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(12) **United States Patent**  
Kawamura et al.

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(45) **Date of Patent:** Aug. 12, 2025

(54) **IMAGING LENS AND IMAGING APPARATUS**(71) Applicant: **FUJIFILM Corporation**, Tokyo (JP)(72) Inventors: **Daiki Kawamura**, Saitama (JP); **Michio Cho**, Saitama (JP)(73) Assignee: **FUJIFILM Corporation**, Tokyo (JP)

(\* ) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days.

(21) Appl. No.: **18/498,290**(22) Filed: **Oct. 31, 2023**(65) **Prior Publication Data**

US 2024/0103256 A1 Mar. 28, 2024

**Related U.S. Application Data**

(63) Continuation of application No. 17/155,283, filed on Jan. 22, 2021, now Pat. No. 11,841,486.

(30) **Foreign Application Priority Data**Jan. 29, 2020 (JP) ..... 2020-012799  
Dec. 28, 2020 (JP) ..... 2020-219164(51) **Int. Cl.****G02B 15/14** (2006.01)  
**G02B 15/20** (2006.01)  
**G02B 27/00** (2006.01)(52) **U.S. Cl.**CPC ..... **G02B 15/1421** (2019.08); **G02B 15/20** (2013.01); **G02B 27/0025** (2013.01)(58) **Field of Classification Search**

CPC ..... G02B 15/1421; G02B 15/20; G02B 27/0025; G02B 7/04; G02B 9/12;

(Continued)

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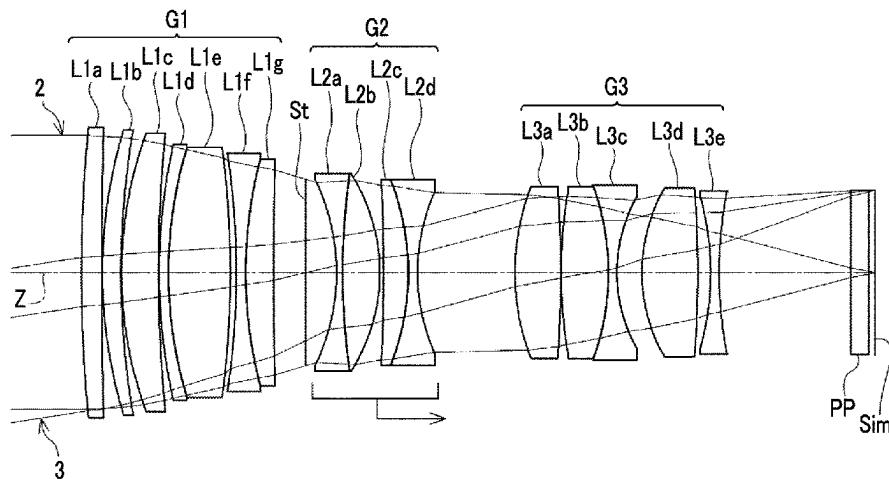
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An Office Action; "Notice of Reasons for Refusal," mailed by the Japanese Patent Office on Oct. 4, 2022, which corresponds to Japanese Patent Application No. 2020-219164 and is related to U.S. Appl. No. 17/155,283; with English language translation.

(Continued)

*Primary Examiner* — Thomas K Pham*Assistant Examiner* — Kuei-Jen L Edenfield(74) *Attorney, Agent, or Firm* — Studebaker Brackett PLLC(57) **ABSTRACT**

An imaging lens includes a positive first lens group and a second lens group, which are continuous in order from the position closest to the object side, as lens groups. During focusing, the distance between the first lens group and the second lens group changes. A stop is disposed closer to the image side than a lens which is second from the object side. A combined refractive power of all lenses closer to the object side than the stop is positive. The imaging lens includes an LA positive lens and an LB positive lens that satisfy a predetermined conditional expression at a position closer to the object side than the stop. An Abbe number of the LB positive lens is the maximum among Abbe numbers of all positive lenses closer to the object side than the stop.

**16 Claims, 61 Drawing Sheets**EXAMPLE 10

(58) **Field of Classification Search**

CPC . G02B 9/14; G02B 9/08; G02B 15/14; G02B 27/00; G02B 15/143; G02B 15/143101; G02B 15/143103; G02B 15/143105; G02B 7/09; G02B 7/105  
USPC ..... 359/689, 690, 691, 692, 693, 698, 705,  
359/739

See application file for complete search history.

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An Office Action; mailed by the United States Patent and Trademark Office on Dec. 10, 2024, which corresponds to U.S. Appl. No. 18/496,189 and is related to U.S. Appl. No. 18/498,290.

\* cited by examiner

**FIG. 1**  
**EXAMPLE 1**

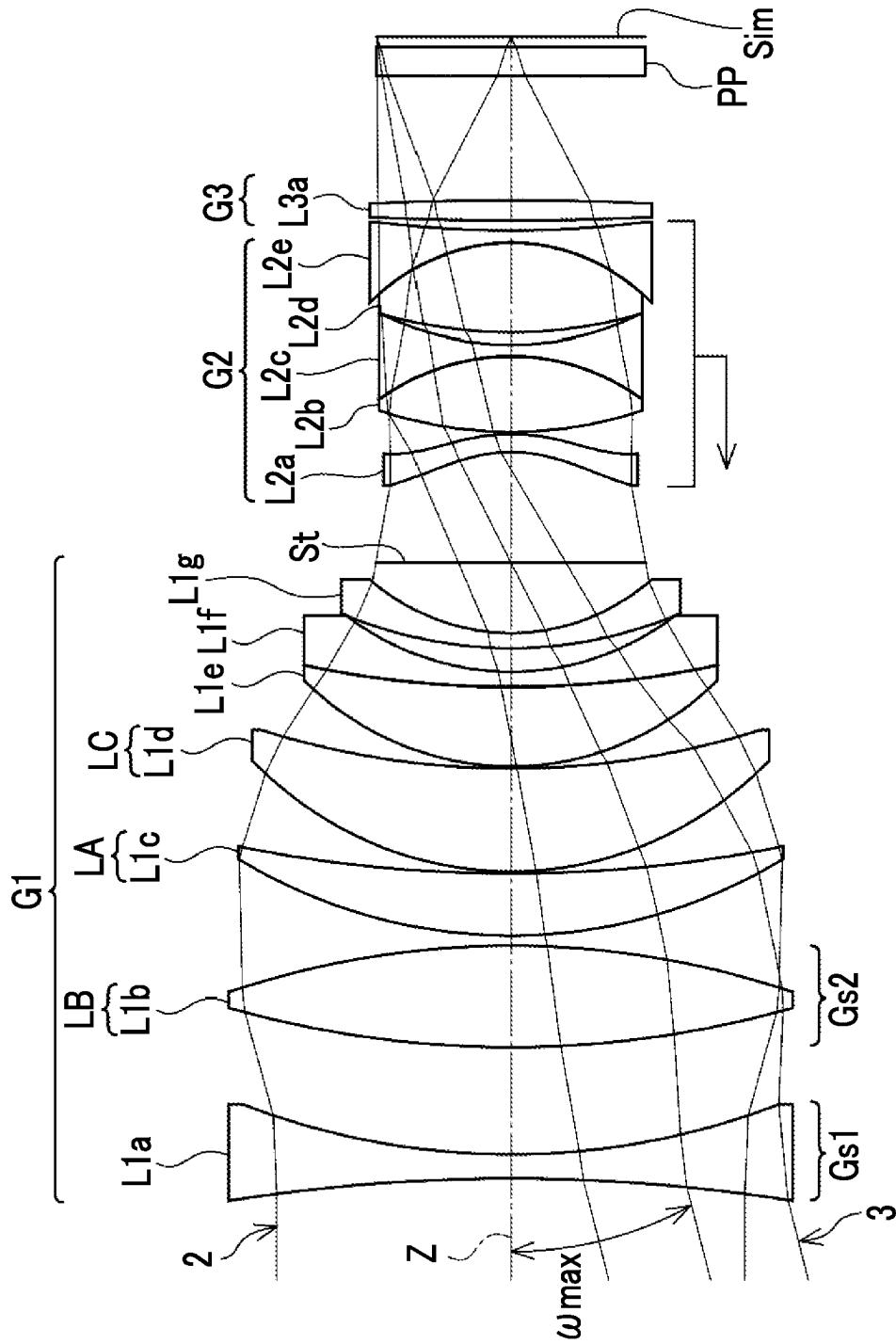


FIG. 2

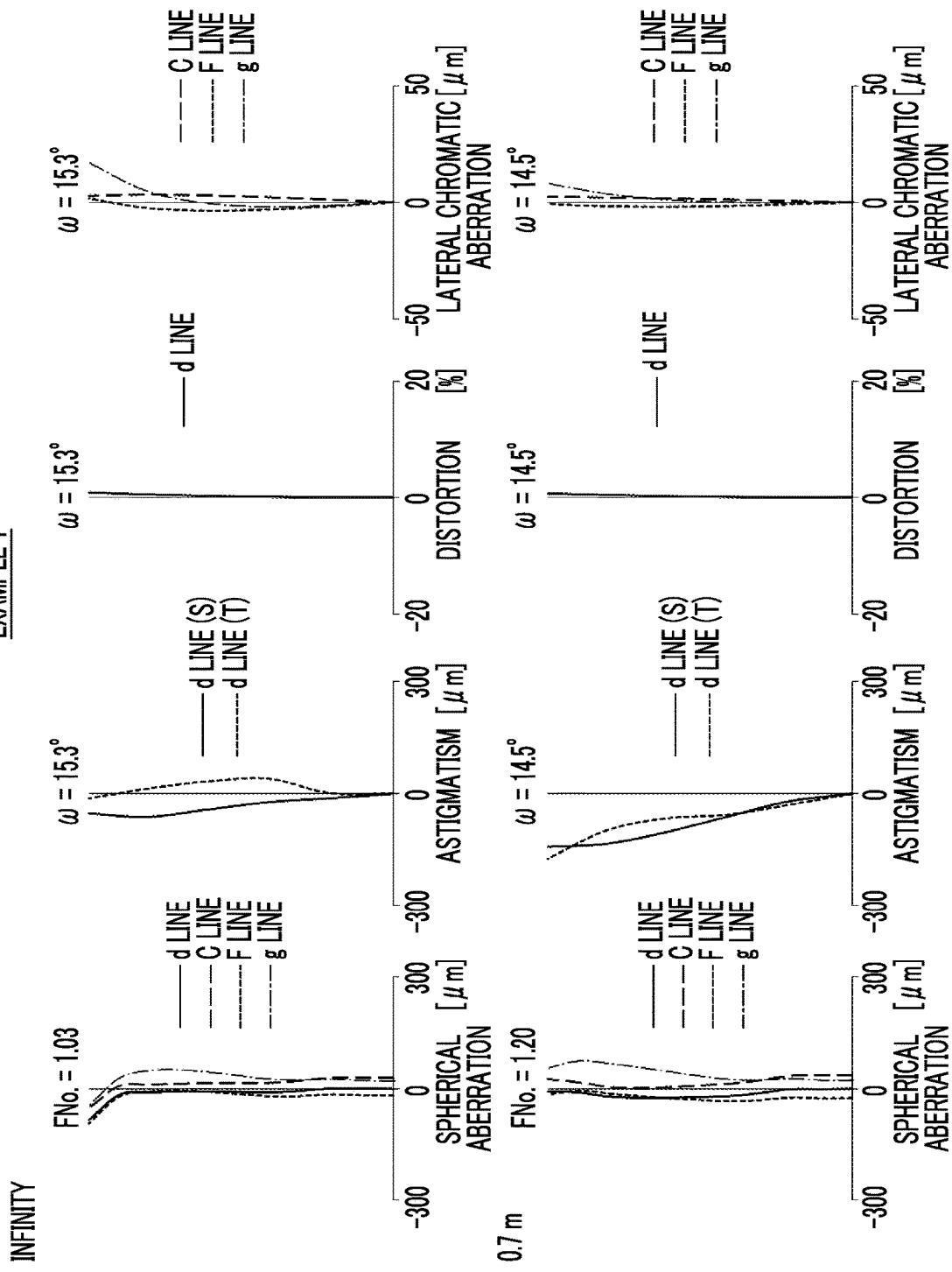
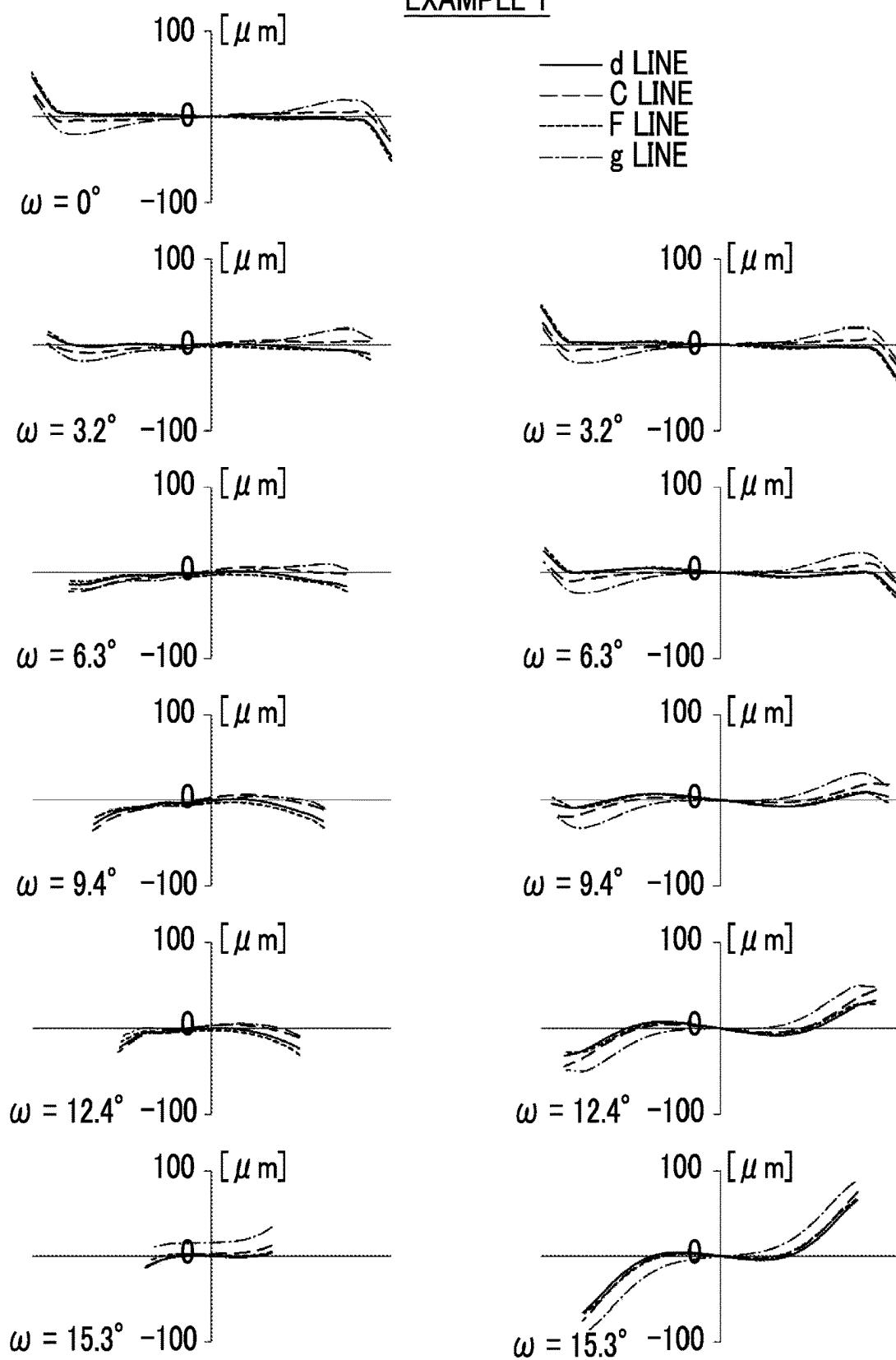
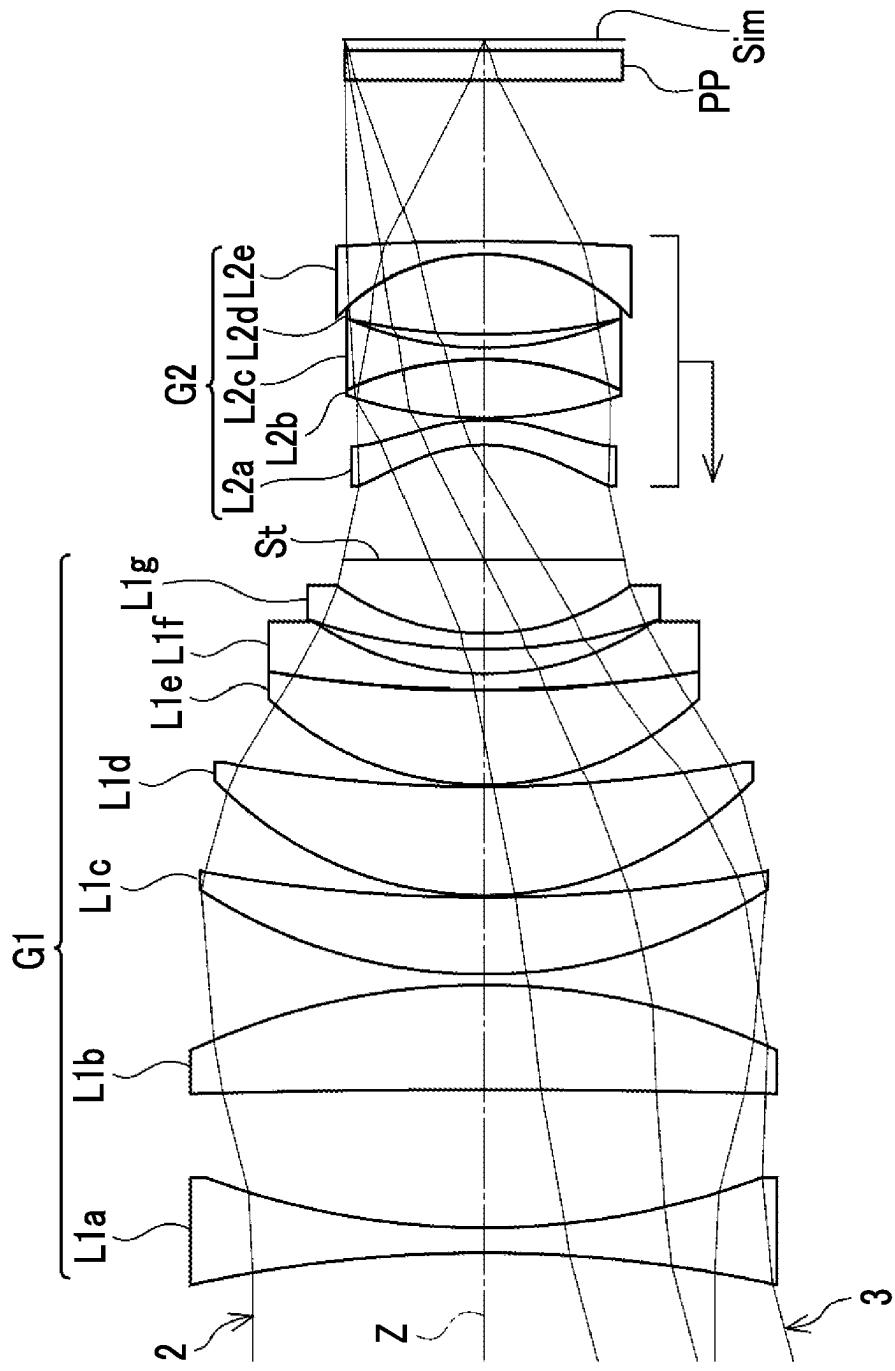
EXAMPLE 1

FIG. 3

EXAMPLE 1

**FIG. 4**  
**EXAMPLE 2**



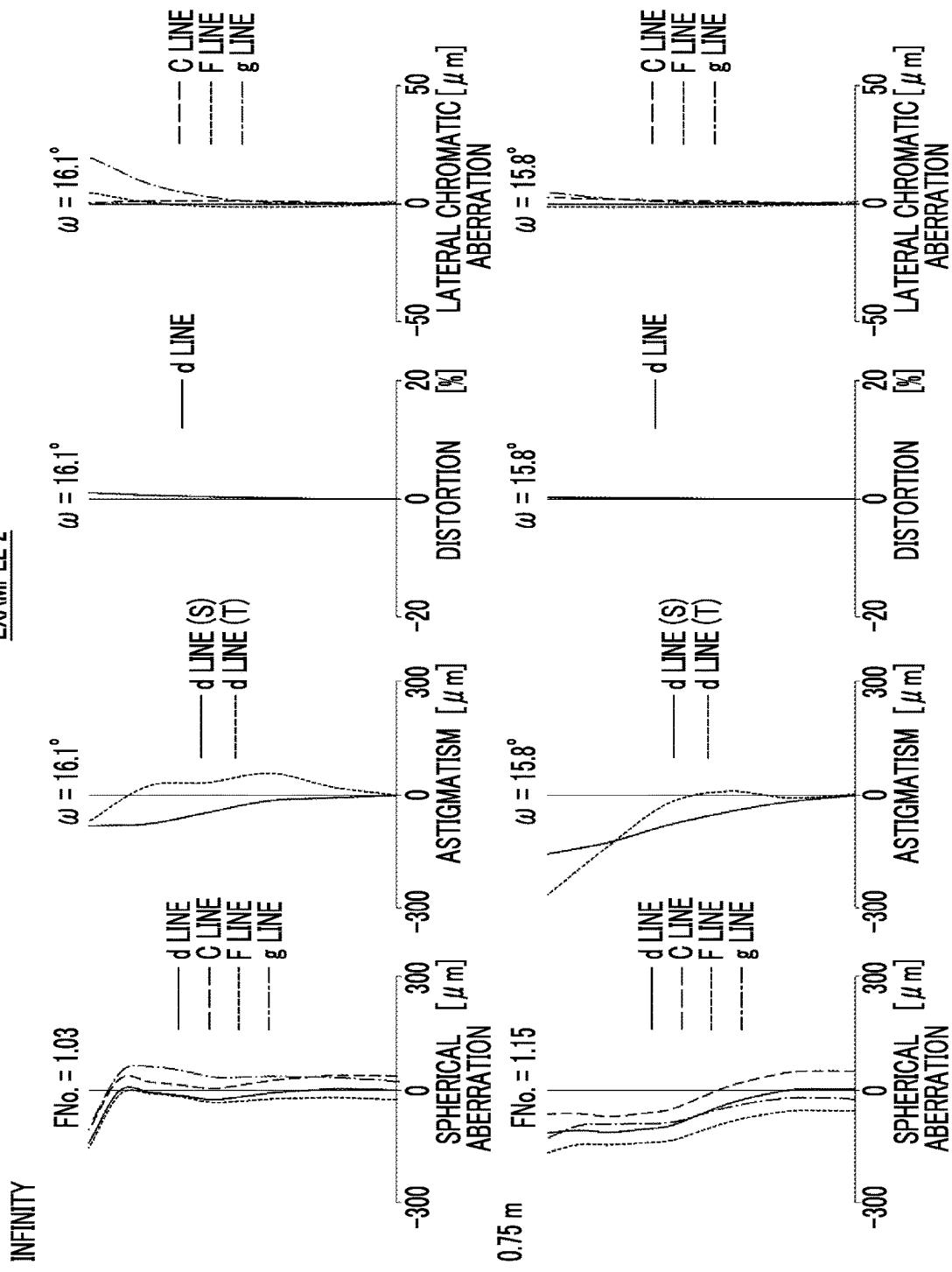
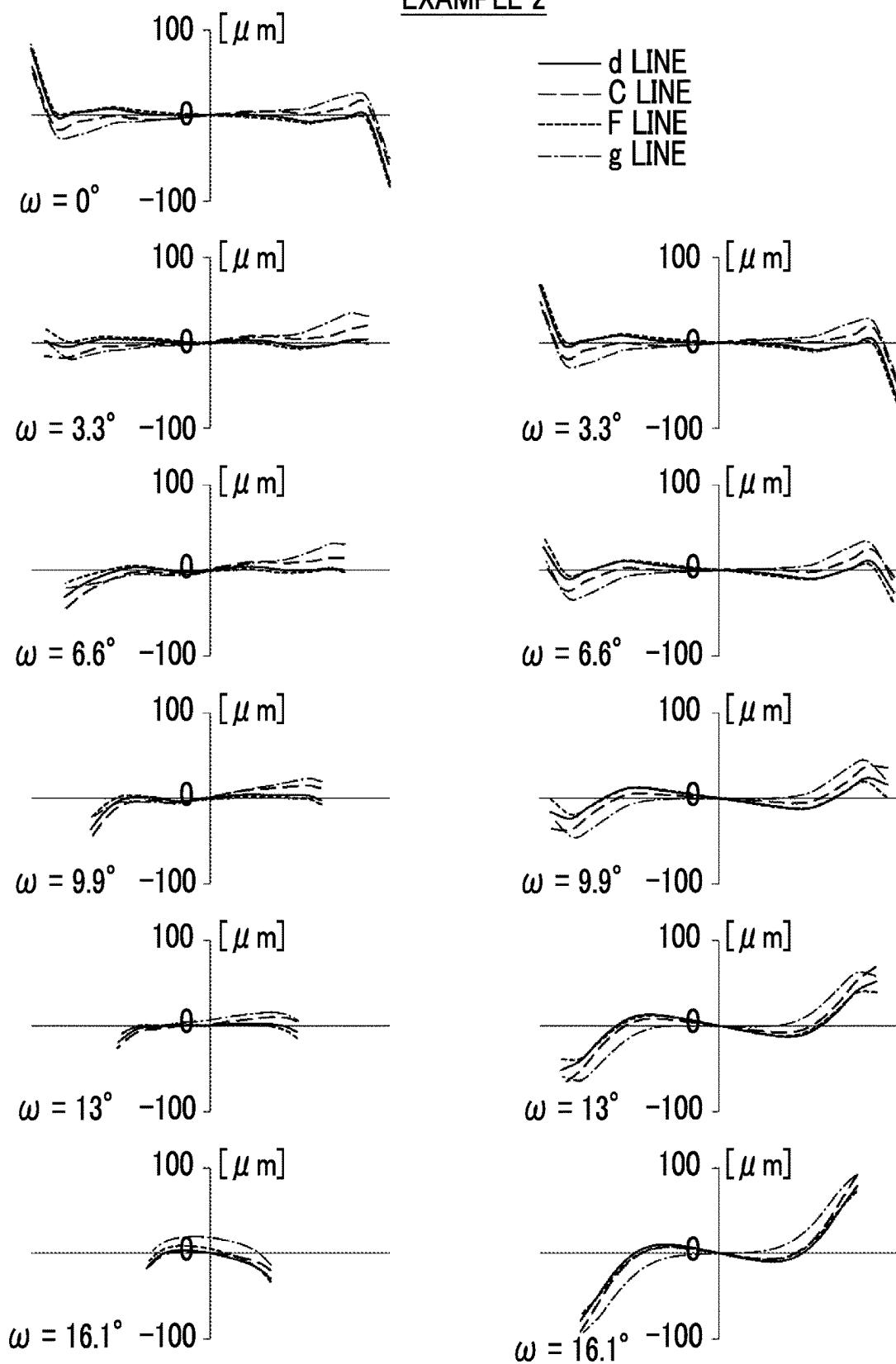
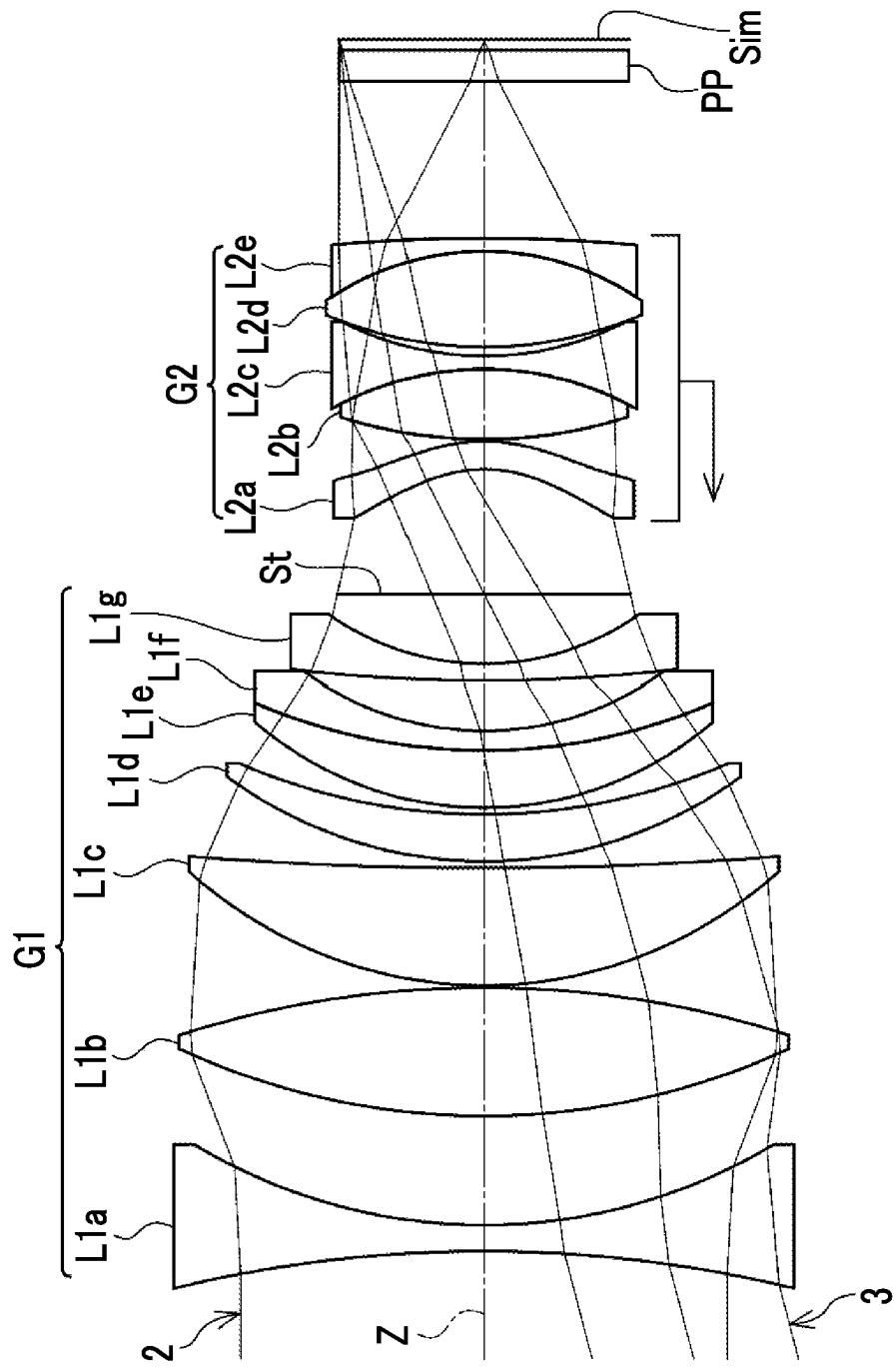
**FIG. 5**EXAMPLE 2

FIG. 6

EXAMPLE 2

**FIG. 7**  
**EXAMPLE 3**



8  
E.G.  
II

**EXAMPLE 3**

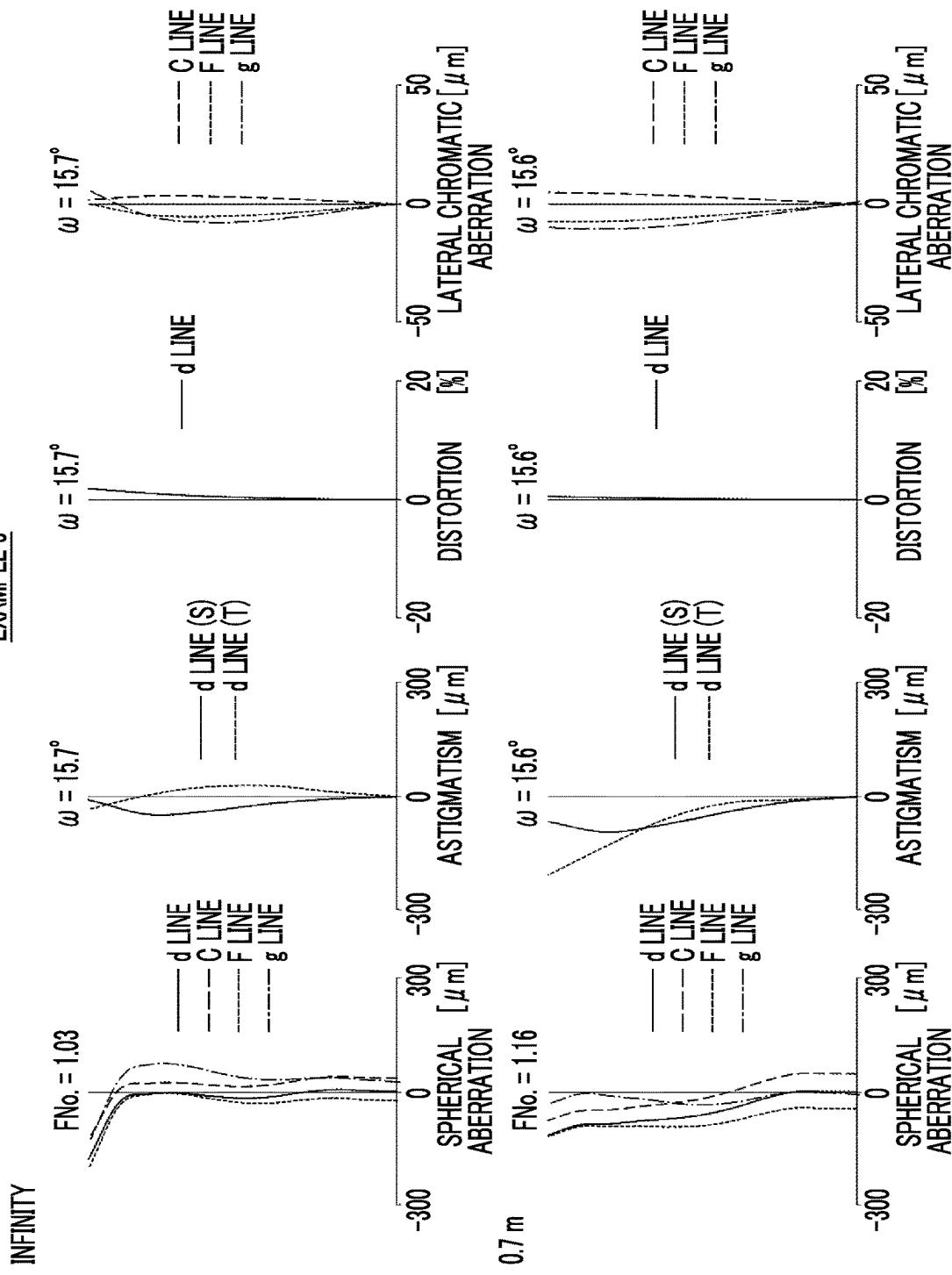
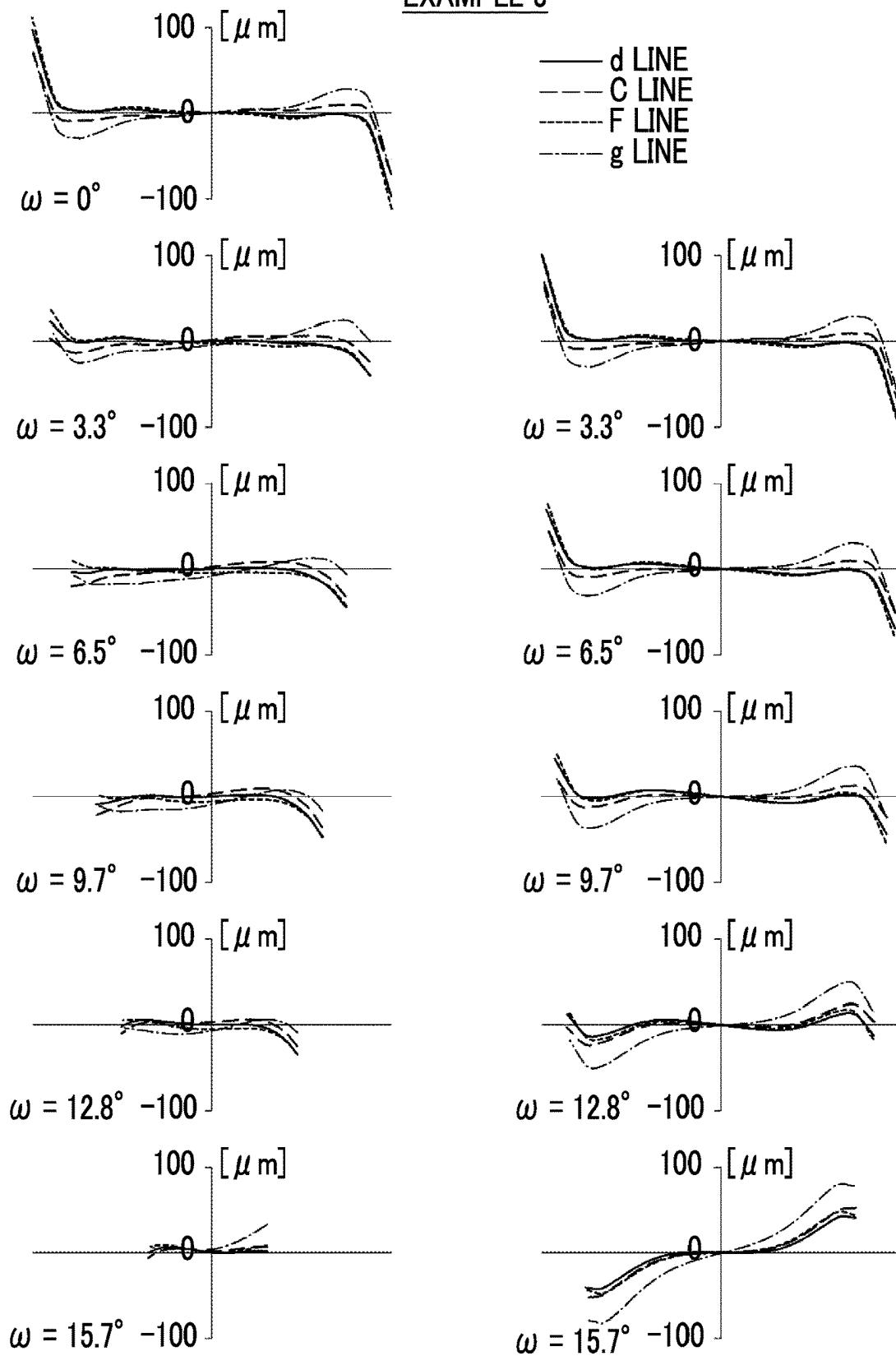
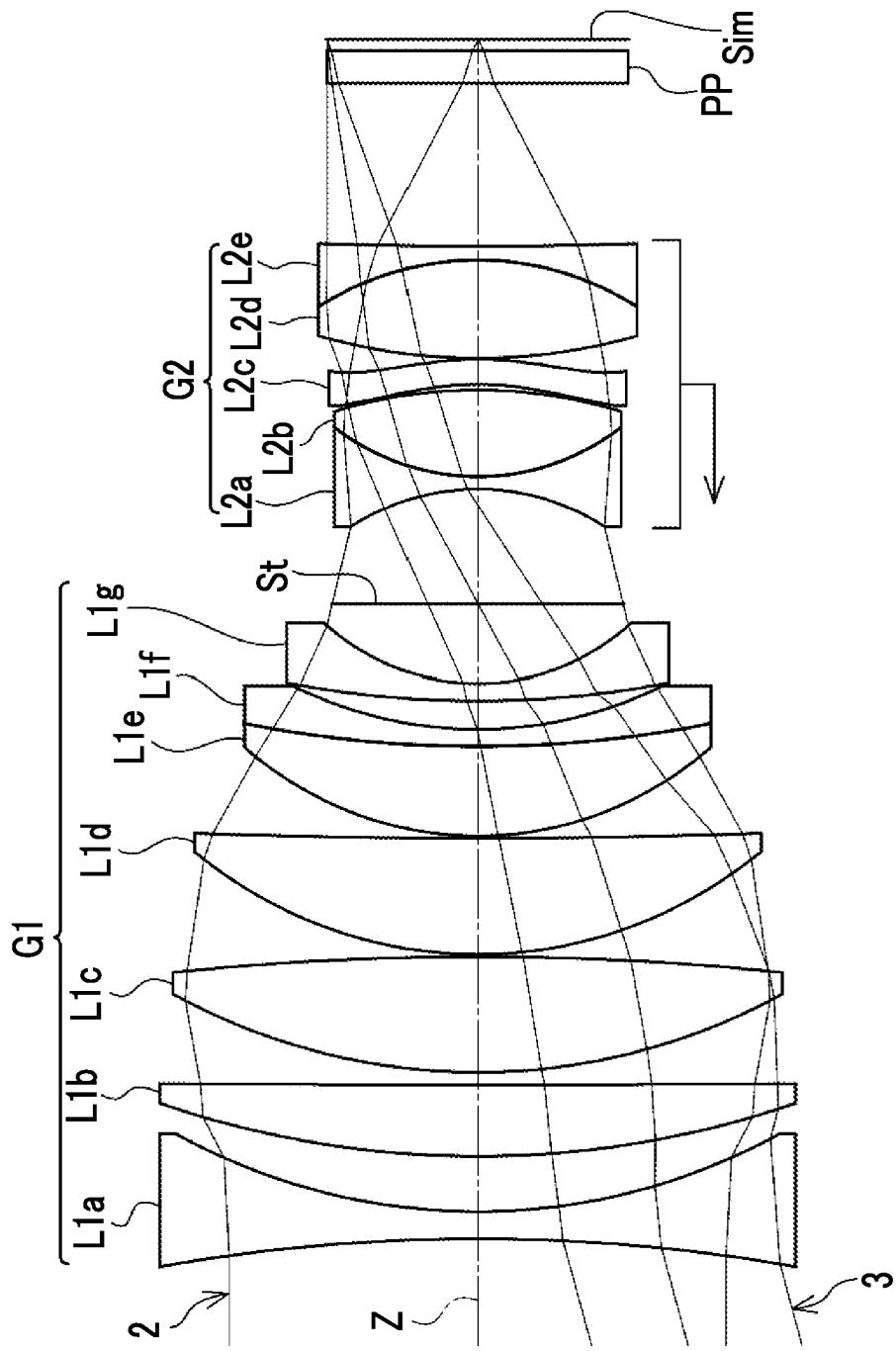


