

**U.S. Pat. No. 9,366,845 (Claims 1-34)**

| <b>Claims 1-17</b>                                                                                                                                                                                                                                                                                        | <b>Claim 18</b>                                                                                                                | <b>Claim 19</b>                              | <b>Claims 20-34</b>                                                                                                                                                                                                                                                                                                                       |
|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| [1.1] A photographing optical lens assembly comprising, in order from an object side to an image side:                                                                                                                                                                                                    | [18.1] An image capturing unit, comprising:                                                                                    | [19.1] An electronic device, comprising:     | [20.1] A photographing optical lens assembly comprising, in order from an object side to an image side:                                                                                                                                                                                                                                   |
| [1.2] a first lens element having positive refractive power;                                                                                                                                                                                                                                              | [18.2] the photographing optical lens assembly of claim 1;                                                                     | [19.2] the image capturing unit of claim 18. | [20.2] a first lens element having positive refractive power;                                                                                                                                                                                                                                                                             |
| [1.3] a second lens element having negative refractive power;                                                                                                                                                                                                                                             | [18.3] and an image sensor, wherein the image sensor is disposed on the image side of the photographing optical lens assembly. |                                              | [20.3] a second lens element;                                                                                                                                                                                                                                                                                                             |
| [1.4] a third lens element;                                                                                                                                                                                                                                                                               |                                                                                                                                |                                              | [20.4] a third lens element having positive refractive power;                                                                                                                                                                                                                                                                             |
| [1.5] a fourth lens element having positive refractive power;                                                                                                                                                                                                                                             |                                                                                                                                |                                              | [20.5] a fourth lens element having positive refractive power;                                                                                                                                                                                                                                                                            |
| [1.6] a fifth lens element with negative refractive power having an object-side surface being concave in a paraxial region thereof and an image-side surface being convex in a paraxial region thereof;                                                                                                   |                                                                                                                                |                                              | [20.6] a fifth lens element;                                                                                                                                                                                                                                                                                                              |
| [1.7] a sixth lens element having an image-side surface being concave in a paraxial region thereof, wherein both of an object-side surface and the image-side surface of the sixth lens element are aspheric, and the image-side surface of the sixth lens element has at least one inflection point; and |                                                                                                                                |                                              | [20.7] a sixth lens element with positive refractive power having an image-side surface being concave in a paraxial region thereof, wherein both of an object-side surface and the image-side surface of the sixth lens element are aspheric, and the image-side surface of the sixth lens element has at least one inflection point; and |

**U.S. Pat. No. 9,366,845 (Claims 1-34)**

| <b>Claims 1-17</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  | <b>Claim 18</b> | <b>Claim 19</b> | <b>Claims 20-34</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |
|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------|-----------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| [1.8] a seventh lens element having an image-side surface being concave in a paraxial region thereof, wherein both of an object-side surface and the image-side surface of the seventh lens element are aspheric, and the image-side surface of the seventh lens element has at least one inflection point;                                                                                                                                                                                                                                                                                                                                                                                                                                                         |                 |                 | [20.8] a seventh lens element having an image-side surface being concave in a paraxial region thereof, wherein both of an object-side surface and the image-side surface of the seventh lens element are aspheric, and the image-side surface of the seventh lens element has at least one inflection point;                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |
| [1.9] wherein the photographing optical lens assembly has a total of seven lens elements,                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |                 |                 | [20.9] wherein the photographing optical lens assembly has a total of seven lens elements,                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |
| [1.10] there is a non-axial critical point on the image-side surface of the sixth lens element at which a tangent to the image-side surface of the sixth lens element is perpendicular to an optical axis, there is a non-axial critical point on the image-side surface of the seventh lens element at which a tangent to the image-side surface of the seventh lens element is perpendicular to the optical axis, a vertical distance between the non-axial critical point on the image-side surface of the sixth lens element and the optical axis is $Y_{c62}$ , a vertical distance between the non-axial critical point on the image-side surface of the seventh lens element and the optical axis is $Y_{c72}$ , a focal length of the photographing optical |                 |                 | [20.10] there is a non-axial critical point on the image-side surface of the seventh lens element at which a tangent to the image-side surface of the seventh lens element is perpendicular to an optical axis, a focal length of the photographing optical lens assembly is $f$ , a vertical distance between the non-axial critical point on the image-side surface of the seventh lens element and the optical axis is $Y_{c72}$ , a focal length of the first lens element is $f_1$ , a focal length of the second lens element is $f_2$ , an axial distance between an object-side surface of the first lens element and an image surface is $TL$ , a maximum image height of the photographing optical lens assembly is $ImgH$ , and the following conditions are satisfied:<br>$0.1 < Y_{c72}/f < 0.9$ ; |

