US010365455B2

(12) **United States Patent**
Jo

(10) **Patent No.: US 10,365,455 B2**
(45) **Date of Patent: Jul. 30, 2019**

(54) **OPTICAL SYSTEM**

(71) Applicant: **Samsung Electro-Mechanics Co., Ltd.**, Suwon-si (KR)

(72) Inventor: **Yong Joo Jo**, Suwon-si (KR)

(73) Assignee: **Samsung Electro-Mechanics Co., Ltd.**, Suwon-si (KR)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 506 days.

(21) Appl. No.: **14/670,103**

(22) Filed: **Mar. 26, 2015**

(65) **Prior Publication Data**

US 2016/0109688 A1 Apr. 21, 2016

(30) **Foreign Application Priority Data**

Oct. 20, 2014 (KR) 10-2014-0142082

(51) **Int. Cl.**
G02B 13/00 (2006.01)
H04N 5/225 (2006.01)

(52) **U.S. Cl.**
CPC ***G02B 13/0045*** (2013.01); ***H04N 5/2253*** (2013.01); ***H04N 5/2254*** (2013.01)

(58) **Field of Classification Search**
CPC G02B 9/62; G02B 9/64; G02B 13/0045; H04N 5/2253
USPC 359/713, 756–762
See application file for complete search history.

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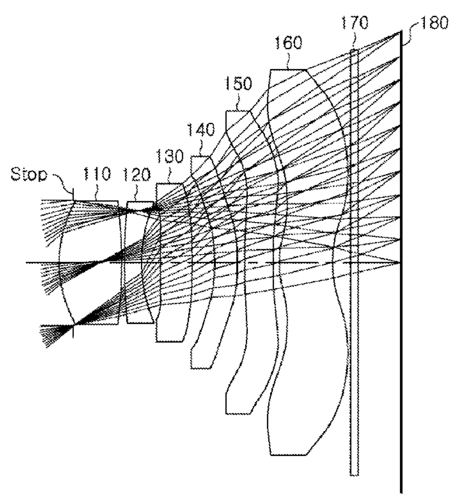
Primary Examiner — Darryl J Collins
Assistant Examiner — Gary W O'Neill
(74) *Attorney, Agent, or Firm* — NSIP Law

(57) **ABSTRACT**

An optical system includes: a first lens having refractive power; a second lens having refractive power; a third lens having refractive power and comprising an image-side surface which is convex in a paraxial region; a fourth lens having refractive power; a fifth lens having refractive power and comprising an image-side surface which is concave in the paraxial region; a sixth lens having refractive power; and a stop disposed in front of an object-side surface of the first lens. The first to sixth lenses are sequentially disposed from an object side. A radius of the stop SD and an overall focal length of the optical system f satisfy: 0.2<SD/f<0.6. An aberration improvement effect and high degrees of resolution and brightness may be obtained.

30 Claims, 17 Drawing Sheets



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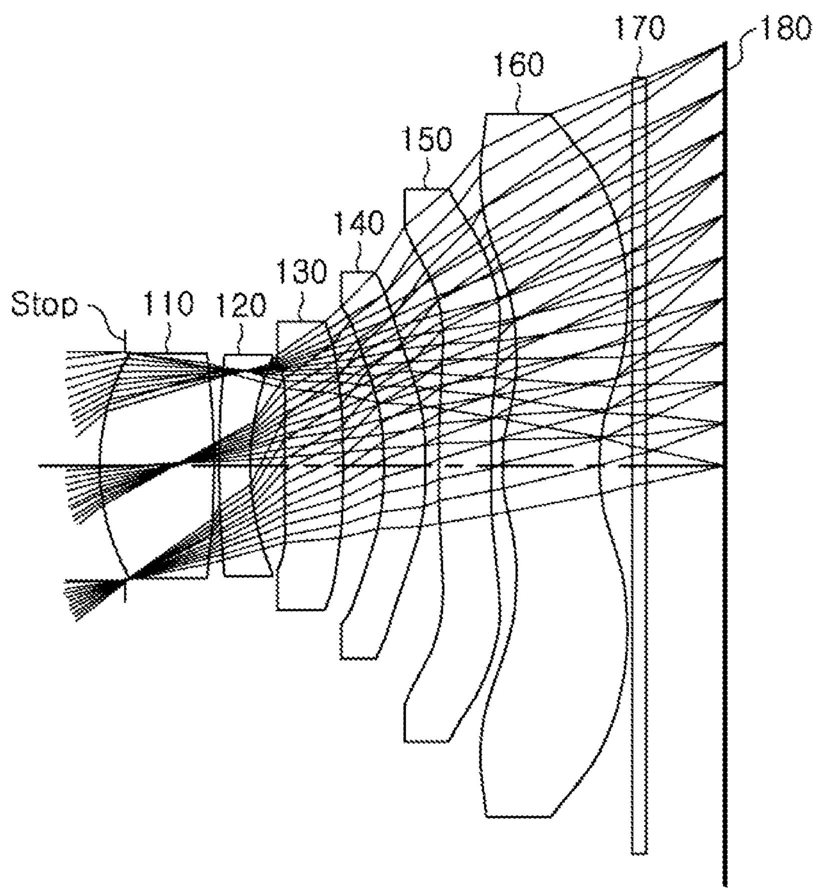

FIG. 1

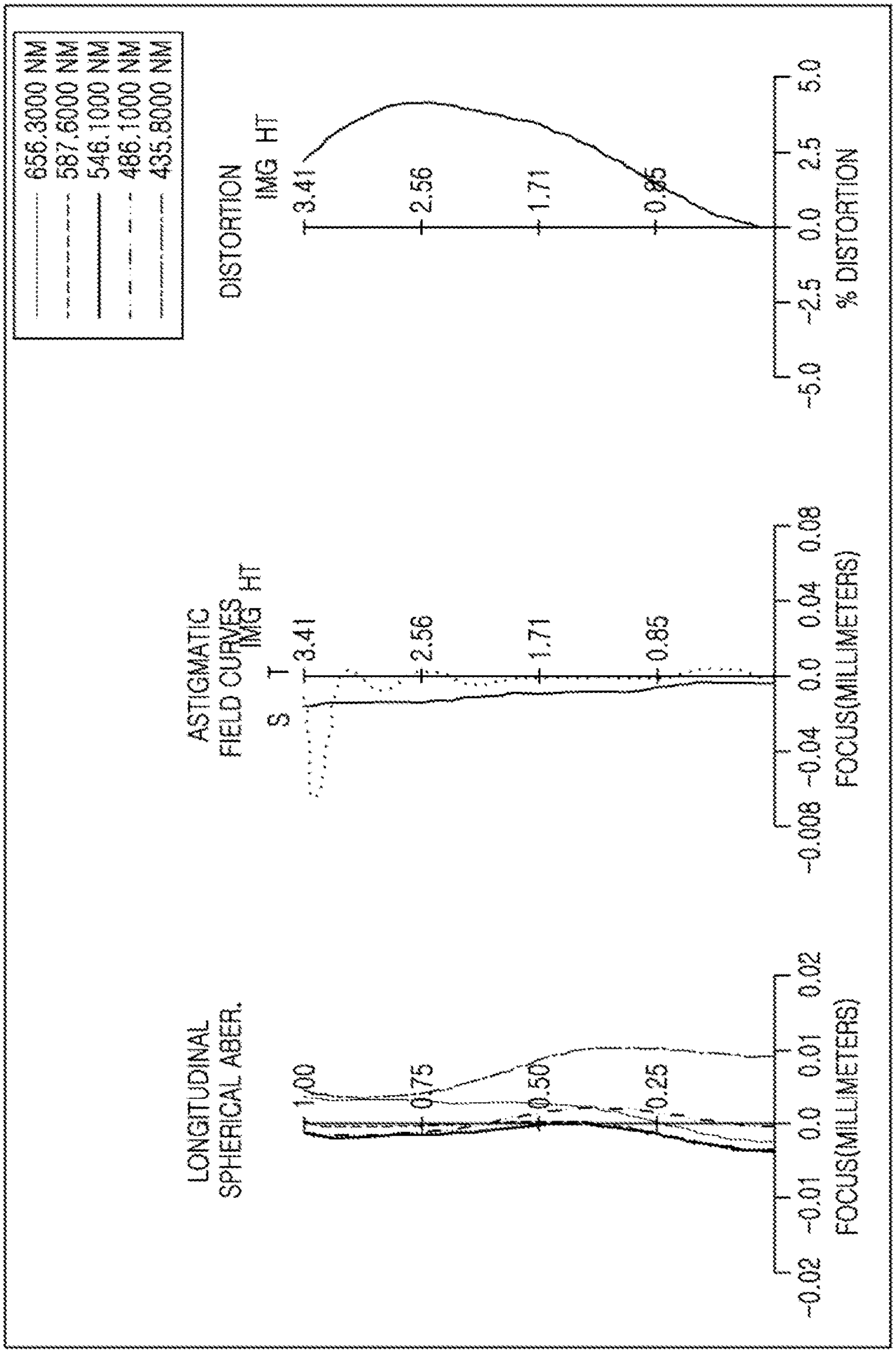
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FIG. 2

Surface	Radius	Thickness	index	abbe
object	Infinity	Infinity		
Stop	Infinity	-0.2		
1	1.75297	0.933159	1.544	56
2	-11.60468	0.04		
3	10.77031	0.26	1.65	21.5
4	2.60444	0.277373		
5	-415.90995	0.467597	1.544	56
6	-15.19837	0.332274		
7	-3.53069	0.35	1.65	21.5
8	-3.64307	0.11715		
9	-109.29655	0.413218	1.65	21.5
10	8.78381	0.105132		
11	1.57574	0.77363	1.544	56
12	1.42813	0.280467		
13	Infinity	0.11		
14	Infinity	0.63746		
Image	Infinity	0.003527		