FIG. 9

EXAMPLE 3

**FIG. 10**  
**EXAMPLE 4**



**FIG. 11**  
**EXAMPLE 4**

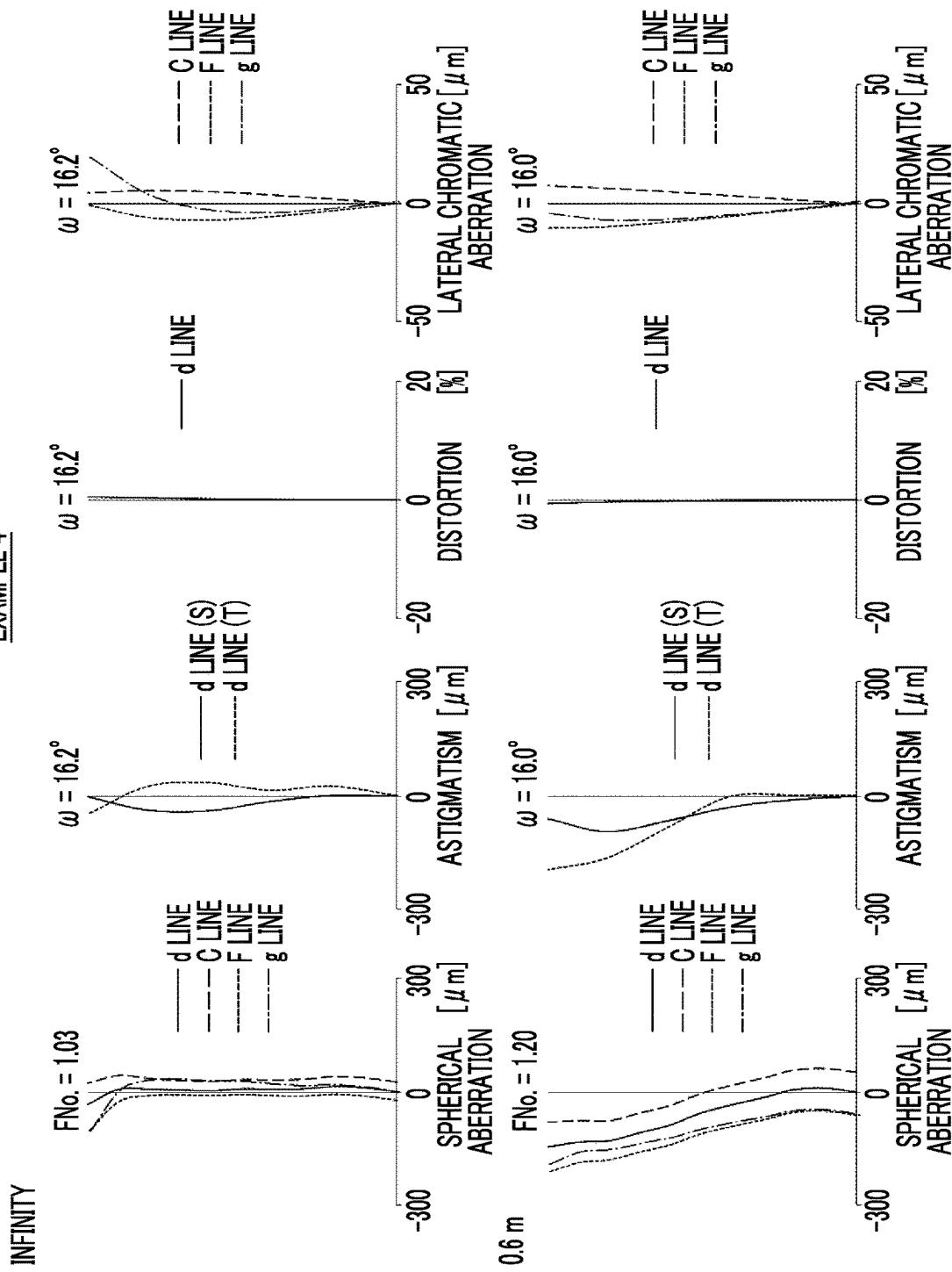
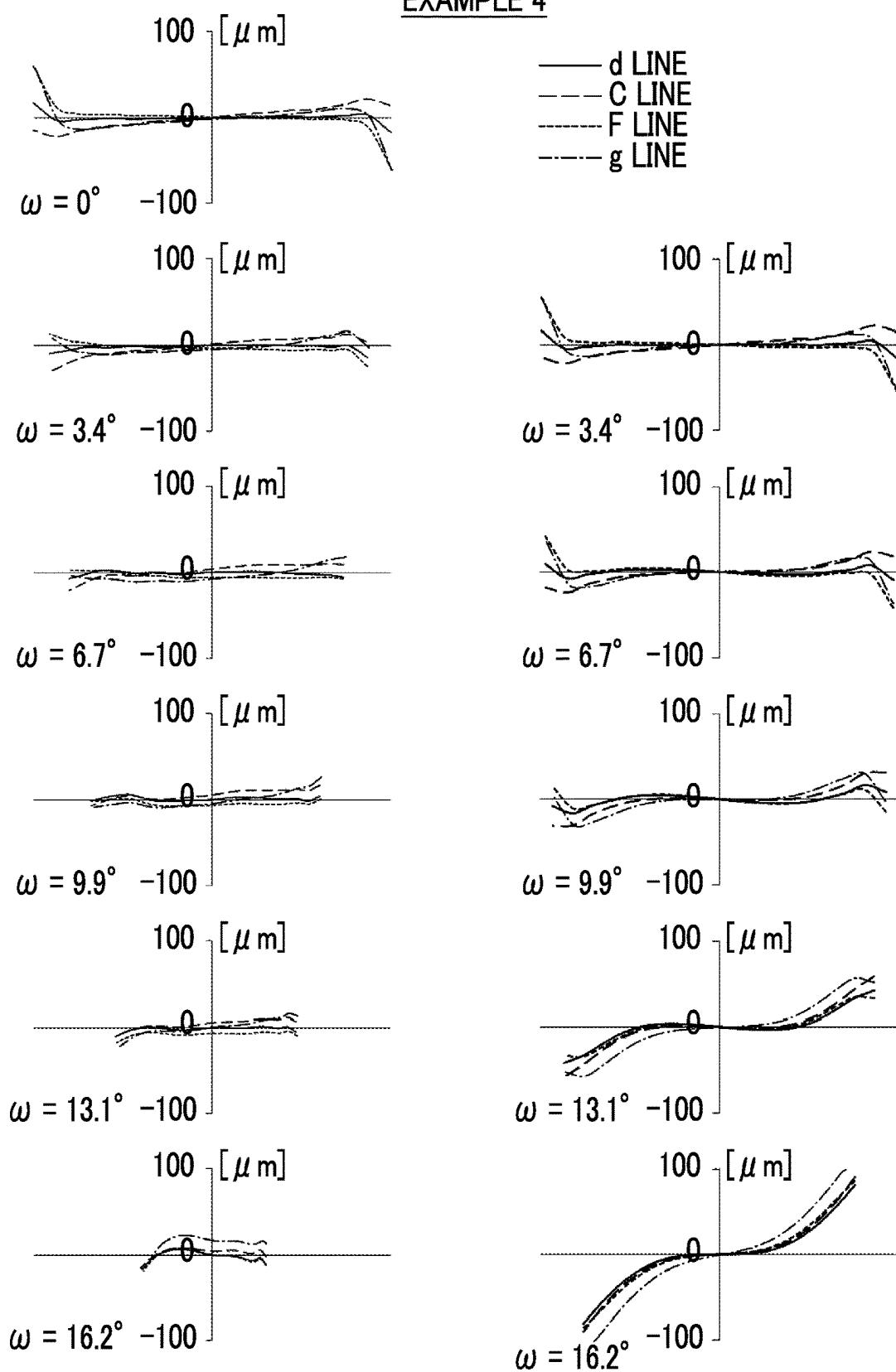
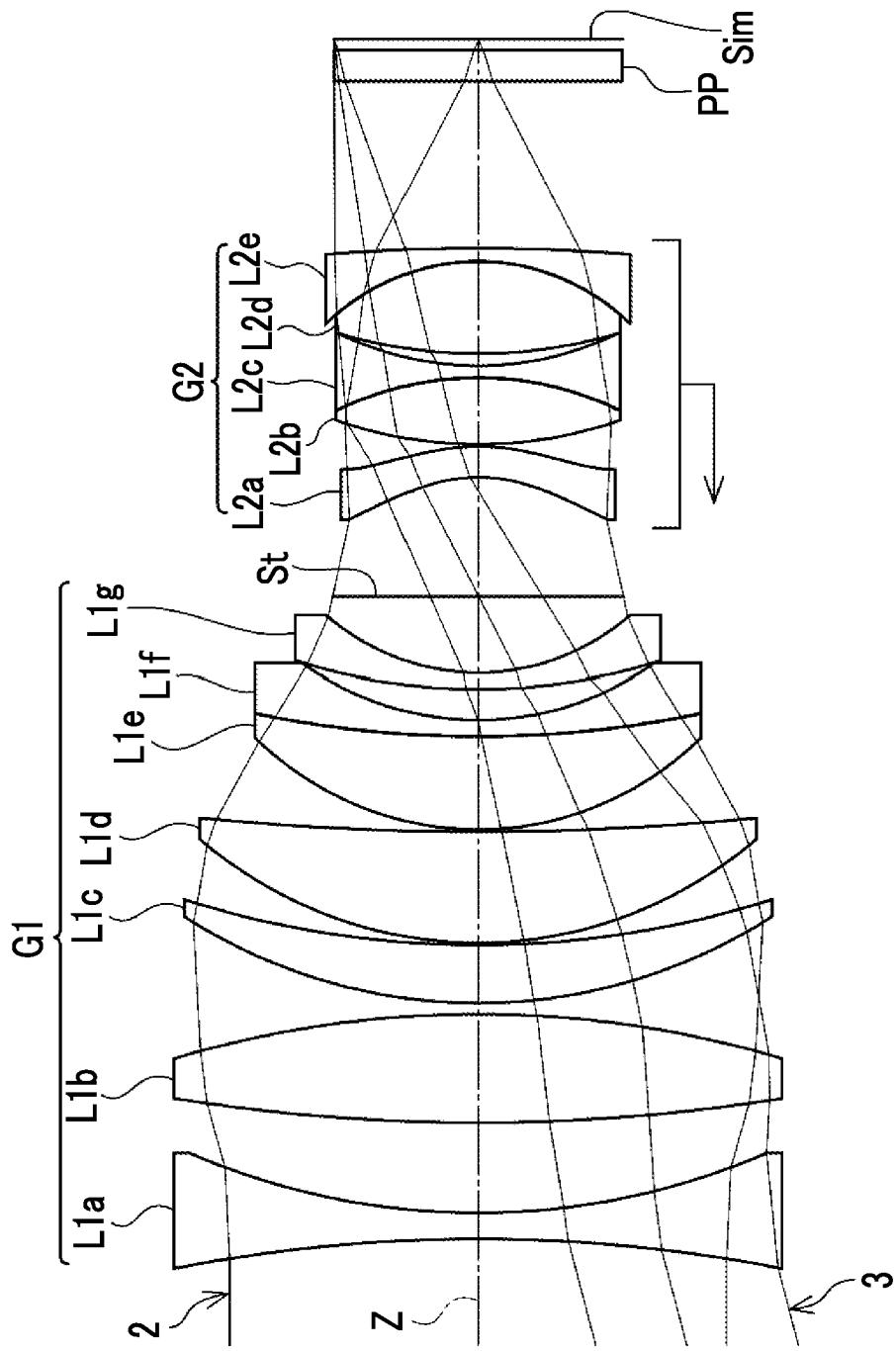


FIG. 12

EXAMPLE 4

**FIG. 13**  
EXAMPLE 5



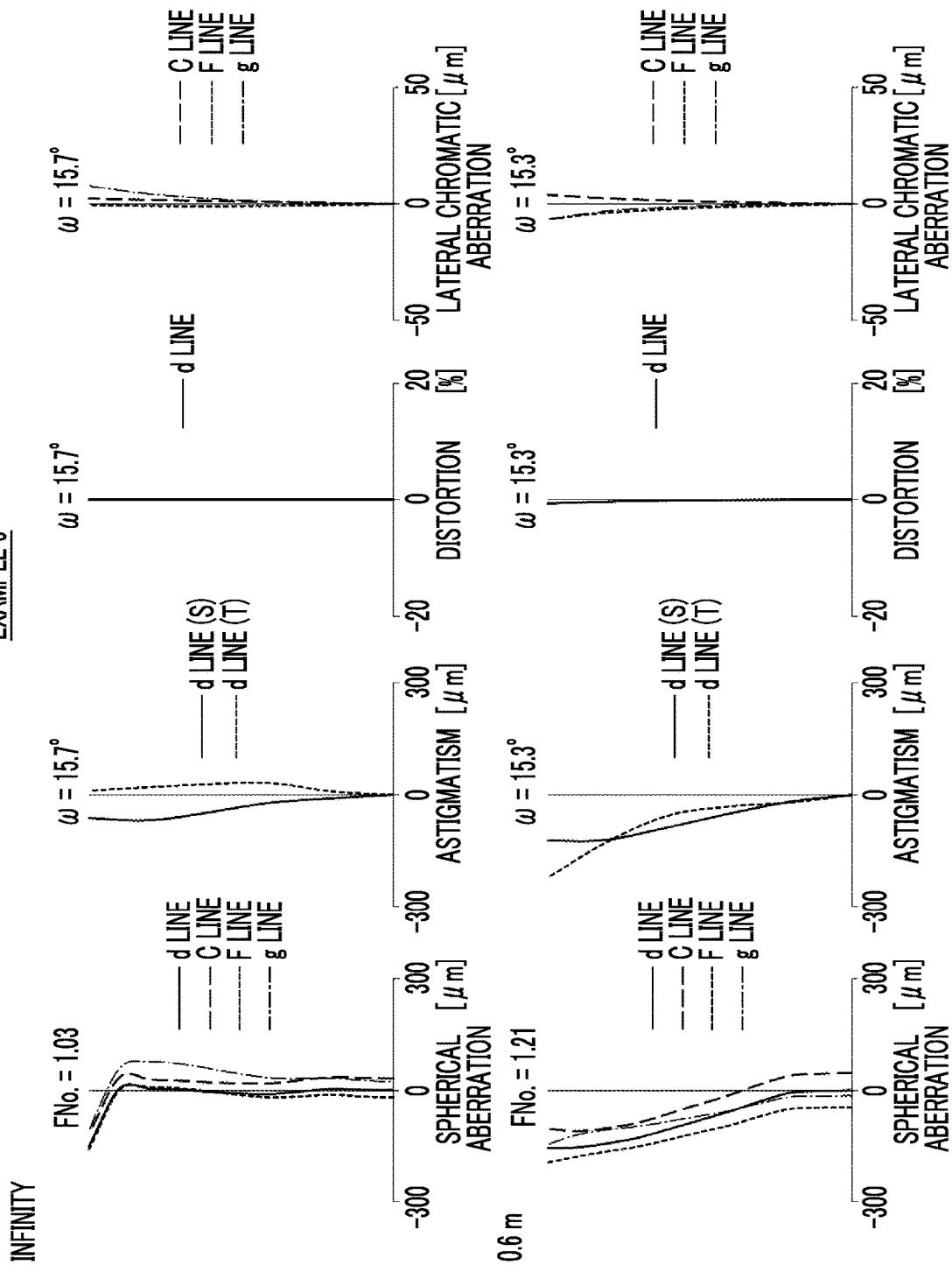
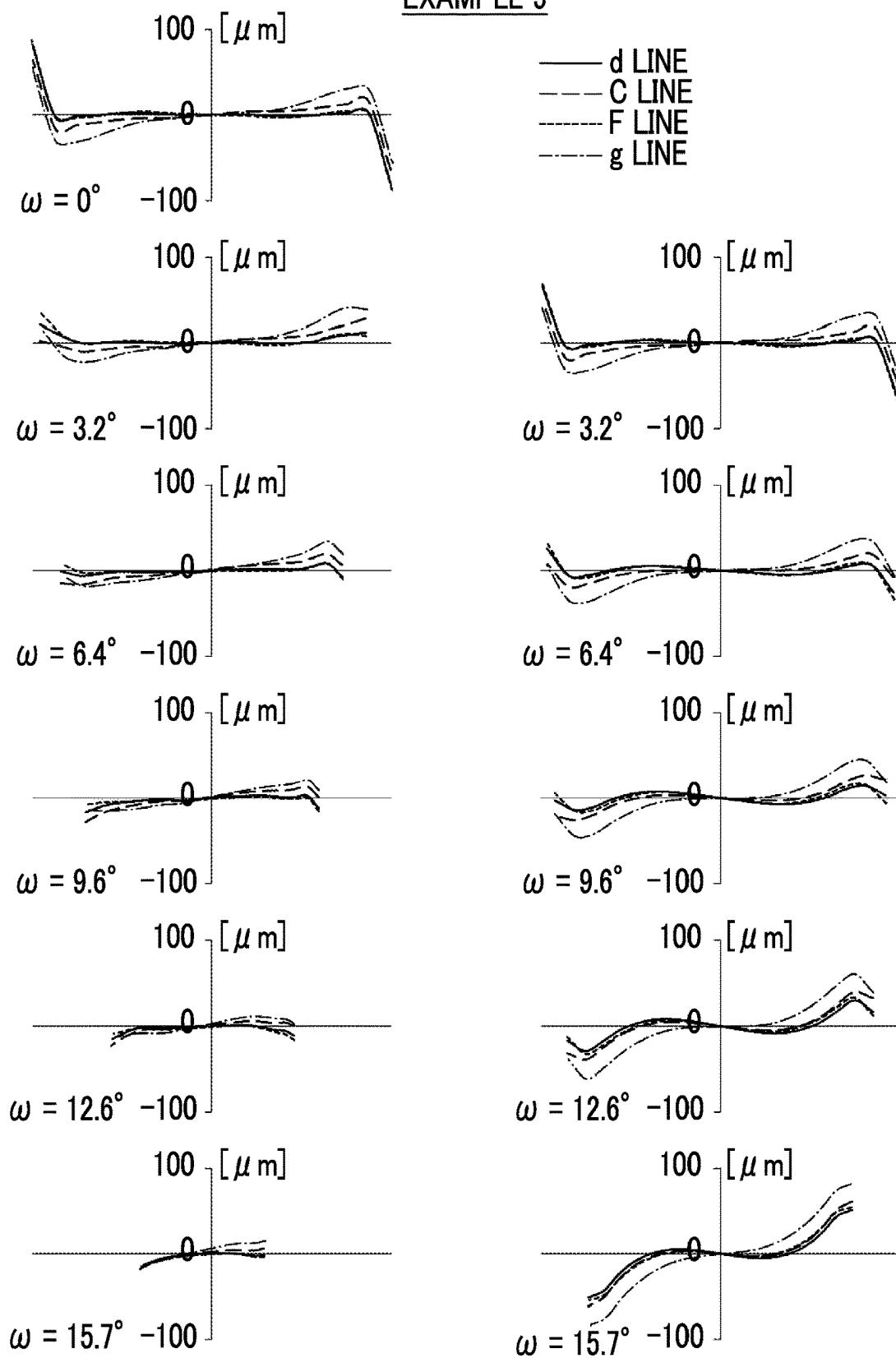
**FIG. 14****EXAMPLE 5**

FIG. 15

EXAMPLE 5

**FIG. 16**  
EXAMPLE 6

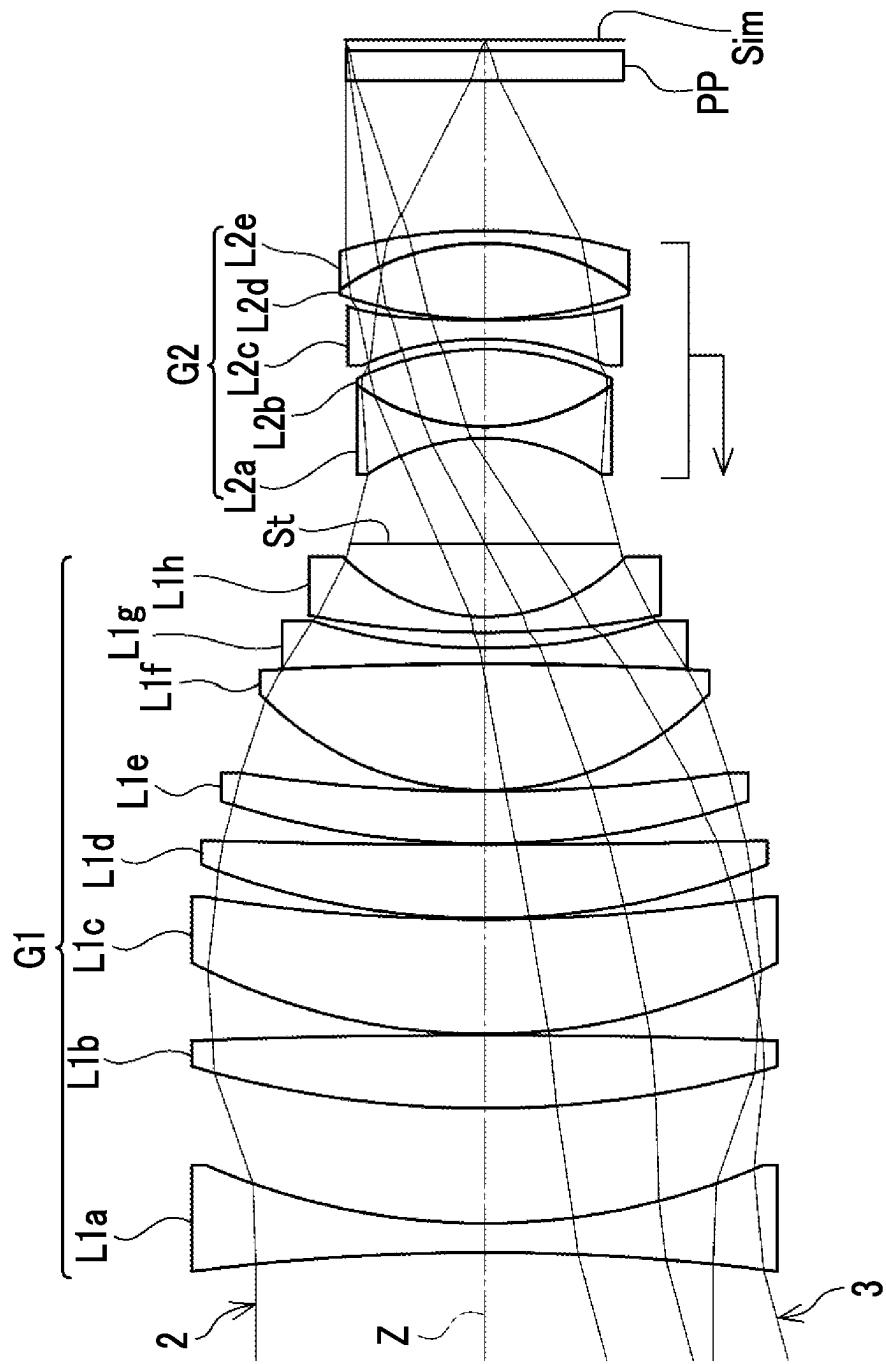


FIG. 17

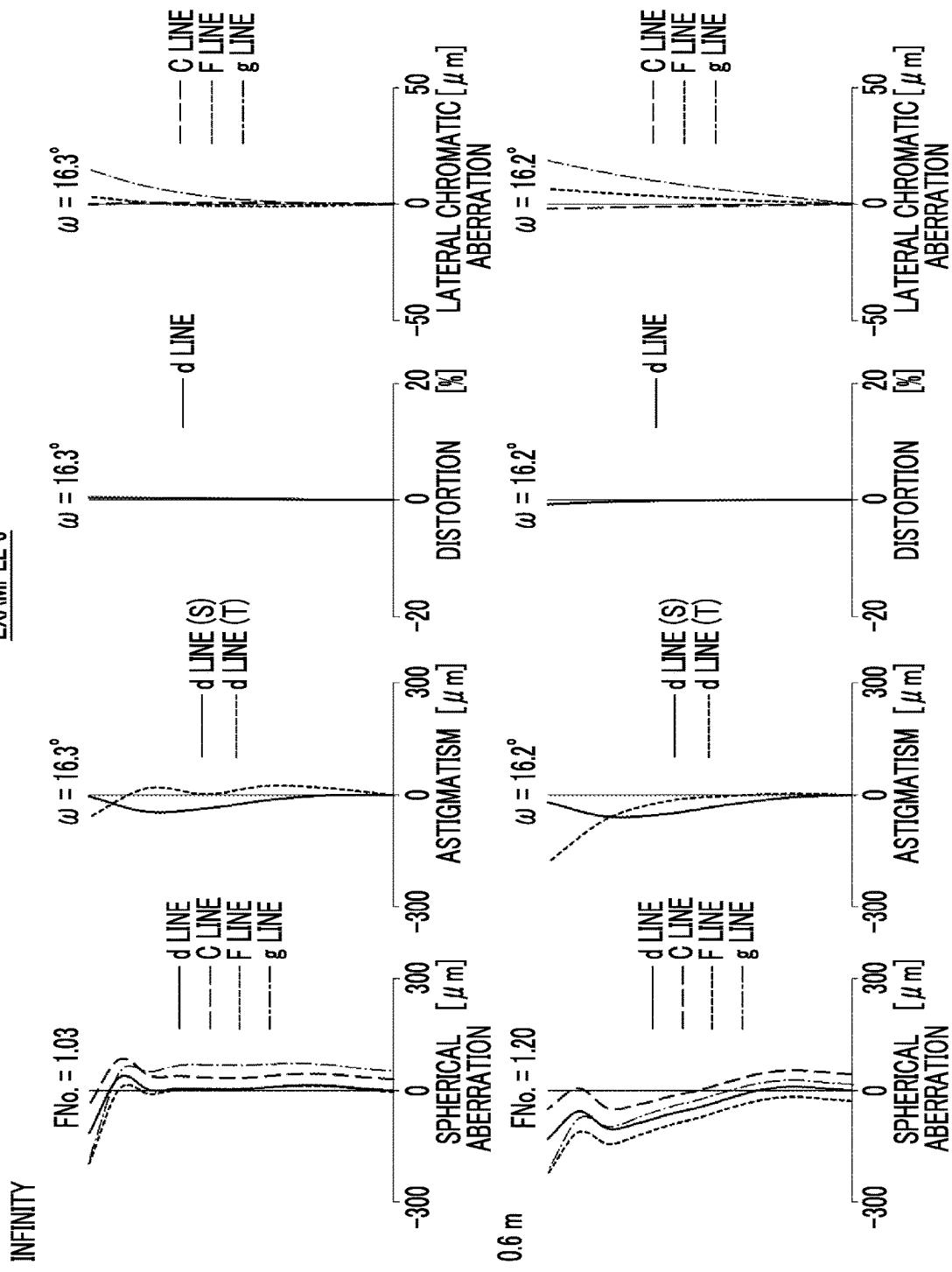
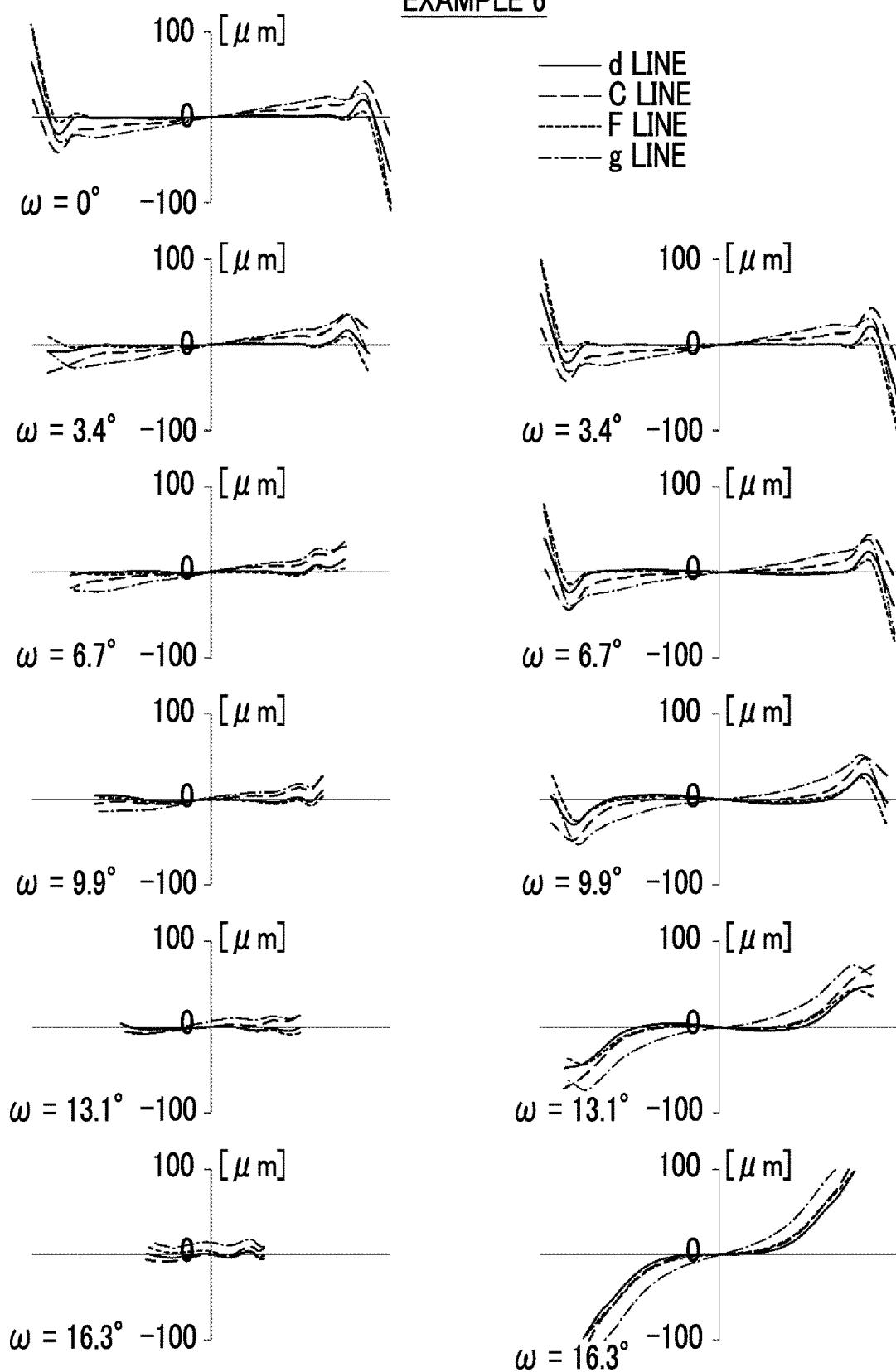
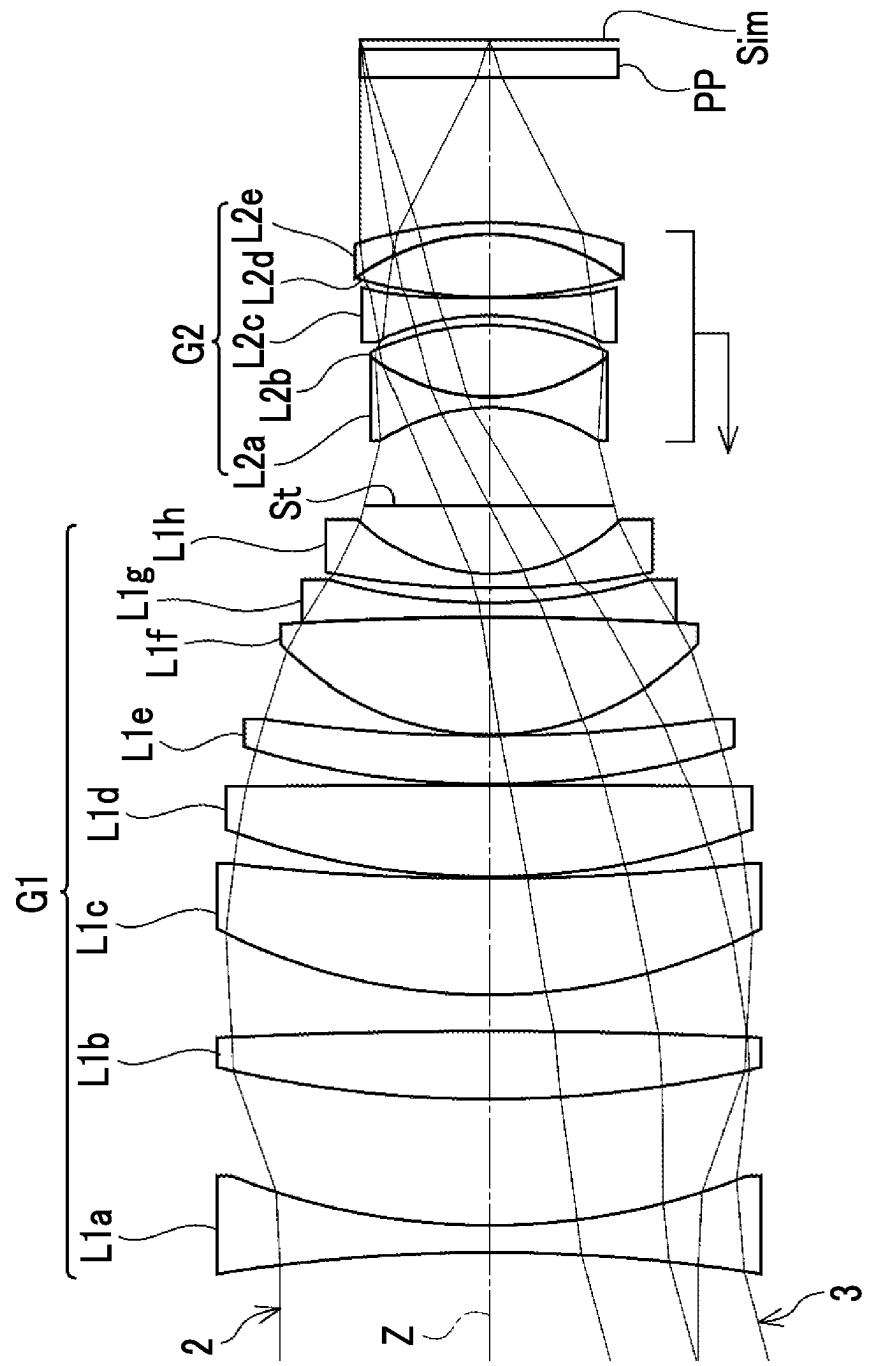
EXAMPLE 6

FIG. 18

EXAMPLE 6

**FIG. 19**  
**EXAMPLE 7**



**FIG. 20**  
EXAMPLE 7

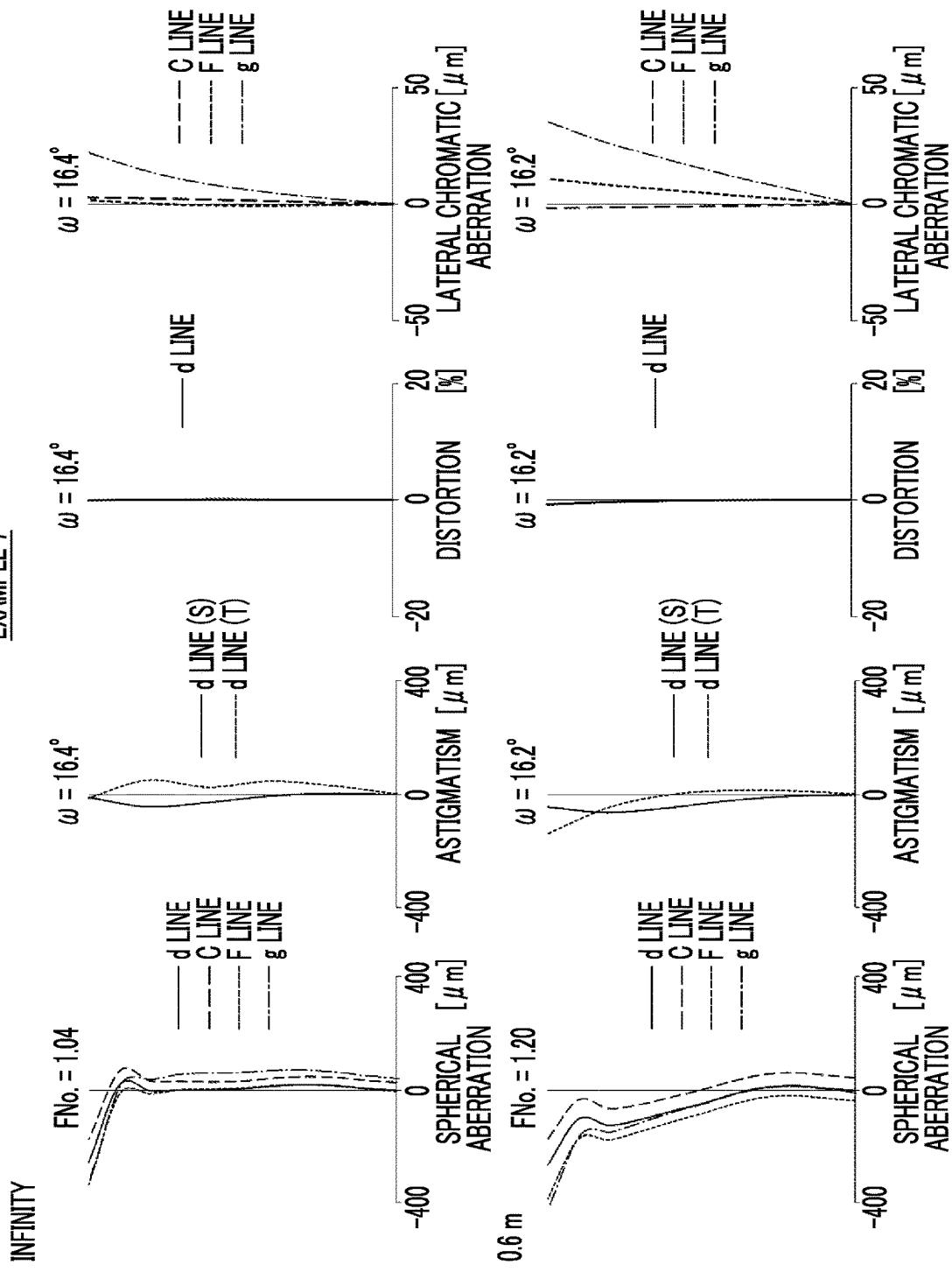
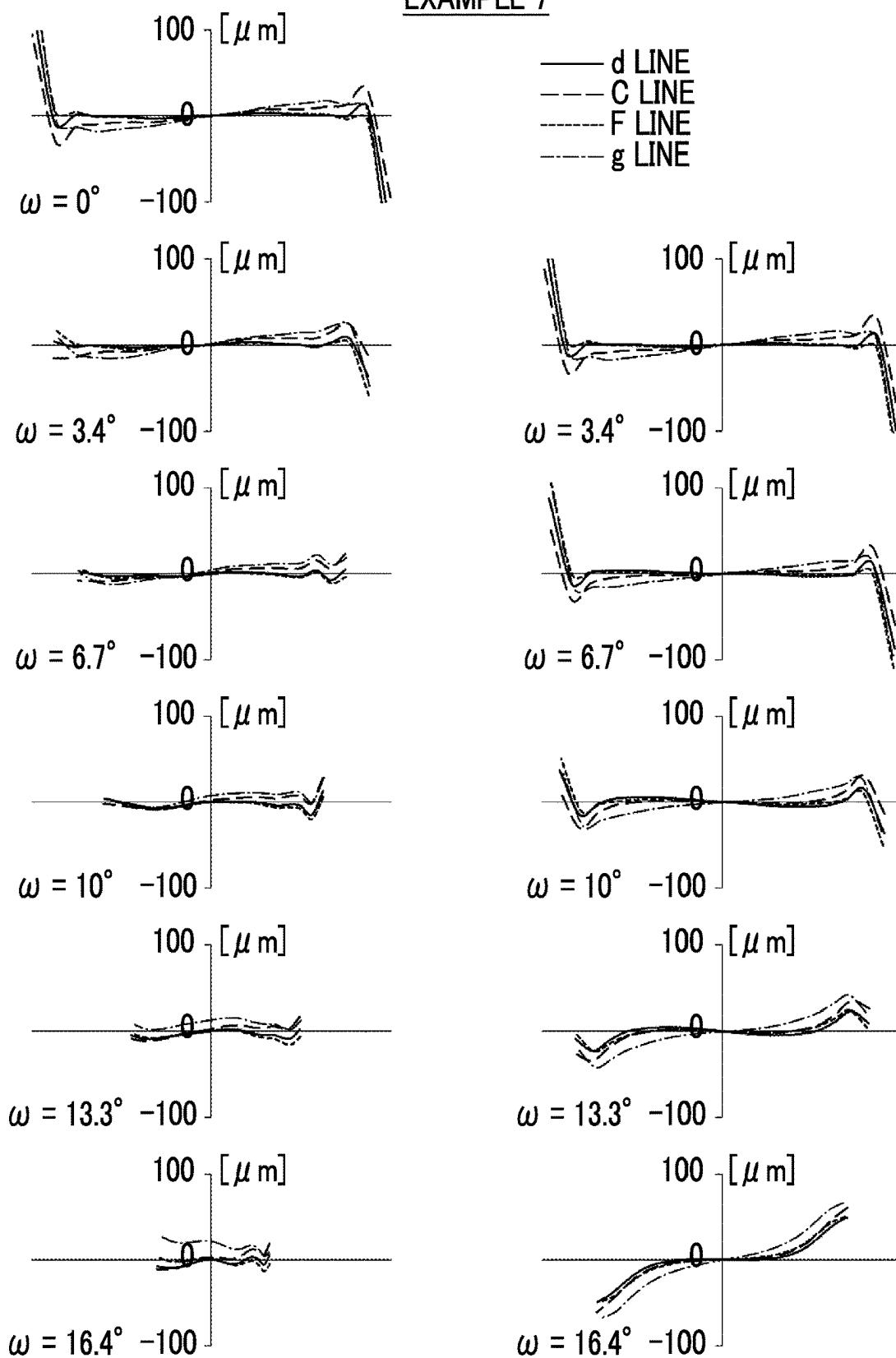


FIG. 21

EXAMPLE 7

**FIG. 22**  
**EXAMPLE 8**

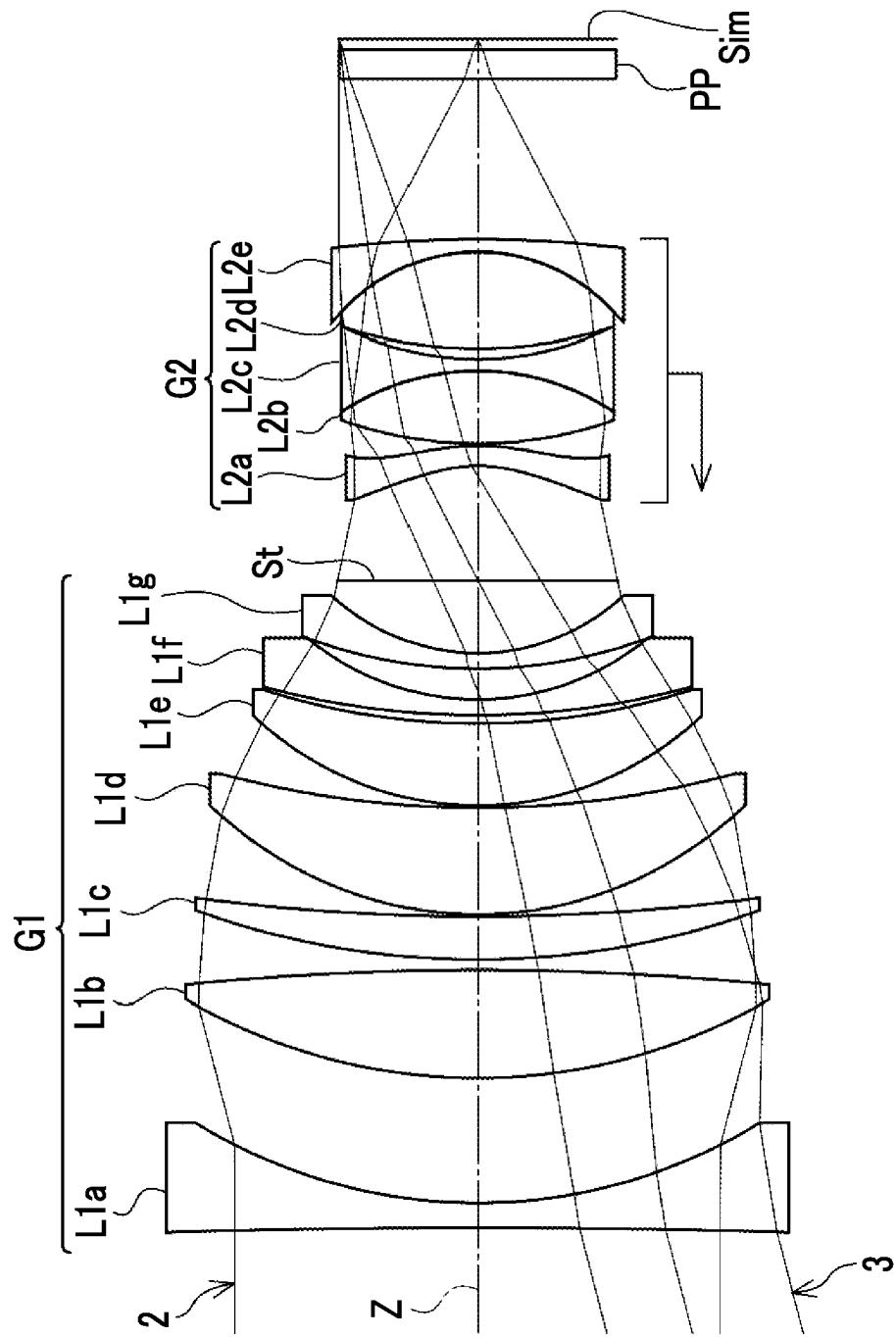


FIG. 23

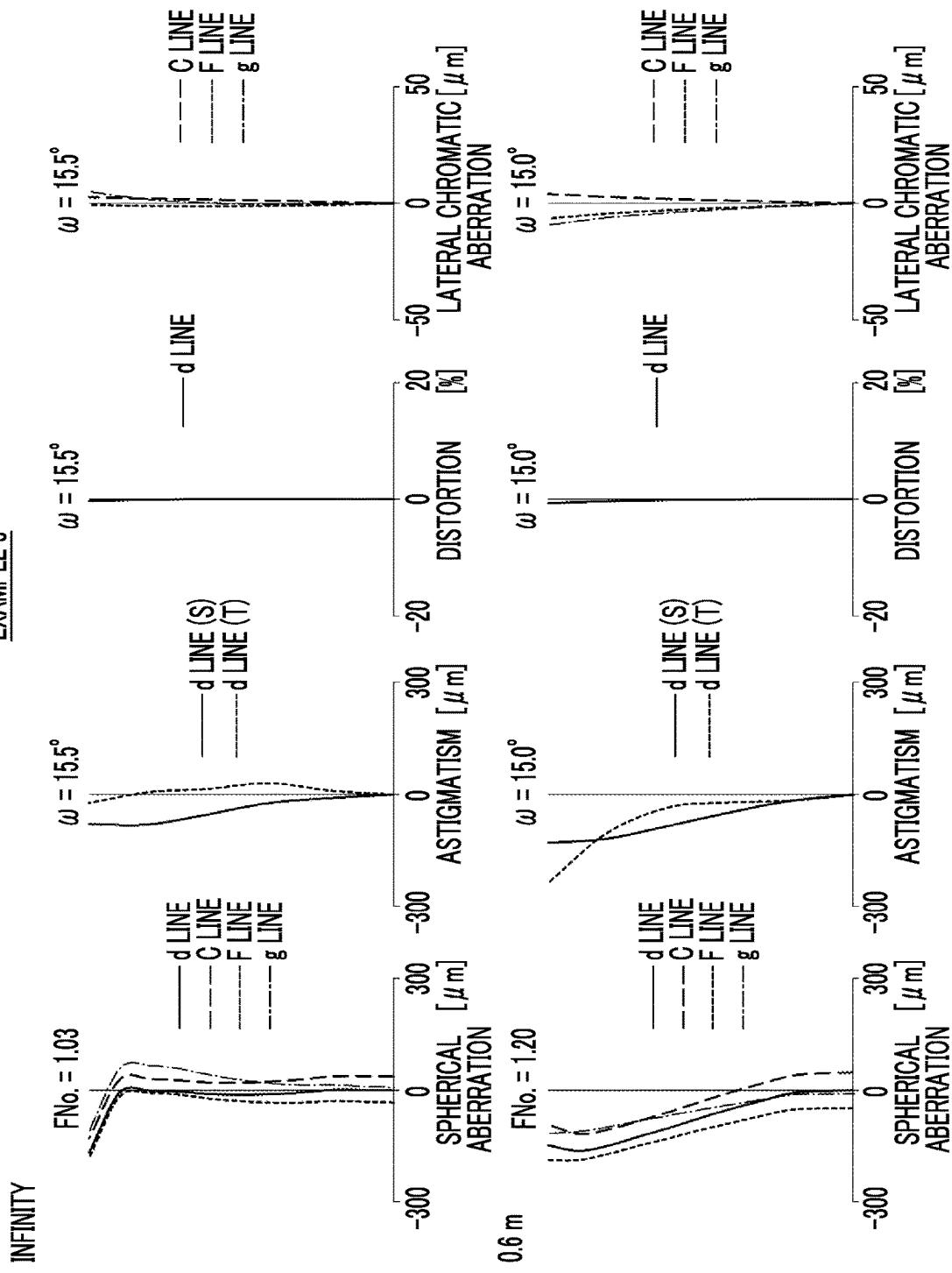
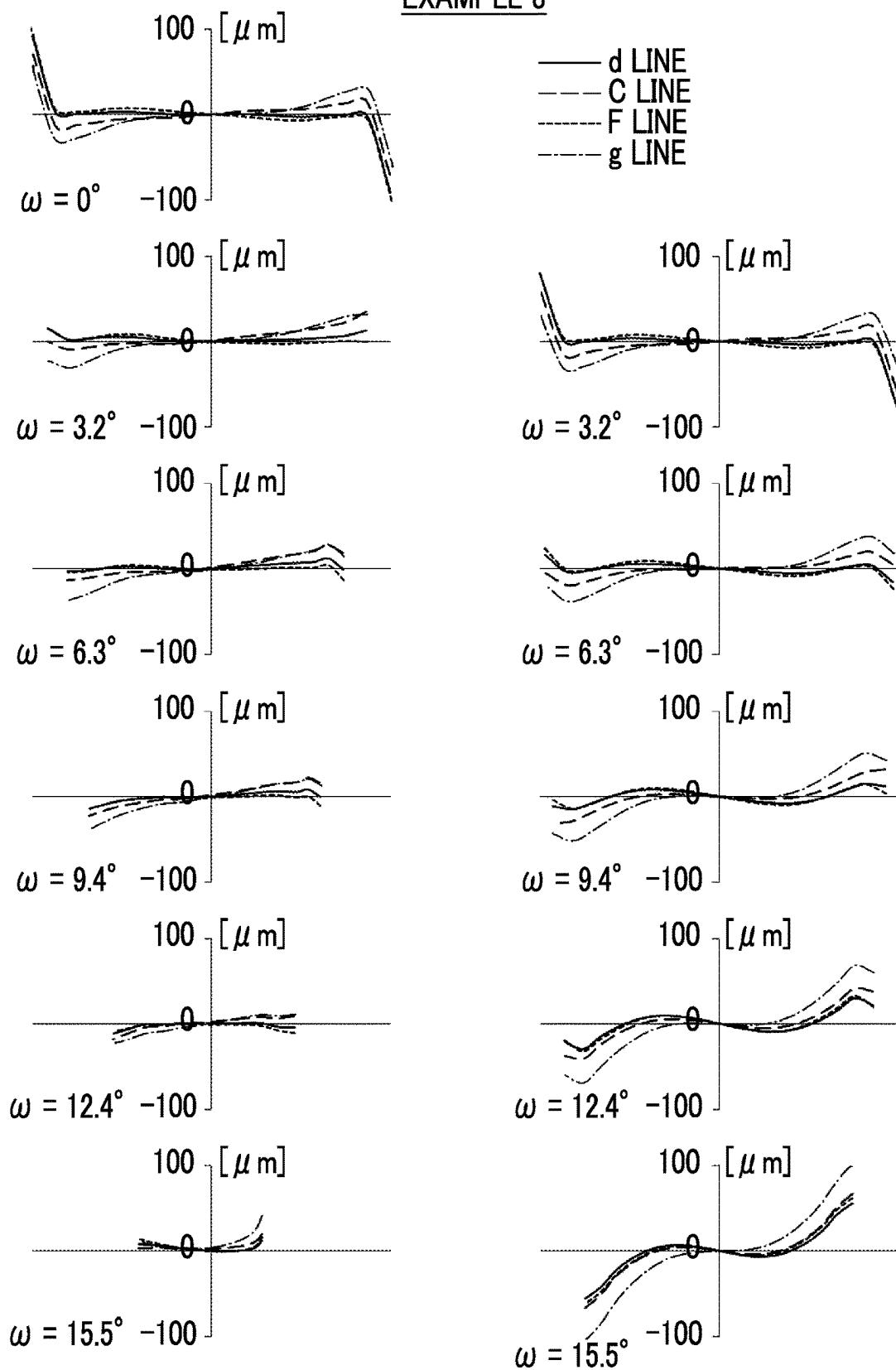
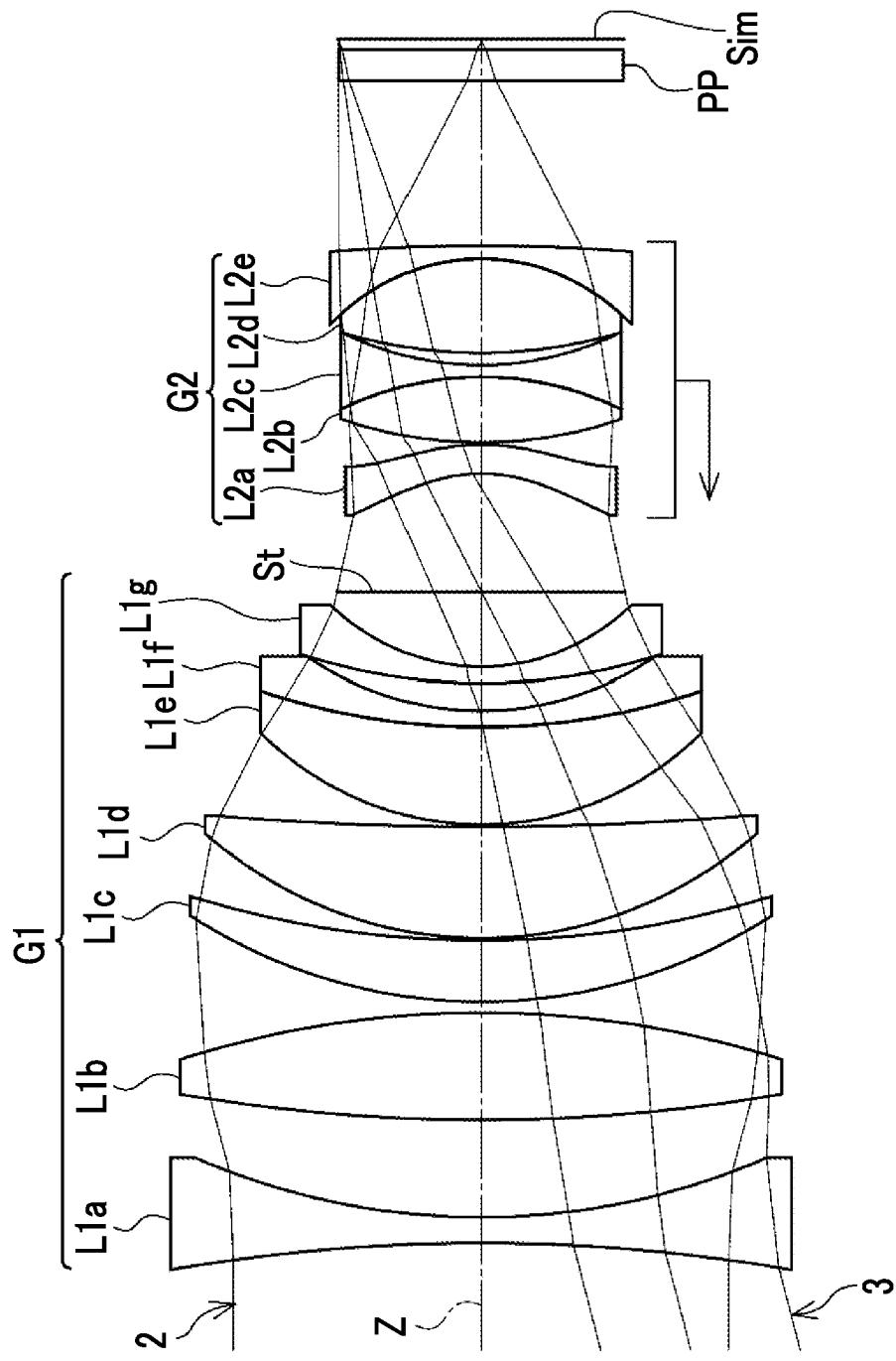
EXAMPLE 8

