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(54) **CAMERA OPTICAL LENS**

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G02B 9/64 (2006.01)

(52) **U.S. Cl.**
CPC ***G02B 13/0045*** (2013.01); ***G02B 9/64*** (2013.01)

(58) **Field of Classification Search**
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USPC 359/708
See application file for complete search history.

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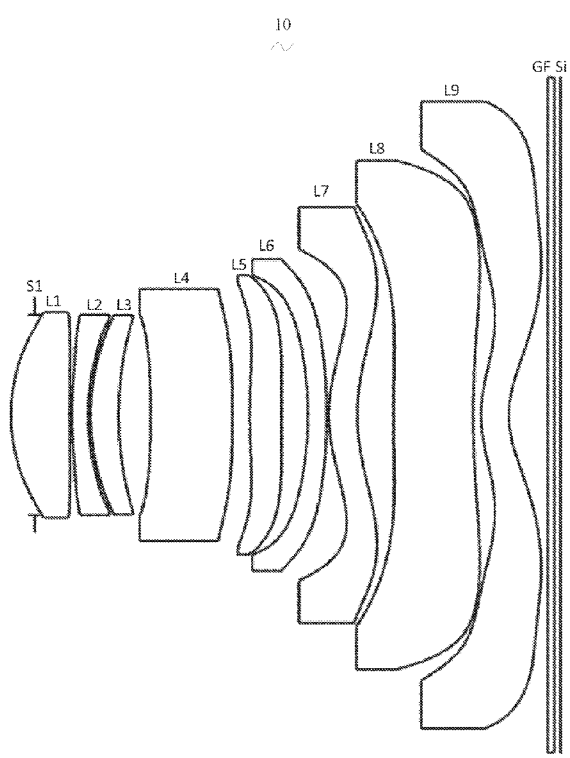
(57) **ABSTRACT**

A camera optical lens is provided, including from an object side to an image side: a first lens; a second lens having negative refractive power; a third lens; a fourth lens; a fifth lens; a sixth lens; a seventh lens; an eighth lens; and a ninth lens, wherein the camera optical lens satisfies following conditions: $0.70 \leq f1/f \leq 1.80$; and $2.00 \leq d15/d16 \leq 10.00$, where f denotes a focal length of the camera optical lens; f1 denotes a focal length of the first lens; d15 denotes an on-axis thickness of the eighth lens; and d16 denotes an on-axis distance from an image side surface of the eighth lens to an object side surface of the ninth lens. The above camera optical lens can meet design requirements for large aperture, wide angle and ultra-thinness, while maintaining good imaging quality.

10 Claims, 9 Drawing Sheets



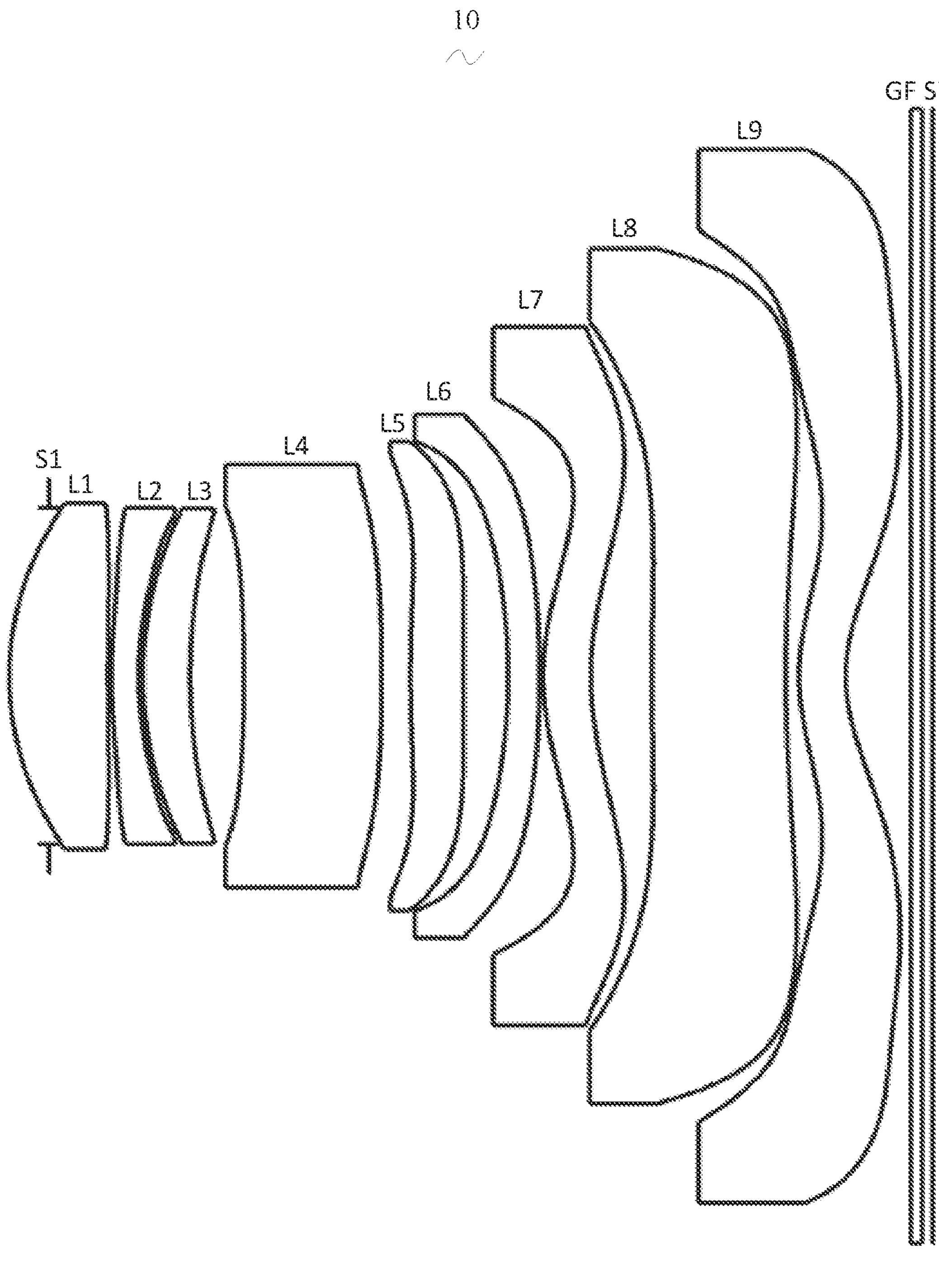
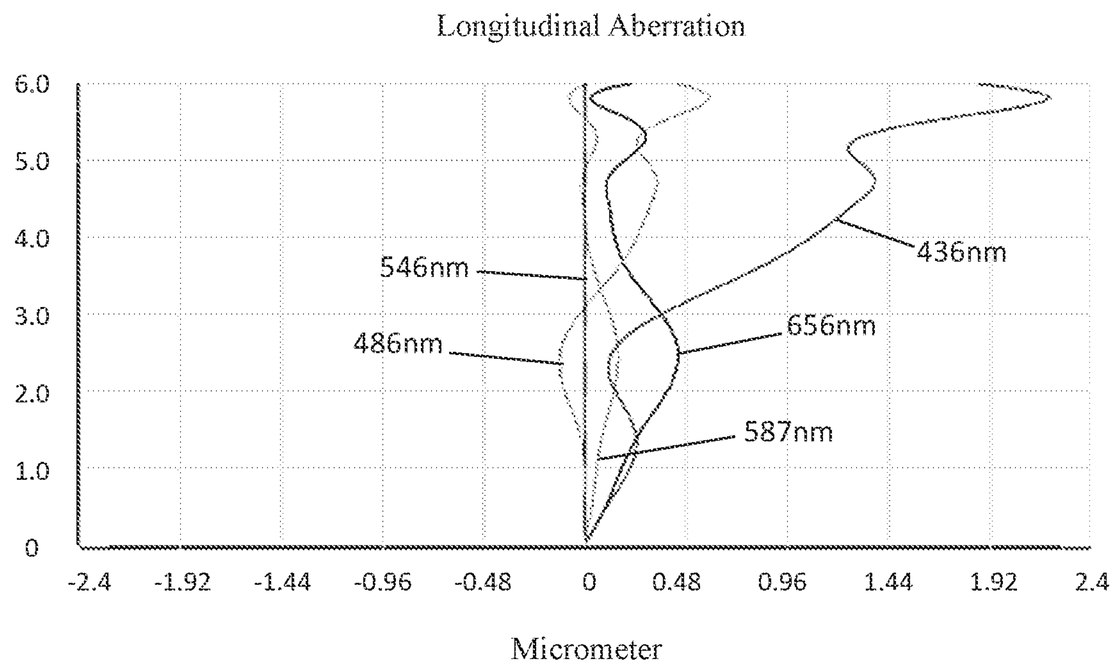


FIG.1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436nm
656nm
587nm
Micrometer

FIG. 2

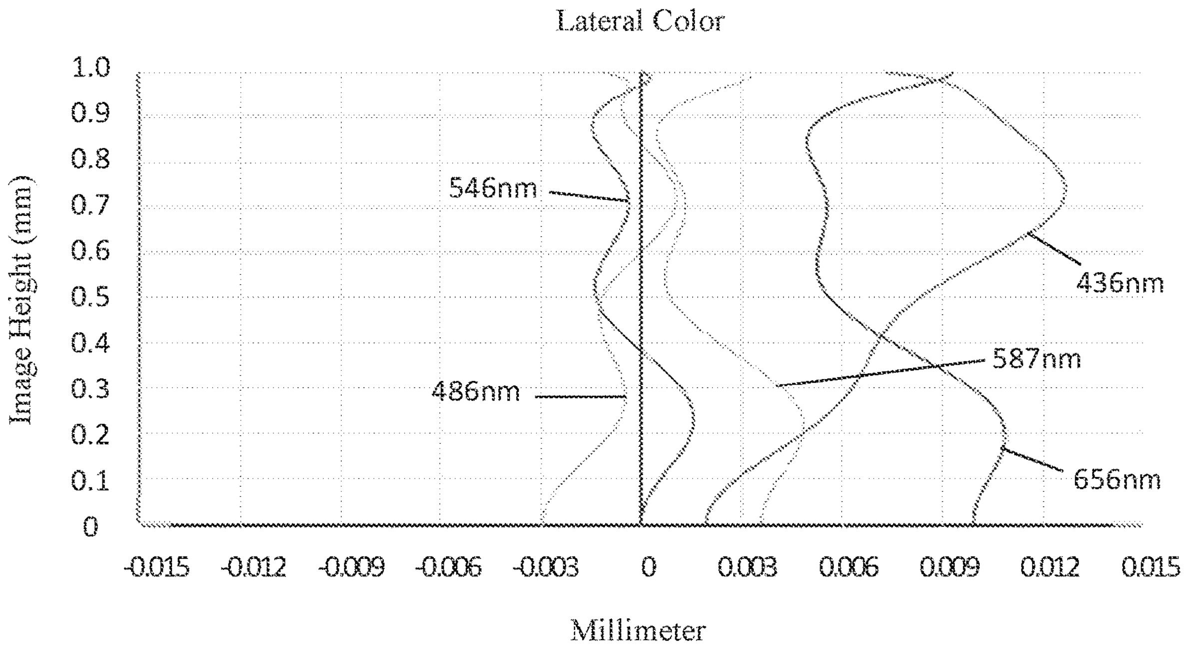
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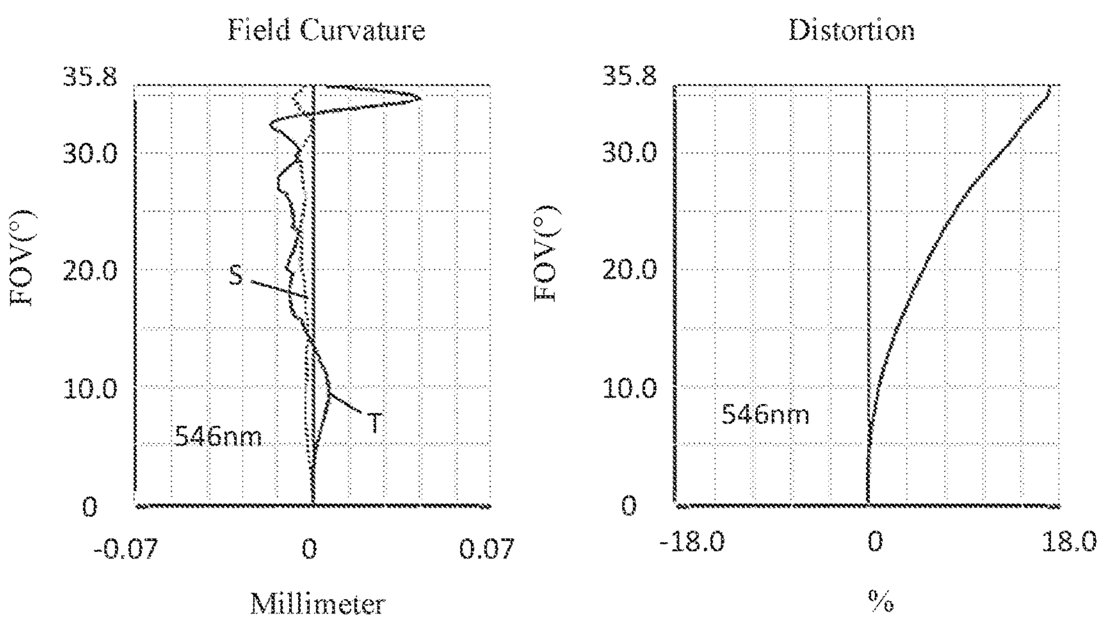
Image Height (mm)
546nm
486nm
436nm
587nm
656nm
-0.015
-0.012
-0.009
-0.006
-0.003
0
0.003
0.006
0.009
0.012
0.015
Millimeter

