



(51) International Patent Classification:

G02B 13/00 (2006.01)

G02B 13/08 (2006.01)

G02B 15/14 (2006.01)

No.9680, Shennan Avenue, Dachong Community, Yuehai Street, Nanshan District, Shenzhen, Guangdong 518057 (CN).

(21) International Application Number:

PCT/CN2023/100815

(22) International Filing Date:

16 June 2023 (16.06.2023)

(25) Filing Language:

English

(26) Publication Language:

English

(71) Applicant: GUANGDONG OPPO MOBILE TELECOMMUNICATIONS CORP., LTD. [CN/CN];

No. 18, Haibin Road, Wusha, Chang'an, Dongguan, Guangdong 523860 (CN).

(81) Designated States (unless otherwise indicated, for every kind of national protection available):

AE, AG, AL, AM, AO, AT, AU, AZ, BA, BB, BG, BH, BN, BR, BW, BY, BZ, CA, CH, CL, CN, CO, CR, CU, CV, CZ, DE, DJ, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IQ, IR, IS, IT, JM, JO, JP, KE, KG, KH, KN, KP, KR, KW, KZ, LA, LC, LK, LR, LS, LU, LY, MA, MD, MG, MK, MN, MU, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PA, PE, PG, PH, PL, PT, QA, RO, RS, RU, RW, SA, SC, SD, SE, SG, SK, SL, ST, SV, SY, TH, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, WS, ZA, ZM, ZW.

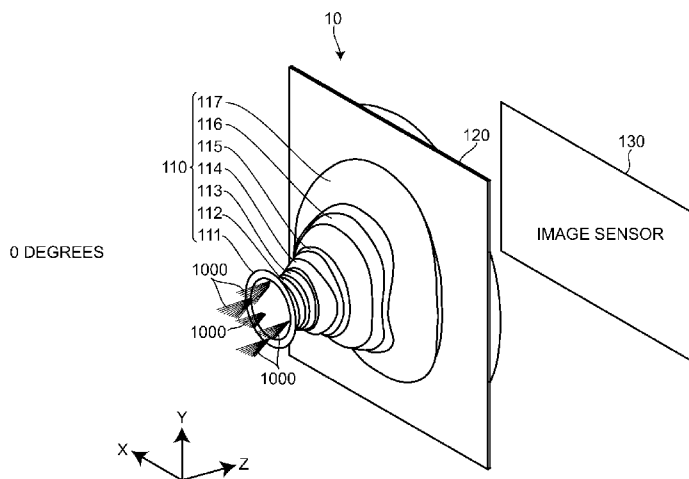
(72) Inventor: NABETA, Kenshi; 13F, Ocean Gate Minato Mirai, 3-7-1, Minatomirai, Nishi-ku, Kanagawa 220-0012 (JP).

(84) Designated States (unless otherwise indicated, for every kind of regional protection available):

ARIPO (BW, CV, GH, GM, KE, LR, LS, MW, MZ, NA, RW, SC, SD, SL, ST, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, RU, TJ, TM), European (AL, AT, BE, BG, CH, CY, CZ,

(54) Title: IMAGING LENS AND IMAGING DEVICE

FIG.4



(57) Abstract: An imaging lens (110) includes a lens group including: in order from an object side, a first lens (111) having positive refractive power and an object-side surface having a convex shape; a second lens (112) having negative refractive power; a plurality of intermediate lens (113, 114, 115, 116); and a final lens (117) having negative refractive power and an image-side surface having a concave shape near an optical axis. The lens group has one or more rotationally-asymmetric surfaces, and changes an angle of view by rotating the lens group relative to an imaging element around the optical axis.

DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT,
LU, LV, MC, ME, MK, MT, NL, NO, PL, PT, RO, RS, SE,
SI, SK, SM, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN,
GQ, GW, KM, ML, MR, NE, SN, TD, TG).

Published:

— *with international search report (Art. 21(3))*

IMAGING LENS AND IMAGING DEVICE

[Technical Field]

[0001] The present disclosure relates to an imaging lens and an imaging device.

[Background Art]

[0002] Conventionally, a smartphone is equipped with a plurality of cameras including a wide angle camera and a super-wide angle camera. In response to a zoom magnification, the smartphone switches to a camera with an angle of view corresponding to the magnification among the plurality of cameras to acquire an optical zoom image. Moreover, in order to acquire an image with a higher optical magnification, the smartphone may be equipped with a periscope camera.

[Disclosure of Invention]

[Problem to be Solved by the Invention]

[0003] However, the smartphone is equipped with a plurality of cameras. Each camera has a single focus lens. The focal lengths of the single focus lenses are different for the respective cameras. The smartphone acquires an optical zoom image by being equipped with the plurality of cameras. If an optical zoom lens camera can be introduced into the smartphone, the number of installed single focus lens cameras can be reduced, but the conventional imaging lens with the optical zoom lens has a long total track length to drive the optical zoom lens in an optical axis direction and thus the camera pops out in the optical axis direction.

[0004] The present disclosure has been made in view of the above-described problem, and an aim of the present disclosure is to provide an imaging lens and an imaging device, which can acquire images with different angles of view with a group of lenses.

[Means for Solving Problem]

[0005] To solve the problem described above and achieve an aim of the present disclosure, an imaging lens according to one aspect of the present disclosure includes a lens group including: in order from an object side, a first lens having positive refractive power and an object-side surface having a convex shape; a second lens having negative refractive power; a plurality of intermediate lens; and a final lens having negative refractive power and an image-side surface having a concave shape near an optical axis. The lens group has one or more rotationally-asymmetric surfaces, and changes an angle of view by rotating the lens group relative to an imaging element around the optical axis.

[Effect of the Invention]

[0006] According to one aspect of the present disclosure, it is possible to acquire images with different angles of view with a group of lenses.

[Brief Description of Drawings]

[0007] FIG. 1 is a perspective view illustrating a camera of an imaging device according to an embodiment;

[0008] FIG. 2 is an YZ cross-sectional view illustrating the camera of the

imaging device according to the embodiment;

[0009] FIG. 3 is an XZ cross-sectional view illustrating the camera of the imaging device according to the embodiment;

[0010] FIG. 4 is a diagram illustrating an example of a state when an imaging lens is rotated relative to an image sensor in the camera of the imaging device according to the embodiment;

[0011] FIG. 5 is a diagram illustrating an example of a graph indicating aberration of the imaging lens of the imaging device according to the embodiment;

[0012] FIG. 6 is a conceptual diagram illustrating a difference in angles of view between an image acquired by the imaging lens with a rotation angle of zero degrees and an image acquired by the imaging lens with a rotation angle of 90 degrees in the imaging device according to the embodiment;

[0013] FIG. 7 is a diagram illustrating an example of a relationship between a camera with the imaging lens with the rotation angle of zero degrees, an effective image circle, and an image height distribution in the imaging device according to the embodiment;

[0014] FIG. 8 is a diagram illustrating an example of a relationship between the camera with the imaging lens with the rotation angle of 90 degrees, the effective image circle, and the image height distribution in the imaging device according to the embodiment;

[0015] FIG. 9 is a diagram obtained by enlarging an area inside a rectangular frame of the image height distribution illustrated in FIG. 7;

[0016] FIG. 10 is a diagram obtained by enlarging an area inside the rectangular frame of the image height distribution illustrated in FIG. 8;

[0017] FIG. 11 is a diagram illustrating an example of an external configuration of the imaging device according to the embodiment;

[0018] FIG. 12 is a diagram illustrating an example of a hardware block configuration of the imaging device according to the embodiment;

[0019] FIG. 13 is a diagram illustrating an example of rotary optical zoom operations by the imaging device according to the embodiment;

[0020] FIG. 14 is a comparative example explaining an example of the effect of the embodiment when single focus lenses are used; and

[0021] FIG. 15 is a comparative example explaining an example of the effect of the embodiment when the single focus lenses are used.

[Embodiment(s) of Carrying Out the Invention]

[0022] Hereinafter, an imaging lens and an imaging device according to an embodiment will be described in detail with reference to the accompanying drawings. Note that the present invention is not limited to the embodiment.

[0023] Embodiment

FIGS. 1 to 3 are diagrams illustrating an example of a configuration of a camera of an imaging device according to the embodiment. FIG. 1 is a perspective view illustrating the camera of the imaging device according to the embodiment. FIG. 2 is an YZ cross-sectional view illustrating the camera

of the imaging device according to the embodiment. FIG. 3 is an XZ cross-sectional view illustrating the camera of the imaging device according to the embodiment.

[0024] The camera of the imaging device according to the embodiment performs an optical zoom by the rotation of an imaging lens. Therefore, the imaging lens is configured to be rotatable around an optical axis. For example, a camera 10 illustrated in FIG. 1 includes an imaging lens 110 that includes a group of lenses in which a plurality of lenses are arranged on the optical axis, and the entire of the imaging lens 110 can be integrally rotated. The number of lenses included in the lens group is seven as an example.

[0025] The imaging lens 110 is rotatably held around the optical axis by a holding unit of a housing of the camera 10 as an example. The camera 10 rotates the imaging lens 110 up to a position of a predetermined rotation angle to stop the imaging lens by driving a motor. In the present embodiment, the imaging lens 110 has two stop positions, namely, a position of the rotation angle of zero degrees and a position of the rotation angle of 90 degrees. The rotation of the imaging lens 110 to the position of the rotation angle of zero degrees and the position of the rotation angle of 90 degrees may be performed by the one-directional drive, or may be performed by the bi-directional drive that is alternately performed in the positive and negative directions. The imaging lens 110 may be rotated by a combination of a stepping motor and a gear mechanism, for example, or may be rotated by employing the other driving system. For example, the other driving system such as an ultrasonic motor or an electromagnetic coil may be employed as appropriate.

[0026] Note that the rotation of the imaging lens 110 is not limited to the control by the camera 10. The rotation of the imaging lens 110 may be performed by manual control in which a person directly rotates the imaging lens 110 with a finger.

[0027] Moreover, the camera 10 illustrated in FIG. 1 has a configuration that light passing through an IR filter 120 is incident on an image sensor 130, but this is only the example of the configuration of the camera and thus the camera configuration is not limited to the configuration having the IR filter 120.

[0028] The image sensor 130 is arranged on the image side of the imaging lens 110, and photo-electrically converts an image on an image surface with a plurality of pixels arranged in a two-dimensional array to output a pixel signal. As an example, the image sensor is a solid-state imaging element such as CCD (charge coupled device) and CMOS (complementary metal-oxide-semiconductor).

[0029] Configuration of Imaging Lens

The imaging lens 110 is a group of lenses in which a first lens 111, a second lens 112, a third lens 113, a fourth lens 114, a fifth lens 115, a sixth lens 116, and a seventh lens 117 are arranged on the optical axis in

order from the object side. In the present embodiment, because the number of lenses is seven, the third lens 113, the fourth lens 114, the fifth lens 115, and the sixth lens 116 correspond to the intermediate lenses, and the seventh lens 117 corresponds to the final lens.

[0030] Herein, the first lens 111 has positive refractive power and an object-side surface having a convex shape. The second lens 112 has negative refractive power. The seventh lens 117 that is the final lens has negative refractive power and an image-side surface having a concave shape near the optical axis.

[0031] Moreover, the imaging lens 110 has a rotationally-asymmetric surface on at least one surface among the first lens 111 to the seventh lens 117. The lens having the rotationally-asymmetric surface employs plastic material etc. made of plastic.

[0032] In the present embodiment, the imaging lens 110 having different focal lengths in the vertical direction and the horizontal direction is illustrated. As illustrated in FIG. 2, an optical path 1000 in the vertical direction has a path different from the optical path 1000 (see FIG. 3) in the horizontal direction, and this means that the imaging lens is rotational asymmetry.

