35919E-02
A12 =				5.72204E-02	

Surface #	7	8	9	10	11
k =	-7.99320E+01	-9.56572E+00	-5.54905E-01	-1.82719E+01	-7.16634E+00
A4 =	6.72215E-03	-3.47275E-02	1.58402E-01	-1.56647E-01	-8.31298E-02
A6 =	-9.64769E-02	-3.52672E-03	7.31393E-03	2.39218E-02	2.39218E-02
A8 =	2.06512E-03	-1.70155E-02	4.77308E-03	6.48211E-02	-6.44900E-03
A10 =	2.01998E-02	-1.84517E-02	-4.63070E-05	-1.18069E-02	8.59340E-04
A12 =		-3.13137E-02		8.31841E-04	-5.65007E-05

FIG. 18

TABLE 11

(Embodiment 6)

$f = 3.99$ mm, $Fno = 2.40$, $HFOV = 34.8$ deg.

Surface #	Object	Curvature	Radius	Thickness	Material	Indcx	Abbc #	Focal length
0	Object	Plano		Infinity				
1	Ape. Stop	Plano		-0.096				
2	Lens 1	1.94480 (ASP)		0.588	Plastic	1.544	55.9	2.90
3		-7.40970 (ASP)		0.109				
4	Lens 2	16.19880 (ASP)		0.280	Plastic	1.614	25.6	-3.64
5		1.95165 (ASP)		0.274				
6	Lens 3	5.49730 (ASP)		0.710	Plastic	1.544	55.9	5.48
7		-6.22580 (ASP)		0.522				
8	Lens 4	-1.06612 (ASP)		0.339	Plastic	1.544	55.9	-151.74
9		-1.20109 (ASP)		0.035				
10	Lens 5	2.13280 (ASP)		0.974	Plastic	1.544	55.9	-13.05
11		1.37623 (ASP)		0.520				
12	IR-filter	Plano		0.300	Glass	1.517	64.2	-
13		Plano		0.434				
14	Image	Plano		-				

Note: Reference wavelength is 587.6 nm. ASP stands for aspherical surfaces.

FIG. 19

TABLE 12
Aspheric Coefficients

Surface #	2	3	4	5	6
k =	-3.34068E-01	0.00000E+00	-1.00000E+00	-3.86421E+00	3.41489E+00
A4 =	-9.18367E-04	5.10772E-02	-1.58527E-02	-1.27311E-02	-2.11773E-02
A6 =	6.06687E-03	-9.08819E-02	-5.25344E-02	-4.51053E-03	-3.62534E-02
A8 =	-2.75510E-02	7.75231E-03	2.06750E-02	6.03643E-02	1.79264E-02
A10 =	-2.11214E-03	-1.67692E-03	-9.86336E-04	-4.09728E-02	4.13207E-03
A12 =				9.88915E-03	

Surface #	7	8	9	10	11
k =	-7.38496E+00	-7.67211E+00	-4.38692E-01	-2.95625E+01	-6.36208E+00
A4 =	7.76275E-03	-7.92502E-02	4.19930E-02	-2.24942E-01	-7.53979E-02
A6 =	-5.78875E-02	-3.39906E-02	-9.67999E-03	8.25289E-02	2.41820E-02
A8 =	9.35002E-03	4.51575E-03	-1.99071E-03	-1.26027E-02	-5.79338E-03
A10 =	-1.00534E-02	-7.56234E-03	8.59382E-03	-2.36457E-03	6.94264E-04
A12 =		-3.11265E-03			-3.74341E-05

FIG. 20

TABLE 13

(Embodiment 7)

$f = 3.70 \text{ mm}$, $Fno = 2.30$, $HFOV = 30.8 \text{ deg.}$

Surface #	Object	Curvature	Radius	Thickness	Material	Index	Abbe #	Focal length
0	Object	Plano		Infinity				
1	Ape. Stop	Plano		0.087				
2	Lens 1	2.00270 (ASP)		0.851	Plastic	1.543	56.5	2.52
3		-3.66050 (ASP)		0.247				
4	Lens 2	-3.78140 (ASP)		0.267	Plastic	1.632	23.4	-3.31
5		4.81860 (ASP)		0.200				
6	Lens 3	-31.05770 (ASP)		0.252	Plastic	1.544	55.9	12.38
7		-5.55180 (ASP)		0.372				
8	Lens 4	-1.15037 (ASP)		0.353	Plastic	1.583	30.2	172.26
9		-1.26594 (ASP)		0.056				
10	Lens 5	1.55897 (ASP)		0.963	Plastic	1.530	55.8	138.56
11		1.25198 (ASP)		0.550				
12	IR-filter	Plano		0.300	Glass	1.517	64.2	-
13		Plano		0.388				
14	Image	Plano		-				

Note: Reference wavelength is 587.6 nm. ASP stands for aspherical surfaces.

FIG. 21

TABLE 14
Aspheric Coefficients

Surface #	2	3	4	5	6
k =	-4.95401E-01	0.00000E+00	-1.00000E+00	4.74087E+00	9.00000E+01
A4 =	-1.56720E-02	-6.80760E-02	-5.59264E-02	2.78914E-03	-1.07943E-02
A6 =	-5.09157E-02	-1.20768E-01	-2.71153E-01	-2.45572E-01	-1.96677E-02
A8 =	3.72929E-02	8.61226E-02	3.73421E-01	2.94077E-01	-6.54713E-02
A10 =	-8.75570E-02	-3.97405E-02	-1.02264E-01	-1.64971E-01	5.98295E-02
A12 =				6.38744E-02	
Surface #	7	8	9	10	11
k =	-9.00000E+01	-8.61072E+00	-1.94153E-01	-1.19762E+01	-4.90446E+00
A4 =	3.21256E-03	2.89576E-02	8.55204E-02	-1.58700E-01	-8.55416E-02
A6 =	9.17955E-03	-1.31972E-01	-9.02842E-03	6.53807E-02	3.16563E-02
A8 =	3.66951E-02	1.09969E-01	-1.01609E-02	-9.57441E-03	-9.56889E-03
A10 =	-1.94597E-02	-3.18846E-02	2.53182E-02	5.16227E-05	1.59991E-03
A12 =		7.66129E-04			-1.22329E-04

FIG. 22

TABLE 15

(Embodiment 8)

$f = 3.69 \text{ mm}$, $F_{no} = 2.20$, $HFOV = 30.6 \text{ deg.}$

Surface #	Curvature	Radius	Thickness	Material	Index	Abbe #	Focal length
0	Object	Plano	Infinity				
1	Ape. Stop	Plano	0.099				
2	Lens 1	1.99392 (ASP)	0.957	Plastic	1.543	56.5	2.50
3		-3.52690 (ASP)	0.214				
4	Lens 2	-3.97180 (ASP)	0.250	Plastic	1.632	23.4	-3.38
5		4.72590 (ASP)	0.287				
6	Lens 3	-11.61070 (ASP)	0.255	Plastic	1.514	56.8	12.33
7		-4.12800 (ASP)	0.333				
8	Lens 4	-1.14764 (ASP)	0.388	Plastic	1.583	30.2	-104.41
9		-1.31538 (ASP)	0.050				
10	Lens 5	1.37738 (ASP)	0.864	Plastic	1.530	55.8	47.92
11		1.13993 (ASP)	0.550				
12	IR-filter	Plano	0.300	Glass	1.517	64.2	-
13		Plano	0.386				
14	Image	Plano	-				

Note: Reference wavelength is 587.6 nm. ASP stands for aspherical surfaces.

FIG. 23

TABLE 16
Aspheric Coefficients

Surface #	2	3	4	5	6
k =	-2.71791E-01	0.00000E+00	-1.00000E+00	3.89171E+00	4.74273E+01
A4 =	-1.14930E-02	-5.82352E-02	-6.13713E-02	-1.63721E-03	-3.12197E-03
A6 =	-4.46382E-02	-1.23552E-01	-2.83986E-01	-2.32188E-01	-6.90064E-03
A8 =	4.31071E-02	9.31718E-02	3.65839E-01	2.91359E-01	-7.26592E-02
A10 =	-7.17053E-02	-3.56157E-02	-9.86008E-02	-1.67469E-01	4.36963E-02
A12 =				5.83842E-02	

Surface #	7	8	9	10	11
k =	-5.86532E+01	-9.29685E+00	-1.80972E-01	-9.34017E+00	-4.27225E+00
A4 =	-1.53704E-03	3.10479E-02	7.43292E-02	-1.53082E-01	-8.97132E-02
A6 =	1.37771E-02	-1.25336E-01	-6.31769E-03	5.66145E-02	3.41426E-02
A8 =	3.93514E-02	1.16997E-01	-8.95230E-03	-7.19206E-03	-1.01143E-02
A10 =	-2.23357E-02	-3.17209E-02	1.98923E-02	1.30553E-05	1.64278E-03
A12 =		3.77373E-04			-1.20823E-04

FIG. 24

TABLE 17

	Embodiment 1	Embodiment 2	Embodiment 3	Embodiment 4	Embodiment 5	Embodiment 6	Embodiment 7	Embodiment 8
f	4.01	3.77	3.52	3.54	3.30	3.99	3.70	3.69
Fno	2.40	2.20	2.40	2.20	2.60	2.40	2.30	2.20
HFOV	35.1	30.6	32.1	31.7	40.2	34.8	30.8	30.6
V1-V2	32.1	33.1	32.5	34.4	32.1	30.3	33.1	33.1
T12/T23	0.60	0.71	1.00	0.82	0.48	0.40	1.24	0.75
CT4/CT5	0.43	0.39	0.43	0.54	0.49	0.35	0.37	0.45
(R1+R2)/(R1-R2)	-0.68	-0.62	-0.54	-0.56	-0.40	-0.58	-0.29	-0.28
f/f1	1.18	1.30	1.11	1.28	1.19	1.38	1.47	1.48
f/f4+ f/f5	1.57	0.08	0.36	0.13	0.56	0.33	0.05	0.11
(CT4+T45)/CT5	0.47	0.58	0.48	0.60	0.54	0.38	0.42	0.51
Sd/Td	0.99	0.99	1.02	1.01	0.81	0.97	1.02	1.03
TTL/lmgH	1.80	2.14	2.09	2.03	1.49	1.75	2.10	2.11

FIG. 25

IMAGE PICKUP OPTICAL LENS ASSEMBLY

Matter enclosed in heavy brackets [] appears in the original patent but forms no part of this reissue specification; matter printed in italics indicates the additions made by reissue; a claim printed with strikethrough indicates that the claim was canceled, disclaimed, or held invalid by a prior post-patent action or proceeding.

This application is a reissue application of U.S. Pat. No. 8,179,615 B1.

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates to an image pickup optical lens assembly, and more particularly to an image pickup optical lens assembly comprised of five lens elements and applied to an electronic product, and the optical lens assembly has the features of a short total length and a low cost.

2. Description of the Related Art

As science and technology advance, the development of present electronic products such as digital still cameras, web cameras, mobile phone cameras tends to have a compact design. In addition, users not only require an optical lens assembly with compact design and low cost only, but also need an optical lens assembly with the features of good image correction capability, high resolution, and high quality of images.

In general, a conventional optical lens assembly of a mini electronic product comes with different designs including the two-lens, three-lens, four-lens, and five-lens design. However, if the image quality taken into consideration, the optical lens assemblies with the four-lens and five-lens designs have advantages on aberration correction and modulation transfer function (MTF), and the resolution of the five-lens design having a higher than the four-lens design is applicable for electronic products of high video quality or high pixel requirement.

In various five-lens designs, an optical lens assembly with a fixed focal length and different combinations of positive or negative refractive powers are adopted. As disclosed in Japanese Pat. Publication Nos. JP2003-131136 and JP2005-266771, a cemented doublet lens is used for shortening the total length of the optical system. As disclosed in Japanese Publication Nos. JP2003-185917 and JP2006-293042, U.S. Pat. Nos. US2004/0196571 and US2003/0117722, and R.O.C. Pat. No. TW M313781, a group of stacked lenses is adopted to achieve the wide angle effect. As disclosed in Japanese Pat. Publication No. JP2003-161879, the fourth and fifth lens elements with different refractive powers are used to constitute the optical system, but the total length is too long and inapplicable for the use of the mini electronic devices.