FIG. 3

surface#	1	2	3	4	5	6	7	8	9	10	11	12
Conic Constant (K)	-0.449842	-11.253646	-12.4411	4.457357	-1.000001	8.349532	5.178262	-28.220618	62.250376	-18.764787	-6.588167	-0.883233
4th Order Coefficient (A)	0.00100503	0.0060599	0.00271654	-0.0558586	-0.0914572	-0.0891381	-0.200228	-0.327898	0.109548	0.0573138	-0.164914	-0.224465
6th Order Coefficient (B)	0.00106608	-0.0159811	0.075758	0.111284	0.0083718	0.077573	0.408322	0.547514	-0.100119	-0.0628692	0.0511963	0.096093
8th Order Coefficient (C)	-0.0134317	-0.0740072	-0.159488	-0.17173	-0.0203979	-0.102557	-0.431399	-0.622292	0.0148558	0.0177702	-0.00731902	-0.0352947
10th Order Coefficient (D)	0.00814016	0.0617329	0.127677	0.185651	0.0166807	0.0835712	0.288914	0.456176	0.00687267	-0.00220371	0.000538823	0.0091881
12th Order Coefficient (E)	-0.00941755	-0.0192946	-0.0347192	-0.123889	-0.00475398	-0.0375674	-0.106621	-0.195963	-0.00289806	8.90118E-05	-1.68562E-05	-0.00154846
14th Order Coefficient (F)	0.00518167	0.00271445	-0.0017115	0.0368257	0.000576302	0.0104986	0.0170003	0.0458903	0.000437603	6.3523E-06	-1.53482E-07	0.00015723
16th Order Coefficient (G)	-0.00329098	-0.000144113	0.00144152	-0.00301921	-0.000025197	-0.00130281	-0.000614321	-0.00506656	-3.02151E-05	-7.47264E-07	2.23963E-08	-8.66409E-06
18th Order Coefficient (H)	0	0	0	0	0	0	0	0.000161234	7.93984E-07	2.06804E-08	-3.8677E-10	1.98267E-07

FIG. 4

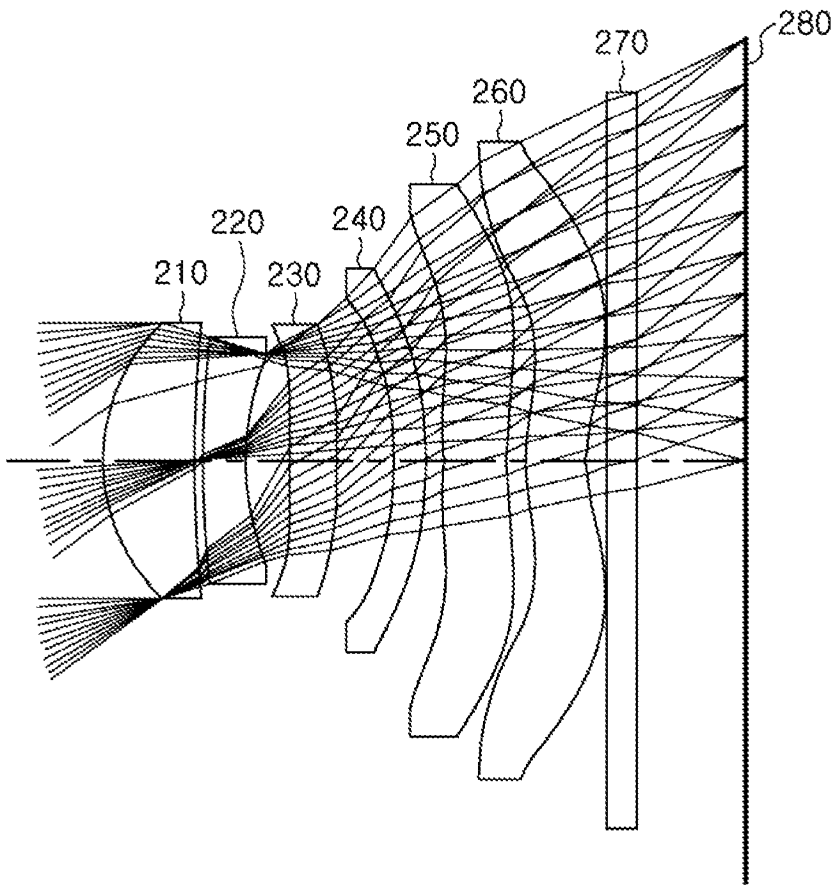

FIG. 5

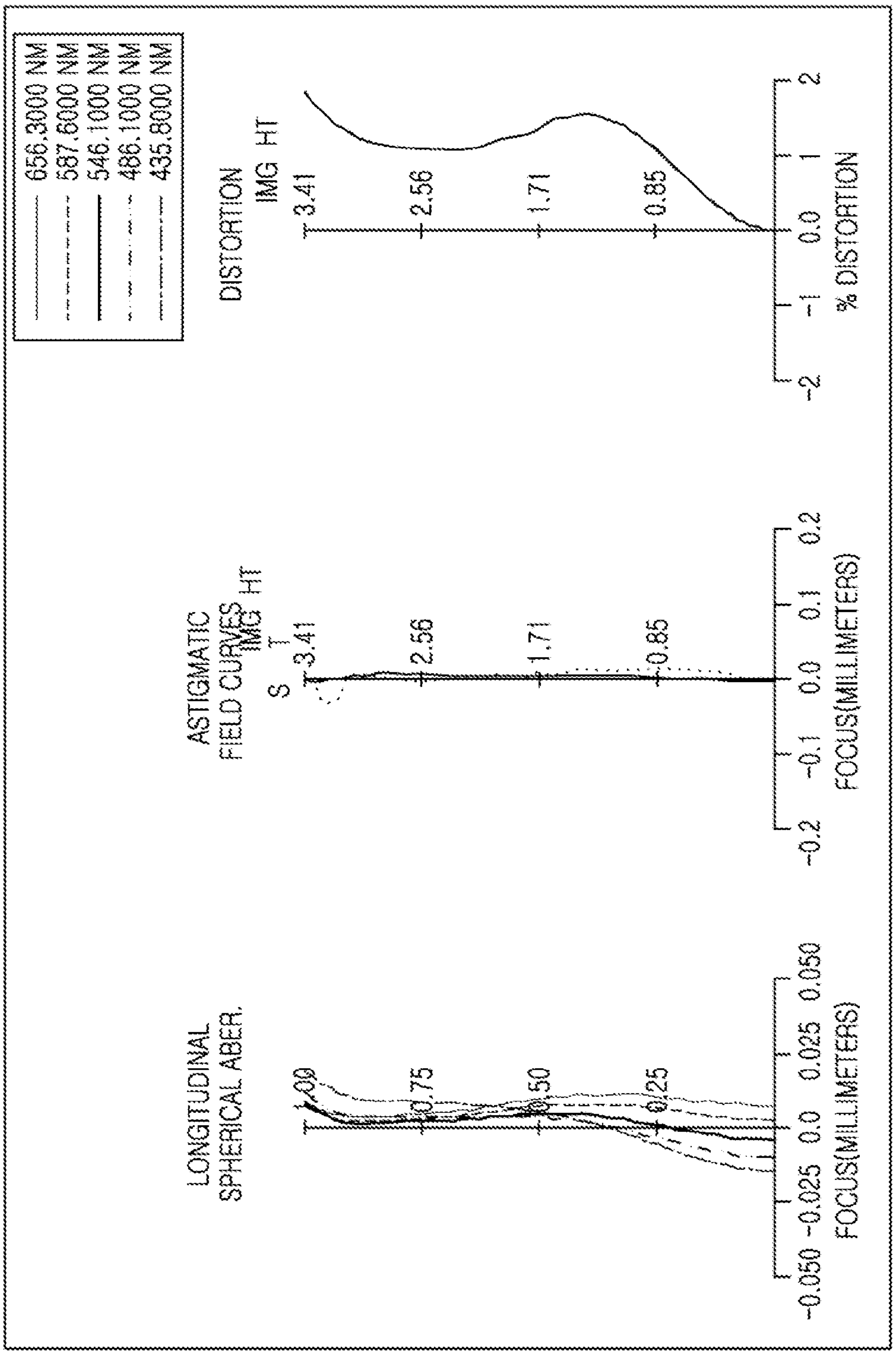
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FIG. 6

Surface	Radius	Thickness	index	abbe
object	Infinity	Infinity		
Stop	Infinity	0		
1	1.54386	0.756625	1.544	56
2	7.36676	0.069536		
3	6.09854	0.348308	1.65	21.5
4	2.60963	0.363295		
5	385.18367	0.363145	1.544	56
6	-19.14258	0.478409		
7	-3.63695	0.25534	1.65	21.5
8	-3.44257	0.138881		
9	80.18601	0.532001	1.65	21.5
10	7.65282	0.139073		
11	1.49851	0.50298	1.544	56
12	1.32355	0.166645		
13	Infinity	0.243377		
14	Infinity	0.885705		
Image	Infinity	0.004178		

FIG. 7

surface#	1	2	3	4	5	6	7	8	9	10	11	12
Conic Constant (K)	-0.052559	-11.253646	-12.441134	5.48487	-1	8.349523	5.559613	-28.221293	62.250377	-18.764726	-5.127431	-0.87948
4th Order Coefficient (A)	0.00360349	-0.107271	-0.144857	-0.0935829	-0.113295	-0.0966778	-0.126119	-0.200357	0.0905406	-0.0268346	-0.252963	-0.33842
6th Order Coefficient (B)	0.0020595	0.153191	0.214307	0.102744	0.0190357	0.046124	0.364476	0.424425	-0.11261	0.0116472	0.0930167	0.177303
8th Order Coefficient (C)	0.00292829	-0.096518	-0.120293	-0.02993	-0.0431131	-0.119407	-0.629414	-0.652356	0.0417211	-0.0162777	-0.0170046	-0.0808554
10th Order Coefficient (D)	-0.00226946	0.0318756	0.0104009	-0.0872016	0.0413532	0.159126	0.578874	0.558076	-0.0072388	0.00724783	0.00182515	0.0265537
12th Order Coefficient (E)	0.00202221	-0.005721	0.0205625	0.132442	-0.0146345	-0.08668	-0.274982	-0.255628	0.000639584	-0.00150178	-0.000116354	-0.00567393
14th Order Coefficient (F)	0	0.000526963	-0.00932828	-0.0918367	0.00225633	0.0223171	0.062242	0.059377	-2.65084E-05	0.000152257	4.00492E-06	0.000735553
16th Order Coefficient (G)	0	-1.94778E-05	0.00124812	0.0241889	-0.000128731	0	-0.0052167	-0.00553433	3.5643E-07	-6.03109E-06	-5.66534E-08	-5.21582E-05
18th Order Coefficient (H)	0	0	0	5.08542E-08	0	0	-1.75775E-08	0	0	0	0	1.54729E-06