FIG.3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10.0
0
FOV(°)
S
T
546nm
-0.07
0
0.07
Millimeter
Distortion
35.8
30.0
20.0
10.0
0
FOV(°)
546nm
-18.0
0
18.0
%

FIG.4

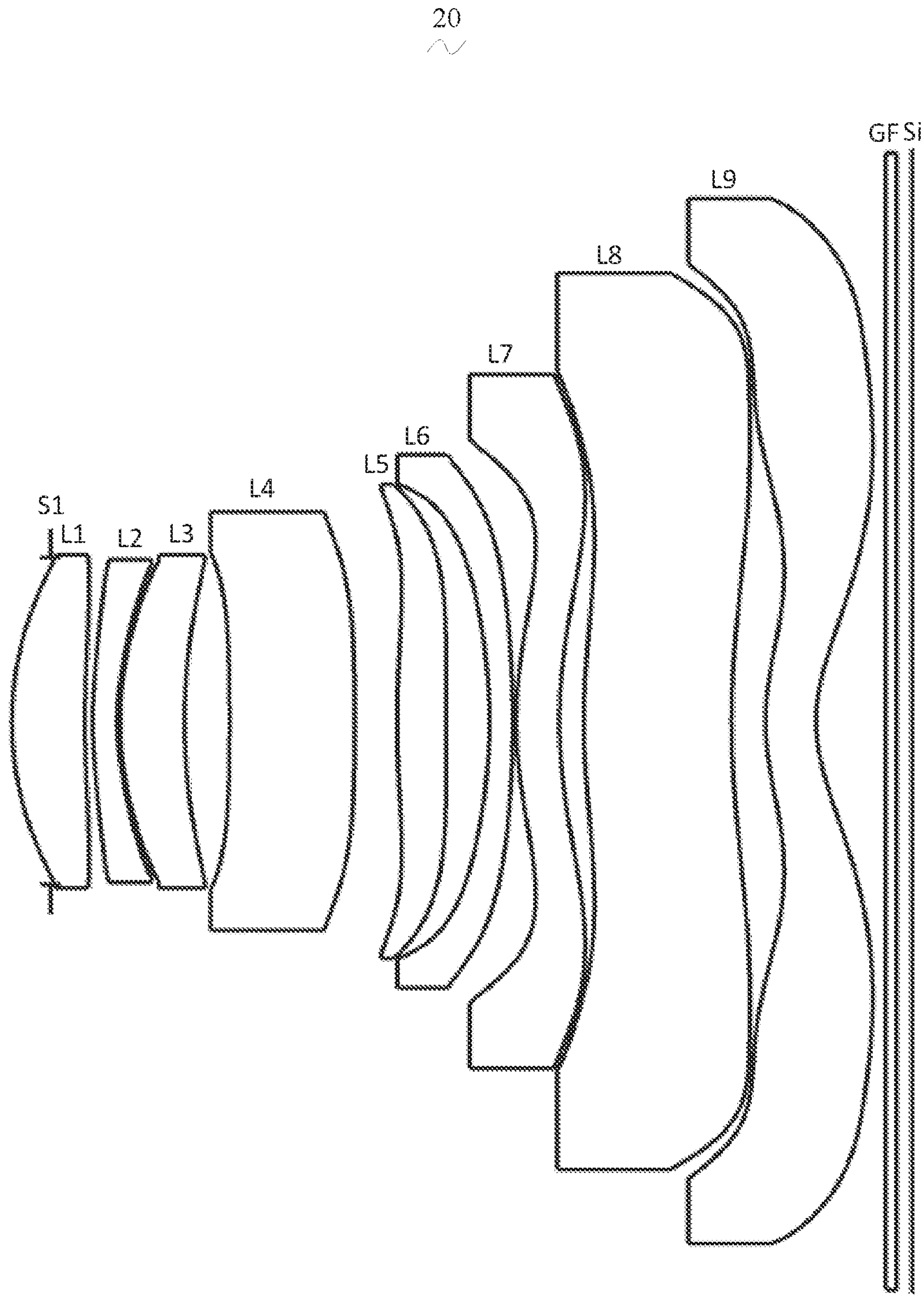
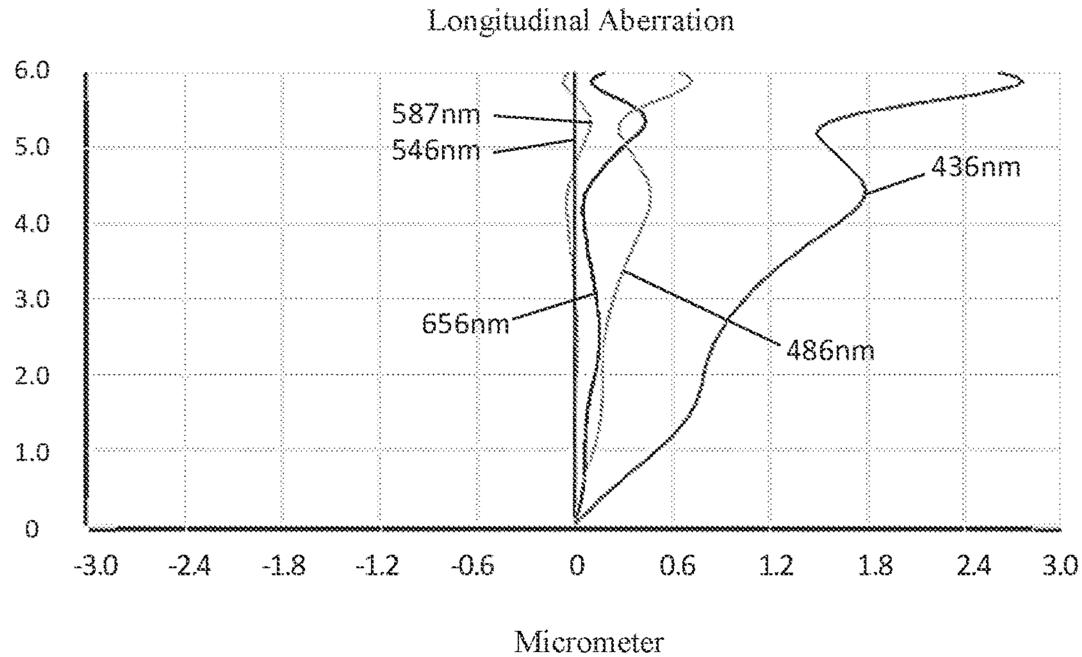


FIG. 5


Longitudinal Aberration
6.0
5.0
4.0
3.0
2.0
1.0
0
587nm
546nm
436nm
656nm
486nm
-3.0
-2.4
-1.8
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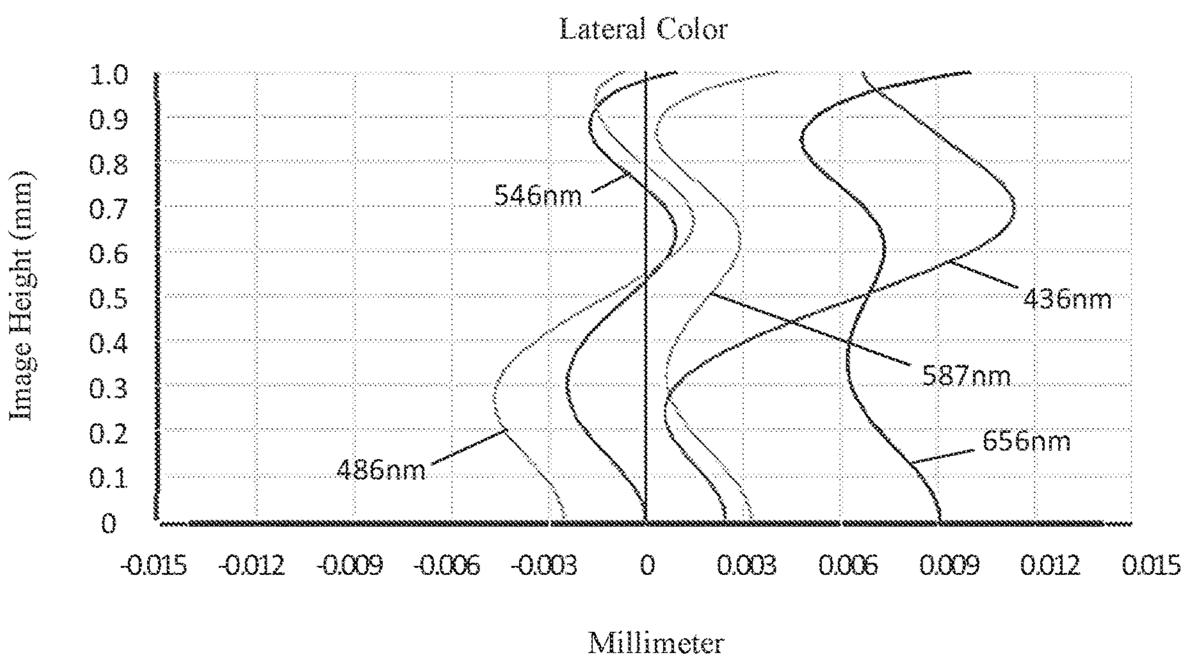
-0.6
0
0.6
1.2
1.8
2.4
3.0
Micrometer

FIG.6


Lateral Color
Image Height (mm)
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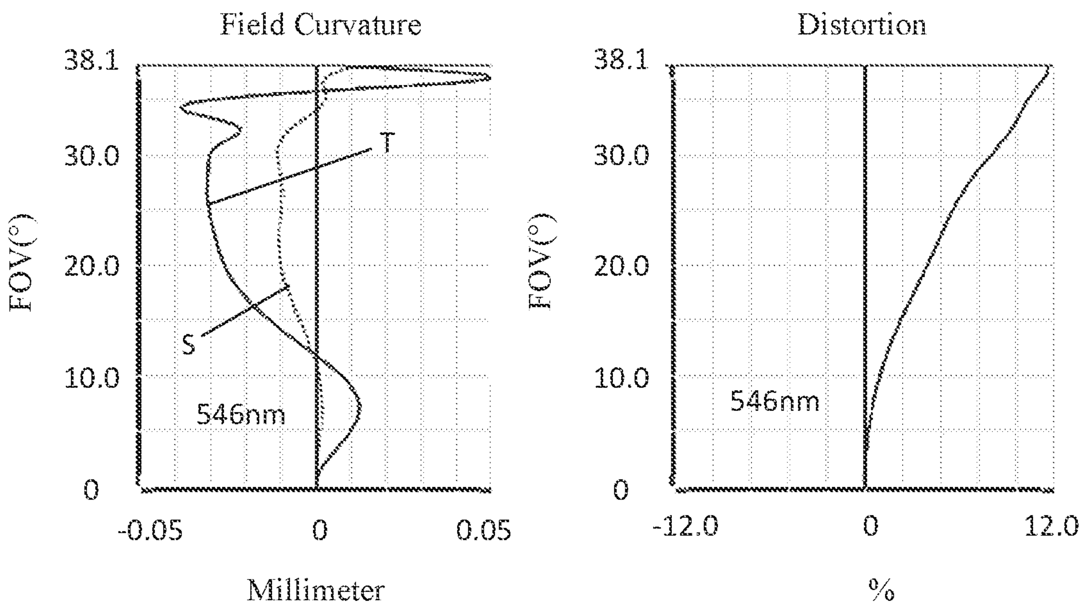
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
546nm
436nm
587nm
656nm
486nm
-0.015
-0.012
-0.009
-0.006
-0.003
0
0.003
0.006
0.009
0.012
0.015
Millimeter

FIG.7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30.0
20.0
10.0
0
FOV(°)
T
S
546nm
-0.05
0
0.05
Millimeter
Distortion
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30.0
20.0
10.0
0
FOV(°)
546nm
-12.0
0
12.0
%