**U.S. Pat. No. 9,366,845 (Claims 1-34)**

| <b>Claims 1-17</b>                                                                                                                                                                                                                                                      | <b>Claim 18</b> | <b>Claim 19</b> | <b>Claims 20-34</b>                                                                                                                                                                                                                                          |
|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------|-----------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| lens assembly is $f$ , a focal length of the first lens element is $f_1$ , a focal length of the seventh lens element is $f_7$ , and the following conditions are satisfied:<br>$0.5 < Y_{c62}/Y_{c72} < 1.5$ ;<br>$0.1 < Y_{c72}/f < 0.9$ ; and<br>$ f_1/f_7  < 3.0$ . |                 |                 | $ f_1/f_2  < 2.0$ ; and<br>$TL/ImgH < 2.20$ .                                                                                                                                                                                                                |
| 2. The photographing optical lens assembly of claim 1, wherein the object-side surface of the sixth lens element is convex in a paraxial region thereof.                                                                                                                |                 |                 | 21. The photographing optical lens assembly of claim 20, wherein the object-side surface of the first lens element is convex in a paraxial region thereof, and the second lens element has an image-side surface being concave in a paraxial region thereof. |
| 3. The photographing optical lens assembly of claim 1, wherein the object-side surface of the seventh lens element is convex in a paraxial region thereof.                                                                                                              |                 |                 | 22. The photographing optical lens assembly of claim 20, wherein the third lens element has an object-side surface being convex in a paraxial region thereof.                                                                                                |
| 4. The photographing optical lens assembly of claim 1, wherein the third lens element has positive refractive power.                                                                                                                                                    |                 |                 | 23. The photographing optical lens assembly of claim 20, wherein the fifth lens element has negative refractive power.                                                                                                                                       |
| [5.1] The photographing optical lens assembly of claim 1, wherein at least three lens elements have positive refractive power among the first lens element, the second lens element, the third lens element, the fourth lens element, the fifth lens element, the       |                 |                 | 24. The photographing optical lens assembly of claim 20, wherein the fifth lens element has an image-side surface being convex in a paraxial region thereof.                                                                                                 |

**U.S. Pat. No. 9,366,845 (Claims 1-34)**

| <b>Claims 1-17</b>                                                                                                                                                                                                                                                                     | <b>Claim 18</b> | <b>Claim 19</b> | <b>Claims 20-34</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |
|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------|-----------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| sixth lens element and the seventh lens element,                                                                                                                                                                                                                                       |                 |                 |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |
| [5.2] the focal length of the photographing optical lens assembly is $f$ , a curvature radius of the image-side surface of the seventh lens element is $R14$ , and the following condition is satisfied:<br>$0 < R14/f < 0.7$ .                                                        |                 |                 | 25. The photographing optical lens assembly of claim 20, wherein the focal length of the photographing optical lens assembly is $f$ , a curvature radius of the image-side surface of the sixth lens element is $R12$ , and the following condition is satisfied:<br>$0 < f/R12 < 3.0$ .                                                                                                                                                                                                                                                  |
| 6. The photographing optical lens assembly of claim 1, wherein the focal length of the photographing optical lens assembly is $f$ , a curvature radius of the image-side surface of the sixth lens element is $R12$ , and the following condition is satisfied:<br>$0 < f/R12 < 5.0$ . |                 |                 | 26. The photographing optical lens assembly of claim 20, wherein the focal length of the first lens element is $f1$ , the focal length of the second lens element is $f2$ , a focal length of the third lens element is $f3$ , a focal length of the fourth lens element is $f4$ , a focal length of the fifth lens element is $f5$ , a focal length of the sixth lens element is $f6$ , a focal length of the seventh lens element is $f7$ , and the following condition is satisfied:<br>$ f1  <  fi $ , wherein $i=2, 3, 4, 5, 6, 7$ . |
| 7. The photographing optical lens assembly of claim 1, wherein the seventh lens element has negative refractive power.                                                                                                                                                                 |                 |                 | 27. The photographing optical lens assembly of claim 20, wherein a curvature radius of the object-side surface of the sixth lens element is $R11$ , a curvature radius of the image-side surface of the sixth lens element is $R12$ , and the following condition is satisfied:<br>$-2.0 < (R11-R12)/(R11+R12) < 0.2$ .                                                                                                                                                                                                                   |
| 8. The photographing optical lens assembly of claim 1, wherein a                                                                                                                                                                                                                       |                 |                 | 28. The photographing optical lens assembly of claim 20, wherein the focal                                                                                                                                                                                                                                                                                                                                                                                                                                                                |