The optical lens assembly for electronic products such as digital still cameras, web cameras, mobile phone cameras requires a compact design, a short focal length, and a good aberration correction. In various designs of the five-lens image pickup optical system with a fixed focal length, the fourth lens element and the fifth lens element with different refractive powers and the fourth lens element or the fifth lens element having an inflection point can comply with the design requirements for a better aberration correction and avoid an excess total length. As disclosed in R.O.C. Pat. Nos. TW M313246, TW201038966, TW201022714, and TW M332199, a good aberration correction can be achieved,

but the total length of the optical system still cannot meet the application requirements of mini electronic devices. As disclosed in U.S. Pat. Nos. 7,826,151, US2010/0254029, and US2010/0253829, the fourth lens element and the fifth lens element having an inflection point are used for the design of a shorter total length. In these prior arts, the fifth lens element having an inflection point is adopted to correct the aberration and distortion of images, but the refractive power from the fourth lens element to the fifth lens element cannot be enhanced easily under the limitation of a reduced total length of the image pickup optical lens assembly, such that the aberration correction of the fifth lens element still cannot meet the requirement. Therefore, the present invention provides a practical and feasible design to shorten the image pickup optical lens assembly, while using the refractive power of the five lens elements and the combination of convex and concave surfaces to improve the image quality for the application on compact electronic devices, in addition to the effect of reducing the total length of the optical lens assembly.

SUMMARY OF THE INVENTION

Therefore, it is a primary objective of the invention to provide an image pickup optical lens assembly, sequentially arranged from an object side to an image side along an optical axis, comprising: the first lens element, the second lens element, the third lens element, the fourth lens element and the fifth lens element, wherein the first lens element with positive refractive power has a convex object-side surface; the second lens element has negative refractive power; the third lens element with refractive power; the fourth lens element with refractive power has a concave object-side surface and a convex image-side surface near the optical axis, and both object-side surface and image-side surface thereof are aspheric; and the fifth lens element with positive or negative refractive power has a convex object-side surface and a concave image-side surface, and both object-side surface and image-side surface are aspheric; and the image pickup optical lens assembly satisfy the following relations:

$$0.3 < T_{12}/T_{23} < 1.8 \quad (1)$$

$$0.2 < CT_4/CT_5 < 0.9 \quad (2)$$

$$0.85 < f/f_1 < 1.55 \quad (3)$$

Wherein, T_{12} is the axial distance from the image-side surface of the first lens element to the object-side surface of the second lens element, T_{23} is the axial distance from the image-side surface of the second lens element to the object-side surface of the third lens element, CT_4 is the thickness of the fourth lens element near the optical axis, CT_5 is the thickness of the fifth lens element near the optical axis, f is the focal length of the image pickup optical lens assembly, and f_1 is the focal length of the first lens element.

The present invention further provides an image pickup optical lens assembly substantially the same as the above, wherein at least one of the object-side surface and the image-side surface of the second lens element is aspheric; at least one of the object-side surface and the image-side surface of the third lens element is aspheric; at least one of the object-side surface and the image-side surface of the fifth lens element has at least one inflection point; and a stop, which can be an aperture stop, and an image sensor are provided for capturing an image, and the stop is disposed between the first lens element and the second lens element, and the stop can be a middle stop disposed between the first lens element and an object to be photographed, or a front stop; and the image

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sensor is installed at a position of an image plane after the first lens element, the second lens element, the third lens element, the fourth lens element and the fifth lens element are assembled. In addition to the relations (1), (2) and (3), one or more of the following relations are satisfied:

$$0.75 < Sd/Td < 1.2 \quad (4)$$

$$TTL/ImgH < 2.3 \quad (5)$$

Wherein, Sd is the axial distance from the stop to the image-side surface of the fifth lens element, Td is the axial distance from the object-side surface of the first lens element to the image-side surface of the fifth lens element, TTL is the axial distance from the object-side surface of the first lens element to the image plane, and ImgH is half of the diagonal length of an effective photosensitive area of the image sensor.

The present invention further provides an image pickup optical lens assembly substantially the same as describe above, wherein at least one of the object-side surface and the image-side surface of the second lens element is aspheric; the third lens element with positive refractive power has at least one of the object-side surface and the image-side surface thereof being aspheric; the fifth lens element is made of plastic, and at least one of the object-side surface and image-side surface of the fifth lens element has at least one inflection point. In addition to the relations (1), (2), (3) and (4), the optical lens assembly further satisfies one or more of the following relations:

$$\text{Preferably, } 0.39 < T_{12}/T_{23} < 1.25 \quad (6)$$

$$\text{Preferably, } 0.3 < CT_4/CT_5 < 0.7 \quad (10)$$

Wherein, T_{12} is the axial distance from the image-side surface of the first lens element to the object-side surface of the second lens element, T_{23} is the axial distance from the image-side surface of the second lens element to the object-side surface of the third lens element, and CT_4 is the thickness of the fourth lens element near the optical axis.

The present invention further provides an image pickup optical lens assembly substantially the same as described above, wherein at least one of the object-side surface and the image-side surface of the second lens element being aspheric; the third lens element with positive refractive power has at least one of the object-side surface and the image-side surface being aspheric; the fourth lens element has positive refractive power; the fifth lens element with negative refractive power is made of plastic, and at least one of the object-side surface and the image-side surface thereof has at least one inflection point. In addition to the relations (1), (2), (3), (4) and (10), the optical lens assembly further satisfies one or more of the following relations:

$$\text{Preferably, } 0.35 < CT_4/CT_5 < 0.55 \quad (12)$$

$$\text{Preferably, } 0.95 < f/f_1 < 1.40 \quad (13)$$

Wherein, CT_4 is the thickness of the fourth lens element near the optical axis, T_{45} is the distance from the image-side surface of the fourth lens element to the object-side surface of the fifth lens element along the optical axis, CT_5 is the thickness of the fifth lens element near the optical axis, f is the focal length of the image pickup optical lens assembly, and f_1 is the focal length of the first lens element.

The present invention further provides an image pickup optical lens assembly, sequentially arranged from an object side to an image side along an optical axis, comprises: the first lens element, the second lens element, the third lens element, the fourth lens element and the fifth lens element, wherein the first lens element with positive refractive power has a convex

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object-side surface; the second lens element with negative refractive power has at least one of the object-side surface and the image-side surface thereof being aspheric; the third lens element with refractive power has at least one of the object-side surface and the image-side surface thereof being aspheric; the fourth lens element with refractive power has a concave object-side surface and a convex image-side surface near the optical axis, and both object-side surface and image-side surface thereof being aspheric; and the fifth lens element with refractive power has a convex object-side surface and a concave image-side surface, and both object-side surface and image-side surface thereof being aspheric, and at least one of the object-side surface and the image-side surface thereof has at least one inflection point. In addition to the relations (1), (2), (3) and (4), the image pickup optical lens assembly further satisfies the following relations:

$$\text{Preferably, } 0.39 < T_{12}/T_{23} < 1.25 \quad (6)$$

$$28.0 < v_1 - v_2 < 42 \quad (7)$$

$$|f/f_4| + |f/f_5| < 0.6 \quad (8)$$

$$-0.8 < (R_1 + R_2)/(R_1 - R_2) < -0.2 \quad (9)$$

$$\text{Preferably, } 0.9 < Sd/Td < 1.1 \quad (14)$$

Wherein, T_{12} is the axial distance from the image-side surface of the first lens element to the object-side surface of the second lens element, T_{23} is the axial distance from the image-side surface of the second lens element to the object-side surface of the third lens element, v_1 is the Abbe number of the first lens element, v_2 is the Abbe number of the second lens element, f is the focal length of the image pickup optical lens assembly, f_4 is the focal length of the fourth lens element, f_5 is the focal length of the fifth lens element, R_1 is the curvature radius of the object-side surface of the first lens element, R_2 is the curvature radius of the image-side surface of the first lens element, Sd is the axial distance from the stop to the image-side surface of the fifth lens element, Td is the axial distance from the object-side surface of the first lens element to the element image-side surface of the fifth lens.

Another objective of the present invention is to provide an image pickup optical lens assembly, sequentially arranged from an object side to an image side along an optical axis, comprising: the first lens element, the second lens element, the third lens element, the fourth lens element and the fifth lens element, wherein the first lens element with positive refractive power has a convex object-side surface; the second lens element has negative refractive power; the third lens element has positive refractive power; the fourth lens element assigned with refractive power has a concave object-side surface and a convex image-side surface near the optical axis, both object-side surface and image-side surface thereof being aspheric; and the fifth lens element with refractive power has a convex object-side surface and a concave image-side surface, both object-side surface and image-side surface thereof being aspheric; and the image pickup optical lens assembly satisfies the following relations:

$$0.3 < T_{12}/T_{23} < 1.8 \quad (1)$$

$$0.3 < (CT_4 + T_{45})/CT_5 < 0.7 \quad (15)$$

$$|f/f_4| + |f/f_5| < 1.8 \quad (11)$$

Wherein, T_{12} is the axial distance from the image-side surface of the first lens element to the object-side surface of the second lens element, T_{23} is the axial distance from the image-side surface of the second lens element to the object-

side surface of the third lens element, CT_4 is the thickness of the fourth lens element near the optical axis, T_{45} is the distance from the image-side surface of the fourth lens element to the object-side surface of the fifth lens element along the optical axis, CT_5 is the thickness of the fifth lens element near the optical axis, f is the focal length of the image pickup optical lens assembly, f_4 is the focal length of the fourth lens element, and f_5 is the focal length of the fifth lens element.

The present invention further provides an image pickup optical lens assembly substantially the same as described above, wherein at least one of the object-side surface and the image-side surface of the fifth lens element has at least one inflection point, and the fifth lens element is made of plastic. For different applications, one or more of the relations are satisfied in addition to the relations (1), (15), and (11):

$$0.85 < f/f_1 < 1.55 \quad (3)$$

$$0.35 < CT_4/CT_5 < 0.55 \quad (12)$$

$$|f/f_4| + |f/f_5| < 0.6 \quad (8)$$

$$-0.8 < (R_1 + R_2)/(R_1 - R_2) < -0.2 \quad (9)$$

Wherein, f is the focal length of the image pickup optical lens assembly, f_1 is the focal length of the first lens element, CT_4 is the thickness of the fourth lens element near the optical axis, CT_5 is the thickness of the fifth lens element near the optical axis, f_4 is the focal length of the fourth lens element, f_5 is the focal length of the fifth lens element, R_1 is the curvature radius of the object-side surface of the first lens element, and R_2 is the curvature radius of the image-side surface of the first lens element.

The present invention further provides an image pickup optical lens assembly, sequentially arranged from an object side to an image side along an optical axis, comprising: the first lens element, the second lens element, the third lens element, the fourth lens element and the fifth lens element, wherein the first lens element with positive refractive power has a convex object-side surface; the second lens element has negative refractive power; the third lens element has positive refractive power; the fourth lens element with positive refractive power has a concave object-side surface and a convex image-side surface near the optical axis, both object-side surface and image-side surface thereof being aspheric; and the fifth lens element with negative refractive power has a convex object-side surface and a concave image-side surface, both object-side surface and image-side surface thereof being aspheric, and at least one of the object-side surface and the image-side surface thereof has at least one inflection point, and the fifth lens element is made of plastic. In addition to the relations (1), (15), and (11), the optical lens assembly further satisfies one or more of the following relations:

$$\text{Preferably, } 0.39 < T_{12}/T_{23} < 1.25 \quad (6)$$

$$0.95 < f/f_1 < 1.40 \quad (13)$$

Wherein, T_{12} is the axial distance from the image-side surface of the first lens element to the object-side surface of the second lens element, T_{23} is the axial distance from the image-side surface of the second lens element to the object-side surface of the third lens element, f is the focal length of the image pickup optical lens assembly, and f_1 is the focal length of the first lens element.