FIG. 8

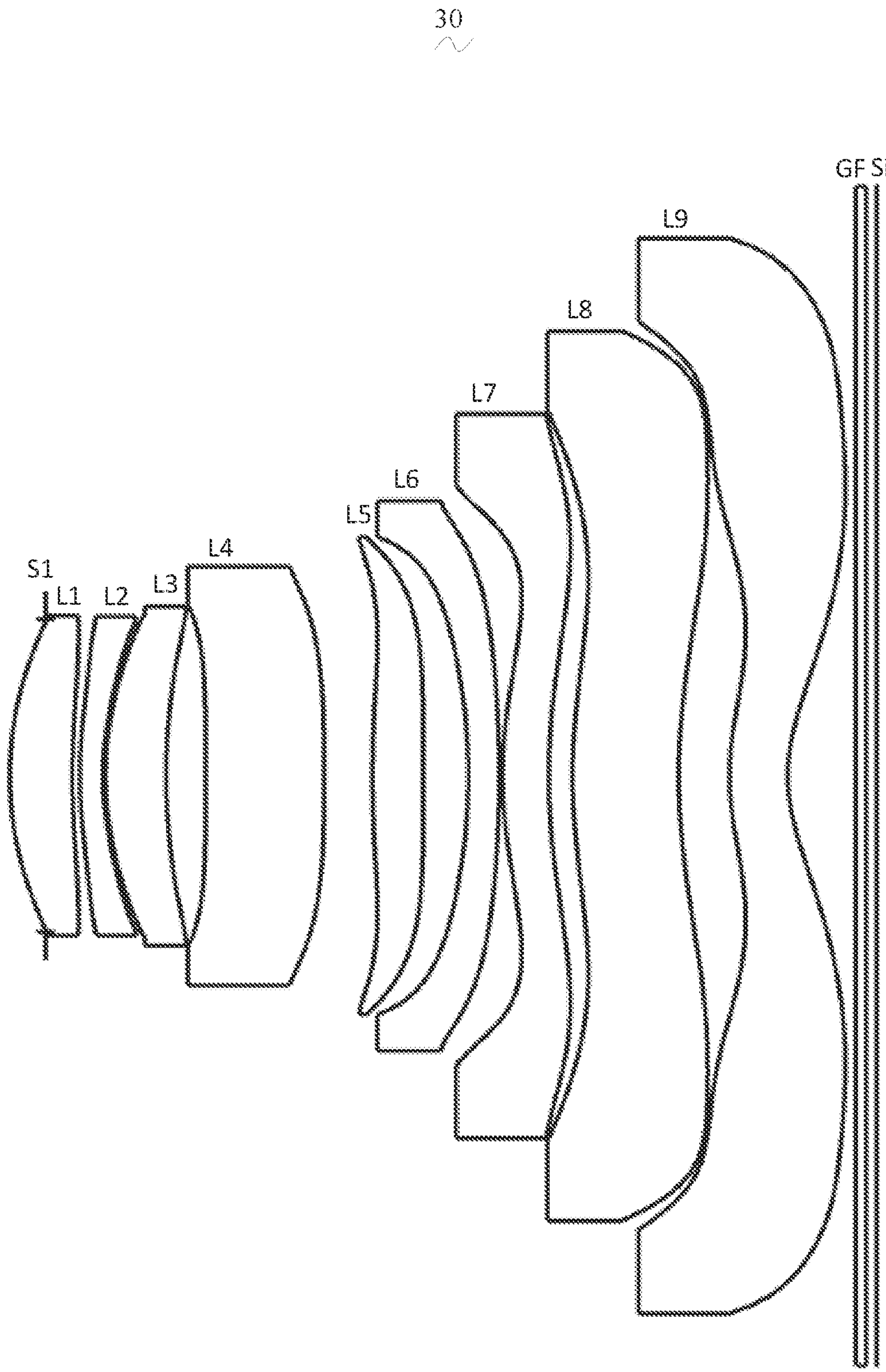
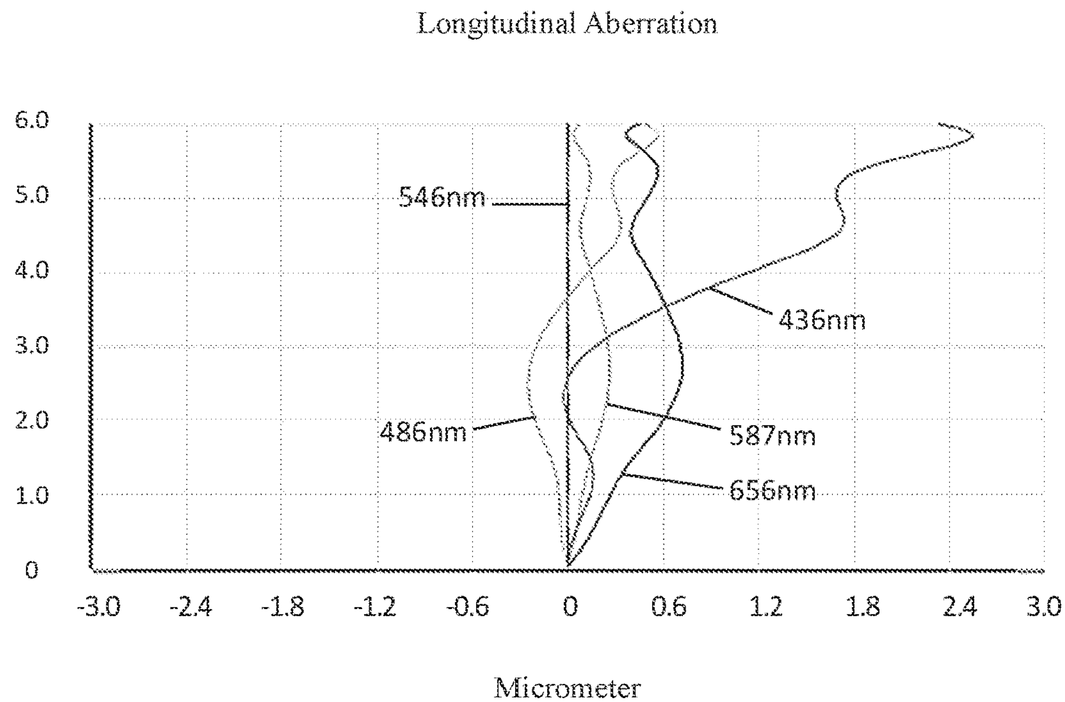


FIG. 9


Longitudinal Aberration
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5.0
4.0
3.0
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1.0
0
546nm
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587nm
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-3.0 -2.4 -1.8 -1.2 -0.6 0 0.6 1.2 1.8 2.4 3.0
Micrometer

FIG.10

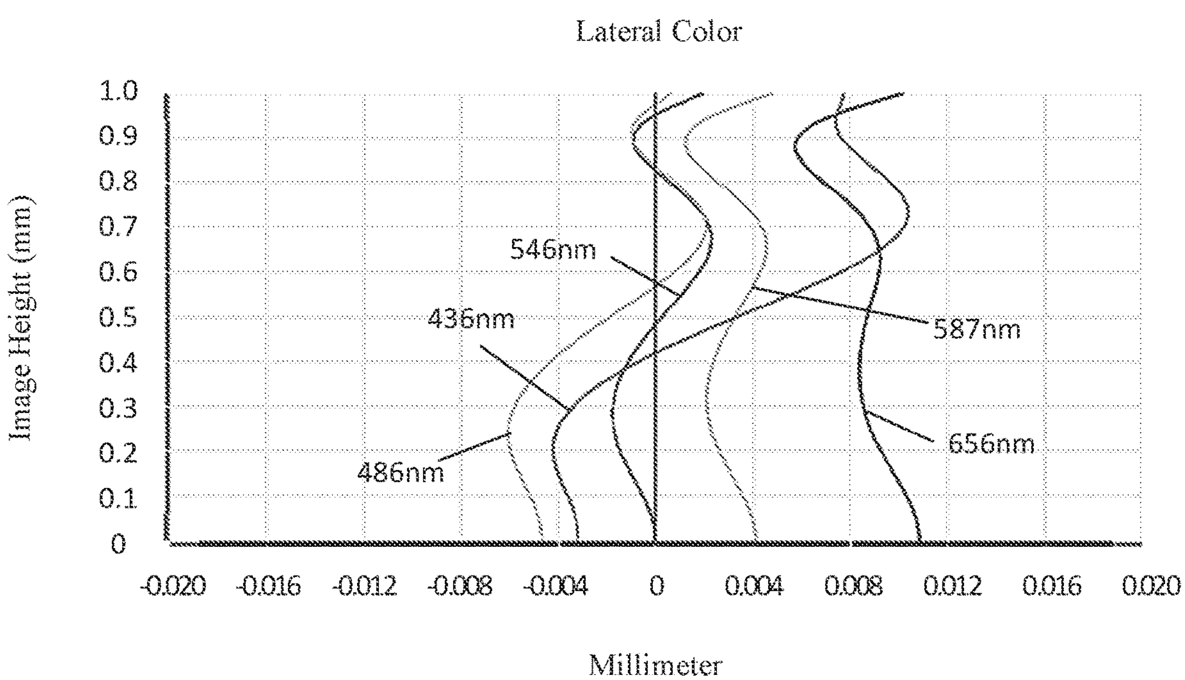
Lateral Color
Image Height (mm)
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
546nm
436nm
587nm
656nm
486nm
-0.020 -0.016 -0.012 -0.008 -0.004 0 0.004 0.008 0.012 0.016 0.020
Millimeter

FIG.11

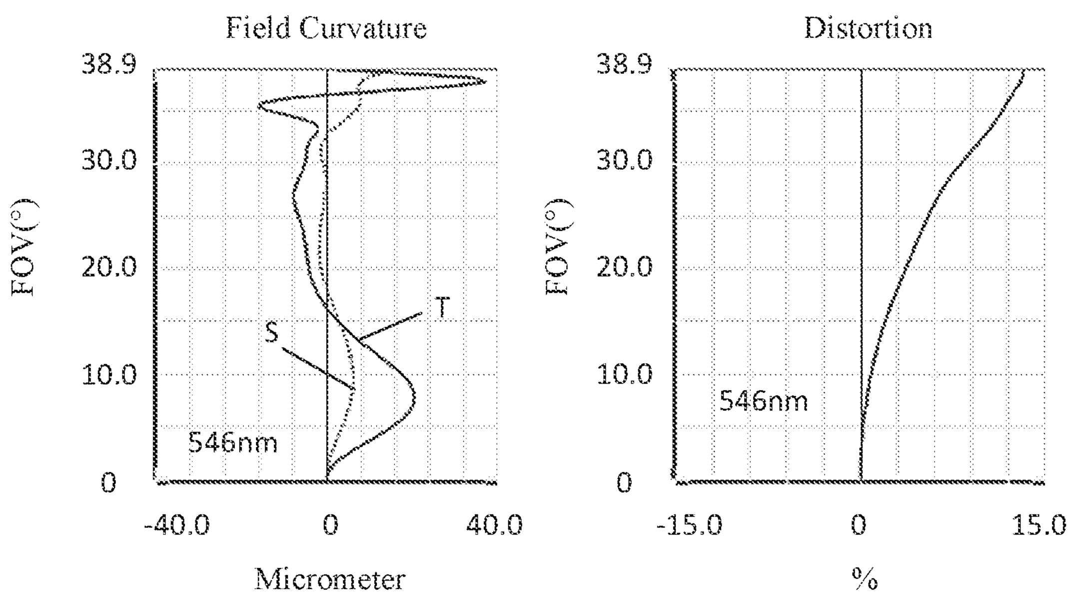
Field Curvature
38.9
30.0
20.0
10.0
0
FOV(°)
T
S
546nm
-40.0
0
40.0
Micrometer
Distortion
38.9
30.0
20.0
10.0
0
FOV(°)
546nm
-15.0
0
15.0
%

FIG.12

CAMERA OPTICAL LENS

TECHNICAL FIELD

The present invention relates to the technical field of optical lens and, in particular, to a camera optical lens suitable for handheld terminal devices such as smart phones or digital cameras, and imaging devices such as monitors or PC lenses.

BACKGROUND

With the emergence of smart phones in recent years, the demand for miniature camera lens is continuously increasing, but in general, the photosensitive devices of camera lens are nothing more than a Charge Coupled Device (CCD) or a Complementary Metal-Oxide Semiconductor Sensor (CMOS Sensor), and as progress of semiconductor manufacturing technology makes the pixel size of the photosensitive devices become smaller, in addition, a current development trend of electronic products requires better performance with thinner and smaller dimensions, miniature camera lenses with good imaging quality therefore have become a mainstream in the market.

In order to obtain better imaging quality, a camera lens traditionally equipped in a camera of a mobile phone generally constitutes three, four, even five or six lenses. However, with development of technology and increase in diversified requirements of users, a camera lens constituted by nine lenses gradually appears in camera design, in case that pixel area of the photosensitive device is continuously reduced and requirements on image quality is continuously increased. Although the common camera lens constituted by nine lenses has good optical performances, its configurations such as refractive power, lens spacing and lens shape still need to be optimized, therefore the camera lens cannot meet design requirements for some optical performances such as large aperture, ultra-thinness and wide angle while maintaining good imaging quality.

SUMMARY

In view of the above problems, the present invention provides a camera optical lens, which may meet design requirements on some optical performances such as large aperture, ultra-thinness and wide angle while maintaining good imaging quality.

Embodiments of the present invention provides a camera optical lens, including from an object side to an image side:

a first lens;
a second lens having negative refractive power;
a third lens;
a fourth lens;
a fifth lens;
a sixth lens;
a seventh lens;
an eighth lens; and
a ninth lens,
wherein the camera optical lens satisfies following conditions:

$$0.70 \le f1/f \le 1.80; \text{ and}$$

$$2.00 \le d15/d16 \le 10.00,$$

where

f denotes a focal length of the camera optical lens;
f1 denotes a focal length of the first lens;
d15 denotes an on-axis thickness of the eighth lens; and
d16 denotes an on-axis distance from an image side surface of the eighth lens to an object side surface of the ninth lens.

As an improvement, wherein the camera optical lens satisfies a following condition:

$$-10.00 \le (R13+R14)/(R13-R14) \le -6.00,$$

where

R13 denotes a central curvature radius of an object side surface of the seventh lens; and
R14 denotes a central curvature radius of an image side surface of the seventh lens.

As an improvement, wherein the camera optical lens satisfies following conditions:

$$-5.52 \le (R1+R2)/(R1-R2) \le -0.88; \text{ and}$$

$$0.04 \le d1/TTL \le 0.16,$$

where

R1 denotes a central curvature radius of an object side surface of the first lens;
R2 denotes a central curvature radius of an image side surface of the first lens;
d1 denotes an on-axis thickness of the first lens; and
TTL denotes a total optical length from the object side surface of the first lens to an image plane of the camera optical lens along an optic axis.