FIG. 8

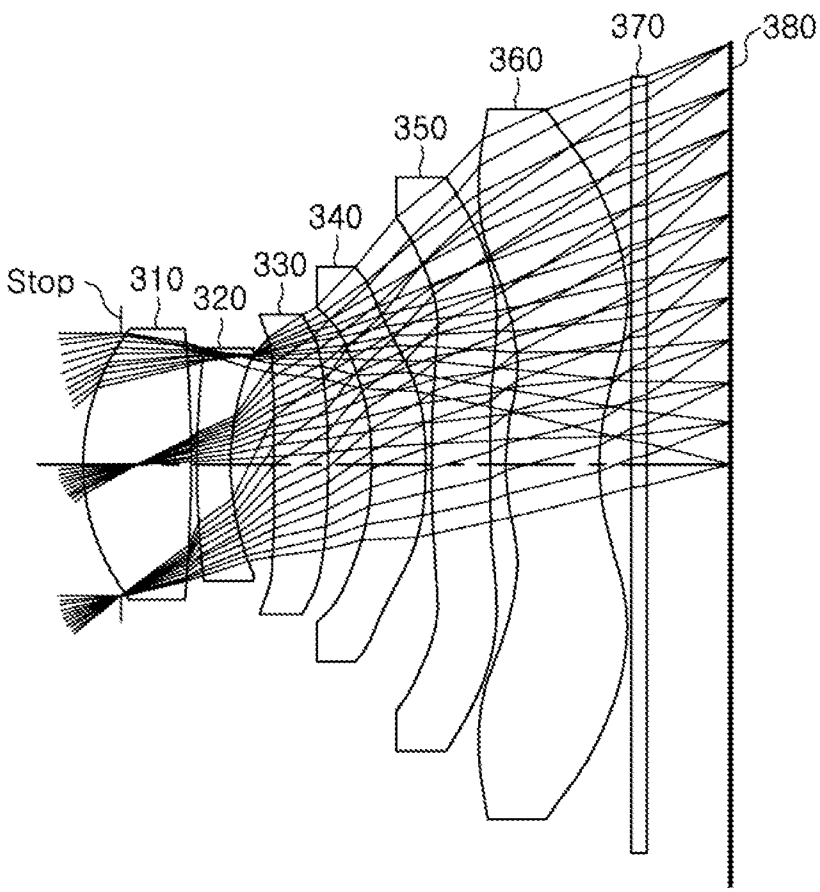

FIG. 9

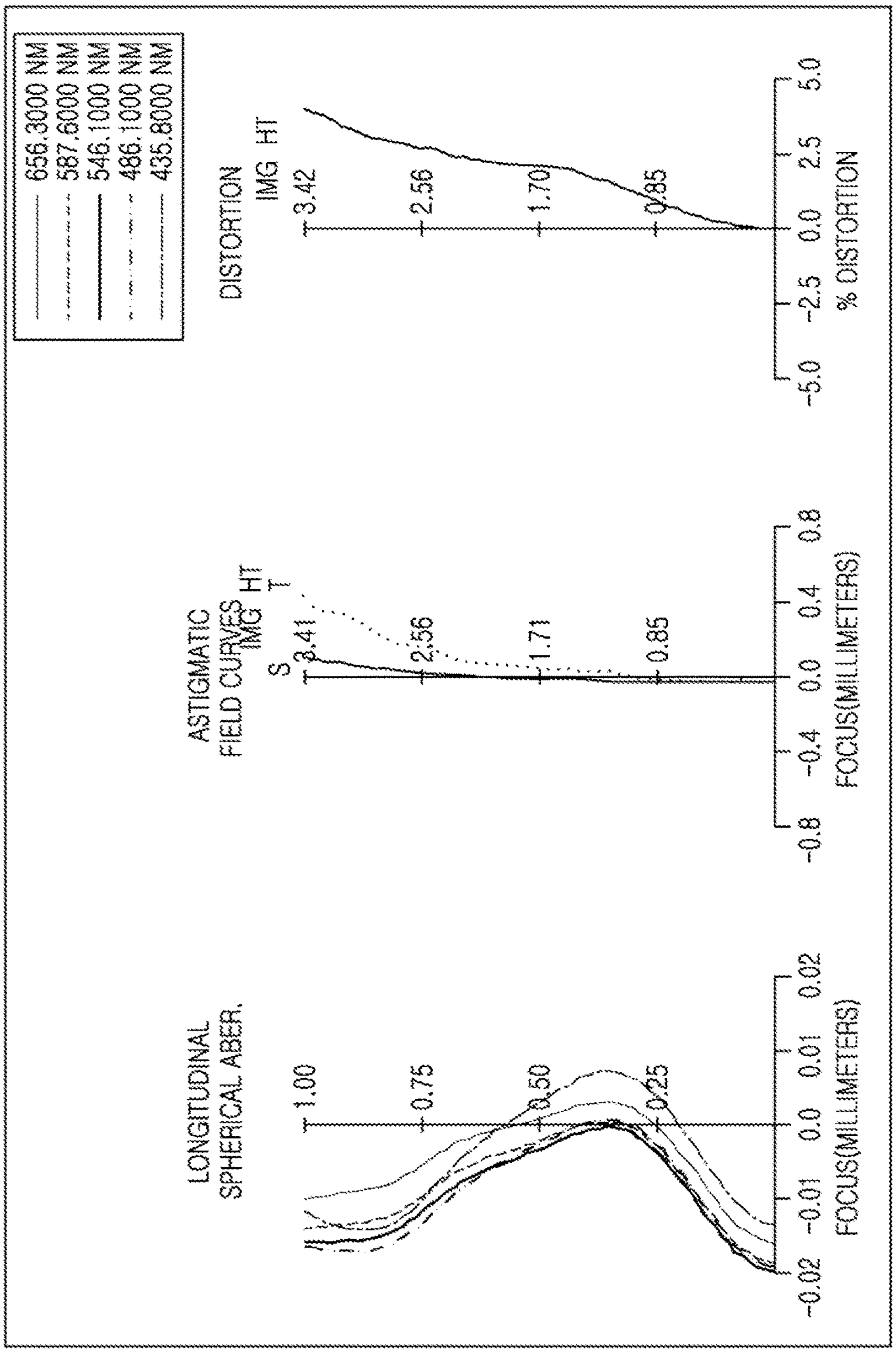
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FIG. 10

Surface	Radius	Thickness	index	abbe
object	Infinity	Infinity		
Stop	Infinity	-0.3		
1	1.76795	0.869339	1.544	56
2	-67.63849	0.057665		
3	7.5392	0.274915	1.65	21.5
4	2.4705	0.344471		
5	21.12793	0.43835	1.544	56
6	-20.59732	0.370079		
7	-3.25122	0.435976	1.65	21.5
8	-3.04163	0.040056		
9	-150	0.475626	1.65	21.5
10	10.59998	0.12528		
11	1.55878	0.756757	1.544	56
12	1.33639	0.271132		
13	Infinity	0.11		
14	Infinity	0.69278		
Image	Infinity	0.019719		

FIG. 11

surface#	1	2	3	4	5	6	7	8	9	10	11	12
Conic Constant (K)	-0.25575	-11.253646	-12.441134	3.88217	-1	8.349523	5.290824	-28.221293	62.250377	-18.763484	-5.920816	-0.872361
4th Order Coefficient (A)	-0.00302343	-0.04531	-0.0852363	-0.0893947	-0.0861022	-0.102289	-0.221975	-0.38017	0.124632	0.0329242	-0.2225	-0.265418
6th Order Coefficient (B)	0.0358615	0.133038	0.227813	0.101413	0.0327803	0.0972539	0.361987	0.57802	-0.108018	-0.0264048	0.0850006	0.121183
8th Order Coefficient (C)	-0.108194	-0.180345	-0.252481	0.0108667	-0.0370855	-0.162109	-0.334772	-0.639115	0.0321874	-0.00162263	-0.0163516	-0.0463323
10th Order Coefficient (D)	0.175081	0.094949	0.108271	-0.285417	0.021828	0.193762	0.215339	0.458291	-0.00509998	0.00341481	0.00188921	0.0124328
12th Order Coefficient (E)	-0.162056	-0.023947	0.00351605	0.437041	-0.00561264	-0.148598	-0.0745034	-0.190085	0.000554684	-0.000873761	-0.000135189	-0.00215333
14th Order Coefficient (F)	0.0776197	0.00291947	-0.013645	-0.300097	0.000651777	0.0629708	0.00833079	0.0414837	-5.10706E-05	0.000103236	5.82267E-06	0.000224831
16th Order Coefficient (G)	-0.0157586	-0.000138473	0.00247186	0.0771892	-2.79363E-05	-0.0118002	0.000471185	-0.00375939	3.46833E-06	-6.04581E-06	-1.38289E-07	-1.27689E-05
18th Order Coefficient (H)	0	0	0	0	0	0	0	1.14319E-05	-1.08042E-07	1.42895E-07	1.39485E-09	3.01897E-07