**U.S. Pat. No. 9,366,845 (Claims 1-34)**

| <b>Claims 1-17</b>                                                                                                                                                                                                                                                                                                          | <b>Claim 18</b> | <b>Claim 19</b> | <b>Claims 20-34</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |
|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------|-----------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| curvature radius of the object-side surface of the seventh lens element is R13, a curvature radius of the image-side surface of the seventh lens element is R14, and the following condition is satisfied:<br>$0 < (R13 - R14) / (R13 + R14) < 1.5$ .                                                                       |                 |                 | length of the photographing optical lens assembly is f, the focal length of the first lens element is f1, the focal length of the second lens element is f2, a focal length of the third lens element is f3, a focal length of the fourth lens element is f4, a focal length of the fifth lens element is f5, a focal length of the sixth lens element is f6, a focal length of the seventh lens element is f7, and the following condition is satisfied:<br>$ f/f_j _{\max} < 1.8$ , wherein $j=1, 2, 3, 4, 5, 6, 7$ .                                                                                                  |
| 9. The photographing optical lens assembly of claim 1, wherein a sum of axial distances between any two lens elements adjacent to each other is $\sum AT$ , a maximum image height of the photographing optical lens assembly is ImgH, and the following condition is satisfied:<br>$0.20 < \sum AT / \text{ImgH} < 0.60$ . |                 |                 | 29. The photographing optical lens assembly of claim 20, wherein an Abbe number of the first lens element is $V1$ , an Abbe number of the second lens element is $V2$ , an Abbe number of the third lens element is $V3$ , an Abbe number of the fourth lens element is $V4$ , an Abbe number of the fifth lens element is $V5$ , an Abbe number of the sixth lens element is $V6$ , an Abbe number of the seventh lens element is $V7$ , and at least three lens elements among the first lens element to the seventh lens element satisfy the following condition:<br>$V_i < 26.0$ , wherein $i=1, 2, 3, 4, 5, 6, 7$ . |
| 10. The photographing optical lens assembly of claim 1, wherein both of an object-side surface and an image-side surface of the first lens element are aspheric, both of an object-side                                                                                                                                     |                 |                 | 30. The photographing optical lens assembly of claim 20, further comprising an aperture stop, wherein the first lens element, the second lens element, the third lens element, the                                                                                                                                                                                                                                                                                                                                                                                                                                       |

**U.S. Pat. No. 9,366,845 (Claims 1-34)**

| Claims 1-17                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     | Claim 18 | Claim 19 | Claims 20-34                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |
|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------|----------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <p>surface and an image-side surface of the second lens element are aspheric, both of an object-side surface and an image-side surface of the third lens element are aspheric, both of an object-side surface and an image-side surface of the fourth lens element are aspheric, both of an object-side surface and an image-side surface of the fifth lens element are aspheric, an axial distance between the object-side surface of the first lens element and an image surface is <math>TL</math>, the focal length of the photographing optical lens assembly is <math>f</math>, and the following condition is satisfied:<br/> <math>0.80 &lt; TL/f &lt; 1.80</math>.</p> |          |          | <p>fourth lens element, the fifth lens element, the sixth lens element and the seventh lens element are all non-cemented lens elements, and the aperture stop is located between an imaged object and the second lens element.</p>                                                                                                                                                                                                                                                                                                                                                                                |
| <p>11. The photographing optical lens assembly of claim 1, wherein a maximum refractive index of one single lens element among the first lens element, the second lens element, the third lens element, the fourth lens element, the fifth lens element, the sixth lens element and the seventh lens element is <math>N_{max}</math>, and the following condition is satisfied:<br/> <math>1.640 \leq N_{max} &lt; 1.750</math>.</p>                                                                                                                                                                                                                                            |          |          | <p>31. The photographing optical lens assembly of claim 20, wherein there is a non-axial critical point on the object-side surface of the sixth lens element at which a tangent to the object-side surface of the sixth lens element is perpendicular to the optical axis, there is a non-axial critical point on the image-side surface of the sixth lens element at which a tangent to the image-side surface of the sixth lens element is perpendicular to the optical axis, a vertical distance between the non-axial critical point on the object-side surface of the sixth lens element and the optical</p> |