As an improvement, wherein the camera optical lens satisfies following conditions:

$$-4.36 \le f2/f \le -1.08;$$

$$1.58 \le (R3+R4)/(R3-R4) \le 7.30; \text{ and}$$

$$0.01 \le d3/TTL \le 0.04,$$

where

f2 denotes a focal length of the second lens;
R3 denotes a central curvature radius of an object side surface of the second lens;
R4 denotes a central curvature radius of an image side surface of the second lens;
d3 denotes an on-axis thickness of the second lens; and
TTL denotes a total optical length from an object side surface of the first lens to an image plane of the camera optical lens along an optic axis.

As an improvement, the camera optical lens satisfies following conditions:

$$0.78 \le f3/f \le 3.42;$$

$$-7.90 \le (R5+R6)/(R5-R6) \le -1.83; \text{ and}$$

$$0.03 \le d5/TTL \le 0.11,$$

where

f3 denotes a focal length of the third lens;
R5 denotes a central curvature radius of an object side surface of the third lens;
R6 denotes a central curvature radius of an image side surface of the third lens;
d5 denotes an on-axis thickness of the third lens; and
TTL denotes a total optical length from an object side surface of the first lens to an image plane of the camera optical lens along an optic axis.

As an improvement, wherein the camera optical lens satisfies following conditions:

$$-45.74 \leq f4/f \leq 5804.23;$$

$$-349.82 \leq (R7+R8)/(R7-R8) \leq 3.85; \text{ and}$$

$$0.07 \leq d7/TTL \leq 0.22,$$

where

f4 denotes a focal length of the fourth lens;

R7 denotes a central curvature radius of an object side surface of the fourth lens;

R8 denotes a central curvature radius of an image side surface of the fourth lens;

d7 denotes an on-axis thickness of the fourth lens; and

TTL denotes a total optical length from an object side surface of the first lens to an image plane of the camera optical lens along an optic axis.

As an improvement, wherein the camera optical lens satisfies following conditions:

$$1.61 \leq f5/f \leq 10.88;$$

$$-6.22 \leq (R9+R10)/(R9-R10) \leq -0.85; \text{ and}$$

$$0.03 \leq d9/TTL \leq 0.09,$$

where

f5 denotes a focal length of the fifth lens;

R9 denotes a central curvature radius of an object side surface of the fifth lens;

R10 denotes a central curvature radius of an image side surface of the fifth lens;

d9 denotes an on-axis thickness of the fifth lens; and

TTL denotes a total optical length from an object side surface of the first lens to an image plane of the camera optical lens along an optic axis.

As an improvement, wherein the camera optical lens satisfies following conditions:

$$-6.13 \leq f6/f \leq -1.68;$$

$$-6.58 \leq (R11+R12)/(R11-R12) \leq -1.61; \text{ and}$$

$$0.01 \leq d11/TTL \leq 0.05,$$

where

f6 denotes a focal length of the sixth lens;

R11 denotes a central curvature radius of an object side surface of the sixth lens;

R12 denotes a central curvature radius of an image side surface of the sixth lens;

d11 denotes an on-axis thickness of the sixth lens; and

TTL denotes a total optical length from an object side surface of the first lens to an image plane of the camera optical lens along an optic axis.

As an improvement, wherein the camera optical lens satisfies following conditions:

$$1.51 \leq f7/f \leq 7.66; \text{ and}$$

$$0.02 \leq d13/TTL \leq 0.08,$$

where

f7 denotes a focal length of the seventh lens;

d13 denotes an on-axis thickness of the seventh lens; and

TTL denotes a total optical length from an object side surface of the first lens to an image plane of the camera optical lens along an optic axis.

As an improvement, wherein the camera optical lens satisfies following conditions:

$$-20.76 \leq f8/f \leq 21.17;$$

$$-62.90 \leq (R15+R16)/(R15-R16) \leq 6.24; \text{ and}$$

$$0.06 \leq d15/TTL \leq 0.25,$$

where

f8 denotes a focal length of the eighth lens;

R15 denotes a central curvature radius of an object side surface of the eighth lens;

R16 denotes a central curvature radius of an image side surface of the eighth lens; and

TTL denotes a total optical length from an object side surface of the first lens to an image plane of the camera optical lens along an optic axis.

As an improvement, wherein the camera optical lens satisfies following conditions:

$$-5.32 \leq f9/f \leq -1.35;$$

$$2.53 \leq (R17+R18)/(R17-R18) \leq 10.69; \text{ and}$$

$$0.03 \leq d17/TTL \leq 0.10,$$

where

f9 denotes a focal length of the ninth lens;

R17 denotes a central curvature radius of an object side surface of the ninth lens;

R18 denotes a central curvature radius of an image side surface of the ninth lens;

d17 denotes an on-axis thickness of the ninth lens; and

TTL denotes a total optical length from an object side surface of the first lens to an image plane of the camera optical lens along an optic axis.

The present invention has following beneficial effects: the camera optical lens according to the present invention not only has excellent optical performances, but also has large aperture, wide angle, and ultra-thinness properties, which is especially suitable for mobile phone camera lens components composed of high-pixel CCD, CMOS and other imaging elements and WEB camera lens.

BRIEF DESCRIPTION OF DRAWINGS

Many aspects of the exemplary embodiments may be better understood with reference to following drawings. The components in the drawings are not necessarily drawn to scale, the emphasis instead being placed upon clearly illustrating the principles of the present invention. Moreover, in the drawings, like reference numerals designate corresponding parts throughout the several views.

FIG. **1** is a structural schematic diagram of a camera optical lens according to Embodiment 1 of the present invention;

FIG. **2** is a schematic diagram of a longitudinal aberration of the camera optical lens shown in FIG. **1**;

FIG. **3** is a schematic diagram of a lateral color of the camera optical lens shown in FIG. **1**;

FIG. **4** is a schematic diagram of a field curvature and a distortion of the camera optical lens shown in FIG. **1**;

FIG. **5** is a structural schematic diagram of a camera optical lens according to Embodiment 2 of the present invention;

FIG. **6** is a schematic diagram of a longitudinal aberration of the camera optical lens shown in FIG. **5**;

FIG. **7** is a schematic diagram of a lateral color of the camera optical lens shown in FIG. **5**;

FIG. **8** is a schematic diagram of a field curvature and a distortion of the camera optical lens shown in FIG. **5**;

FIG. **9** is a structural schematic diagram of a camera optical lens according to Embodiment 3 of the present invention;

FIG. **10** is a schematic diagram of a longitudinal aberration of the camera optical lens shown in FIG. **9**;

FIG. **11** is a schematic diagram of a lateral color of the camera optical lens shown in FIG. **9**; and

FIG. **12** is a schematic diagram of a field curvature and a distortion of the camera optical lens shown in FIG. **9**.

DESCRIPTION OF EMBODIMENTS

In order to better illustrate the objectives, technical solutions and advantages of the present invention, the present invention will be described in further detail below with reference to the accompanying drawings and embodiments. It should be understood that the specific embodiments described herein are only used to explain the present invention but are not used to limit the present invention.

Embodiment 1

Referring to FIG. **1**, the present invention provides a camera optical lens **10**. FIG. **1** shows the camera optical lens **10** according to Embodiment 1 of the present invention. The camera optical lens **10** includes nine lenses. The camera optical lens **10** includes, from an object side to an image side, an aperture S**1**, a first lens L**1**, a second lens L**2**, a third lens L**3**, a fourth lens L**4**, a fifth lens L**5**, a sixth lens L**6**, a seventh lens L**7**, an eighth lens L**8**, and a ninth lens L**9**. An optical element such as an optical filter GF may be arranged between the ninth lens L**9** and an image plane Si.

In this embodiment, the first lens L**1** has positive refractive power, the second lens L**2** has negative refractive power, the third lens L**3** has positive refractive power, the fourth lens L**4** has negative refractive power, the fifth lens L**5** has positive refractive power, the sixth lens L**6** has negative refractive power, the seventh lens L**7** has positive refractive power, the eighth lens L**8** has negative refractive power, and the ninth lens L**9** has negative refractive power. It may be understood that, in other embodiments, the refractive power of the third lens L**3**, the fourth lens L**4**, the fifth lens L**5**, the sixth lens L**6**, the seventh lens L**7**, the eighth lens L**8** and the ninth lens L**9** may change.

In this embodiment, the first lens L**1**, the second lens L**2**, the third lens L**3**, the fourth lens L**4**, the fifth lens L**5**, the sixth lens L**6**, the seventh lens L**7**, the eighth lens L**8**, and the ninth lens L**9** are each made of a plastic material. In other embodiments, the lenses may also be made of a material other than the plastic material.

In this embodiment, a focal length of the camera optical lens **10** is defined as f, and a focal length of the first lens L**1** is defined as f1. The focal length f and the focal length f1 satisfy a following condition: $0.70 \leq f1/f \leq 1.80$, which specifies a ratio of the focal length of the first lens to a total focal length of the system. Within the range of the above condition, it is beneficial to correct system aberrations and improve imaging quality. Optionally, the focal length f and the focal length f1 satisfy a following condition: $0.83 \leq f1/f \leq 1.80$.

An on-axis thickness of the eighth lens L**8** is defined as d15, an on-axis distance from an image side surface of the eighth lens L**8** to an object side surface of the ninth lens L**9** is defined as d16. The on-axis thickness d15 and the on-axis distance d16 satisfy a following condition: $2.00 \leq d15/d16 \leq 10.00$. Within the range of the above condition, it is beneficial to process lenses and assemble the camera lens. Optionally, the on-axis thickness d15 and the on-axis distance d16 satisfy a following condition: $2.05 \leq d15/d16 \leq 9.98$.

A central curvature radius of an object side surface of the seventh lens L**7** is defined as R13, and a central curvature radius of an image side surface of the seventh lens L**7** is defined as R14. The central curvature radius R13 and the central curvature radius R14 satisfy a following condition: $-10.00 \leq (R13+R14)/(R13-R14) \leq -6.00$, which specifies a shape of the seventh lens L**7**. Within the specified range of the condition, a degree of deflection of light passing through the lens may be alleviated, and aberrations may be effectively reduced. Optionally, The central curvature radius R13 and the central curvature radius R14 satisfy a following condition: $-9.83 \leq (R13+R14)/(R13-R14) \leq -6.02$.

In this embodiment, the object side surface of the first lens L**1** is convex in a paraxial region, and the image side surface of the first lens L**1** is concave in the paraxial region.

A central curvature radius of the object side surface of the first lens L**1** is defined as R1, and a central curvature radius of the image side surface of the first lens L**1** is defined as R2. The central curvature radius R1 and the central curvature radius R2 satisfy a following condition: $-5.52 \leq (R1+R2)/(R1-R2) \leq -0.88$. The shape of the first lens L**1** is reasonably controlled so that the first lens L**1** may effectively correct spherical aberration of the system. Optionally, the central curvature radius R1 and the central curvature radius R2 satisfy a following condition: $-3.45 \leq (R1+R2)/(R1-R2) \leq -1.09$.

An on-axis thickness of the first lens L**1** is defined as d1, and a total optical length from the object side surface of the first lens L**1** to the image plane Si of the camera optical lens **10** along an optic axis is defined as TTL. The on-axis thickness d1 and the total optical length TTL satisfy a following condition: $0.04 \leq d1/TTL \leq 0.16$. Within the range of the above condition, it is beneficial to achieve an ultra-thinness effect. Optionally, the on-axis thickness d1 and the total optical length TTL satisfy a following condition: $0.06 \leq d1/TTL \leq 0.13$.

In this embodiment, the object side surface of the second lens L**2** is convex in a paraxial region, and the image side surface of the second lens L**2** is concave in the paraxial region.

A focal length of the camera optical lens **10** is defined as f, and a focal length of the second lens L**2** is defined as f2. The focal length f and the focal length f2 satisfy a following condition: $-4.36 \leq f2/f \leq -1.08$. The negative refractive power of the second lens L**2** is controlled in the reasonable range, it is beneficial to correct aberration of the optical system. Optionally, the focal length f and the focal length f2 satisfy a following condition: $-2.72 \leq f2/f \leq -1.35$.

A central curvature radius of an object side surface of the second lens L**2** is defined as R3, and a central curvature radius of an image side surface of the second lens L**2** is defined as R4. The central curvature radius R3 and the central curvature radius R4 satisfy a following condition: $1.58 \leq (R3+R4)/(R3-R4) \leq 7.30$, which specifies a shape of the second lens L**2**. Within the range of the above condition, as the lens becomes ultra-thinness and wide angle, it is beneficial to correct on-axis chromatic aberration. Optionally, the central curvature radius R3 and the central curvature radius R4 satisfy a following condition: $2.53 \leq (R3+R4)/(R3-R4) \leq 5.84$.

An on-axis thickness of the second lens L**2** is defined as d3, and a total optical length from the object side surface of the first lens L**1** to the image plane Si of the camera optical lens **10** along an optic axis is defined as TTL. The on-axis thickness d3 and the total optical length TTL satisfy a following condition: 0.01≤d3/TTL≤0.04. Within the range of the above condition, it is beneficial to achieve an ultra-thinness effect. Optionally, the on-axis thickness d3 and the total optical length TTL satisfy a following condition: 0.02≤d3/TTL≤0.03.