FIG. 24

EXAMPLE 8

**FIG. 25**  
**EXAMPLE 9**



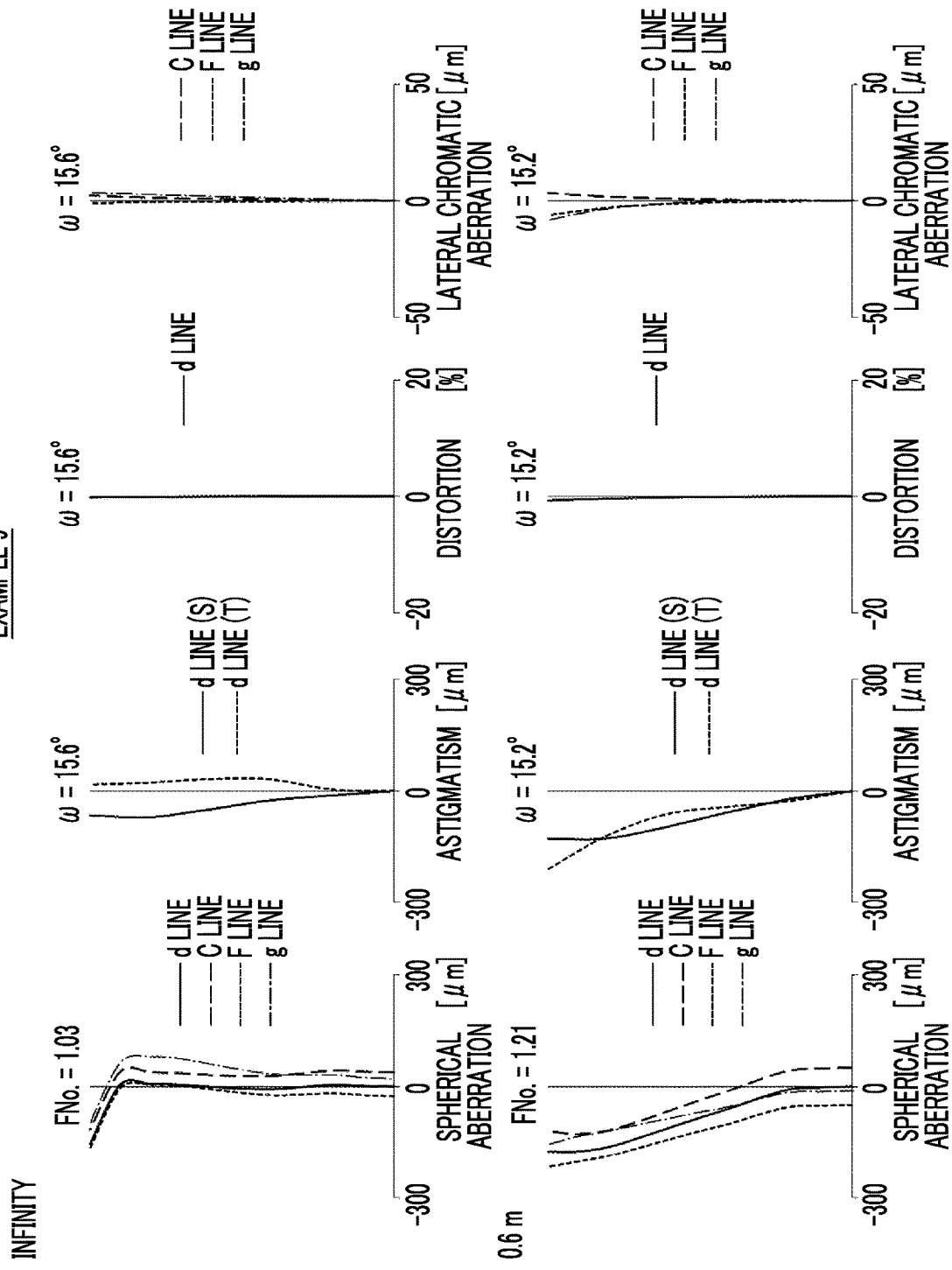
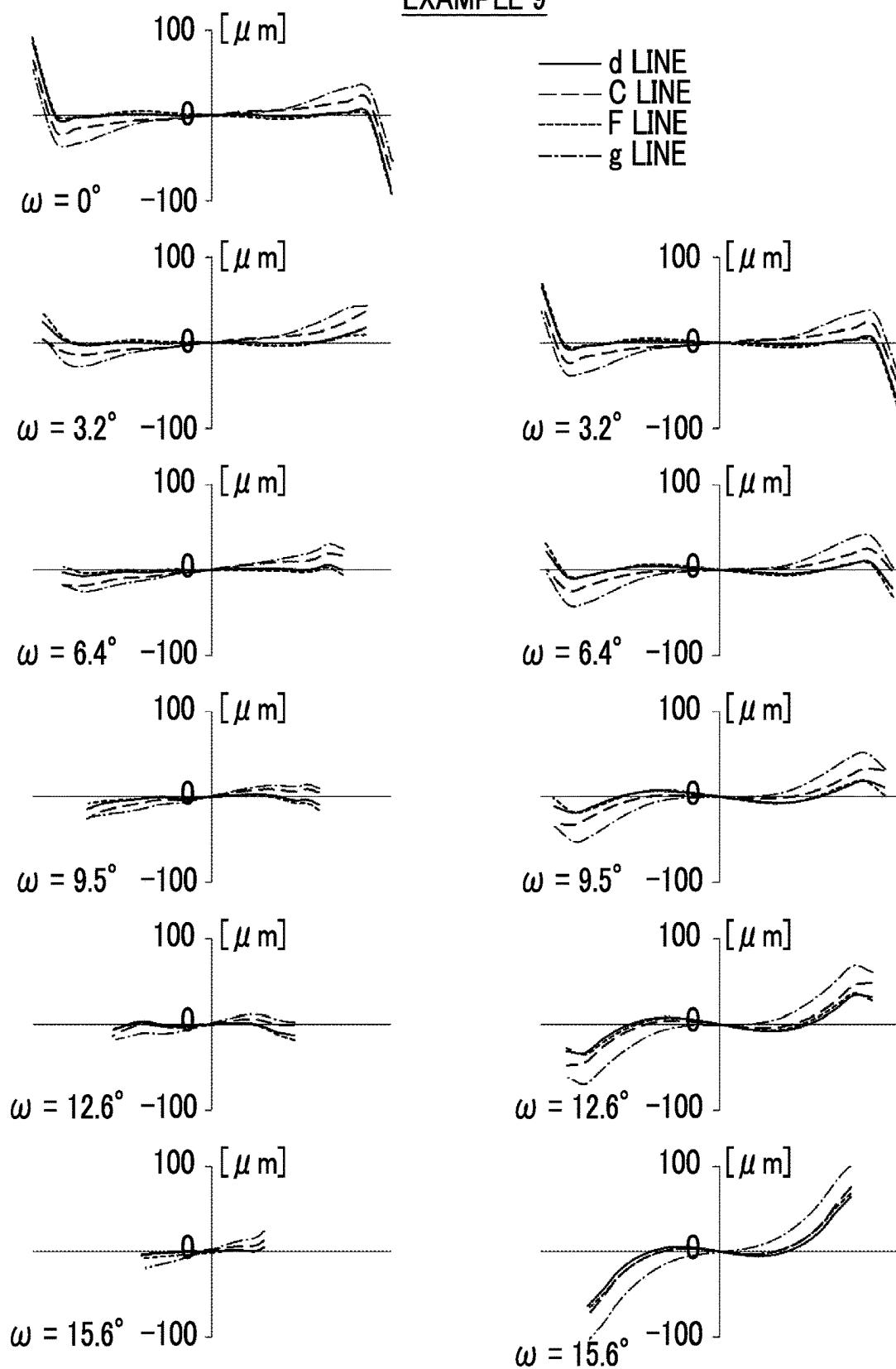
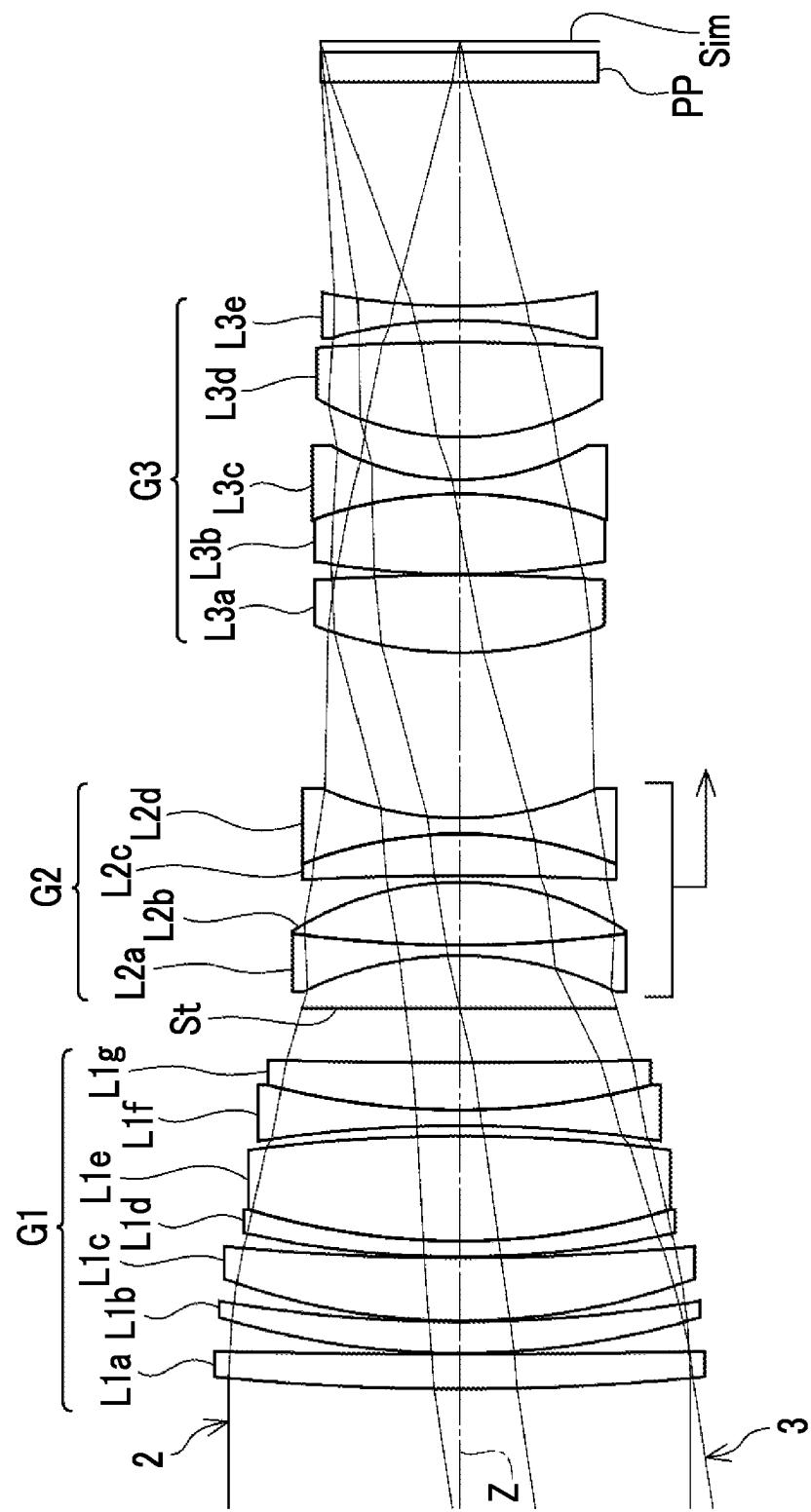
**FIG. 26**EXAMPLE 9

FIG. 27

EXAMPLE 9

**FIG. 28**  
EXAMPLE 10



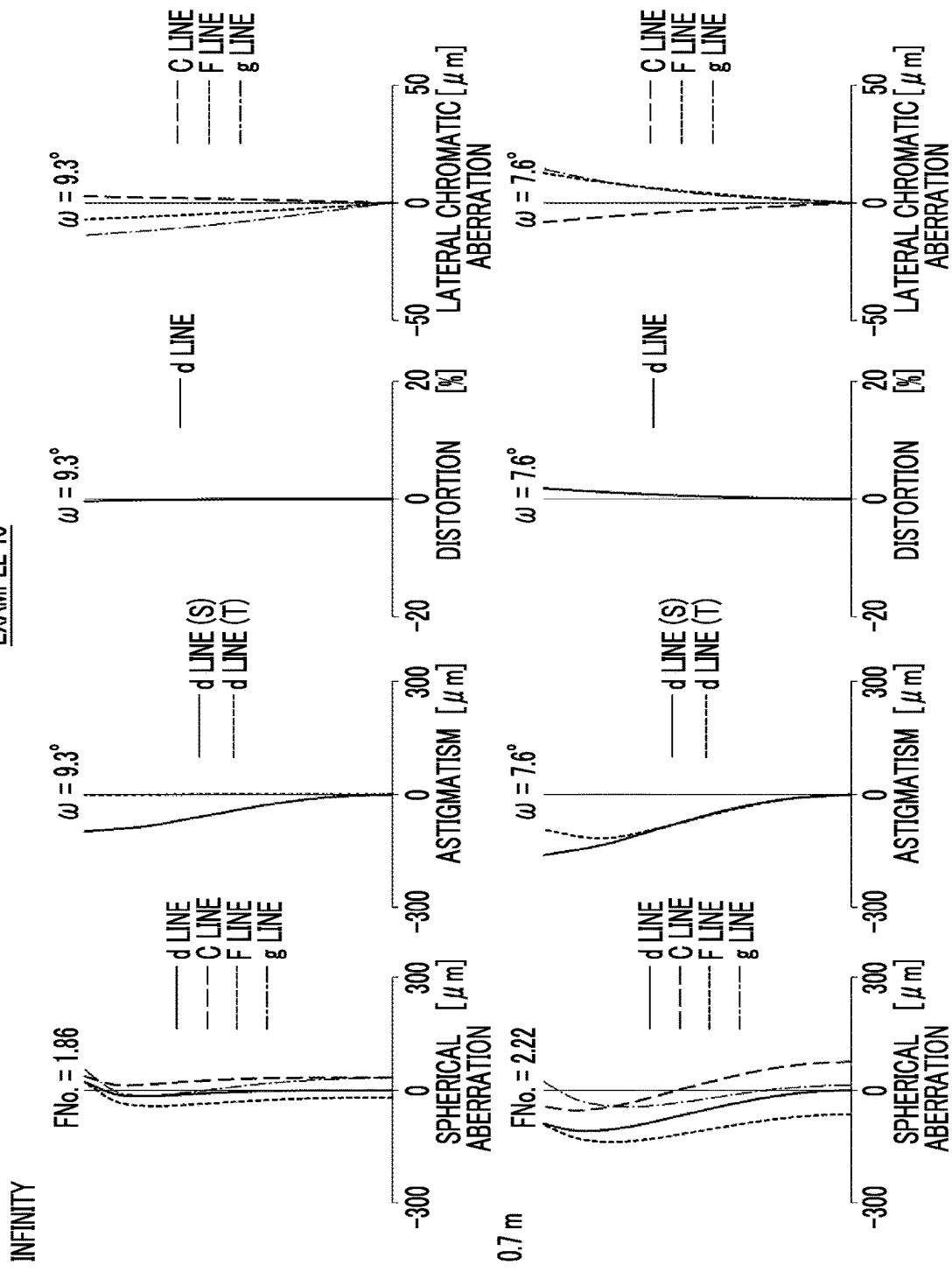
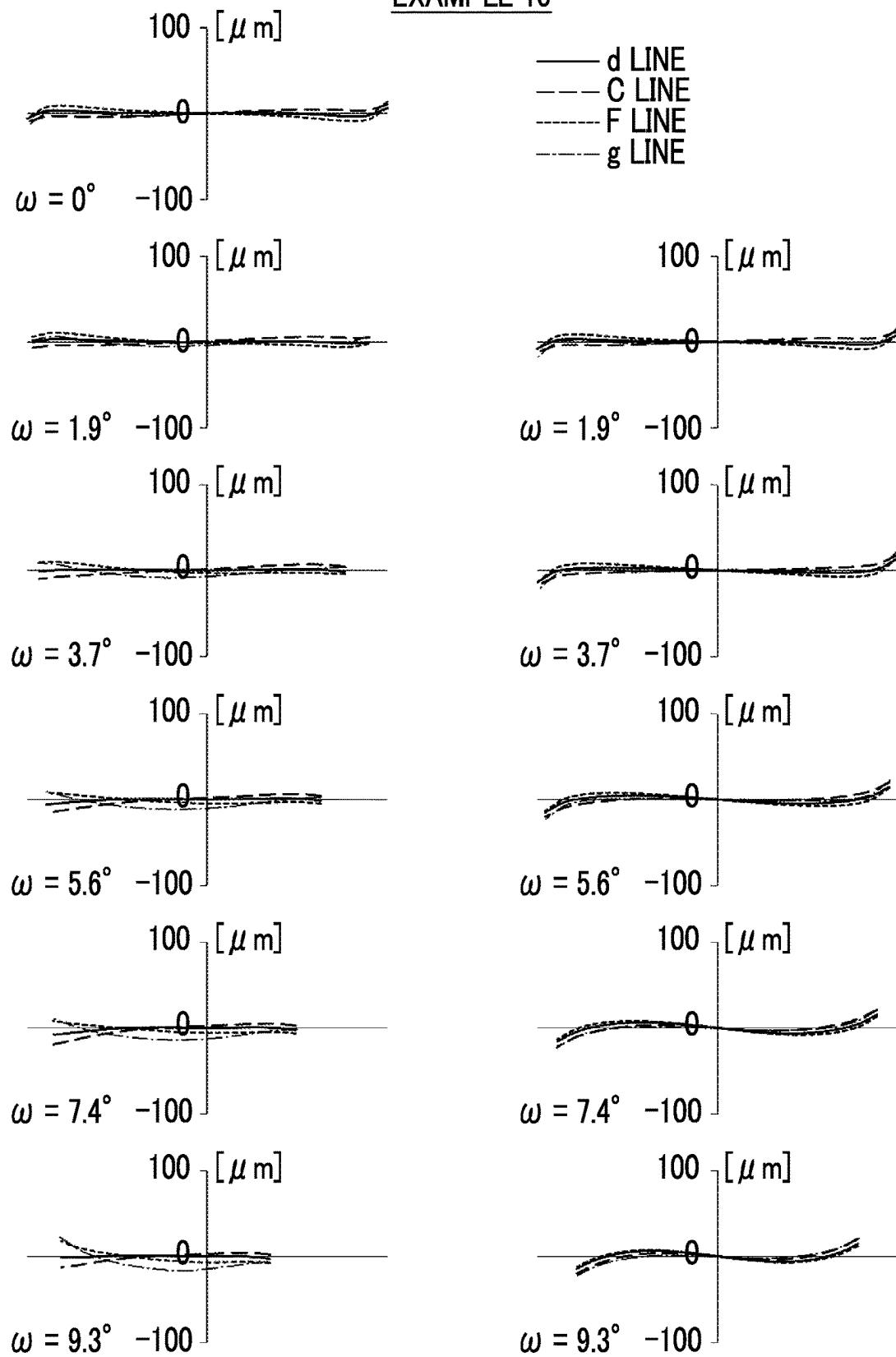
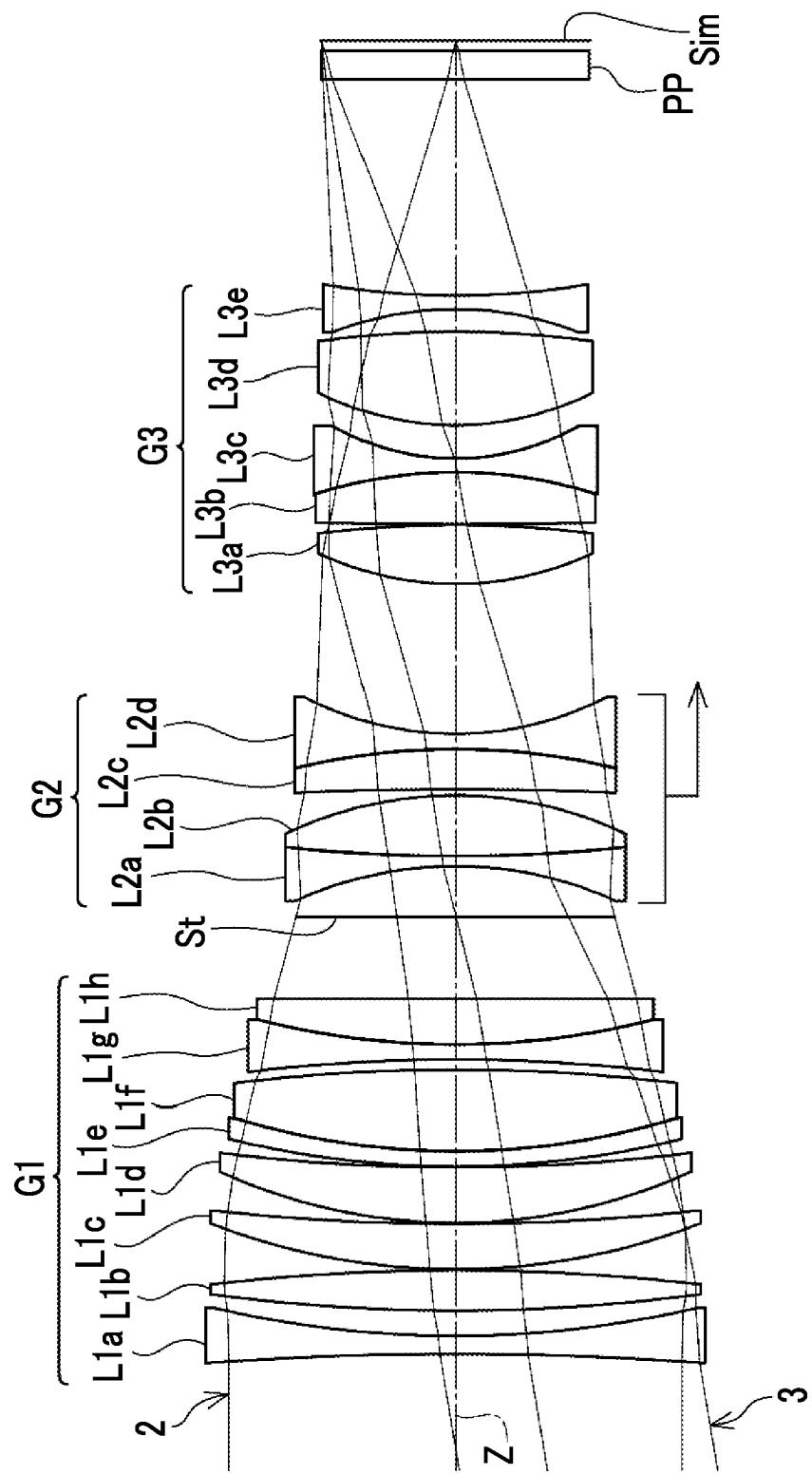
**FIG. 29**EXAMPLE 10

FIG. 30

EXAMPLE 10

**FIG. 31**  
**EXAMPLE 11**



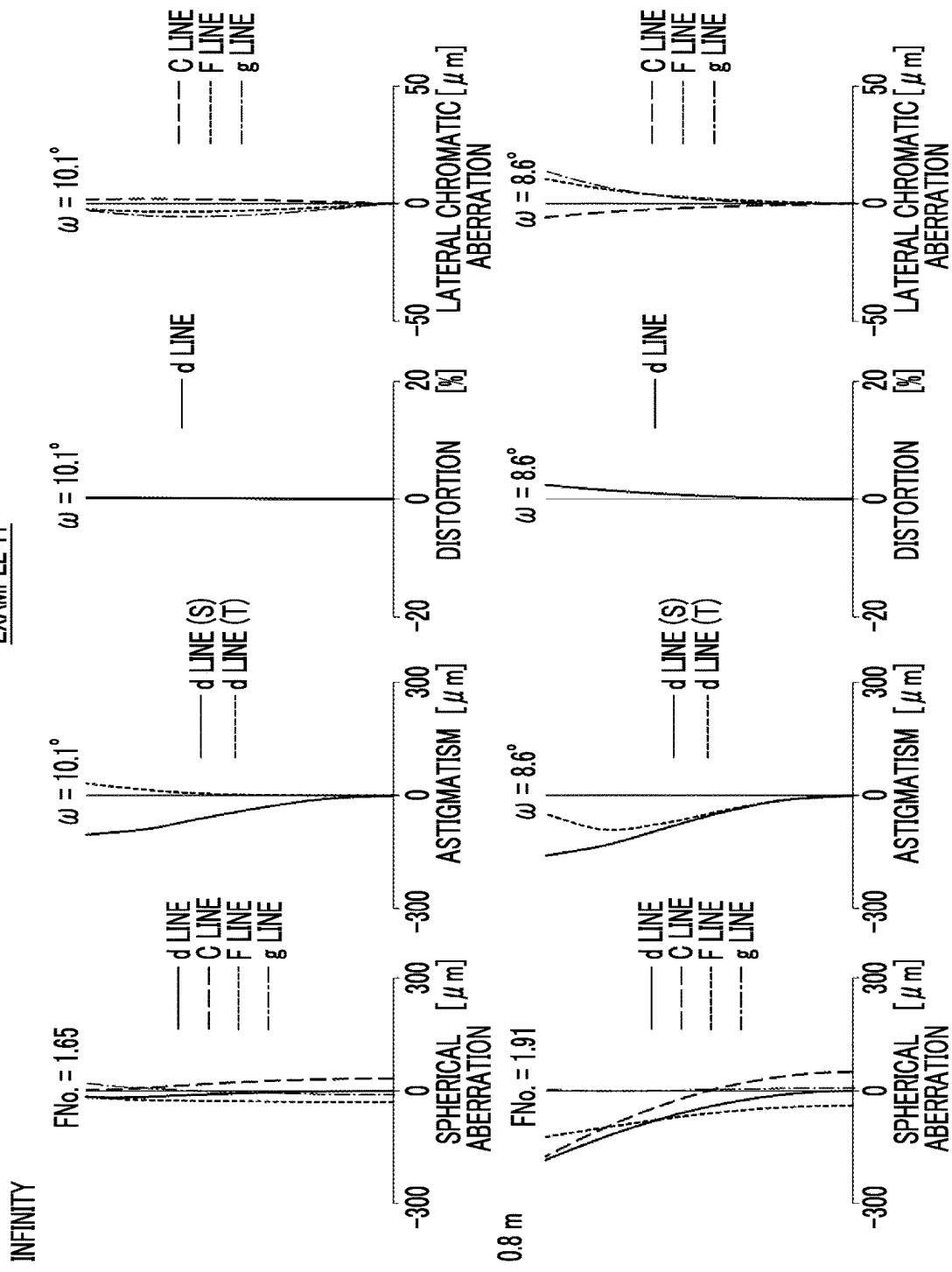
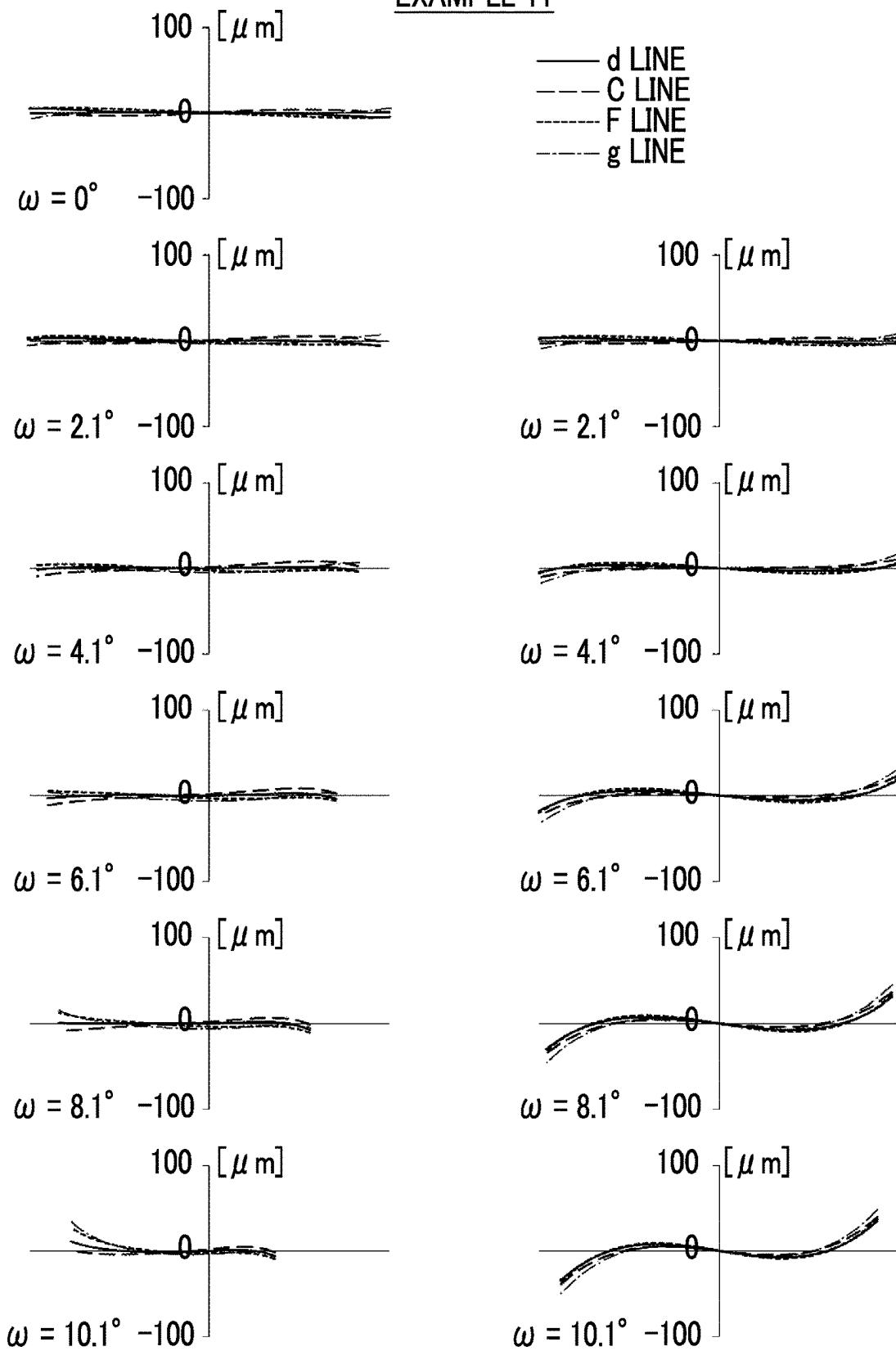
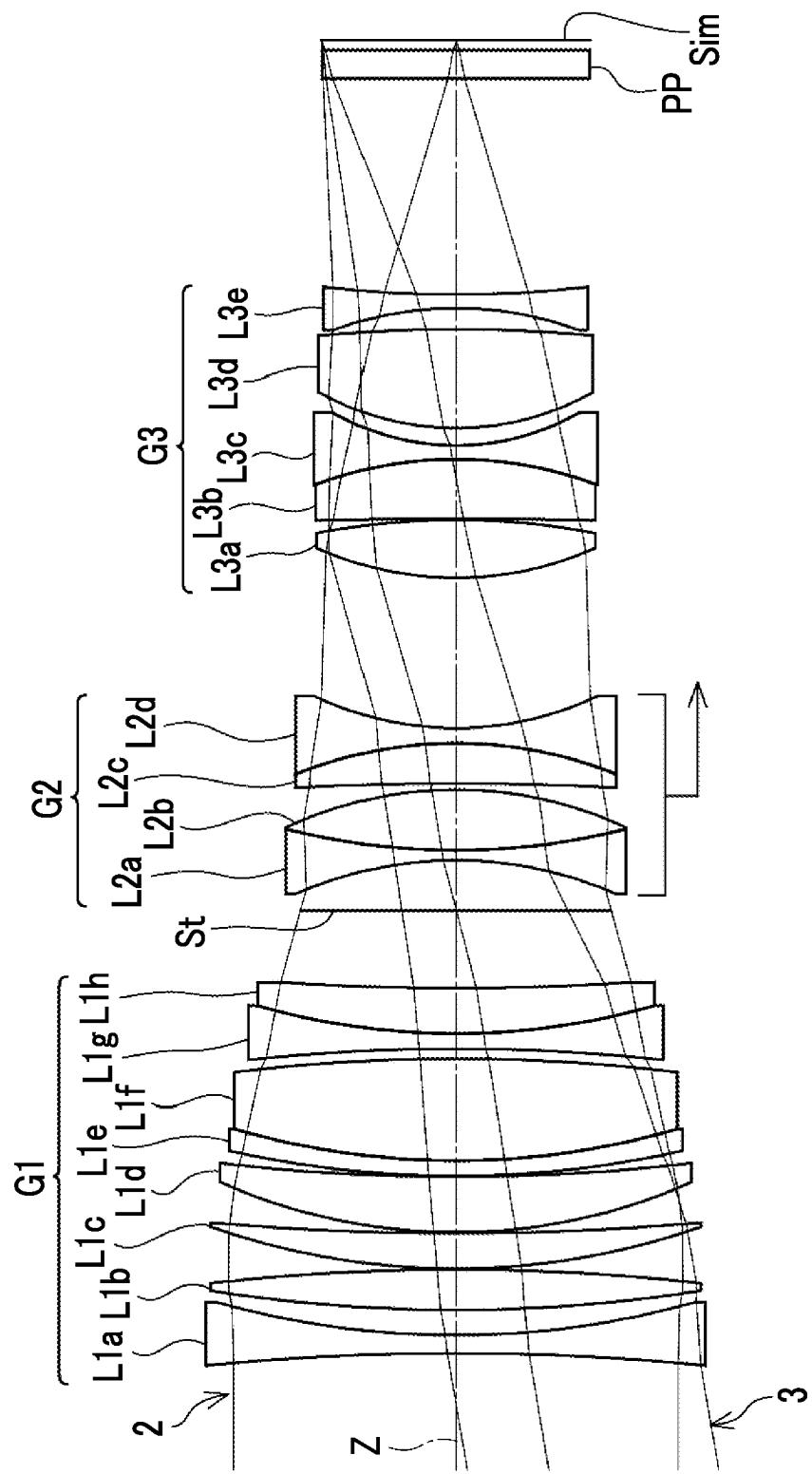
**FIG. 32**EXAMPLE 11

FIG. 33

EXAMPLE 11

**FIG. 34**  
**EXAMPLE 12**



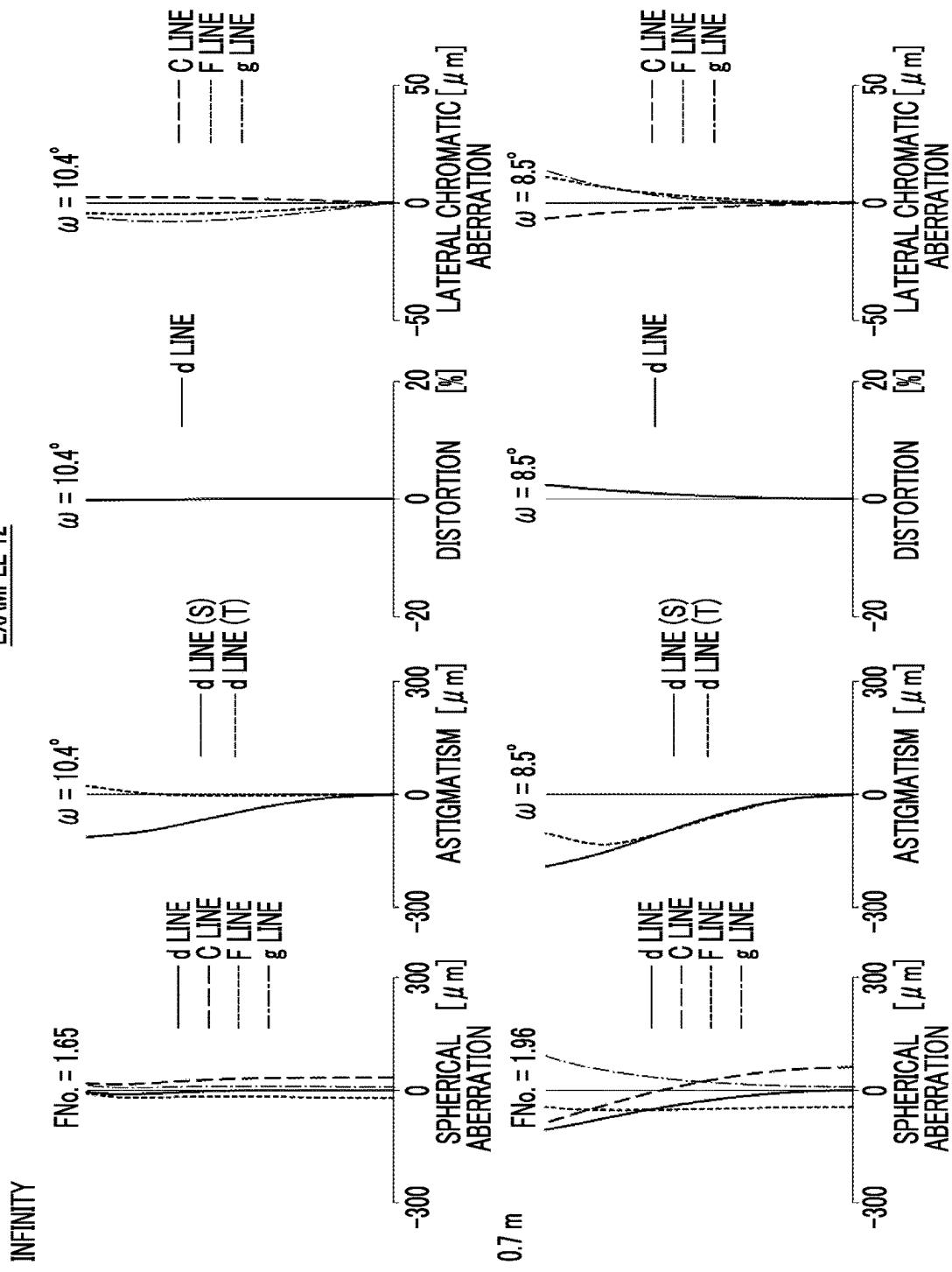
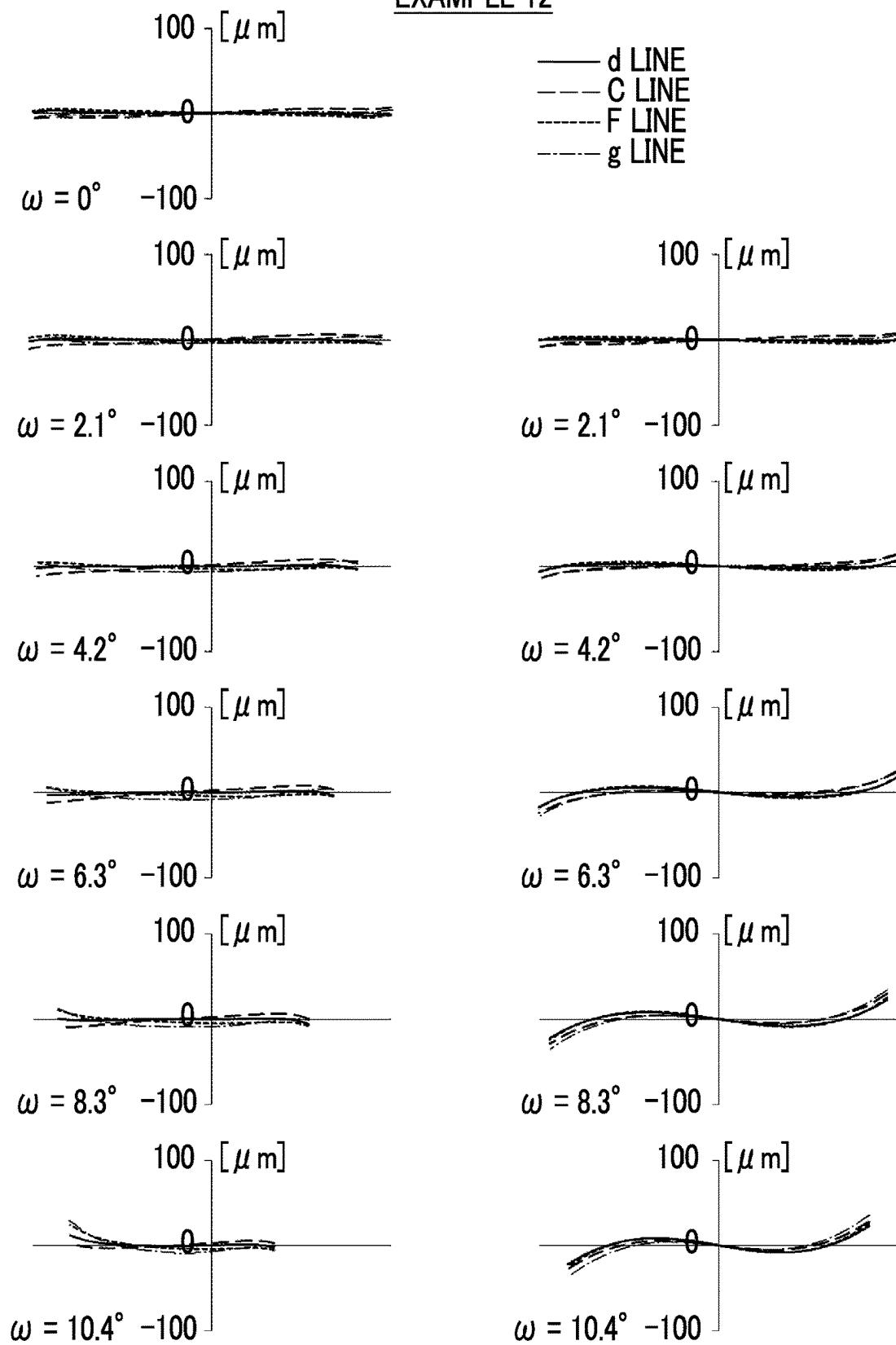
**FIG. 35**EXAMPLE 12