FIG. 12

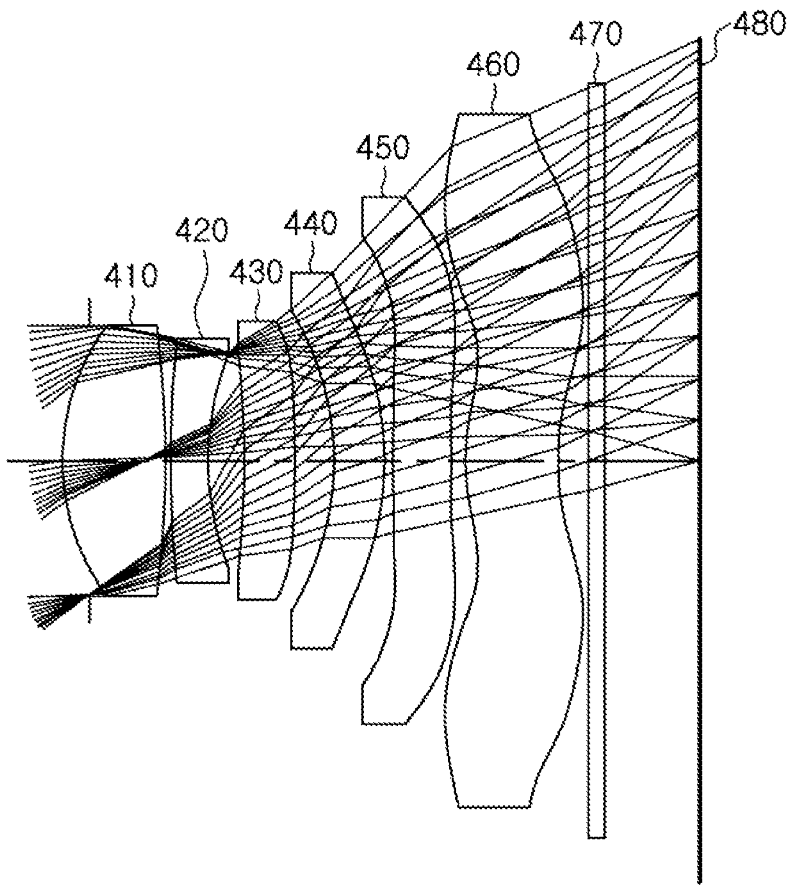
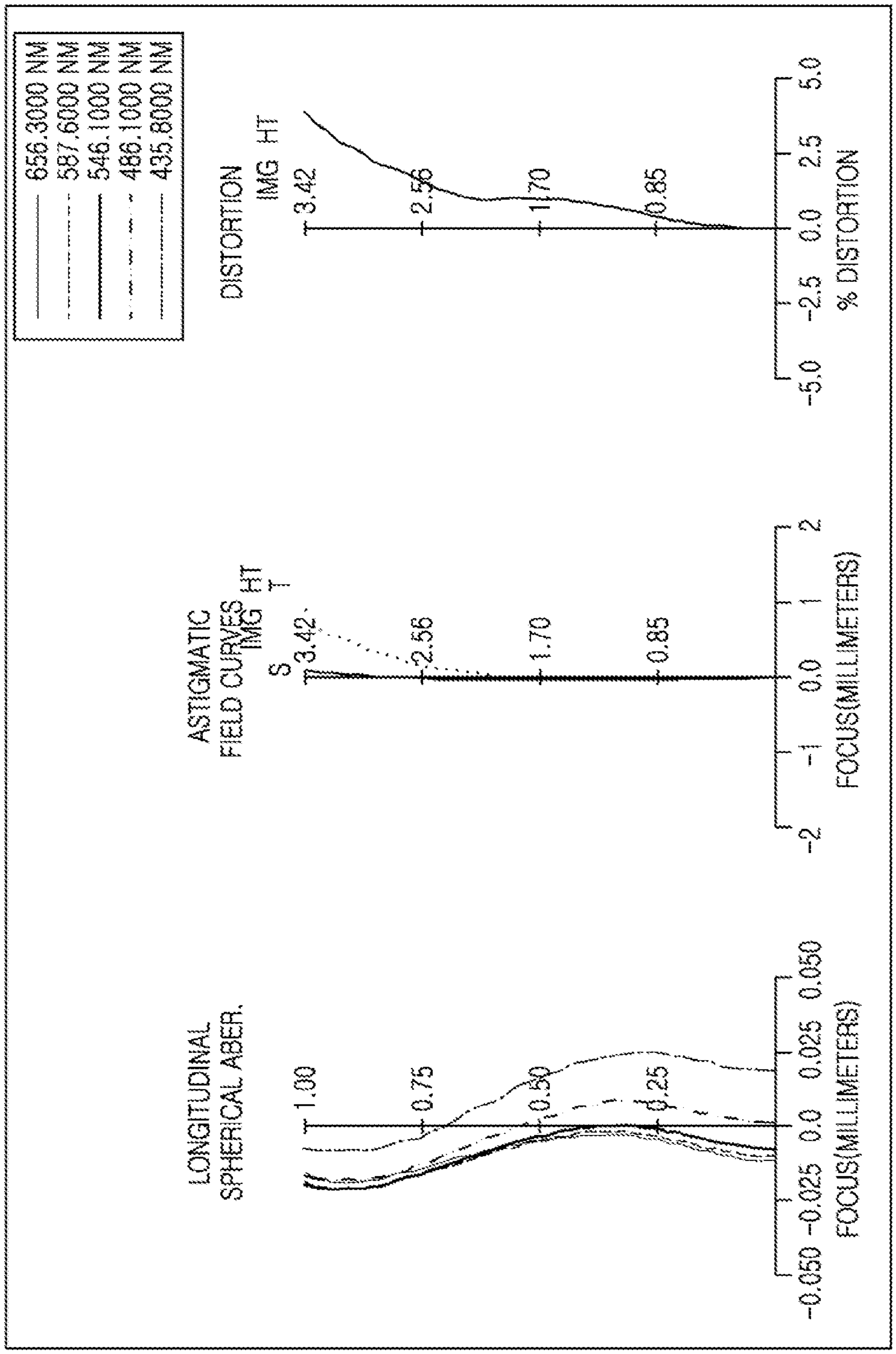


FIG. 13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% DISTORTION

FIG. 14

surface#	1	2	3	4	5	6	7	8	9	10	11	12
Conic Constant (K)	-0.329743	-11.253646	-12.441101	4.046295	-1.000001	8.349533	5.220711	-28.220624	62.250376	-18.764797	-5.754828	-0.862106
4th Order Coefficient (A)	0.000733323	0.00180272	-0.0237036	-0.069467	-0.0786075	-0.100768	-0.227255	-0.34797	0.0960145	-0.0115175	-0.236048	-0.252475
6th Order Coefficient (B)	0.00971879	0.0551512	0.126239	0.105925	0.046488	0.134144	0.458022	0.564116	-0.102197	-0.00417163	0.0953693	0.114132
8th Order Coefficient (C)	-0.0260678	-0.11849	-0.134721	-0.105213	-0.0532971	-0.183014	-0.478663	-0.638104	0.0371847	-0.00554704	-0.0192375	-0.0427592
10th Order Coefficient (D)	0.020684	0.0676235	-0.0124213	0.00113296	0.0274876	0.167025	0.318061	0.467488	-0.00866713	0.00305198	0.00233256	0.0113249
12th Order Coefficient (E)	-0.00219226	-0.0172956	0.107157	0.0905485	-0.00645446	-0.100277	-0.113177	-0.198748	0.00169252	-0.000617535	-0.000176601	-0.00195527
14th Order Coefficient (F)	-0.00348289	0.00209208	-0.061163	-0.089023	0.0007021	0.0325731	0.0144605	0.0453171	-0.000246858	6.23054E-05	8.12608E-06	0.000205986
16th Order Coefficient (G)	0.00316412	-9.75318E-05	0.0105133	0.0268416	-2.86401E-05	-0.00346206	0	-0.00470895	2.06161E-05	-3.15703E-06	-2.07536E-07	-0.00001193
18th Order Coefficient (H)	0	0	0	0	0	0	0	0.000117277	-7.02739E-07	6.42213E-08	2.25495E-09	2.89839E-07

FIG. 15

surface#	1	2	3	4	5	6	7	8	9	10	11	12
Conic Constant (K)	-0.329743	-11.253646	-12.441101	4.046296	-1.000001	8.349533	5.220711	-28.220624	62.250376	-18.764797	-5.754828	-0.862106
4th Order Coefficient (A)	0.000733323	0.00180272	-0.0237036	-0.069467	-0.0786075	-0.100768	-0.227255	-0.34797	0.0960145	-0.0115175	-0.236048	-0.252475
6th Order Coefficient (B)	0.00971879	0.0551512	0.126239	0.105925	0.046488	0.134144	0.458022	0.564116	-0.102197	-0.00417163	0.0953693	0.114132
8th Order Coefficient (C)	-0.0260678	-0.11849	-0.134721	-0.105213	-0.0532971	-0.183014	-0.478663	-0.638104	0.0371847	-0.00554704	-0.0192375	-0.0427592
10th Order Coefficient (D)	0.020684	0.0676235	-0.0124213	0.00113296	0.0274876	0.167025	0.318061	0.467488	-0.00866713	0.00305198	0.00233256	0.0113249
12th Order Coefficient (E)	-0.00219226	-0.0172956	0.107157	0.0905485	-0.00645446	-0.100277	-0.113177	-0.198748	0.00169252	-0.000617535	-0.000176601	-0.00195527
14th Order Coefficient (F)	-0.00948289	0.00209208	-0.061163	-0.089023	0.0007021	0.0325731	0.0144605	0.0453171	-0.000246858	6.23054E-05	8.12608E-06	0.000205986
16th Order Coefficient (G)	0.00316412	-9.75318E-05	0.0105133	0.0268416	-2.86401E-05	-0.00346206	0	-0.00470895	2.06161E-05	-3.15703E-06	-2.07536E-07	-0.00001193
18th Order Coefficient (H)	0	0	0	0	0	0	0	0.000117277	-7.02739E-07	6.42213E-08	2.25495E-09	2.89839E-07