In this embodiment, the object side surface of the third lens L**3** is convex in a paraxial region, and the image side surface of the third lens L**3** is concave in the paraxial region.

A focal length of the camera optical lens **10** is defined as f, and a focal length of the third lens L**3** is defined as f3. The focal length f and the focal length f3 satisfy a following condition: 0.78≤f3/f≤3.42. With appropriate configuration of the refractive power, the system may obtain better imaging quality and lower sensitivity. Optionally, the focal length f and the focal length f3 satisfy a following condition: 1.25≤f3/f≤2.74.

A central curvature radius of an object side surface of the third lens L**3** is defined as R5, and a central curvature radius of an image side surface of the third lens L**3** is defined as R6. The central curvature radius R5 and the central curvature radius R6 satisfy a following condition: −7.90≤(R5+R6)/(R5−R6)≤−1.83, which specifies a shape of the third lens L**3**. Within the specified range of the condition, a degree of deflection of light passing through the lens may be alleviated, and aberrations may be effectively reduced. Optionally, the central curvature radius R5 and the central curvature radius R6 satisfy a following condition: −4.94≤(R5+R6)/(R5−R6)≤−2.28.

An on-axis thickness of the third lens L**3** is defined as d5, and a total optical length from the object side surface of the first lens L**1** to the image plane Si of the camera optical lens **10** along an optic axis is defined as TTL. The on-axis thickness d5 and the total optical length TTL satisfy a following condition: 0.03≤d5/TTL≤0.11. Within the range of the above condition, it is beneficial to achieve an ultra-thinness effect. Optionally, the on-axis thickness d5 and the total optical length TTL satisfy a following condition: 0.04≤d5/TTL≤0.09.

In this embodiment, the object side surface of the fourth lens L**4** is concave in a paraxial region, and the image side surface of the fourth lens L**4** is convex in the paraxial region.

A focal length of the camera optical lens **10** is defined as f, and a focal length of the fourth lens L**4** is defined as f4. The focal length f and the focal length f4 satisfy a following condition: −45.74≤f4/f≤5804.23. With appropriate configuration of the refractive power, the system may obtain better imaging quality and lower sensitivity. Optionally, the focal length f and the focal length f4 satisfy a following condition: −28.59≤f4/f≤4643.38.

A central curvature radius of an object side surface of the fourth lens L**4** is defined as R7, and a central curvature radius of an image side surface of the fourth lens L**4** is defined as R8. The central curvature radius R7 and the central curvature radius R8 satisfy a following condition: −349.82≤(R7+R8)/(R7−R8)≤3.85, which specifies a shape of the fourth lens L**4**. Within the range of the above condition, it is beneficial to correct aberration of off-axis angle with the development of ultra-thinness and wide angle. Optionally, the central curvature radius R7 and the central curvature radius R8 satisfy a following condition: −218.64≤(R7+R8)/(R7−R8)≤3.08.

An on-axis thickness of the fourth lens L**4** is defined as d7, and a total optical length from the object side surface of the first lens L**1** to the image plane Si of the camera optical lens **10** along an optic axis is defined as TTL. The on-axis thickness d7 and the total optical length TTL satisfy a following condition: 0.07≤d7/TTL≤0.22. Within the range of the above condition, it is beneficial to achieve an ultra-thinness effect. Optionally, the on-axis thickness d7 and the total optical length TTL satisfy a following condition: 0.11≤d7/TTL≤0.18.

In this embodiment, the object side surface of the fifth lens L**5** is convex in a paraxial region, and the image side surface of the fifth lens L**5** is concave in the paraxial region.

A focal length of the camera optical lens **10** is defined as f, and a focal length of the fifth lens L**5** is defined as f5. The focal length f and the focal length f5 satisfy a following condition: 1.61≤f5/f≤10.88. The limitation on the fifth lens L**5** may effectively make the camera lens have a gentle light angle, thereby reducing tolerance sensitivity. Optionally, the focal length f and the focal length f5 satisfy a following condition: 2.58≤f5/f≤8.70.

A central curvature radius of an object side surface of the fifth lens is defined as R9, and a central curvature radius of an image side surface of the fifth lens is defined as R10. The central curvature radius R9 and the central curvature radius R10 satisfy a following condition: −6.22≤(R9+R10)/(R9−R10)≤−0.85, which specifies a shape of the fifth lens L**5**. Within the range of the above condition, it is beneficial to correct aberration of off-axis angle with the development of ultra-thinness and wide angle. Optionally, the central curvature radius R9 and the central curvature radius R10 satisfy a following condition: −3.89≤(R9+R10)/(R9−R10)≤−1.06.

An on-axis thickness of the fifth lens L**5** is defined as d9, and a total optical length from the object side surface of the first lens L**1** to the image plane Si of the camera optical lens **10** along an optic axis is defined as TTL. The on-axis thickness d9 and the total optical length TTL satisfy a following condition: 0.03≤d9/TTL≤0.09. Within the range of the condition, it is beneficial to achieve an ultra-thinness effect. Optionally, the on-axis thickness d9 and the total optical length TTL satisfy a following condition: 0.04≤d9/TTL≤0.07.

In this embodiment, the object side surface of the sixth lens L**6** is concave in a paraxial region, and the image side surface of the sixth lens L**6** is convex in the paraxial region.

A focal length of the camera optical lens **10** is defined as f, and a focal length of the sixth lens L**6** is defined as f6. The focal length f and the focal length f6 satisfy a following condition: −6.13≤f6/f≤−1.68. With appropriate configuration of the refractive power, the system may obtain better imaging quality and lower sensitivity. Optionally, the focal length f and the focal length f6 satisfy a following condition: −3.83≤f6/f≤−2.10.

A central curvature radius of an object side surface of the sixth lens L**6** is defined as R11, and a central curvature radius of an image side surface of the sixth lens is defined as R12. The central curvature radius R11 and the central curvature radius R12 satisfy a following condition: −6.58≤(R11+R12)/(R11−R12)≤−1.61, which specifies a shape of the sixth lens L**6**. Within the range of the above condition, it is beneficial to correct aberration of off-axis angle with the development of ultra-thinness and wide angle. Optionally, the central curvature radius R11 and the central curvature radius R12 satisfy a following condition: −4.12≤(R11+R12)/(R11−R12)≤−2.02.

An on-axis thickness of the sixth lens L**6** is defined as d11, and a total optical length from the object side surface of the first lens L**1** to the image plane Si of the camera optical lens **10** along an optic axis is defined as TTL. The on-axis thickness d11 and the total optical length TTL satisfy a following condition: 0.01≤d11/TTL≤0.05. Within the range of the condition, it is beneficial to achieve an ultra-thinness effect. Optionally, the on-axis thickness d11 and the total optical length TTL satisfy a following condition: $0.02 \le d11/TTL \le 0.04$.

In this embodiment, the object side surface of the seventh lens L7 is convex in a paraxial region, and the image side surface of the seventh lens L7 is concave in the paraxial region.

A focal length of the camera optical lens **10** is defined as f, and a focal length of the seventh lens L7 is defined as P. The focal length f and the focal length P satisfy a following condition: $1.51 \le f7/f \le 7.66$. With appropriate configuration of the refractive power, the system may obtain better imaging quality and lower sensitivity. Optionally, the focal length f and the focal length P satisfy a following condition: $2.42 \le f7/f \le 6.13$.

An on-axis thickness of the seventh lens L7 is defined as d13, and a total optical length from the object side surface of the first lens L1 to the image plane Si of the camera optical lens **10** along an optic axis is defined as TTL. The on-axis thickness d13 and the total optical length TTL satisfy a following condition: $0.02 \le d13/TTL \le 0.08$. Within the range of the condition, it is beneficial to achieve an ultra-thinness effect. Optionally, the on-axis thickness d13 and the total optical length TTL satisfy a following condition: $0.04 \le d13/TTL \le 0.06$.

In this embodiment, the object side surface of the eighth lens L8 is convex in a paraxial region, and the image side surface of the eighth lens L8 is concave in the paraxial region.

The focal length of the camera optical lens **10** is defined as f, and a focal length of the eighth lens L8 is defined as f8. The focal length f and the focal length f8 satisfy a following condition: $-20.76 \le f8/ \le 21.17$. With appropriate configuration of the refractive power, the system may obtain better imaging quality and lower sensitivity. Optionally, the focal length f and the focal length f8 satisfy a following condition: $-12.97 \le f8/f \le 16.94$.

A central curvature radius of an object side surface of the eighth lens L8 is defined as R15, and a central curvature radius of an image side surface of the eighth lens L8 is defined as R16. The central curvature radius R15 and the central curvature radius R16 satisfy a following condition: $-62.90 \le (R15+R16)/(R15-R16) \le 6.24$, which specifies a shape of the eighth lens. Within the range of the above condition, it is beneficial to correct aberration of off-axis angle with the development of ultra-thinness and wide angle. Optionally, the central curvature radius R15 and the central curvature radius R16 satisfy a following condition: $-39.31 \le (R15+R16)/(R15-R16) \le 4.99$.

An on-axis thickness of the eighth lens L8 is defined as d15, and a total optical length from the object side surface of the first lens L1 to the image plane Si of the camera optical lens **10** along an optic axis is defined as TTL. The on-axis thickness d15 and the total optical length TTL satisfy a following condition: $0.06 \le d15/TTL \le 0.25$. Within the range of the above condition, it is beneficial to achieve an ultra-thinness effect. Optionally, the on-axis thickness d15 and the total optical length TTL satisfy a following condition: $0.10 \le d15/TTL \le 0.20$.

In this embodiment, the object side surface of the ninth lens L9 is convex in a paraxial region, and the image side surface of the ninth lens L9 is concave in the paraxial region.

The focal length of the camera optical lens **10** is defined as f, and a focal length of the ninth lens L9 is defined as f9. The focal length f and the focal length f9 satisfy a following condition: $-5.32 \le f9/f \le -1.35$. With appropriate configuration of the refractive power, the system may obtain better imaging quality and lower sensitivity. Optionally, the focal length f and the focal length f9 satisfy a following condition: $-3.32 \le f9/f \le -1.68$.

A central curvature radius of an object side surface of the ninth lens L9 is defined as R17, and a central curvature radius of an image side surface of the ninth lens L9 is defined as R18. The central curvature radius R17 and the central curvature radius R18 satisfy a following condition: $2.53 \le (R17+R18)/(R17-R18) \le 10.69$, which specifies a shape of the ninth lens. Within the range of the above condition, it is beneficial to correct aberration of off-axis angle with the development of ultra-thinness and wide angle. Optionally, the central curvature radius R17 and the central curvature radius R18 satisfy a following condition: $4.04 \le (R17+R18)/(R17-R18) \le 8.55$.

An on-axis thickness of the ninth lens L9 is defined as d17, and a total optical length from the object side surface of the first lens L1 to the image plane Si of the camera optical lens **10** along an optic axis is defined as TTL. The on-axis thickness d17 and the total optical length TTL satisfy a following condition: $0.03 \le d17/TTL \le 0.10$. Within the range of the condition, it is beneficial to achieve an ultra-thinness effect. Optionally, the on-axis thickness d17 and the total optical length TTL satisfy a following condition: $0.04 \le d17/TTL \le 0.08$.

In this embodiment, an image height of the camera optical lens **10** is IH, and a total optical length from the object side surface of the first lens L1 to the image plane Si of the camera optical lens **10** along an optic axis is defined as TTL. The image height IH and the total optical length TTL satisfy a following condition: $TTL/IH \le 1.55$. Within the range of the condition, it is beneficial to achieve an ultra-thinness effect.

In this embodiment, a field of view FOV of the camera optical lens **10** is greater than or equal to 71.50°, so that a wide angle effect is achieved, thereby obtaining a good imaging quality of the camera optical lens.

In this embodiment, an F number FNO of the camera optical lens **10** is less than or equal to 2.01, so that a large aperture is achieved, thereby obtaining a good imaging quality of the camera optical lens.

When the above conditions are satisfied, the camera optical lens **10** may meet the design requirements for large aperture, wide angle and ultra-thinness while maintaining good optical performances. According to properties of the camera optical lens **10**, the camera optical lens **10** is especially suitable for mobile phone camera lens components composed of high-pixel CCD, CMOS and other imaging elements and WEB camera lens.

The camera optical lens **10** of the present invention will be described below with examples. The symbols recorded in each example will be described as follows. The focal length, on-axis distance, central curvature radius, on-axis thickness, inflection point position, and arrest point position are each in unit of millimeter (mm).

TTL denotes a total optical length (on-axis distance from the object side surface of the first lens L1 to the image plane Si), with a unit of millimeter (mm).

F number FNO denotes a ratio of an effective focal length of the camera optical lens to an entrance pupil diameter.

Optionally, the object side surface and/or the image side surface of the lens may be provided with inflection points and/or arrest points in order to meet high-quality imaging requirements. The description below may be referred to in specific embodiments as follows.

Design data of the camera optical lens **10** according to Embodiment 1 of the present invention are shown in Tables 1 and 2.