With appropriate gaps formed among the first lens element, second lens element, third lens element, fourth lens element and fifth lens element along the optical axis of the present invention, good aberration correction and modulation transfer function (MTF) can be achieved and the total length of the

optical lens assembly can be shortened effectively for its application as an image pickup optical lens assembly for mini electronic products.

In the image pickup optical lens assembly of the present invention, the combination of the first lens element with greater positive refractive power and the second lens element with negative refractive power constitutes a lens assembly with a greater refractive power for a better aberration correction. The third lens element and the fourth lens element can enhance the effective range of the assembled first lens element and second lens element and correct the aberration produced by the first lens element with positive refractive power and the second lens element and the color difference of the system. Similarly, for the fourth lens element and the fifth lens element, the fourth lens element adjusts the image range and the modulation transfer function (MTF), and the thicker fifth lens element enhances the range of the image edge area and corrects the aberration and color difference of the image of the fourth lens element to improve the overall resolution of the image pickup optical lens assembly, such that the aberration and distortion of the image pickup optical lens assembly can meet the high-resolution requirement. For different applications, the fourth lens element can be assigned with negative refractive power to enhance the correction of aberration and color difference of the images of the fourth lens element.

In the image pickup optical lens assembly of the present invention, the combination of the first lens element with positive refractive power, the second lens element with negative refractive power and the fourth lens element with positive refractive power can shorten the total length of the image pickup optical lens assembly effectively by the refractive power compensation of the second lens element and the fifth lens element, such that a greater range of effective pixels of the image sensor can be achieved for the same total length of the optical lens assembly. In other words, a shorter image pickup optical lens assembly can be designed within the same range of effective pixels of the image sensor.

In the image pickup optical lens assembly of the present invention, the fifth lens element is made of plastic to facilitate the manufacture and to reduce the cost.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1A is a schematic view of an image pickup optical lens assembly in accordance with the first preferred embodiment of the present invention;

FIG. 1B is a series of aberration curves of the first preferred embodiment of the present invention;

FIG. 2A is a schematic view of an image pickup optical lens assembly in accordance with the second preferred embodiment of the present invention;

FIG. 2B is a series of aberration curves of the second preferred embodiment of the present invention;

FIG. 3A is a schematic view of an image pickup optical lens assembly in accordance with the third preferred embodiment of the present invention;

FIG. 3B is a series of aberration curves of the third preferred embodiment of the present invention;

FIG. 4A is a schematic view of an image pickup optical lens assembly in accordance with the fourth preferred embodiment of the present invention;

FIG. 4B is a series of aberration curves of the fourth preferred embodiment of the present invention;

FIG. 5A is a schematic view of an image pickup optical lens assembly in accordance with the fifth preferred embodiment of the present invention;

FIG. 5B is a series of aberration curves of the fifth preferred embodiment of the present invention;

FIG. 6A is a schematic view of an image pickup optical lens assembly in accordance with the sixth preferred embodiment of the present invention;

FIG. 6B is a series of aberration curves of the sixth preferred embodiment of the present invention;

FIG. 7A is a schematic view of an image pickup optical lens assembly in accordance with the seventh preferred embodiment of the present invention;

FIG. 7B is a series of aberration curves of the seventh preferred embodiment of the present invention;

FIG. 8A is a schematic view of an image pickup optical lens assembly in accordance with the eighth preferred embodiment of the present invention;

FIG. 8B is a series of aberration curves of the eighth preferred embodiment of the present invention;

FIG. 9 shows Table 1 that lists optical data of the first preferred embodiment of the present invention;

FIG. 10 shows Table 2 that lists aspherical surface data of the first preferred embodiment of the present invention;

FIG. 11 shows Table 3 that lists optical data of the second preferred embodiment of the present invention;

FIG. 12 shows Table 4 that lists aspherical surface data of the second preferred embodiment of the present invention;

FIG. 13 shows Table 5 that lists optical data of the third preferred embodiment of the present invention;

FIG. 14 shows Table 6 that lists aspherical surface data of the third preferred embodiment of the present invention;

FIG. 15 shows Table 7 that lists optical data of the fourth preferred embodiment of the present invention;

FIG. 16 shows Table 8 that lists aspherical surface data of the fourth preferred embodiment of the present invention;

FIG. 17 shows Table 9 that lists optical data of the fifth preferred embodiment of the present invention;

FIG. 18 shows Table 10 that lists aspherical surface data of the fifth preferred embodiment of the present invention;

FIG. 19 shows Table 11 that lists optical data of the sixth preferred embodiment of the present invention;

FIG. 20 shows Table 12 that lists aspherical surface data of the sixth preferred embodiment of the present invention;

FIG. 21 shows Table 13 that lists optical data of the seventh preferred embodiment of the present invention;

FIG. 22 shows Table 14 that lists aspherical surface data of the seventh preferred embodiment of the present invention;

FIG. 23 shows Table 15 that lists optical data of the eighth preferred embodiment of the present invention;

FIG. 24 shows Table 16 that lists aspherical surface data of the eighth preferred embodiment of the present invention; and

FIG. 25 shows Table 17 that lists data of related relations of the first to eighth preferred embodiments of the present invention.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

The technical measures taken by the present invention to achieve the foregoing objectives and effects will become apparent with the detailed description of preferred embodiments together with related drawings as follows. It is noteworthy to point out that same numerals are used for representing same respective elements in the drawings for the purpose of illustrating the present invention.

With reference to FIG. 1A for an image pickup optical lens assembly of the present invention, the image pickup optical lens assembly, sequentially arranged from an object side to an image side along an optical axis, comprises: the first lens

element (110), the second lens element (120), the third lens element (130), the fourth lens element (140) and the fifth lens element (150), wherein the first lens element (110) with positive refractive power has a convex object-side surface (111) near the optical axis, and the object-side surface (111) and an image-side surface (112) thereof being aspheric or spheric; the second lens element (120) with negative refractive power has an object-side surface (121) and an image-side surface (122) being aspheric or spheric; the third lens element (130) with refractive power, preferably positive refractive power has an object-side surface (131) and an image-side surface (132) being aspheric or spheric; the fourth lens element (140) with positive refractive power has a concave object-side surface (141) and a convex image-side surface (142) near the optical axis, both object-side surface (141) and image-side surface (142) thereof being aspheric or spheric; and the fifth lens element with refractive power has a convex object-side surface (151) and a concave image-side surface (152) near the optical axis, both object-side surface (151) and image-side surface (152) thereof being aspheric or spheric, and at least one of the object-side surface (151) and the image-side surface (152) thereof has at least one inflection point. The image pickup optical lens assembly further comprises an aperture stop (100) and an infrared filter (160), wherein the aperture stop (100) is disposed between the first lens element (110) and an object to be photographed objected to be photographed, and the infrared filter (160) is generally made of plate glass and disposed between the fifth lens element (150) and an image plane (170) without affecting the focal length of the image pickup optical lens assembly of the present invention. The image pickup optical lens assembly further comprises an image sensor (180) installed at the image plane (170). The first lens element (110), the second lens element (120), the third lens element (130), the fourth lens element (140) and the fifth lens element (150) come with aspheric optical surfaces in compliance with the aspheric surface formula as given in Equation (16):

$$X(Y) = \frac{(Y^2/R)}{1 + \sqrt{1 - (1 + K)(Y/R)^2}} + \sum_i (A_i) \cdot Y^i \quad (16)$$

Wherein, X is the relative height between a point on the aspherical surface with a distance Y to the optical axis and a plane tangent to the tip of the aspherical surface along the optical axis;

Y is the distance from a point on the aspherical surface to the optical axis;

K is the conic coefficient; and

A_i is the ith level aspherical surface coefficient.

With the installation of the aforementioned first lens element (110), second lens element (120), third lens element (130), fourth lens element (140), fifth lens element (150), aperture stop (100) and image sensor (180), the image pickup optical lens assembly of the present invention satisfies relations (1), (2) and (3).

If the ratio of the thickness T₁₂ of the air gap between the first lens element (110) and the second lens element (120) to the thickness T₃₄ of the air gap between the second lens element (120) and the third lens element (130) is limited (as shown in the relation (1)), light can pass through the first lens element (110) and the air gap and enter the third lens element (130) within a specific range of refraction angle to increase the refraction angle and decrease the total length. If the ratio of the thickness of the fourth lens element (140) to the thick-

ness of the fifth lens element (150) is decreased (as shown in the relation (2)), then the thickness of the fifth lens element (150) will be increased to provide a larger range. If the ratio of the focal length f of the image pickup optical lens assembly to the focal length f_1 of the first lens element (110) is limited (as shown in the relation (3)), then the focal length f_1 of the first lens element (110) will be increased to reduce the focal length f of the image pickup optical lens assembly and increase the refractive power of the first lens element (110) and improve the sensitivity of image pickup optical lens assembly contributed by the first lens element (110).

If S_d is the distance from the aperture stop (100) to the image-side surface of the fifth lens element (152) along the optical axis, and T_d is the distance from the object-side surface of the first lens element (111) to the image-side surface of the fifth lens element (152) along the optical axis, and the relation (4) is satisfied, then the distance from the first lens element to the fifth lens element can be limited to shorten the length of the image pickup optical lens assembly. If the relation (5) is satisfied, the total length TTL of the image pickup optical lens assembly can be reduced effectively, such that a larger range of the effective pixel area of the image sensor can be achieved in the same total length. If the relation (7) is satisfied, the aberration of the first lens element (110) and the second lens element (120) can be corrected easily. If the relation (8) is satisfied, the sum of the ratio of the focal length f of the image pickup optical lens assembly to the focal length f_4 of the fourth lens element (140) and the ratio of the focal length f of the image pickup optical lens assembly to the focal length f_5 of the fifth lens element (150) is limited, such that the design of the focal length f_4 of the fourth lens element (140) and the focal length f_5 of the fifth lens element (150) can be balanced the limited conditions in order to allocate the required refractive power of the fourth lens element (140) and the fifth lens element (150) of the image pickup optical lens assembly, and prevent the sensitivity of the system from being too high, and facilitating the reduction of the total length of the lens assembly.

If the curvature radius R_1 of the object-side surface (111) of the first lens element (110), and the curvature radius R_2 of the image-side surface (112) of the first lens element 110 are limited (as shown in the relation (9)), the surface shapes of the object-side surface of first lens element (111) and the image-side surface of the first lens element (112) are changed, not only favoring the aberration correction of the first lens element (110), but also increasing the refractive power of the first lens element (110).

The present invention further provides an image pickup optical lens assembly as shown in FIG. 4A, and the image pickup optical lens assembly sequentially arranged from an object side to an image side along an optical axis, comprises: the first lens element (410), the second lens element (420), the third lens element (430), the fourth lens element (440) and the fifth lens element (450), wherein the first lens element (410) with positive refractive power has a convex object-side surface (411) near the optical axis, and the object-side surface (411) and an image-side surface (412) thereof being aspheric or spheric; the second lens element (420) with negative refractive power has aspheric or spheric object-side surface (421) and image-side surface (422); the third lens element (430) with refractive power, preferably positive refractive power, has aspheric or spheric object-side surface (431) and image-side surface (432); the fourth lens element (440) with negative refractive power has a concave object-side surface (441) and a convex image-side surface (442) near the optical axis, both object-side surface (441) and image-side surface (442) thereof being aspheric or spheric; and the fifth lens

element with refractive power has a convex object-side surface (451) and a concave image-side surface (452) near the optical axis, both object-side surface (451) and image-side surface (452) being aspheric or spheric, and at least one of the object-side surface (451) and image-side surface (452) thereof has at least one inflection point. The image pickup optical lens assembly further comprises an aperture stop (400) and an infrared filter (460), wherein the aperture stop (400) is disposed between the first lens element (410) and an object to be photographed; the infrared filter (460) is generally made of plate glass and installed between the fifth lens element (450) and an image plane, without affecting the focal length of the image pickup optical lens assembly of the present invention. The image pickup optical lens assembly further comprises an image sensor (480) installed at the image plane (470) for imaging an object to be photographed. The first lens element (410), the second lens element (420), the third lens element (430), the fourth lens element (440) and the fifth lens element (450) come with an aspheric surface in compliance with the aspherical surface formula as given in Equation (16).