FIG. 16

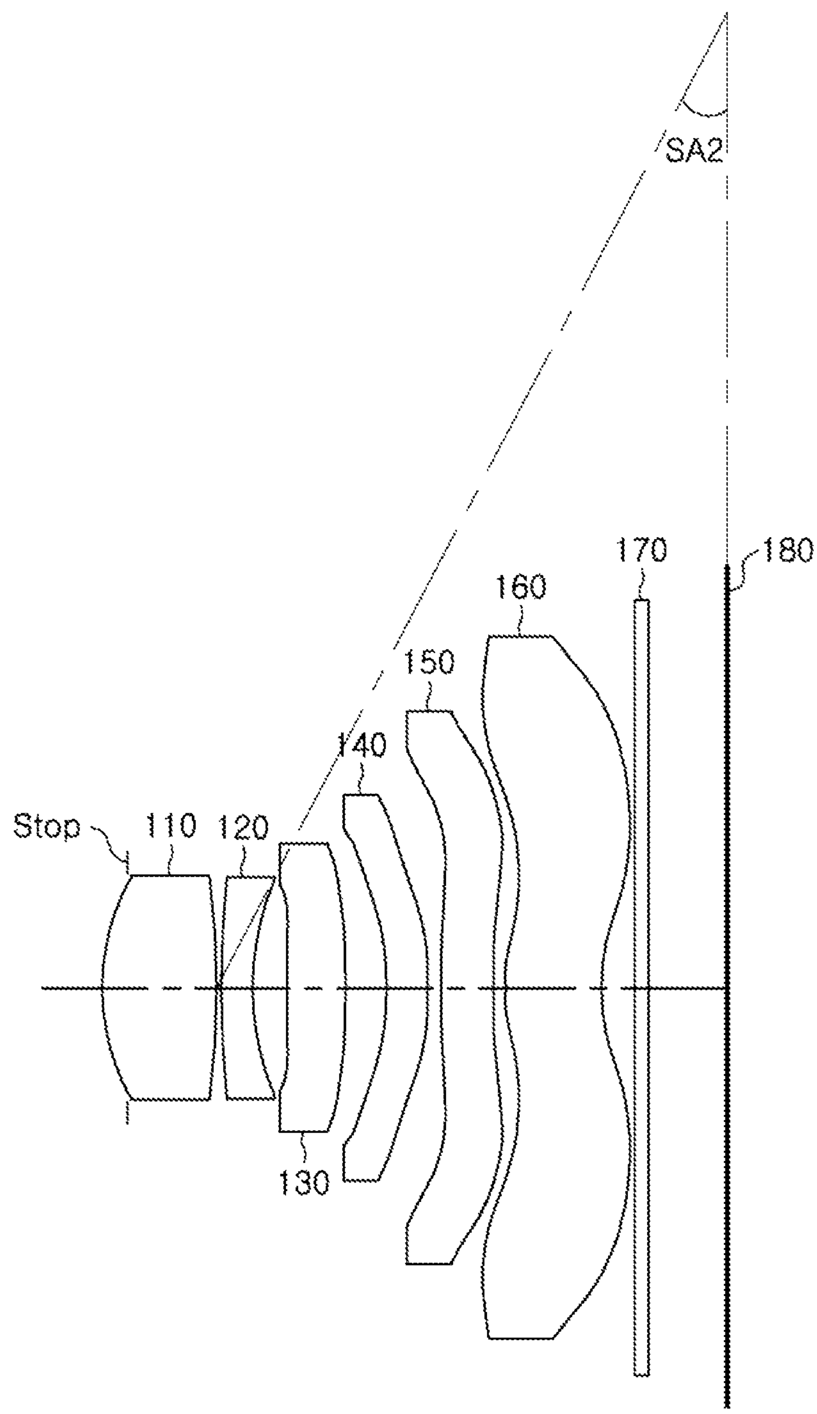

FIG. 17

OPTICAL SYSTEM

CROSS-REFERENCE TO RELATED APPLICATION

This application claims priority and benefit of Korean Patent Application No. 10-2014-0142082, filed on Oct. 20, 2014, with the Korean Intellectual Property Office, the disclosure of which is incorporated in its entirety herein by reference.

BACKGROUND

Some embodiments of the present disclosure may relate to an optical system.

Recently, mobile communications terminals have commonly been provided with camera modules, enabling image capturing and video calling. In addition, as levels of functionality of cameras in such mobile communications terminals have gradually increased, cameras for use in mobile communications terminals have gradually been required to have higher levels of resolution and performance.

However, since there is a trend for mobile communications terminals to be miniaturized and lightened, there are limitations in obtaining camera modules having high levels of resolution and high degrees of performance.

In order to resolve such issues, recently, camera lenses have been formed of plastic, a material lighter than glass, and lens modules have been configured of five or more lenses to achieve high degrees of resolution.

SUMMARY

An aspect of the present disclosure may provide an optical system in which an aberration improvement effect, a high degree of brightness, and/or a high degree of resolution may be implemented.

According to an aspect of the present disclosure, an optical system may include: a first lens having refractive power; a second lens having refractive power; a third lens having refractive power and comprising an image-side surface which is convex in a paraxial region; a fourth lens having refractive power; a fifth lens having refractive power and comprising an image-side surface which is concave in the paraxial region; a sixth lens having refractive power; and a stop disposed in front of an object-side surface of the first lens. The first to sixth lenses may be sequentially disposed from an object side to an image side. A radius of the stop SD and an overall focal length of the optical system f satisfy: $0.2<SD/f<0.6$, whereby an aberration improvement effect and high degrees of resolution and brightness may be obtained.

Other embodiments are also described. The above summary does not include an exhaustive list of all aspects of the present invention. It is contemplated that the invention includes all optical systems that can be practiced from all suitable combinations of the various aspects summarized above, as well as those disclosed in the Detailed Description below and particularly pointed out in the claims filed with the application. Such combinations have particular advantages not specifically recited in the above summary.

BRIEF DESCRIPTION OF DRAWINGS

The above and other aspects, features and advantages of the present disclosure will be more clearly understood from

the following detailed description taken in conjunction with the accompanying drawings, in which:

FIG. **1** is a schematic view of an optical system according to a first exemplary embodiment in the present disclosure;

FIG. **2** is graphs having curves representing aberration characteristics of the optical system illustrated in FIG. **1**;

FIG. **3** is a table showing characteristics of lenses in the optical system illustrated in FIG. **1**;

FIG. **4** is a table showing aspherical surface coefficients of lenses in the optical system illustrated in FIG. **1**;

FIG. **5** is a schematic view of an optical system according to a second exemplary embodiment in the present disclosure;

FIG. **6** is graphs having curves representing aberration characteristics of the optical system illustrated in FIG. **5**;

FIG. **7** is a table showing characteristics of lenses in the optical system illustrated in FIG. **5**;

FIG. **8** is a table showing aspherical surface coefficients of lenses in the optical system illustrated in FIG. **5**;

FIG. **9** is a schematic view of an optical system according to a third exemplary embodiment in the present disclosure;

FIG. **10** is graphs having curves representing aberration characteristics of the optical system illustrated in FIG. **9**;

FIG. **11** is a table showing characteristics of lenses in the optical system illustrated in FIG. **9**;

FIG. **12** is a table showing aspherical surface coefficients of lenses in the optical system illustrated in FIG. **9**;

FIG. **13** is a schematic view of an optical system according to a fourth exemplary embodiment in the present disclosure;

FIG. **14** is graphs having curves representing aberration characteristics of the optical system illustrated in FIG. **13**;

FIG. **15** is a table showing characteristics of lenses in the optical system illustrated in FIG. **13**;

FIG. **16** is a table showing aspherical surface coefficients of lenses in the optical system illustrated in FIG. **13**; and

FIG. **17** is an exemplary view showing an angle between a tangent line passing through an edge of an effective portion of an image-side surface of a second lens and an imaging surface of an image sensor in the optical system illustrated in FIG. **1**.

DETAILED DESCRIPTION

Hereinafter, embodiments of the present disclosure will be described in detail with reference to the accompanying drawings.

The disclosure may, however, be embodied in many different forms and should not be construed as being limited to the embodiments set forth herein. Rather, these embodiments are provided so that this disclosure will be thorough and complete, and will fully convey the scope of the disclosure to those skilled in the art.

In the drawings, the shapes and dimensions of elements may be exaggerated for clarity, and the same reference numerals will be used throughout to designate the same or like elements.

In the drawings, the thicknesses, sizes, and shapes of lenses have been slightly exaggerated for convenience of explanation. Particularly, the shapes of spherical surfaces and aspherical surfaces are illustrated byway of example, but are not limited to those illustrated in the drawings.

In embodiments of the present specification, a first lens refers to a lens closest to an object, and a sixth lens refers to a lens closest to an image sensor.

In addition, a first surface of each lens refers to a surface thereof closer to or facing the object side (or an object-side surface) and a second surface of each lens refers to a surface thereof closer to or facing the image side (or an image-side surface). Further, unless otherwise indicated herein, in embodiments of the present disclosure, numerical values of radii of curvature, thicknesses, and the like, of lenses are represented by millimeters (mm). In addition, a paraxial region may refer to a very narrow region on an optical axis and/or in the vicinity of an optical axis.

An optical system according to exemplary embodiments may include six or more lenses.

For example, the optical system may include a first lens, a second lens, a third lens, a fourth lens, a fifth lens, and a sixth lens.

However, the optical system is not limited to including only six lenses, and may further include other components or additional one or more lenses, if necessary. For example, the optical system may include a stop for controlling an amount of light. In addition, the optical system may further include an infrared cut-off filter filtering infrared light. Additionally, the optical system may further include an image sensor converting an image of a subject incident on the image sensor into electrical signals. Further, the optical system may further include a gap maintaining member adjusting gaps between lenses.

At least one or more of the first to sixth lenses configuring the optical system according to exemplary embodiments may be formed of plastic. However, at least one or more of the first to sixth lenses may be formed of other materials, for example, but not limited to, glass.

In addition, at least one or more of the first to sixth lenses may have one or both aspherical surfaces. Further, each of the first to sixth lenses may have at least one or both aspherical surfaces.

For instance, at least one of first and second surfaces of the first to sixth lenses may be aspherical. Here, the aspherical surfaces of the first to sixth lenses may be represented by the following Equation 1:

$$Z = \frac{cY^2}{1+\sqrt{1-(1+K)c^2Y^2}} + AY^4 + BY^6 + CY^8 + DY^{10} + EY^{12} + FY^{14} + \ldots \quad \text{[Equation 1]}$$

Here, c is a curvature (an inverse of a radius of curvature) at an apex of the lens, K is a conic constant, and Y is a distance from a certain point on the aspherical surface of the lens to an optical axis in a direction perpendicular to the optical axis. In addition, constants A to F are aspherical surface coefficients and, Z is a distance between the certain point on the aspherical surface at the distance Y and a tangential plane meeting the apex of the aspherical surface of the lens.

The optical system including the first to sixth lenses may have lenses having positive refractive power, negative refractive power, positive refractive power, positive or negative refractive power, negative refractive power, positive refractive power, sequentially from the object side.

The optical system configured as described above may, for example, but not limited to, improve optical performance through aberration improvement. In addition, in some embodiments of the optical system configured as described above, all of the six lenses may be formed of plastic.

The optical system according to exemplary embodiments may satisfy Conditional Expression 1.

$$0.2 < SD/f < 0.6 \quad \text{[Conditional Expression 1]}$$

Here, SD is a radius of the stop, and f is an overall focal length of the optical system.

The optical system according to exemplary embodiments may satisfy Conditional Expression 2.

$$1.1 < TTL/f < 1.35 \quad \text{[Conditional Expression 2]}$$

Here, TTL is a distance from an object-side surface of the first lens to an imaging surface of the image sensor, and f is the overall focal length of the optical system.

The optical system according to exemplary embodiments may satisfy Conditional Expression 3.

$$1.0 < |r9|/f < 40 \quad \text{[Conditional Expression 3]}$$

Here, f is the overall focal length of the optical system, and r9 is a radius of curvature of an object-side surface of the fifth lens.

The optical system according to exemplary embodiments may satisfy Conditional Expression 4.

$$|v5-v6| > 20 \quad \text{[Conditional Expression 4]}$$

Here, v5 is an Abbe number of the fifth lens, and v6 is an Abbe number of the sixth lens.