TABLE 1

	R	d			nd		vd
S1	∞	d0 =	−0.390				
R1	3.261	d1 =	0.980	nd1	1.5444	v1	55.82
R2	24.104	d2 =	0.041				
R3	6.674	d3 =	0.264	nd2	1.6400	v2	23.54
R4	3.465	d4 =	0.046				
R5	3.806	d5 =	0.470	nd3	1.5444	v3	55.82
R6	6.386	d6 =	0.540				
R7	−18.865	d7 =	1.369	nd4	1.5444	v4	55.82
R8	−24.569	d8 =	0.288				
R9	13.896	d9 =	0.527	nd5	1.5444	v5	55.82
R10	27.078	d10 =	0.448				
R11	−6.412	d11 =	0.311	nd6	1.6400	v6	23.54
R12	−12.006	d12 =	0.036				
R13	2.878	d13 =	0.476	nd7	1.5444	v7	55.82
R14	3.589	d14 =	0.606				
R15	24.240	d15 =	1.334	nd8	1.5444	v8	55.82
R16	14.840	d16 =	0.134				
R17	2.406	d17 =	0.464	nd9	1.5346	v9	55.69
R18	1.814	d18 =	0.650				
R19	∞	d19 =	0.110	ndg	1.5168	vg	64.17
R20	∞	d20 =	0.107				

The reference signs are explained as follows.

S**1**: aperture;

R: central curvature radius of an optical surface;

R1: central curvature radius of the object side surface of the first lens L**1**;

R2: central curvature radius of the image side surface of the first lens L**1**;

R3: central curvature radius of the object side surface of the second lens L**2**;

R4: central curvature radius of the image side surface of the second lens L**2**;

R5: central curvature radius of the object side surface of the third lens L**3**;

R6: central curvature radius of the image side surface of the third lens L**3**;

R7: central curvature radius of the object side surface of the fourth lens L**4**;

R8: central curvature radius of the image side surface of the fourth lens L**4**;

R9: central curvature radius of the object side surface of the fifth lens L**5**;

R10: central curvature radius of the image side surface of the fifth lens L**5**;

R11: central curvature radius of the object side surface of the sixth lens L**6**;

R12: central curvature radius of the image side surface of the sixth lens L**6**;

R13: central curvature radius of the object side surface of the seventh lens L**7**;

R14: central curvature radius of the image side surface of the seventh lens L**7**;

R15: central curvature radius of the object side surface of the eighth lens L**8**;

R16: central curvature radius of the image side surface of the eighth lens L**8**;

R17: central curvature radius of the object side surface of the ninth lens L**9**;

R18: central curvature radius of the image side surface of the ninth lens L**9**;

R19: central curvature radius of the object side surface of the optical filter GF;

R20: central curvature radius of the image side surface of the optical filter GF;

d: on-axis thickness of a lens and an on-axis distance between lenses;

d0: on-axis distance from the aperture S**1** to the object side surface of the first lens L**1**;

d1: on-axis thickness of the first lens L**1**;

d2: on-axis distance from the image side surface of the first lens L**1** to the object side surface of the second lens L**2**;

d3: on-axis thickness of the second lens L**2**;

d4: on-axis distance from the image side surface of the second lens L**2** to the object side surface of the third lens L**3**;

d5: on-axis thickness of the third lens L**3**;

d6: on-axis distance from the image side surface of the third lens L**3** to the object side surface of the fourth lens L**4**;

d7: on-axis thickness of the fourth lens L**4**;

d8: on-axis distance from the image side surface of the fourth lens L**4** to the object side surface of the fifth lens L**5**;

d9: on-axis thickness of the fifth lens L**5**;

d10: on-axis distance from the image side surface of the fifth lens L**5** to the object side surface of the sixth lens L**6**;

d11: on-axis thickness of the sixth lens L**6**;

d12: on-axis distance from the image side surface of the sixth lens L**6** to the object side surface of the seventh lens L**7**;

d13: on-axis thickness of the seventh lens L**7**;

d14: on-axis distance from the image side surface of the seventh lens L**7** to the object side surface of the eighth lens L**8**;

d15: on-axis thickness of the eighth lens L**8**;

d16: on-axis distance from the image side surface of the eighth lens L**8** to the object side surface of the ninth lens L**9**;

d17: on-axis thickness of the ninth lens L**9**;

d18: on-axis distance from the image side surface of the ninth lens L**9** to the object side surface of the optical filter GF;

d19: on-axis thickness of the optical filter GF;

d20: on-axis distance from the image side surface of the optical filter GF to the image plane Si;

nd: refractive index of a d-line;

nd1: refractive index of the d-line of the first lens L**1**;

nd2: refractive index of the d-line of the second lens L**2**;

nd3: refractive index of the d-line of the third lens L**3**;

nd4: refractive index of the d-line of the fourth lens L**4**;

nd5: refractive index of the d-line of the fifth lens L**5**;

nd6: refractive index of the d-line of the sixth lens L**6**;

nd7: refractive index of the d-line of the seventh lens L**7**;

nd8: refractive index of the d-line of the eighth lens L**8**;

nd9: refractive index of the d-line of the ninth lens L**9**;

ndg: refractive index of the d-line of the optical filter GF;

vd: Abbe number;

v1: Abbe number of the first lens L**1**;

v2: Abbe number of the second lens L**2**;

v3: Abbe number of the third lens L**3**;

v4: Abbe number of the fourth lens L**4**;

v5: Abbe number of the fifth lens L**5**;

v6: Abbe number of the sixth lens L**6**;
v7: Abbe number of the seventh lens L**7**;
v8: Abbe number of the eighth lens L**8**;
v9: Abbe number of the ninth lens L**9**;
vg: Abbe number of the optical filter GF.

Table 2 shows aspherical surface data of each lens in the camera optical lens **10** according to Embodiment 1 of the present invention.

TABLE 2

	Conic coefficient	Aspherical surface coefficient				
	k	A4	A6	A8	A10	A12
R1	1.2636E−01	1.2543E−03	−9.1743E−04	4.3744E−04	−1.4996E−04	9.3345E−06
R2	2.3921E+01	−1.8860E−02	8.7865E−03	−2.9424E−03	5.6053E−04	−6.0057E−05
R3	−1.9165E+01	−2.8802E−02	1.2544E−02	−2.8740E−03	5.1324E−04	−5.4371E−05
R4	−1.4012E+01	3.9517E−03	−1.3452E−03	2.2944E−03	−9.1893E−04	1.8696E−04
R5	−1.8858E+01	2.1654E−02	−4.8635E−03	9.2773E−04	−9.9225E−05	−1.0788E−05
R6	9.3508E+00	−5.6050E−03	1.6534E−03	−7.3889E−04	−1.3680E−06	−1.2580E−05
R7	−1.3005E+02	−9.1895E−03	−7.3985E−04	4.7084E−04	−1.8214E−04	4.4759E−06
R8	−5.3242E+02	−1.1823E−02	5.8399E−04	−8.4888E−05	2.0613E−05	2.9153E−06
R9	−2.1443E+02	−3.8845E−03	−2.3797E−03	7.1099E−05	2.5771E−05	2.6102E−07
R10	−1.7551E+03	−1.4674E−02	3.2036E−03	−8.2109E−04	−1.7471E−04	1.0436E−04
R11	4.3673E+00	−1.3793E−03	5.7697E−03	−2.7980E−03	5.4713E−04	−5.5538E−05
R12	1.3659E+01	−9.5617E−03	5.4796E−03	−1.9221E−03	3.1724E−04	−2.6951E−05
R13	−4.6248E+00	−1.5497E−02	1.7602E−03	−5.3194E−04	6.6444E−05	−6.1584E−06
R14	−4.1555E+00	−1.0891E−02	8.5204E−04	−1.5919E−04	1.5210E−05	−5.9725E−07
R15	−4.1555E+00	−8.8309E−03	1.0465E−03	−1.5988E−04	1.4635E−05	−6.2487E−07
R16	−4.1555E+00	−4.3747E−03	9.1565E−04	−1.6668E−04	1.4733E−05	−6.1428E−07
R17	−4.7278E+00	−3.7245E−02	4.9091E−03	−3.6427E−04	1.9344E−05	−7.6546E−07
R18	−3.6290E+00	−2.6346E−02	4.2428E−03	−4.6519E−04	3.2941E−05	−1.3968E−06

	Conic coefficient	Aspherical surface coefficient			
	k	A14	A16	A18	A20
R1	1.2636E−01	−8.0543E−08	5.4548E−08	−9.0555E−08	−4.4422E−09
R2	2.3921E+01	−1.4803E−06	6.7034E−07	3.5990E−07	−1.0239E−07
R3	−1.9165E+01	6.5809E−06	1.0465E−07	3.1539E−07	−1.3475E−07
R4	−1.4012E+01	1.6398E−05	−2.9021E−06	−7.3381E−07	−3.3269E−08
R5	−1.8858E+01	9.3903E−06	1.6956E−06	3.0245E−07	−2.1798E−07
R6	9.3508E+00	−3.6869E−06	1.8857E−06	1.8377E−07	−1.4992E−07
R7	−1.3005E+02	7.9648E−06	−3.4677E−07	−4.1533E−07	1.6668E−08
R8	−5.3242E+02	1.1645E−08	−9.1950E−08	7.6719E−09	1.4864E−09
R9	−2.1443E+02	3.4939E−09	−1.6396E−08	9.8368E−10	6.4949E−10
R10	−1.7551E+03	−1.6182E−05	8.0079E−07	8.1986E−10	3.7362E−10
R11	4.3673E+00	2.4847E−06	−1.9988E−09	−2.9919E−09	−1.7476E−09
R12	1.3659E+01	8.9036E−07	−4.3436E−09	5.5606E−10	1.3295E−10
R13	−4.6248E+00	2.0979E−07	3.3287E−09	2.0502E−10	3.6196E−12
R14	−4.1555E+00	7.9906E−09	8.2046E−11	−9.1024E−13	−1.4198E−13
R15	−4.1555E+00	7.2168E−09	8.5910E−11	2.0501E−12	3.8301E−14
R16	−4.1555E+00	7.6242E−09	9.4536E−11	4.6762E−13	−8.8506E−14
R17	−4.7278E+00	1.8388E−08	−2.0523E−10	2.8922E−13	1.4949E−14
R18	−3.6290E+00	3.2514E−08	−3.2873E−10	−3.0890E−13	1.9426E−14

Here, k denotes a conic coefficient, and A4, A6, A8, A10, A12, A14, A16, A18, and A20 denote an aspherical coefficient, respectively.

$$y=(x^2/R)/\{1+[1-(k+1)(x^2/R^2)]^{1/2}\}+A4x^4+A6x^6+A8x^8+A10x^{10}+A12x^{12}+A14x^{14}+A16x^{16}+A18x^{18}+A20x^{20} \quad (1)$$

Here, x denotes a vertical distance between a point on an aspherical curve and the optical axis, and y denotes a depth of the aspherical surface, i.e., a vertical distance between a point on the aspherical surface having a distance x from the optical axis and a tangent plane tangent to a vertex on an aspherical optical axis.

For convenience, the aspherical surface of each lens surface uses the aspherical surface shown in the above formula (1). However, the present invention is not limited to the aspherical polynomial form shown in the formula (1).

Design data of the inflection point and the arrest point of each lens in the camera optical lens **10** according to Embodiment 1 of the present invention are shown in Tables 3 and 4. Here, P1R1 and P1R2 denote the object side surface and image side surface of the first lens L**1**, respectively. P2R1 and P2R2 denote the object side surface and image side surface of the second lens L**2**, respectively. P3R1 and P3R2 denote the object side surface and image side surface of the third lens L**3**, respectively. P4R1 and P4R2 denote the object side surface and image side surface of the fourth lens L**4**, respectively. P5R1 and P5R2 denote the object side surface and image side surface of the fifth lens L**5**, respectively. P6R1 and P6R2 denote the object side surface and image side surface of the sixth lens L**6**, respectively. P7R1 and P7R2 denote the object side surface and image side surface of the seventh lens L**7**, respectively. P8R1 and P8R2 denote the object side surface and image side surface of the eighth lens L**8**, respectively. P9R1 and P9R2 denote the object side surface and image side surface of the ninth lens L**9**, respectively. Data in an "inflection point position" column are a vertical distance from an inflexion point provided on a surface of each lens to the optical axis of the camera optical lens **10**. Data in an "arrest point position" column are a vertical distance from an arrest point provided on the surface of each lens to the optical axis of the camera optical lens **10**.

TABLE 3

	Number of inflexion points	Inflexion point position 1	Inflexion point position 2	Inflexion point position 3	Inflexion point position 4
P1R1	1	1.745	/	/	/
P1R2	1	0.505	/	/	/
P2R1	2	0.845	1.005	/	/
P2R2	0	/	/	/	/
P3R1	0	/	/	/	/
P3R2	1	1.605	/	/	/
P4R1	0	/	/	/	/
P4R2	1	1.905	/	/	/
P5R1	2	0.695	2.175	/	/
P5R2	1	0.385	/	/	/
P6R1	0	/	/	/	/
P6R2	1	2.675	/	/	/
P7R1	1	1.095	/	/	/
P7R2	2	1.265	3.355	/	/
P8R1	1	0.665	/	/	/
P8R2	1	1.625	/	/	/
P9R1	4	0.825	2.745	3.305	4.725
P9R2	3	1.035	3.565	3.995	/

TABLE 4

	Number of arrest points	Arrest point position 1
P1R1	0	/
P1R2	1	1.025
P2R1	0	/
P2R2	0	/
P3R1	0	/
P3R2	0	/
P4R1	0	/
P4R2	0	/
P5R1	1	1.165
P5R2	1	0.705
P6R1	0	/
P6R2	0	/
P7R1	1	1.915
P7R2	1	2.295
P8R1	1	1.205
P8R2	1	2.595
P9R1	1	1.715
P9R2	1	2.725

FIG. **2** and FIG. **3** are schematic diagrams of a longitudinal aberration and a lateral color of the camera optical lens **10** after light having a wavelength of 656 nm, 587 nm, 546 nm, 486 nm, and 436 nm passes through the camera optical lens **10** according to Embodiment 1, respectively. FIG. **4** is a schematic diagram of a field curvature and a distortion of the camera optical lens **10** after light having a wavelength of 546 nm passes through the camera optical lens **10** according to Embodiment 1. A field curvature S in FIG. **4** is a field curvature in a sagittal direction, and T is a field curvature in a meridian direction.