With the installation of the first lens element (410), the second lens element (420), the third lens element (430), the fourth lens element (440), the fifth lens element (450), the aperture stop (400) and the image sensor (480), the image pickup optical lens assembly of the present invention satisfies one or more of the relations (1) to (15).

The image pickup optical lens assembly of the present invention is described in details by preferred embodiments and related drawings as follows.

First Preferred Embodiment

With reference to FIGS. 1A and 1B for a schematic view of an optical system and a series of aberration curves in accordance with the first preferred embodiment of the present invention respectively, the image pickup optical lens assembly is an optical system comprising five lens elements, an infrared filter (160), an aperture stop (100) and an image sensor (180). More specifically, the image pickup optical lens assembly, sequentially arranged from an object side to an image side along an optical axis, comprises: a bi-convex first lens element (110) with positive refractive power and made of plastic, and both object-side surface (111) and image-side surface (112) thereof being aspheric; the second lens element (120) with negative refractive power, made of plastic, and having a convex object-side surface (121) and a concave image-side surface (122) near the optical axis, both object-side surface (121) and image-side surface (122) thereof being aspheric; the third lens element (130) with positive refractive power, made of plastic, and having a convex object-side surface (131) and a concave image-side surface (132) near the optical axis, both object-side surface (131) and image-side surface (132) thereof being aspheric; the fourth lens element (140) with positive refractive power, made of plastic, and having a concave object-side surface (141) and a convex image-side surface (142) near the optical axis, both object-side surface (141) and image-side surface (142) thereof being aspheric; the fifth lens element (150) with negative refractive power, made of plastic, and having a convex object-side surface (151) and a concave image-side surface (152) near the optical axis, both object-side surface (151) and image-side surface (152) thereof being aspheric, and at least one of the object-side surface (151) and the image-side surface (152) thereof having at least one inflection point; an infrared filter (IR-filter) (160) made of plate glass without affecting the focal length of the image pickup optical lens assembly of the

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present invention; and an image sensor (180) installed at an image plane (170). In this preferred embodiment, the image pickup optical lens assembly further comprises an aperture stop (100) disposed between the first lens element (110) and an object to be photographed.

With reference to FIG. 9 (Table 1) for the optical data of this preferred embodiment, the object-side surface of the first lens element (111), the image-side surface of the first lens element (112), the object-side surface of the second lens element (121), the image-side surface of the second lens element (122), the object-side surface of the third lens element (131), the image-side surface of the third lens element (132), the object-side surface of the fourth lens element (141), the image-side surface (142) of the fourth lens element, the object-side surface of the fifth lens element (151) and the image-side surface of the fifth lens element (152) are in compliance with the aspherical formula as shown in Equation (16) and the aspherical surface parameters are listed in FIG. 10 (Table 2).

In the image pickup optical lens assembly of the first preferred embodiment, the overall focal length of the image pickup optical lens assembly is $f=4.01$ (mm), the overall aperture stop value of the image pickup optical lens assembly (f-number) is $Fno=2.40$ and half of the maximum view angle is $HFOV=35.1$ (degrees).

With reference to Table 1 for the following data of this preferred embodiment, if T_{12} is the distance from the image-side surface of the first lens element (112) to the object-side surface of the second lens element (121) along the optical axis, T_{23} is the distance from the image-side surface of the second lens element (122) to the object-side surface of the third lens element (131) along the optical axis, CT_4 is the thickness of the fourth lens element (140) near the optical axis, CT_5 is the thickness of the fifth lens element (150) near the optical axis, f is the focal length of the image pickup optical lens assembly, and f_1 is the focal length of the first lens element (110), then the relations (1), (2) and (3) of $T_{12}/T_{23}=0.60$, $CT_4/CT_5=0.43$ and $f/f_1=1.18$ will be satisfied respectively.

If Td is the distance from the object-side surface of the first lens element (111) to the image-side surface of the fifth lens element (152) along optical axis, Sd is the distance from the aperture stop (100) to the image-side surface of the fifth lens element (152), then the relation (4) of $Sd/Td=0.99$ will be satisfied; if TTL is the distance from the object-side surface of the first lens element (111) to the image plane (170) along the optical axis, and $ImgH$ is half of the diagonal length of the effective photosensitive area of the image sensor (180), then the relation (5) of $TTL/ImgH=1.80$; and if CT_4 is the thickness of the fourth lens element (140) and CT_5 is the thickness of the fifth lens element (150), and T_{45} is the distance from the image-side surface of the fourth lens element (142) to the object-side surface of the fifth lens element (151), then the relation (15) of $(CT_4+T_{45})/CT_5=0.47$ will be satisfied.

In this preferred embodiment, if v_1 is the Abbe number of the first lens element (110) and v_2 is the Abbe number of the second lens element (120), then the relation (7) of $v_1-v_2=32.1$ will be satisfied; if f_4 is the focal length of the fourth lens element (140) and f_5 is the focal length of the fifth lens element (150), and f is the focal length of the image pickup optical lens assembly, then the relation (8) of $|f/f_4|+|f/f_5|=1.57$ will be satisfied; and if R_1 is the curvature radius of the object-side surface of the first lens element (111) and R_2 is the curvature radius of the image-side surface of the first lens element (112), then the relation (9) of $(R_1+R_2)/(R_1-R_2)=-0.68$ will be satisfied; and related computing data of the relations are listed in FIG. 25 (Table 17).

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From the optical data as shown in FIG. 9 (Table 1) and the aberration curve as shown in FIG. 1B, good compensation effects of the longitudinal spherical aberration, astigmatic field curving and distortion can be achieved by the image pickup optical lens assembly in accordance with this preferred embodiment of the present invention.

Second Preferred Embodiment

With reference to FIGS. 2A and 2B for a schematic view of an optical system and a series of aberration curves in accordance with the first preferred embodiment of the present invention respectively, the image pickup optical lens assembly is an optical system comprising five lens elements, an infrared filter (260), an aperture stop (200) and an image sensor (280). More specifically, the image pickup optical lens assembly, sequentially arranged from an object side to an image side along an optical axis, comprises: a bi-convex first lens element (210) with positive refractive power and made of plastic, and both object-side surface (211) and image-side surface (212) thereof being aspheric; the second lens element (220) with negative refractive power, made of plastic, and having a concave object-side surface (221) and a concave image-side surface (222) near the optical axis, both object-side surface (221) and image-side surface (222) thereof being aspheric; the third lens element (230) with positive refractive power, made of plastic, and having a concave object-side surface (231) and a convex image-side surface (232) near the optical axis, both object-side surface (231) and image-side surface (232) thereof being aspheric; the fourth lens element (240) with positive refractive power, made of plastic, and having a concave object-side surface (241) and a convex image-side surface (242) near the optical axis, both object-side surface (241) and image-side surface (242) thereof being aspheric; the fifth lens element (250) with negative refractive power, made of plastic, and having a convex object-side surface (251) and a concave image-side surface (252) near the optical axis, both object-side surface (251) and image-side surface (252) thereof being aspheric, and at least one of the object-side surface (251) and the image-side surface (252) thereof having at least one inflection point; an infrared filter (IR-filter) (260) made of plate glass without affecting the focal length of the image pickup optical lens assembly of the present invention; and an image sensor (280) installed at an image plane (270). In this preferred embodiment, the image pickup optical lens assembly further comprises an aperture stop (200) disposed between the first lens element (210) and an object to be photographed.

With reference to FIG. 11 (Table 3) for the optical data of this preferred embodiment, the object-side surface of the first lens element (211), the image-side surface of the first lens element (212), the object-side surface of the second lens element (221), the image-side surface of the second lens element (222), the object-side surface of the third lens element (231), the image-side surface of the third lens element (232), the object-side surface of the fourth lens element (241), the image-side surface (242) of the fourth lens element, the object-side surface of the fifth lens element (251) and the image-side surface of the fifth lens element (252) are in compliance with the aspherical formula as shown in Equation (16) and the aspherical surface parameters are listed in FIG. 12 (Table 4).

In the image pickup optical lens assembly of the second preferred embodiment, the overall focal length of the image pickup optical lens assembly is $f=3.77$ (mm), the overall

aperture stop value of the image pickup optical lens assembly (f-number) is $F_{no}=2.20$ and half of the maximum view angle is $HFOV=30.6$ (degrees).

With reference to Table 3 for the following data of this preferred embodiment, if T_{12} is the distance from the image-side surface of the first lens element (212) to the object-side surface of the second lens element (221) along the optical axis, T_{23} is the distance from the image-side surface of the second lens element (222) to the object-side surface of the third lens element (231) along the optical axis, CT_4 is the thickness of the fourth lens element (240) along the optical axis, CT_5 is the thickness of the fifth lens element (250) along the optical axis, f is the focal length of the image pickup optical lens assembly, and f_1 is the focal length of the first lens element (210), then the relations (1), (2) and (3) of $T_{12}/T_{23}=0.71$, $CT_4/CT_5=0.39$ and $f/f_1=1.30$ will be satisfied respectively.

If T_d is the distance from the object-side surface of the first lens element (211) to the image-side surface of the fifth lens element (252) along optical axis, S_d is the distance from the aperture stop (200) to the image-side surface of the fifth lens element (252), then the relation (4) of $S_d/T_d=0.99$ will be satisfied; if TTL is the distance from the object-side surface of the first lens element (211) to the image plane (270) along the optical axis, and $ImgH$ is half of the diagonal length of the effective photosensitive area of the image sensor (280), then the relation (5) of $TTL/ImgH=2.14$; and if CT_4 is the thickness of the fourth lens element (240) and CT_5 is the thickness of the fifth lens element (250), and T_{45} is the distance from the image-side surface of the fourth lens element (242) to the object-side surface of the fifth lens element (251), then the relation (15) of $(CT_4+T_{45})/CT_5=0.58$ will be satisfied.

In this preferred embodiment, if v_1 is the Abbe number of the first lens element (210) and v_2 is the Abbe number of the second lens element (220), then the relation (7) of $v_1-v_2=33.1$ will be satisfied; if f_4 is the focal length of the fourth lens element (240) and f_5 is the focal length of the fifth lens element (250), and f is the focal length of the image pickup optical lens assembly, then the relation (8) of $|f/f_4|+|f/f_5|=0.08$ will be satisfied; and if R_1 is the curvature radius of the object-side surface of the first lens element (211) and R_2 is the curvature radius of the image-side surface of the first lens element (212), then the relation (9) of $(R_1+R_2)/(R_1-R_2)=-0.62$ will be satisfied; and related computing data of the relations are listed in FIG. 25 (Table 17).

From the optical data as shown in FIG. 11 (Table 3) and the aberration curve as shown in FIG. 2B, good compensation effects of the longitudinal spherical aberration, astigmatic field curving and distortion can be achieved by the image pickup optical lens assembly in accordance with this preferred embodiment of the present invention.

Third Preferred Embodiment

With reference to FIGS. 3A and 3B for a schematic view of an optical system and a series of aberration curves in accordance with the first preferred embodiment of the present invention respectively, the image pickup optical lens assembly is an optical system comprising five lens elements, an infrared filter (360), an aperture stop (300) and an image sensor (380). More specifically, the image pickup optical lens assembly, sequentially arranged from an object side to an image side along an optical axis, comprises: a bi-convex first lens element (310) with positive refractive power and made of plastic, and both object-side surface (311) and image-side surface (312) thereof being aspheric; the second lens element (320) with negative refractive power, made of plastic, and

having a convex object-side surface (321) and a convex image-side surface (322) near the optical axis, both object-side surface (321) and image-side surface (322) thereof being aspheric; the third lens element (330) with positive refractive power, made of plastic, and having a convex object-side surface (331) and a concave image-side surface (332) near the optical axis, both object-side surface (331) and image-side surface (332) thereof being aspheric; the fourth lens element (340) with positive refractive power, made of plastic, and having a concave object-side surface (341) and a convex image-side surface (342) near the optical axis, both object-side surface (341) and image-side surface (342) thereof being aspheric; the fifth lens element (350) with negative refractive power, made of plastic, and having a convex object-side surface (351) and a concave image-side surface (352) near the optical axis, both object-side surface (351) and image-side surface (352) thereof being aspheric, and at least one of the object-side surface (351) and the image-side surface (352) thereof having at least one inflection point; an infrared filter (IR-filter) (360) made of plate glass without affecting the focal length of the image pickup optical lens assembly of the present invention; and an image sensor (380) installed at an image plane (370). In this preferred embodiment, the image pickup optical lens assembly further comprises an aperture stop (300) disposed between the first lens element (310) and an object to be photographed.