**U.S. Pat. No. 9,366,845 (Claims 1-34)**

| <b>Claims 1-17</b>                                                                                                                                                                                                        | <b>Claim 18</b> | <b>Claim 19</b> | <b>Claims 20-34</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |
|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------|-----------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|                                                                                                                                                                                                                           |                 |                 | axis is $Y_{c61}$ , a vertical distance between the non-axial critical point on the image-side surface of the sixth lens element and the optical axis is $Y_{c62}$ , and the following condition is satisfied:<br>$0.30 < Y_{c62}/Y_{c61} < 1.80$ .                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |
| 12. The photographing optical lens assembly of claim 1, wherein an Abbe number of the second lens element is $V_2$ , and the following condition is satisfied:<br>$V_2 < 26.0$ .                                          |                 |                 | 32. The photographing optical lens assembly of claim 20, wherein the focal length of the photographing optical lens assembly is $f$ , a focal length of the third lens element is $f_3$ , and the following condition is satisfied:<br>$-0.5 < f/f_3 < 0.6$ .                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |
| 13. The photographing optical lens assembly of claim 1, wherein the focal length of the photographing optical lens assembly is $f$ , and the following condition is satisfied:<br>$3.0[\text{mm}] < f < 6.5[\text{mm}]$ . |                 |                 | 33. The photographing optical lens assembly of claim 20, wherein an axial distance between the first lens element and the second lens element is $T_{12}$ , an axial distance between the second lens element and the third lens element is $T_{23}$ , an axial distance between the third lens element and the fourth lens element is $T_{34}$ , an axial distance between the fourth lens element and the fifth lens element is $T_{45}$ , an axial distance between the fifth lens element and the sixth lens element is $T_{56}$ , an axial distance between the sixth lens element and the seventh lens element is $T_{67}$ , and the following condition is satisfied:<br>$0 < (T_{12}/T_{23}) + (T_{34}/T_{45}) + (T_{56}/T_{67}) < 3.8$ . |
| 14. The photographing optical lens assembly of claim 1, further                                                                                                                                                           |                 |                 | 34. The photographing optical lens assembly of claim 20, further                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |

**U.S. Pat. No. 9,366,845 (Claims 1-34)**

| <b>Claims 1-17</b>                                                                                                                                                                                                                                                                                                                                          | <b>Claim 18</b> | <b>Claim 19</b> | <b>Claims 20-34</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |
|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------|-----------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| comprising an aperture stop, wherein an axial distance between the aperture stop and the image-side surface of the seventh lens element is SD, an axial distance between an object-side surface of the first lens element and the image-side surface of the seventh lens element is TD, and the following condition is satisfied:<br>$0.75 < SD/TD < 1.1$ . |                 |                 | comprising aperture stop, wherein the aperture stop is located between an imaged object and the first lens element, an axial distance between the second lens element and the third lens element is T23, a central thickness of the second lens element is CT2, the focal length of the photographing optical lens assembly is f, a curvature radius of an image-side surface of the third lens element is R6, and the following conditions are satisfied:<br>$0.3 < T23/CT2 < 3.0$ ; and<br>$-1.0 < f/R6 < 2.5$ . |
| 15. The photographing optical lens assembly of claim 1, wherein a curvature radius of an object-side surface of the first lens element is R1, a curvature radius of an image-side surface of the first lens element is R2, and the following condition is satisfied:<br>$-0.2 < R1/R2 < 0.2$ .                                                              |                 |                 |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |
| 16. The photographing optical lens assembly of claim 1, wherein the focal length of the photographing optical lens assembly is f, an entrance pupil diameter of the photographing optical lens assembly is EPD, half of a maximal field of view of the photographing optical lens assembly                                                                  |                 |                 |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |

**U.S. Pat. No. 9,366,845 (Claims 1-34)**

| <b>Claims 1-17</b>                                                                                                                                                                                                                                                                                                                                                                                                                                           | <b>Claim 18</b> | <b>Claim 19</b> | <b>Claims 20-34</b> |
|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------|-----------------|---------------------|
| is HFOV, and the following conditions are satisfied:<br>$1.2 < f/EPD < 2.6$ ; and<br>$15[\text{deg.}] < \text{HFOV} < 45[\text{deg.}]$ .                                                                                                                                                                                                                                                                                                                     |                 |                 |                     |
| 17. The photographing optical lens assembly of claim 1, wherein a central thickness of the first lens element is CT1, a central thickness of the second lens element is CT2, an axial distance between the second lens element and the third lens element is T23, an axial distance between the third lens element and the fourth lens element is T34, and the following conditions are satisfied:<br>$1.0 < CT1/CT2 < 5.5$ ; and<br>$0.5 < T23/T34 < 4.5$ . |                 |                 |                     |