The optical system according to exemplary embodiments may satisfy Conditional Expression 5.

$$v1-v2 > 20 \quad \text{[Conditional Expression 5]}$$

Here, v1 is an Abbe number of the first lens, and v2 is an Abbe number of the second lens.

The optical system according to exemplary embodiments may satisfy Conditional Expression 6.

$$1.3 < f/f1 < 1.6 \quad \text{[Conditional Expression 6]}$$

Here, f is the overall focal length of the optical system, and f1 is a focal length of the first lens.

The optical system according to exemplary embodiments may satisfy Conditional Expression 7.

$$0.1 < f/f3 < 0.3 \quad \text{[Conditional Expression 7]}$$

Here, f is the overall focal length of the optical system, and f3 is a focal length of the third lens.

The optical system according to exemplary embodiments may satisfy Conditional Expression 8.

$$0.2 < |f/f5| < 0.4 \quad \text{[Conditional Expression 8]}$$

Here, f is the overall focal length of the optical system, and f5 is a focal length of the fifth lens.

The optical system according to exemplary embodiments may satisfy Conditional Expression 9.

$$0 < f1/f3 < 0.2 \quad \text{[Conditional Expression 9]}$$

Here, f1 is the focal length of the first lens, and f3 is the focal length of the third lens.

The optical system according to exemplary embodiments may satisfy Conditional Expression 10.

$$2 < |f/f1| + |f/f2| < 2.5 \quad \text{[Conditional Expression 10]}$$

Here, f is the overall focal length of the optical system, f1 is the focal length of the first lens, and f2 is a focal length of the second lens.

The optical system according to exemplary embodiments may satisfy Conditional Expression 11.

$$0.1 < |f/f3| + |f/f4| < 0.4 \quad \text{[Conditional Expression 11]}$$

Here, f is the overall focal length of the optical system, f3 is the focal length of the third lens, and f4 is a focal length of the fourth lens.

The optical system according to exemplary embodiments may satisfy Conditional Expression 12.

$$0.3<|f/f5|+|f/f6|<0.6 \quad \text{[Conditional Expression 12]}$$

Here, f is the overall focal length of the optical system, f5 is the focal length of the fifth lens, and f6 is a focal length of the sixth lens.

The optical system according to exemplary embodiments may satisfy Conditional Expression 13.

$$1.5<TTL/ImgH<1.7 \quad \text{[Conditional Expression 13]}$$

Here, TTL is the distance from the object-side surface of the first lens to the imaging surface of the image sensor, and ImgH is a diagonal length of the imaging surface of the image sensor.

The optical system according to exemplary embodiments may satisfy Conditional Expression 14.

$$65<FOV<80 \quad \text{[Conditional Expression 14]}$$

Here, FOV is a field of view of the optical system. Here, the FOV is represented by degrees.

The optical system according to exemplary embodiments may satisfy Conditional Expression 15.

$$SA2\leq 30 \quad \text{[Conditional Expression 15]}$$

Here, SA2 is an angle between a tangent line passing through an edge of an effective diameter of an image-side surface of the second lens and the imaging surface of the image sensor (see FIG. **17**). Here, the SA2 is represented by degrees.

Next, the first to sixth lenses configuring the optical system according to exemplary embodiments will be described.

The first lens may have positive refractive power. However, the first lens may have negative refractive power. In addition, both surfaces of the first lens may be convex. For instance, a first surface of the first lens may be convex toward the object in a paraxial region, and a second surface of the first lens may be convex toward the image sensor in the paraxial region. However, one or both of object-side and image-side surfaces of the first lens may be concave.

Alternatively, the first lens may have a meniscus shape which is convex toward the object. In detail, a first surface of the first lens may be convex toward the object in the paraxial region and a second surface of the first lens may be concave toward the image sensor in the paraxial region.

At least one of the first and second surfaces of the first lens may be aspherical. For example, both surfaces of the first lens may be aspherical.

The second lens may have negative refractive power. However, the second lens may have positive refractive power. In addition, the second lens may have a meniscus shape which is convex toward the object. For example, a first surface of the second lens may be convex toward the object in the paraxial region and a second surface of the second lens may be concave toward the image sensor in the paraxial region. However, the object-side surface of the second lens may be concave and/or the image-side surface of the second lens may be convex.

At least one of the first and second surfaces of the second lens may be aspherical. For example, both surfaces of the second lens may be aspherical.

The third lens may have positive refractive power. However, the third lens may have negative refractive power. In addition, the third lens may have a meniscus shape which is convex toward the image sensor. For instance, a first surface of the third lens may be concave toward the object in the paraxial region and a second surface of the third lens may be convex toward the image sensor in the paraxial region. However, the object-side surface of the third lens may be convex and/or the image-side surface of the second lens may be concave.

Alternatively, both surfaces of the third lens may be convex. For example, a first surface of the third lens may be convex toward the object in the paraxial region, and a second surface of the third lens may be convex toward the image sensor in the paraxial region.

At least one of the first and second surfaces of the third lens may be aspherical. For example, both surfaces of the third lens may be aspherical.

The fourth lens may have positive or negative refractive power. In addition, the fourth lens may have a meniscus shape which is convex toward the image sensor. In detail, a first surface of the fourth lens may be concave toward the object in the paraxial region and a second surface of the fourth lens may be convex toward the image sensor in the paraxial region. However, the object-side surface of the fourth lens may be convex and/or the image-side surface of the fourth lens may be concave.

At least one of the first and second surfaces of the fourth lens may be aspherical. For example, both surfaces of the fourth lens may be aspherical.

The fifth lens may have negative refractive power. However, the fifth lens may have positive refractive power. In addition, both surfaces of the fifth lens may be concave. For instance, a first surface of the fifth lens may be concave toward the object in the paraxial region, and a second surface of the fifth lens may be concave toward the image sensor in the paraxial region. However, one or both of object-side and image-side surfaces of the fifth lens may be convex.

Alternatively, the fifth lens may have a meniscus shape which is convex toward the object. In detail, a first surface of the fifth lens may be convex toward the object in the paraxial region and a second surface of the fifth lens may be concave toward the image sensor in the paraxial region. However, the object-side surface of the fifth lens may be concave and/or the image-side surface of the fifth lens may be convex.

At least one of the first and second surfaces of the fifth lens may be aspherical. For example, both surfaces of the fifth lens may be aspherical.

In addition, at least one or more inflection points may be formed on at least one or both of the first and second surfaces of the fifth lens. For example, the second surface of the fifth lens may be concave in the paraxial region and become convex at an edge thereof.

The sixth lens may have positive refractive power. However, the sixth lens may have negative refractive power. In addition, the sixth lens may have a meniscus shape which is convex toward the object. For instance, a first surface of the sixth lens may be convex toward the object in the paraxial region and a second surface of the sixth lens may be concave toward the image sensor in the paraxial region. However, the object-side surface of the sixth lens may be concave and/or the image-side surface of the sixth lens may be convex.

At least one of the first and second surfaces of the sixth lens may be aspherical. For example, both surfaces of the sixth lens may be aspherical.

In addition, at least one or more inflection points may be formed on at least one or both of the first and second surfaces of the sixth lens. For example, the second surface of the sixth lens may be concave in the paraxial region and become convex at an edge thereof.

In the optical system configured as described above, a plurality of lenses may perform an aberration correction function improving aberration performance.

An optical system according to a first exemplary embodiment in the present disclosure will be described with reference to FIGS. **1** through **4**.

The optical system according to the first exemplary embodiment may include a first lens **110**, a second lens **120**, a third lens **130**, a fourth lens **140**, a fifth lens **150**, and a sixth lens **160**, and may further include a stop, an infrared cut-off filter **170**, and an image sensor **180**.

As illustrated in Table 1 (shown below), a focal length (f1) of the first lens **110** may be 2.85 mm, a focal length (f2) of the second lens **120** may be −5.3 mm, a focal length (f3) of the third lens **130** may be 28.86 mm, a focal length (f4) of the fourth lens **140** may be 741.25 mm, a focal length (f5) of the fifth lens **150** may be −12.35 mm, a focal length (f6) of the sixth lens **160** may be 32.76 mm, and an overall focal length (f) of the optical system may be 4.16 mm.

TABLE 1

FOV	68
Fno	2.2
TTL	5.7
f	4.16
f1	2.85
f2	−5.3
f3	28.86
f4	741.25
f5	−12.35
f6	32.76
SD/f	0.22
TTL/f	1.36
|r9|/f	26
|v5-v6|	35
v1-v2	35

Here, respective characteristics (radii of curvature, thicknesses, refractive indices, and Abbe numbers) of the lenses **110** to **160** are illustrated in the table of FIG. **3**.

In the first exemplary embodiment, the first lens **110** may have positive refractive power and both surfaces of the first lens **110** may be convex. For example, a first surface of the first lens **110** may be convex toward an object in the paraxial region, and a second surface of the first lens **110** may be convex toward the image sensor in the paraxial region. However, alternatively, the first lens **110** may have negative refractive power, and/or at least one of object-side and image-side surfaces of the first lens **110** may be concave.

The second lens **120** may have negative refractive power. In addition, the second lens **120** may have a meniscus shape which is convex toward the object. For example, a first surface of the second lens **120** may be convex toward the object in the paraxial region and a second surface of the second lens **120** may be concave toward the image sensor in the paraxial region. However, alternatively, the second lens **120** may have positive refractive power, the object-side surface of the second lens **120** may be concave, and/or the image-side surface of the second lens **120** may be convex.

The third lens **130** may have positive refractive power. In addition, the third lens **130** may have a meniscus shape which is convex toward the image sensor. For example, a first surface of the third lens **130** may be concave toward the object in the paraxial region and a second surface of the third lens **130** may be convex toward the image sensor in the paraxial region. However, alternatively, the third lens **130** may have negative refractive power, the object-side surface of the third lens **130** may be convex, and/or the image-side surface of the third lens **130** may be concave.

The fourth lens **140** may have positive refractive power. In addition, the fourth lens **140** may have a meniscus shape which is convex toward the image sensor. For example, a first surface of the fourth lens **140** may be concave toward the object in the paraxial region and a second surface of the fourth lens **140** may be convex toward the image sensor in the paraxial region. However, alternatively, the fourth lens **140** may have negative refractive power, the object-side surface of the fourth lens **140** may be convex, and/or the image-side surface of the fourth lens **140** may be concave.