FIG. 36

EXAMPLE 12

**FIG. 37**  
**EXAMPLE 13**

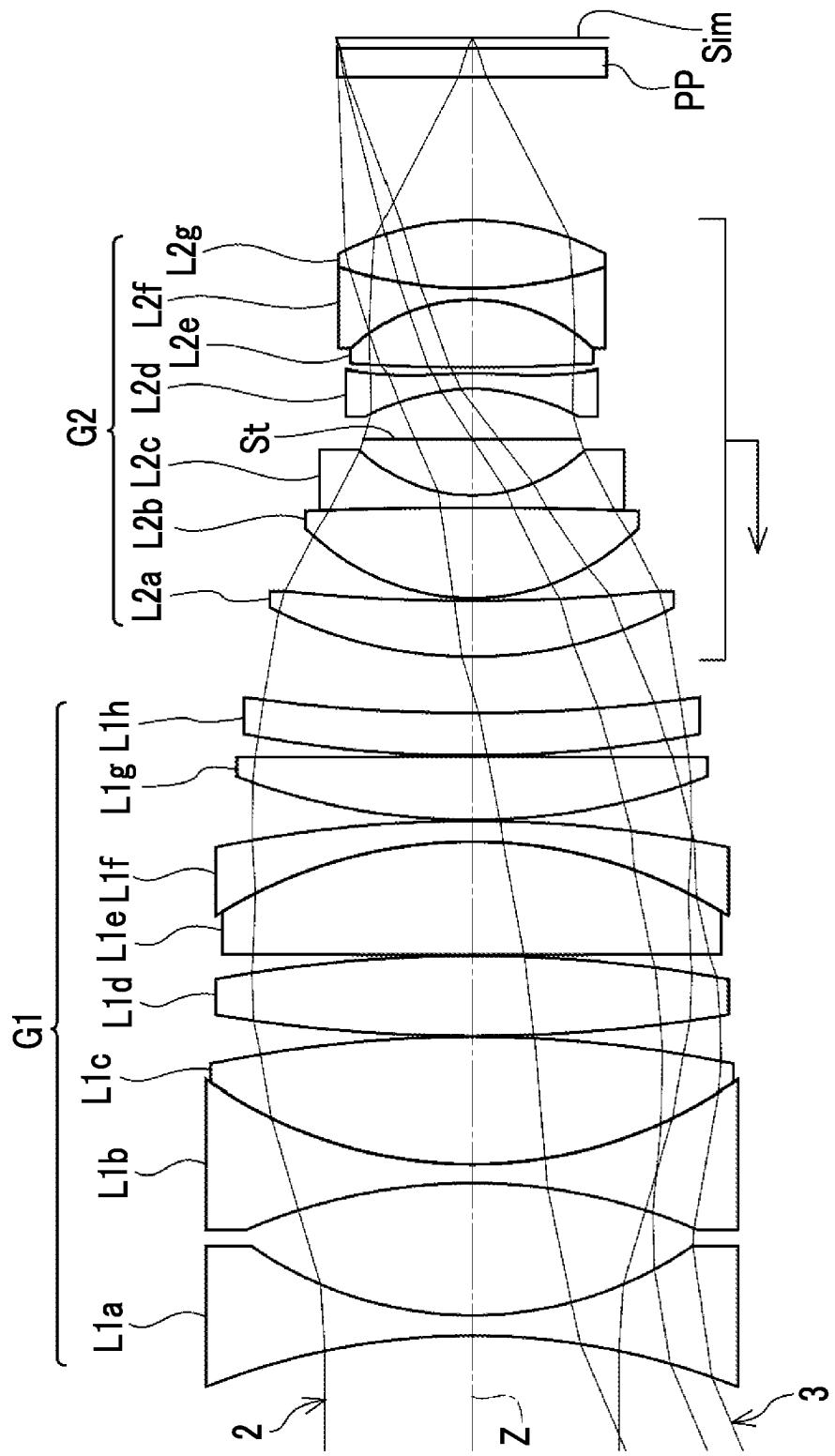


FIG. 38

**EXAMPLE 13**

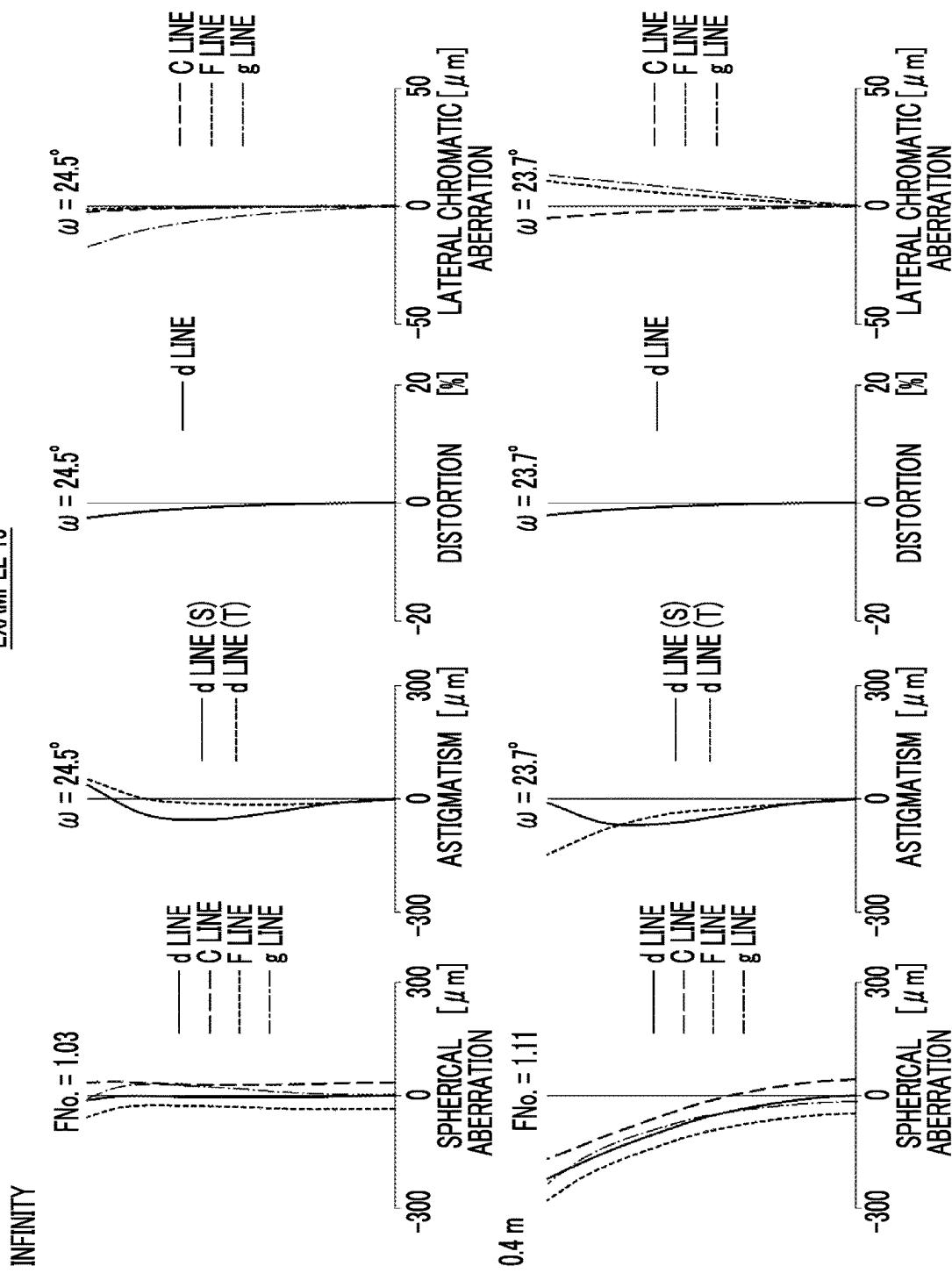
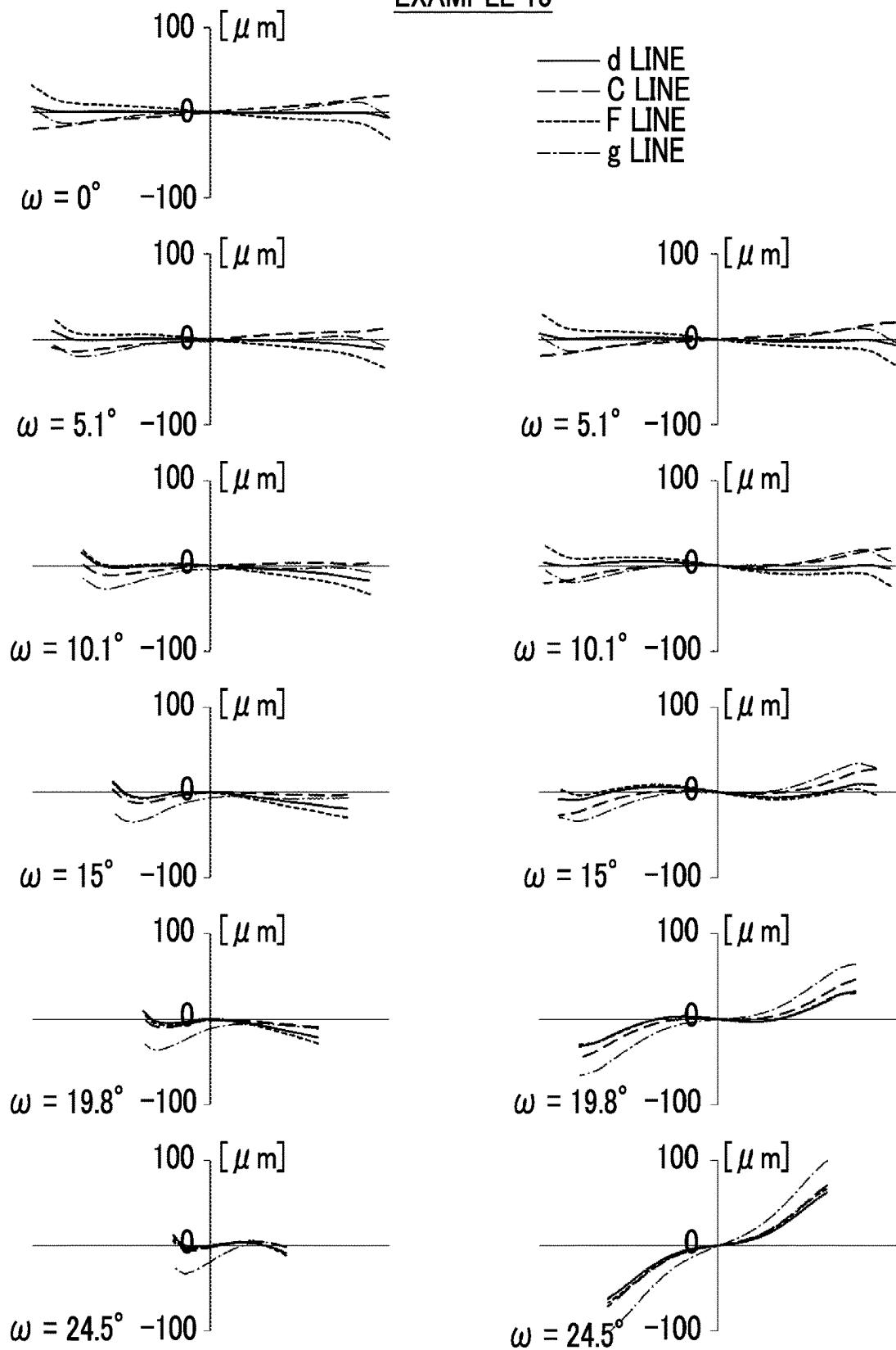
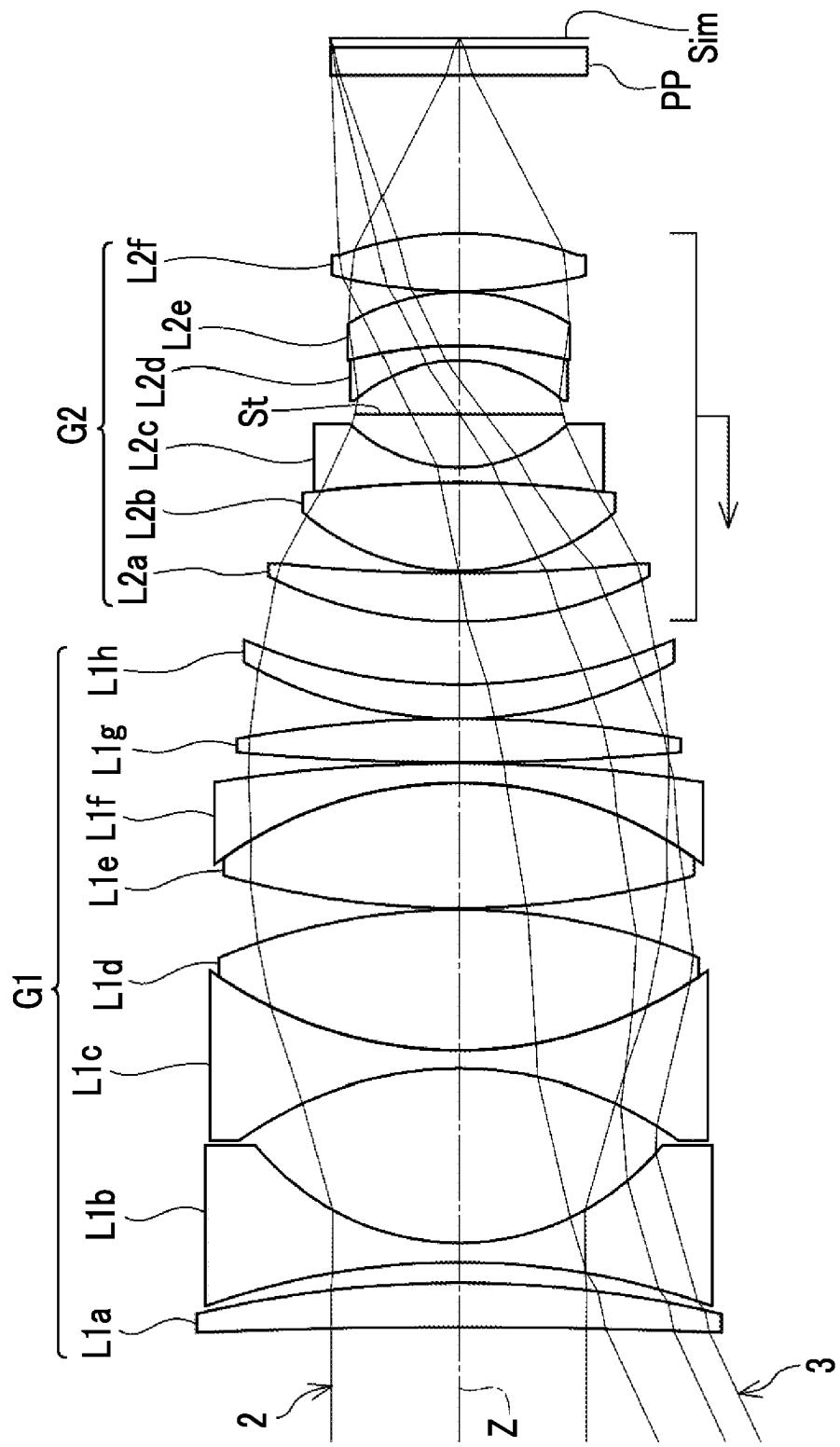


FIG. 39

EXAMPLE 13

**FIG. 40**  
**EXAMPLE 14**



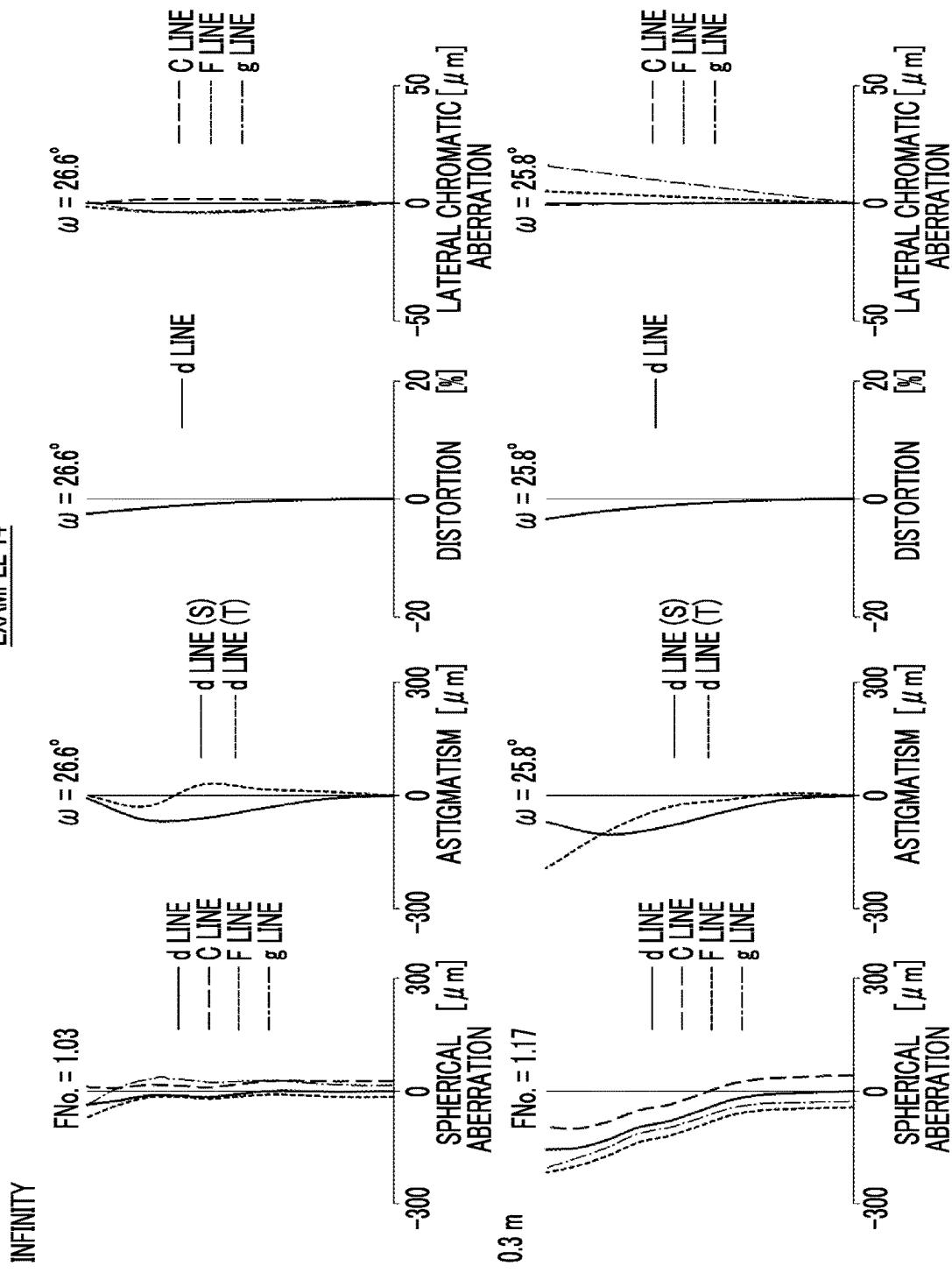
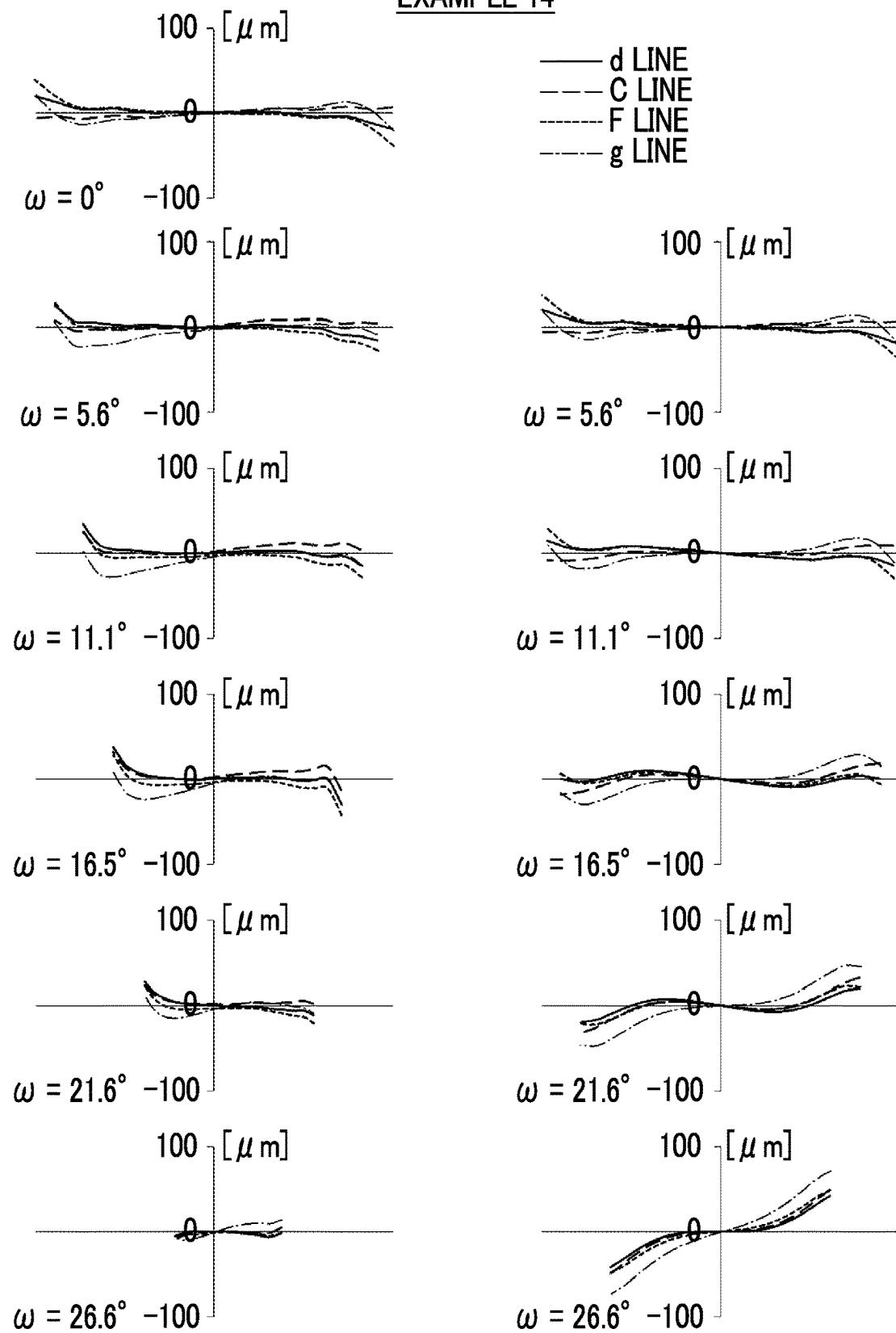
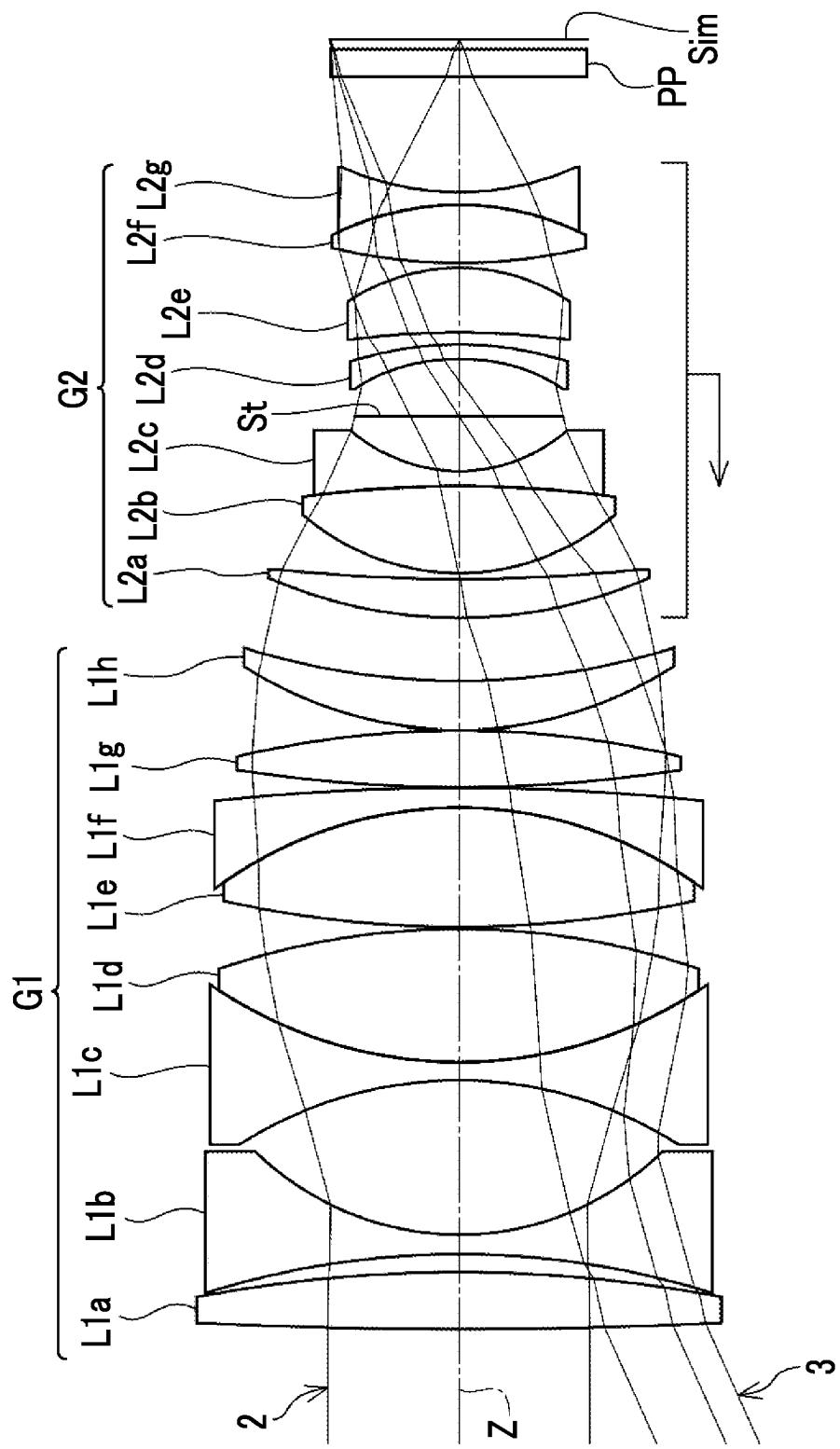
**FIG. 41**EXAMPLE 14

FIG. 42

EXAMPLE 14

**FIG. 43**  
**EXAMPLE 15**



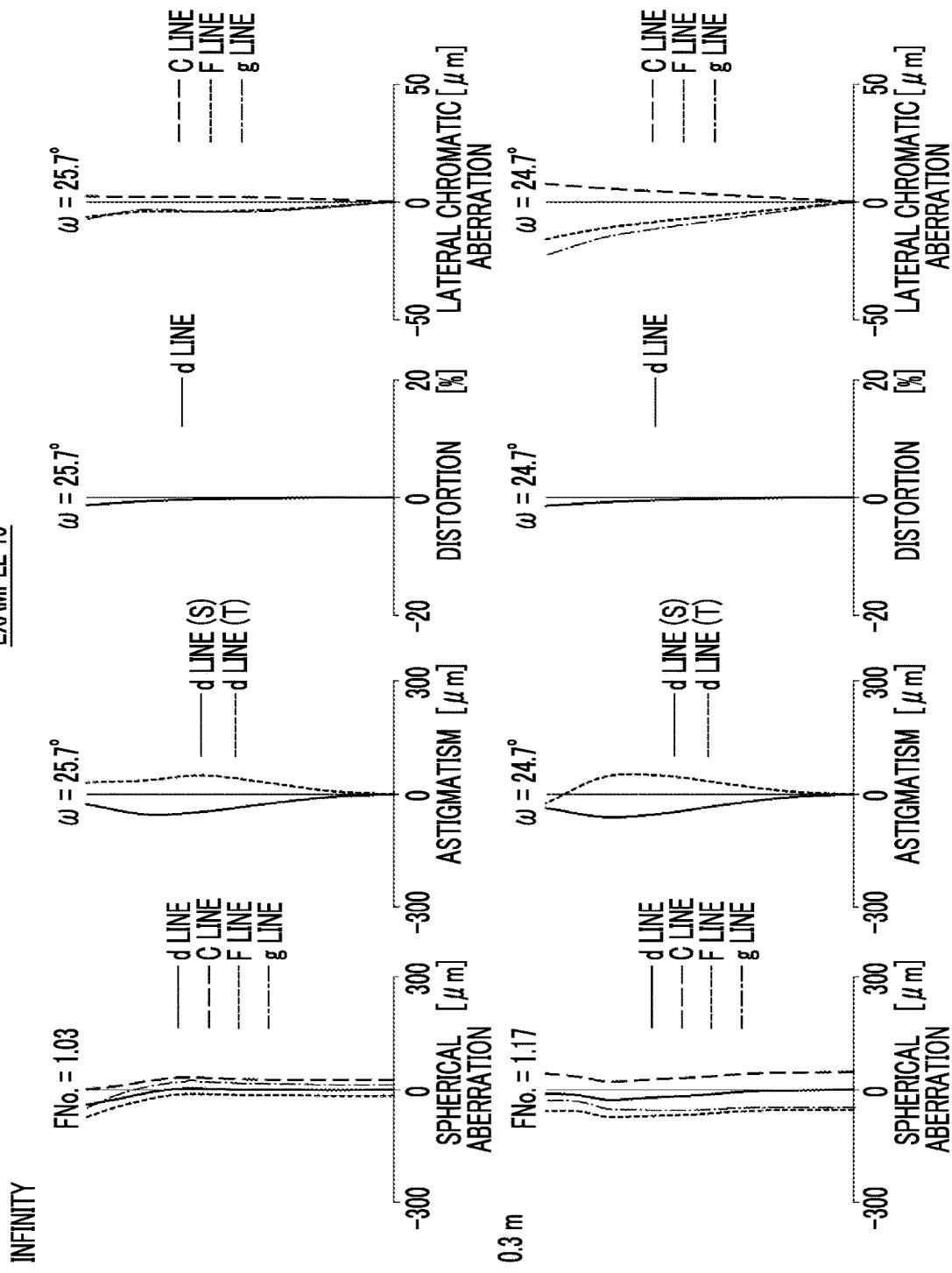
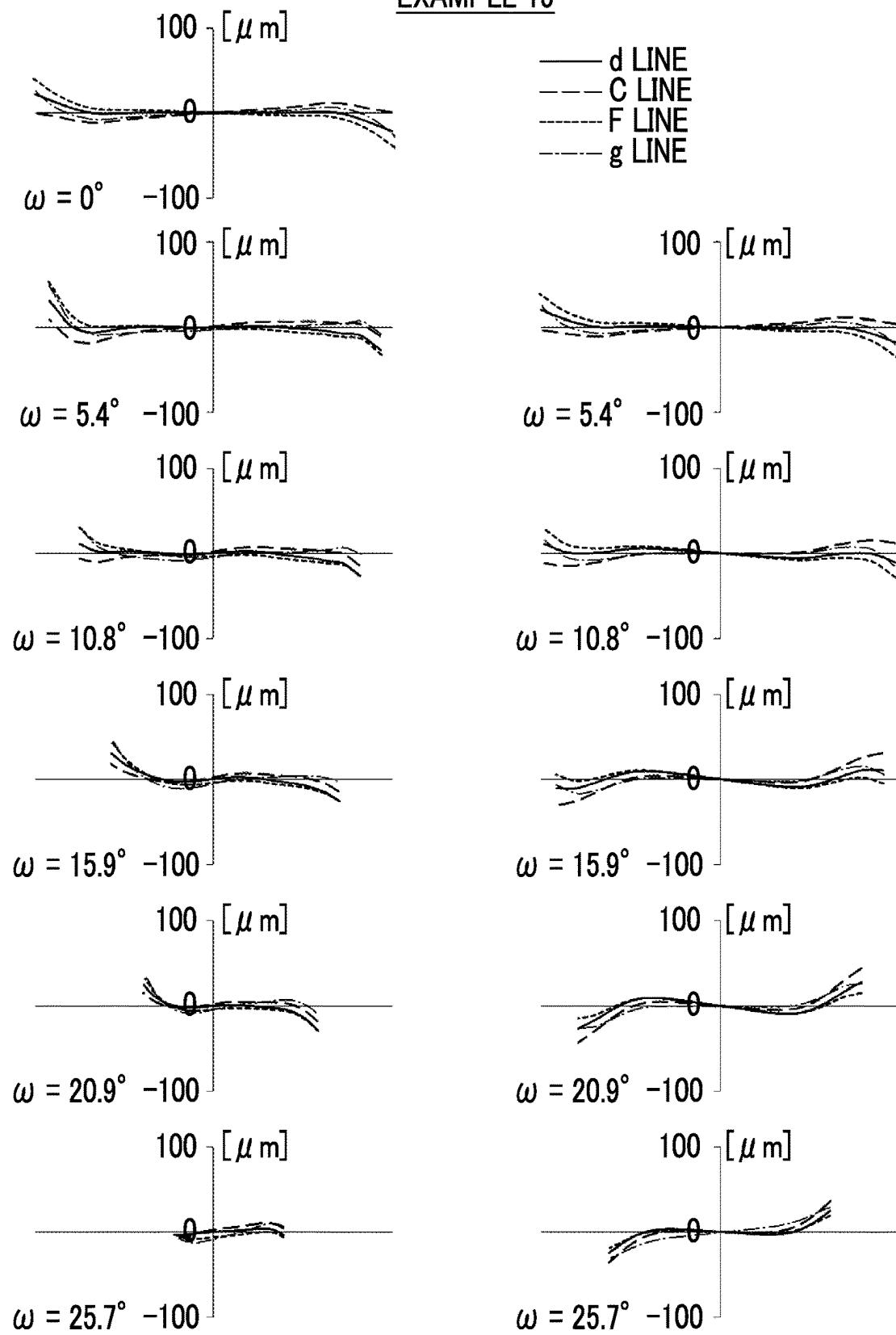
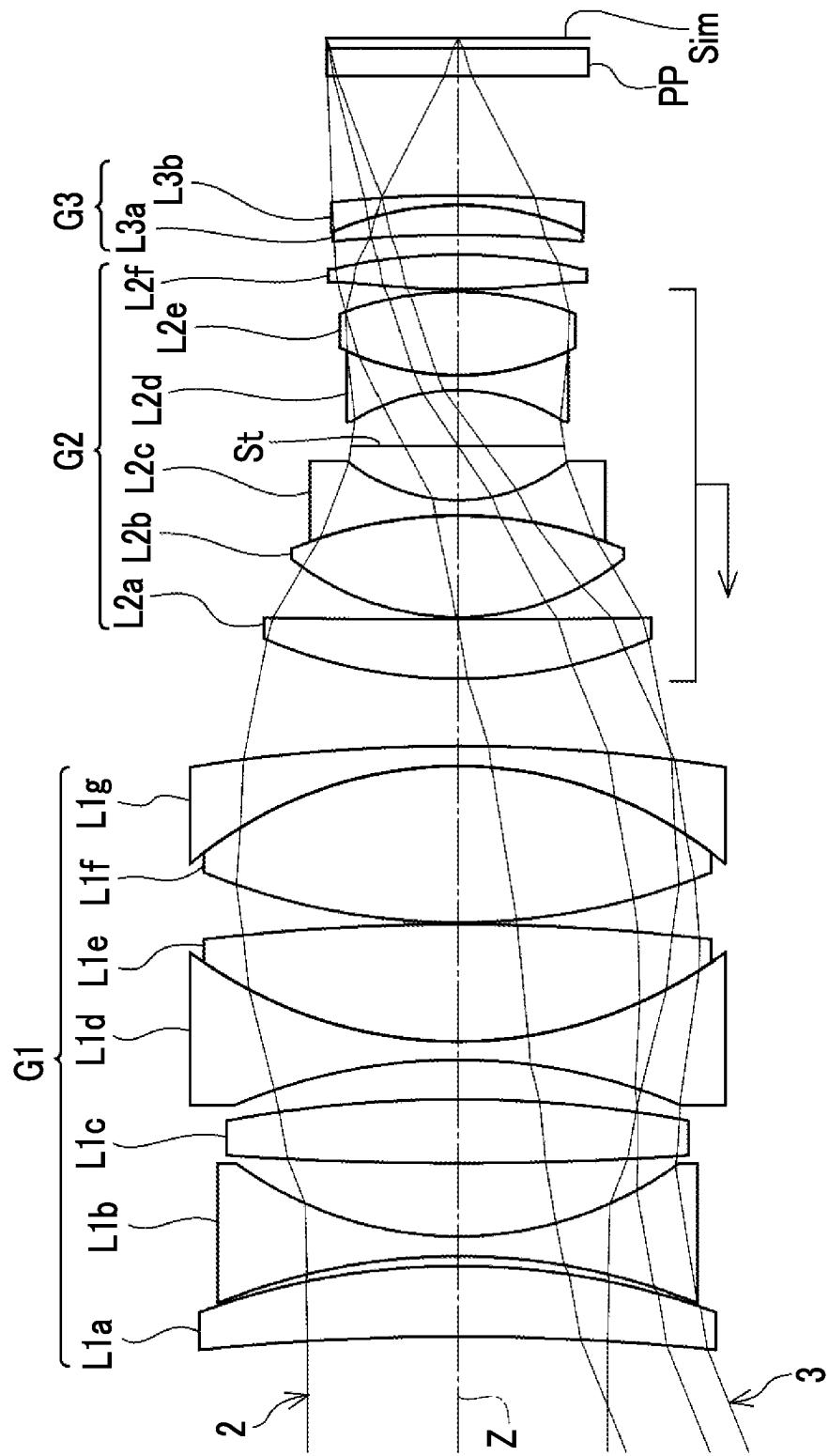
**FIG. 44****EXAMPLE 15**

FIG. 45

EXAMPLE 15

**FIG. 46**  
**EXAMPLE 16**



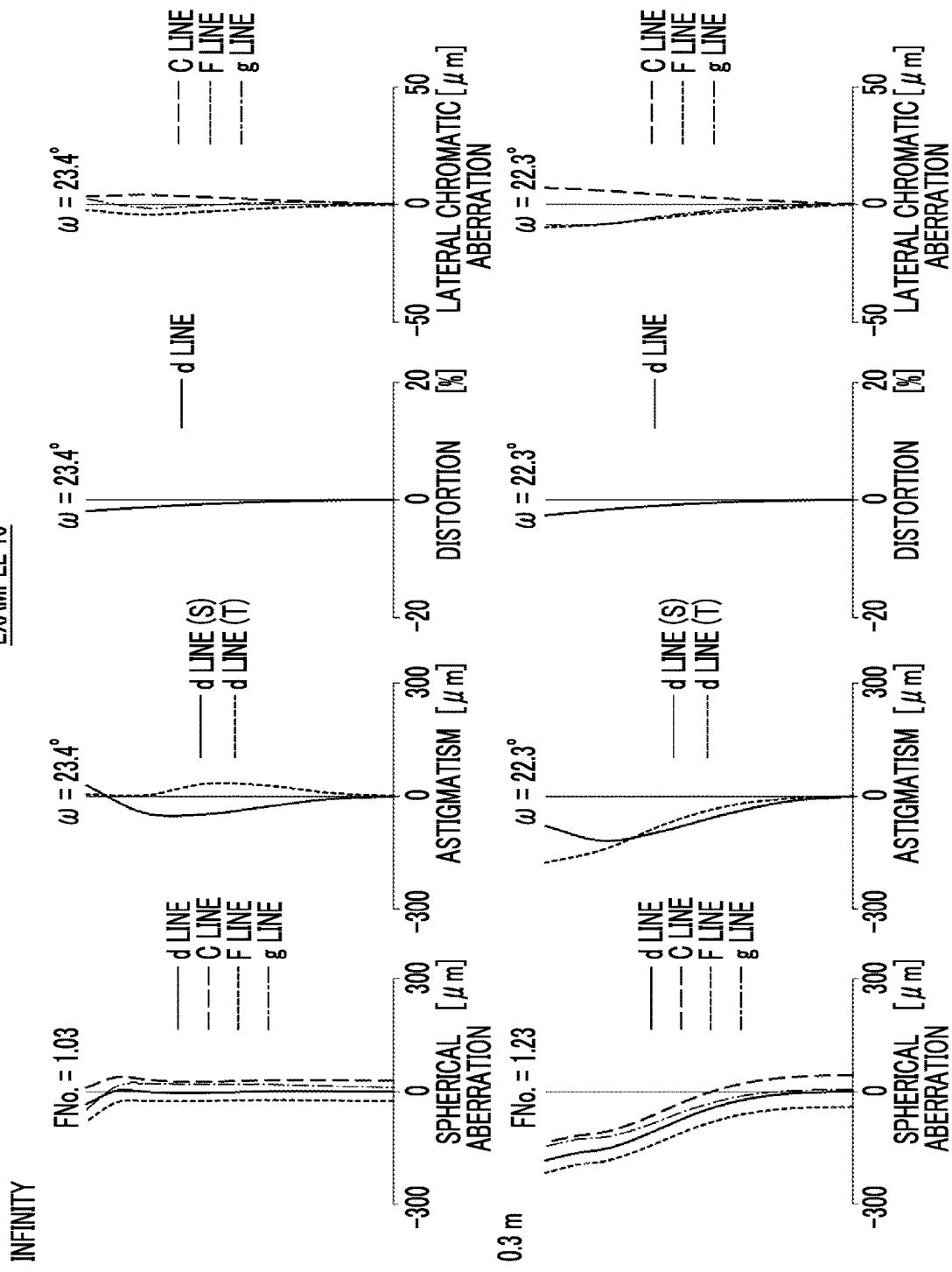
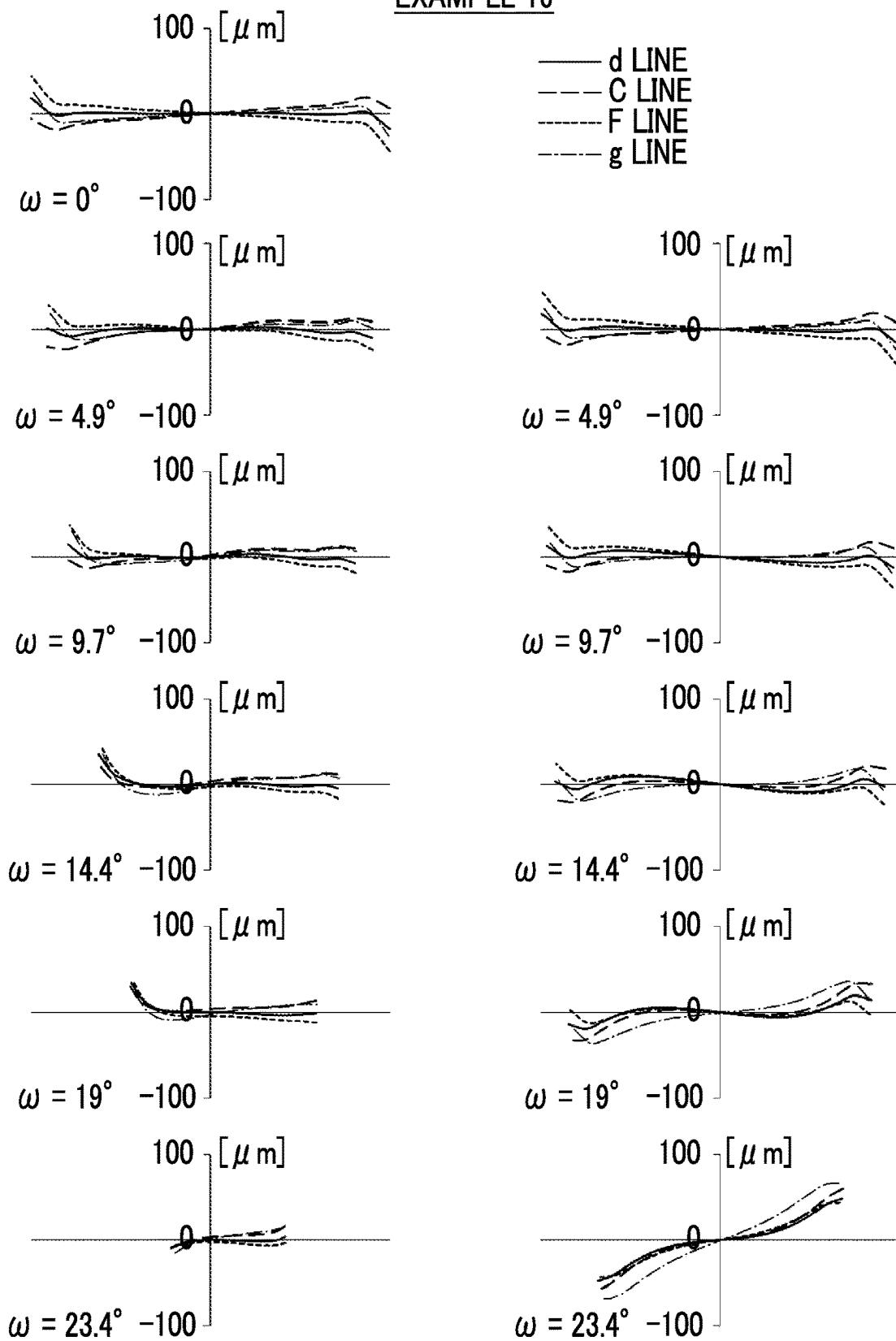
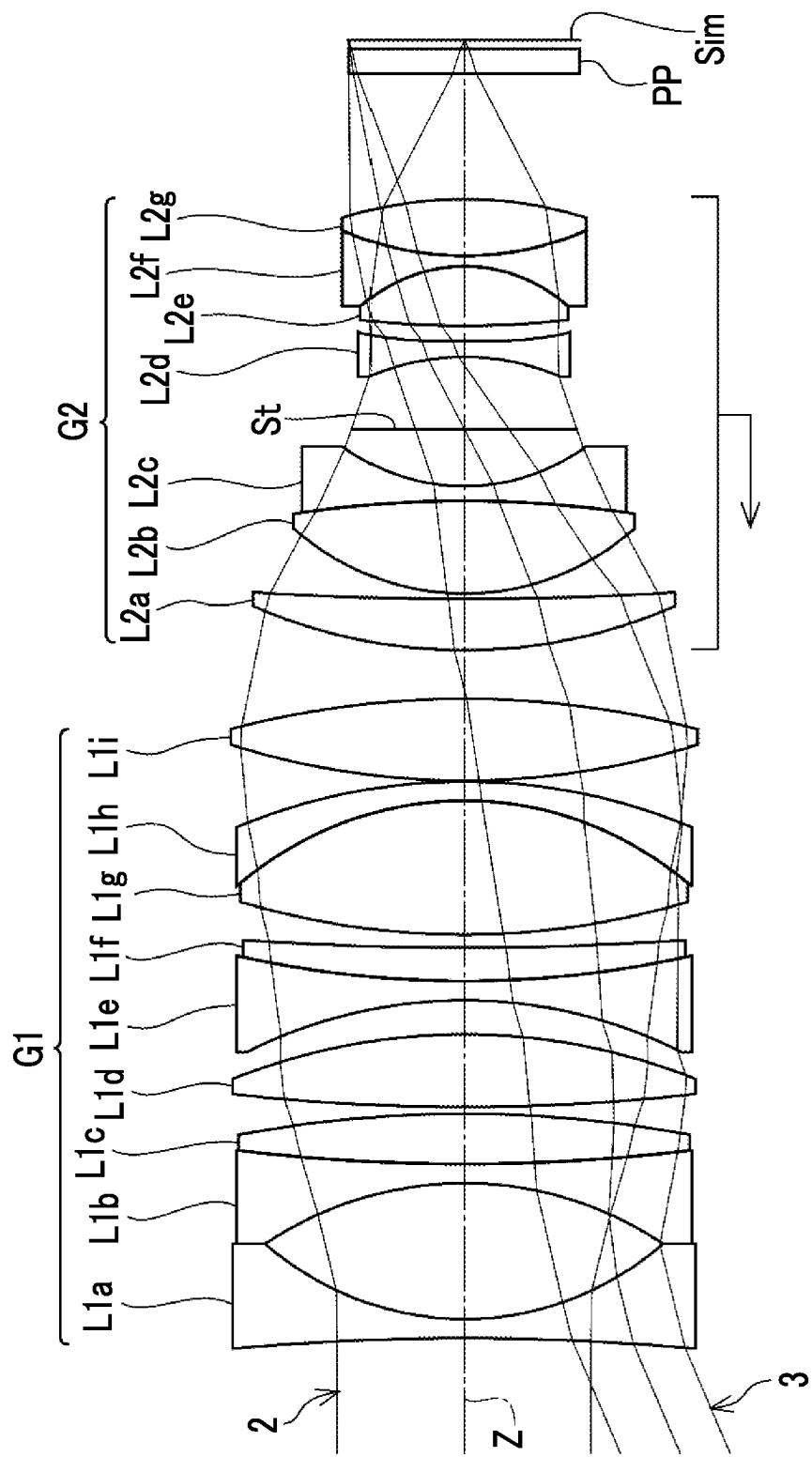
**FIG. 47****EXAMPLE 16**