With reference to FIG. 13 (Table 5) for the optical data of this preferred embodiment, the object-side surface of the first lens element (311), the image-side surface of the first lens element (312), the object-side surface of the second lens element (321), the image-side surface of the second lens element (322), the object-side surface of the third lens element (331), the image-side surface of the third lens element (332), the object-side surface of the fourth lens element (341), the image-side surface (342) of the fourth lens element, the object-side surface of the fifth lens element (351) and the image-side surface of the fifth lens element (352) are in compliance with the aspherical formula as shown in Equation (16) and the aspherical surface parameters are listed in FIG. 14 (Table 6).

In the image pickup optical lens assembly of the third preferred embodiment, the overall focal length of the image pickup optical lens assembly is $f=3.52$ (mm), the overall aperture stop value of the image pickup optical lens assembly (f-number) is $F_{no}=2.40$ and half of the maximum view angle is $HFOV=32.1$ (degrees).

With reference to Table 5 for the following data of this preferred embodiment, if T_{12} is the distance from the image-side surface of the first lens element (312) to the object-side surface of the second lens element (321) along the optical axis, T_{23} is the distance from the image-side surface of the second lens element (322) to the object-side surface of the third lens element (331) along the optical axis, CT_4 is the thickness of the fourth lens element (340) along the optical axis, CT_5 is the thickness of the fifth lens element (350) along the optical axis, f is the focal length of the image pickup optical lens assembly, and f_1 is the focal length of the first lens element (310), then the relations (1), (2) and (3) of $T_{12}/T_{23}=1.00$, $CT_4/CT_5=0.43$ and $f/f_1=1.11$ will be satisfied respectively.

If T_d is the distance from the object-side surface of the first lens element (311) to the image-side surface of the fifth lens element (352) along optical axis, S_d is the distance from the aperture stop (300) to the image-side surface of the fifth lens element (352), then the relation (4) of $S_d/T_d=1.02$ will be satisfied; if TTL is the distance from the object-side surface of the first lens element (311) to the image plane (370) along the

optical axis, and ImgH is half of the diagonal length of the effective photosensitive area of the image sensor (380), then the relation (5) of $\text{TTL}/\text{ImgH}=2.09$; and if CT_4 is the thickness of the fourth lens element (340) and CT_5 is the thickness of the fifth lens element (350), and T_{45} is the distance from the image-side surface of the fourth lens element (342) to the object-side surface of the fifth lens element (351), then the relation (15) of $(\text{CT}_4+T_{45})/\text{CT}_5=0.48$ will be satisfied.

In this preferred embodiment, if v_1 is the Abbe number of the first lens element (310) and v_2 is the Abbe number of the second lens element (320), then the relation (7) of $v_1-v_2=32.5$ will be satisfied; if f_4 is the focal length of the fourth lens element (340) and f_5 is the focal length of the fifth lens element (350), and f is the focal length of the image pickup optical lens assembly, then the relation (8) of $|f/f_4|+|f/f_5|=0.36$ will be satisfied; and if R_1 is the curvature radius of the object-side surface of the first lens element (311) and R_2 is the curvature radius of the image-side surface of the first lens element (312), then the relation (9) of $(R_1+R_2)/(R_1-R_2)=-0.54$ will be satisfied; and related computing data of the relations are listed in FIG. 25 (Table 17).

From the optical data as shown in FIG. 13 (Table 5) and the aberration curve as shown in FIG. 3B, good compensation effects of the longitudinal spherical aberration, astigmatic field curving and distortion can be achieved by the image pickup optical lens assembly in accordance with this preferred embodiment of the present invention.

Fourth Preferred Embodiment

With reference to FIGS. 4A and 4B for a schematic view of an optical system and a series of aberration curves in accordance with the first preferred embodiment of the present invention respectively, the image pickup optical lens assembly is an optical system comprising five lens elements, an infrared filter (460), an aperture stop (400) and an image sensor (480). More specifically, the image pickup optical lens assembly, sequentially arranged from an object side to an image side along an optical axis, comprises: a bi-convex first lens element (410) with positive refractive power and made of plastic, and both object-side surface (411) and image-side surface (412) thereof being aspheric; the second lens element (420) with negative refractive power, made of plastic, and having a concave object-side surface (421) and a concave image-side surface (422) near the optical axis, both object-side surface (421) and image-side surface (422) thereof being aspheric; the third lens element (430) with positive refractive power, made of plastic, and having a concave object-side surface (431) and a convex image-side surface (432) near the optical axis, both object-side surface (431) and image-side surface (432) thereof being aspheric; the fourth lens element (440) with positive refractive power, made of plastic, and having a concave object-side surface (441) and a convex image-side surface (442) near the optical axis, both object-side surface (441) and image-side surface (442) thereof being aspheric; the fifth lens element (450) with negative refractive power, made of plastic, and having a convex object-side surface (451) and a concave image-side surface (452) near the optical axis, both object-side surface (451) and image-side surface (452) thereof being aspheric, and at least one of the object-side surface (451) and the image-side surface (452) thereof having at least one inflection point; an infrared filter (IR-filter) (460) made of plate glass without affecting the focal length of the image pickup optical lens assembly of the present invention; and an image sensor (480) installed at an image plane (470). In this preferred embodiment, the image

pickup optical lens assembly further comprises an aperture stop (400) disposed between the first lens element (410) and an object to be photographed.

With reference to FIG. 15 (Table 7) for the optical data of this preferred embodiment, the object-side surface of the first lens element (411), the image-side surface of the first lens element (412), the object-side surface of the second lens element (421), the image-side surface of the second lens element (422), the object-side surface of the third lens element (431), the image-side surface of the third lens element (432), the object-side surface of the fourth lens element (441), the image-side surface (442) of the fourth lens element, the object-side surface of the fifth lens element (451) and the image-side surface of the fifth lens element (452) are in compliance with the aspherical formula as shown in Equation (16) and the aspherical surface parameters are listed in FIG. 16 (Table 8).

In the image pickup optical lens assembly of the fourth preferred embodiment, the overall focal length of the image pickup optical lens assembly is $f=3.54$ (mm), the overall aperture stop value of the image pickup optical lens assembly (f-number) is $\text{Fno}=2.20$ and half of the maximum view angle is $\text{HFOV}=31.7$ (degrees).

With reference to Table 7 for the following data of this preferred embodiment, if T_{12} is the distance from the image-side surface of the first lens element (412) to the object-side surface of the second lens element (421) along the optical axis, T_{23} is the distance from the image-side surface of the second lens element (422) to the object-side surface of the third lens element (431) along the optical axis, CT_4 is the thickness of the fourth lens element (440) along the optical axis, CT_5 is the thickness of the fifth lens element (450) along the optical axis, f is the focal length of the image pickup optical lens assembly, and f_1 is the focal length of the first lens element (410), then the relations (1), (2) and (3) of $T_{12}/T_{23}=0.82$, $\text{CT}_4/\text{CT}_5=0.54$ and $f/f_1=1.28$ will be satisfied respectively.

If T_d is the distance from the object-side surface of the first lens element (411) to the image-side surface of the fifth lens element (452) along optical axis, S_d is the distance from the aperture stop (400) to the image-side surface of the fifth lens element (452), then the relation (4) of $S_d/T_d=1.01$ will be satisfied; if TTL is the distance from the object-side surface of the first lens element (411) to the image plane (470) along the optical axis, and ImgH is half of the diagonal length of the effective photosensitive area of the image sensor (480), then the relation (5) of $\text{TTL}/\text{ImgH}=2.03$; and if CT_4 is the thickness of the fourth lens element (440) and CT_5 is the thickness of the fifth lens element (450), and T_{45} is the distance from the image-side surface of the fourth lens element (442) to the object-side surface of the fifth lens element (451), then the relation (15) of $(\text{CT}_4+T_{45})/\text{CT}_5=0.60$ will be satisfied.

In this preferred embodiment, if v_1 is the Abbe number of the first lens element (410) and v_2 is the Abbe number of the second lens element (420), then the relation (7) of $v_1-v_2=34.4$ will be satisfied; if f_4 is the focal length of the fourth lens element (440) and f_5 is the focal length of the fifth lens element (450), and f is the focal length of the image pickup optical lens assembly, then the relation (8) of $|f/f_4|+|f/f_5|=0.13$ will be satisfied; and if R_1 is the curvature radius of the object-side surface of the first lens element (411) and R_2 is the curvature radius of the image-side surface of the first lens element (412), then the relation (9) of $(R_1+R_2)/(R_1-R_2)=-0.56$ will be satisfied; and related computing data of the relations are listed in FIG. 25 (Table 17).

From the optical data as shown in FIG. 15 (Table 7) and the aberration curve as shown in FIG. 4B, good compensation

effects of the longitudinal spherical aberration, astigmatic field curving and distortion can be achieved by the image pickup optical lens assembly in accordance with this preferred embodiment of the present invention.

Fifth Preferred Embodiment

With reference to FIGS. 5A and 5B for a schematic view of an optical system and a series of aberration curves in accordance with the first preferred embodiment of the present invention respectively, the image pickup optical lens assembly is an optical system comprising five lens elements, an infrared filter (560), an aperture stop (500) and an image sensor (580). More specifically, the image pickup optical lens assembly, sequentially arranged from an object side to an image side along an optical axis, comprises: a bi-convex first lens element (510) with positive refractive power and made of plastic, and both object-side surface (511) and image-side surface (512) thereof being aspheric; the second lens element (520) with negative refractive power, made of plastic, and having a convex object-side surface (521) and a concave image-side surface (522) near the optical axis, both object-side surface (521) and image-side surface (522) thereof being aspheric; the third lens element (530) with positive refractive power, made of plastic, and having a convex object-side surface (531) and a convex image-side surface (532) near the optical axis, both object-side surface (531) and image-side surface (532) thereof being aspheric; the fourth lens element (540) with positive refractive power, made of plastic, and having a concave object-side surface (541) and a convex image-side surface (542) near the optical axis, both object-side surface (541) and image-side surface (542) thereof being aspheric; the fifth lens element (550) with negative refractive power, made of plastic, and having a convex object-side surface (551) and a concave image-side surface (552) near the optical axis, both object-side surface (551) and image-side surface (552) thereof being aspheric, and at least one of the object-side surface (551) and the image-side surface (552) thereof having at least one inflection point; an infrared filter (IR-filter) (560) made of plate glass without affecting the focal length of the image pickup optical lens assembly of the present invention; and an image sensor (580) installed at an image plane (570). In this preferred embodiment, the image pickup optical lens assembly further comprises an aperture stop (500) disposed between the first lens element (510) and the second lens element (520).

With reference to FIG. 17 (Table 9) for the optical data of this preferred embodiment, the object-side surface of the first lens element (511), the image-side surface of the first lens element (512), the object-side surface of the second lens element (521), the image-side surface of the second lens element (522), the object-side surface of the third lens element (531), the image-side surface of the third lens element (532), the object-side surface of the fourth lens element (541), the image-side surface (542) of the fourth lens element, the object-side surface of the fifth lens element (551) and the image-side surface of the fifth lens element (552) are in compliance with the aspherical formula as shown in Equation (16) and the aspherical surface parameters are listed in FIG. 18 (Table 10).