[0033] FIG. 4 is a diagram illustrating an example of a state when the imaging lens is rotated relative to the image sensor 130 in the camera of the imaging device according to the embodiment. In the present embodiment, a rotary optical zoom is performed by rotating 90 degrees the imaging lens 110 having different focal lengths in the vertical direction and the horizontal direction as an example. For this reason, the state where the imaging lens 110 is rotated by 90 degrees in the direction of an arrow A is illustrated. Note that the image sensor 130 illustrated in FIG. 4 is illustrated to indicate the rotation of the imaging lens 110 relative to the image sensor 130 and corresponds to the image sensor 130 of the camera 10 illustrated in FIGS. 2 and 3.

[0034] As illustrated in FIG. 4, the seven lenses are integrally rotated by 90 degrees around the optical axis relative to the image sensor 130 to change an angle of view.

[0035] Example

Herein, the rotationally-asymmetric surface is provided by the following Equation 1.

[0036]

$$Z = C \cdot r^2 / \{1 + [1 - (1 + K) \cdot C^2 \cdot r^2]^{1/2}\} + \delta(\mu, \theta) / \sigma(r) \quad (1)$$

Herein, Z: Depth of aspheric surface, C: Paraxial curvature = 1/R, R: Curvature radius, r: Distance from optical axis to lens surface, μ : Distance from optical axis to lens surface / Normalization radius of lens, θ : Angle between r and optical axis, NRADIUS: Normalization radius of lens, and K: Conic coefficient (second aspherical coefficient).

[0037] Tables 1 to 4 are examples of the embodiment when an optical design

simulation is performed by optical software. Table 1 illustrates an example of numerical values of each optical component of the camera 10. Tables 2A to 2C illustrate examples of numerical values of the rotationally-asymmetric surface based on Equation (1). Table 3 illustrates an example of focal lengths of the lenses (the first lens 111 to the seventh lens 117). Table 4 illustrates an example of results of the overall performance of the camera 10. Moreover, FIG. 5 is a graph illustrating an example of aberration of the imaging lens 110.

[0038]

Table 1

	R (CURVATURE RADIUS)	D (INTERVAL)	N _d (REFRACTIVE INDEX)	v _d (ABBE NUMBER)
		1.00E+18		
		0.626		
STOP	1.00E+18	-0.626		
L1R1	2.966	0.964	1.546	56.140
L1R2	21.699	0.140		
L2R1	11.628	0.450	1.677	19.240
L2R2	4.804	0.663		
L3R1	-10.185	0.450	1.677	19.240
L3R2	-8.102	0.201		
L4R1	-20.141	0.606	1.546	56.140
L4R2	-44.317	0.990		
L5R1	-5.430	0.451	1.570	37.400
L5R2	-6.898	0.515		
L6R1	-21.769	0.714	1.546	56.140
L6R2	-19.632	1.332		
L7R1	-13.005	1.133	1.546	56.140
L7R2	-31.115	0.491		
IRCF	1.00E+18	0.210	1.5180	64.17
	1.00E+18	0.590		

Note that L1, L2, L3, L4, L5, L6, and L7 respectively indicate the first lens 111, the second lens 112, the third lens 113, the fourth lens 114, the fifth lens 115, the sixth lens 116, and the seventh lens 117. Moreover, R1 targets the object-side surface, and R2 targets the image-side surface. Moreover, IRCF indicates a numerical value for the IR filter 120.

[0039]

Table 2A

	L1R1	L1R2	L2R1	L2R2	L3R1	L3R2
R	2.966279103283580E+00	2.169941051754580E+01	1.162802740355370E+01	4.803696536431480E+00	-1.018456702746510E+01	-8.102320102278960E+00
NRADIUS	1.789883745757060E+00	1.727450326136360E+00	1.687522749348810E+00	1.600057978492080E+00	1.782750238831370E+00	2.139950781523440E+00
K	2.590447030158140E-01	6.732954884717950E+01	3.566501583447890E+01	4.161549390516420E+00	-1.467687544509380E+01	-2.219003328756660E+01
C17 (Q2D9)	5.125316599275820E-02	-5.443070754770030E-03	-1.030691719737600E-01	-1.304602031159850E-01	1.928994251366060E-01	1.465923676436560E-01
C24 (Q2D16)	-1.399638109504780E-02	-5.205797976795130E-03	1.000552624548370E-02	2.927355166483580E-02	-7.815237420302300E-04	6.198377029652210E-02
C33 (Q2D25)	3.524838209882700E-03	2.022365495595170E-03	-2.144908444772290E-05	-8.534055628985830E-03	-6.820442173784600E-03	-3.542315954216510E-03
C44 (Q2D36)	-6.039037906653040E-04	-9.965721989787360E-04	-1.19803557777690E-03	2.265657680236010E-03	5.614894823778370E-03	-1.189193074460620E-03
C57 (Q2D49)	1.296307814175050E-04	5.366312159960830E-05	4.394336910314600E-04	-4.125286907455950E-04	-2.612555188950470E-03	6.988778647978860E-04
C72 (Q2D64)	9.653983567886560E-05	3.211743907910460E-07	6.367849459398830E-07	-4.349320857244270E-06	1.116258279656690E-03	1.435602168995650E-03
C73 (Q2D81)	-1.051757518324290E-06	0.000000000000000E+00	0.000000000000000E+00	4.841369960484340E-08	-1.624754087159450E-06	-9.838973292986000E-06
C74 (Q2D100)	1.100485890019600E-07	0.000000000000000E+00	0.000000000000000E+00	0.000000000000000E+00	5.862728968963890E-09	4.770983852431240E-08
C75 (Q2D121)	-1.236608554271160E-08	0.000000000000000E+00	0.000000000000000E+00	0.000000000000000E+00	0.000000000000000E+00	0.000000000000000E+00
C76 (Q2D144)	0.000000000000000E+00	0.000000000000000E+00	0.000000000000000E+00	0.000000000000000E+00	0.000000000000000E+00	0.000000000000000E+00
C77 (Q2D169)	0.000000000000000E+00	0.000000000000000E+00	0.000000000000000E+00	0.000000000000000E+00	0.000000000000000E+00	0.000000000000000E+00
C78 (Q2D196)	0.000000000000000E+00	0.000000000000000E+00	0.000000000000000E+00	0.000000000000000E+00	0.000000000000000E+00	0.000000000000000E+00
C79 (Q2D225)	0.000000000000000E+00	0.000000000000000E+00	0.000000000000000E+00	0.000000000000000E+00	0.000000000000000E+00	0.000000000000000E+00
C80 (Q2D256)	0.000000000000000E+00	0.000000000000000E+00	0.000000000000000E+00	0.000000000000000E+00	0.000000000000000E+00	0.000000000000000E+00
C13 (Q2D5)	1.703623401856480E-02	-4.110740948043330E-02	9.446987885426690E-02	1.175411653435450E-01	6.185856603130900E-02	4.623015934026070E-02
C20 (Q2D12)	5.630159581972870E-03	8.810663514324780E-03	1.563024922391850E-02	2.548522162290110E-03	2.682354479098760E-02	-5.923022525108470E-02
C29 (Q2D21)	-4.401588110743620E-04	-3.917860390248950E-03	-1.677369549856090E-03	5.960657158207790E-03	-2.332762956366990E-02	1.307903907541230E-02
C40 (Q2D32)	-3.178468148174480E-04	-2.979964048336400E-03	-2.563912835351130E-03	-3.276134855995960E-03	5.526393337044270E-03	-8.199227056364560E-04
C53 (Q2D45)	3.155236367367190E-04	1.529633822418930E-03	1.138443679848330E-03	1.330635222375400E-03	4.644084456064990E-05	5.078202228768460E-03
C68 (Q2D60)	-1.957030455811280E-04	-5.284360535663310E-05	-4.776347476610340E-05	-1.062379001292920E-04	-5.048469707680620E-04	-3.031360353925640E-03
C25 (Q2D17)	1.678366096346530E-02	3.670481266249190E-02	2.293885677288480E-02	1.756911784244080E-02	-8.972476468955710E-02	-7.755782050009990E-02
C36 (Q2D28)	-1.014927574605480E-02	-1.178159533588500E-02	4.902190587825720E-03	7.517570509185720E-03	1.631191528578960E-02	-5.090497017096670E-02
C49 (Q2D41)	2.460118443562670E-03	1.108651769113650E-03	-5.627490168510960E-04	-8.031202360620230E-04	-5.629179508992870E-03	1.145521659127940E-02
C64 (Q2D56)	-4.105798223743660E-04	5.769017031986550E-05	-1.976937893873710E-04	-2.710699687605940E-04	-5.405704162598730E-04	-8.250874478542020E-03
C45 (Q2D37)	1.102097831397670E-03	-1.884911219677780E-03	8.305332910896180E-04	4.027282271406170E-03	-1.702108392491280E-02	-2.591515838536430E-02
C60 (Q2D52)	-1.149604267583470E-07	9.163425538049600E-04	4.503300670226820E-04	-8.162527239971120E-04	3.547891458519350E-03	1.5037688935964240E-02

[0040]

Table 2B

	L4R1	L4R2	L5R1	L5R2
R	-2.014120476665940E+01	4.431707162620890E+01	-5.430490942961690E+00	-6.897593582618460E+00
NRADIUS	2.528925900799590E+00	2.648491458565750E+00	2.873325941117410E+00	3.290854047927020E+00
K	6.092776220984560E+01	-9.900000000000000E+01	2.265359520569250E+00	7.014399369371990E-01
C17 (Q2D9)	-4.272170841129990E-01	-1.559779210681570E-01	9.181996674576450E-01	-3.220063529749160E-01
C24 (Q2D16)	1.863969828696700E-01	2.507250072282750E-01	-1.420989324819180E-01	2.202600437698410E-01
C33 (Q2D25)	1.965710734278920E-02	-1.037119362438870E-01	1.475963025100260E-01	2.405906824488400E-01
C44 (Q2D36)	3.192403288026650E-03	4.239765841702040E-02	-5.060615278209050E-02	-1.928551994677680E-02
C57 (Q2D49)	-1.090538740137390E-02	-2.879787240958760E-03	1.258631970338460E-02	-5.788447547342040E-02
C72 (Q2D64)	7.317839121349570E-03	2.916715747306820E-03	-1.160994390514790E-02	4.36401113303180E-03
C73 (Q2D81)	2.122705464601710E-03	4.897602570913250E-04	1.137807373241200E-02	1.444476673932940E-02
C74 (Q2D100)	-2.990688432458200E-07	4.968038440633650E-07	-8.388871180386710E-03	-7.227367160948690E-03
C75 (Q2D121)	-1.222327998373630E-06	-1.041478937757740E-06	4.797299869123430E-03	-6.559320388871470E-03
C76 (Q2D144)	1.113036286248810E-06	-3.831026442746580E-07	3.224497492348180E-03	5.514566969147250E-03
C77 (Q2D169)	-7.167852567047110E-07	-1.470523565139100E-07	1.075849006390710E-03	4.920734307296330E-03
C78 (Q2D196)	3.873078504579300E-07	-5.692812399260560E-08	1.776005188589560E-03	-7.560273147003360E-04
C79 (Q2D225)	-1.751345910516730E-07	-1.872440624772760E-08	-1.003059841851340E-03	-6.894378320386650E-04
C80 (Q2D256)	6.027236576500170E-08	-9.588451588271600E-09	4.709188519358420E-04	-1.113377940953340E-07
C13 (Q2D5)	-1.585387655627820E-01	4.472239609108640E-01	-1.576122410164300E-01	2.930506667279770E-01
C20 (Q2D12)	3.938033093242740E-02	4.693696744482440E-02	1.405780825727350E-01	-3.017175668915320E-01
C29 (Q2D21)	-7.796751923507440E-03	8.691877069932720E-03	-1.261390918362070E-01	3.983268389301600E-02
C40 (Q2D32)	3.645551387541620E-02	1.983671534539630E-03	-1.096042847119700E-02	-1.374864638101910E-02
C53 (Q2D45)	2.627018850224210E-02	8.954126510456520E-03	6.003048686531310E-03	1.092265147042970E-03
C68 (Q2D60)	-1.963620100601220E-02	-8.542285841864470E-03	-1.647964862945830E-02	-3.137540486818870E-02
C25 (Q2D17)	4.986101539170330E-02	-2.408810080032050E-02	1.873962981445700E-01	1.482033155980880E-01
C36 (Q2D28)	1.107538982096970E-01	2.228829422400350E-01	6.802769647570530E-02	-8.993905310355910E-02
C49 (Q2D41)	-2.423769804701940E-02	4.384352954927770E-02	-7.166995412993450E-02	-1.340470164941130E-02
C64 (Q2D56)	-7.643348256342770E-03	-4.402533135966620E-04	4.002786256383060E-03	-3.071090470760530E-02
C45 (Q2D37)	7.755122450822270E-02	1.207380649390970E-01	8.784553946415840E-02	-6.652176394889340E-03
C60 (Q2D52)	-1.911358635268090E-03	-7.749416093994900E-02	-7.330969960180230E-02	-4.844985717624000E-02