FIG. 48

EXAMPLE 16

**FIG. 49**  
**EXAMPLE 17**



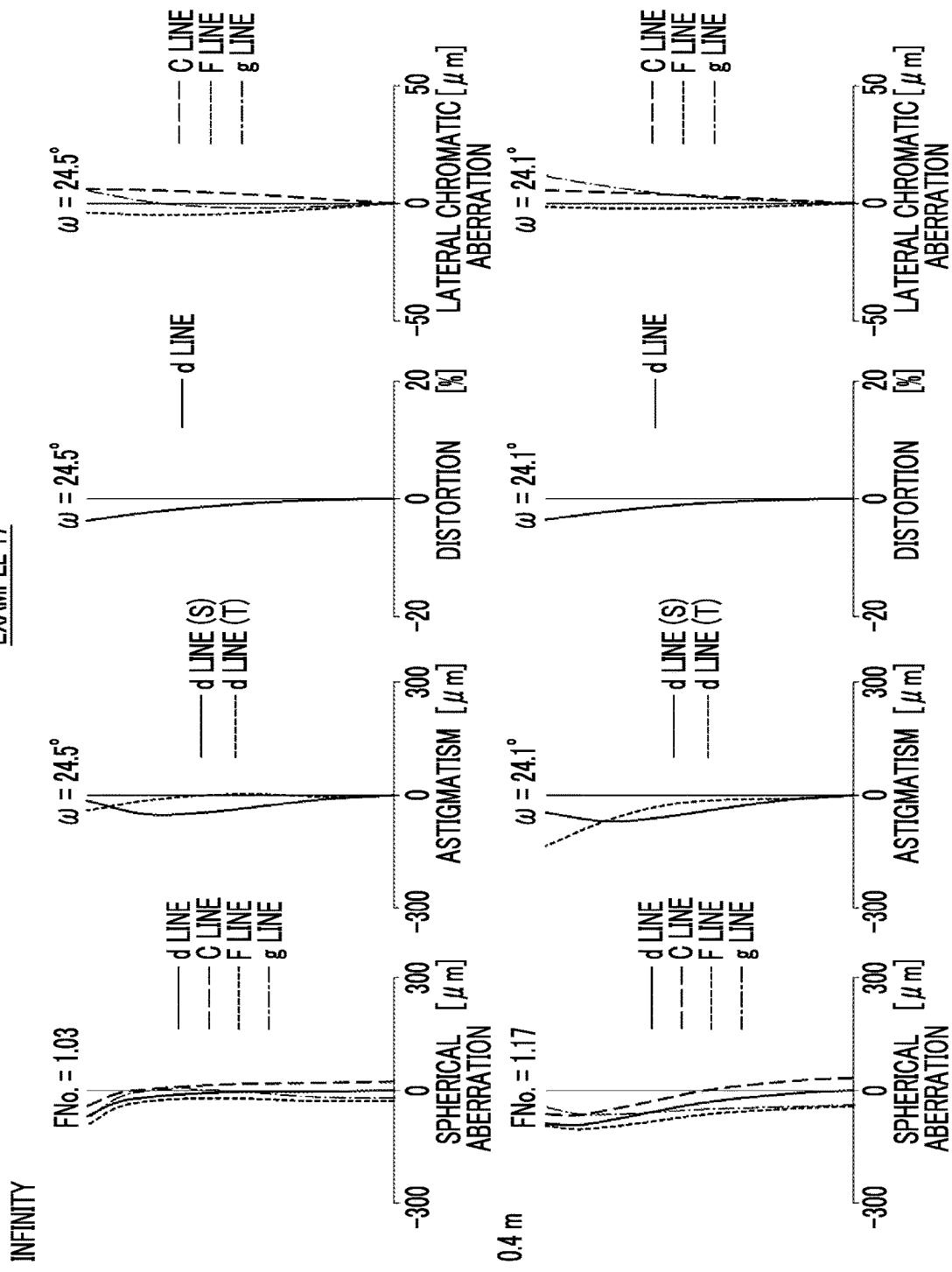
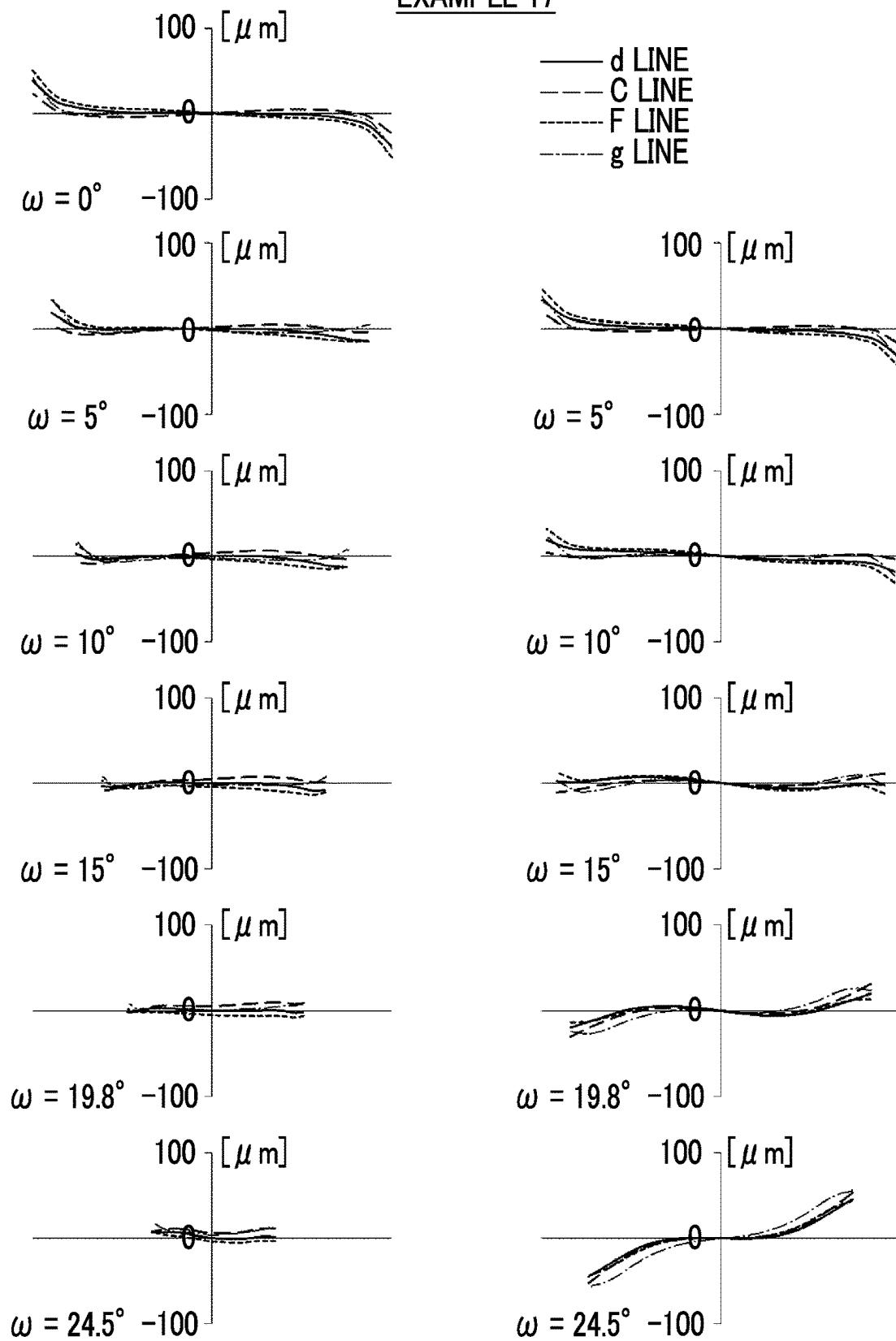
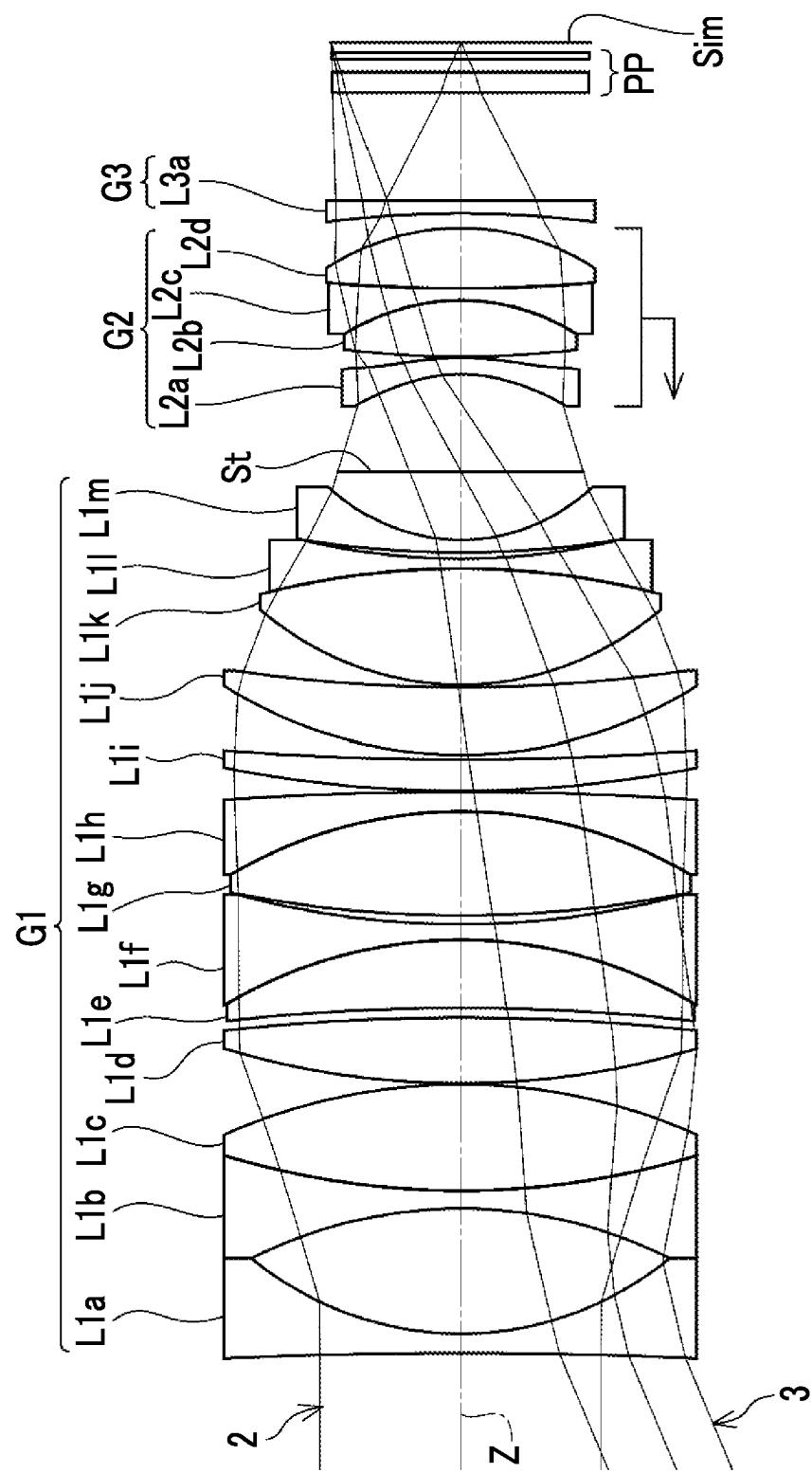
**FIG. 50**EXAMPLE 17

FIG. 51

EXAMPLE 17

**FIG. 52**  
EXAMPLE 18



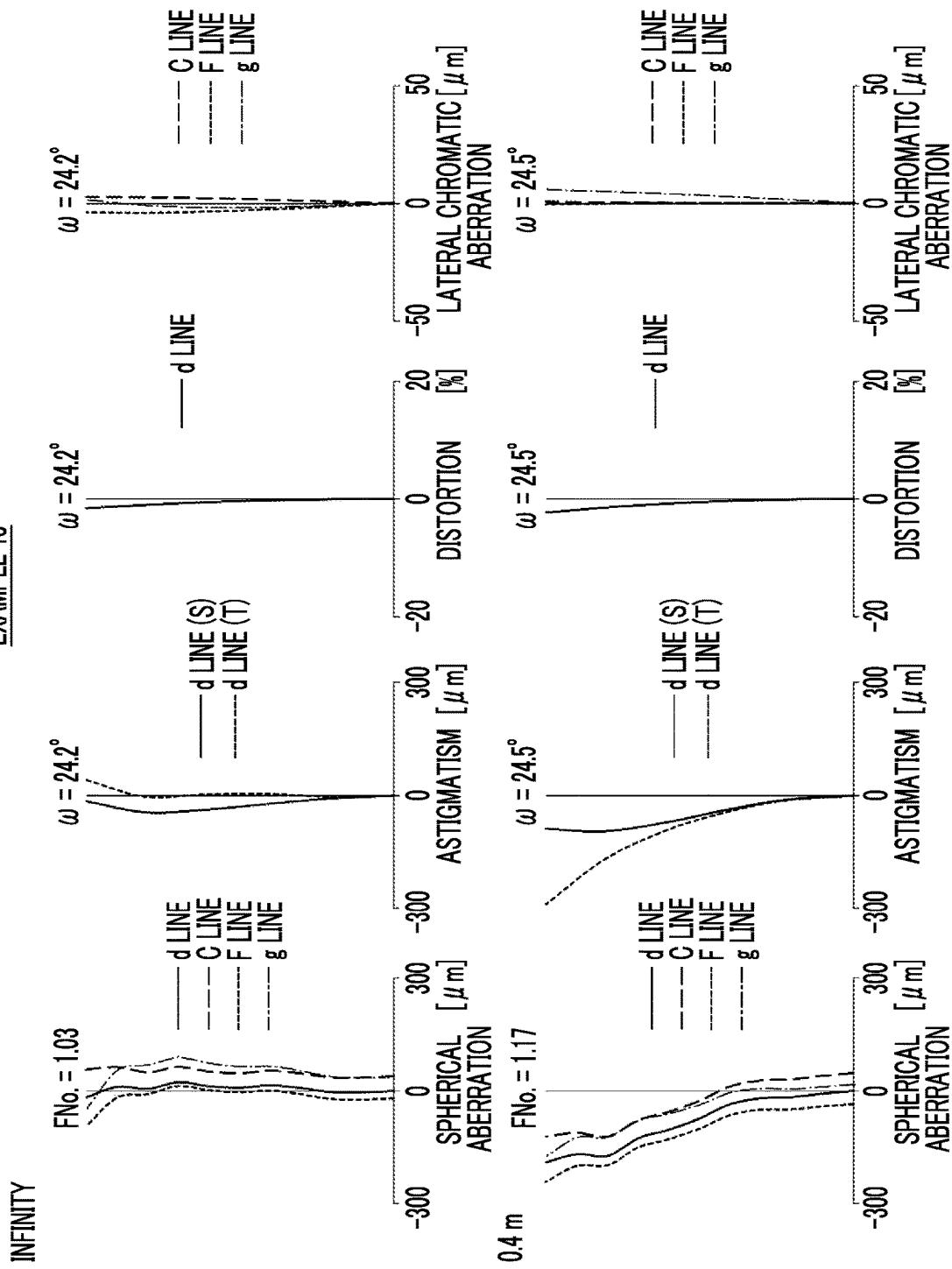
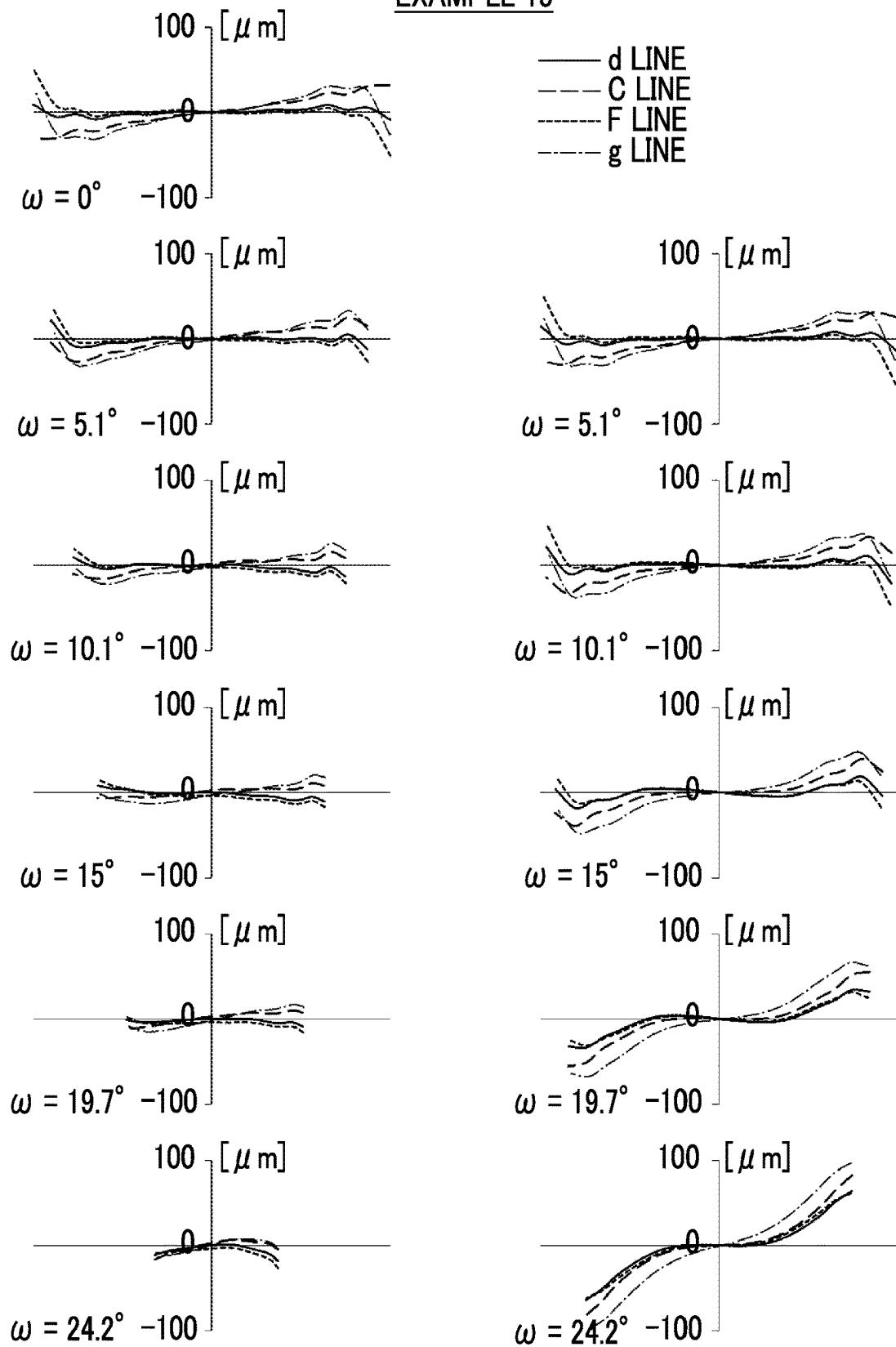
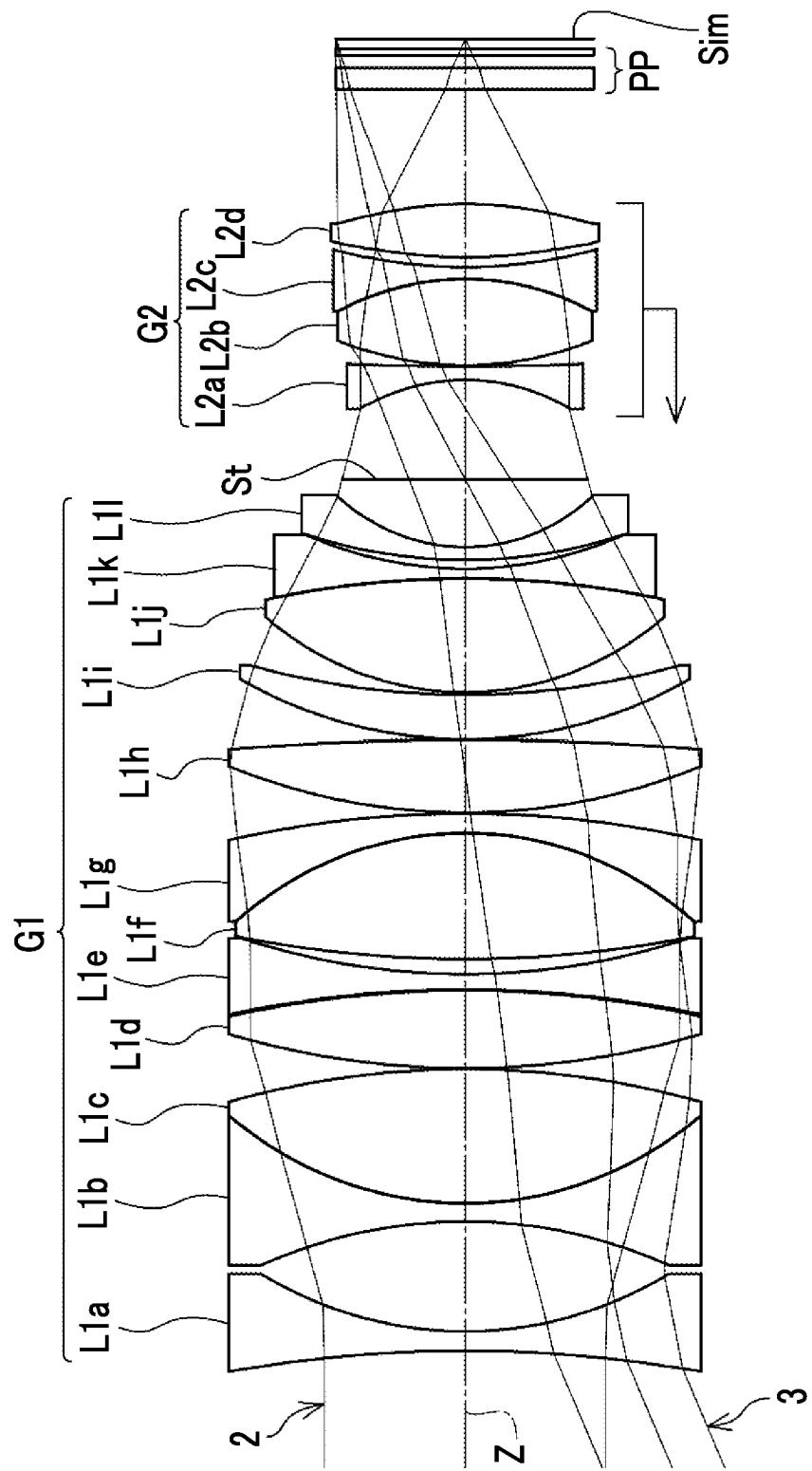
**FIG. 53**EXAMPLE 18

FIG. 54

EXAMPLE 18

**FIG. 55**  
EXAMPLE 19



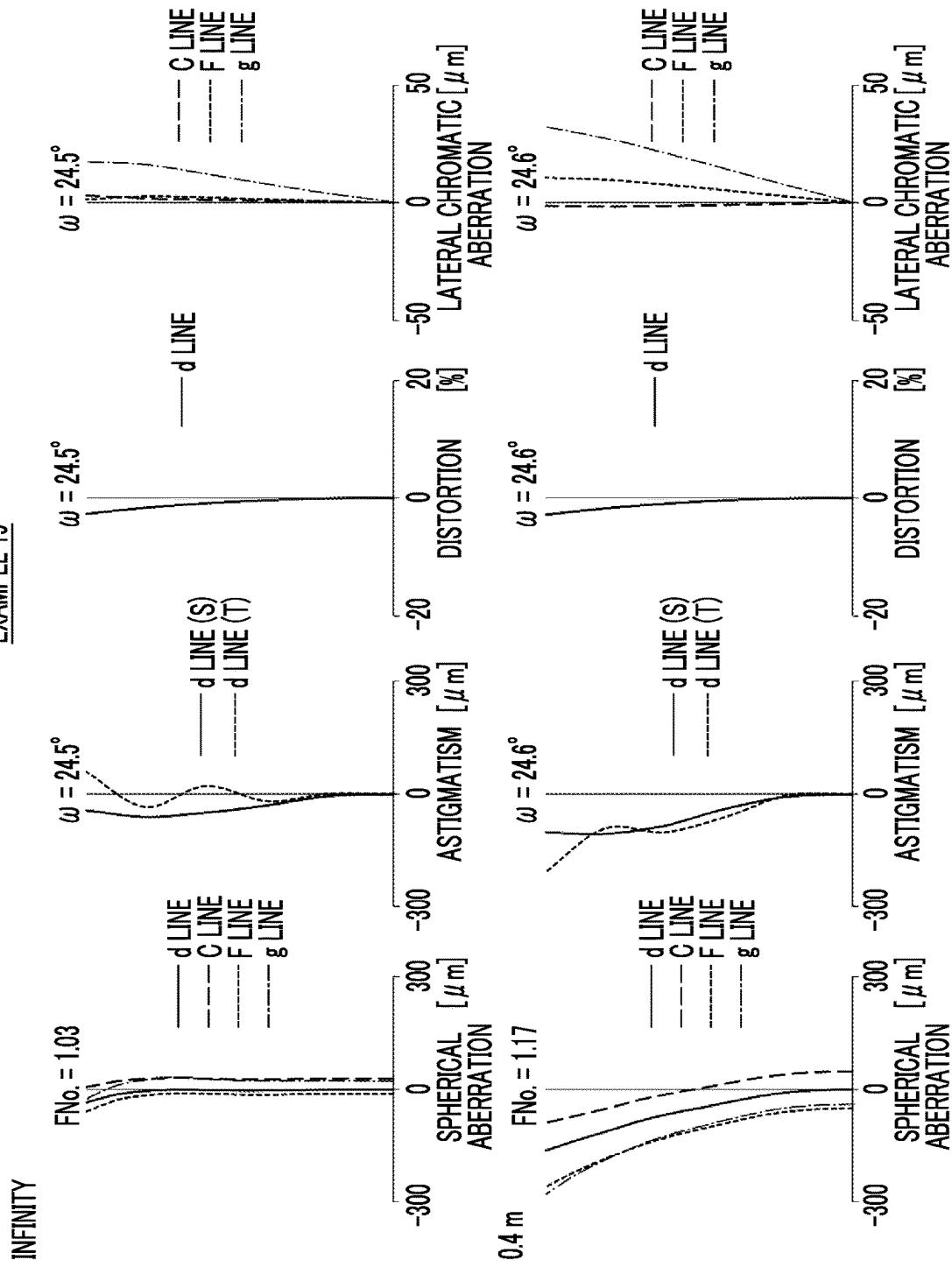
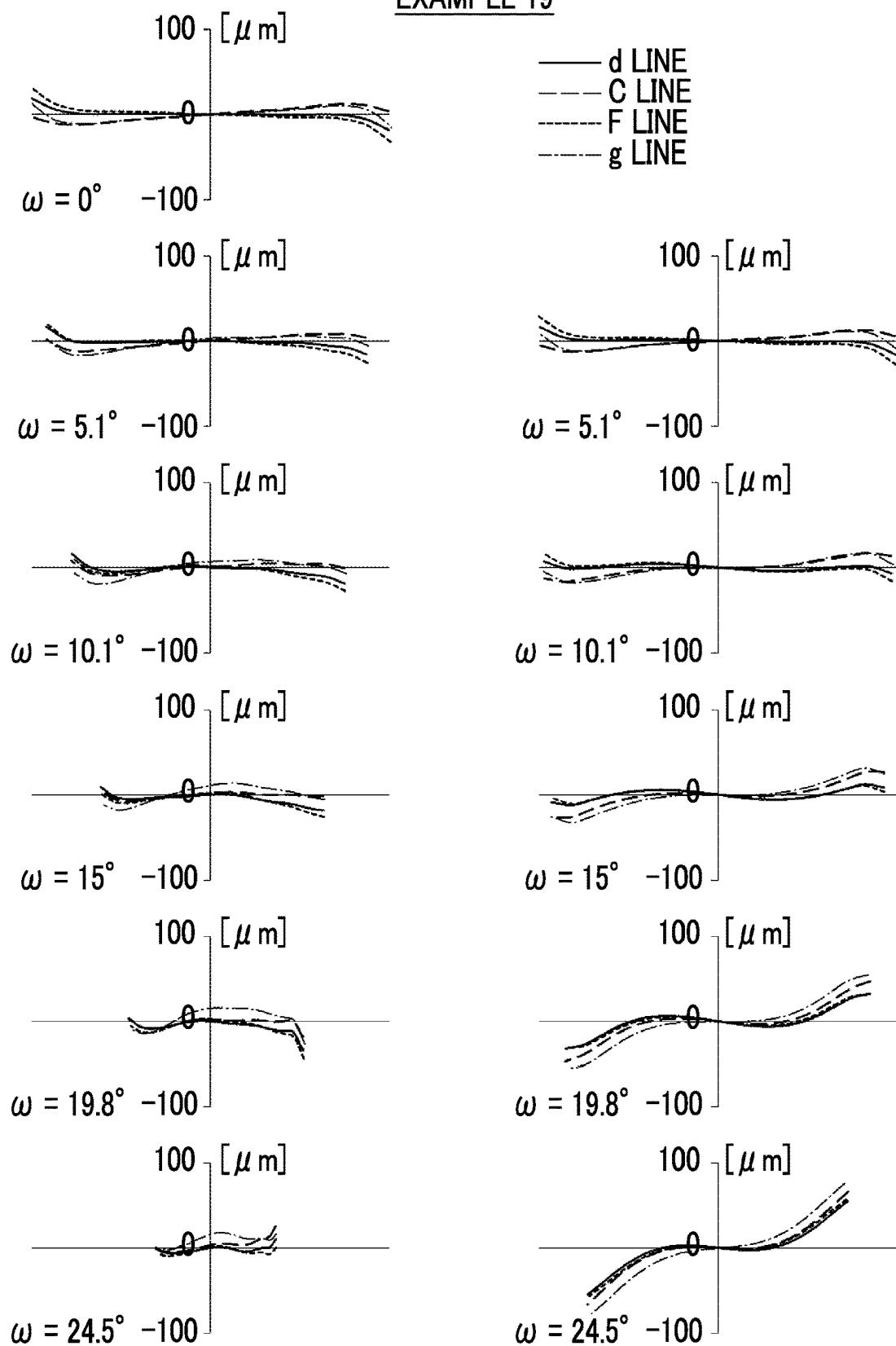
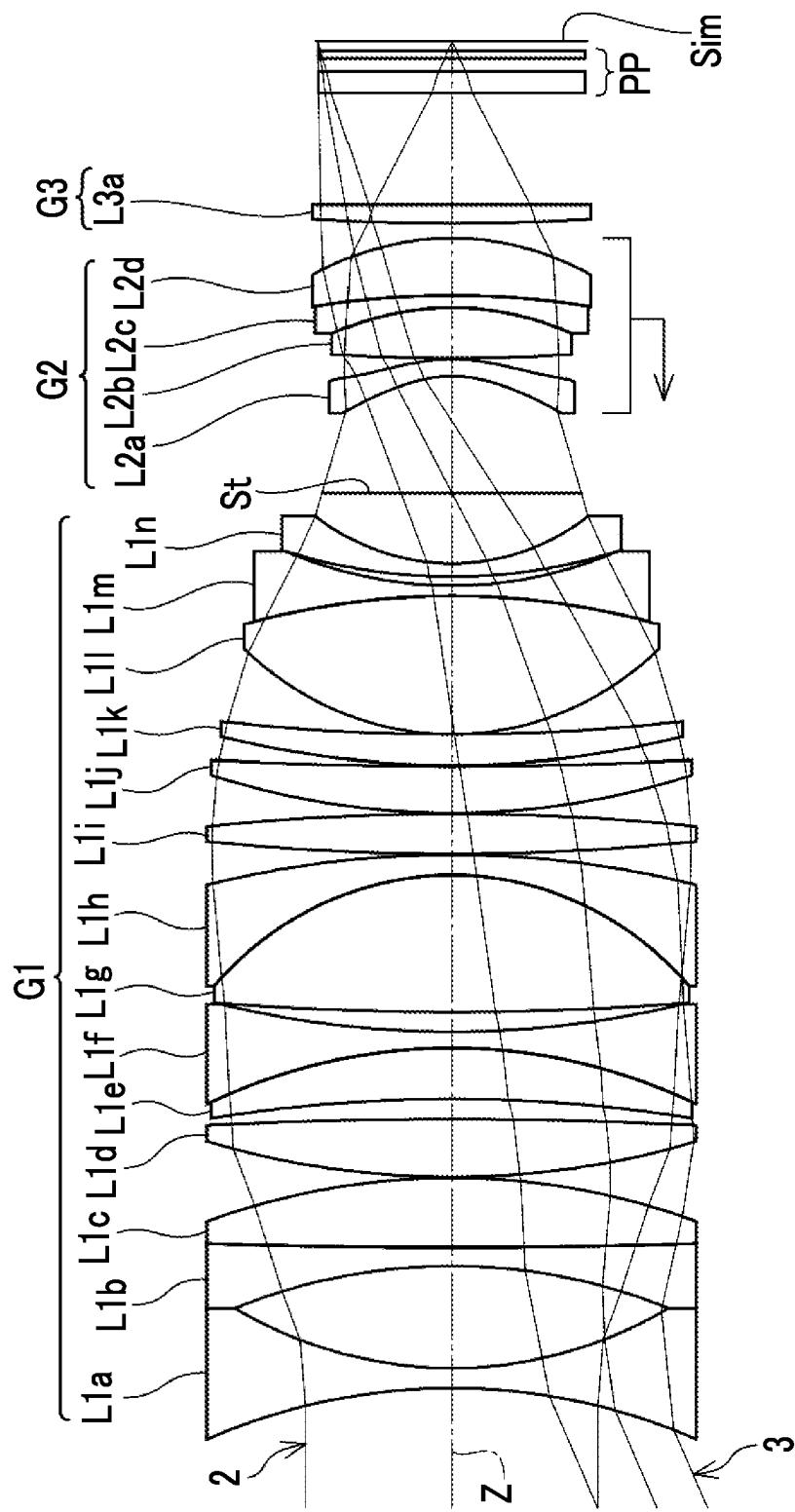
**FIG. 56**EXAMPLE 19

FIG. 57

EXAMPLE 19

**FIG. 58**  
**EXAMPLE 20**



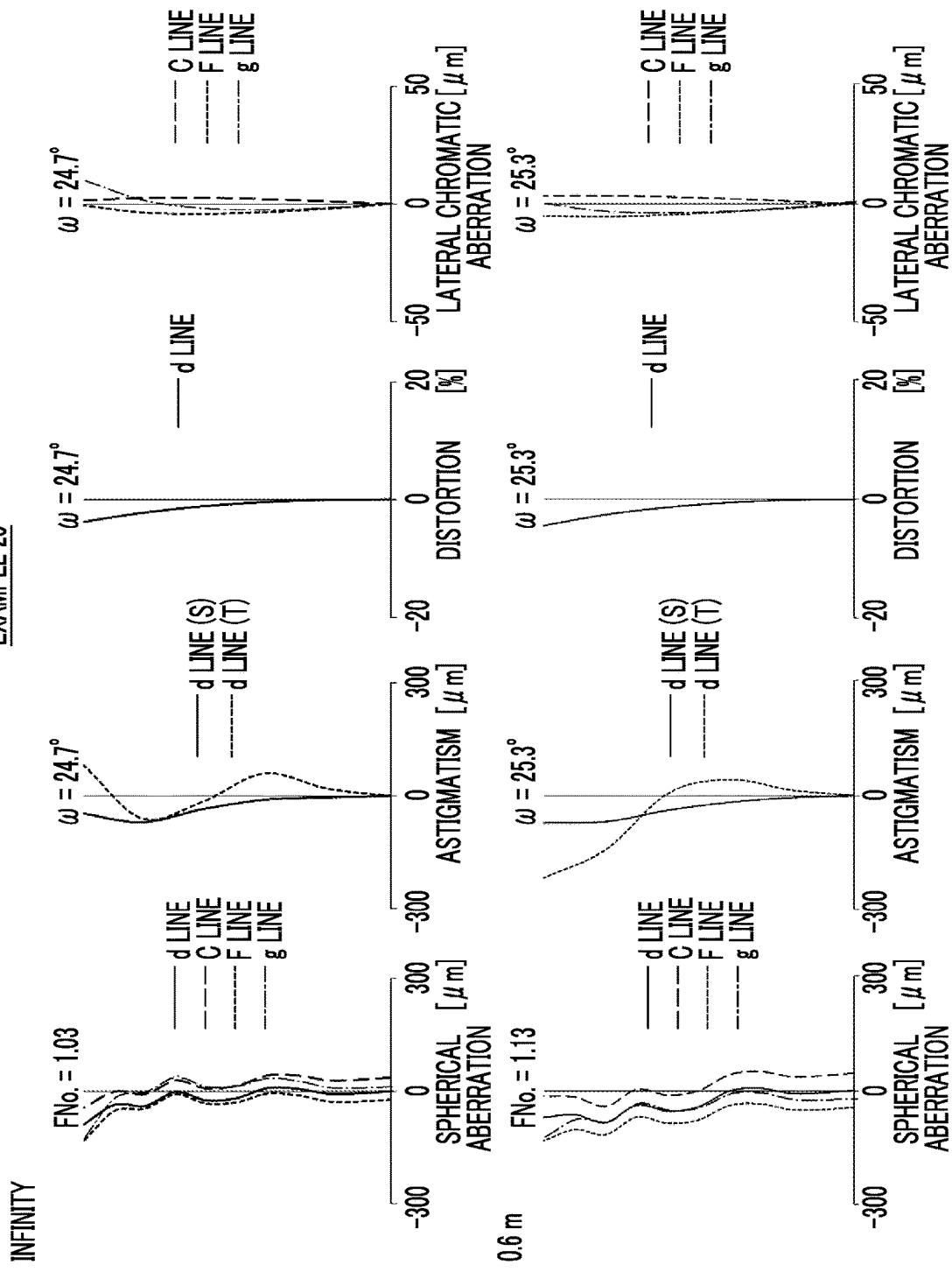
**FIG. 59****EXAMPLE 20**

FIG. 60

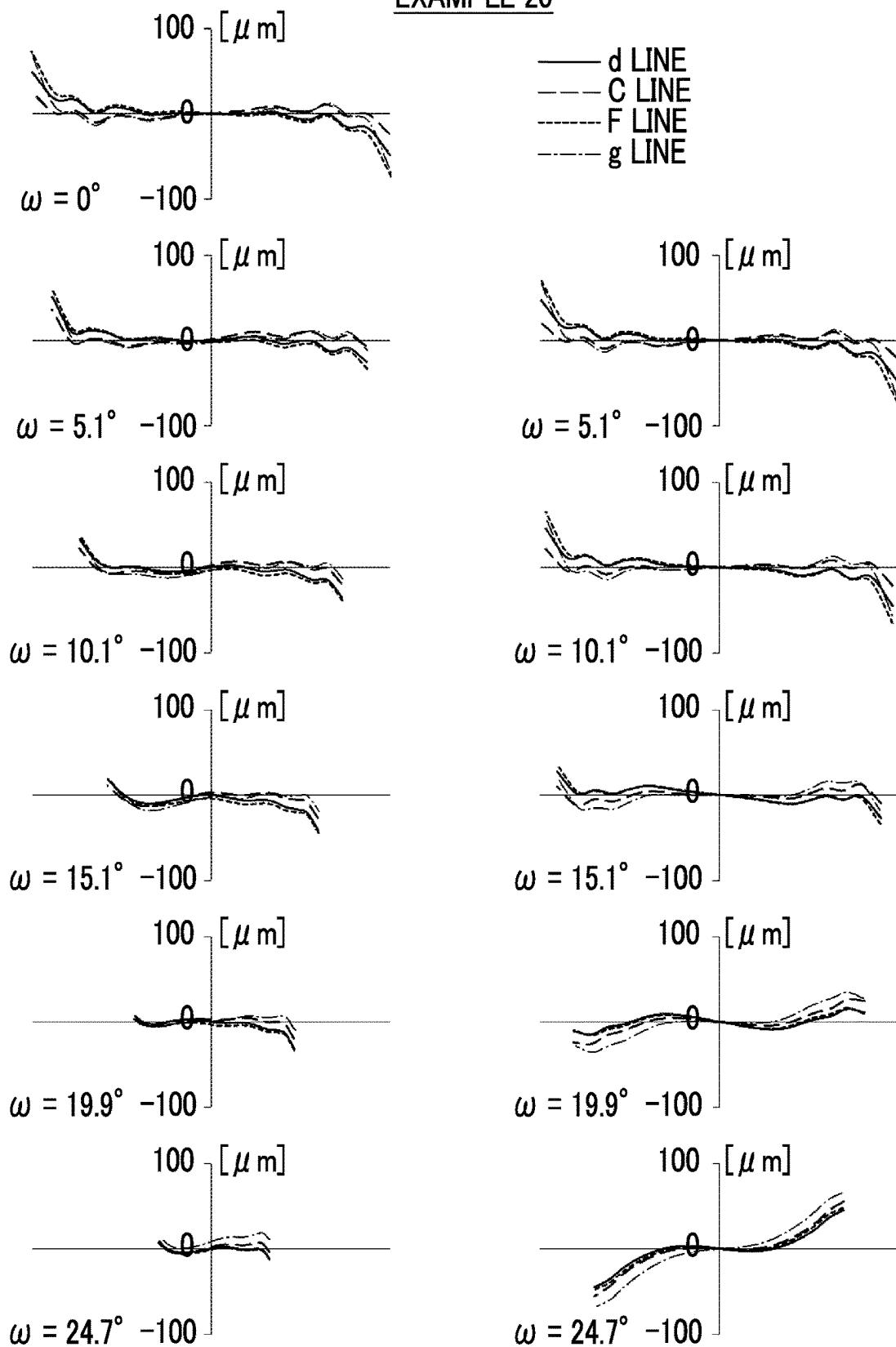
EXAMPLE 20

FIG. 61

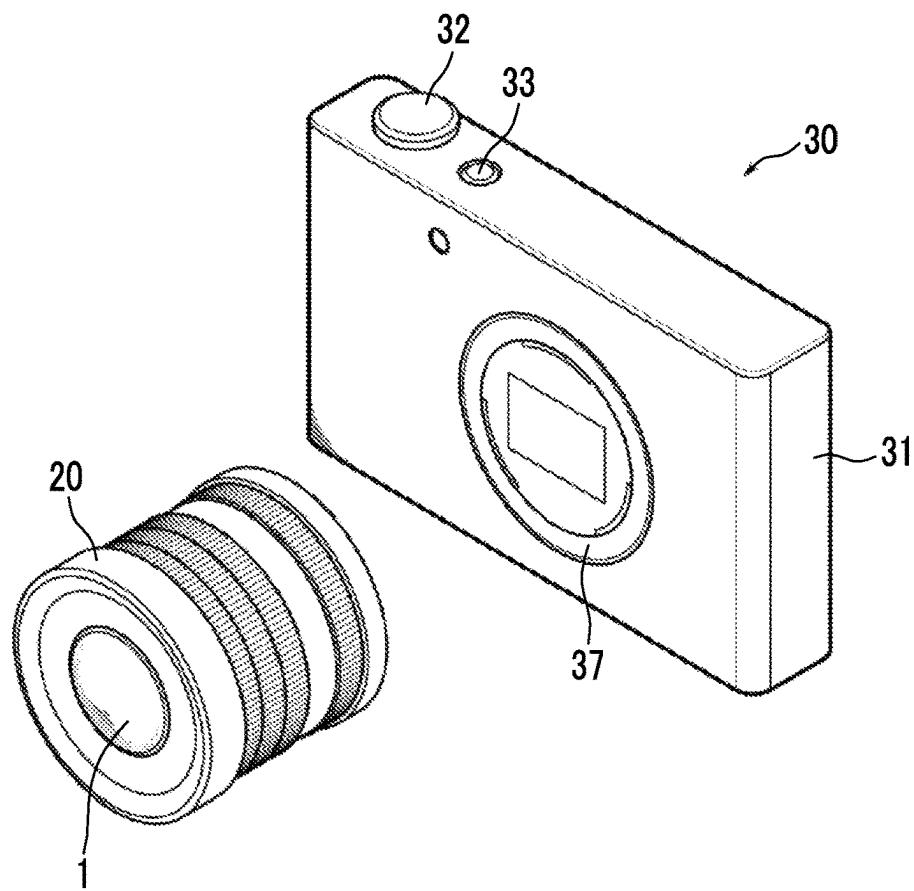
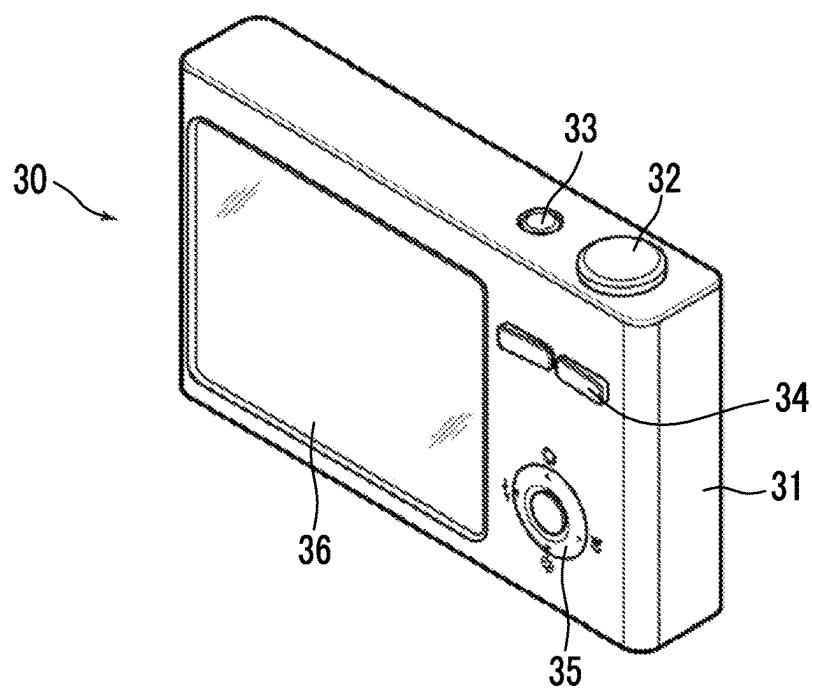


FIG. 62



**1**  
**IMAGING LENS AND IMAGING  
APPARATUS**

**CROSS-REFERENCE TO RELATED  
APPLICATIONS**

The present application is a Continuation of U.S. patent application Ser. No. 17/155,283, filed on Jan. 22, 2021, which claims priority under 35 U.S.C. § 119 to Japanese Patent Application No. 2020-012799, filed on Jan. 29, 2020, and Japanese Patent Application No. 2020-219164, filed on Dec. 28, 2020, the contents of which are hereby expressly incorporated herein by reference in their entirety.