In the image pickup optical lens assembly of the fifth preferred embodiment, the overall focal length of the image pickup optical lens assembly is $f=3.30$ (mm), the overall aperture stop value of the image pickup optical lens assembly (f-number) is $Fno=2.60$ and half of the maximum view angle is $HFOV=40.2$ (degrees).

With reference to Table 9 for the following data of this preferred embodiment, if T_{12} is the distance from the image-side surface of the first lens element (512) to the object-side surface of the second lens element (521) along the optical axis, T_{23} is the distance from the image-side surface of the second lens element (522) to the object-side surface of the third lens element (531) along the optical axis, CT_4 is the thickness of the fourth lens element (540) along the optical axis, CT_5 is the thickness of the fifth lens element (550) along the optical axis, f is the focal length of the image pickup optical lens assembly, and f_1 is the focal length of the first lens element (510), then the relations (1), (2) and (3) of $T_{12}/T_{23}=0.48$, $CT_4/CT_5=0.49$ and $f/f_1=1.19$ will be satisfied respectively.

If T_d is the distance from the object-side surface of the first lens element (511) to the image-side surface of the fifth lens element (552) along optical axis, S_d is the distance from the aperture stop (500) to the image-side surface of the fifth lens element (552), then the relation (4) of $S_d/T_d=0.81$ will be satisfied; if TTL is the distance from the object-side surface of the first lens element (511) to the image plane (570) along the optical axis, and $ImgH$ is half of the diagonal length of the effective photosensitive area of the image sensor (580), then the relation (5) of $TTL/ImgH=1.49$; and if CT_4 is the thickness of the fourth lens element (540) and CT_5 is the thickness of the fifth lens element (550), and T_{45} is the distance from the image-side surface of the fourth lens element (542) to the object-side surface of the fifth lens element (551), then the relation (15) of $(CT_4+T_{45})/CT_5=0.54$ will be satisfied.

In this preferred embodiment, if v_1 is the Abbe number of the first lens element (510) and v_2 is the Abbe number of the second lens element (520), then the relation (7) of $v_1-v_2=32.1$ will be satisfied; if f_4 is the focal length of the fourth lens element (540) and f_5 is the focal length of the fifth lens element (550), and f is the focal length of the image pickup optical lens assembly, then the relation (8) of $|f/f_4|+|f/f_5|=0.56$ will be satisfied; and if R_1 is the curvature radius of the object-side surface of the first lens element (511) and R_2 is the curvature radius of the image-side surface of the first lens element (512), then the relation (9) of $(R_1+R_2)/(R_1-R_2)=-0.40$ will be satisfied; and related computing data of the relations are listed in FIG. 25 (Table 17).

From the optical data as shown in FIG. 17 (Table 9) and the aberration curve as shown in FIG. 5B, good compensation effects of the longitudinal spherical aberration, astigmatic field curving and distortion can be achieved by the image pickup optical lens assembly in accordance with this preferred embodiment of the present invention.

Sixth Preferred Embodiment

With reference to FIGS. 6A and 6B for a schematic view of an optical system and a series of aberration curves in accordance with the first preferred embodiment of the present invention respectively, the image pickup optical lens assembly is an optical system comprising five lens elements, an infrared filter (660), an aperture stop (600) and an image sensor (680). More specifically, the image pickup optical lens assembly, sequentially arranged from an object side to an image side along an optical axis, comprises: a bi-convex first lens element (610) with positive refractive power and made of plastic, and both object-side surface (611) and image-side surface (612) thereof being aspheric; the second lens element (620) with negative refractive power, made of plastic, and having a convex object-side surface (621) and a concave image-side surface (622) near the optical axis, both object-side surface (621) and image-side surface (622) thereof being

aspheric; the third lens element (630) with positive refractive power, made of plastic, and having a convex object-side surface (631) and a convex image-side surface (632) near the optical axis, both object-side surface (631) and image-side surface (632) thereof being aspheric; the fourth lens element (640) with positive refractive power, made of plastic, and having a concave object-side surface (641) and a convex image-side surface (642) near the optical axis, both object-side surface (641) and image-side surface (642) thereof being aspheric; the fifth lens element (650) with negative refractive power, made of plastic, and having a convex object-side surface (651) and a concave image-side surface (652) near the optical axis, both object-side surface (651) and image-side surface (652) thereof being aspheric, and at least one of the object-side surface (651) and the image-side surface (652) thereof having at least one inflection point; an infrared filter (IR-filter) (660) made of plate glass without affecting the focal length of the image pickup optical lens assembly of the present invention; and an image sensor (680) installed at an image plane (670). In this preferred embodiment, the image pickup optical lens assembly further comprises an aperture stop (600) disposed between the first lens element (610) and an object to be photographed.

With reference to FIG. 19 (Table 11) for the optical data of this preferred embodiment, the object-side surface of the first lens element (611), the image-side surface of the first lens element (612), the object-side surface of the second lens element (621), the image-side surface of the second lens element (622), the object-side surface of the third lens element (631), the image-side surface of the third lens element (632), the object-side surface of the fourth lens element (641), the image-side surface (642) of the fourth lens element, the object-side surface of the fifth lens element (651) and the image-side surface of the fifth lens element (652) are in compliance with the aspherical formula as shown in Equation (16) and the aspherical surface parameters are listed in FIG. 20 (Table 12).

In the image pickup optical lens assembly of the sixth preferred embodiment, the overall focal length of the image pickup optical lens assembly is $f=3.99$ (mm), the overall aperture stop value of the image pickup optical lens assembly (f-number) is $Fno=2.40$ and half of the maximum view angle is $HFOV=34.8$ (degrees).

With reference to Table 11 for the following data of this preferred embodiment, if T_{12} is the distance from the image-side surface of the first lens element (612) to the object-side surface of the second lens element (621) along the optical axis, T_{23} is the distance from the image-side surface of the second lens element (622) to the object-side surface of the third lens element (631) along the optical axis, CT_4 is the thickness of the fourth lens element (640) along the optical axis, CT_5 is the thickness of the fifth lens element (650) along the optical axis, f is the focal length of the image pickup optical lens assembly, and f_1 is the focal length of the first lens element (610), then the relations (1), (2) and (3) of $T_{12}/T_{23}=0.40$, $CT_4/CT_5=0.35$ and $f/f_1=1.38$ will be satisfied respectively.

If Td is the distance from the object-side surface of the first lens element (611) to the image-side surface of the fifth lens element (652) along optical axis, Sd is the distance from the aperture stop (600) to the image-side surface of the fifth lens element (652), then the relation (4) of $Sd/Td=0.97$ will be satisfied; if TTL is the distance from the object-side surface of the first lens element (611) to the image plane (670) along the optical axis, and $ImgH$ is half of the diagonal length of the effective photosensitive area of the image sensor (680), then the relation (5) of $TTL/ImgH=1.75$; and if CT_4 is the thick-

ness of the fourth lens element (640) and CT_5 is the thickness of the fifth lens element (650), and T_{45} is the distance from the image-side surface of the fourth lens element (642) to the object-side surface of the fifth lens element (651), then the relation (15) of $(CT_4+T_{45})/CT_5=0.38$ will be satisfied.

In this preferred embodiment, if v_1 is the Abbe number of the first lens element (610) and v_2 is the Abbe number of the second lens element (620), then the relation (7) of $v_1-v_2=30.3$ will be satisfied; if f_4 is the focal length of the fourth lens element (640) and f_5 is the focal length of the fifth lens element (650), and f is the focal length of the image pickup optical lens assembly, then the relation (8) of $|f/f_4|+|f/f_5|=0.33$ will be satisfied; and if R_1 is the curvature radius of the object-side surface of the first lens element (611) and R_2 is the curvature radius of the image-side surface of the first lens element (612), then the relation (9) of $(R_1+R_2)/(R_1-R_2)=-0.58$ will be satisfied; and related computing data of the relations are listed in FIG. 25 (Table 17).

From the optical data as shown in FIG. 19 (Table 11) and the aberration curve as shown in FIG. 6B, good compensation effects of the longitudinal spherical aberration, astigmatic field curving and distortion can be achieved by the image pickup optical lens assembly in accordance with this preferred embodiment of the present invention.

Seventh Preferred Embodiment

With reference to FIGS. 7A and 7B for a schematic view of an optical system and a series of aberration curves in accordance with the first preferred embodiment of the present invention respectively, the image pickup optical lens assembly is an optical system comprising five lens elements, an infrared filter (760), an aperture stop (700) and an image sensor (780). More specifically, the image pickup optical lens assembly, sequentially arranged from an object side to an image side along an optical axis, comprises: a bi-convex first lens element (710) with positive refractive power and made of plastic, and both object-side surface (711) and image-side surface (712) thereof being aspheric; the second lens element (720) with negative refractive power, made of plastic, and having a concave object-side surface (721) and a concave image-side surface (722) near the optical axis, both object-side surface (721) and image-side surface (722) thereof being aspheric; the third lens element (730) with positive refractive power, made of plastic, and having a concave object-side surface (731) and a convex image-side surface (732) near the optical axis, both object-side surface (731) and image-side surface (732) thereof being aspheric; the fourth lens element (740) with positive refractive power, made of plastic, and having a concave object-side surface (741) and a convex image-side surface (742) near the optical axis, both object-side surface (741) and image-side surface (742) thereof being aspheric; the fifth lens element (750) with negative refractive power, made of plastic, and having a convex object-side surface (751) and a concave image-side surface (752) near the optical axis, both object-side surface (751) and image-side surface (752) thereof being aspheric, and at least one of the object-side surface (751) and the image-side surface (752) thereof having at least one inflection point; an infrared filter (IR-filter) (760) made of plate glass without affecting the focal length of the image pickup optical lens assembly of the present invention; and an image sensor (780) installed at an image plane (770). In this preferred embodiment, the image pickup optical lens assembly further comprises an aperture stop (700) disposed between the first lens element (710) and an object to be photographed.

With reference to FIG. 21 (Table 13) for the optical data of this preferred embodiment, the object-side surface of the first lens element (711), the image-side surface of the first lens element (712), the object-side surface of the second lens element (721), the image-side surface of the second lens element (722), the object-side surface of the third lens element (731), the image-side surface of the third lens element (732), the object-side surface of the fourth lens element (741), the image-side surface (742) of the fourth lens element, the object-side surface of the fifth lens element (751) and the image-side surface of the fifth lens element (752) are in compliance with the aspherical formula as shown in Equation (16) and the aspherical surface parameters are listed in FIG. 22 (Table 14).

In the image pickup optical lens assembly of the seventh preferred embodiment, the overall focal length of the image pickup optical lens assembly is $f=3.70$ (mm), the overall aperture stop value of the image pickup optical lens assembly (f-number) is $Fno=2.30$ and half of the maximum view angle is $HFOV=30.8$ (degrees).

With reference to Table 13 for the following data of this preferred embodiment, if T_{12} is the distance from the image-side surface of the first lens element (712) to the object-side surface of the second lens element (721) along the optical axis, T_{23} is the distance from the image-side surface of the second lens element (722) to the object-side surface of the third lens element (731) along the optical axis, CT_4 is the thickness of the fourth lens element (740) along the optical axis, CT_5 is the thickness of the fifth lens element (750) along the optical axis, f is the focal length of the image pickup optical lens assembly, and f_1 is the focal length of the first lens element (710), then the relations (1), (2) and (3) of $T_{12}/T_{23}=1.24$, $CT_4/CT_5=0.37$ and $f/f_1=1.47$ will be satisfied respectively.

If T_d is the distance from the object-side surface of the first lens element (711) to the image-side surface of the fifth lens element (752) along optical axis, S_d is the distance from the aperture stop (700) to the image-side surface of the fifth lens element (752), then the relation (4) of $S_d/T_d=1.02$ will be satisfied; if TTL is the distance from the object-side surface of the first lens element (711) to the image plane (770) along the optical axis, and $ImgH$ is half of the diagonal length of the effective photosensitive area of the image sensor (780), then the relation (5) of $TTL/ImgH=2.10$; and if CT_4 is the thickness of the fourth lens element (740) and CT_5 is the thickness of the fifth lens element (750), and T_{45} is the distance from the image-side surface of the fourth lens element (742) to the object-side surface of the fifth lens element (751), then the relation (15) of $(CT_4+T_{45})/CT_5=0.42$ will be satisfied.