[0041]

Table 2C

	L6R1	L6R2	L7R1	L7R2
R	-2.176873278772120E+01	-1.963163884859580E+01	-1.300509688696700E+01	-3.111497383674660E+01
NRADIUS	5.013457639286690E+00	5.015931319630450E+00	7.321516753302960E+00	7.528534840507190E+00
K	1.457647461911470E+01	1.308097509817180E+01	-3.154268293827140E+00	1.577586894374840E+01
C17 (Q2D9)	1.026714644597080E-02	1.212013959267210E+00	1.097048666063560E+00	2.121298396203830E+00
C24 (Q2D16)	1.364223064365770E+00	8.378897314411460E-01	-8.834942016865020E-01	7.542584534553170E-01
C33 (Q2D25)	5.505285533005650E-01	-3.576873144019560E-01	-6.183807575043630E-01	-4.621246757058230E-01
C44 (Q2D36)	-2.776412862190210E-01	3.324770543010290E-01	2.585370509086340E-01	6.795601435038510E-01
C57 (Q2D49)	-1.001884694528300E-01	3.118796865606630E-02	1.262535304479830E-01	1.886063831999080E-01
C72 (Q2D64)	9.247228531097160E-02	-1.850950957294870E-01	4.875234215405110E-01	-2.551272656722740E-01
C73 (Q2D81)	9.095788397435160E-03	8.508399164713450E-02	1.542380206220480E-01	7.292899252149480E-01
C74 (Q2D100)	-6.675261828425890E-02	-2.957979195276060E-02	2.312524875814510E-01	-2.201545172978220E-01
C75 (Q2D121)	-4.503886070273490E-03	-3.194779747128100E-02	2.934603722563160E-02	9.858893318863130E-02
C76 (Q2D144)	2.558992875363610E-02	5.955180152992930E-02	-3.836118984198040E-02	-8.562939458215940E-02
C77 (Q2D169)	6.407752424106230E-03	1.781376292855050E-03	4.014788879321160E-02	2.585402350192760E-01
C78 (Q2D196)	-3.391838051907280E-03	-1.703243662189060E-02	-6.231888157205330E-02	-2.246154784399830E-01
C79 (Q2D225)	-1.413218134282620E-03	8.652205603993550E-03	2.051204356222900E-02	1.648068027805280E-01
C80 (Q2D256)	-3.120411953716480E-06	-3.045857209116320E-05	3.522425920716230E-02	-3.244480188423300E-02
C13 (Q2D5)	-3.201541141640130E-01	1.316618961010380E-01	-3.379599130866080E+00	-3.882645838766840E-01
C20 (Q2D12)	7.589638979937170E-02	-8.514725722624910E-01	1.809408019304430E+00	-8.909228154895130E-01
C29 (Q2D21)	1.125820459387350E-02	5.386429269604900E-02	-1.236822451528780E+00	1.757145776524770E+00
C40 (Q2D32)	1.277621558119570E-01	2.839382797844740E-01	6.592028568739620E-03	-1.772690085561880E+00
C53 (Q2D45)	-3.979946296557280E-02	-1.96638434728740E-01	2.379753407886830E-01	1.438645812115540E+00
C68 (Q2D60)	-1.723953172027950E-01	-1.553311841978850E-01	-3.398071950152560E-03	-3.734073860702650E-01
C25 (Q2D17)	1.079048758682830E-01	1.021363473068220E+00	-3.279927125327250E+00	-4.712398672705870E-01
C36 (Q2D28)	-2.926186496007170E-01	-1.065967882085700E+00	-3.294772154272060E-01	-8.268466312395620E-03
C49 (Q2D41)	-1.467760668752810E-01	-4.642108042005890E-02	-1.436668816846140E-01	1.418214086758570E-01
C64 (Q2D56)	1.438748962455020E-02	1.072438836134850E-01	-3.016828941074950E-02	-2.422314739314420E-01
C45 (Q2D37)	-2.984897309060500E-01	1.586961539772340E-01	-1.767812639475940E+00	2.702617449292570E-01
C60 (Q2D52)	-6.020669071472570E-02	-4.809195774709710E-01	-1.548752331577660E-01	-1.492809574640400E-01

[0042]

Table 3**FOCAL LENGTH OF LENS Y-Z PLANE X-Z PLANE**

L1	6.27	5.20	[mm]
L2	-14.12	-10.65	[mm]
L3	-48.28	50.82	[mm]
L4	82.29	-11.38	[mm]
L5	41.49	-440.88	[mm]
L6	50.54	11.24	[mm]
L7	-24.23	-5.51	[mm]

[0043]

Table 4**Y-Z PLANE X-Z PLANE**

FOCAL LENGTH (FL)	7.124	9.111	[mm]
Fno	1.95		
ANGLE OF VIEW	84.68	63.00	[deg]
TOTAL TRACK LENGTH (INF)	9.900		[mm]
SENSOR SIZE	16.3839		[mm]
FLANGE FOCAL LENGTH	0.800		[mm]

As illustrated in Table 3, each of the lenses of the imaging lens 110 has different focal lengths in the YZ plane and the XZ plane, and the focal length (FL) in the YZ plane is shorter than the focal length (FL) in the XZ plane in the entire of the imaging lens 110 as illustrated in Table 4. That means the focal length in the vertical direction is shorter than the focal length in the horizontal direction in the entire of the imaging lens 110. Moreover, the total track length in the optical axis direction as illustrated in Table 4 is constant even when the rotation angle is zero degrees or even when the rotation angle is 90 degrees after rotation, but the angle of view changes after rotation. The sensor size of the image sensor 130 is 16.3839 in an example of the present embodiment.

[0044] A table obtained by summarizing conditions based on the above results is Table 5. Table 5 illustrates an example of a feasible range of the imaging lens and the camera that perform a rotary optical zoom.

[0045]

Table 5

CONDITION
-
$F3x / F3y < 0$
$F4x / F4y < 0$
$F5x / F5y < 0$
$FLx / FLy > 1.2$
$Fnoy < 2.4$
$FOVy < 90$
$TTL / ImgH < 0.65$

[0046] Condition 1

$F3x / F3y < 0$

Herein, F3x: Horizontal focal length of third lens and F3y: Vertical focal length of third lens.

[0047] Condition 2

$F4x / F4y < 0$

Herein, F4x: Horizontal focal length of fourth lens and F4y: Vertical focal length of fourth lens.

[0048] Condition 3

$F5x / F5y < 0$

Herein, F5x: Horizontal focal length of fifth lens and F5y: Vertical focal length of fifth lens.

[0049] Condition 4

$FLx / FLy > 1.2$

Herein, FLx: Horizontal focal length of whole lens system and FLy: Vertical focal length of whole lens system.

[0050] Condition 5

$Fnoy < 2.4$

Herein, Fnoy: Vertical Fno.

[0051] Condition 6

$FOVy < 90$

Herein, FOVy: Vertical angle of view of whole lens system.

[0052] Condition 7

$TTL / ImgH < 0.65$

Herein, TTL: Total track length of lenses at infinity of whole lens system and ImgH: Diagonal length of effective pixel area of imaging surface of whole lens system.

[0053] FIGS. 6 to 10 are diagrams explaining a difference in angles of view between the imaging lens 110 with the rotation angle of zero degrees and the imaging lens 110 with the rotation angle of 90 degrees. Note that the rotation direction is a direction of arrow A illustrated in FIG. 4 as an example.

[0054] FIG. 6 is a conceptual diagram illustrating a difference in angles of view between an image acquired at the rotation angle of zero degrees and an image acquired at the rotation angle of 90 degrees. Because the angle of view is a wide angle when the rotation angle of the imaging lens 110 is zero degrees, a wide-angle image 501 as illustrated in FIG. 6 is acquired by the image sensor 130. On the other hand, because the angle of view is changed to a standard angle of view when the imaging lens 110 is rotated and is stopped at the rotation angle of 90 degrees, a standard image 502 as illustrated in FIG. 6 is acquired by the image sensor 130. The standard image 502 is an image acquired by optically stretching an image via the imaging lens 110 at the rotation angle of 90 degrees, and corresponds to an optical zoom image of about 1.3 times for the wide-angle image 501 of a magnification of 1.0. As described above, in the present example, the standard image 502 is acquired as an optical zoom image of an image area 500 of the wide-angle image 501. A difference in angles of view between the rotation angle of zero degrees and the rotation angle of 90 degrees will be further described with reference to FIGS. 7 to 10.

[0055] The imaging lens 110 of the camera 10 illustrated in FIG. 7 has the wide angle because the focal length is short at the rotation angle of zero degrees. FIG. 7 illustrates an effective image circle 300 and an image height distribution 400 of the camera 10 at the rotation angle of zero degrees. The image height distribution 400 is an image height distribution every 10% on the image surface. A rectangular frame 201 that includes a diagonal length of the effective pixel area of the image sensor 130 is illustrated in each of the effective image circle 300 and the image height distribution 400.

[0056] If the imaging lens 110 of the camera 10 illustrated in FIG. 8 is rotated to the rotation angle of 90 degrees, the focal length becomes longer and the angle of view is changed from the wide angle to the standard. FIG. 8 illustrates the effective image circle 300 and the image height distribution 400 of the camera 10 at the rotation angle of 90 degrees. The image height distribution 400 is an image height distribution every 10% on the image surface. A rectangular frame 202 that includes the diagonal length of the effective pixel area of the image sensor 130 is illustrated in each of the effective image circle 300 and the image height distribution 400.

[0057] The rectangular frame 201 in a shooting range illustrated in FIG. 7 becomes the rectangular frame 202 to narrow the angle of view for shooting as illustrated in FIG. 8, after rotating the imaging lens 110 to the rotation angle of 90 degrees. Therefore, a portion in the range of the wide angle is optically stretched, and the image of the portion is acquired by the image

sensor 130.

[0058] FIG. 9 is a diagram corresponding to an area 451 inside the rectangular frame 201 of the image height distribution 400 illustrated in FIG. 7. FIG. 9 illustrates the view as well as the image 501 corresponding to the area 451 acquired by the image sensor 130.

[0059] FIG. 10 is a diagram corresponding to an area 452 inside the rectangular frame 202 of the image height distribution 400 illustrated in FIG. 8. FIG. 10 illustrates the view as well as the image 502 corresponding to the area 452 acquired by the image sensor 130. Note that the view of the image 502 illustrated in FIG. 10 has the same direction as that of the image 501 illustrated in FIG. 9.

[0060] As illustrated in FIGS. 9 and 10, by rotating the imaging lens 110 to the rotation angle of 90 degrees, the imaging lens 110 shows an optical zoom function to acquire an image changed from the wide-angle image 501 to the standard image 502.

[0061] Therefore, in the present embodiment, an optical zoom image of about 1.3 times is obtained by rotating the imaging lens 110 by 90 degrees.

[0062] Imaging Device

FIG. 11 is a diagram illustrating an example of an external configuration of the imaging device according to the embodiment. FIG. 12 is a diagram illustrating an example of a hardware block configuration of the imaging device according to the embodiment.

[0063] An imaging device 1 illustrated in FIG. 11 is a smartphone. As an example, a configuration of the smartphone equipped with the standard to super-wide angle cameras is illustrated. The camera 10 illustrated in FIG. 11 is a camera configured to perform a rotary optical zoom, and acquires a standard image and a wide-angle image. The smartphone is equipped with a super-wide angle camera 15 as a camera configured to acquire a super-wide angle image. The super-wide angle camera 15 is a conventional camera. The imaging device 1 may be additionally equipped with a telephoto camera, a periscope camera, or a periscopic zoom camera.