**BACKGROUND OF THE INVENTION**

1. Field of the Invention

The present disclosure relates to an imaging lens and an imaging apparatus.

2. Description of the Related Art

Conventionally, as an imaging lens that can be used in an imaging apparatus such as a digital camera, imaging lenses described in JP2015-141384A and JP2016-173398A below are known.

**SUMMARY OF THE INVENTION**

In recent years, there has been a demand for a suitable imaging lens which has a small F number and in which various aberrations are satisfactorily corrected.

The present disclosure has been made in consideration of the above-mentioned situation, and its object is to provide a suitable imaging lens, which has a small F number and in which various aberrations are satisfactorily corrected, and an imaging apparatus comprising the imaging lens.

According to an aspect of the present disclosure, there is provided an imaging lens comprising, as lens groups, successively in order from a position closest to an object side to an image side: a first lens group that has a positive refractive power; and a second lens group that has a refractive power, in which during focusing, a distance between the first lens group and the second lens group changes, and mutual distances between all lenses in the first lens group and mutual distances between all lenses in the second lens group are constant, a stop is disposed closer to the image side than a lens which is second from the object side, a combined refractive power of all lenses closer to the object side than the stop is positive, at least one LA positive lens and at least one LB positive lens are provided closer to the object side than the stop, an Abbe number of the LB positive lens based on a d line is a maximum of Abbe numbers of all the positive lenses closer to the object side than the stop based on the d line, a refractive index of the LA positive lens at the d line is NdA, an Abbe number of the LA positive lens based on the d line is vdA, and assuming that the Abbe number of the LB positive lens based on the d line is vdB, Conditional Expressions (1), (2), and (3) are satisfied.

$$1.86 < NdA < 2.2$$

(1)

$$10 < vdA < 35$$

(2)

$$57 < vdB < 105$$

(3)

**2**

It is preferable that the imaging lens according to the aspect of the present disclosure satisfies at least one of Conditional Expression (1-1), (2-1), or (3-1).

$$5 \quad 1.88 < NdA < 2.15 \quad (1-1)$$

$$13.5 < vdA < 31 \quad (2-1)$$

$$62 < vdB < 92 \quad (3-1)$$

10 It is preferable that the first lens group includes at least two positive lenses and at least two negative lenses.

It is preferable that the second lens group includes at least two positive lenses and at least two negative lenses.

15 It is preferable that the first lens group remains stationary with respect to an image plane and the second lens group moves during focusing.

It is preferable that only one lens group moves during focusing. In that case, it is preferable that the lens group that moves during focusing is only the second lens group.

20 It is preferable that the first lens group includes at least two negative lenses. Assuming that an average value of Abbe numbers of two negative lenses based on the d lines is vdn1 where the two negative lenses are selected from negative lenses having smaller Abbe numbers based on the d line among the negative lenses included in the first lens group, it is preferable that the imaging lens of the present disclosure satisfies Conditional Expression (4), and it is more preferable that the imaging lens satisfies Conditional Expression (4-1).

$$30 \quad 15 < vdh1 < 28 \quad (4)$$

$$16 < vdn1 < 25 \quad (4-1)$$

35 It is preferable that during focusing, the first lens group remains stationary with respect to an image plane, and the first lens group includes at least one LA positive lens.

40 In the imaging lens according to the aspect of the present disclosure, assuming that a sum of a distance on an optical axis from a lens surface closest to the object side to a lens surface closest to the image side and a back focal length at an air-converted distance in a state where an object at infinity is in focus is TL, an F number of the imaging lens in the state where the object at infinity is in focus is FNo, and a focal length of the imaging lens in the state where the object at infinity is in focus is f, it is preferable that Conditional Expression (5) is satisfied.

$$45 \quad 1.5 < TL \times FNo / f < 5 \quad (5)$$

50 It is preferable that the imaging lens according to the aspect of the present disclosure comprises, in order from an object side to an image side, as lens groups, only two lens groups consisting of the first lens group that remains stationary with respect to an image plane during focusing and the second lens group that moves during focusing, or comprises, in order from the object side to the image side, as lens groups, only three lens groups consisting of the first lens group that remains stationary with respect to the image plane during focusing, the second lens group that moves during focusing, and a third lens group that consists of two or less lenses and remains stationary with respect to the image plane during focusing.

55 The second lens group may be a lens group having a positive refractive power.

60 It is preferable that the first lens group includes at least three negative lenses.

65 It is preferable that the second lens group includes at least two positive lenses and at least three negative lenses.

The imaging lens according to the aspect of the present disclosure may be configured such that, in a case where one lens component is one single lens or one cemented lens, among the lens component closest to the object side and the lens component which is second from the object side, one lens component has a negative refractive power and the other lens component has a positive refractive power, and on-axis ray emitted from a lens surface closest to the image side in the one lens component having a negative refractive power to the image side in a state where the object at infinity is in focus is divergent light.

It is preferable that at least one of the lens closest to the object side or a lens which is second from the object side is a negative lens of which the object side lens surface has a concave shape.

It is preferable that the lens closest to the object side is a negative lens.

It is preferable that the imaging lens according to the aspect of the present disclosure comprises, successively in order from the position closest to the object side: a single lens that has a negative refractive power, a single lens that has a positive refractive power, and a single lens that has a positive refractive power.

It is preferable that the object side lens surface of the lens closest to the object side has a concave shape.

It is preferable that the imaging lens according to the aspect of the present disclosure comprises at least one LC positive lens closer to the object side than the stop, in which the LC positive lens is a positive lens having a maximum or second largest Abbe number based on the d line among all positive lenses closer to the object side than the stop, and assuming that the Abbe number of the LC positive lens based on the d line is vdc, Conditional Expression (6) is satisfied.

$$57 < vdc < 102 \quad (6)$$

Assuming that a minimum value of refractive indexes of all positive lenses closer to the object side than the stop at the d line is Ndfm, it is preferable that the imaging lens according to the aspect of the present disclosure satisfies Conditional Expression (7).

$$1.46 < Ndfm < 1.72 \quad (7)$$

It is preferable that the stop is disposed in a lens group which remains stationary with respect to an image plane during focusing, or the stop is disposed between the lens groups.

It is preferable that the stop is disposed between the first lens group and the second lens group, and the first lens group and the stop remain stationary with respect to an image plane and the second lens group moves during focusing.

It is preferable that the second lens group moves during focusing, and the number of lenses included in the second lens group is preferably 7 or less, more preferably 6 or less, and yet more preferably 5 or less.

The number of lenses disposed closer to the object side than the stop is preferably 8 or less, more preferably 7 or less.

The number of lenses included in the imaging lens according to the aspect of the present disclosure is preferably 13 or less, and more preferably 12 or less.

The imaging lens according to the aspect of the present disclosure comprises at least two positive lenses closer to the image side than the stop, in which assuming that an average value of the refractive indexes of all positive lenses closer to the image side than the stop at the d line is Ndpr, it is preferable that Conditional Expression (8) is satisfied.

$$1.77 < Ndpr < 2.15 \quad (8)$$

It is preferable that during focusing, the second lens group moves, and the second lens group includes at least one positive lens, and assuming that an average value of refractive indexes of all the positive lenses in the second lens group at the d line is Nd2p, it is preferable that the imaging lens according to the aspect of the present disclosure satisfies Conditional Expression (9).

$$1.7 < Nd2p < 2.2 \quad (9)$$

It is preferable that the second lens group moves during focusing, and the second lens group includes at least two cemented lenses.

It is preferable that three positive lenses are successively arranged in the first lens group. It is more preferable that four positive lenses are successively arranged in the first lens group.

Assuming that a focal length of the first lens group is f1, and a focal length of the imaging lens in a state where an object at infinity is in focus is f, it is preferable that the imaging lens according to the aspect of the present disclosure satisfies Conditional Expression (10).

$$0.5 < f1/f < 3.5 \quad (10)$$

Assuming that a maximum half angle of view of the imaging lens in a state where an object at infinity is in focus is  $\omega_{max}$ , and an F number of the imaging lens in the state where the object at infinity is in focus is FNo, it is preferable that the imaging lens according to the aspect of the present disclosure satisfies Conditional Expression (11).

$$1.8 < 1/\{\tan(\omega_{max}) \times FNo\} < 4.5 \quad (11)$$

It is preferable that the second lens group moves during focusing. Assuming that a focal length of the second lens group is f2, and a focal length of the imaging lens in a state where the object at infinity is in focus is f, it is preferable that the imaging lens according to the aspect of the present disclosure satisfies Conditional Expression (12).

$$0.3 < |f2|/f < 2.2 \quad (12)$$

Assuming that a focal length of the first lens group is f1, and a focal length of the second lens group is f2, it is preferable that the imaging lens according to the aspect of the present disclosure satisfies Conditional Expression (13).

$$1 < f1/f2 < 5 \quad (13)$$

It is preferable that the second lens group moves during focusing. Assuming that a lateral magnification of the second lens group in the state where an object at infinity is in focus is  $\beta_2$ , and a combined lateral magnification of all lenses closer to the image side than the second lens group in a state where the object at infinity is in focus is  $\beta_r$  in a case where a lens is disposed closer to the image side than the second lens group, and  $\beta_r$  is set to 1 in a case where no lens is disposed closer to the image side than the second lens group, it is preferable that the imaging lens according to the aspect of the present disclosure satisfies Conditional Expression (14).

$$0.3 < |(1 - \beta_2^2) \times \beta_r^2| < 1.5 \quad (14)$$

Assuming that a distance on an optical axis from a lens surface closest to the object side to the stop in a state where an object at infinity is in focus is Tf, and a sum of a distance on an optical axis from a lens surface closest to the object side to a lens surface closest to the image side and a back focal length at an air-converted distance in the state where the object at infinity is in focus is TL, it is preferable that the

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imaging lens according to the aspect of the present disclosure satisfies Conditional Expression (15).

$$0.2 < f_f / TL < 0.65 \quad (15)$$

It is preferable that the first lens group includes, successively in order from the position closest to the object side, a first unit which has a negative refractive power and a second unit which is separated from the first unit by a maximum air distance on an optical axis in the first lens group and has a positive refractive power, and the second unit consists of one single lens or one cemented lens. Assuming that a focal length of the imaging lens in a state where an object at infinity is in focus is  $f$ , and a combined focal length of all lenses closer to the image side than the second unit of the imaging lens in the state where the object at infinity is in focus is  $f_m$ , it is preferable that the imaging lens according to the aspect of the present disclosure satisfies Conditional Expression (16).

$$0.7 < f / f_m < 0.98 \quad (16)$$

In a case where the first lens group includes the first unit and the second unit, it is preferable that the first unit consists of one negative lens, and the second unit consists of one positive lens.

Assuming that a partial dispersion ratio between a g line and an F line of the LA positive lens is  $\theta_{gFA}$ , it is preferable that the imaging lens according to the aspect of the present disclosure satisfies Conditional Expression (17).

$$0.01 < \theta_{gFA} + 0.00162 \times v_{dA} - 0.64159 < 0.06 \quad (17)$$

Assuming that a partial dispersion ratio of the LB positive lens between a g line and an F line is  $\theta_{gFB}$ , it is preferable that the imaging lens according to the aspect of the present disclosure satisfies Conditional Expression (18).

$$0.01 < \theta_{gFB} + 0.00162 \times v_{dB} - 0.64159 < 0.05 \quad (18)$$

It is preferable that the first lens group includes at least two negative lenses. Assuming that an average value of Abbe numbers of two negative lenses based on the d lines is  $v_{dn1}$  where the two negative lenses are selected from negative lenses having smaller Abbe numbers based on the d line among the negative lenses included in the first lens group, and an average value of partial dispersion ratios of two negative lenses between a g line and an F line is  $\theta_{gFn1}$  where the two negative lenses are selected from the negative lenses having smaller Abbe numbers based on the d line among the negative lenses included in the first lens group, it is preferable that the imaging lens according to the aspect of the present disclosure satisfies Conditional Expression (19).

$$0.01 < \theta_{gFn1} + 0.00162 \times v_{dh1} - 0.64159 < 0.05 \quad (19)$$

The imaging apparatus of the present disclosure includes the imaging lens according to the aspect of the present disclosure.

In the present specification, it should be noted that the terms "consisting of ~" and "consists of ~" mean that the lens may include not only the above-mentioned elements but also lenses substantially having no refractive powers, optical elements, which are not lenses, such as a stop, a filter, and a cover glass, and mechanism parts such as a lens flange, a lens barrel, an imaging element, and a camera shaking correction mechanism.

In addition, the term "~- group that has a positive refractive power" in the present specification means that the group has a positive refractive power as a whole. Likewise, the "~- group having a negative refractive power" means that the group has a negative refractive power as a whole. "A lens having a positive refractive power", "a lens having a positive

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power", and "a positive lens" are synonymous. "A lens having a negative refractive power", "a lens having a negative power", and "a negative lens" are synonymous. The term "a single lens" means one lens that is not cemented.

The "lens group" is not limited to a configuration in which the lens group consists of a plurality of lenses, but the lens group may consist of only one lens. A compound aspheric lens (a lens which is integrally composed of a spherical lens and a film having an aspheric shape formed on the spherical lens, and functions as one aspheric lens as a whole) is not be considered as a cemented lens, and is treated as a single lens. Unless otherwise specified, the sign of the refractive power, the surface shape of the lens surface, and the radius of curvature of a lens including an aspheric surface are considered in the paraxial region. Regarding the sign of the radius of curvature, the sign of the radius of curvature of the surface convex toward the object side is positive and the sign of the radius of curvature of the surface convex toward the image side is negative.

In the present specification, the term "whole system" means "imaging lens". In the present specification, the phrase "closest to the object side in the whole system" is also simply referred to as the "closest to the object side". Further, the phrase "in order from the object side to the image side" regarding the arrangement order is also simply referred to as "in order from the object side". The term "focal length" used in a conditional expression is a paraxial focal length. The value of "FNo" used in the conditional expression is the value of the open F number. The term "back focal length" is the distance on the optical axis from the lens surface closest to the image side to the image side focal position of the imaging lens. The values used in Conditional Expressions are values in the case of using the d line as a reference in a state where the object at infinity is in focus. The partial dispersion ratio  $\theta_{gF}$  between the g line and the F line of a certain lens is defined by  $\theta_{gF} = (Ng - NF) / (NF - NC)$ , where Ng, NF, and NC are the refractive indexes of the lens at the g line, the F line, and the C line. The "d line", "C line", "F line", and "g line" described in the present specification are emission lines. The wavelength of the d line is 587.56 nm (nanometers) and the wavelength of the C line is 656.27 nm (nanometers), the wavelength of F line is 486.13 nm (nanometers), and the wavelength of g line is 435.84 nm (nanometers).

According to the present disclosure, it is possible to provide a suitable imaging lens, which has a small F number and in which various aberrations are satisfactorily corrected, and an imaging apparatus comprising the imaging lens.

## BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a cross-sectional view showing a configuration and rays of an imaging lens (an imaging lens of Example 1) according to an embodiment.

FIG. 2 shows spherical aberration diagrams, astigmatism diagrams, distortion diagrams, lateral chromatic aberration diagrams of the imaging lens of Example 1.

FIG. 3 shows lateral aberration diagrams of the imaging lens according to Example 1.

FIG. 4 is a cross-sectional view showing a configuration and rays of an imaging lens of Example 2.

FIG. 5 shows spherical aberration diagrams, astigmatism diagrams, distortion diagrams, lateral chromatic aberration diagrams of the imaging lens of Example 2.

FIG. 6 shows lateral aberration diagrams of the imaging lens according to Example 2.



## DESCRIPTION OF THE PREFERRED EMBODIMENTS

Hereinafter, embodiments of the present disclosure will be described in detail with reference to the accompanying drawings. FIG. 1 is a diagram showing a configuration in a cross section including an optical axis Z of an imaging lens according to an embodiment of the present disclosure. The example shown in FIG. 1 corresponds to the imaging lens of Example 1 to be described later. FIG. 1 shows a state where the object at infinity is in focus, and shows on-axis rays 2 and rays with the maximum angle of view 3, where the left side is the object side and the right side is the image side.

FIG. 1 shows an example in which an optical member PP having a parallel plate shape is disposed between an imaging lens and an image plane Sim under assumption that the imaging lens is applied to the imaging apparatus. The optical member PP is a member assumed to include at various filters, a cover glass, and/or the like. The various filters include, for example, a low pass filter, an infrared cut filter, and a filter that cuts a specific wavelength region. The optical member PP has no refractive power, and the optical member PP may be configured to be omitted.

The imaging lens according to the present disclosure is a single-focus lens, and comprises, successively in order from the position closest to the object side to the image side along the optical axis Z, a first lens group G1 having a positive refractive power, and a second lens group G2 having a refractive power, as lens groups. Further, an aperture stop St is disposed closer to the image side than the lens which is second from the object side. By making the refractive power of the first lens group G1 positive, there is an advantageous in shortening the total lens length.

The imaging lens of the present disclosure may further comprise a lens group closer to the image side than the second lens group G2. It should be noted that the term "lens group" in the present specification refers to a part including the at least one lens, which is a constituent part of the imaging lens and is divided by an air distance that changes during focusing. During focusing, the lens groups move or remain stationary, and the mutual distance between the lenses in one lens group does not change.

As an example, the imaging lens shown in FIG. 1 consists of a first lens group G1, an aperture stop St, a second lens group G2, and a third lens group G3 in order from the object side. Further, the aperture stop St shown in FIG. 1 does not indicate a shape thereof, but indicates a position thereof on the optical axis. In the imaging lens of FIG. 1, as an example, the first lens group G1 consists of seven lenses L1a to L1g in order from the object side, and the second lens group G2 consists of five lenses L2a to L2e in order from the object side, and the third lens group G3 consists of one lens L3a. However, in the imaging lens of the present disclosure, the number of lenses composing each lens group may be different from that in the example shown in FIG. 1.

The imaging lens of the present disclosure is configured such that the distance between the first lens group G1 and the second lens group G2 changes during focusing from an object at infinity to an object at a short distance and the mutual distance between all the lenses in the first lens group and the mutual distance between all the lenses in the second lens group are constant. The phrase "during focusing, the mutual distance is constant" described herein means that the mutual distance remains unchanged during focusing. By changing the distance between the lens groups during focusing, it is possible to suppress fluctuation in field curvature during focusing, as compared with the configuration in

which focusing is performed by integrally moving the entire imaging lens. It should be noted that the term "integrally moving" described herein means moving in the same amount and in the same direction at the same time.

In the imaging lens of FIG. 1, as an example, during focusing from the object at infinity to the closest object, the first lens group G1 and the third lens group G3 remain stationary with respect to the image plane Sim, and the second lens group G2 moves to the object side along the optical axis Z. That is, in the imaging lens of FIG. 1, the lens group that moves during focusing (hereinafter referred to as the focusing lens group) consists of the second lens group G2. The horizontal left arrow under the second lens group G2 in FIG. 1 means that the second lens group G2 moves to the object side during focusing from the object at infinity to the closest object.

This imaging lens is configured such that the combined refractive power of all the lenses closer to the object side than the aperture stop St is positive. Further, this imaging lens is configured to include at least one LA positive lens LA and at least one LB positive lens LB closer to the object side than the aperture stop St. The LA positive lens LA is disposed closer to the object side than the aperture stop St, and is a positive lens that satisfies Conditional Expressions (1) and (2), where the refractive index of the LA positive lens LA at the d line is NdA and the Abbe number of the LA positive lens LA based on the d line is vdA.

$$1.86 < NdA < 2.2 \quad (1)$$

$$10 < vdA < 35 \quad (2)$$

The LB positive lens LB is disposed closer to the object side than the aperture stop St, and is a positive lens of which the Abbe number based on the d line is largest among Abbe numbers of all positive lenses closer to the object side than the aperture stop St based on the d line and which satisfies Conditional Expression (3). Here, the Abbe number of the LB positive lens LB based on the d line is vdB.

$$57 < vdB < 105 \quad (3)$$

In the example of FIG. 1, the lens L1c corresponds to the LA positive lens LA and the lens L1b corresponds to the LB positive lens LB.

By not allowing the result of Conditional Expression (1) to be equal to or less than the lower limit, the absolute value of the radius of curvature of the lens is prevented from becoming excessively small. Therefore, occurrence of spherical aberration can be suppressed. By not allowing the result of Conditional Expression (1) to be equal to or greater than the upper limit, the specific gravity of the lens is prevented from becoming excessively large. Thus, there is an advantage in achieving weight reduction.

By not allowing the result of Conditional Expression (2) to be equal to or less than the lower limit, there is an advantage in satisfactorily correcting first-order chromatic aberration. By not allowing the result of Conditional Expression (2) to be equal to or greater than the upper limit, there is an advantage in satisfactorily correcting second-order chromatic aberration. By satisfying Conditional Expression (2), there is an advantage in satisfactorily correcting the first-order chromatic aberration and the second-order chromatic aberration.

By not allowing the result of Conditional Expression (3) to be equal to or less than the lower limit, there is an advantage in satisfactorily correcting chromatic aberration, particularly longitudinal chromatic aberration. By not allowing the result of Conditional Expression (3) to be equal to or

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greater than the upper limit, it is possible to prevent the refractive index of the LB positive lens LB from becoming excessively low. In a case where a positive lens is composed of a material having a low refractive index, spherical aberration and coma aberration are likely to occur. However, by not allowing the result of Conditional Expression (3) to be equal to or greater than the upper limit, occurrence of spherical aberration and coma aberration can be suppressed.

In the imaging lens of the present disclosure, a high-refractive-index and high-dispersion LA positive lens LA that satisfies Conditional Expressions (1) and (2) is disposed closer to the object side than the aperture stop St, and a low-dispersion LB positive lens LB that satisfies Conditional Expression (3) is also disposed. The plurality of lenses disposed closer to the object side than the aperture stop St have positive refractive power as a whole, and the LA positive lens LA composed of a material satisfying Conditional Expressions (1) and (2) is disposed. Thereby, the correction effect of the second-order chromatic aberration can be obtained. By controlling the amount of chromatic aberration caused by the LA positive lens LA and the LB positive lens LB, the first-order chromatic aberration and the second-order chromatic aberration can be balanced. Further, by disposing the positive lens composed of the high-refractive-index material that satisfies Conditional Expression (1), it is possible to prevent the absolute value of the radius of curvature of each positive lens from becoming excessively small. This facilitates a balanced correction of chromatic aberration and monochromatic aberration such as spherical aberration and coma aberration.

In order to obtain more favorable characteristics, it is preferable that the LA positive lens LA satisfies at least one of Conditional Expression (1-1), (1-2), (2-1), (2-2), or (2-3).

$$1.88 < N_{dA} < 2.15 \quad (1-1)$$

$$1.91 < N_{dA} < 2.15 \quad (1-2)$$

$$13.5 < v_{dA} < 31 \quad (2-1)$$

$$14 < v_{dA} < 28 \quad (2-2)$$

$$14.5 < v_{dA} < 22 \quad (2-3)$$

In order to obtain more favorable characteristics, the LB positive lens LB preferably satisfies Conditional Expression (3-1), and more preferably satisfies Conditional Expression (3-2).

$$62 < v_{dB} < 92 \quad (3-1)$$

$$66 < v_{dB} < 88 \quad (3-2)$$

Further, assuming that the Abbe number of the LA positive lens LA based on the d line is  $v_{dA}$  and the partial dispersion ratio of the LA positive lens LA between the g line and the F line is  $\theta_{gFA}$ , it is preferable to satisfy Conditional Expression (17). By not allowing the result of Conditional Expression (17) to be equal to or less than the lower limit, it is possible to prevent second-order chromatic aberration from being insufficiently corrected. By not allowing the result of Conditional Expression (17) to be equal to or greater than the upper limit, it is possible to prevent second-order chromatic aberration from being excessively corrected. In order to obtain more favorable characteristics, it is more preferable to satisfy Conditional Expression (17-1).

$$0.01 < \theta_{gFA} + 0.00162 \times v_{dA} - 0.64159 < 0.06 \quad (17)$$

$$0.015 < \theta_{gFA} + 0.00162 \times v_{dA} - 0.64159 < 0.055 \quad (17-1)$$

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In Conditional Expression (17),  $\theta_{gFA} + 0.00162 \times v_{dA} - 0.64159$  is  $\Delta\theta_{gFA}$  represented by the following expression.

$\Delta\theta_{gFA} = \theta_{gFA} - (-0.00162 \times v_{dA} + 0.64159)$   $\Delta\theta_{gFA}$  is a value indicating the abnormal dispersion of the material used for the LA positive lens LA, and the larger this value, the higher the abnormal dispersion. The abnormal dispersion can be considered in terms of using an orthogonal coordinate system in which the horizontal axis represents the Abbe number  $v_d$  based on the d line and the vertical axis represents the partial dispersion ratio  $\theta_{gF}$  between the g line and the F line. In this orthogonal coordinate system, a straight line passing through two points of  $(v_d, \theta_{gF}) = (60.49, 0.5436)$  and  $(v_d, \theta_{gF}) = (36.26, 0.5828)$  is set as a reference line. The deviation from this reference line indicates the degree of abnormal dispersion.  $\Delta\theta_{gFA}$  indicates the deviation of the partial dispersion ratio from this reference line. The above definition of deviation is based on the definition of abnormal dispersion of Ohara Inc.

Likewise, assuming that the partial dispersion ratio of the LB positive lens LB between the g line and the F line is  $\theta_{gFB}$ , it is preferable to satisfy Conditional Expression (18).  $\theta_{gFB} + 0.00162 \times v_{dB} - 0.64159$  in Conditional Expression (18) is a value indicating the abnormal dispersion of the material used for the LB positive lens LB, and the larger this value, the higher the abnormal dispersion. By not allowing the result of Conditional Expression (18) to be equal to or less than the lower limit, it becomes easy to satisfactorily correct chromatic aberration, particularly longitudinal chromatic aberration. By not allowing the result of Conditional Expression (18) to be equal to or greater than the upper limit, a material other than the low refractive index material can be selected. Therefore, the absolute value of the radius of curvature of the lens can be prevented from becoming excessively small. Thereby, it becomes easy to correct spherical aberration and coma aberration. By satisfying conditional expression (18), it becomes easy to correct chromatic aberration, spherical aberration, and coma aberration in a balanced manner. In order to obtain more favorable characteristics, it is more preferable to satisfy Conditional Expression (18-1).

$$0.01 < \theta_{gFB} + 0.00162 \times v_{dB} - 0.64159 < 0.05 \quad (18)$$

$$0.012 < \theta_{gFB} + 0.00162 \times v_{dB} - 0.64159 < 0.035 \quad (18-1)$$

Another preferable configuration and another possible configuration of the imaging lens of the present disclosure will be described below. It is preferable that during focusing, the first lens group G1 remains stationary with respect to the image plane Sim, and the first lens group G1 includes at least one LA positive lens LA. The reason for this is as follows. In a case where the LA positive lens LA composed of a material having a high refractive index and a high dispersion is disposed in the focusing lens group, fluctuations in chromatic aberration and spherical aberration are likely to be large during focusing. Thus, it is desirable that the LA positive lens LA is disposed in the first lens group that does not move. Alternatively, in a case where the LA positive lens LA is disposed in the focusing lens group, it is necessary for a negative lens to be further disposed in the focusing lens group in order to cancel the aberration occurring in the LA positive lens LA. This leads to an increase in size of the lens group. From the above circumstances, it is more preferable that the first lens group G1 remains stationary with respect to the image plane Sim during focusing, and the first lens group G1 includes all the LA positive lenses LA.

It is preferable that the imaging lens includes at least one LC positive lens LC closer to the object side than the

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aperture stop St. The LC positive lens LC is a positive lens that is disposed closer to the object side than the aperture stop St and has the largest or second largest Abbe number based on the d line among all the positive lenses closer to the object side than the aperture stop St, and is a positive lens that satisfies Conditional Expression (6). Here, the Abbe number of the LC positive lens LC based on the d line is vdc.

$$57 < vdc < 102 \quad (6)$$

FIG. 1 shows an example in which the lens L1d corresponds to the LC positive lens LC.

By not allowing the result of Conditional Expression (6) to be equal to or less than the lower limit, it is possible to satisfactorily correct chromatic aberration, particularly longitudinal chromatic aberration. By not allowing the result of Conditional Expression (6) to be equal to or greater than the upper limit, the refractive index of the LC positive lens LC is prevented from becoming excessively low. Therefore, occurrence of spherical aberration and coma aberration can be suppressed. The imaging lens has, at a position closer to the object side than the aperture stop St, an LB positive lens LB composed of a low dispersion material that satisfies Conditional Expression (3), and has the LC positive lens LC composed of a low dispersion material that satisfies Conditional Expression (6). Thereby, it is possible to satisfactorily correct chromatic aberration and spherical aberration. In the configuration having the LB positive lens LB and the LC positive lens LC, the refractive power of the LB positive lens LB can be weakened as compared with the configuration in which the positive lens composed of the low dispersion material is only the LB positive lens LB. As a result, the absolute value of the radius of curvature of the LB positive lens LB is prevented from becoming excessively small. Therefore, occurrence of spherical aberration can be suppressed. Further, it is possible to make the refractive index of the LC positive lens LC higher than that of the LB positive lens LB due to the characteristics of the refractive index and Abbe number of the optical material. Therefore, in a case where the imaging lens has two positive lenses formed of a low-dispersion material closer to the object side than the aperture stop St, as compared with the configuration in which both of these two lenses are LB positive lenses LB, in the configuration in which these two lenses are one LB positive lens LB and one LC positive lens LC, the absolute value of the radius of curvature of these two positive lenses can be increased. Thus, there is an advantage in suppressing occurrence of spherical aberration.

In order to obtain more favorable characteristics, the LC positive lens LC preferably satisfies Conditional Expression (6-1), and more preferably Conditional Expression (6-2).

$$62 < vdc < 88 \quad (6-1)$$

$$66 < vdc < 80 \quad (6-2)$$

Assuming that the minimum value of the refractive indexes of all positive lenses closer to the object side than the aperture stop St at the d line is Ndfm, it is preferable to satisfy Conditional Expression (7). By not allowing the result of Conditional Expression (7) to be equal to or less than the lower limit, the absolute value of the radius of curvature of the lens is prevented from becoming excessively small, and occurrence of spherical aberration can be suppressed. Further, the positive lens disposed in the first lens group G1 having a large lens diameter is prevented from becoming excessively thick. Thus, there is an advantage in reducing the size of the lens system. By not allowing the

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result of Conditional Expression (7) to be equal to or greater than the upper limit, a low dispersion material can be selected. Thus, there is an advantage in correcting chromatic aberration. In order to obtain more favorable characteristics, it is more preferable to satisfy Conditional Expression (7-1).

$$1.46 < Ndfm < 1.72 \quad (7)$$

$$1.52 < Ndfm < 1.68 \quad (7-1)$$

It is preferable that the imaging lens includes at least two positive lenses closer to the image side than the aperture stop St. Assuming that the average value of the refractive indexes of all the positive lenses closer to the image side than the aperture stop St at the d line is Ndpr, it is preferable to satisfy Conditional Expression (8). By disposing two or more positive lenses closer to the image side than the aperture stop St, astigmatism and field curvature can be satisfactorily corrected. By not allowing the result of Conditional Expression (8) to be equal to or less than the lower limit, the absolute value of the radius of curvature of the lens is prevented from becoming excessively small. As a result, it becomes easy to satisfactorily correct astigmatism and field curvature. By not allowing the result of Conditional Expression (8) to be equal to or greater than the upper limit, materials other than high-dispersion materials can be selected. Thus, there is an advantage in correcting chromatic aberration. In order to obtain more favorable characteristics, it is more preferable to satisfy Conditional Expression (8-1), and it is yet more preferable to satisfy Conditional Expression (8-2).

$$1.77 < Ndpr < 2.15 \quad (8)$$

$$1.81 < Ndpr < 2.1 \quad (8-1)$$

$$1.87 < Ndpr < 2.05 \quad (8-2)$$

It is preferable that the first lens group G1 includes at least two positive lenses and at least two negative lenses. In such a case, spherical aberration, coma aberration, and longitudinal chromatic aberration can be satisfactorily corrected. As a result, it becomes easy to suppress fluctuation in aberration caused by change in distance between the first lens group G1 and the second lens group G2 during focusing.

It is preferable that three positive lenses are successively arranged in the first lens group. In such a case, the height of the on-axis marginal ray can be gently lowered by the three positive lenses successively arranged. Therefore, occurrence of spherical aberration can be suppressed. In order to more satisfactorily suppress occurrence of spherical aberration, it is preferable that four positive lenses are successively arranged in the first lens group.

It is preferable that the first lens group G1 includes at least two negative lenses. Assuming that an average value of Abbe numbers of two negative lenses based on the d lines is vdn1 where the two negative lenses are selected from negative lenses having smaller Abbe numbers based on the d line among the negative lenses included in the first lens group G1, it is preferable to satisfy Conditional Expression (4). The Abbe numbers of "the two negative lenses selected from negative lenses having smaller Abbe numbers" may be equal. Specifically, in a case where there are two or more negative lenses having the minimum Abbe number of all the negative lenses in the first lens group, the minimum value is vdn1. In a case where there is only one negative lens having the minimum Abbe number of all the negative lenses in the first lens group, an average value of the minimum value and a second smallest value of the Abbe numbers of all the negative lenses in the first lens group is vdn1. In order to

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avoid redundant description, in the above description, the "Abbe number based on the d line" is simply referred to as "Abbe number". By not allowing the result of Conditional Expression (4) to be equal to or less than the lower limit, there is an advantage in satisfactorily correcting second-order chromatic aberration. By not allowing the result of Conditional Expression (4) to be equal to or greater than the upper limit, there is an advantage in satisfactorily correcting first-order chromatic aberration. By satisfying Conditional Expression (4), there is an advantage in correcting first-order chromatic aberration and second-order chromatic aberration in a balanced manner. In order to obtain more favorable characteristics, it is more preferable to satisfy Conditional Expression (4-1).

$$15 < vdn1 < 28 \quad (4)$$

$$16 < vdn1 < 25 \quad (4-1)$$

It is preferable that the first lens group G1 includes at least two negative lenses. Assuming that an average value of Abbe numbers of two negative lenses based on the d lines is  $vdn1$  where the two negative lenses are selected from negative lenses having smaller Abbe numbers based on the d line among the negative lenses included in the first lens group G1, and an average value of partial dispersion ratios of two negative lenses between a g line and an F line is  $\theta gFn1$  where the two negative lenses are selected from the negative lenses having smaller Abbe numbers based on the d line among the negative lenses included in the first lens group G1, it is preferable to satisfy Conditional Expression (19). Similarly to Conditional Expression (4), in Conditional Expression (19), the Abbe numbers of "the two negative lenses selected from negative lenses having smaller Abbe numbers" may be equal. Similarly to  $\theta gFA + 0.00162 \times vdnA - 0.64159$  in Conditional Expression (17),  $\theta gFn1 + 0.00162 \times vdn1 - 0.64159$  in Conditional Expression (19) is a value indicating the average value of the abnormal dispersion of two negative lenses selected from negative lenses having smaller Abbe numbers among the negative lenses arranged in the first lens group G1, and the larger this value, the higher the abnormal dispersion. By not allowing the result of Conditional Expression (19) to be equal to or less than the lower limit, it becomes easy to satisfactorily correct first-order chromatic aberration. By not allowing the result of Conditional Expression (19) to be equal to or greater than the upper limit, it becomes easy to satisfactorily correct second-order chromatic aberration. By satisfying Conditional Expression (19), it becomes easy to correct first-order chromatic aberration and second-order chromatic aberration in a balanced manner. In order to obtain more favorable characteristics, it is more preferable to satisfy Conditional Expression (19-1).

$$0.01 < \theta gFn1 + 0.00162 \times vdn1 - 0.64159 < 0.05 \quad (19)$$

$$0.016 < \theta gFn1 + 0.00162 \times vdn1 - 0.64159 < 0.042 \quad (19-1)$$

It is preferable that the first lens group G1 includes at least three negative lenses. In such a case, it becomes easy to satisfactorily correct chromatic aberration, and there is also an advantage in correcting field curvature.

Assuming that a focal length of the first lens group G1 is  $f1$  and a focal length of the imaging lens in a state where the object at infinity is in focus is  $f$ , it is preferable to satisfy Conditional Expression (10). By not allowing the result of Conditional Expression (10) to be equal to or less than the lower limit, the refractive power of the first lens group G1 is prevented from becoming excessively strong. Thus, there

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is an advantage in satisfactorily correcting various aberrations, particularly spherical aberration. By not allowing the result of Conditional Expression (10) to be equal to or greater than the upper limit, the refractive power of the first lens group G1 is prevented from becoming excessively weak. Thus, there is an advantage in shortening the total lens length. In order to obtain more favorable characteristics, it is more preferable to satisfy Conditional Expression (10-1), it is yet more preferable to satisfy Conditional Expression (10-2), and it is most preferable to satisfy Conditional Expression (10-3).

$$0.5 < f1/f < 3.5 \quad (10)$$

$$0.7 < f1/f < 3.3 \quad (10-1)$$

$$1.4 < f1/f < 3.2 \quad (10-2)$$

$$1.8 < f1/f < 2.9 \quad (10-3)$$

The first lens group G1 may be configured to include, successively in order from the position closest to the object side, a first unit Gs1 that has a negative refractive power and a second unit Gs2 that is separated from the first unit Gs1 by the maximum air distance on the optical axis in the first lens group and has a positive refractive power. The first unit Gs1 is a unit including at least one lens, and the second unit Gs2 is a unit consisting of one single lens or one cemented lens. In such a case, the first unit Gs1 and the second unit Gs2 can be made to have the same configuration as a wide conversion lens. As a result, it becomes easy to suppress sagittal coma aberration while widening the angle of view. In the example of FIG. 1, the first unit Gs1 consists of the lens L1a, and the second unit Gs2 consists of the lens L1b.

In the configuration in which the first lens group G1 has the first unit Gs1 and the second unit Gs2, assuming that the focal length of the imaging lens in the state where the object at infinity is in focus is  $f$ , and the combined focal length of all the lenses closer to the image side than the second unit Gs2 of the imaging lenses in the state where the object at infinity is in focus is  $fm$ , it is preferable to satisfy Conditional Expression (16). By not allowing the result of Conditional Expression (16) to be equal to or less than the lower limit, there is an advantage in reducing the coma aberration occurring in the first unit Gs1 and the second unit Gs2. By not allowing the result of Conditional Expression (16) to be equal to or greater than the upper limit, there is an advantage in reducing aberration, particularly coma aberration, occurring in the lens closer to the image side than the second unit Gs2. In order to obtain more favorable characteristics, it is more preferable to satisfy Conditional Expression (16-1).

$$0.7 < f/fm < 0.98 \quad (16)$$

$$0.75 < f/fm < 0.95 \quad (16-1)$$

In a case where the first lens group G1 has the above-mentioned first unit Gs1 and second unit Gs2, it is preferable that the first unit Gs1 consists of one negative lens and the second unit Gs2 consists of one positive lens. In such a case, the number of lenses in the first unit Gs1 and the second unit Gs2 having large lens diameters is small. Thus, there is an advantage in reducing the size and the weight of the imaging lens.

In the lens component closest to the object side and the lens component which is second from the object side of the whole system, one has a negative refractive power and the other has a positive refractive power. In the state where the object at infinity is in focus, it is preferable that the on-axis ray 2 emitted from the lens surface closest to the image side

in the one lens component having a negative refractive power to the image side is divergent light. It should be noted that one lens component means one single lens or one cemented lens. In the example of FIG. 1, the lens L1a that is the lens component closest to the object side in the whole system has a negative refractive power, and the lens L1b that is the lens component which is second from the object side of the whole system has a positive refractive power. As shown in FIG. 1, the on-axis ray 2 emitted from the lens L1a to the image side between the lens L1a and the lens L1b has a ray diameter that increases toward the image side and is divergent light.

As described above, by disposing the lens component having a negative refractive power at a position closer to the object, it is possible to decrease the angle of the principal ray with the maximum angle of view, which is emitted from the lens component having a negative refractive power to the image side, with respect to the optical axis Z. Thus, it becomes easy to suppress sagittal coma aberration. Further, by disposing the lens component having a negative refractive power in the first lens group, it is possible to prevent a positive refractive power of the first lens group G1 from becoming excessively strong, and to suppress occurrence of spherical aberration and field curvature. However, in a case where negative refractive powers are successively arranged such that both the lens component closest to the object side and the lens component which is second from the object side have a negative refractive power, the whole lens system becomes large. Therefore, it is preferable that one of the two lens components has a negative refractive power and the other has a positive refractive power. Further, by making the on-axis ray 2 emitted from the one lens component having a negative refractive power as divergent light, it is possible to adopt a configuration in which the ray is once spread and then converged again in the first lens group G1 having a positive refractive power. Thus, there is an advantage in suppressing sagittal coma aberration.

It is preferable that at least one of the lens closest to the object side or the lens which is second from the object side of the whole system is a negative lens of which the object side lens surface is concave. By disposing the negative lens at a position closer to the object in such a manner, it is possible to reduce the angle of the principal ray with the maximum angle of view, which is emitted from the negative lens to the image side, with respect to the optical axis Z. As a result, it becomes easy to suppress sagittal coma aberration. Further, by making the object side lens surface of the negative lens concave, there is an advantage in correcting spherical aberration.

It is preferable that the object side lens surface of the lens closest to the object side in the whole system is concave. In such a case, there is an advantage in correcting spherical aberration.

It is preferable that the lens closest to the object side in the whole system is a negative lens. In such a case, it is possible to reduce the angle of the principal ray with the maximum angle of view, which is emitted from the lens closest to the object side to the image side, with respect to the optical axis Z. Therefore, it becomes easy to suppress sagittal coma aberration.

The imaging lens may be configured to include a single lens having a negative refractive power, a single lens having a positive refractive power, and a single lens having a positive refractive power, successively in order from the closest to the object side in the whole system. By making the lens closest to the object side a negative lens, it becomes easy to suppress sagittal coma aberration as described above.

Moreover, since the positive lens that is disposed successively to the lens closest to the object side is able to gently lower the height of the on-axis marginal ray, it is possible to suppress occurrence of spherical aberration. Further, by using only one negative lens among the three lenses of the first lens to the third lens counted from the lens closest to the object side, it is possible to suppress an increase in size of the lens system.

The second lens group G2 may be configured as a lens group having a positive refractive power. In such a case, the height of the on-axis marginal ray should be gently lowered until the light from the object is incident into the first lens group G1 having a positive refractive power and is emitted from the second lens group G2. Therefore, occurrence of spherical aberration can be suppressed even in a case where the F number is reduced.

Assuming that a focal length of the first lens group G1 is f1, and a focal length of the second lens group G2 is f2, it is preferable to satisfy Conditional Expression (13). By not allowing the result of Conditional Expression (13) to be equal to or less than the lower limit, it is possible to prevent the refractive power of the first lens group G1 from becoming excessively strong. By not allowing the result of Conditional Expression (13) to be equal to or greater than the upper limit, it is possible to prevent the refractive power of the second lens group G2 from becoming excessively strong. By satisfying Conditional Expression (13), it becomes easy to suppress various aberrations occurring in each of the first lens group G1 and the second lens group G2. In order to obtain more favorable characteristics, it is more preferable to satisfy Conditional Expression (13-1), it is yet more preferable to satisfy Conditional Expression (13-2), and it is most preferable to satisfy Conditional Expression (13-3).

$$1 < f_1/f_2 < 5 \quad (13)$$

$$1.2 < f_1/f_2 < 4.4 \quad (13-1)$$

$$2.3 < f_1/f_2 < 4.2 \quad (13-2)$$

$$2.5 < f_1/f_2 < 4 \quad (13-3)$$

It is preferable that the second lens group G2 includes at least two positive lenses and at least two negative lenses. In such a case, various aberrations, particularly, field curvature can be satisfactorily corrected. As a result, it becomes easy to suppress fluctuation in aberration caused by change in distance between the first lens group G1 and the second lens group G2 during focusing.

It is preferable that the second lens group G2 includes at least three positive lenses and at least two negative lenses. In such a case, various aberrations can be satisfactorily corrected. As a result, it becomes easy to suppress fluctuation in aberration during focusing.

Regarding the behavior of each lens group during focusing, it is preferable that the first lens group G1 remains stationary with respect to the image plane Sim and the second lens group G2 moves during focusing. In a lens system having a large aperture ratio, the lens closest to the object side tends to have a large diameter, and thus tends to have a heavy weight. Therefore, in a case where the first lens group G1 is configured to be moved during focusing, a plurality of inconveniences will be described below. First, during focusing, a heavy lens has to be moved, which makes an increase in autofocus speed difficult. Further, a large motor having a high torque is required to move the lens having a large weight. Therefore, the entire lens device

becomes large. Furthermore, since the total lens length changes with the movement of the lens closest to the object side having a large diameter, the barycentric position of the imaging lens changes during imaging. For the above reasons, it is preferable to use the inner focus method or the rear focus method. Further, the configuration in which the first lens group G1 does not move during focusing has an advantage that the firmness of the lens device can be easily ensured.