The fifth lens **150** may have negative refractive power and both surfaces of the fifth lens **150** may be concave. For example, a first surface of the fifth lens **150** may be concave toward the object in the paraxial region, and a second surface of the fifth lens **150** may be concave toward the image sensor in the paraxial region. In addition, at least one inflection point may be formed on at least one of the first and second surfaces of the fifth lens **150**. However, alternatively, the fifth lens **150** may have positive refractive power, and/or at least one of object-side and image-side surfaces of the fifth lens **150** may be convex.

The sixth lens **160** may have positive refractive power. In addition, the sixth lens **160** may have a meniscus shape which is convex toward the object. For example, a first surface of the sixth lens **160** may be convex toward the object in the paraxial region and a second surface of the sixth lens **160** may be concave toward the image sensor in the paraxial region. However, alternatively, the sixth lens **160** may have negative refractive power, the object-side surface of the sixth lens **160** may be concave, and/or the image-side surface of the sixth lens **160** may be convex. In addition, at least one or more inflection points may be formed on at least one or both of the first and second surfaces of the sixth lens **160**.

Meanwhile, the respective surfaces of the first to sixth lenses **110** to **160** may have aspherical coefficients as illustrated in the table of FIG. **4**.

In addition, the stop may be disposed in front of an object-side surface of the first lens **110**. However, alternatively, the stop may be disposed anywhere between the first lens **110** and the sixth lens **160**.

In addition, the optical system configured as described above may have aberration characteristics illustrated in FIG. **2**.

An optical system according to a second exemplary embodiment in the present disclosure will be described with reference to FIGS. **5** through **8**.

The optical system according to the second exemplary embodiment may include a first lens **210**, a second lens **220**, a third lens **230**, a fourth lens **240**, a fifth lens **250**, and a sixth lens **260**, and may further include a stop, an infrared cut-off filter **270**, and an image sensor **280**.

As illustrated in Table 2 (shown below), a focal length (f1) of the first lens **210** may be 3.42 mm, a focal length (f2) of the second lens **220** may be −7.24 mm, a focal length (f3) of the third lens **230** may be 33.42 mm, a focal length (f4) of the fourth lens **240** may be 64.65 mm, a focal length (f5) of the fifth lens **250** may be −12.94 mm, a focal length (f6) of the sixth lens **260** may be 1380 mm, and an overall focal length (f) of the optical system may be 4.71 mm.

TABLE 2

FOV	70
Fno	2.2
TTL	5.3
f	4.71
f1	3.42
f2	−7.24
f3	33.42
f4	64.65
f5	−12.94
f6	1380
SD/f	0.51
TTL/f	1.13
|r9|/f	17
|v5-v6|	35
v1-v2	35

Here, respective characteristics (radii of curvature, thicknesses, refractive indices, and Abbe numbers) of the lenses **210** to **260** are illustrated in the table of FIG. **7**.

In the second exemplary embodiment, the first lens **210** may have positive refractive power. In addition, the first lens **210** may have a meniscus shape which is convex toward the object. For example, a first surface of the first lens **210** may be convex toward the object in the paraxial region and a second surface of the first lens **210** may be concave toward the image sensor in the paraxial region. However, alternatively, the first lens **210** may have negative refractive power, the object-side surface of the first lens **210** may be concave, and/or the image-side surface of the first lens **210** may be convex.

The second lens **220** may have negative refractive power. In addition, the second lens **220** may have a meniscus shape which is convex toward the object. For example, a first surface of the second lens **220** may be convex toward the object in the paraxial region and a second surface of the second lens **220** may be concave toward the image sensor in the paraxial region. However, alternatively, the second lens **220** may have positive refractive power, the object-side surface of the second lens **220** may be concave, and/or the image-side surface of the second lens **220** may be convex.

The third lens **230** may have positive refractive power and both surfaces of the third lens **230** may be convex. For example, a first surface of the third lens **230** may be convex toward the object in the paraxial region, and a second surface of the third lens **230** may be convex toward the image sensor in the paraxial region. However, alternatively, the third lens **230** may have negative refractive power, and/or at least one of the object-side and image-side surfaces of the third lens **230** may be concave.

The fourth lens **240** may have positive refractive power. In addition, the fourth lens **240** may have a meniscus shape which is convex toward the image sensor. For example, a first surface of the fourth lens **240** may be concave toward the object in the paraxial region and a second surface of the fourth lens **240** may be convex toward the image sensor in the paraxial region. However, alternatively, the fourth lens **240** may have negative refractive power, the object-side surface of the fourth lens **240** may be convex, and/or the image-side surface of the fourth lens **240** may be concave.

The fifth lens **250** may have negative refractive power. In addition, the fifth lens **250** may have a meniscus shape which is convex toward the object. For example, a first surface of the fifth lens **250** may be convex toward the object in the paraxial region and a second surface of the fifth lens **250** may be concave toward the image sensor in the paraxial region. However, alternatively, the fifth lens **250** may have positive refractive power, the object-side surface of the fifth lens **250** may be concave, and/or the image-side surface of the fifth lens **250** may be convex. In addition, at least one or more inflection points may be formed on at least one or both of the first and second surfaces of the fifth lens **250**.

The sixth lens **260** may have negative refractive power. In addition, the sixth lens **260** may have a meniscus shape which is convex toward the object. For example, a first surface of the sixth lens **260** may be convex toward the object in the paraxial region and a second surface of the sixth lens **260** may be concave toward the image sensor in the paraxial region. However, alternatively, the sixth lens **260** may have positive refractive power, the object-side surface of the sixth lens **260** may be concave, and/or the image-side surface of the sixth lens **260** may be convex. In addition, at least one or more inflection points may be formed on at least one or both of the first and second surfaces of the sixth lens **260**.

Meanwhile, the respective surfaces of the first to sixth lenses **210** to **260** may have aspherical coefficients as illustrated in the table of FIG. **8**.

In addition, the stop may be disposed in front of an object-side surface of the first lens **210**. However, alternatively, the stop may be disposed anywhere between the first lens **210** and the sixth lens **260**.

In addition, the optical system configured as described above may have aberration characteristics illustrated in FIG. **6**.

An optical system according to a third exemplary embodiment in the present disclosure will be described with reference to FIGS. **9** through **12**.

The optical system according to the third exemplary embodiment may include a first lens **310**, a second lens **320**, a third lens **330**, a fourth lens **340**, a fifth lens **350**, and a sixth lens **360**, and may further include a stop, an infrared cut-off filter **370**, and an image sensor **380**.

As illustrated in Table 3 (shown below), a focal length (f1) of the first lens **310** may be 3.16 mm, a focal length (f2) of the second lens **320** may be −5.71 mm, a focal length (f3) of the third lens **330** may be 19.16 mm, a focal length (f4) of the fourth lens **340** may be 39 mm, a focal length (f5) of the fifth lens **350** may be −15 mm, a focal length (f6) of the sixth lens **360** may be 84 mm, and an overall focal length (f) of the optical system may be 4.2 mm.

TABLE 3

FOV	75
Fno	1.9
TTL	5.3
f	4.2
f1	3.16
f2	−5.71
f3	19.16
f4	39
f5	−15
f6	84
SD/ f	0.55
TTL/f	1.26
|r9|/f	35
|v5-v6|	35
v1-v2	35

Here, respective characteristics (radii of curvature, thicknesses, refractive indices, and Abbe numbers) of the lenses **310** to **360** are illustrated in the table of FIG. **11**.

In the third exemplary embodiment, the first lens **310** may have positive refractive power and both surfaces of the first lens **310** may be convex. For example, a first surface of the first lens **310** may be convex toward the object in the paraxial region, and a second surface of the first lens **310** may be convex toward the image sensor in the paraxial region. However, alternatively, the first lens **310** may have negative refractive power, and/or at least one of the object-side and image-side surfaces of the first lens **310** may be concave.

The second lens **320** may have negative refractive power. In addition, the second lens **320** may have a meniscus shape which is convex toward the object. For example, a first surface of the second lens **320** may be convex toward the object in the paraxial region and a second surface of the second lens **320** may be concave toward the image sensor in the paraxial region. However, alternatively, the second lens **320** may have positive refractive power, the object-side surface of the second lens **320** may be concave, and/or the image-side surface of the second lens **320** may be convex.

The third lens **130** may have positive refractive power and both surfaces of the third lens **130** may be convex. For example, a first surface of the third lens **330** may be convex toward the object in the paraxial region, and a second surface of the third lens **330** may be convex toward the image sensor in the paraxial region. However, alternatively, the third lens **130** may have negative refractive power, and/or at least one of the object-side and image-side surfaces of the third lens **130** may be concave.

The fourth lens **340** may have positive refractive power. In addition, the fourth lens **340** may have a meniscus shape which is convex toward the image sensor. For example, a first surface of the fourth lens **340** may be concave toward the object in the paraxial region and a second surface of the fourth lens **340** may be convex toward the image sensor in the paraxial region. However, alternatively, the fourth lens **340** may have negative refractive power, the object-side surface of the fourth lens **340** may be convex, and/or the image-side surface of the fourth lens **340** may be concave.

The fifth lens **350** may have negative refractive power and both surfaces of the fifth lens **350** may be concave. For example, a first surface of the fifth lens **350** may be concave toward the object in the paraxial region, and a second surface of the fifth lens **350** may be concave toward the image sensor in the paraxial region. However, alternatively, the fifth lens **350** may have positive refractive power, and/or at least one of the object-side and image-side surfaces of the fifth lens **350** may be convex. In addition, at least one or more inflection points may be formed on at least one or both of the first and second surfaces of the fifth lens **350**.

The sixth lens **360** may have positive refractive power. In addition, the sixth lens **360** may have a meniscus shape which is convex toward the object. For example, a first surface of the sixth lens **360** may be convex toward the object in the paraxial region and a second surface of the sixth lens **360** may be concave toward the image sensor in the paraxial region. However, alternatively, the sixth lens **360** may have negative refractive power, the object-side surface of the sixth lens **360** may be concave, and/or the image-side surface of the sixth lens **360** may be convex. In addition, at least one or more inflection points may be formed on at least one or both of the first and second surfaces of the sixth lens **360**.

Meanwhile, the respective surfaces of the first to sixth lenses **310** to **360** may have aspherical coefficients as illustrated in the table of FIG. **12**.

In addition, the stop may be disposed in front of an object-side surface of the first lens **310**. However, alternatively, the stop may be disposed anywhere between the first lens **310** and the sixth lens **360**.

In addition, the optical system configured as described above may have aberration characteristics illustrated in FIG. **10**.