Table 13 below shows numerical values corresponding to various numerical values in Embodiments 1, 2, and 3 and parameters specified in the conditions.

As shown in Table 13, Embodiment 1 satisfies various conditions.

In this embodiment, the entrance pupil diameter ENPD of the camera optical lens **10** is 3.551 mm, a full-field image height IH is 6.000 mm, and a field of view FOV in a diagonal direction is 71.60°. The camera optical lens **10** satisfies design requirements for large aperture, wide angle and ultra-thinness. The on-axis and off-axis chromatic aberrations are fully corrected, thereby achieving excellent optical performances.

Embodiment 2

Embodiment 2 is basically the same as Embodiment 1, and involves symbols having the same meanings as Embodiment 1, and only differences therebetween are listed below.

FIG. **5** shows a camera optical lens **20** according to Embodiment 2 of the present invention. The fourth lens L**4** has positive refractive power, and the eighth lens L**8** has positive refractive power.

Design data of the camera optical lens **20** according to Embodiment 2 of the present invention are shown in Tables 5 and 6.

TABLE 5

	R	d		nd		νd	
S1	∞	d0 =	−0.390				
R1	3.499	d1 =	0.738	nd1	1.5444	ν1	55.82
R2	10.444	d2 =	0.077				
R3	4.871	d3 =	0.249	nd2	1.6400	ν2	23.54
R4	2.998	d4 =	0.029				
R5	3.313	d5 =	0.652	nd3	1.5444	ν3	55.82
R6	6.702	d6 =	0.455				
R7	−32.521	d7 =	1.266	nd4	1.5444	ν4	55.82
R8	−32.895	d8 =	0.426				
R9	10.201	d9 =	0.495	nd5	1.5444	ν5	55.82
R10	43.481	d10 =	0.438				
R11	−6.143	d11 =	0.237	nd6	1.6400	ν6	23.54
R12	−13.644	d12 =	0.033				
R13	4.164	d13 =	0.436	nd7	1.5444	ν7	55.82
R14	5.125	d14 =	0.250				
R15	7.734	d15 =	1.493	nd8	1.5444	ν8	55.82
R16	9.242	d16 =	0.340				
R17	2.494	d17 =	0.514	nd9	1.5346	ν9	55.69
R18	1.759	d18 =	0.700				
R19	∞	d19 =	0.110	ndg	1.5168	νg	64.17
R20	∞	d20 =	0.161				

Table 6 shows aspherical surface data of each lens in the camera optical lens **20** according to Embodiment 2 of the present invention.

TABLE 6

	Conic coefficient	Aspherical surface coefficient				
	k	A4	A6	A8	A10	A12
R1	8.5368E−02	1.0867E−03	−9.3703E−04	4.0530E−04	−1.6381E−04	6.5852E−06
R2	−3.4472E+01	−1.9525E−02	8.7309E−03	−2.9444E−03	5.5804E−04	−6.1027E−05
R3	−1.6355E+01	−2.8900E−02	1.2502E−02	−2.8547E−03	5.1984E−04	−5.4073E−05
R4	−1.3077E+01	3.8128E−03	−1.3402E−03	2.2709E−03	−9.3120E−04	1.8424E−04
R5	−1.6073E+01	2.2979E−02	−4.9153E−03	9.0544E−04	−9.7642E−05	−9.6767E−06
R6	9.6067E+00	−5.4116E−03	1.4754E−03	−7.0864E−04	4.5396E−06	−1.4691E−05
R7	−7.4927E+01	−1.0753E−02	−1.0790E−03	4.5505E−04	−1.9696E−04	−1.4180E−06
R8	−5.4815E+02	−1.4195E−02	4.2315E−04	−9.8153E−05	1.8043E−05	2.3642E−06

TABLE 6-continued

R9	−1.3069E+02	−1.3249E−03	−2.3515E−03	5.9956E−05	2.3226E−05	−1.1612E−07
R10	−5.3945E+03	−1.5493E−02	3.3862E−03	−8.1780E−04	−1.7561E−04	1.0429E−04
R11	4.3393E+00	−6.2617E−04	5.8340E−03	−2.7843E−03	5.5012E−04	−5.5468E−05
R12	1.5417E+01	−9.1385E−03	5.4768E−03	−1.9215E−03	3.1751E−04	−2.6871E−05
R13	−6.6764E+00	−1.3203E−02	1.7491E−03	−5.4205E−04	6.6339E−05	−6.0708E−06
R14	−1.6508E+00	−1.0150E−02	8.2962E−04	−1.6108E−04	1.5120E−05	−6.0001E−07
R15	−1.6508E+00	−1.2367E−02	1.1642E−03	−1.5574E−04	1.4681E−05	−6.2916E−07
R16	−1.6508E+00	−6.4843E−03	9.5673E−04	−1.5976E−04	1.4818E−05	−6.1904E−07
R17	−6.7309E+00	−3.7023E−02	4.9745E−03	−3.6396E−04	1.9322E−05	−7.6608E−07
R18	−4.1134E+00	−2.4201E−02	4.1261E−03	−4.6488E−04	3.2984E−05	−1.3965E−06

	Conic coefficient	Aspherical surface coefficient			
	k	A14	A16	A18	A20
R1	8.5368E−02	−1.9027E−07	1.5686E−07	−7.3387E−08	−2.3035E−08
R2	−3.4472E+01	−1.7806E−06	5.1100E−07	3.2364E−07	−9.6476E−08
R3	−1.6355E+01	6.2606E−06	1.6416E−09	3.0037E−07	−1.3952E−07
R4	−1.3077E+01	1.6176E−05	−2.8625E−06	−7.3983E−07	−6.5328E−08
R5	−1.6073E+01	9.6054E−06	1.7294E−06	3.0329E−07	−2.3334E−07
R6	9.6067E+00	−5.1195E−06	1.4715E−06	1.6623E−07	−8.5310E−08
R7	−7.4927E+01	6.8760E−06	−3.7190E−07	−3.8648E−07	5.4717E−09
R8	−5.4815E+02	−7.5366E−08	−9.7901E−08	8.7480E−09	2.9026E−09
R9	−1.3069E+02	−4.0066E−08	−2.1178E−08	3.5869E−10	5.6342E−10
R10	−5.3945E+03	−1.6183E−05	8.0220E−07	1.5132E−09	6.2064E−10
R11	4.3393E+00	2.4392E−06	−8.3426E−09	−2.6842E−09	−1.4529E−09
R12	1.5417E+01	9.0084E−07	−3.7379E−09	4.7712E−10	9.9752E−11
R13	−6.6764E+00	2.2550E−07	5.0464E−09	3.2074E−10	2.3728E−12
R14	−1.6508E+00	7.9758E−09	8.8495E−11	−2.4489E−13	−1.0323E−13
R15	−1.6508E+00	6.8151E−09	6.6285E−11	1.7285E−12	9.4783E−14
R16	−1.6508E+00	7.3258E−09	8.5674E−11	5.7277E−13	−4.5573E−14
R17	−6.7309E+00	1.8382E−08	−2.0525E−10	2.7646E−13	1.3430E−14
R18	−4.1134E+00	3.2499E−08	−3.2856E−10	−2.8408E−13	1.8439E−14

Design data of the inflection point and the arrest point of each lens in the camera optical lens **20** according to Embodiment 2 of the present invention are shown in Tables 7 and 8.

TABLE 7

	Number of inflexion points	Inflexion point position 1	Inflexion point position 2	Inflexion point position 3	Inflexion point position 4
P1R1	1	1.625	/	/	/
P1R2	1	0.765	/	/	/
P2R1	0	/	/	/	/
P2R2	0	/	/	/	/
P3R1	0	/	/	/	/
P3R2	1	1.465	/	/	/
P4R1	0	/	/	/	/
P4R2	1	2.025	/	/	/
P5R1	2	0.815	2.295	/	/
P5R2	1	0.305	/	/	/
P6R1	0	/	/	/	/
P6R2	1	2.655	/	/	/
P7R1	2	1.075	2.845	/	/
P7R2	2	1.365	3.445	/	/
P8R1	1	1.035	/	/	/
P8R2	2	1.535	4.725	/	/
P9R1	4	0.765	2.555	3.595	4.815
P9R2	1	1.025	/	/	/

TABLE 8

	Number of arrest points	Arrest point position 1
P1R1	0	/
P1R2	1	1.465
P2R1	0	/
P2R2	0	/
P3R1	0	/

TABLE 8-continued

	Number of arrest points	Arrest point position 1
P3R2	0	/
P4R1	0	/
P4R2	0	/
P5R1	1	1.365
P5R2	1	0.545
P6R1	0	/
P6R2	0	/
P7R1	1	1.835
P7R2	1	2.355
P8R1	1	1.915
P8R2	1	2.965
P9R1	1	1.575
P9R2	1	2.895

FIG. **6** and FIG. **7** are schematic diagrams of a longitudinal aberration and a lateral color of the camera optical lens **20** after light having a wavelength of 656 nm, 587 nm, 546 nm, 486 nm, and 436 nm passes through the camera optical lens **20** according to Embodiment 2, respectively. FIG. **8** is a schematic diagram of a field curvature and a distortion after light having a wavelength of 546 nm passes through the camera optical lens **20** according to Embodiment 2. The field curvature S in FIG. **8** is a field curvature in a sagittal direction, and T is a field curvature in a meridional direction.

As shown in Table 13, Embodiment 2 satisfies various conditions.

In this embodiment, an entrance pupil diameter ENPD of the camera optical lens **20** is 3.429 mm, a full-field image height IH is 6.000 mm, and a field of view FOV in a diagonal direction is 76.20°. The camera optical lens **20** satisfies design requirements for large aperture, wide angle, and ultra-thinness. The on-axis and off-axis chromatic aberrations are fully corrected, thereby achieving excellent optical performances.

Embodiment 3

Embodiment 3 is basically the same as Embodiment 1, and involves symbols having the same meanings as Embodiment 1, and only differences therebetween are listed below.

FIG. **9** shows a camera optical lens **30** according to Embodiment 3 of the present invention. The fourth lens L**4** has positive refractive power, and the eighth lens L**8** has positive refractive power.

Design data of the camera optical lens **30** of Embodiment 3 of the present invention are shown in Tables 9 and 10.

TABLE 9

	R		d		nd		vd
S1	∞	d0 =	−0.370				
R1	3.621	d1 =	0.645	nd1	0.0000	v1	55.82
R2	7.731	d2 =	0.077				
R3	4.486	d3 =	0.237	nd2	0.0000	v2	23.54
R4	2.957	d4 =	0.028				

TABLE 9-continued

	R		d		nd		vd
R5	3.188	d5 =	0.625	nd3	0.0000	v3	55.82
R6	6.849	d6 =	0.411				
R7	−60.783	d7 =	1.218	nd4	0.0000	v4	55.82
R8	−26.689	d8 =	0.496				
R9	10.217	d9 =	0.523	nd5	0.0000	v5	55.82
R10	85.515	d10 =	0.464				
R11	−6.155	d11 =	0.319	nd6	0.0000	v6	23.54
R12	−14.820	d12 =	0.033				
R13	4.393	d13 =	0.475	nd7	0.0000	v7	55.82
R14	6.138	d14 =	0.249				
R15	6.120	d15 =	1.093	nd8	0.0000	v8	55.82
R16	6.522	d16 =	0.522				
R17	2.670	d17 =	0.601	nd9	0.0000	v9	55.69
R18	1.788	d18 =	0.700				
R19	∞	d19 =	0.110	ndg	0.0000	vg	64.17
R20	∞	d20 =	0.107				

Table 10 shows aspherical surface data of each lens in the camera optical lens **30** of Embodiment 3 of the present invention.