It is preferable that the aperture stop St is disposed between the lens groups, or it is preferable that the aperture stop St is disposed in the lens group that remains stationary with respect to the image plane Sim during focusing. That is, it is preferable that the aperture stop St is not included in the focusing lens group. Since the focusing lens group does not include the aperture stop unit, it is possible to reduce the weight of the focusing lens group and achieve an increase in autofocus speed. Further, in a case where the focusing lens group can be reduced in weight, a large high torque motor becomes unnecessary. Thus, there is an advantage in achieving reduction in size and weight of the whole lens system.

From the above circumstances, in a case where importance is attached to reduction in size and weight and the like, it is preferable that the aperture stop St is disposed between the first lens group G1 and the second lens group G2, and the first lens group G1 and the aperture stop St remain stationary with respect to the image plane Sim and the second lens group G2 moves during focusing.

It is preferable that only one lens group moves during focusing. By using only one lens group that moves during focusing, the structure can be simplified, and reduction in size and weight of the lens device can be achieved. In a lens system having a large aperture ratio, the focal depth is extremely low, and the performance change due to tilting and/or axial misalignment of the lens is likely to be large. In particular, in the focusing lens group which is the movable lens group, it is desirable that the number of the movable lens groups is small since structurally it is difficult to completely eliminate the tilting of the lens and the axial misalignment.

As described above, it is preferable that the first lens group G1 remains stationary with respect to the image plane Sim during focusing, and it is preferable that only one lens group moves during focusing. Therefore, it is preferable that the only lens group that moves during focusing is the second lens group G2.

In a case where the second lens group G2 moves during focusing, it is preferable that the number of lenses included in the second lens group G2 is 7 or less. By reducing the number of lenses in the second lens group G2, which is the focusing lens group, the weight of the focusing lens group can be reduced. Thus, there is an advantage in increasing the autofocus speed. Further, in a case where the focusing lens group can be reduced in weight, a large high torque motor becomes unnecessary. Thus, there is an advantage in achieving reduction in size and weight of the whole lens system. Therefore, in the configuration in which the second lens group G2 moves during focusing, the number of lenses included in the second lens group G2 is more preferably 6 or less, and yet more preferably 5 or less.

In the configuration in which the second lens group G2 moves during focusing, the second lens group G2 includes at least one positive lens. Assuming that the average value of the refractive indexes of all the positive lenses in the second lens group at the d line is Nd2p, it is preferable to satisfy Conditional Expression (9). By not allowing the result of Conditional Expression (9) to be equal to or less

than the lower limit, it becomes easy to satisfactorily correct astigmatism and field curvature. By not allowing the result of Conditional Expression (9) to be equal to or greater than the upper limit, the specific gravity of the lens material is prevented from becoming excessively large. Therefore, the weight of the focusing lens group can be prevented from becoming heavy. Further, since it is possible to select a material other than the high-dispersion material, it is possible to suppress fluctuation in chromatic aberration in a case where the focusing lens moves. In order to obtain more favorable characteristics, it is more preferable to satisfy Conditional Expression (9-1), it is yet more preferable to satisfy Conditional Expression (9-2), and it is most preferable to satisfy Conditional Expression (9-3).

$$1.7 < Nd2p < 2.2 \quad (9)$$

$$1.77 < Nd2p < 2.15 \quad (9-1)$$

$$1.81 < Nd2p < 2.1 \quad (9-2)$$

$$1.87 < Nd2p < 2.05 \quad (9-3)$$

In a case where the second lens group G2 moves during focusing, it is preferable that the second lens group G2 includes at least two cemented lenses. In this case, it is possible to suppress fluctuation in chromatic aberration during focusing.

In the configuration in which the second lens group G2 moves during focusing, assuming that a focal length of the second lens group G2 is f2, and a focal length of the imaging lens in a state where the object at infinity is in focus is f, it is preferable to satisfy Conditional Expression (12). By not allowing the result of Conditional Expression (12) to be equal to or less than the lower limit, the refractive power of the second lens group G2 is prevented from becoming excessively strong. Therefore, it becomes easy to suppress occurrence of various aberrations occurring in the second lens group G2. By not allowing the result of Conditional Expression (12) to be equal to or greater than the upper limit, the amount of movement of the second lens group G2 during focusing can be reduced. Thus, there is an advantage in reducing the size of the lens system. In order to obtain more favorable characteristics, it is more preferable to satisfy Conditional Expression (12-1), it is yet more preferable to satisfy Conditional Expression (12-2), and it is most preferable to satisfy Conditional Expression (12-3).

$$0.3 < |f2|/f < 2.2 \quad (12)$$

$$0.4 < |f2|/f < 1.9 \quad (12-1)$$

$$0.45 < |f2|/f < 1.2 \quad (12-2)$$

$$0.5 < |f2|/f < 1 \quad (12-3)$$

In the configuration in which the second lens group G2 moves during focusing, assuming that a lateral magnification of the second lens group G2 in the state where an object at infinity is in focus is β2, and a combined lateral magnification of all lenses closer to the image side than the second lens group G2 in a state where the object at infinity is in focus is βr in a case where a lens is disposed closer to the image side than the second lens group G2, and βr is set to 1 in a case where no lens is disposed closer to the image side than the second lens group G2, it is preferable to satisfy Conditional Expression (14). In Conditional Expression (14),  $|-(1-\beta_2^2) \times \beta r^2|$  represents the amount of movement of the image plane position with respect to the amount of movement of the second lens group G2 during focusing, and

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represents so-called focus sensitivity. By not allowing the result of Conditional Expression (14) to be equal to or less than the lower limit, it is possible to reduce the amount of movement of the second lens group G2 during focusing. Thus, there is an advantage in reducing the size of the lens system. By not allowing the result of Conditional Expression (14) to be equal to or greater than the upper limit, it is possible to suppress the strictness in accuracy of the stopping of the focusing lens group in the focusing operation. Further, by not allowing the result of Conditional Expression (14) to be equal to or greater than the upper limit, it becomes unnecessary to increase the refractive power of the second lens group G2 for focus sensitivity. Therefore, it becomes easy to correct spherical aberration and coma aberration. In order to obtain more favorable characteristics, it is more preferable to satisfy Conditional Expression (14-1), and it is yet more preferable to satisfy Conditional Expression (14-2).

$$0.3 < |(1-\beta_2^2) \times \beta r^2| < 1.5 \quad (14)$$

$$0.4 < |(1-\beta_2^2) \times \beta r^2| < 1.4 \quad (14-1)$$

$$0.6 < |(1-\beta_2^2) \times \beta r^2| < 1 \quad (14-2)$$

As shown in FIG. 1, it is preferable that the imaging lens of the present disclosure comprises, in order from the object side to the image side, as lens groups, only three lens groups consisting of the first lens group G1 that remains stationary with respect to the image plane Sim during focusing, the second lens group G2 that moves during focusing, and a third lens group G3 that consists of two or less lenses and remains stationary with respect to the image plane Sim during focusing. Alternatively, as shown in examples described below, it is preferable that the imaging lens of the present disclosure comprises, in order from the object side to the image side, as lens groups, only two lens groups consisting of the first lens group G1 that remains stationary with respect to the image plane Sim during focusing and the second lens group G2 that moves during focusing. The first lens group G1 remains stationary with respect to the image plane Sim and the second lens group G2 moves during focusing, and the operational effects are as described above. In a case where the lens is not disposed closer to the image side than the second lens group G2, it becomes easy to ensure the stroke of the second lens group G2, which is the focusing lens group, while suppressing an increase in total lens length. Alternatively, even in a case where the lens is disposed closer to the image side than the second lens group G2, by reducing the number of the arranged lenses to two or less, it becomes easy to ensure the stroke of the second lens group G2, which is the focusing lens group, while suppressing an increase in total lens length. Thereby, it becomes easy to increase the maximum imaging magnification. In a case where a large number of lenses are arranged closer to the image side than the second lens group G2 while maintaining the total lens length, the stroke of the second lens group G2 may be reduced and the maximum imaging magnification may be reduced. Alternatively, in a case where the refractive power of the second lens group G2 is increased in order to obtain the same maximum imaging magnification while maintaining the total lens length, various aberrations, particularly spherical aberration and field curvature, which occur in the second lens group G2, increase.

The number of lenses included in the imaging lens is preferably 13 or less, and more preferably 12 or less. By configuring the imaging lens with a small number of lenses, reduction in size and weight can be achieved.

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The number of lenses disposed closer to the object side than the aperture stop St is preferably 8 or less, and more preferably 7 or less. A lens disposed closer to the object side than the aperture stop St is likely to have a large lens outer diameter and a heavy weight. Therefore, it is preferable to keep the number of lenses closer to the object side than the aperture stop St small.

Assuming that a distance on an optical axis from a lens surface closest to the object side to the aperture stop St in a state where an object at infinity is in focus is Tf, and a sum of a distance on an optical axis from a lens surface closest to the object side to a lens surface closest to the image side and a back focal length at an air-converted distance in the state where the object at infinity is in focus is TL, it is preferable to satisfy Conditional Expression (15). The first lens group G1 disposed closest to the object side has a positive refractive power. Thus, by not allowing the result of Conditional Expression (15) to be equal to or less than the lower limit, it is possible to further reduce the height of the ray in the lens disposed closer to the image side than the aperture stop St. Thereby, there is an advantage in suppressing occurrence of various aberrations in the lens disposed closer to the image side than the aperture stop St. Further, by not allowing the result of Conditional Expression (15) to be less than or equal to the lower limit, it becomes easy to dispose as many lenses as necessary for correcting spherical aberration, longitudinal chromatic aberration, and the like at the position closer to the object side than the aperture stop St. By not allowing the result of Conditional Expression (15) to be equal to or greater than the upper limit, it is possible to suppress an increase in diameter of the lens disposed closer to the object side than the aperture stop St. Thus, it becomes easy to achieve reduction in size and weight of the whole lens system. In order to obtain more favorable characteristics, it is more preferable to satisfy Conditional Expression (15-1), and it is yet more preferable to satisfy Conditional Expression (15-2).

$$0.2 < Tf/TL < 0.65 \quad (15)$$

$$0.4 < Tf/TL < 0.64 \quad (15-1)$$

$$0.48 < Tf/TL < 0.61 \quad (15-2)$$

Assuming that a sum of a distance on an optical axis from a lens surface closest to the object side to a lens surface closest to the image side and a back focal length at an air-converted distance in a state where an object at infinity is in focus is TL, an F number of the imaging lens in the state where the object at infinity is in focus is FNo, and a focal length of the imaging lens in the state where the object at infinity is in focus is f, it is preferable that Conditional Expression (5) is satisfied. By not allowing the result of Conditional Expression (5) to be equal to or less than the lower limit, there is an advantage in satisfactorily correcting various aberrations. More specifically, it becomes easy to arrange the optimum number of lenses to correct various aberrations. Thus, there is an advantage in obtaining higher imaging performance. By not allowing the result of Conditional Expression (5) to be equal to or greater than the upper limit, there is an advantage in suppressing an increase in size of the lens system. In order to obtain more favorable characteristics, it is more preferable to satisfy Conditional Expression (5-1), and it is yet more preferable to satisfy Conditional Expression (5-2).

$$1.5 < TL \times FNo/f < 5 \quad (5)$$

$$1.8 < TL \times FNo/f < 3.5 \quad (5-1)$$

$$2 < TL \times FNo/f < 3.2 \quad (5-2)$$

Assuming that a maximum half angle of view of the imaging lens in a state where an object at infinity is in focus is  $\omega_{\max}$ , and an F number of the imaging lens in the state where the object at infinity is in focus is  $F_{No}$ , it is preferable to satisfy Conditional Expression (11). Considering Conditional Expression (11) on the assumption that a small F number is maintained, the smaller the value of  $1/\{\tan(\omega_{\max}) \times F_{No}\}$  of Conditional Expression (11) is, the lens system becomes a wider-angle type optical system. As the value becomes larger, the lens system becomes closer to the telephoto type optical system. In a case where the result of Conditional Expression (11) is equal to or less than the lower limit while a small F number is maintained, it becomes difficult to correct sagittal coma aberration. In order to correct sagittal coma aberration, the number of lenses of the first lens group G1 having a large outer diameter increases. As a result, there is a problem in that the size of the lens system may increase. On the other hand, in a case where the result of Conditional Expression (11) is equal to or greater than the upper limit while a small F number is maintained, the entrance pupil diameter becomes large and the diameter of the whole lens system becomes large. As a result, there is a problem in that the size of the lens system may increase. Alternatively, there is a problem in that it may be necessary to increase the total lens length in order to correct longitudinal chromatic aberration that occurs as the lens system becomes closer to a telephoto type optical system. As described above, by satisfying Conditional Expression (11), there is an advantage in achieving both a small F number and reduction in size of the lens system. In order to obtain more favorable characteristics, it is more preferable to satisfy Conditional Expression (11-1), and it is yet more preferable to satisfy Conditional Expression (11-2).

$$1.8 < 1/\{\tan(\omega_{\max}) \times F_{No}\} < 4.5 \quad (11)$$

$$2.4 < 1/\{\tan(\omega_{\max}) \times F_{No}\} < 4.2 \quad (11-1)$$

$$2.8 < 1/\{\tan(\omega_{\max}) \times F_{No}\} < 3.8 \quad (11-2)$$

Next, a possible configuration example of the imaging lens of the present disclosure will be described. In each of the first to fifteenth configuration examples described below, only the second lens group G2 is configured to move along the optical axis Z during focusing. In the following description of the configuration examples, "first", "second" and the like attached to the cemented lenses are given for each configuration example. Therefore, for example, even in the case of the "first cemented lens", the configurations of the lenses included in the cemented lens may be different in a case where the configuration examples are different.

The imaging lens of the first configuration example consists of, in order from the object side, a first lens group G1, an aperture stop St, a second lens group G2, and a third lens group G3. The first lens group G1 consists of, in order from the object side, a biconcave lens, a positive lens convex toward the image side, two positive meniscus lenses each of which is convex toward the object side, a first cemented lens, and a negative meniscus lens convex toward the object side. The first cemented lens is configured such that a positive meniscus lens convex toward the object side and a negative meniscus lens convex toward the object side are cemented in order from the object side. The second lens group G2 consists of, in order from the object side, a negative meniscus lens concave toward the object side, a second cemented lens, and a third cemented lens. The second cemented lens is formed by cementing a biconvex lens and a biconcave lens in order from the object side. The third cemented lens is

formed by cementing a biconvex lens and a negative lens concave toward the object side in order from the object side. The third lens group G3 consists of only biconvex lenses.

The imaging lens of the second configuration example 5 consists of, in order from the object side, a first lens group G1, an aperture stop St, and a second lens group G2. The first lens group G1 and the second lens group G2 of the second configuration example are the same as the first lens group G1 and the second lens group G2 of the first configuration example, respectively.

The imaging lens of the third configuration example 15 consists of, in order from the object side, a first lens group G1, an aperture stop St, and a second lens group G2. The first lens group G1 consists of, in order from the object side, a biconcave lens, a positive meniscus lens convex toward the object side, a biconvex lens, a positive meniscus lens convex toward the object side, a first cemented lens, and a negative meniscus lens convex toward the object side. The first cemented lens is configured such that a positive meniscus lens 20 convex toward the object side and a negative meniscus lens convex toward the object side are cemented in order from the object side. The second lens group G2 consists of, in order from the object side, a second cemented lens, a negative meniscus lens concave toward the object side, and a third cemented lens. The second cemented lens is formed by cementing a biconcave lens and a biconvex lens in order from the object side. The third cemented lens is formed by cementing a biconvex lens and a biconcave lens in order from the object side.

The imaging lens of the fourth configuration example 30 consists of, in order from the object side, a first lens group G1, an aperture stop St, and a second lens group G2. The first lens group G1 consists of, in order from the object side, a biconcave lens, a biconvex lens, three positive lenses convex toward the object side, a first cemented lens, and a negative meniscus lens convex toward the object side. The first cemented lens is formed by cementing a biconvex lens and a biconcave lens in order from the object side. The second lens group G2 consists of, in order from the object side, a second cemented lens, a biconcave lens, and a third cemented lens. The second cemented lens is formed by cementing a biconcave lens and a biconvex lens in order from the object side. The third cemented lens is formed by cementing a biconvex lens and a negative meniscus lens concave toward the object side in order from the object side.

The imaging lens of the fifth configuration example 40 consists of, in order from the object side, a first lens group G1, an aperture stop St, and a second lens group G2. The first lens group G1 consists of, in order from the object side, a biconcave lens, a biconvex lens, three positive meniscus lenses each of which is convex toward the object side, and two negative meniscus lenses convex toward the object side. The second lens group G2 consists of, in order from the object side, a negative meniscus lens concave toward the object side, a first cemented lens, and a second cemented lens. The first cemented lens is formed by cementing a biconvex lens and a biconcave lens in order from the object side. The third cemented lens is formed by cementing a biconvex lens and a negative meniscus lens concave toward the object side in order from the object side.

The imaging lens of the sixth configuration example 50 consists of, in order from the object side, a first lens group G1, an aperture stop St, a second lens group G2, and a third lens group G3. The first lens group G1 consists of, in order from the object side, three positive meniscus lenses each of which is convex toward the object side, a first cemented lens, and a second cemented lens. The first cemented lens is

formed by cementing a negative meniscus lens convex toward the object side and a biconvex lens in order from the object side. The second cemented lens is formed by cementing a biconcave lens and a positive meniscus lens convex toward the object side in order from the object side. The second lens group G2 consists of, in order from the object side, a third cemented lens and a fourth cemented lens. The third cemented lens is formed by cementing a biconcave lens and a biconvex lens in order from the object side. The fourth cemented lens is formed by cementing a positive meniscus lens concave toward the object side and a biconcave lens in order from the object side. The third lens group G3 consists of, in order from the object side, a biconvex lens, a fifth cemented lens, a biconvex lens, and a biconcave lens. The fifth cemented lens is formed by cementing a positive lens convex toward the image side and a biconcave lens in order from the object side.

The imaging lens of the seventh configuration example consists of, in order from the object side, a first lens group G1, an aperture stop St, a second lens group G2, and a third lens group G3. The first lens group G1 consists of, in order from the object side, a biconcave lens, a biconvex lens, two positive meniscus lenses each of which is convex toward the object side, a first cemented lens, and a second cemented lens. The first cemented lens is formed by cementing a negative meniscus lens convex toward the object side and a biconvex lens in order from the object side. The second cemented lens is formed by cementing a biconcave lens and a positive lens convex toward the object side in order from the object side. The second lens group G2 and the third lens group G3 of the seventh configuration example are similar to the second lens group G2 and the third lens group G3 of the sixth configuration example, respectively.

The imaging lens of the eighth configuration example consists of, in order from the object side, a first lens group G1 and a second lens group G2. The first lens group G1 consists of, in order from the object side, a biconcave lens, a first cemented lens, a biconvex lens, a second cemented lens, a biconvex lens, and a positive meniscus lens convex toward the object side. The first cemented lens is formed by cementing a biconcave lens and a biconvex lens in order from the object side. The second cemented lens is formed by cementing a biconvex lens and a negative meniscus lens concave toward the object side in order from the object side. The second lens group G2 consists of, in order from the object side, a positive meniscus lens convex toward the object side, a third cemented lens, an aperture stop St, a negative meniscus lens concave toward the object side, and a fourth cemented lens. The third cemented lens is formed by cementing a biconvex lens and a biconcave lens in order from the object side. The fourth cemented lens is formed by cementing a biconvex lens, a biconcave lens, and a biconvex lens in order from the object side.

The imaging lens of the ninth configuration example consists of, in order from the object side, a first lens group G1 and a second lens group G2. The first lens group G1 consists of, in order from the object side, a positive lens convex toward the image side, a biconcave lens, a first cemented lens, a second cemented lens, a biconvex lens, and a positive meniscus lens convex toward the object side. The first cemented lens is formed by cementing a biconcave lens and a biconvex lens in order from the object side. The second cemented lens is formed by cementing a biconvex lens and a negative meniscus lens concave toward the object side in order from the object side. The second lens group G2 consists of, in order from the object side, a positive meniscus lens convex toward the object side, a third cemented lens, an

aperture stop St, a fourth cemented lens, and a biconvex lens. The third cemented lens is formed by cementing a biconvex lens and a biconcave lens in order from the object side. The fourth cemented lens is configured such that a negative meniscus lens concave toward the object side and a positive meniscus lens concave toward the object side are cemented in order from the object side.

The imaging lens of the tenth configuration example consists of, in order from the object side, a first lens group G1 and a second lens group G2. The first lens group G1 of the tenth configuration example is similar to the first lens group G1 of the ninth configuration example. The second lens group G2 of the tenth configuration example consists of, in order from the object side, a positive meniscus lens convex toward the object side, a third cemented lens, an aperture stop St, a negative meniscus lens concave toward the object side, a positive meniscus lens concave toward the object side, and a fourth cemented lens. The third cemented lens is formed by cementing a biconvex lens and a biconcave lens in order from the object side. The fourth cemented lens is formed by cementing a biconvex lens and a biconcave lens in order from the object side.

The imaging lens of the eleventh configuration example consists of, in order from the object side, a first lens group G1, a second lens group G2, and a third lens group G3. The first lens group G1 consists of, in order from the object side, a positive meniscus lens convex toward the image side, a biconcave lens, a biconvex lens, a first cemented lens, and a second cemented lens. The first cemented lens is formed by 25 cementing a biconcave lens and a biconvex lens in order from the object side. The second cemented lens is formed by 30 cementing a biconvex lens and a negative meniscus lens concave toward the object side in order from the object side. The second lens group G2 consists of, in order from the 35 object side, a positive meniscus lens convex toward the object side, a third cemented lens, an aperture stop St, a fourth cemented lens, and a biconvex lens. The third cemented lens is formed by cementing a biconvex lens and a biconcave lens in order from the object side. The fourth 40 cemented lens is formed by cementing a biconcave lens and a biconvex lens in order from the object side. The third lens group G3 consists of a cemented lens in which a positive meniscus lens concave toward the object side and a negative meniscus lens concave toward the object side are cemented 45 in order from the object side.

The imaging lens of the twelfth configuration example consists of, in order from the object side, a first lens group G1 and a second lens group G2. The first lens group G1 consists of, in order from the object side, a biconcave lens, 50 a first cemented lens, a biconvex lens, a second cemented lens, a third cemented lens, and a biconvex lens. The first cemented lens is formed by cementing a biconcave lens and a biconvex lens in order from the object side. The second cemented lens is formed by cementing a biconcave lens and 55 a positive meniscus lens convex toward the object side in order from the object side. The third cemented lens is formed by cementing a biconvex lens and a negative meniscus lens concave toward the object side in order from the object side. The second lens group G2 consists of, in order from the 60 object side, a positive meniscus lens convex toward the object side, a fourth cemented lens, an aperture stop St, a biconcave lens, and a fifth cemented lens. The fourth cemented lens is formed by cementing a biconvex lens and a biconcave lens in order from the object side. The fifth cemented lens is formed by cementing a biconvex lens, a 65 biconcave lens, and a biconvex lens in order from the object side.

The imaging lens of the thirteenth configuration example consists of, in order from the object side, a first lens group G1, an aperture stop St, a second lens group G2, and a third lens group G3. The first lens group G1 consists of, in order from the object side, a biconcave lens, a first cemented lens, a biconvex lens, a second cemented lens, a third cemented lens, two positive meniscus lenses each of which is convex toward the object side, a fourth cemented lens, and a negative meniscus lens convex toward the object side. The first cemented lens is formed by cementing a biconcave lens and a biconvex lens in order from the object side. The second cemented lens is formed by cementing a positive meniscus lens concave toward the object side and a biconcave lens in order from the object side. The third cemented lens is formed by cementing a biconvex lens and a negative meniscus lens concave toward the object side in order from the object side. The fourth cemented lens is formed by cementing a biconvex lens and a biconcave lens in order from the object side. The second lens group G2 consists of, in order from the object side, a negative meniscus lens concave toward the object side, and a fifth cemented lens. The fifth cemented lens is formed by cementing a biconvex lens, a biconcave lens, and a biconvex lens in order from the object side. The third lens group G3 consists of only a plano-concave lens concave toward the object side.

The imaging lens of the fourteenth configuration example consists of, in order from the object side, a first lens group G1, an aperture stop St, and a second lens group G2. The first lens group G1 consists of, in order from the object side, a biconcave lens, a first cemented lens, a biconvex lens, a biconcave lens, a second cemented lens, a biconvex lens, a positive meniscus lens convex toward the object side, a third cemented lens, and a negative meniscus lens convex toward the object side. The first cemented lens is formed by cementing a biconcave lens and a biconvex lens in order from the object side. The second cemented lens is formed by cementing a biconvex lens and a negative meniscus lens concave toward the object side in order from the object side. The third cemented lens is formed by cementing a biconvex lens and a biconcave lens in order from the object side. The second lens group G2 consists of, in order from the object side, a biconcave lens, a fourth cemented lens, and a biconvex lens. The fourth cemented lens is formed by cementing a biconvex lens and a biconcave lens in order from the object side.

The imaging lens of the fifteenth configuration example consists of, in order from the object side, a first lens group G1, an aperture stop St, a second lens group G2, and a third lens group G3. The first lens group G1 consists of, in order from the object side, a biconcave lens, a first cemented lens, a biconvex lens, a second cemented lens, a third cemented lens, a biconvex lens, two positive meniscus lenses each of which is convex toward the object side, a fourth cemented lens, and a negative meniscus lens convex toward the object side. The first cemented lens is formed by cementing a biconcave lens and a biconvex lens in order from the object side. The second cemented lens is formed by cementing a positive meniscus lens concave toward the object side and a biconcave lens in order from the object side. The third cemented lens is formed by cementing a biconvex lens and a negative meniscus lens concave toward the object side in order from the object side. The fourth cemented lens is formed by cementing a biconvex lens and a biconcave lens in order from the object side. The second lens group G2 consists of, in order from the object side, a negative meniscus lens concave toward the object side, and a fifth cemented lens. The fifth cemented lens is formed by cementing,

order from the object side, a biconvex lens, a negative meniscus lens concave toward the object side, and a positive meniscus lens concave toward the object side. The third lens group G3 consists of a plano-convex lens convex toward the object side.

The above-mentioned preferred configurations and available configurations may be optional combinations, and it is preferable to selectively adopt the configurations in accordance with required specification. According to the technology of the present disclosure, it is possible to realize a suitable imaging lens which has a small F number and in which aberration is satisfactorily corrected.

Next, numerical examples of the imaging lens of the present disclosure will be described.

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### Example 1

FIG. 1 shows a cross-sectional configuration of an imaging lens of Example 1, and an illustration method and a configuration thereof is as described above. Therefore, repeated description is partially omitted herein. The imaging lens of Example 1 consists of, in order from the object side, a first lens group G1 that has a positive refractive power, an aperture stop St, a second lens group G2 that has a positive refractive power, and a third lens group G3 that has a positive refractive power. During focusing from the object at infinity to the closest object, the first lens group G1 and the third lens group G3 remain stationary with respect to the image plane Sim, and the second lens group G2 moves to the object side along the optical axis Z. The first lens group G1 consists of seven lenses L1a to L1g in order from the object side. The second lens group G2 consists of five lenses L2a to L2e in order from the object side. The third lens group G3 consists of one lens L3a.

Regarding the imaging lens of Example 1, Table 1 shows basic lens data, Table 2 shows a specification, Table 3 shows variable surface distances, and Table 4 shows aspheric surface coefficients. In Table 1, the column of Sn shows surface numbers. The surface closest to the object side is the first surface, and the surface numbers increase one by one toward the image side. The column of R shows radii of curvature of the respective surfaces. The column of D shows surface distances on the optical axis between the respective surfaces and the surfaces adjacent to the image side. Further, the column of Nd shows a refractive index of each constituent element at the d line, the column of vd shows an Abbe number of each constituent element based on the d line, and the column of  $\theta_{\text{gF}}$  shows a partial dispersion ratio of each constituent element between the g line and the F line.

In Table 1, the sign of the radius of curvature of the surface convex toward the object side is positive and the sign of the radius of curvature of the surface convex toward the image side is negative. Table 1 also shows the aperture stop St and the optical member PP, and in the column of the surface number of the surface corresponding to the aperture stop St, the surface number and (St) are noted. A value at the bottom place of D in Table 1 indicates a distance between the image plane Sim and the surface closest to the image side in the table. In Table 1, the variable surface distances, which are distances variable during focusing, are referenced by the reference signs DD[ ], and are written into places of D, where object side surface numbers of distances are noted in [ ].

Table 2 shows values of the focal length f, the F number FNo., and the maximum total angle of view  $2\omega_{\text{max}}$  of the imaging lens. FNo. is the same as FNo used in the above conditional expression. The unit of  $2\omega_{\text{max}}$  is degree. The

values shown in Table 2 are values in the case of using the d line as a reference in a state where the object at infinity is in focus.

In Table 3, the column labelled "Infinity" shows values of the variable surface distance in the state where the object at infinity is in focus and the column labelled "0.7 m" shows values of the variable surface distance in the state where an object at a distance of 0.7 m (meters) from the object to the image plane Sim is in focus.

In Table 1, the reference sign \* is attached to surface numbers of aspheric surfaces, and numerical values of the paraxial radius of curvature are written into the column of the radius of curvature of the aspheric surface. In Table 4, the row of Sn shows surface numbers of the aspheric surfaces, and the rows of KA and Am (m is an integer of 3 or more, and is different for each surface) shows numerical values of the aspheric surface coefficients for each aspheric surface. The "E±n" (n: an integer) in numerical values of the aspheric surface coefficients of Table 4 indicates " $10^{\pm n}$ ". KA and Am are the aspheric surface coefficients in the aspheric surface expression represented by the following expression.

$$Zd = C \times h^2 / \{1 + (1 - KA \times C^2 \times h^2)^{1/2}\} + \sum Am \times h^m$$

Zd is an aspheric surface depth (a length of a perpendicular from a point on an aspheric surface at height h to a plane that is perpendicular to the optical axis and contacts with the vertex of the aspheric surface),

h is a height (a distance from the optical axis to the lens surface),

C is an inverse of paraxial radius of curvature,

KA and Am are aspheric surface coefficients, and

$\Sigma$  in the aspheric surface expression means the sum with respect to m.

In data of each table, a degree is used as a unit of an angle, and mm (millimeter) is used as a unit of a length, but appropriate different units may be used since the optical system can be used even in a case where the system is enlarged or reduced in proportion. Further, each of the following tables shows numerical values rounded off to predetermined decimal places.

TABLE 1

Sn	R	D	Nd	vd	Example 1	
					θgF	
1	-202.46222	2.400	1.61750	36.25	0.58409	
2	84.17703	10.655				
3	116.82988	10.000	1.45860	90.19	0.53516	
4	-99.70316	1.010				
5	58.97589	6.168	2.00272	19.32	0.64514	
6	157.48112	0.200				
7	39.80574	10.250	1.59282	68.62	0.54414	
8	93.85195	0.200				
9	32.50135	7.910	1.53945	63.48	0.53990	
10	113.27635	1.500	1.85896	22.73	0.62844	
11	30.08960	2.350				
12	48.57213	1.500	1.98613	16.48	0.66558	
13	23.70172	7.000				
14(St)	∞	DD[14]				
*15	-16.62654	1.800	1.68948	31.02	0.59874	
*16	-20.47694	0.200				
17	46.52462	7.524	1.95375	32.32	0.59015	
18	-24.94567	1.110	1.78555	25.72	0.61045	
19	32.92450	1.205				
20	53.58123	8.896	1.95375	32.32	0.59015	
21	-21.67977	1.210	1.63849	34.39	0.58799	
22	121.65386	DD[22]				
23	350.00000	2.000	1.90602	23.33	0.62075	
24	-350.00000	12.401				

TABLE 1-continued

Sn	R	D	Example 1		
			Nd	vd	θgF
25	∞		2.850	1.51680	64.20
26	∞		1.000		0.53430

TABLE 2

Example 1		
f		51.529
FNo.		1.03
2ωmax		30.6

TABLE 3

Example 1		
Infinity		0.7 m
DD[14]	11.000	5.227
DD[22]	1.004	6.777

TABLE 4

Sn	Example 1	
	15	16
KA	1.0000000E+00	1.0000000E+00
A3	0.0000000E+00	0.0000000E+00
A4	1.4134736E-05	1.5709981E-05
A5	2.6259559E-05	2.5965284E-05
A6	-3.3907589E-06	-4.2475360E-06
A7	-2.4053109E-07	-1.2459177E-08
A8	1.0812258E-07	1.0406812E-07
A9	-2.4866912E-09	-8.5930892E-09
A10	-1.7843185E-09	-1.0929846E-09
A11	1.2258615E-10	1.6907154E-10
A12	1.6697433E-11	4.3662373E-12
A13	-1.8317390E-12	-1.5987613E-12
A14	-7.6120774E-14	1.5886683E-14
A15	1.4012767E-14	8.3615812E-15
A16	2.5265457E-17	-2.3879418E-16
A17	-5.5017957E-17	-2.3215598E-17
A18	1.1014057E-18	9.2450531E-19
A19	8.7746514E-20	2.6760815E-20
A20	-2.9531051E-21	-1.2643529E-21

FIGS. 2 and 3 each show aberration diagrams of the imaging lens of Example 1. FIG. 2 shows spherical aberration diagrams, astigmatism diagrams, distortion diagrams, and lateral chromatic aberration diagrams in order from the left. In FIG. 2, the upper part labeled "INFINITY" shows aberration diagrams in a state where the object at infinity is in focus, and the lower part labeled "0.7 m" shows aberration diagrams in a state where an object at the distance of 0.7 m (meter) from the object to the image plane Sim is in focus. In the spherical aberration diagram, aberrations at the d line, the C line, the F line, and the g line are indicated by the solid line, the long dashed line, the short dashed line, and the chain line, respectively. In the astigmatism diagram, aberration in the sagittal direction at the d line is indicated by the solid line, and aberration in the tangential direction at the d line is indicated by the short dashed line. In the distortion diagram, aberration at the d line is indicated by the solid line. In the lateral chromatic aberration diagram, aberrations at the C line, the F line, and the g line are respectively indicated

by the long dashed line, the short dashed line, and the chain line. In the spherical aberration diagram, FNo. indicates an F number. In the other aberration diagrams,  $\omega$  indicates a half angle of view. In FIG. 2, values of FNo. and  $w$  corresponding to the upper part in the vertical axis of each diagram are shown next to “=”.<sup>5</sup>

FIG. 3 shows lateral aberration diagram in a state where the object at infinity is in focus. The left column shows tangential aberration and the right column shows sagittal aberration for each angle of view. In FIG. 3,  $w$  means a half angle of view. In the lateral aberration diagram, aberrations at the d line, the C line, the F line, and the g line are indicated by the solid line, the long dashed line, the short dashed line, and the chain line, respectively.<sup>10</sup>

Symbols, meanings, description methods, and illustration methods of the respective data pieces according to Example 1 are the same as those in the following examples unless otherwise noted. Therefore, in the following description, repeated description will be partially omitted.<sup>15</sup>

### Example 2

FIG. 4 shows a cross-sectional configuration of the imaging lens of Example 2. The imaging lens of Example 2 consists of, in order from the object side, the first lens group G1 that has a positive refractive power, the aperture stop St, and the second lens group G2 that has a positive refractive power. During focusing from the object at infinity to the closest object, the first lens group G1 remains stationary with respect to the image plane Sim, and the second lens group G2 moves to the object side along the optical axis Z. The first lens group G1 consists of seven lenses L1a to L1g in order from the object side. The second lens group G2 consists of five lenses L2a to L2e in order from the object side.<sup>20</sup>

Regarding the imaging lens of Example 2, Table 5 shows basic lens data, Table 6 shows specification, Table 7 shows variable surface distances, Table 8 shows aspheric surface coefficients, and FIGS. 5 and 6 show aberration diagrams. In FIG. 5, the upper part shows aberration diagrams in a state where the object at infinity is in focus, and the lower part shows aberration diagrams in a state where the object at the distance of 0.75 m (meter) from the object to the image plane Sim is in focus. FIG. 6 shows lateral aberration diagram in a state where the object at infinity is in focus.<sup>30</sup>

TABLE 5

Sn	R	D	Nd	vd	Example 2	
					$\theta_{gF}$	
1	-147.83201	2.400	1.56607	42.61	0.57194	
2	86.55844	13.196				
3	-1112.59959	10.000	1.49700	81.61	0.53887	
4	-74.96995	1.010				
5	56.10284	7.350	1.92286	20.88	0.63900	
6	168.76278	0.200				
7	39.99940	10.364	1.49700	81.61	0.53887	
8	153.92109	0.200				
9	33.63361	9.003	1.58350	61.79	0.54178	
10	143.73093	1.500	1.89286	20.36	0.63944	
11	32.94000	2.350				
12	58.54173	1.500	1.98613	16.48	0.66558	
13	26.84925	7.000				
14(St)	$\infty$	DD[14]				
*15	-16.34007	2.374	1.68948	31.02	0.59874	
*16	-20.92321	0.200				
17	46.16889	5.601	2.00100	29.13	0.59952	
18	-34.75772	1.110	1.82933	23.53	0.61772	

TABLE 5-continued

Sn	R	D	Nd	Example 2	
				vd	$\theta_{gF}$
19	36.00359	1.259			
20	65.48463	7.692	2.00100	29.13	0.59952
21	-21.60337	1.210	1.72399	28.80	0.60142
22	-221.70851	DD[22]			
23	$\infty$	2.850	1.51680	64.20	0.53430
24	$\infty$	1.000			

TABLE 6

f	Example 2	
	FNo.	z <sub>0max</sub>
	48.912	
	1.03	
	32.2	

TABLE 7

Infinity	Example 2	
	DD[14]	DD[22]
	11.000	6.974
	15.398	19.418

TABLE 8

Sn	Example 2	
	15	16
K4	1.0000000E+00	1.0000000E+00
A3	0.0000000E+00	0.0000000E+00
A4	1.1642920E-05	1.4474213E-05
A5	2.1306014E-05	2.0258437E-05
A6	-3.3814546E-06	-4.0400080E-05
A7	-1.9812243E-07	4.7913832E-08
A8	1.0663262E-07	9.6017868E-08
A9	-1.5803952E-09	-8.4598138E-09
A10	-1.8092896E-09	-9.9449719E-10
A11	9.0694353E-11	1.5710711E-10
A12	1.8185970E-11	4.0001956E-12
A13	-1.4218748E-12	-1.4517868E-12
A14	-9.8519189E-14	1.3061204E-14
A15	1.1294372E-14	7.4850181E-15
A16	1.8703189E-16	-2.0136740E-16
A17	-4.5775183E-17	-2.0557864E-17
A18	5.1939904E-19	7.6973691E-19
A19	7.4994186E-20	2.3482464E-20
A20	-2.1146255E-21	-1.0301864E-21

Example 3

FIG. 7 shows a cross-sectional configuration of the imaging lens of Example 3. The imaging lens of Example 3 consists of, in order from the object side, the first lens group G1 that has a positive refractive power, the aperture stop St, and the second lens group G2 that has a positive refractive power. During focusing from the object at infinity to the closest object, the first lens group G1 remains stationary with respect to the image plane Sim, and the second lens group G2 moves to the object side along the optical axis Z. The first lens group G1 consists of seven lenses L1a to L1g in order from the object side. The second lens group G2 consists of five lenses L2a to L2e in order from the object side.<sup>55</sup>

Regarding the imaging lens of Example 3, Table 9 shows basic lens data, Table 10 shows specification, Table 11 shows variable surface distances, Table 12 shows aspheric surface coefficients, and FIGS. 8 and 9 show aberration diagrams. In FIG. 8, the upper part shows aberration diagrams in a state where the object at infinity is in focus, and the lower part shows aberration diagrams in a state where the object at the distance of 0.7 m (meter) from the object to the image plane Sim is in focus. FIG. 9 shows lateral aberration diagram in a state where the object at infinity is in focus.

TABLE 9

Example 3					
Sn	R	D	Nd	vd	θgF
1	-138.62827	2.400	1.54072	47.23	0.56780
2	58.55723	10.030			
3	75.89616	11.800	1.59282	68.62	0.54414
4	-105.01257	0.200			
5	45.45982	10.800	1.59282	68.62	0.54414
6	399.21443	0.600			
7	44.95362	4.320	1.95906	17.47	0.65993
8	63.84817	0.600			
9	36.12697	5.270	1.78800	47.52	0.55545
10	60.17700	1.800	1.89286	20.36	0.63944
11	31.65635	4.565			
12	177.12407	1.520	1.80809	22.76	0.63073
13	27.86122	6.406			
14(St)	∞	DD[14]			
*15	-14.64464	2.550	1.68863	31.20	0.60109
*16	-18.73058	0.200			
17	49.66071	6.450	1.88300	39.22	0.57295
18	-32.52200	1.210	1.69895	30.05	0.60174
19	32.52200	0.820			
20	42.22428	8.800	1.88300	39.22	0.57295
21	-28.75400	1.210	1.62005	36.35	0.58602
22	-178.14293	DD[22]			
23	∞	2.850	1.51680	64.20	0.53430
24	∞	1.000			

TABLE 10

Example 3		
f	49.549	
FNo.	1.03	
Zoomax	31.4	

TABLE 11

Example 3		
Infinity	0.7 m	
DD[14]	11.466	7.025
DD[22]	14.401	18.842

TABLE 12

Example 3		
Sn	15	16
KA	1.0000000E+00	1.0000000E+00
A3	0.0000000E+00	0.0000000E+00
A4	5.0823068E-05	3.9661172E-05
A5	5.6696216E-06	7.3155985E-06
A6	-1.1665918E-06	-1.9241870E-06
A7	2.3011235E-07	2.0632606E-07
A8	-8.5462646E-09	2.7709406E-08
A9	-3.9871990E-09	-6.9926396E-09

TABLE 12-continued

Example 3					
Sn	15	16			
5	A10	5.8946218E-10	-2.2702122E-11		
	A11	6.8551648E-12	9.8429055E-11		
	A12	-7.4371184E-12	-3.5432557E-12		
	A13	3.9451971E-13	-7.7218349E-13		
	A14	3.7621265E-14	4.3918443E-14		
10	A15	-4.2785117E-15	3.5209637E-15		
	A16	-2.5668735E-17	-2.5005394E-16		
	A17	1.8252095E-17	-8.7077803E-18		
	A18	-4.3536351E-19	7.1579377E-19		
	A19	-2.9072588E-20	9.0040531E-21		
	A20	1.1528202E-21	-8.3059544E-22		

Example 4

FIG. 10 shows a cross-sectional configuration of the imaging lens of Example 4. The imaging lens of Example 4 consists of, in order from the object side, the first lens group G1 that has a positive refractive power, the aperture stop St, and the second lens group G2 that has a positive refractive power. During focusing from the object at infinity to the closest object, the first lens group G1 remains stationary with respect to the image plane Sim, and the second lens group G2 moves to the object side along the optical axis Z. The first lens group G1 consists of seven lenses L1a to L1g in order from the object side. The second lens group G2 consists of five lenses L2a to L2e in order from the object side.

Regarding the imaging lens of Example 4, Table 13 shows basic lens data, Table 14 shows specification, Table 15 shows variable surface distances, Table 16 shows aspheric surface coefficients, and FIGS. 11 and 12 show aberration diagrams. In FIG. 11, the upper part shows aberration diagrams in a state where the object at infinity is in focus, and the lower part shows aberration diagrams in a state where the object at the distance of 0.6 m (meter) from the object to the image plane Sim is in focus. FIG. 12 shows lateral aberration diagram in a state where the object at infinity is in focus.

TABLE 13

Example 4						
Sn	R	D	Nd	vd	θgF	
45	1	-184.15927	2.400	1.80000	29.84	0.60178
	2	62.61647	4.878			
	3	98.51388	6.313	1.98613	16.48	0.66558
	4	4034.13252	1.100			
	5	63.34975	10.200	1.59282	68.62	0.54414
	6	-296.07052	0.200			
	7	44.03004	10.250	1.59282	68.62	0.54414
	8	795.08982	0.200			
	9	34.85519	7.910	1.87070	40.73	0.56825
	10	121.35104	1.500	1.89286	20.36	0.63944
	11	41.54155	2.500			
	12	103.47070	1.500	1.85896	22.73	0.62844
	13	22.43821	7.000			
	14(St)	∞	DD[14]			
50	15	-23.29314	1.110	1.59270	35.31	0.59336
	16	23.13973	7.642	1.88300	39.22	0.57295
	17	-49.13842	0.500			
	*18	-31.45625	2.200	1.68948	31.02	0.59874
	*19	-35.44240	0.100			
	20	57.70265	8.669	1.88300	39.22	0.57295
55	21	-29.44571	1.210	1.59270	35.31	0.59336
	22	455.30805	DD[22]			

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TABLE 13-continued

Example 4					
Sn	R	D	Nd	vd	$\theta gF$
23	$\infty$	2.850	1.51680	64.20	0.53430
24	$\infty$	1.000			

TABLE 14

Example 4		
f	48.495	
FNo.	1.03	
$2\omega_{max}$	32.4	

TABLE 15

Example 4		
Infinity	0.6 m	
DD[14]	10.100	5.021
DD[22]	14.402	19.481

TABLE 16

Example 4		
Sn	18	19
KA	1.000000E+00	1.000000E+00
A3	0.000000E+00	0.000000E+00
A4	-4.1880254E-05	-1.8080969E-05
A5	2.2277957E-05	1.7658879E-05
A6	-1.0486644E-06	-1.2728716E-06
A7	-6.0774700E-07	-2.8821944E-07
A8	6.5534778E-08	3.8775713E-08
A9	9.8049532E-09	3.2995970E-09
A10	-1.3866580E-09	-5.0968526E-10
A11	-9.2054942E-11	-2.6981943E-11
A12	1.6184890E-11	3.7414083E-12
A13	4.5994752E-13	1.6196819E-13
A14	-1.1024413E-13	-1.4531348E-14
A15	-7.7379704E-16	-6.8886559E-16
A16	4.2085620E-16	1.7953337E-17
A17	-2.3252064E-18	1.8140969E-18
A18	-7.7399797E-19	5.5970230E-20
A19	8.4567070E-21	-2.1514981E-21
A20	4.0991440E-22	-1.5749796E-22

Example 5

FIG. 13 shows a cross-sectional configuration of the imaging lens of Example 5. The imaging lens of Example 5 consists of, in order from the object side, the first lens group G1 that has a positive refractive power, the aperture stop St, and the second lens group G2 that has a positive refractive power. During focusing from the object at infinity to the closest object, the first lens group G1 remains stationary with respect to the image plane Sim, and the second lens group G2 moves to the object side along the optical axis Z. The first lens group G1 consists of seven lenses L1a to L1g in order from the object side. The second lens group G2 consists of five lenses L2a to L2e in order from the object side.