[0064] As illustrated in FIG. 12, the imaging device 1 includes a CPU (central processing unit) 21, a memory 22, a controller 23, an image processing unit 24, a display 25, and a touch panel 26. These components are connected to one another by a bus 30. Moreover, in addition to these components, the imaging device includes a communication interface, a microphone, a speaker, a sensor, and the like. The sensor includes an acceleration sensor, a GPS (global positioning system) sensor, and the like.

[0065] The CPU 21 executes a processing program stored in the memory 22 to overall control components of hardware blocks. The memory 22 includes a volatile or non-volatile memory.

[0066] The controller 23 controls the camera 10. The camera 10 outputs image signals based on the control by the controller 23, and outputs image data after image signal processing. Moreover, the controller 23 is an example of a

rotation control unit, and controls the rotation of the imaging lens 110 of the camera 10. Moreover, the controller 23 also controls the super-wide angle camera 15. The super-wide angle camera 15 outputs image signals based on the control by the controller 23, and outputs image data after image signal processing.

[0067] The image processing unit 24 acquires the image data output from the camera 10 and performs a generation process of an image for display and/or a generation process of an image for recording.

[0068] In the generation process of the image for display and the generation process of the image for recording, the image processing unit 24 corrects the distortion of image, and the like. For example, the image processing unit 24 corrects the nonuniformity of angle of view and the distortion of image from an acquisition image, corresponding to wide-angle image, acquired by the camera 10 at zero degrees and an acquisition image, corresponding to standard image, acquired by the camera at 90 degrees.

[0069] Moreover, based on the image data output from the camera 10, the image processing unit 24 generates a digital zoom image in response to a zoom magnification based on the instruction of a user.

[0070] The display 25 is an example of a display unit, and displays information for display under the control by the CPU 21. The display 25 is a display device such as liquid crystal as an example. As an example, the information for display includes a touch operation button, setting information, an image for display generated by the image processing unit 24, and the like.

[0071] The touch panel 26 is an example of an operating unit, and accepts a touch operation performed by the user. For example, the touch panel 26 accepts a touch operation that is performed by the user on the touch operation button displayed on the display 25. Moreover, the touch panel 26 accepts a zoom operation when the user performs a predetermined operation during displaying the image for display displayed on the display 25. As an example, the touch panel 26 accepts the zoom operation when the user performs an operation of the finger such as pinch-out on a screen during displaying the image for display.

[0072] The information received by the touch panel 26 is reported to the CPU 21, and the CPU 21 controls each component to execute a predetermined process.

[0073] Operations of Rotary Optical Zoom

FIG. 13 is a diagram illustrating an example of rotary optical zoom operations by the imaging device. For example, it is considered that the user performs shooting with wide-angle image setting. In that case, the imaging device 1 displays an image 601 with a zoom magnification of 1.0 on the screen as illustrated in FIG. 13. The image 601 is an image to be updated at a predetermined frame rate.

[0074] When the user performs a predetermined operation such as pinch-out on the screen during displaying the image 601, the imaging device 1 accepts the operation as a zoom operation to activate each component. As illustrated in

FIG. 13, the camera 10 performs an operation by which the imaging lens 110 is rotated by 90 degrees in the direction of arrow.

[0075] As illustrated in FIG. 13, the imaging device 1 displays a digital zoom image 700 based on the image 601 on the screen, and, when the rotation of the imaging lens 110 is completed, performs shooting with an optical zoom magnification of about 1.3 times after rotation and displays a optical zoom image 602 on the screen. Herein, the optical zoom image 602 corresponds to an image captured at the standard angle of view.

[0076] Note that, it has been herein described that the imaging lens 110 performs a rotation operation by pinch-out etc. of the user performed on the screen as an example, but the imaging lens 110 may perform a rotation operation depending on a degree of the zoom operation on the image. For example, when stepwise performing the digital zoom display and receiving an operation such as pinch-out in a certain step, the imaging lens 110 may perform the rotation operation.

[0077] Moreover, a pull operation from the standard to the wide angle may be performed by an operation opposite to the zoom operation through a predetermined operation such as pinch-in.

[0078] Moreover, the imaging device 1 may accept a predetermined operation by using a hardware key.

[0079] Effect of Embodiment

FIGS. 14 and 15 are comparative diagrams explaining an example of the effect of the embodiment. FIGS. 14 and 15 illustrate a comparative example when single focus lenses are used.

[0080] As illustrated in FIG. 14, when the single focus lenses are used, the imaging device performs zoom shooting by providing a wide angle camera 11 and a standard camera 12. Therefore, the number of cameras increases, and thus an occupancy rate for one camera is susceptible to larger limitation due to the number of cameras.

[0081] Moreover, as illustrated in FIG. 15, when taking a single focus camera for wide angle as an example, the image 500 inside a rectangular frame 200 is a wide-angle image and a standard image whose angle of view is different cannot be acquired. A case where the single focus lens is rotated is also similar.

[0082] On the other hand, in the present embodiment, images with different angles of view can be acquired with a group of lenses. In other words, the images with different angles of view can be acquired by one camera to be able to be realized without the limitation of another camera.

[0083] Moreover, even compared to the conventional two groups of zoom lenses, the camera according to the present embodiment can be realized with a group of lenses without using a technology having a high degree of difficulty such as zoom lens because the camera according to the present embodiment is a rotary optical zoom system. Moreover, even compared to the conventional zoom lens, the camera according to the present embodiment can realize the minimization of

total track length of lenses while employing a large-sized image sensor and a large-diameter lens because the optical system of the main camera is the base. Furthermore, even when performing zooming, the camera according to the present embodiment can suppress the thickness of the camera and popping out of the lens from the camera because the total track length of the lenses is not changed.

[0084] Note that the smartphone has been exemplified as an example in the present embodiment but the present embodiment may be applied to other imaging devices. For example, the present embodiment may be applied to a tablet PC, an electronic camera, or the like. Moreover, as above, the main configuration of the lens has been described, but the camera may additionally include a focus adjusting unit, a camera shake correcting unit, and the like. Moreover, as an example, the case where the angle of view is switched by one camera from the standard to the wide angle has been illustrated, but a range of switching the angle of view with one camera is not limited to the change from the standard to the wide angle. The range may be changed as appropriate so that the other range of switching the angle of view is available.

[0085] While certain embodiments have been described, these embodiments have been presented by way of example only, and are not intended to limit the scope of the inventions. Indeed, the novel embodiments described herein may be embodied in a variety of other forms; furthermore, various omissions, substitutions and changes in the form of the embodiments described herein may be made without departing from the spirit of the inventions. The accompanying claims and their equivalents are intended to cover such forms or modifications as would fall within the scope and spirit of the inventions.

[Explanations of Letters or Numerals]

[0086]

- 1: Imaging device
- 10: Camera
- 110: Imaging lens
- 111: First lens
- 112: Second lens
- 113: Third lens
- 114: Fourth lens
- 115: Fifth lens
- 116: Sixth lens
- 117: Seventh lens
- 120: IR filter
- 130: Image sensor

claims

1. An imaging lens comprising:
 - a lens group comprising: in order from an object side,
 - a first lens having positive refractive power and an object-side surface having a convex shape;
 - a second lens having negative refractive power;
 - a plurality of intermediate lens; and
 - a final lens having negative refractive power and an image-side surface having a concave shape near an optical axis, wherein
 - the lens group:
 - has one or more rotationally-asymmetric surfaces; and
 - changes an angle of view by rotating the lens group relative to an imaging element around the optical axis.
2. The imaging lens according to claim 1, wherein the lens group has different focal lengths in a horizontal direction and a vertical direction.
3. The imaging lens according to claim 1 or 2, wherein
 - the plurality of intermediate lens includes a third lens, a fourth lens, a fifth lens, and a sixth lens, and
 - the final lens includes a seventh lens.
4. The imaging lens according to claim 3, wherein
 - " $F_{3x}/F_{3y} < 0$ " is satisfied, wherein F_{3x} : a horizontal focal length of the third lens and F_{3y} : a vertical focal length of the third lens.
5. The imaging lens according to claim 3 or 4, wherein
 - " $F_{4x}/F_{4y} < 0$ " is satisfied, wherein F_{4x} : a horizontal focal length of the fourth lens and F_{4y} : a vertical focal length of the fourth lens.
6. The imaging lens according to any one of claims 3 to 5, wherein
 - " $F_{5x}/F_{5y} < 0$ " is satisfied, wherein F_{5x} : a horizontal focal length of the fifth lens and F_{5y} : a vertical focal length of the fifth lens.
7. The imaging lens according to any one of claims 3 to 6, wherein
 - " $FL_x/FL_y > 1.2$ " is satisfied, wherein FL_x : a horizontal focal length of a whole lens system and FL_y : a vertical focal length of the whole lens system.
8. The imaging lens according to any one of claims 3 to 7, wherein
 - " $F_{\text{noy}} < 2.4$ " is satisfied, wherein F_{noy} : a vertical F_{no} .
9. The imaging lens according to any one of claims 3 to 8, wherein
 - " $FOV_y < 90^\circ$ " is satisfied, wherein FOV_y : a vertical angle of view of the whole lens system.

10. The imaging lens according to any one of claims 3 to 9, wherein
"TTL/ImgH < 0.65" is satisfied, wherein TTL: a total track length of the lenses at infinity of the whole lens system and ImgH: a diagonal length of an effective pixel area of an imaging surface of the whole lens system.
11. The imaging lens according to any one of claims 1 to 10, wherein a lens having the rotationally-asymmetric surface is made of plastic material.
12. An imaging device comprising:
an imaging lens according to any one of claims 1 to 11;
a rotation control unit configured to rotate the imaging lens around the optical axis; and
an imaging element configured to acquire images with different angles of view of the imaging lens.
13. The imaging device according to claim 12, further comprising:
an operating unit configured to perform a zoom operation; and
a display unit configured to display a display image based on an output image of the imaging element, wherein
the display unit is configured to: switch the display image during the display to a display image with a different angle of view; and display the display image after switching, when the imaging lens is rotated up to a predetermined rotation angle based on the zoom operation.