In this preferred embodiment, if v_1 is the Abbe number of the first lens element (710) and v_2 is the Abbe number of the second lens element (720), then the relation (7) of $v_1-v_2=33.1$ will be satisfied; if f_4 is the focal length of the fourth lens element (740) and f_5 is the focal length of the fifth lens element (750), and f is the focal length of the image pickup optical lens assembly, then the relation (8) of $|f/f_4|+|f/f_5|=0.05$ will be satisfied; and if R_1 is the curvature radius of the object-side surface of the first lens element (711) and R_2 is the curvature radius of the image-side surface of the first lens element (712), then the relation (9) of $(R_1+R_2)/(R_1-R_2)=-0.29$ will be satisfied; and related computing data of the relations are listed in FIG. 25 (Table 17).

From the optical data as shown in FIG. 21 (Table 13) and the aberration curve as shown in FIG. 7B, good compensation effects of the longitudinal spherical aberration, astigmatic field curving and distortion can be achieved by the image

pickup optical lens assembly in accordance with this preferred embodiment of the present invention.

Eighth Preferred Embodiment

With reference to FIGS. 8A and 8B for a schematic view of an optical system and a series of aberration curves in accordance with the first preferred embodiment of the present invention respectively, the image pickup optical lens assembly is an optical system comprising five lens elements, an infrared filter (860), an aperture stop (800) and an image sensor (880). More specifically, the image pickup optical lens assembly, sequentially arranged from an object side to an image side along an optical axis, comprises: a bi-convex first lens element (810) with positive refractive power and made of plastic, and both object-side surface (811) and image-side surface (812) thereof being aspheric; the second lens element (820) with negative refractive power, made of plastic, and having a concave object-side surface (821) and a concave image-side surface (822) near the optical axis, both object-side surface (821) and image-side surface (822) thereof being aspheric; the third lens element (830) with positive refractive power, made of plastic, and having a concave object-side surface (831) and a convex image-side surface (832) near the optical axis, both object-side surface (831) and image-side surface (832) thereof being aspheric; the fourth lens element (840) with positive refractive power, made of plastic, and having a concave object-side surface (841) and a convex image-side surface (842) near the optical axis, both object-side surface (841) and image-side surface (842) thereof being aspheric; the fifth lens element (850) with negative refractive power, made of plastic, and having a convex object-side surface (851) and a concave image-side surface (852) near the optical axis, both object-side surface (851) and image-side surface (852) thereof being aspheric, and at least one of the object-side surface (851) and the image-side surface (852) thereof having at least one inflection point; an infrared filter (IR-filter) (860) made of plate glass without affecting the focal length of the image pickup optical lens assembly of the present invention; and an image sensor (880) installed at an image plane (870). In this preferred embodiment, the image pickup optical lens assembly further comprises an aperture stop (800) disposed between the first lens element (810) and an object to be photographed.

With reference to FIG. 23 (Table 15) for the optical data of this preferred embodiment, the object-side surface of the first lens element (811), the image-side surface of the first lens element (812), the object-side surface of the second lens element (821), the image-side surface of the second lens element (822), the object-side surface of the third lens element (831), the image-side surface of the third lens element (832), the object-side surface of the fourth lens element (841), the image-side surface (842) of the fourth lens element, the object-side surface of the fifth lens element (851) and the image-side surface of the fifth lens element (852) are in compliance with the aspherical formula as shown in Equation (16) and the aspherical surface parameters are listed in FIG. 24 (Table 16).

In the image pickup optical lens assembly of the eighth preferred embodiment, the overall focal length of the image pickup optical lens assembly is $f=3.69$ (mm), the overall aperture stop value of the image pickup optical lens assembly (f-number) is $Fno=2.20$ and half of the maximum view angle is $HFOV=30.6$ (degrees).

With reference to Table 15 for the following data of this preferred embodiment, if T_{12} is the distance from the image-side surface of the first lens element (812) to the object-side

surface of the second lens element (821) along the optical axis, T_{23} is the distance from the image-side surface of the second lens element (822) to the object-side surface of the third lens element (831) along the optical axis, CT_4 is the thickness of the fourth lens element (840) along the optical axis, CT_5 is the thickness of the fifth lens element (850) along the optical axis, f is the focal length of the image pickup optical lens assembly, and f_1 is the focal length of the first lens element (810), then the relations (1), (2) and (3) of $T_{12}/T_{23}=0.75$, $CT_4/CT_5=0.45$ and $f/f_1=1.48$ will be satisfied respectively.

If T_d is the distance from the object-side surface of the first lens element (811) to the image-side surface of the fifth lens element (852) along optical axis, S_d is the distance from the aperture stop (800) to the image-side surface of the fifth lens element (852), then the relation (4) of $S_d/T_d=1.03$ will be satisfied; if TTL is the distance from the object-side surface of the first lens element (811) to the image plane (870) along the optical axis, and $ImgH$ is half of the diagonal length of the effective photosensitive area of the image sensor (880), then the relation (5) of $TTL/ImgH=2.11$; and if CT_4 is the thickness of the fourth lens element (840) and CT_5 is the thickness of the fifth lens element (850), and T_{45} is the distance from the image-side surface of the fourth lens element (842) to the object-side surface of the fifth lens element (851), then the relation (15) of $(CT_4+T_{45})/CT_5=0.51$ will be satisfied.

In this preferred embodiment, if v_1 is the Abbe number of the first lens element (810) and v_2 is the Abbe number of the second lens element (820), then the relation (7) of $v_1-v_2=33.1$ will be satisfied; if f_4 is the focal length of the fourth lens element (840) and f_5 is the focal length of the fifth lens element (850), and f is the focal length of the image pickup optical lens assembly, then the relation (8) of $|f/f_4|+|f/f_5|=0.11$ will be satisfied; and if R_1 is the curvature radius of the object-side surface of the first lens element (811) and R_2 is the curvature radius of the image-side surface of the first lens element (812), then the relation (9) of $(R_1+R_2)/(R_1-R_2)=-0.28$ will be satisfied; and related computing data of the relations are listed in FIG. 25 (Table 17).

From the optical data as shown in FIG. 23 (Table 15) and the aberration curve as shown in FIG. 8B, good compensation effects of the longitudinal spherical aberration, astigmatic field curving and distortion can be achieved by the image pickup optical lens assembly in accordance with this preferred embodiment of the present invention.

In the image pickup optical lens assembly of the present invention, the lens can be made of glass or plastic. If the lens is made of glass, the refractive power for the image pickup optical system can be selected more flexibly. If the lens is made of plastic, the production cost can be reduced effectively. In addition, an aspherical surface is formed on an optical surface of the lens, and the aspherical surface can be easily manufactured into a shape other than that of a spherical surface to have more control factors to eliminate or reduce aberrations, so as to reduce the number of lenses used and the total length of the image pickup optical system of the present invention.

In the image pickup optical lens assembly of the present invention, if the lens surface is a convex surface, the lens surface proximate to the axis is a convex surface; and if the lens surface is a concave surface, the lens surface proximate to the axis is a concave surface.

In the image pickup optical lens assembly of the present invention, at least one aperture stop (not shown in the figure) such as a glare stop or a field stop is provided for reducing stray lights to facilitate improving the image quality.

Tables 1 to 16 (corresponding to FIGS. 9 to 24 respectively) show changes of values of an imagery optical system in accordance with each preferred embodiment of the present invention. However, the changes of values in the preferred embodiments of the present invention are obtained from experiments. Even if different values are used, products of the same structure are intended to be covered by the scope of the present invention. It is noteworthy to point out that the aforementioned description and the illustration of related drawings are provided for the purpose of explaining the technical characteristics of the present invention, but not intended for limiting the scope of the present invention.

While the invention has been described by means of specific embodiments, numerous modifications and variations could be made thereto by those skilled in the art without departing from the scope and spirit of the invention set forth in the claims.

What is claimed is:

1. An image pickup optical lens assembly, sequentially arranged from an object side to an image side, comprising:
 - a first lens element with positive refractive power, having a convex object-side surface;
 - a second lens element with negative refractive power, having a convex object-side surface and a concave image-side surface;
 - a third lens element with refractive power;
 - a fourth lens element with negative refractive power, having a concave object-side surface and a convex image-side surface, both object-side surface and image-side surface thereof being aspheric; and
 - a fifth lens element with refractive power, having a convex object-side surface and a concave image-side surface, both object-side surface and image-side surface thereof being aspheric, and at least one of the object-side surface and the image-side surface of the fifth element having at least one inflection point;

wherein the image pickup optical lens assembly has a total of five lens elements with refractive power, T_{12} is an axial distance between the first lens element and the second lens element, T_{23} is an axial distance between the second lens element and the third lens element, CT_4 is a thickness of the fourth lens element near the optical axis, CT_5 is a thickness of the fifth lens element near the optical axis, f is a focal length of the image pickup optical lens assembly, f_1 is a focal length of the first lens element, and the following relations are satisfied:

$$0.3 < T_{12}/T_{23} < 1.8;$$

$$0.2 < CT_4/CT_5 < 0.9;$$

$$0.85 < f/f_1 < 1.55.$$

2. The image pickup optical lens assembly of claim 1, wherein at least one of the object-side surface and the image-side surface of the second lens element is aspheric; and at least one of [the] an object-side surface and [the] an image-side surface of the third lens element is aspheric; and at least one of the object-side surface and the image-side surface of the fifth lens element has at least one inflection point].

3. The image pickup optical lens assembly of claim [2] 1, wherein S_d is an axial distance from [the] a stop to the image-side surface of the fifth lens element, T_d is an axial distance from the object-side surface of the first lens element to the image-side surface of the fifth lens element, and the following relation is satisfied:

$$0.75 < S_d/T_d < 1.2.$$

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4. The image pickup optical lens assembly of claim [3] *I*, further comprising an image sensor at an image plane, wherein TTL is an axial distance from the object-side surface of the first lens element to the image plane, ImgH is half of the diagonal length of an effective photosensitive area of the image sensor, and the following relation is satisfied:

$$\text{TTL}/\text{ImgH} < 2.3.$$

5. The image pickup optical lens assembly of claim [3] *I*, wherein the third lens element has positive refractive power, and the fifth lens element is made of plastic.

[6. The image pickup optical lens assembly of claim 5, wherein *f* is the focal length of the image pickup optical lens assembly, and *f*₁ is the focal length of the first lens element, and the following relation is satisfied:

$$0.95 < f/f_1 < 1.40.]$$

7. The image pickup optical lens assembly of claim [5] *I*, wherein CT₄ is the thickness of the fourth lens element near the optical axis, CT₅ is the thickness of the fifth lens element near the optical axis, and the following relation is [preferably] satisfied:

$$[0.3] \ 0.2 < \text{CT}_4/\text{CT}_5 < 0.7.$$

8. The image pickup optical lens assembly of claim [7] *I*, wherein [the fourth lens element has positive refractive power, and] the fifth lens element has negative refractive power.