An optical system according to a fourth exemplary embodiment in the present disclosure will be described with reference to FIGS. **13** through **16**.

The optical system according to the fourth exemplary embodiment may include a first lens **410**, a second lens **420**, a third lens **430**, a fourth lens **440**, a fifth lens **450**, and a sixth lens **460**, and may further include a stop, an infrared cut-off filter **470**, and an image sensor **480**.

As illustrated in Table 4 (shown below), a focal length (f1) of the first lens **410** may be 2.88 mm, a focal length (f2) of the second lens **420** may be −4.95 mm, a focal length (f3) of the third lens **430** may be 20.7 mm, a focal length (f4) of the fourth lens **440** may be −74.3 mm, a focal length (f5) of the fifth lens **450** may be −12.4 mm, a focal length (f6) of the sixth lens **460** may be 25.66 mm, and an overall focal length (f) of the optical system may be 4.4 mm.

TABLE 4

FOV	75
Fno	1.9
TTL	5.3
f	4.4
f1	2.88
f2	−4.95
f3	20.7
f4	−74.3
f5	−12.4
f6	25.66
SD/f	0.58
TTL/f	1.2
|r9|/f	35
|v5-v6|	35
v1-v2	35

Here, respective characteristics (radii of curvature, thicknesses, refractive indices, and Abbe numbers) of the lenses **410** to **460** are illustrated in the table of FIG. **15**.

In the fourth exemplary embodiment, the first lens **410** may have positive refractive power and both surfaces of the first lens **410** may be convex. For example, a first surface of the first lens **410** may be convex toward the object in the paraxial region, and a second surface of the first lens **410** may be convex toward the image sensor in the paraxial region. However, alternatively, the first lens **410** may have negative refractive power, and/or at least one of the object-side and image-side surfaces of the first lens **410** may be concave.

The second lens **420** may have negative refractive power. In addition, the second lens **420** may have a meniscus shape which is convex toward the object. For example, a first surface of the second lens **420** may be convex toward the object in the paraxial region and a second surface of the second lens **420** may be concave toward the image sensor in the paraxial region. However, alternatively, the second lens **420** may have positive refractive power, the object-side surface of the second lens **420** may be concave, and/or the image-side surface of the second lens **420** may be convex.

The third lens **430** may have positive refractive power. In addition, the third lens **430** may have a meniscus shape which is convex toward the image sensor. For example, a first surface of the third lens **430** may be concave toward the object in the paraxial region and a second surface of the third lens **430** may be convex toward the image sensor in the paraxial region. However, alternatively, the third lens **430** may have negative refractive power, the object-side surface of the third lens 430 may be convex, and/or the image-side surface of the third lens 430 may be concave.

The fourth lens 440 may have negative refractive power. In addition, the fourth lens 440 may have a meniscus shape which is convex toward the image sensor. For example, a first surface of the fourth lens 440 may be concave toward the object in the paraxial region and a second surface of the fourth lens 440 may be convex toward the image sensor in the paraxial region. However, alternatively, the fourth lens 440 may have positive refractive power, the object-side surface of the fourth lens 440 may be convex, and/or the image-side surface of the fourth lens 440 may be concave.

The fifth lens 450 may have negative refractive power and both surfaces of the fifth lens 450 may be concave. For example, a first surface of the fifth lens 450 may be concave toward the object in the paraxial region, and a second surface of the fifth lens 450 may be concave toward the image sensor in the paraxial region. However, alternatively, the fifth lens 450 may have positive refractive power, and/or at least one of the object-side and image-side surfaces of the fifth lens 450 may be convex. In addition, at least one or more inflection points may be formed on at least one or both of the first and second surfaces of the fifth lens 450.

The sixth lens 460 may have positive refractive power. In addition, the sixth lens 460 may have a meniscus shape which is convex toward the object. For example, a first surface of the sixth lens 460 may be convex toward the object in the paraxial region and a second surface of the sixth lens 460 may be concave toward the image sensor in the paraxial region. However, alternatively, the sixth lens 460 may have negative refractive power, the object-side surface of the sixth lens 460 may be concave, and/or the image-side surface of the sixth lens 460 may be convex. In addition, at least one or more inflection points may be formed on at least one or both of the first and second surfaces of the sixth lens 460.

Meanwhile, the respective surfaces of the first to sixth lenses 410 to 460 may have aspherical coefficients as illustrated in the table of FIG. 16.

In addition, the stop may be disposed in front of an object-side surface of the first lens 410. However, alternatively, the stop may be disposed anywhere between the first lens 410 and the sixth lens 460.

In addition, the optical system configured as described above may have aberration characteristics illustrated in FIG. 14.

As set forth above, in the optical system according to some exemplary embodiments of the present disclosure, for example, an aberration improvement effect and high degrees of brightness and resolution may be obtained.

While exemplary embodiments have been shown and described above, it will be apparent to those skilled in the art that modifications and variations could be made without departing from the scope of the present invention as defined by the appended claims.

What is claimed is:

1. An optical system comprising:
- a first lens having positive refractive power;
- a second lens having negative refractive power and a convex object-side surface;
- a third lens having positive refractive power and a convex image-side surface;
- a fourth lens having negative refractive power;
- a fifth lens having refractive power and a concave image-side surface in the paraxial region;
- a sixth lens having refractive power and a convex object-side surface; and
- wherein the first to sixth lenses are sequentially disposed from an object side, and
- wherein an overall focal length of the optical system f and a focal length of the fifth lens f5 satisfy:

$$0.2<|f/f5|<0.4, \text{ and}$$

- wherein the focal length of the fifth lens f5 and a focal length of the sixth lens f6 satisfy:

$$0.3<|f/f5|+|f/f6|<0.6.$$

2. The optical system of claim 1, wherein a distance from an object-side surface of the first lens to an imaging surface of an image sensor TTL and the overall focal length of the optical system f satisfy:

$$1.1<TTL/f<1.35.$$

3. The optical system of claim 1, wherein a radius of curvature of an object-side surface of the fifth lens r9 and the overall focal length of the optical system f satisfy:

$$1.0<||r9|/f<40.$$

4. The optical system of claim 1, wherein an Abbe number of the fifth lens v5 and an Abbe number of the sixth lens v6 satisfy:

$$|v5-v6|>20.$$

5. The optical system of claim 1, wherein an Abbe number of the first lens v1 and an Abbe number of the second lens v2 satisfy:

$$v1-v2>20.$$

6. The optical system of claim 1, wherein a focal length of the first lens f1 and the overall focal length of the optical system f satisfy:

$$1.3<f/f1<1.6.$$

7. The optical system of claim 1, wherein the overall focal length of the optical system f and a focal length of the third lens f3 satisfy:

$$0.1<f/f3<0.3.$$

8. The optical system of claim 1, wherein a focal length of the first lens f1 and a focal length of the third lens f3 satisfy:

$$0<f1/f3<0.2.$$

9. The optical system of claim 1, wherein a focal length of the first lens f1 and a focal length of the second lens f2 satisfy:

$$2<|f/f1|+|f/f2|<2.5.$$

10. The optical system of claim 1, wherein a focal length of the third lens f3 and a focal length of the fourth lens f4 satisfy:

$$0.1<|f/f3|+|f/f4|<0.4.$$

11. The optical system of claim 1, wherein a distance from the object-side surface of the first lens to an imaging surface of an image sensor TTL and a diagonal length of the imaging surface of the image sensor ImgH satisfy:

$$1.5<TTL/ImgH<1.7.$$

12. The optical system of claim 1, wherein a field of view of the optical system is between 65° and 80°.

13. The optical system of claim 1, wherein an object-side surface of the first lens is convex.

14. The optical system of claim 1, wherein an image-side surface of the first lens is convex.

15. The optical system of claim **1**, wherein an image-side surface of the second lens is concave.

16. The optical system of claim **1**, wherein an object-side surface of the third lens is concave.

17. The optical system of claim **1**, wherein an object-side surface of the fourth lens is concave.

18. The optical system of claim **1**, wherein an image-side surface of the fourth lens is convex.

19. The optical system of claim **1**, wherein the refractive power of the fifth lens is negative.

20. The optical system of claim **1**, wherein an object-side surface of the fifth lens is concave.

21. The optical system of claim **1**, wherein at least one or more inflection points are formed on at least one or both of an object-side surface and the image-side surface of the fifth lens.

22. The optical system of claim **1**, wherein the refractive power of the sixth lens is positive.

23. The optical system of claim **1**, wherein an image-side surface of the sixth lens is concave.

24. The optical system of claim **1**, wherein at least one or more inflection points on at least one or both of an object-side surface and an image-side surface of the sixth lens.

25. The optical system of claim **1**, wherein at least one or both of an object-side surface and an image-side surface of each of the first to sixth lenses is aspherical.

26. An optical system comprising:

a first lens having positive refractive power;

a second lens having negative refractive power and a convex object-side surface;

a third lens having positive refractive power and a convex image-side surface;

a fourth lens having negative refractive power;

a fifth lens having refractive power and a concave image-side surface; and

a sixth lens having refractive power,

wherein the first to sixth lenses are sequentially disposed from an object side, and

wherein an Abbe number of the first lens v1 and an Abbe number of the second lens v2 satisfy:

$$v1-v2>20, \text{ and}$$

wherein an overall focal length of the optical system f, a focal length of the fifth lens f5 and a focal length of the sixth lens f6 satisfy:

$$0.3<|f/f5|+|f/f6|<0.6.$$

27. An optical system comprising:

a stop; and

first, second, third, fourth, fifth, and sixth lenses disposed sequentially from an object side, wherein

the first lens has positive refractive power,

the second lens has negative refractive power and a convex object-side surface,

the third lens has positive refractive power,

the fourth lens has negative refractive power,

the fifth lens has concave image-side surface,

the sixth lens has a convex object-side surface, and

a radius of the stop SD and an overall focal length of the optical system f satisfy:

$$0.2<SD/f<0.6, \text{ and}$$

wherein a focal length of the fifth lens f5, and a focal length of the sixth lens f6, satisfy:

$$0.3<|f/f5|+|f/f6|<0.6.$$

28. The optical system of claim **27**, wherein an image-side surface of the third lens is convex.

29. The optical system of claim **27**, wherein the fifth lens has negative refractive power, and the sixth lens has positive refractive power.

30. The optical system of claim **27**, wherein a distance from an object-side surface of the first lens to an imaging surface of an image sensor TTL and an overall focal length of the optical system f satisfy:

$$1.1<TTL/f<1.35.$$

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