FIG.1

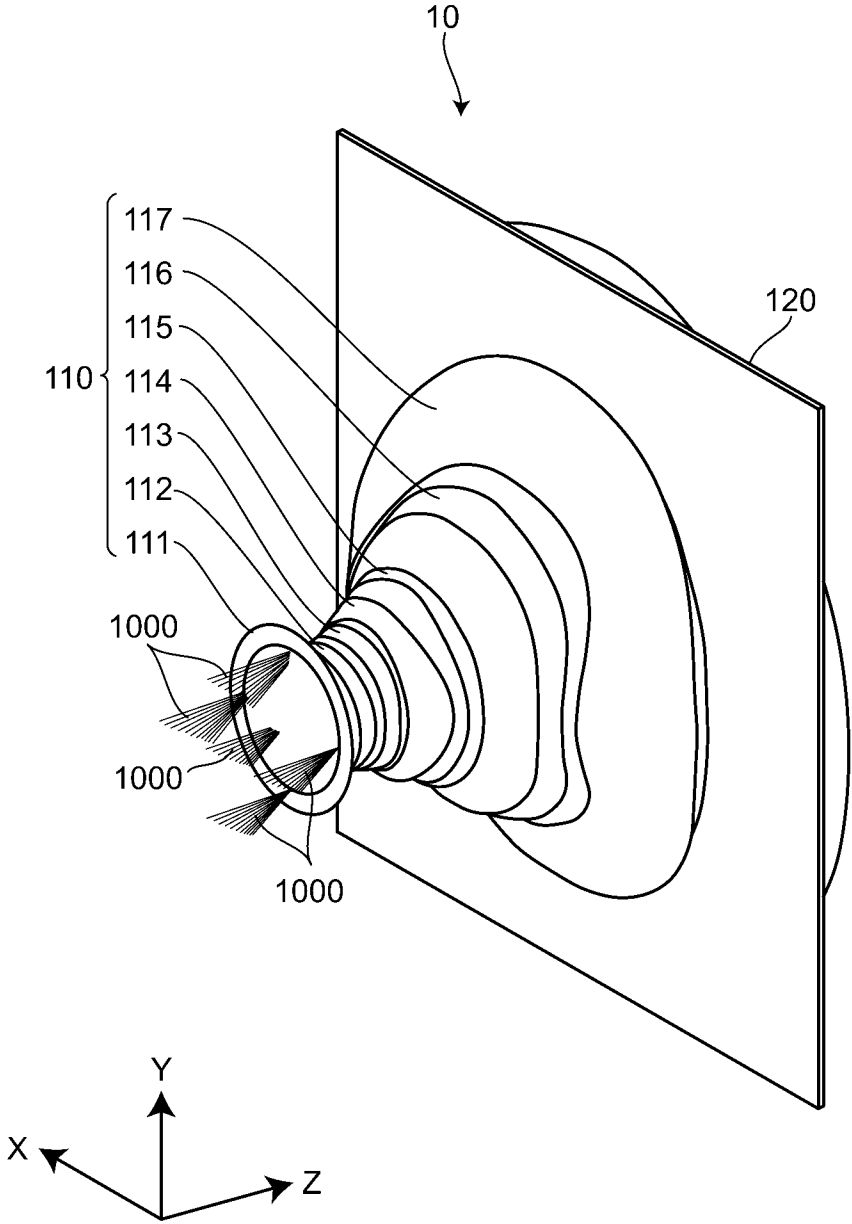
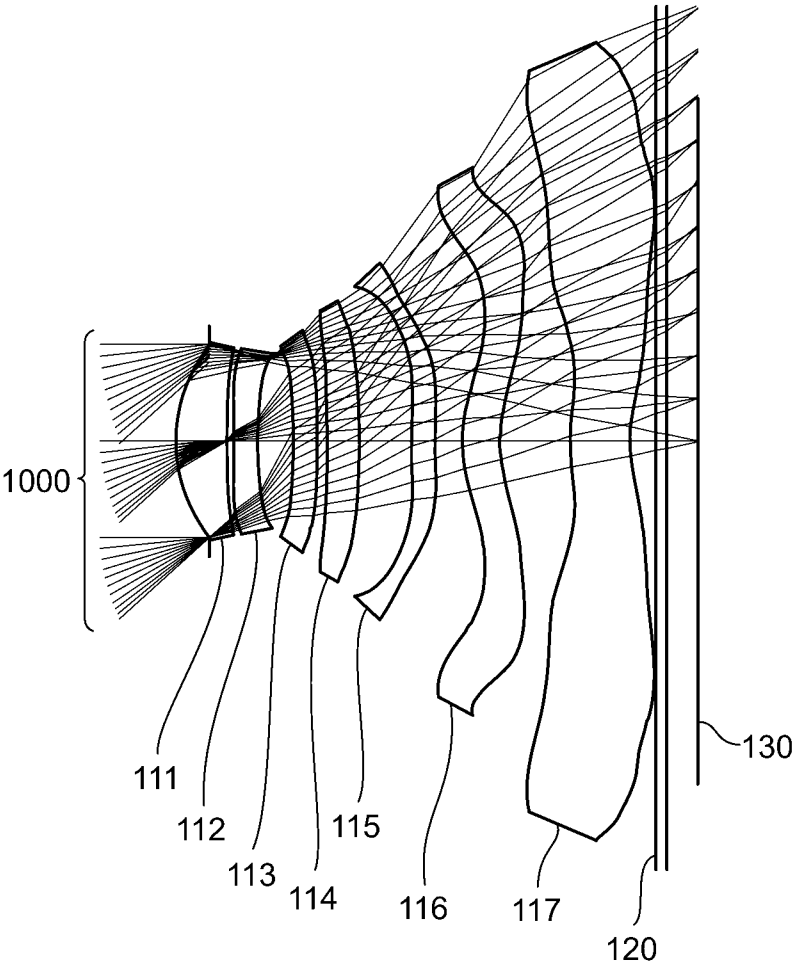


FIG.2



YZ CROSS SECTION

FIG.3

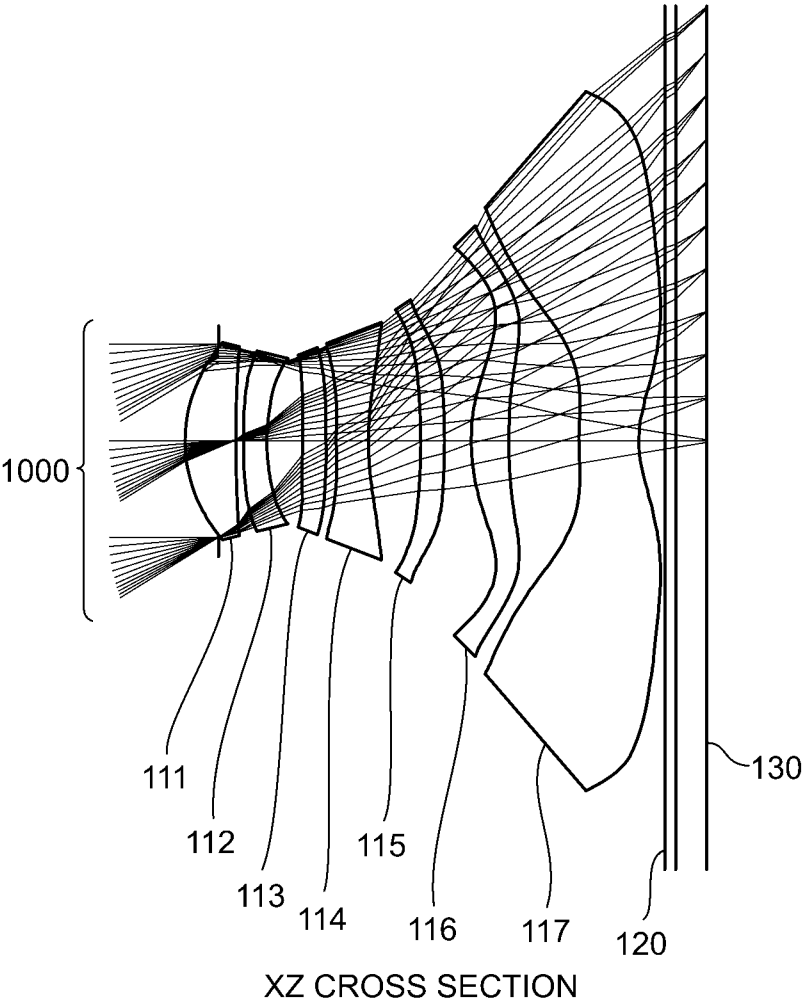


FIG.4

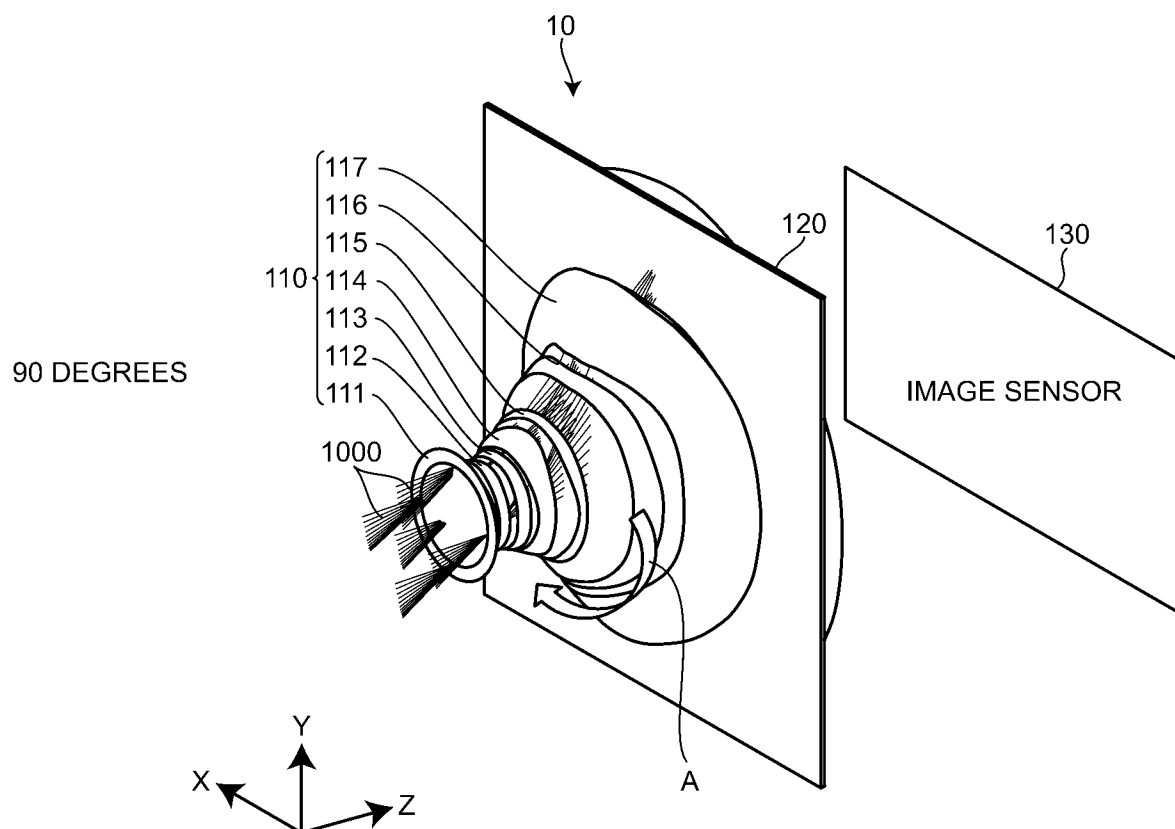
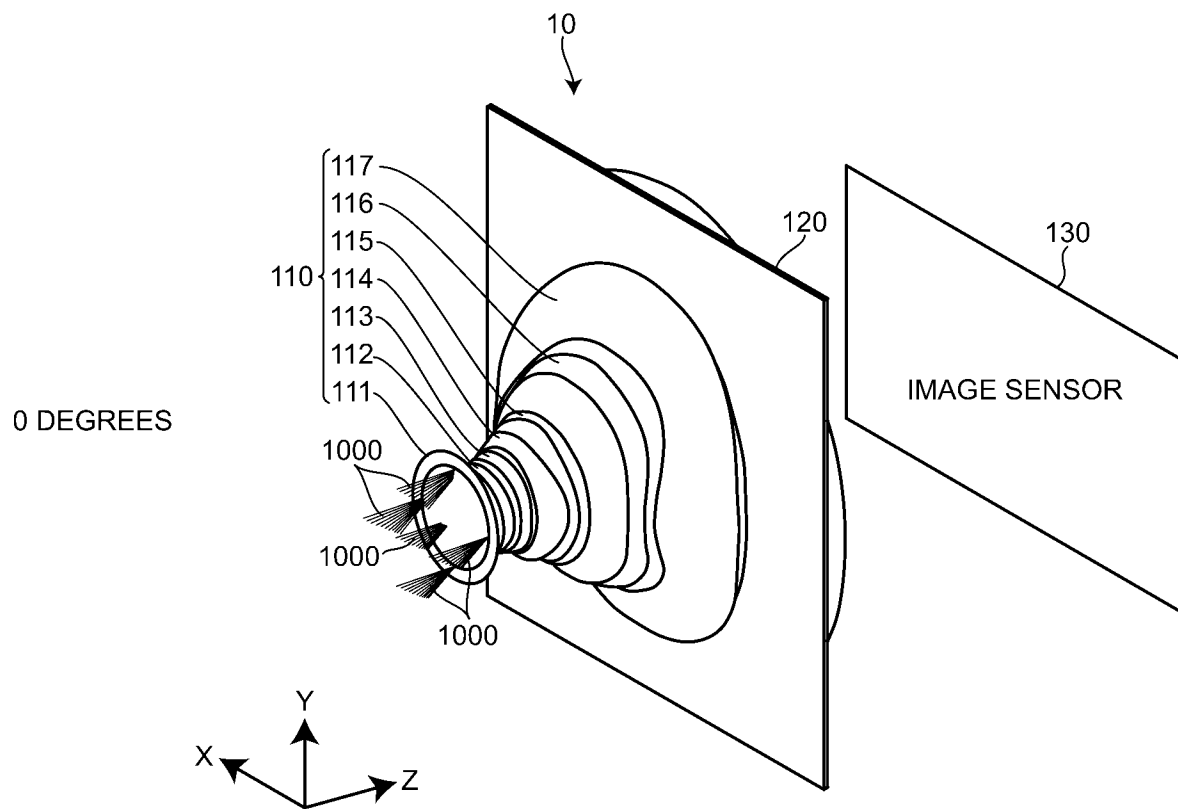