TABLE 10

	Conic coefficient	Aspherical surface coefficient				
	k	A4	A6	A8	A10	A12
R1	5.0773E−02	9.0217E−04	−9.2850E−04	3.9129E−04	−1.7099E−04	4.8620E−06
R2	−3.5235E+01	−1.9478E−02	8.7014E−03	−2.9705E−03	5.5089E−04	−6.2207E−05
R3	−1.6337E+01	−2.9033E−02	1.2529E−02	−2.8325E−03	5.2350E−04	−5.4420E−05
R4	−1.3464E+01	3.8309E−03	−1.3502E−03	2.2646E−03	−9.3260E−04	1.8358E−04
R5	−1.5492E+01	2.2757E−02	−5.0126E−03	8.8622E−04	−1.0145E−04	−1.1000E−05
R6	9.6643E+00	−5.3609E−03	1.5610E−03	−6.8870E−04	5.3112E−06	−1.5134E−05
R7	−7.5277E+01	−1.0716E−02	−1.1679E−03	4.5338E−04	−1.9515E−04	−1.4083E−06
R8	−4.2227E+02	−1.4721E−02	3.0325E−04	−1.1604E−04	1.6019E−05	2.2237E−06
R9	−1.1578E+02	−3.4392E−04	−2.3470E−03	5.6032E−05	2.2889E−05	−1.3121E−07
R10	−1.9245E+04	−1.6293E−02	3.3824E−03	−8.1706E−04	−1.7584E−04	1.0424E−04
R11	4.3184E+00	−4.0667E−04	5.8559E−03	−2.7813E−03	5.5079E−04	−5.5490E−05
R12	1.2926E+01	−8.6523E−03	5.4963E−03	−1.9195E−03	3.1770E−04	−2.6859E−05
R13	−5.7145E+00	−1.2876E−02	1.7414E−03	−5.3871E−04	6.6779E−05	−6.0563E−06
R14	−1.2248E+00	−9.0993E−03	8.5051E−04	−1.6100E−04	1.5108E−05	−6.0130E−07
R15	−1.2248E+00	−1.3261E−02	1.1497E−03	−1.5651E−04	1.4746E−05	−6.2448E−07
R16	−1.2248E+00	−7.4203E−03	9.1236E−04	−1.5791E−04	1.4890E−05	−6.1893E−07
R17	−7.2829E+00	−3.7351E−02	5.0037E−03	−3.6477E−04	1.9288E−05	−7.6573E−07
R18	−4.1104E+00	−2.3636E−02	4.0981E−03	−4.6474E−04	3.3006E−05	−1.3963E−06

	Conic coefficient	Aspherical surface coefficient			
	k	A14	A16	A18	A20
R1	5.0773E−02	−4.2364E−07	1.4481E−07	−8.1292E−08	−3.4596E−08
R2	−3.5235E+01	−1.8852E−06	5.0391E−07	3.0432E−07	−1.0910E−07
R3	−1.6337E+01	5.9292E−06	−7.2662E−08	2.9768E−07	−1.4430E−07
R4	−1.3464E+01	1.5889E−05	−2.9557E−06	−7.5614E−07	−6.1250E−08
R5	−1.5492E+01	9.1013E−06	1.5768E−06	2.9035E−07	−2.0933E−07
R6	9.6643E+00	−5.2095E−06	1.4826E−06	1.7830E−07	−8.2053E−08
R7	−7.5277E+01	6.6749E−06	−4.8905E−07	−3.3457E−07	9.9801E−09
R8	−4.2227E+02	−6.7902E−08	−9.3127E−08	9.7682E−09	3.0587E−09
R9	−1.1578E+02	−4.0559E−08	−2.1326E−08	3.1687E−10	5.5469E−10
R10	−1.9245E+04	−1.6186E−05	8.0257E−07	1.7624E−09	6.9120E−10
R11	4.3184E+00	2.4203E−06	−1.0328E−08	−2.4708E−09	−1.3280E−09
R12	1.2926E+01	9.0023E−07	−4.1004E−09	4.0170E−10	8.7521E−11
R13	−5.7145E+00	2.2426E−07	4.8178E−09	3.0038E−10	1.1004E−12
R14	−1.2248E+00	7.8758E−09	8.1943E−11	−6.2036E−13	−1.1978E−13
R15	−1.2248E+00	6.9986E−09	6.9734E−11	1.4850E−12	5.7587E−14
R16	−1.2248E+00	7.2518E−09	8.2505E−11	5.0474E−13	−4.4974E−14
R17	−7.2829E+00	1.8411E−08	−2.0468E−10	2.7002E−13	1.2176E−14
R18	−4.1104E+00	3.2486E−08	−3.2915E−10	−2.8857E−13	1.9122E−14

Design data of the inflection point and the arrest point of each lens in the camera optical lens **30** according to Embodiment 3 of the present invention are shown in Tables 11 and 12.

TABLE 11

	Number of inflexion points	Inflexion point position 1	Inflexion point position 2	Inflexion point position 3
P1R1	1	1.565	/	/
P1R2	1	0.815	/	/
P2R1	0	/	/	/
P2R2	0	/	/	/
P3R1	0	/	/	/
P3R2	1	1.465	/	/
P4R1	0	/	/	/
P4R2	1	2.065	/	/
P5R1	2	0.865	2.305	/
P5R2	1	0.235	/	/
P6R1	0	/	/	/
P6R2	1	2.665	/	/
P7R1	2	1.105	2.845	/
P7R2	2	1.375	3.405	/
P8R1	1	1.135	/	/
P8R2	1	1.615	/	/
P9R1	3	0.755	2.565	3.555
P9R2	1	1.045	/	/

TABLE 12

	Number of arrest points	Arrest point position 1
P1R1	0	/
P1R2	1	1.505
P2R1	0	/
P2R2	0	/
P3R1	0	/
P3R2	0	/
P4R1	0	/
P4R2	0	/
P5R1	1	1.435
P5R2	1	0.395
P6R1	0	/
P6R2	0	/
P7R1	1	1.865
P7R2	1	2.385
P8R1	1	2.085
P8R2	1	3.095
P9R1	1	1.515
P9R2	1	3.035

FIG. **10** and FIG. **11** are schematic diagrams of a longitudinal aberration and a lateral color after light having a wavelength of 656 nm, 587 nm, 546 nm, 486 nm, and 436 nm passes through the camera optical lens **30** according to Embodiment 3. FIG. **12** is a schematic diagram of a field curvature and a distortion of the camera optical lens **30** after light having a wavelength of 546 nm passes through the camera optical lens **30** according to Embodiment 3. The field curvature S in FIG. **12** is a field curvature in a sagittal direction, and T is a field curvature in a meridional direction.

Table 13 below shows numerical values corresponding to each condition in this embodiment according to the above conditions. It is appreciated that, the cameral optical lens **30** in this embodiment satisfies the above conditions.

In this embodiment, an entrance pupil diameter ENPD of the camera optical lens **30** is 3.281 mm, a full-field image height IH is 6.000 mm, and a field of view FOV in a diagonal direction is 77.80°. The camera optical lens **30** satisfies design requirements for large aperture, wide angle and ultra-thinness. The on-axis and off-axis chromatic aberrations are fully corrected, thereby achieving excellent optical performances.

TABLE 13

Parameters and conditions	Embodiment 1	Embodiment 2	Embodiment 3
f1/f	0.96	1.35	1.80
d15/d16	9.96	4.39	2.09
f	7.101	6.858	6.563
f1	6.785	9.277	11.806
f2	−11.517	−12.724	−14.292
f3	16.194	11.224	10.290
f4	−162.392	26536.919	85.943
f5	51.484	24.251	21.171
f6	−21.764	−17.506	−16.524
f7	21.498	35.008	25.786
f8	−73.700	64.233	92.642
f9	−18.880	−14.684	−13.247
f12	13.384	25.491	44.915
FNO	2.00	2.00	2.00
TTL	9.201	9.099	8.933
IH	6.000	6.000	6.000
FOV	71.60°	76.20°	77.80°

The above are only preferred embodiments of the present disclosure. Here, it should be noted that those skilled in the art may make modifications without departing from the inventive concept of the present disclosure, but these shall fall into the protection scope of the present disclosure.

What is claimed is:

1. A camera optical lens, comprising from an object side to an image side:

a first lens;

a second lens having negative refractive power;

a third lens;

a fourth lens;

a fifth lens;

a sixth lens;

a seventh lens;

an eighth lens; and

a ninth lens,

wherein the camera optical lens satisfies following conditions:

$$0.70 \leq f1/f \leq 1.80;$$

$$-10.0 \leq (R13+R14)/(R13-R14) \leq -6.00; \text{ and}$$

$$2.00 \leq d15/d16 \leq 10.00,$$

where

f denotes a focal length of the camera optical lens;

f1 denotes a focal length of the first lens;

R13 denotes a central curvature radius of an object side surface of the seventh lens;

R14 denotes a central curvature radius of an image side surface of the seventh lens;

d15 denotes an on-axis thickness of the eighth lens; and

d16 denotes an on-axis distance from an image side surface of the eighth lens to an object side surface of the ninth lens.

2. The camera optical lens as described in claim **1**, wherein the camera optical lens satisfies following conditions:

$$-5.52 \leq (R1+R2)/(R1-R2) \leq -0.88; \text{ and}$$

$$0.04 \leq d1/TTL \leq 0.16,$$

where

R1 denotes a central curvature radius of an object side surface of the first lens;

R2 denotes a central curvature radius of an image side surface of the first lens;

d1 denotes an on-axis thickness of the first lens; and

TTL denotes a total optical length from the object side surface of the first lens to an image plane of the camera optical lens along an optic axis.

3. The camera optical lens as described in claim **1**, wherein the camera optical lens satisfies following conditions:

$$-4.36 \leq f2/f \leq -1.08;$$

$$1.58 \leq (R3+R4)/(R3-R4) \leq 7.30; \text{ and}$$

$$0.01 \leq d3/TTL \leq 0.04,$$

where

f2 denotes a focal length of the second lens;

R3 denotes a central curvature radius of an object side surface of the second lens;

R4 denotes a central curvature radius of an image side surface of the second lens;

d3 denotes an on-axis thickness of the second lens; and

TTL denotes a total optical length from an object side surface of the first lens to an image plane of the camera optical lens along an optic axis.

4. The camera optical lens as described in claim **1**, the camera optical lens satisfies following conditions:

$$0.78 \leq f3/f \leq 3.42;$$

$$-7.90 \leq (R5+R6)/(R5-R6) \leq -1.83; \text{ and}$$

$$0.03 \leq d5/TTL \leq 0.11,$$

where

f3 denotes a focal length of the third lens;

R5 denotes a central curvature radius of an object side surface of the third lens;

R6 denotes a central curvature radius of an image side surface of the third lens;

d5 denotes an on-axis thickness of the third lens; and

TTL denotes a total optical length from an object side surface of the first lens to an image plane of the camera optical lens along an optic axis.

5. The camera optical lens as described in claim **1**, wherein the camera optical lens satisfies following conditions:

$$-45.74 \leq f4/f \leq 5804.23;$$

$$-349.82 \leq (R7+R8)/(R7-R8) \leq 3.85; \text{ and}$$

$$0.07 \leq d7/TTL \leq 0.22,$$

where

f4 denotes a focal length of the fourth lens;

R7 denotes a central curvature radius of an object side surface of the fourth lens;

R8 denotes a central curvature radius of an image side surface of the fourth lens;

d7 denotes an on-axis thickness of the fourth lens; and

TTL denotes a total optical length from an object side surface of the first lens to an image plane of the camera optical lens along an optic axis.

6. The camera optical lens as described in claim **1**, wherein the camera optical lens satisfies following conditions:

$$1.61 \leq f5/f \leq 10.88;$$

$$-6.22 \leq (R9+R10)/(R9-R10) \leq -0.85; \text{ and}$$

$$0.03 \leq d9/TTL \leq 0.09,$$

where

f5 denotes a focal length of the fifth lens;

R9 denotes a central curvature radius of an object side surface of the fifth lens;

R10 denotes a central curvature radius of an image side surface of the fifth lens;

d9 denotes an on-axis thickness of the fifth lens; and

TTL denotes a total optical length from an object side surface of the first lens to an image plane of the camera optical lens along an optic axis.

7. The camera optical lens as described in claim **1**, wherein the camera optical lens satisfies following conditions:

$$-6.13 \leq f6/f \leq -1.68;$$

$$-6.58 \leq (R11+R12)/(R11-R12) \leq -1.61; \text{ and}$$

$$0.01 \leq d11/TTL \leq 0.05,$$

where

f6 denotes a focal length of the sixth lens;

R11 denotes a central curvature radius of an object side surface of the sixth lens;

R12 denotes a central curvature radius of an image side surface of the sixth lens;

d11 denotes an on-axis thickness of the sixth lens; and

TTL denotes a total optical length from an object side surface of the first lens to an image plane of the camera optical lens along an optic axis.

8. The camera optical lens as described in claim **1**, wherein the camera optical lens satisfies following conditions:

$$1.51 \leq f7/f \leq 7.66; \text{ and}$$

$$0.02 \leq d13/TTL \leq 0.08,$$

where

f7 denotes a focal length of the seventh lens;

d13 denotes an on-axis thickness of the seventh lens; and

TTL denotes a total optical length from an object side surface of the first lens to an image plane of the camera optical lens along an optic axis.

9. The camera optical lens as described in claim **1**, wherein the camera optical lens satisfies following conditions:

$$-20.76 \leq f8/f \leq 21.17;$$

$$-62.90 \leq (R15+R16)/(R15-R16) \leq 6.24; \text{ and}$$

$$0.06 \leq d15/TTL \leq 0.25,$$

where

f8 denotes a focal length of the eighth lens;

R15 denotes a central curvature radius of an object side surface of the eighth lens;

R16 denotes a central curvature radius of the image side surface of the eighth lens; and

TTL denotes a total optical length from an object side surface of the first lens to an image plane of the camera optical lens along an optic axis.

10. The camera optical lens as described in claim **1**, wherein the camera optical lens satisfies following conditions:

$$-5.32 \leq f9/f \leq -1.35;$$

$$2.53 \leq (R17+R18)/(R17-R18) \leq 10.69; \text{ and}$$

$$0.03 \leq d17/TTL \leq 0.10,$$

where

f9 denotes a focal length of the ninth lens;

R17 denotes a central curvature radius of the object side surface of the ninth lens;

R18 denotes a central curvature radius of an image side surface of the ninth lens;

d17 denotes an on-axis thickness of the ninth lens; and

TTL denotes a total optical length from an object side surface of the first lens to an image plane of the camera optical lens along an optic axis.

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