9. The image pickup optical lens assembly of claim [7] *I*, wherein CT₄ is the thickness of the fourth lens element near the optical axis, CT₅ is the thickness of the fifth lens element near the optical axis, and the following relation is [preferably] satisfied:

$$[0.35] \ 0.2 < \text{CT}_4/\text{CT}_5 < 0.55.$$

[10. The image pickup optical lens assembly of claim 3, wherein T₁₂ is the axial distance between the first lens element and the second lens element, T₂₃ is the axial distance between the second lens element and the third lens element, and the following relation is preferably satisfied:

$$0.39 < T_{12}/T_{23} < 1.25.]$$

11. The image pickup optical lens assembly of claim [10] *I*, wherein *v*₁ is the Abbe number of the first lens element, *v*₂ is the Abbe number of the second lens element, and the following relation is satisfied:

$$28 < v_1 - v_2 < 42.$$

12. The image pickup optical lens assembly of claim [11] *I*, wherein *f* is the focal length of the image pickup optical lens assembly, *f*₄ is a focal length of the fourth lens element, *f*₅ is a focal length of the fifth lens element, and the following relation is satisfied:

$$|f/f_4| + |f/f_5| < [0.6] \ 1.8.$$

13. The image pickup optical lens assembly of claim [10] *I*, wherein R₁ is a curvature radius of the object-side surface of the first lens element, R₂ is a curvature radius of [the] *an* image-side surface of the first lens element, and the following relation is satisfied:

$$-0.8 < (R_1 + R_2)/(R_1 - R_2) < -0.2.$$

14. The image pickup optical lens assembly of claim [10] *I*, wherein Td is [the] *an* axial distance from the object-side surface of the first lens element to the image-side surface of

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the fifth lens element, Sd is [the] *an* axial distance from [the] *a* stop to the image-side surface of the fifth lens element, and the following relation is [preferably] satisfied:

$$0.9 < \text{Sd}/\text{Td} < 1.1.$$

15. An image pickup optical lens assembly, sequentially arranged from an object side to an image side, comprising:

a first lens element with positive refractive power, having a convex object-side surface;

a second lens element with negative refractive power, *and at least one of an object-side surface and an image-side surface of the second lens element being aspheric*;

a third lens element with positive refractive power, *having a convex image-side surface*;

a fourth lens element with refractive power, having a concave object-side surface and a convex image-side surface, both object-side surface and image-side surface thereof being aspheric; and

a fifth lens element with refractive power, having a convex object-side surface and a concave image-side surface, both object-side surface and image-side surface thereof being aspheric, *at least one of the object-side surface and the image-side surface of the fifth element having at least one inflection point, and the fifth lens element is made of plastic*;

wherein *the image pickup optical lens assembly has a total of five lens elements with refractive power, and a gap on the optical axis is formed between any two adjacent lens elements among the first lens element, the second lens element, the third lens element, the fourth lens element and the fifth lens element*; *the image pickup optical lens assembly further comprises a stop between an object and the first lens element*, T₁₂ is an axial distance between the first lens element and the second lens element, T₂₃ is an axial distance between the second lens element and the third lens element, CT₄ is a thickness of the fourth lens element near the optical axis, T₄₅ is an axial distance between the fourth lens element and the fifth lens element, CT₅ is a thickness of the fifth lens element near the optical axis, *f* is a focal length of the image pickup optical lens assembly, *f*₄ is a focal length of the fourth lens element, *f*₅ is a focal length of the fifth lens element, *Td* is an axial distance from the object-side surface of the first lens element to the image-side surface of the fifth lens element, *Sd* is an axial distance from the stop to the image-side surface of the fifth lens element, and the following relations are satisfied:

$$0.3 < T_{12}/T_{23} < 1.8;$$

$$0.3 < (\text{CT}_4 + \text{T}_{45})/\text{CT}_5 < 0.7;$$

$$|f/f_4| + |f/f_5| < 1.8;$$

$$0.9 < \text{Sd}/\text{Td} < 1.1.$$

[16. The image pickup optical lens assembly of claim 15, wherein at least one of the object-side surface and the image-side surface of the fifth lens element has at least one inflection point, and the fifth lens element is made of plastic.]

17. The image pickup optical lens assembly of claim [16] 15, wherein *f* is the focal length of the image pickup optical lens assembly, *f*₁ is a focal length of the first lens element, the following relation is satisfied:

$$0.85 < f/f_1 < 1.55.$$

18. The image pickup optical lens assembly of claim [16] 15, wherein CT₄ is the thickness of the fourth lens element

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near the optical axis, CT_5 is the thickness of the fifth lens element near the optical axis, and the following relation is satisfied:

$$[0.35] \ 0.2 < CT_4/CT_5 < 0.55.$$

19. The image pickup optical lens assembly of claim [16] 15, wherein f is the focal length of the image pickup optical lens assembly, f_4 is the focal length of the fourth lens element, f_5 is the focal length of the fifth lens element, and the following relation is [preferably] satisfied:

$$|f/f_4| + |f/f_5| < 0.6.$$

20. The image pickup optical lens assembly of claim [16] 15, wherein R_1 is a curvature radius of the object-side surface of the first lens element, R_2 is a curvature radius of [the] an image-side surface of the first lens element, and the following relation is [preferably] satisfied:

$$-0.8 < (R_1 + R_2)/(R_1 - R_2) < -0.2.$$

21. The image pickup optical lens assembly of claim [16] 15, wherein [the fourth lens element has positive refractive power, and] the fifth lens element has negative refractive power.

[22. The image pickup optical lens assembly of claim 21, wherein T_{12} is the axial distance between the first lens element and the second lens element, T_{23} is the axial distance between the second lens element and the third lens element, and the following relation is preferably satisfied:

$$0.39 < T_{12}/T_{23} < 1.25.]$$

23. The image pickup optical lens assembly of claim [21] 15, wherein f is the focal length of the image pickup optical lens assembly, f_1 is a focal length of the first lens element, and the following relation is satisfied:

$$0.95 < f/f_1 < 1.40.$$

24. The image pickup optical lens assembly of claim 15, wherein the fourth lens element has negative refractive power.

25. The image pickup optical lens assembly of claim 15, wherein v_1 is the Abbe number of the first lens element, v_2 is the Abbe number of the second lens element, and the following relation is satisfied:

$$28 < v_1 - v_2 < 42.$$

26. An image pickup optical lens assembly, sequentially arranged from an object side to an image side, comprising:

a first lens element with positive refractive power, having a convex object-side surface;

a second lens element with negative refractive power, having a convex object-side surface and a concave image-side surface;

a third lens element with positive refractive power;

a fourth lens element with negative refractive power, having a concave object-side surface and a convex image-side surface, both object-side surface and image-side surface thereof being aspheric; and

a fifth lens element with refractive power, having an object-side surface and a concave image-side surface, both object-side surface and image-side surface thereof being aspheric, and the image-side surface of the fifth element having at least one inflection point;

wherein the image pickup optical lens assembly has a total of five lens elements with refractive power, the image pickup optical lens assembly further comprises a stop between an object and the first lens element; CT_4 is a thickness of the fourth lens element near the optical axis, CT_5 is a thickness of the fifth lens element near the optical axis, Sd is an axial distance from the stop to the

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image-side surface of the fifth lens element, Td is an axial distance from the object-side surface of the first lens element to the image-side surface of the fifth lens element, and the following relations are satisfied:

$$0.2 < CT_4/CT_5 < 0.9;$$

$$0.9 < Sd/Td < 1.1.$$

27. The image pickup optical lens assembly of claim 26, wherein the third lens element comprises a convex image-side surface.

28. The image pickup optical lens assembly of claim 26, wherein the object-side surface of the fifth lens element is convex.

29. The image pickup optical lens assembly of claim 26, wherein the fifth lens element has negative refractive power.

30. The image pickup optical lens assembly of claim 26, wherein CT_4 is the thickness of the fourth lens element near the optical axis, CT_5 is the thickness of the fifth lens element near the optical axis, T_{45} is the axial distance between the fourth lens element and the fifth lens element, and the following relation is satisfied:

$$0.3 < (CT_4 + T_{45})/CT_5 < 0.7.$$

31. The image pickup optical lens assembly of claim 26, wherein f is the focal length of the image pickup optical lens assembly, f_4 is a focal length of the fourth lens element, f_5 is a focal length of the fifth lens element, and the following relation is satisfied:

$$|f/f_4| + |f/f_5| < 1.8.$$

32. The image pickup optical lens assembly of claim 26, wherein v_1 is the Abbe number of the first lens element, v_2 is the Abbe number of the second lens element, and the following relation is satisfied:

$$28 < v_1 - v_2 < 42.$$

33. The image pickup optical lens assembly of claim 26, further comprising an image sensor at an image plane, wherein TTL is an axial distance from the object-side surface of the first lens element to the image plane, $ImgH$ is half of the diagonal length of an effective photosensitive area of the image sensor, and the following relation is satisfied:

$$TTL/ImgH < 1.75.$$

34. An image pickup optical lens assembly, sequentially arranged from an object side to an image side, comprising:

a first lens element with positive refractive power, having a convex object-side surface;

a second lens element with negative refractive power, and at least one of an object-side surface and an image-side surface of the second lens element being aspheric;

a third lens element with positive refractive power;

a fourth lens element with negative refractive power, having a concave object-side surface and a convex image-side surface, both object-side surface and image-side surface thereof being aspheric; and

a fifth lens element with refractive power, having a concave image-side surface, both object-side surface and image-side surface thereof being aspheric, and the image-side surface of the fifth lens element having at least one inflection point;

wherein the image pickup optical lens assembly has a total of five lens elements with refractive power, a gap on the optical axis is formed between any two adjacent lens elements among the first lens element, the second lens element, the third lens element, the fourth lens element and the fifth lens element; the image pickup optical lens

assembly further comprises a stop between an object and the first lens element, f is a focal length of the image pickup optical lens assembly, f_1 is a focal length of the first lens element, Td is an axial distance from the object-side surface of the first lens element to the image-side surface of the fifth lens element, Sd is an axial distance from the stop to the image-side surface of the fifth lens element, and the following relations are satisfied:

$$0.85 < f/f_1 < 1.55;$$

$$0.9 < Sd/Td < 1.1.$$

35. The image pickup optical lens assembly of claim 34, wherein the third lens element comprises a convex image-side surface.

36. The image pickup optical lens assembly of claim 34, wherein the object-side surface of the fifth lens element is convex.

37. The image pickup optical lens assembly of claim 34, wherein the fifth lens element has negative refractive power.

38. The image pickup optical lens assembly of claim 34, wherein the object-side surface of the second lens element is convex and the image-side surface of the second lens element is concave.

39. The image pickup optical lens assembly of claim 34, wherein v_1 is the Abbe number of the first lens element, v_2 is the Abbe number of the second lens element, and the following relation is satisfied:

$$28 < v_1 - v_2 < 42.$$

40. The image pickup optical lens assembly of claim 34, wherein f is the focal length of the image pickup optical lens assembly, f_1 is a focal length of the first lens element, and the following relation is satisfied:

$$0.85 < f/f_1 < 1.40.$$

41. The image pickup optical lens assembly of claim 34, wherein CT_4 is a thickness of the fourth lens element near the

optical axis, CT_5 is a thickness of the fifth lens element near the optical axis, and the following relation is satisfied:

$$0.2 < CT_4/CT_5 < 0.9.$$

42. The image pickup optical lens assembly of claim 34, wherein CT_4 is a thickness of the fourth lens element near the optical axis, CT_5 is a thickness of the fifth lens element near the optical axis, and the following relation is satisfied:

$$0.2 < CT_4/CT_5 < 0.55.$$

43. The image pickup optical lens assembly of claim 34, wherein CT_4 is a thickness of the fourth lens element near the optical axis, CT_5 is a thickness of the fifth lens element near the optical axis, T_{45} is an axial distance between the fourth lens element and the fifth lens element, and the following relation is satisfied:

$$0.3 < (CT_4 + T_{45})/CT_5 < 0.7.$$

44. The image pickup optical lens assembly of claim 34, wherein f is the focal length of the image pickup optical lens assembly, f_4 is a focal length of the fourth lens element, f_5 is a focal length of the fifth lens element, and the following relation is satisfied:

$$|f/f_4| + |f/f_5| < 1.8.$$

45. The image pickup optical lens assembly of claim 34, wherein f is the focal length of the image pickup optical lens assembly, f_4 is a focal length of the fourth lens element, f_5 is a focal length of the fifth lens element, and the following relation is satisfied:

$$|f/f_4| + |f/f_5| < 0.6.$$

46. The image pickup optical lens assembly of claim 34, further comprising an image sensor at an image plane, wherein TTL is an axial distance from the object-side surface of the first lens element to the image plane, $ImgH$ is half of the diagonal length of an effective photosensitive area of the image sensor, and the following relation is satisfied:

$$TTL/ImgH \leq 1.75.$$

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