FIG.5

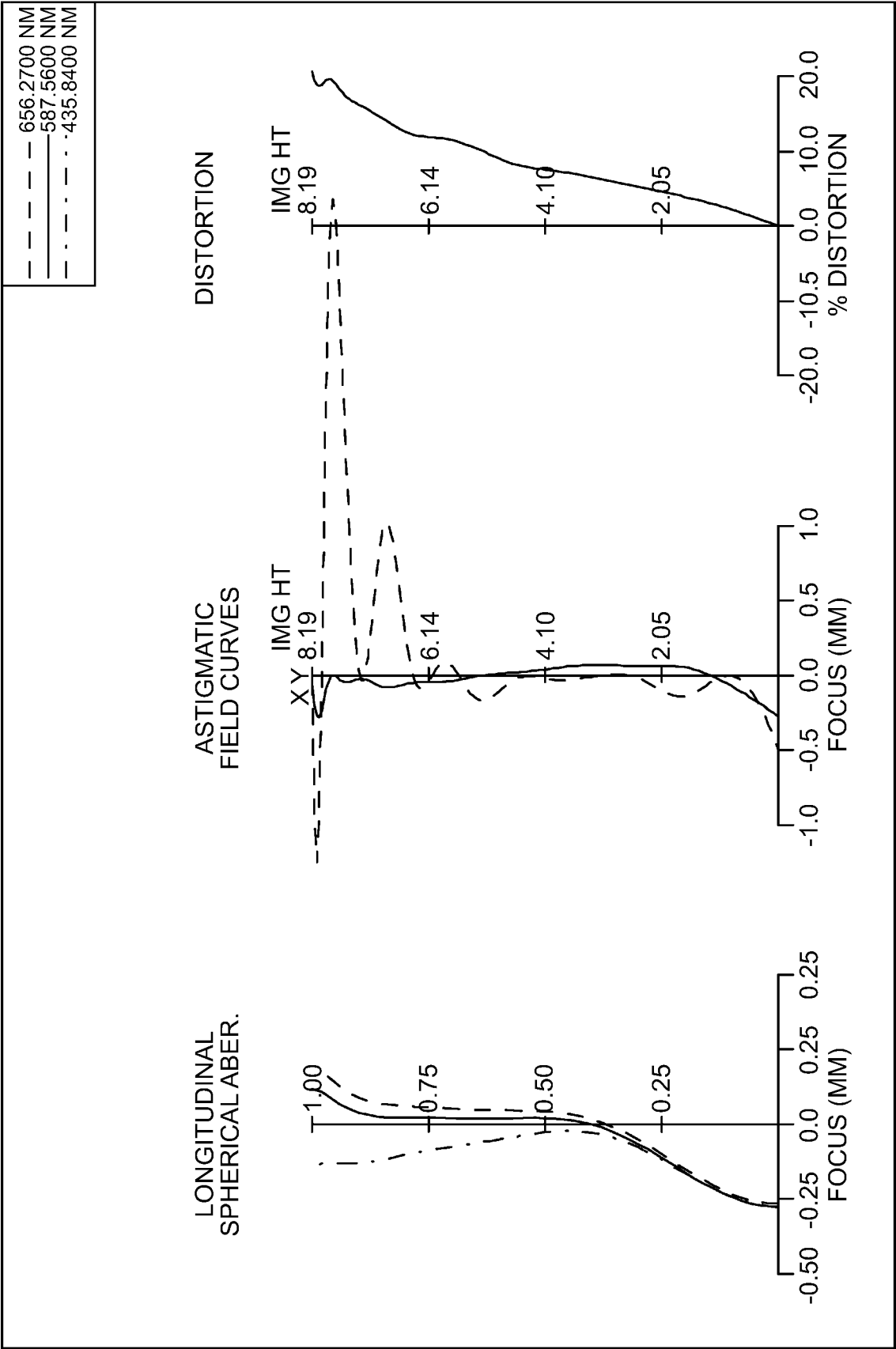


FIG.6

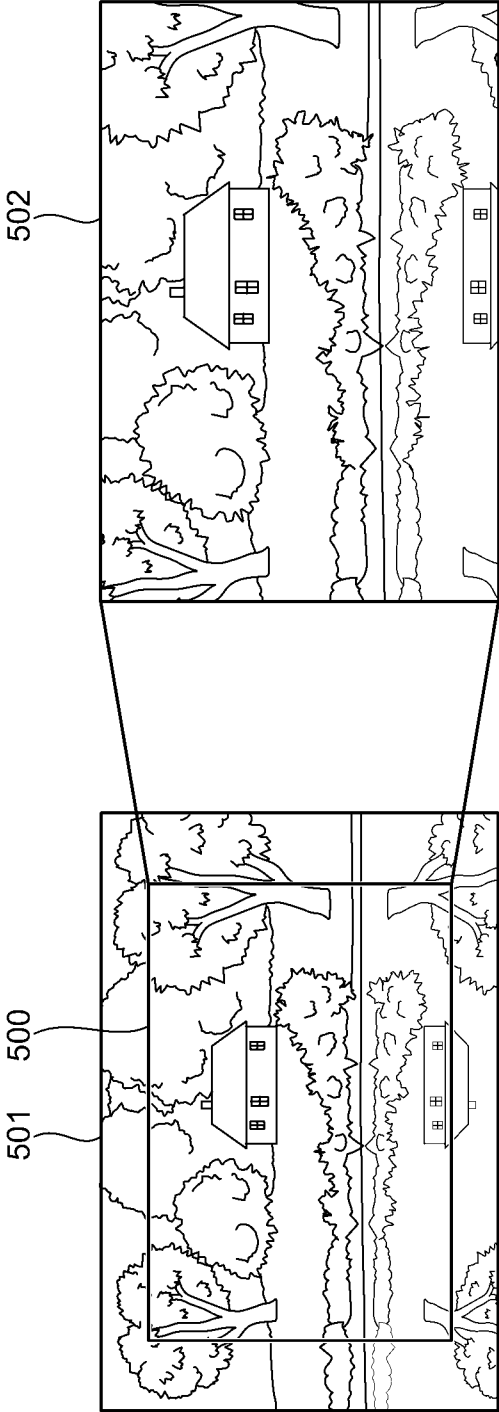


FIG.7

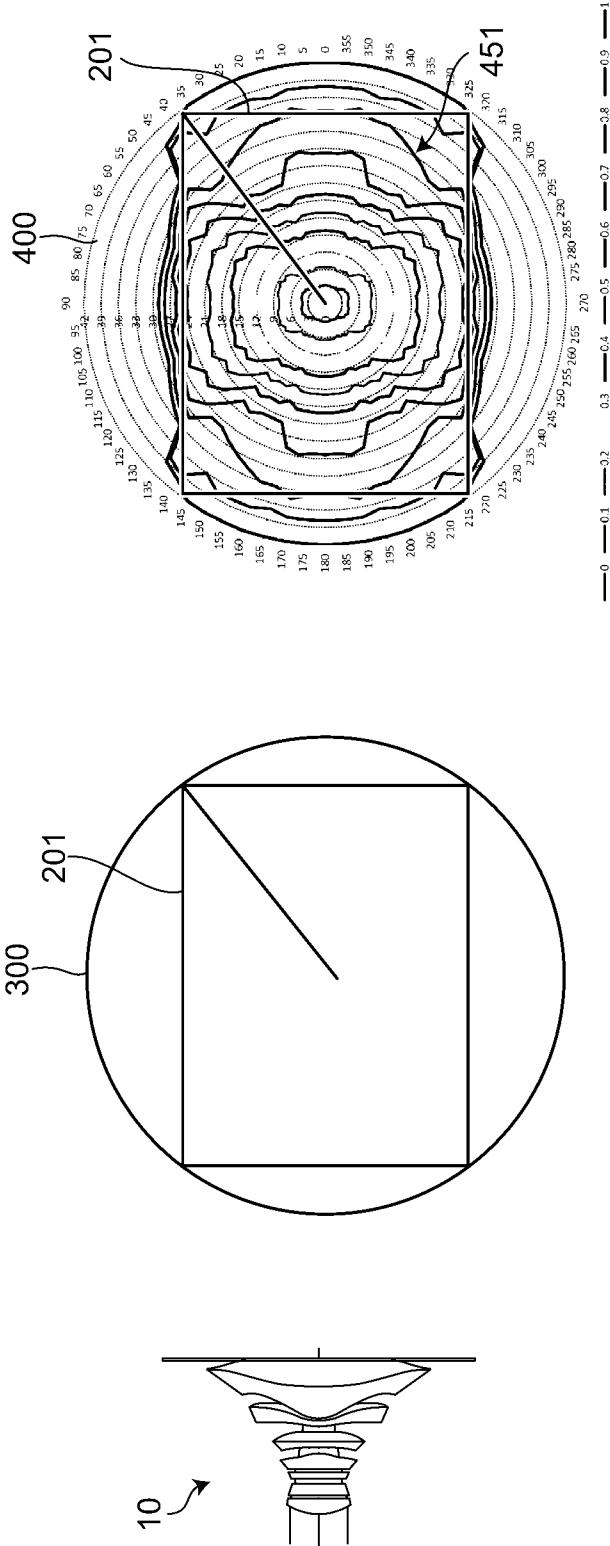


FIG.8

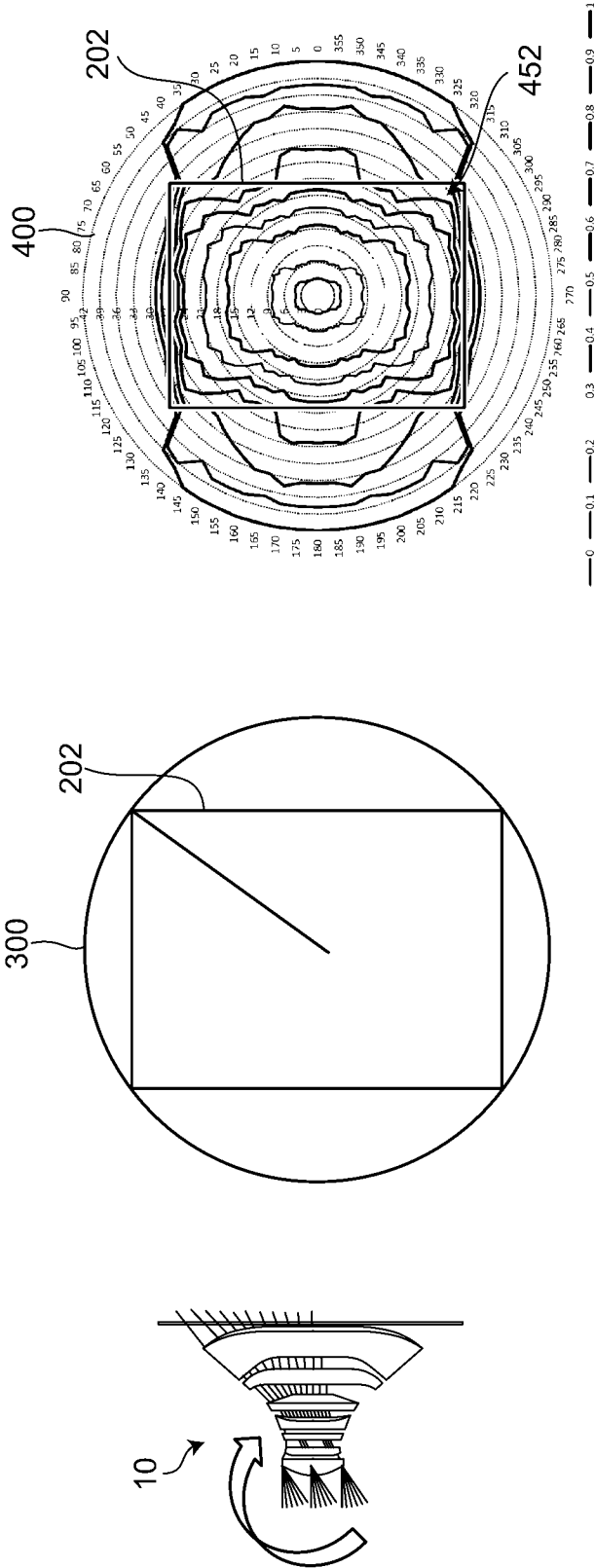


FIG.9

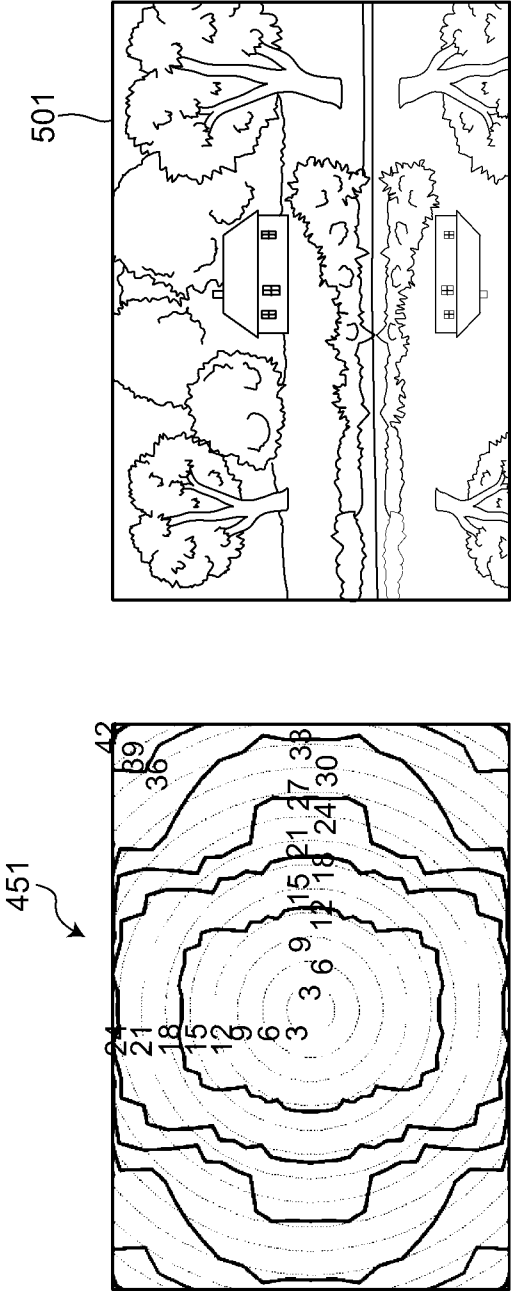


FIG.10

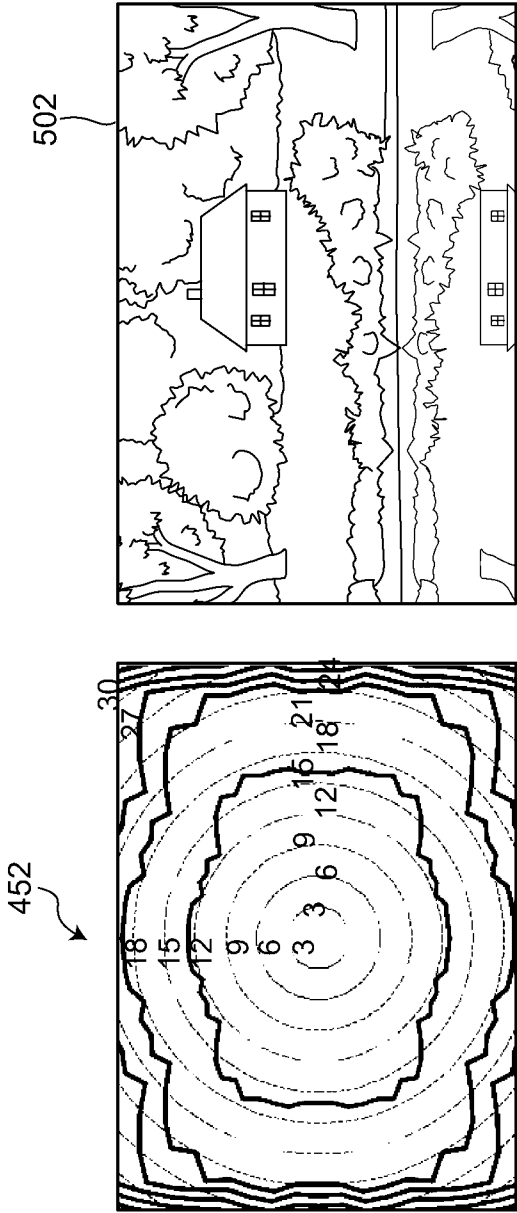


FIG.11

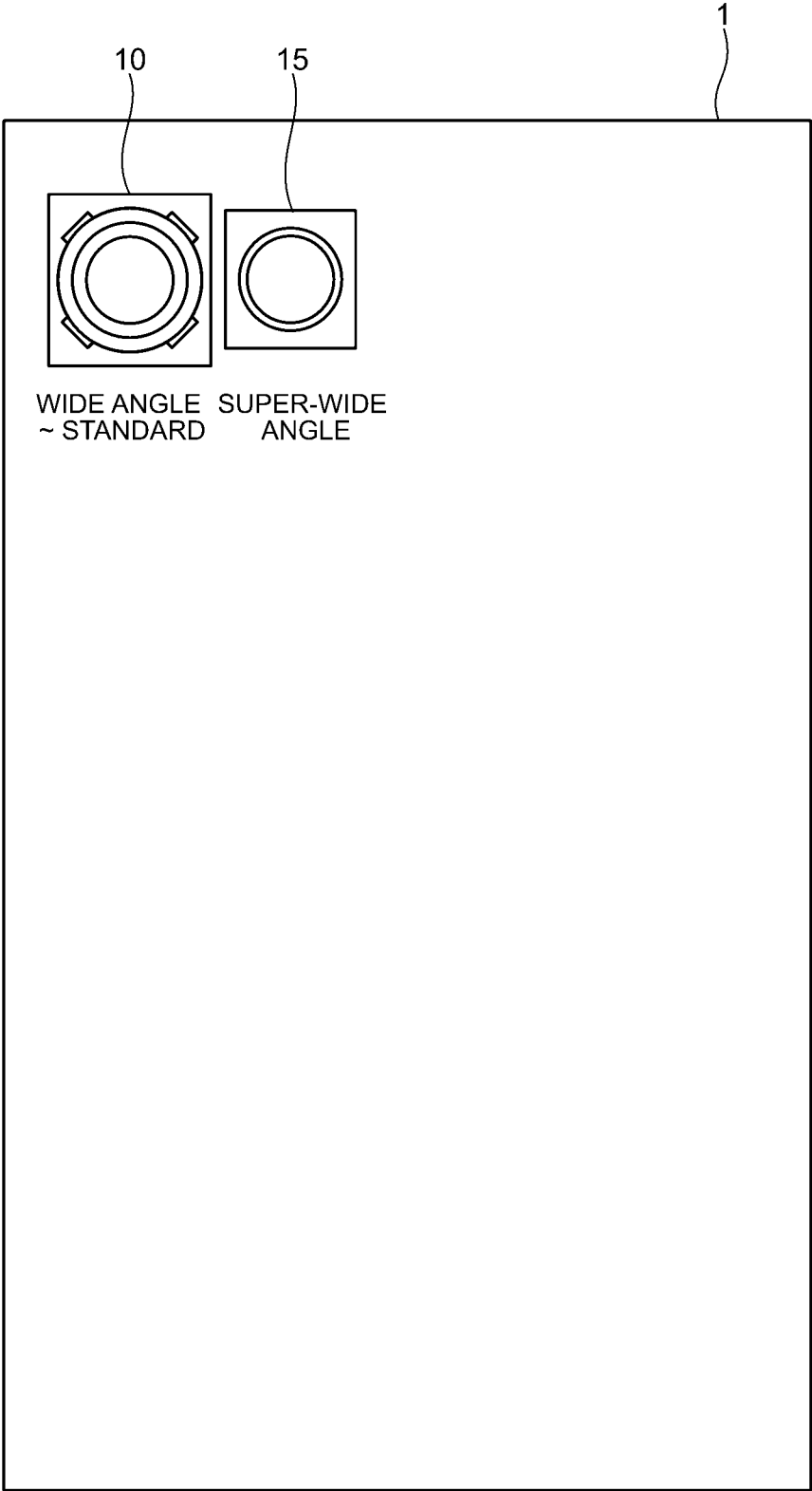


FIG.12

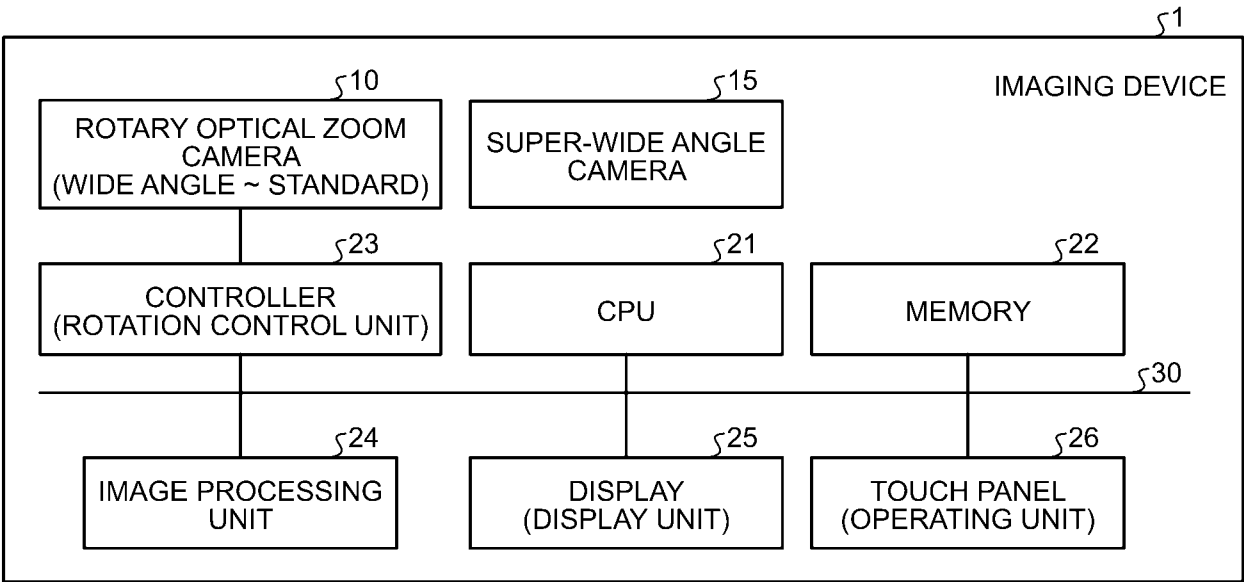


FIG.13

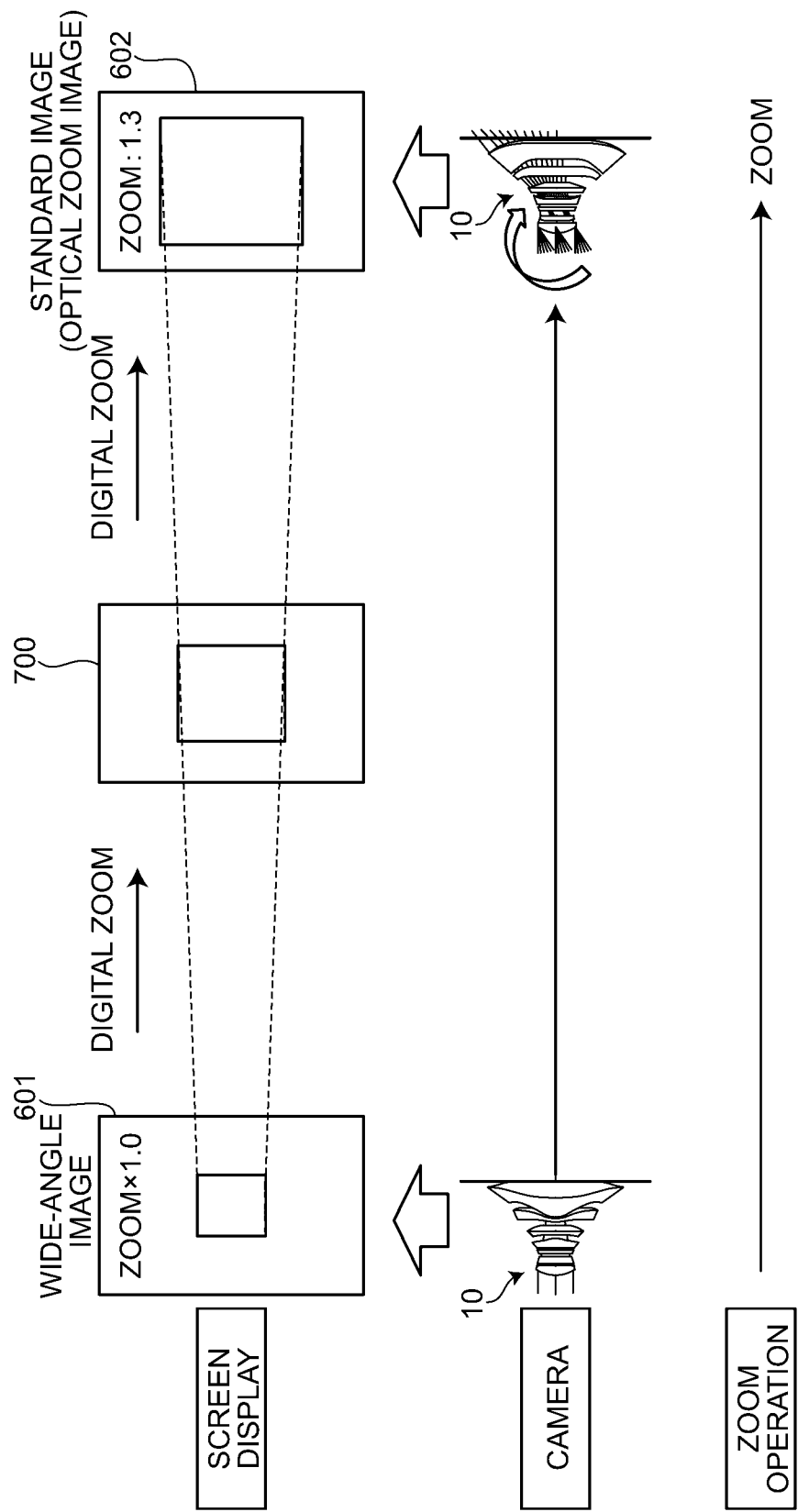


FIG.14

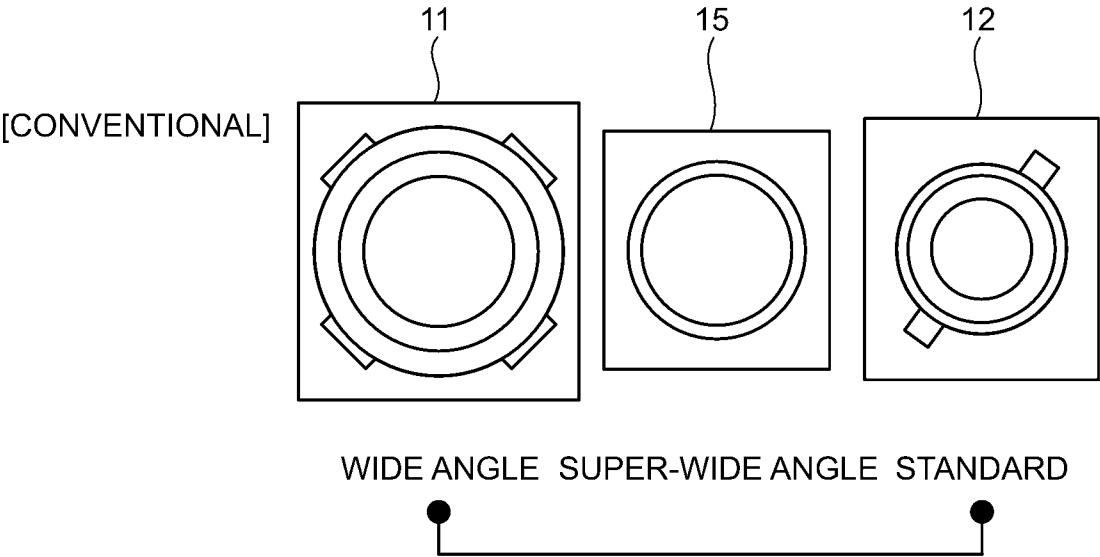
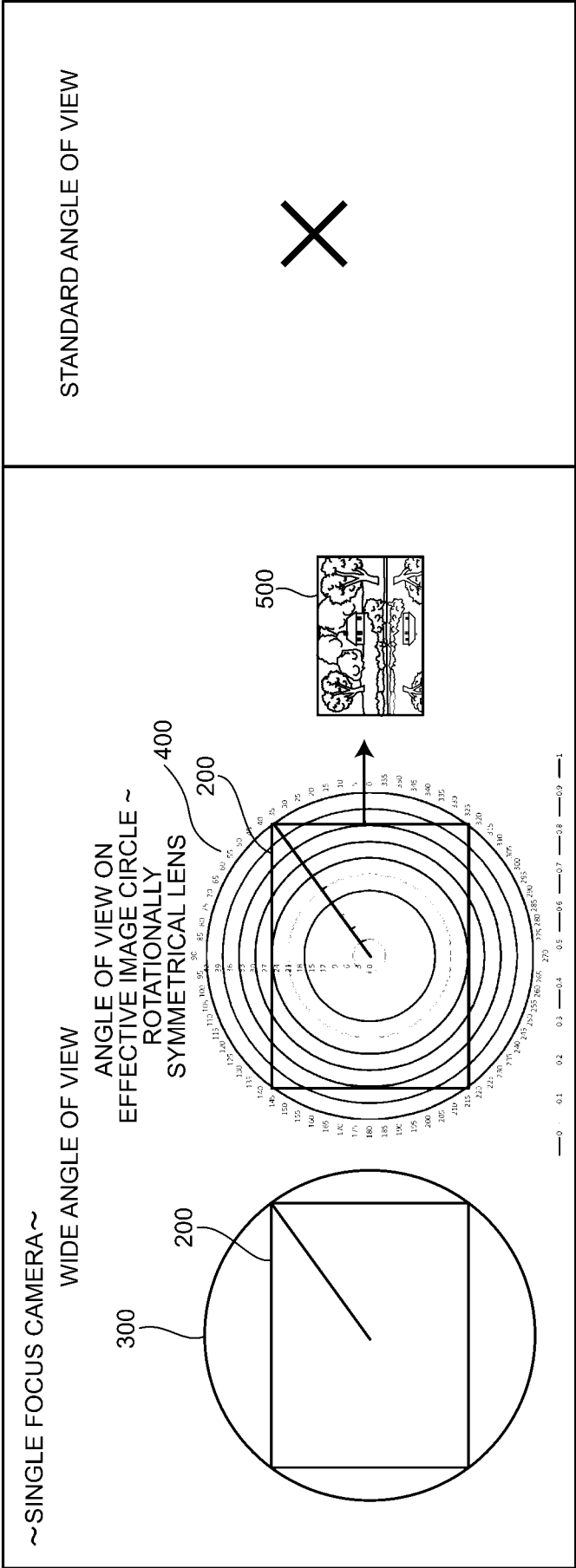


FIG.15

[CONVENTIONAL]



INTERNATIONAL SEARCH REPORT

International application No.

PCT/CN2023/100815

A. CLASSIFICATION OF SUBJECT MATTER G02B13/00(2006.01)i; G02B15/14(2006.01)i; G02B13/08(2006.01)i According to International Patent Classification (IPC) or to both national classification and IPC		
B. FIELDS SEARCHED Minimum documentation searched (classification system followed by classification symbols) IPC:G02B Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched Electronic data base consulted during the international search (name of data base and, where practicable, search terms used) CNTXT,ENTXTC,WPABS,ENTXT:x,y,horizont+,vertical,direction,view+,angle,lens,chang+,motor,rotat+,asymmetric,positive,negative,wide		
C. DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 2021263281 A1 (AAC OPTICS (CHANGZHOU) CO., LTD.) 26 August 2021 (2021-08-26) description, paragraphs [0025]-[0121], figure 1	1-3, 7-13
A	CN 111505811 A (AAC OPTICS (CHANGZHOU) CO., LTD.) 07 August 2020 (2020-08-07) 全文	1-13
A	CN 114128250 A (IMMER VISION, INC.) 01 March 2022 (2022-03-01) the whole document	1-13
A	CN 1376949 A (NIKON CORPORATION) 30 October 2002 (2002-10-30) the whole document	1-13
A	US 2010321791 A1 (NIKON CORPORATION) 23 December 2010 (2010-12-23) the whole document	1-13
A	US 2023028080 A1 (CANON KABUSHIKI KAISHA) 26 January 2023 (2023-01-26) the whole document	1-13
☐ Further documents are listed in the continuation of Box C. ☒ See patent family annex.		
* Special categories of cited documents: “A” document defining the general state of the art which is not considered to be of particular relevance “D” document cited by the applicant in the international application “E” earlier application or patent but published on or after the international filing date “L” document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified) “O” document referring to an oral disclosure, use, exhibition or other means “P” document published prior to the international filing date but later than the priority date claimed “T” later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention “X” document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone “Y” document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art “&” document member of the same patent family		
Date of the actual completion of the international search 06 December 2023		Date of mailing of the international search report 19 December 2023
Name and mailing address of the ISA/CN CHINA NATIONAL INTELLECTUAL PROPERTY ADMINISTRATION 6, Xitucheng Rd., Jimen Bridge, Haidian District, Beijing 100088, China		Authorized officer GUO,Kai Telephone No. (+86) 010-53962380

INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.

PCT/CN2023/100815

Patent document cited in search report			Publication date (day/month/year)	Patent family member(s)			Publication date (day/month/year)
US	2021263281	A1	26 August 2021	CN	111308651	A	19 June 2020
				WO	2021168891	A1	02 September 2021
				JP	2021135487	A	13 September 2021
CN	111505811	A	07 August 2020	JP	7011691	B1	27 January 2022
				JP	2022022937	A	07 February 2022
				WO	2022000659	A1	06 January 2022
				US	2022003962	A1	06 January 2022
				US	11662554	B2	30 May 2023
CN	114128250	A	01 March 2022	US	2021014417	A1	14 January 2021
				US	11659287	B2	23 May 2023
				US	2023269493	A1	24 August 2023
				WO	2021005513	A1	14 January 2021
CN	1376949	A	30 October 2002	KR	20020076159	A	09 October 2002
				JP	2002287023	A	03 October 2002
				TW	521321	B	21 February 2003
				EP	1245984	A2	02 October 2002
				US	2003007138	A1	09 January 2003
				US	6912094	B2	28 June 2005
US	2010321791	A1	23 December 2010	WO	2009142090	A1	26 November 2009
				JP	2009282214	A	03 December 2009
				JP	5168641	B2	21 March 2013
				US	8339712	B2	25 December 2012
US	2023028080	A1	26 January 2023	JP	2023010106	A	20 January 2023