Regarding the imaging lens of Example 5, Table 17 shows basic lens data, Table 18 shows specification, Table 19 shows variable surface distances, Table 20 shows aspheric

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surface coefficients, and FIGS. 14 and 15 show aberration diagrams. In FIG. 14, the upper part shows aberration diagrams in a state where the object at infinity is in focus, and the lower part shows aberration diagrams in a state where the object at the distance of 0.6 m (meter) from the object to the image plane Sim is in focus. FIG. 15 shows lateral aberration diagram in a state where the object at infinity is in focus.

10

TABLE 17

Example 5					
Sn	R	D	Nd	vd	$\theta gF$
1	-165.93122	2.400	1.56037	43.68	0.57006
2	76.27518	8.339			
3	203.54358	10.000	1.59522	67.73	0.54426
4	-111.87010	1.010			
5	56.74170	5.365	1.89286	20.36	0.63944
6	102.45084	0.200			
7	44.31471	10.250	1.59522	67.73	0.54426
8	292.61942	0.200			
9	32.85510	8.595	1.69253	56.87	0.54266
10	115.66155	1.500	1.78472	25.68	0.61052
11	31.63618	2.819			
12	63.52660	1.500	1.89286	20.36	0.63944
13	23.88347	7.000			
14(St)	$\infty$	DD[14]			
*15	-16.34570	2.837	1.68948	31.02	0.59874
*16	-22.88973	0.200			
17	45.14005	6.141	1.90043	37.37	0.57720
18	-33.79047	1.110	1.70834	29.58	0.59931
19	33.20670	1.120			
20	51.98052	8.500	1.90043	37.37	0.57720
21	-22.44701	1.210	1.60763	37.24	0.58209
22	-201.05993	DD[22]			
23	$\infty$	2.850	1.54763	54.98	0.55247
24	$\infty$	1.000			

35

TABLE 18

Example 5		
f	50.617	
FNo.	1.03	
$2\omega_{max}$	31.4	

45

TABLE 19

Example 5		
Sn	15	16
DD[14]	11.000	5.612
DD[22]	15.436	20.824

55

TABLE 20

Example 5		
Sn	15	16
KA	1.000000E+00	1.000000E+00
A3	0.000000E+00	0.000000E+00
A4	3.1181867E-05	2.6530803E-05
A5	1.4794096E-05	1.5226995E-05
A6	-2.8122797E-06	-3.5186055E-06
A7	8.9003214E-08	2.0389209E-07
A8	6.9213577E-08	7.3115649E-08
A9	-8.7233682E-09	-1.1688257E-08
A10	-8.1799110E-10	-5.0238456E-10
A11	1.9725575E-10	1.9915512E-10

TABLE 20-continued

Sn	15	16
A12	3.0890969E-12	-2.4972651E-12
A13	-2.3953381E-12	-1.7930323E-12
A14	4.0298515E-14	6.6348784E-14
A15	1.6625829E-14	9.1585232E-15
A16	-5.7273231E-16	-4.6481540E-16
A17	-6.1842548E-17	-2.5090883E-17
A18	2.7969524E-18	1.4869080E-18
A19	9.5479576E-20	2.8685321E-20
A20	-4.9925629E-21	-1.8543937E-21

Example 6

FIG. 16 shows a cross-sectional configuration of the imaging lens of Example 6. The imaging lens of Example 6 consists of, in order from the object side, a first lens group G1 that has a positive refractive power, an aperture stop St, and a second lens group G2 that has a positive refractive power. During focusing from the object at infinity to the closest object, the first lens group G1 remains stationary with respect to the image plane Sim, and the second lens group G2 moves to the object side along the optical axis Z. The first lens group G1 consists of eight lenses L1a to L1h in order from the object side. The second lens group G2 consists of five lenses L2a to L2e in order from the object side.

Regarding the imaging lens of Example 6, Table 21 shows basic lens data, Table 22 shows specification, Table 23 shows variable surface distances, Table 24 shows aspheric surface coefficients, and FIGS. 17 and 18 show aberration diagrams. In FIG. 17, the upper part shows aberration diagrams in a state where the object at infinity is in focus, and the lower part shows aberration diagrams in a state where the object at the distance of 0.6 m (meter) from the object to the image plane Sim is in focus. FIG. 18 shows lateral aberration diagram in a state where the object at infinity is in focus.

TABLE 21

Sn	R	D	Nd	vd	θgF
1	-247.95976	2.800	1.77791	26.10	0.61461
2	75.89689	11.010			
3	114.39503	7.000	1.92286	18.90	0.64960
4	-837.42367	0.100			
5	69.26549	11.000	1.58525	61.72	0.54210
6	196.03197	0.100			
7	84.81564	7.038	1.53775	74.70	0.53936
8	1034.21503	0.100			
9	91.91092	5.000	1.53775	74.70	0.53936
10	177.41757	0.100			
11	33.30279	12.000	1.88300	39.22	0.57295
12	-424.49645	1.510	1.72186	28.91	0.60113
13	61.07419	1.500			
14	98.63832	1.500	1.91717	19.14	0.63501
15	21.08130	7.000			
16(St)	∞	DD[16]			
17	-22.42941	1.100	1.58780	39.22	0.57813
18	23.14403	7.400	1.88300	39.22	0.57295
19	-31.61388	1.000			
*20	-33.94641	1.800	1.61724	36.28	0.58403
*21	173.48601	0.100			
22	47.71113	7.271	1.81834	46.17	0.55821
23	-26.72012	1.210	1.69584	30.30	0.60324
24	-56.34422	DD[24]			

TABLE 21-continued

Sn	R	D	Nd	vd	θgF
25	∞	2.850	1.51680	64.20	0.53430
26	∞	1.000			
10					
TABLE 22					
Example 6					
15					
f                          48.498					
FNo.                    1.03					
2ωmax                32.6					

TABLE 23

Sn	20	21
K4	1.0000000E+00	1.0000000E+00
A3	0.0000000E+00	0.0000000E+00
A4	-2.3773046E-05	3.0929722E-06
A5	5.6674484E-06	4.8487684E-06
A6	5.6970844E-08	-5.0456910E-07
A7	-1.9176909E-07	1.5258010E-08
A8	1.9626233E-08	6.7914018E-09
A9	2.9049337E-09	-1.5524880E-09
A10	-6.6057808E-10	-1.1339723E-11
A11	-1.9889473E-11	2.4115890E-11
A12	1.0577029E-11	-4.6114184E-13
A13	7.5098137E-15	-1.8660180E-13
A14	-9.7929627E-14	3.8327989E-15
A15	7.5328476E-16	7.9224149E-16
A16	5.3398130E-16	-7.7601860E-18
A17	-4.2992770E-18	-1.7504256E-18
A18	-1.5949215E-18	-2.1972718E-20
A19	7.7287369E-21	1.5807498E-21
A20	2.0144963E-21	7.7734912E-23

TABLE 24

Sn	20	21
K4	1.0000000E+00	1.0000000E+00
A3	0.0000000E+00	0.0000000E+00
A4	-2.3773046E-05	3.0929722E-06
A5	5.6674484E-06	4.8487684E-06
A6	5.6970844E-08	-5.0456910E-07
A7	-1.9176909E-07	1.5258010E-08
A8	1.9626233E-08	6.7914018E-09
A9	2.9049337E-09	-1.5524880E-09
A10	-6.6057808E-10	-1.1339723E-11
A11	-1.9889473E-11	2.4115890E-11
A12	1.0577029E-11	-4.6114184E-13
A13	7.5098137E-15	-1.8660180E-13
A14	-9.7929627E-14	3.8327989E-15
A15	7.5328476E-16	7.9224149E-16
A16	5.3398130E-16	-7.7601860E-18
A17	-4.2992770E-18	-1.7504256E-18
A18	-1.5949215E-18	-2.1972718E-20
A19	7.7287369E-21	1.5807498E-21
A20	2.0144963E-21	7.7734912E-23

Example 7

FIG. 19 shows a cross-sectional configuration of the imaging lens of Example 7. The imaging lens of Example 7 consists of, in order from the object side, the first lens group G1 that has a positive refractive power, the aperture stop St, and the second lens group G2 that has a positive refractive power. During focusing from the object at infinity to the closest object, the first lens group G1 remains stationary with respect to the image plane Sim, and the second lens group G2 moves to the object side along the optical axis Z. The first lens group G1 consists of eight lenses L1a to L1h in order from the object side. The second lens group G2 consists of five lenses L2a to L2e in order from the object side.

65 Regarding the imaging lens of Example 7, Table 25 shows basic lens data, Table 26 shows specification, Table 27 shows variable surface distances, Table 28 shows aspheric

surface coefficients, and FIGS. 20 and 21 show aberration diagrams. In FIG. 20, the upper part shows aberration diagrams in a state where the object at infinity is in focus, and the lower part shows aberration diagrams in a state where the object at the distance of 0.6 m (meter) from the object to the image plane Sim is in focus. FIG. 21 shows lateral aberration diagram in a state where the object at infinity is in focus.

TABLE 25

Sn	Example 7				
	R	D	Nd	vd	$\theta_{gF}$
1	-204.30501	2.800	1.81294	24.35	0.61887
2	81.96794	13.010			
3	137.60012	7.000	2.10420	17.02	0.66311
4	-656.31103	3.750			
5	69.54614	12.000	1.57265	62.21	0.54137
6	267.60481	0.193			
7	88.85695	9.422	1.43875	94.66	0.53402
8	-2937.87944	0.100			
9	96.07701	5.000	1.43875	94.66	0.53402
10	181.83582	0.100			
11	33.17157	12.000	1.88300	39.22	0.57295
12	-374.98026	1.510	1.76530	26.82	0.60713
13	66.58003	1.500			
14	97.44593	1.500	1.96720	17.42	0.64384
15	21.58463	7.000			
16(St)	$\infty$	DD[16]			
17	-22.85203	1.100	1.56026	43.70	0.57003
18	22.46642	7.400	1.88300	39.22	0.57295
19	-31.83440	1.000			
*20	-30.58326	1.800	1.66113	32.78	0.59162
*21	340.35421	0.100			
22	55.88143	6.486	1.81271	42.14	0.56732
23	-26.29030	1.210	1.70642	29.68	0.60465
24	-49.33676	DD[24]			
25	$\infty$	2.850	1.51680	64.20	0.53430
26	$\infty$	1.000			

TABLE 26

Example 7		
f	48.220	
FNo.	1.04	
Zoomax	32.8	

TABLE 27

Example 7		
Infinity	0.6 m	
DD[16]	10.100	4.858
DD[24]	14.973	20.215

TABLE 28

Sn	Example 7	
	20	21
KA	1.0000000E+00	1.0000000E+00
A3	0.0000000E+00	0.0000000E+00
A4	-2.1813953E-05	5.6632078E-06
A5	5.5899615E-06	4.4402595E-06
A6	8.3363623E-08	-4.7071845E-07
A7	-1.9184059E-07	1.5982530E-08
A8	1.9586298E-08	6.7572477E-09
A9	2.8981856E-09	-1.5590421E-09

TABLE 28-continued

Sn	Example 7	
	20	21
5	A10	-6.6105638E-10
10	A11	-1.9888631E-11
	A12	1.0581175E-11
	A13	8.0018964E-15
	A14	-9.7926487E-14
	A15	7.5055780E-16
	A16	5.3398130E-16
	A17	-4.2992770E-18
	A18	-1.5949215E-18
	A19	7.7287369E-21
	A20	2.0144963E-21

Example 8

FIG. 22 shows a cross-sectional configuration of the imaging lens of Example 8. The imaging lens of Example 8 consists of, in order from the object side, the first lens group G1 that has a positive refractive power, the aperture stop St, and the second lens group G2 that has a positive refractive power. During focusing from the object at infinity to the closest object, the first lens group G1 remains stationary with respect to the image plane Sim, and the second lens group G2 moves to the object side along the optical axis Z. The first lens group G1 consists of seven lenses L1a to L1g in order from the object side. The second lens group G2 consists of five lenses L2a to L2e in order from the object side.

Regarding the imaging lens of Example 8, Table 29 shows basic lens data, Table 30 shows specification, Table 31 shows variable surface distances, Table 32 shows aspheric surface coefficients, and FIGS. 23 and 24 show aberration diagrams. In FIG. 23, the upper part shows aberration diagrams in a state where the object at infinity is in focus, and the lower part shows aberration diagrams in a state where the object at the distance of 0.6 m (meter) from the object to the image plane Sim is in focus. FIG. 24 shows lateral aberration diagram in a state where the object at infinity is in focus.

TABLE 29

Sn	Example 8				
	R	D	Nd	vd	$\theta_{gF}$
1	-1250.00000	2.400	1.50911	53.29	0.55329
2	58.56667	12.004			
3	63.53662	10.300	1.55032	75.50	0.54001
4	-324.18577	1.010			
5	91.24308	4.145	1.55032	75.50	0.54001
6	237.79601	0.200			
7	41.36102	10.250	1.59282	68.62	0.54414
8	108.29456	0.200			
9	35.06677	7.900	2.00069	25.46	0.61364
10	76.31169	0.806			
11	90.22442	1.500	1.78880	28.43	0.60092
12	28.87926	2.968			
13	53.65263	1.500	1.89286	20.36	0.63944
14	23.13445	7.000			
15(St)	$\infty$	DD[15]			
*16	-16.70584	1.943	1.68948	31.02	0.59874
*17	-24.50468	0.200			
18	44.48608	6.995	1.88300	39.22	0.57295
19	-26.79392	1.110	1.71036	29.48	0.59958
20	33.02652	1.005			
21	48.60027	9.237	1.85150	40.78	0.56958
22	-19.88726	1.210	1.56738	42.37	0.57237

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TABLE 29-continued

Example 8					
Sn	R	D	Nd	vd	$\theta_{GF}$
23	-131.23867	DD[23]			
24	$\infty$	2.850	1.51680	64.20	0.53430
25	$\infty$	1.000			

TABLE 30

Example 8	
f	51.521
FNo.	1.03
$\omega_{\max}$	31.0

TABLE 32

Sn	16	17
KA	1.0000000E+00	1.0000000E+00
A3	0.0000000E+00	0.0000000E+00
A4	7.0570380E-05	6.6014243E-05
A5	1.9198543E-05	1.9606733E-05
A6	-3.3289534E-06	-4.2582967E-06
A7	-9.0333134E-08	1.4153915E-07
A8	9.0099971E-08	9.0936965E-08
A9	-4.1396511E-09	-1.1106603E-08
A10	-1.4390577E-09	-8.1411034E-10
A11	1.2641084E-10	1.9638299E-10
A12	1.3445189E-11	1.0722851E-12
A13	-1.7282916E-12	-1.7929595E-12
A14	-6.2059351E-14	3.9257132E-14
A15	1.2881202E-14	9.2275563E-15
A16	2.3758855E-17	-3.3269509E-16
A17	-5.0325955E-17	-2.5409216E-17
A18	9.0421501E-19	1.1130994E-18
A19	8.0548323E-20	2.9170042E-20
A20	-2.4717980E-21	-1.3898997E-21

### Example 9

FIG. 25 shows a cross-sectional configuration of the imaging lens of Example 9. The imaging lens of Example 9 consists of, in order from the object side, the first lens group G1 that has a positive refractive power, the aperture stop St, and the second lens group G2 that has a positive refractive power. During focusing from the object at infinity to the closest object, the first lens group G1 remains stationary with respect to the image plane Sim, and the second lens group G2 moves to the object side along the optical axis Z. The first lens group G1 consists of seven lenses L1a to L1g in order from the object side. The second lens group G2 consists of five lenses L2a to L2e in order from the object side.

Regarding the imaging lens of Example 9, Table 33 shows basic lens data, Table 34 shows specification, Table 35

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shows variable surface distances, Table 36 shows aspheric surface coefficients, and FIGS. 26 and 27 show aberration diagrams. In FIG. 26, the upper part shows aberration diagrams in a state where the object at infinity is in focus, and the lower part shows aberration diagrams in a state where the object at the distance of 0.6 m (meter) from the object to the image plane Sim is in focus. FIG. 27 shows lateral aberration diagram in a state where the object at infinity is in focus.

TABLE 33

Example 9						
Sn	R	D	Nd	vd	θgF	
15						
1	-193.76114	2.400	1.54760	46.08	0.56589	
2	75.97796	9.081				
3	189.01581	10.000	1.49700	81.61	0.53887	
4	-105.13621	1.010				
5	56.49917	5.721	1.92119	23.96	0.62025	
20						
6	104.36406	0.200				
7	43.70727	10.385	1.49700	81.61	0.53887	
8	340.80096	0.200				
9	32.58246	9.094	1.75819	43.78	0.56631	
10	73.72282	1.500	1.78472	25.68	0.61052	
25						
11	32.68245	2.542				
12	61.75401	1.500	1.89286	20.36	0.63944	
13	22.41400	7.000				
14(St)	∞	DD[14]				
*15	-16.41866	2.693	1.68948	31.02	0.59874	
*16	-22.88517	0.200				
17	45.64284	6.105	1.88300	39.22	0.57295	
18	-33.87303	1.110	1.68877	30.80	0.59625	
30						
19	33.14697	1.132				
20	52.16226	8.770	1.88300	39.22	0.57295	
21	-21.44050	1.210	1.59203	38.80	0.57897	
22	-202.15701	DD[22]				
23	∞	2.850	1.51680	64.20	0.53430	
24	∞	1.000				
35						
TABLE 34						
Example 9						
40	f			51.018		
	FNo.			1.03		
	2ωmax			31.2		
45						
TABLE 35						
Example 9						
50			Infinity		0.6 m	
	DD[14]		11.000		5.539	
	DD[22]		15.401		20.862	

TABLE 36

Example 9			
	Sn	15	16
60	KA	1.0000000E+00	1.0000000E+00
	A3	0.0000000E+00	0.0000000E+00
	A4	2.5050662E-05	2.1927553E-05
	A5	1.6399123E-05	1.6962214E-05
	A6	-2.7037336E-06	-3.5614573E-06
	A7	2.2716407E-08	1.6637583E-07
	A8	7.0481328E-08	7.6462842E-08
	A9	-7.0934969E-09	-1.1129036E-08
	A10	-9.1743883E-10	-5.7804163E-10

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TABLE 36-continued

Sn	15	16
A11	1.7293397E-10	1.9360903E-10
A12	5.1834973E-12	-1.4806257E-12
A13	-2.1727289E-12	-1.7572338E-12
A14	1.7187231E-14	5.7682678E-14
A15	1.5404695E-14	9.0145899E-15
A16	-4.2947569E-16	-4.1936383E-16
A17	-5.8157492E-17	-2.4764768E-17
A18	2.3258567E-18	1.3542989E-18
A19	9.0773374E-20	2.8368189E-20
A20	-4.3526649E-21	-1.6904315E-21

Example 10

FIG. 28 shows a cross-sectional configuration of the imaging lens of Example 10. The imaging lens of Example 10 consists of, in order from the object side, a first lens group G1 having a positive refractive power, an aperture stop St, a second lens group G2 having a negative refractive power, and a third lens group G3 having a positive refractive power. During focusing from the object at infinity to the closest object, the first lens group G1 and the third lens group G3 remain stationary with respect to the image plane Sim, and the second lens group G2 moves to the image side along the optical axis Z. The first lens group G1 consists of seven lenses L1a to L1g in order from the object side. The second lens group G2 consists of four lenses L2a to L2d in order from the object side. The third lens group G3 consists of five lenses L3a to L3e in order from the object side.

Regarding the imaging lens of Example 10, Table 37 shows basic lens data, Table 38 shows specification, Table 39 shows variable surface distances, and FIGS. 29 and 30 shows aberration diagrams. In FIG. 29, the upper part shows aberration diagrams in a state where the object at infinity is in focus, and the lower part shows aberration diagrams in a state where the object at the distance of 0.7 m (meter) from the object to the image plane Sim is in focus. FIG. 30 shows lateral aberration diagram in a state where the object at infinity is in focus.

TABLE 37

Sn	R	D	Nd	vd	$\theta gF$
1	272.44778	3.300	2.05090	26.94	0.60519
2	1081.40696	0.100			
3	89.65014	3.000	1.59282	68.62	0.54414
4	152.15669	0.100			
5	74.09242	6.000	1.59282	68.62	0.54414
6	263.34977	0.100			
7	107.02621	1.500	1.85896	22.73	0.62844
8	78.42749	10.010	1.76212	31.60	0.59550
9	-175.82899	1.000			
10	-144.21433	1.500	1.85896	22.73	0.62844
11	80.87758	4.510	1.56883	56.36	0.54890
12	716.45491	5.217			
13(St)	$\infty$	DD[13]			
14	-38.44224	1.000	1.87904	40.10	0.56811
15	130.29249	6.010	1.59410	60.47	0.55516
16	-33.25476	0.600			
17	-351.00941	4.000	2.00272	19.32	0.64514
18	-45.80501	1.500	1.64173	39.35	0.57903
19	36.04598	DD[19]			
20	43.30755	7.389	1.59522	67.73	0.54426
21	-236.34955	0.100			
22	90.49741	7.652	1.83481	42.72	0.56486

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TABLE 37-continued

Sn	R	D	Nd	vd	$\theta gF$
5	23	-46.09199	1.360	1.67270	32.10 0.59891
	24	27.92315	4.075		
	25	30.74850	9.035	1.65463	48.36 0.56208
	26	-201.70415	2.100		
	27	-51.13607	1.350	1.48749	70.44 0.53062
10	28	76.12890	21.401		
	29	$\infty$	2.850	1.51680	64.20 0.53430
	30	$\infty$	1.000		

TABLE 38

f	87.302
FNo.	1.86
$2\omega_{max}$	18.6

TABLE 39

Infinity	0.7 m
DD[13]	5.000
DD[19]	15.702

Example 11

FIG. 31 shows a cross-sectional configuration of the imaging lens of Example 11. The imaging lens of Example 11 consists of, in order from the object side, a first lens group G1 having a positive refractive power, an aperture stop St, a second lens group G2 having a negative refractive power, and a third lens group G3 having a positive refractive power. During focusing from the object at infinity to the closest object, the first lens group G1 and the third lens group G3 remain stationary with respect to the image plane Sim, and the second lens group G2 moves to the image side along the optical axis Z. The first lens group G1 consists of eight lenses L1a to L1h in order from the object side. The second lens group G2 consists of four lenses L2a to L2d in order from the object side. The third lens group G3 consists of five lenses L3a to L3e in order from the object side.

Regarding the imaging lens of Example 11, Table 40 shows basic lens data, Table 41 shows specification, Table 42 shows variable surface distances, and FIGS. 32 and 33 shows aberration diagrams. In FIG. 32, the upper part shows aberration diagrams in a state where the object at infinity is in focus, and the lower part shows aberration diagrams in a state where the object at the distance of 0.8 m (meter) from the object to the image plane Sim is in focus. FIG. 33 shows lateral aberration diagram in a state where the object at infinity is in focus.

TABLE 40

Sn	R	D	Nd	vd	$\theta gF$
60	1	-386.94657	1.800	1.69680	55.53 0.54341
	2	119.46581	2.500		

TABLE 40-continued

Sn	R	D	Nd	vd	$\theta gF$
3	207.26394	4.000	1.95375	32.32	0.59015
4	-238.96341	0.100			
5	76.64894	4.500	1.59522	67.73	0.54426
6	248.42469	0.100			
7	63.92071	5.500	1.43875	94.66	0.53402
8	216.59149	0.100			
9	107.16236	1.500	1.85025	30.05	0.59797
10	85.24799	7.998	1.65412	39.68	0.57378
11	-205.11243	1.000			
12	-197.70982	1.500	1.92119	23.96	0.62025
13	90.62875	4.510	1.45860	90.19	0.53516
14	-30275.61759	8.130			
15(St)	$\infty$	DD[15]			
16	-43.49420	1.000	1.89190	37.13	0.57813
17	185.12129	6.010	1.77250	49.60	0.55212
18	-44.59399	0.600			
19	-428.71303	4.000	2.10420	17.02	0.66311
20	-76.05920	1.500	1.58144	40.75	0.57757
21	37.00980	DD[21]			
22	36.00466	5.851	1.59522	67.73	0.54426
23	-124.44012	0.100			
24	829.97224	5.140	1.90043	37.37	0.57720
25	-51.93826	1.360	1.67270	32.10	0.59891
26	28.10820	3.300			
27	34.48127	9.174	1.77250	49.60	0.55212
28	-110.39811	2.231			
29	-38.11168	1.350	1.48749	70.44	0.53062
30	89.57871	21.429			
31	$\infty$	2.850	1.51680	64.20	0.53430
32	$\infty$	1.000			

TABLE 41

Example 11		
f	79.213	
FNo.	1.65	
2ωmax	20.2	

TABLE 42

Example 11		
Infinity	0.8 m	
DD[15]	5.043	18.069
DD[21]	14.864	1.838

Example 12

FIG. 34 shows a cross-sectional configuration of the imaging lens of Example 12. The imaging lens of Example 12 consists of, in order from the object side, a first lens group G1 having a positive refractive power, an aperture stop St, a second lens group G2 having a negative refractive power, and a third lens group G3 having a positive refractive power. During focusing from the object at infinity to the closest object, the first lens group G1 and the third lens group G3 remain stationary with respect to the image plane Sim, and the second lens group G2 moves to the image side along the optical axis Z. The first lens group G1 consists of eight lenses L1a to L1h in order from the object side. The second lens group G2 consists of four lenses L2a to L2d in order from the object side. The third lens group G3 consists of five lenses L3a to L3e in order from the object side.

Regarding the imaging lens of Example 12, Table 43 shows basic lens data, Table 44 shows specification, Table

45 shows variable surface distances, and FIGS. 35 and 36 shows aberration diagrams. In FIG. 35, the upper part shows aberration diagrams in a state where the object at infinity is in focus, and the lower part shows aberration diagrams in a state where the object at the distance of 0.7 m (meter) from the object to the image plane Sim is in focus. FIG. 36 shows lateral aberration diagram in a state where the object at infinity is in focus.

TABLE 43

Sn	R	D	Nd	vd	$\theta gF$
1	-291.68052	1.800	1.64769	33.79	0.59393
2	99.99894	2.500			
3	177.53930	4.000	1.92119	23.96	0.62025
4	-250.63993	0.100			
5	83.49241	3.500	1.59522	67.73	0.54426
6	315.24688	0.100			
7	65.26695	5.500	1.55032	75.50	0.54001
8	230.27246	0.100			
9	117.55484	1.500	2.00069	25.46	0.61364
10	89.18435	10.010	1.67300	38.26	0.57580
11	-205.86865	1.000			
12	-214.55358	1.500	1.85896	22.73	0.62844
13	81.16463	4.510	1.62299	58.16	0.54589
14	301.17897	7.667			
15(St)	$\infty$	DD[15]			
16	-44.85924	1.000	1.89190	37.13	0.57813
17	78.25190	6.010	1.72916	54.68	0.54451
18	-44.95132	0.600			
19	-344.73789	4.000	1.94595	17.98	0.65460
20	-48.43416	1.500	1.58144	40.75	0.57757
21	36.97488	DD[21]			
22	38.40711	5.751	1.59522	67.73	0.54426
23	-82.40638	0.100			
24	-707.34003	5.905	1.85150	40.78	0.56958
25	-45.35298	1.360	1.67270	32.10	0.59891
26	27.74475	1.726			
27	31.49767	9.688	1.80400	46.53	0.55775
28	-172.72812	2.100			
29	-40.02478	1.350	1.48749	70.44	0.53062
30	129.32128	21.402			
31	$\infty$	2.850	1.51680	64.20	0.53430
32	$\infty$	1.000			

TABLE 44

Sn	R	D	Nd	vd	$\theta gF$
f	77.634				
FNo.	1.65				
2ωmax	20.8				

TABLE 45

Sn	R	D	Nd	vd	$\theta gF$
45	Infinity	0.7 m			
DD[15]	5.000	19.027			
DD[21]	14.908	0.881			

Example 13

FIG. 37 shows a cross-sectional configuration of the imaging lens of Example 13. The imaging lens of Example 13 consists of, in order from the object side, a first lens group G1 that has a positive refractive power, and a second lens group G2 that has a positive refractive power. During focusing from the object at infinity to the closest object, the first lens group G1 and the second lens group G2 remain stationary with respect to the image plane Sim, and the second lens group G2 moves to the image side along the optical axis Z. The first lens group G1 consists of five lenses L1a to L1e in order from the object side. The second lens group G2 consists of three lenses L2a to L2c in order from the object side.

first lens group G1 remains stationary with respect to the image plane Sim, and the second lens group G2 moves to the object side along the optical axis Z. The first lens group G1 consists of eight lenses L1a to L1h in order from the object side. The second lens group G2 consists of lenses L2a to L2c, an aperture stop St, and lenses L2d to L2g in order from the object side.

Regarding the imaging lens of Example 13, Table 46 shows basic lens data, Table 47 shows specification, Table 48 shows variable surface distances, Table 49 shows aspheric surface coefficients, and FIGS. 38 and 39 show aberration diagrams. In FIG. 38, the upper part shows aberration diagrams in a state where the object at infinity is in focus, and the lower part shows aberration diagrams in a state where the object at the distance of 0.4 m (meter) from the object to the image plane Sim is in focus. FIG. 39 shows lateral aberration diagram in a state where the object at infinity is in focus.

TABLE 46

Example 13					
Sn	R	D	Nd	vd	θgF
1	-80.28635	2.000	1.48749	70.24	0.53007
2	42.98733	13.000			
3	-63.79046	1.860	1.62004	36.26	0.58800
4	51.39741	12.441	1.88299	40.78	0.56829
5	-144.73231	0.100			
6	176.27919	7.877	2.00069	25.46	0.61364
7	-160.05852	0.100			
8	24017.51177	11.145	1.49700	81.54	0.53748
9	-53.46758	2.020	1.95906	17.47	0.65993
10	-141.76150	0.100			
11	73.80784	6.228	1.43875	94.66	0.53402
12	-6705.69476	0.100			
13	135.56611	4.200	1.49700	81.54	0.53748
14	188.15073	DD[14]			
15	48.95259	5.513	1.95906	17.47	0.65993
16	205.45635	0.253			
17	25.65935	8.918	1.59282	68.62	0.54414
18	-442.23226	1.200	1.80809	22.76	0.63073
19	17.92257	5.504			
20(St)	∞	5.000			
*21	-17.88285	1.500	1.68948	31.02	0.59874
*22	-49.72259	0.500			
23	213.02720	6.649	1.81600	46.62	0.55682
24	-19.33525	1.120	1.62004	36.26	0.58800
25	47.67656	6.689	1.88299	40.78	0.56829
26	-31.38846	DD[26]			
27	∞	2.850	1.51680	64.20	0.53430
28	∞	1.000			

TABLE 47

Example 13		
f	32.024	
FNo.	1.03	
2ωmax	49.0	

TABLE 48

Example 13		
Infinity	0.4 m	
DD[14]	5.524	1.833
DD[26]	14.098	17.789

TABLE 49

Example 13		
Sn	21	22
KA	1.000000E+00	1.000000E+00
A3	0.000000E+00	0.000000E+00
A4	1.7715606E-04	1.7642986E-04
A5	1.7074166E-05	1.6477612E-05
A6	-5.3189612E-06	-4.6629565E-06
A7	-1.7052372E-07	-2.6282483E-07
A8	1.0629596E-07	1.1534278E-07
A9	3.7804819E-10	-2.9531996E-10
A10	-1.7627478E-09	-1.9368547E-09
A11	3.7456752E-11	8.2583641E-11
A12	2.1780336E-11	1.9811305E-11
A13	-1.0619291E-12	-1.3990529E-12
A14	-1.6070128E-13	-1.1461723E-13
A15	1.2952078E-14	1.1207794E-14
A16	4.9200989E-16	2.9951674E-16
A17	-7.4222889E-17	-4.5040584E-17
A18	6.6519028E-19	5.5182976E-20
A19	1.6312319E-19	7.2914615E-20
A20	-5.4198359E-21	-1.3034388E-21

Example 14

FIG. 40 shows a cross-sectional configuration of the imaging lens of Example 14. The imaging lens of Example 14 consists of, in order from the object side, a first lens group G1 that has a positive refractive power, and a second lens group G2 that has a positive refractive power. During focusing from the object at infinity to the closest object, the first lens group G1 remains stationary with respect to the image plane Sim, and the second lens group G2 moves to the object side along the optical axis Z. The first lens group G1 consists of eight lenses L1a to L1h in order from the object side. The second lens group G2 consists of, in order from the object side, lenses L2a to L2c, an aperture stop St, and lenses L2d to L2f.

Regarding the imaging lens of Example 14, Table 50 shows basic lens data, Table 51 shows specification, Table 52 shows variable surface distances, Table 53 shows aspheric surface coefficients, and FIGS. 41 and 42 show aberration diagrams. In FIG. 41, the upper part shows aberration diagrams in a state where the object at infinity is in focus, and the lower part shows aberration diagrams in a state where the object at the distance of 0.3 m (meter) from the object to the image plane Sim is in focus. FIG. 42 shows lateral aberration diagram in a state where the object at infinity is in focus.

TABLE 50

Example 14					
Sn	R	D	Nd	vd	θgF
1	-741.84965	4.557	2.00001	16.35	0.64993
2	-133.27267	2.137			
3	-88.69549	2.000	1.51957	51.33	0.55675
4	30.12135	17.951			
5	-43.59777	1.860	1.72220	28.89	0.60118
6	50.07951	14.509	1.99166	26.42	0.61104
7	-73.94447	0.200			
8	102.81602	12.918	1.72183	55.41	0.54271
9	-47.50103	2.020	1.96573	16.71	0.64633
10	-188.35959	0.100			
11	282.52887	4.513	1.43875	94.66	0.53402
12	-146.67361	0.010			
13	51.37757	3.531	1.59522	67.73	0.54426
14	63.46607	DD[14]			

TABLE 50-continued

Example 14						
Sn	R	D	Nd	vd	θgF	
15	49.82440	5.000	2.00001	15.00	0.65515	
16	197.53926	0.250				
17	27.63615	9.109	1.59522	67.73	0.54426	
18	-134.79322	1.550	1.85370	22.31	0.62213	
19	18.23355	5.500				
20(St)	∞	5.487				
21	-18.30655	1.500	1.63029	39.17	0.57925	
22	-48.92302	5.529	1.48984	65.39	0.53509	
23	-24.64229	0.100				
*24	56.89240	6.000	1.79341	48.66	0.55129	
*25	-36.65031	DD[25]				
26	∞	2.850	1.51680	64.20	0.53430	
27	∞	1.000				

TABLE 51

Example 14		
f	29.079	
FNo.	1.03	
20max	53.2	

TABLE 52

Example 14		
Infinity	0.3 m	
DD[14]	6.500	1.921
DD[25]	16.342	20.921

TABLE 53

Example 14		
------------	--	--

Sn	24	25
KA	1.0000000E+00	1.0000000E+00
A4	-1.6809135E-06	8.5774318E-06
A6	-2.1517689E-07	-2.0857403E-07
A8	9.2942401E-09	6.7208947E-09
A10	-2.1073323E-10	-1.2334691E-10
A12	2.8305897E-12	1.3706654E-12
A14	-2.3236997E-14	-9.4138699E-15
A16	1.1475262E-16	3.9270429E-17
A18	-3.1366558E-19	-9.1668061E-20
A20	3.6536989E-22	9.2574233E-23

Example 15

FIG. 43 shows a cross-sectional configuration of the imaging lens of Example 15. The imaging lens of Example 15 consists of, in order from the object side, a first lens group G1 that has a positive refractive power, and a second lens group G2 that has a positive refractive power. During focusing from the object at infinity to the closest object, the first lens group G1 remains stationary with respect to the image plane Sim, and the second lens group G2 moves to the object side along the optical axis Z. The first lens group G1 consists of eight lenses L1a to L1h in order from the object side. The second lens group G2 consists of lenses L2a to L2c, an aperture stop St, and lenses L2d to L2g in order from the object side.

Regarding the imaging lens of Example 15, Table 54 shows basic lens data, Table 55 shows specification, Table

56 shows variable surface distances, Table 57 shows aspheric surface coefficients, and FIGS. 44 and 45 show aberration diagrams. In FIG. 44, the upper part shows aberration diagrams in a state where the object at infinity is in focus, and the lower part shows aberration diagrams in a state where the object at the distance of 0.3 m (meter) from the object to the image plane Sim is in focus. FIG. 45 shows lateral aberration diagram in a state where the object at infinity is in focus.

TABLE 54

Example 15						
Sn	R	D	Nd	vd	θgF	
1	642.95860	5.882	2.00001	16.89	0.64786	
2	-164.66697	1.863				
3	-99.52183	2.000	1.61064	54.41	0.55296	
4	33.83357	15.951				
5	-47.68180	1.860	1.70668	31.21	0.59581	
6	51.06375	13.761	1.98542	25.79	0.61339	
7	-87.22549	0.200				
8	126.67025	12.325	1.72259	55.37	0.54271	
9	-47.54495	2.020	1.97455	17.92	0.64243	
10	-275.27420	0.100				
11	171.98328	5.821	1.43875	94.66	0.53402	
12	-113.39789	0.010				
13	46.43027	5.041	1.59522	67.73	0.54426	
14	84.61748	DD[14]				
15	55.77297	4.000	2.00000	15.00	0.65515	
16	202.80478	0.605				
17	27.63715	8.988	1.58689	61.66	0.54186	
18	-134.09655	1.550	1.85789	22.11	0.62292	
19	19.09448	5.638				
20(St)	∞	5.927				
*21	-28.03700	1.500	1.89872	28.11	0.60520	
*22	-44.46753	1.250				
23	-96.25411	6.671	1.74032	53.97	0.54394	
24	-23.20962	0.500				
25	63.33337	6.000	1.90048	37.95	0.57345	
26	-32.84508	1.310	1.47999	58.75	0.54320	
27	33.51612	DD[27]				
28	∞	2.850	1.51680	64.20	0.53430	
29	∞	1.000				

TABLE 55

Example 15		
f	29.906	
FNo.	1.03	
20max	51.4	

TABLE 56

Example 15		
Infinity	0.3 m	
DD[14]	6.500	1.468
DD[27]	11.900	16.932

TABLE 57

Example 15		
Sn	21	22
KA	1.0000000E+00	1.0000000E+00
A4	-5.0827829E-05	-2.1426467E-05
A6	-1.1853379E-07	-4.7548185E-08
A8	9.4795512E-09	5.2403072E-09

TABLE 57-continued

Example 15		
Sn	21	22
A10	-2.7750209E-10	-1.0968658E-10
A12	5.8490730E-12	2.0277440E-12
A14	-7.6027021E-14	-2.5419242E-14
A16	5.7225628E-16	1.8641103E-16
A18	-2.2972054E-18	-7.2476475E-19
A20	3.8030548E-21	1.1546366E-21

Example 16

FIG. 46 shows a cross-sectional configuration of the imaging lens of Example 16. The imaging lens of Example 16 consists of, in order from the object side, a first lens group G1 having a positive refractive power, a second lens group G2 having a positive refractive power, and a third lens group G3 having a negative refractive power. During focusing from the object at infinity to the closest object, the first lens group G1 and the third lens group G3 remain stationary with respect to the image plane Sim, and the second lens group G2 moves to the object side along the optical axis Z. The first lens group G1 consists of seven lenses L1a to L1g in order from the object side. The second lens group G2 consists of, in order from the object side, lenses L2a to L2c, an aperture stop St, and lenses L2d to L2f. The third lens group G3 consists of two lenses L3a and L3b in order from the object side.

Regarding the imaging lens of Example 16, Table 58 shows basic lens data, Table 59 shows specification, Table 60 shows variable surface distances, Table 61 shows aspheric surface coefficients, and FIGS. 47 and 48 show aberration diagrams. In FIG. 47, the upper part shows aberration diagrams in a state where the object at infinity is in focus, and the lower part shows aberration diagrams in a state where the object at the distance of 0.3 m (meter) from the object to the image plane Sim is in focus. FIG. 48 shows lateral aberration diagram in a state where the object at infinity is in focus.

TABLE 58

Example 16					
Sn	R	D	Nd	vd	θgF
1	-297.13714	7.166	1.87070	40.73	0.56825
2	-85.86719	1.000			
3	-73.16221	2.000	1.74077	27.79	0.60961
4	42.66024	7.413			
5	392.24356	6.462	1.87070	40.73	0.56825
6	-146.01920	4.000			
7	-66.16556	1.860	1.72825	28.46	0.60772
8	51.18899	11.866	2.10420	17.02	0.66311
9	-245.64485	0.200			
10	77.22649	15.828	1.88300	40.80	0.56557
11	-47.49919	2.020	1.98613	16.48	0.66558
12	-198.94323	DD[12]			
13	55.79899	6.000	1.92286	20.88	0.63900
14	1076.94076	0.250			
15	30.39757	10.286	1.59410	60.47	0.55516
16	-49.75521	1.550	1.92286	20.88	0.63900
17	20.04359	5.500			
18(St)	∞	5.642			
19	-22.24985	1.510	1.59270	35.31	0.59336
20	30.44450	8.452	1.90043	37.37	0.57668
21	-37.69952	0.270			
*22	87.14518	3.500	1.83481	42.72	0.56486
*23	-62.14252	DD[23]			

TABLE 58-continued

Example 16					
Sn	R	D	Nd	vd	θgF
5	24	-134.06447	3.010	1.64000	60.08 0.53704
	25	-34.88724	1.000	1.65412	39.68 0.57378
	26	-129.28425	12.064		
	27	∞	2.850	1.51680	64.20 0.53430
10	28	∞	1.000		

TABLE 59

Example 16	
f	33.489
FNo.	1.03
2ωmax	46.8

TABLE 60

Example 16	
Infinity	0.3 m
DD[12]	6.714
DD[23]	2.000 7.858

TABLE 61

Example 16		
Sn	22	23
KA	1.0000000E+00	1.0000000E+00
A4	-5.8591082E-06	2.8872810E-06
A6	8.0450854E-09	-1.4218337E-08
A8	-1.8982768E-10	4.2017521E-11
A10	6.8830323E-13	-2.5968320E-13
A12	-2.8216339E-15	-1.0662872E-15

Example 17

FIG. 49 shows a cross-sectional configuration of the imaging lens of Example 17. The imaging lens of Example 17 consists of, in order from the object side, a first lens group G1 that has a positive refractive power, and a second lens group G2 that has a positive refractive power. During focusing from the object at infinity to the closest object, the first lens group G1 remains stationary with respect to the image plane Sim, and the second lens group G2 moves to the object side along the optical axis Z. The first lens group G1 consists of nine lenses L1a to L1i in order from the object side. The second lens group G2 consists of lenses L2a to L2c, an aperture stop St, and lenses L2d to L2g in order from the object side.

Regarding the imaging lens of Example 17, Table 62 shows basic lens data, Table 63 shows specification, Table 64 shows variable surface distances, Table 65 shows aspheric surface coefficients, and FIGS. 50 and 51 show aberration diagrams. In FIG. 50, the upper part shows aberration diagrams in a state where the object at infinity is in focus, and the lower part shows aberration diagrams in a state where the object at the distance of 0.4 m (meter) from the object to the image plane Sim is in focus. FIG. 51 shows lateral aberration diagram in a state where the object at infinity is in focus.

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TABLE 62

Example 17					
Sn	R	D	Nd	vd	θgF
1	-336.27458	2.200	1.48749	70.24	0.53007
2	38.98761	15.631			
3	-46.53554	2.210	1.59551	39.24	0.58043
4	249.77972	5.766	1.88300	39.22	0.57295
5	-160.59902	0.800			
6	276.62948	8.350	2.00069	25.46	0.61364
7	-81.36890	3.916			
8	-63.06549	2.210	1.69895	30.13	0.60298
9	135.70322	3.841	1.88300	39.22	0.57295
10	422.33573	1.500			
11	102.34565	15.415	1.43875	94.66	0.53402
12	-44.71698	2.200	1.85896	22.73	0.62844
13	-77.19256	0.100			
14	101.83391	9.311	1.59282	68.62	0.54414
15	-119.76934	DD[15]			
16	69.07462	5.899	1.95906	17.47	0.65993
17	449.86569	0.600			
18	33.09295	10.662	1.59282	68.62	0.54414
19	-150.72672	1.700	1.85896	22.73	0.62844
20	26.86774	6.577			
21(St)	∞	8.310			
*22	-28.92910	1.800	1.68948	31.02	0.59874
*23	419.15250	1.784			
24	124.99078	6.834	1.88300	39.22	0.57295
25	-19.93892	1.220	1.59270	35.31	0.59336
26	40.55156	6.493	1.87070	40.73	0.56825
27	-53.64933	DD[27]			
28	∞	2.850	1.51680	64.20	0.53430
29	∞	1.000			

TABLE 63

Example 17		
f	32.299	
FNo.	1.03	
2ωmax	49.0	

TABLE 64

Example 17		
	Infinity	0.4 m
DD[15]	5.583	1.508
DD[27]	14.463	18.538

TABLE 65

Example 17		
Sn	22	23
KA	1.0000000E+00	1.0000000E+00
A3	0.0000000E+00	0.0000000E+00
A4	3.5406543E-05	4.9366505E-05
A5	7.0264041E-06	7.9379491E-06
A6	-1.1816569E-06	-1.4343119E-06
A7	-2.2756224E-07	-2.0060437E-07
A8	3.4450831E-08	4.3102131E-08
A9	5.4529188E-09	3.4605387E-09
A10	-8.2702494E-10	-9.3263727E-10
A11	-8.7833902E-11	-3.7283303E-11
A12	1.3514381E-11	1.3092859E-11
A13	8.9890230E-13	2.4405774E-13
A14	-1.4076774E-13	-1.1755255E-13
A15	-5.5890568E-15	-9.1931741E-16
A16	8.9135105E-16	6.5486383E-16
A17	1.9220049E-17	1.7211209E-18

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TABLE 65-continued

Example 17		
Sn	22	23
5	A18	-3.1226127E-18
	A19	-2.7989666E-20
	A20	4.6368363E-21
10		2.8305920E-21

Example 18

FIG. 52 shows a cross-sectional configuration of the imaging lens of Example 18. The imaging lens of Example 18 consists of, in order from the object side, a first lens group G1 having a positive refractive power, an aperture stop St, a second lens group G2 having a positive refractive power, and a third lens group G3 having a negative refractive power. During focusing from the object at infinity to the closest object, the first lens group G1 and the third lens group G3 remain stationary with respect to the image plane Sim, and the second lens group G2 moves to the object side along the optical axis Z. The first lens group G1 consists of thirteen lenses L1a to L1m in order from the object side. The second lens group G2 consists of four lenses L2a to L2d in order from the object side. The third lens group G3 consists of one lens L3a.

Regarding the imaging lens of Example 18, Table 66 shows basic lens data, Table 67 shows specification, Table 68 shows variable surface distances, Table 69 shows aspheric surface coefficients, and FIGS. 53 and 54 show aberration diagrams. In FIG. 53, the upper part shows aberration diagrams in a state where the object at infinity is in focus, and the lower part shows aberration diagrams in a state where the object at the distance of 0.4 m (meter) from the object to the image plane Sim is in focus. FIG. 54 shows lateral aberration diagram in a state where the object at infinity is in focus.

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TABLE 66

Example 18					
Sn	R	D	Nd	vd	θgF
45	1	-633.25261	2.000	1.59551	39.24
	2	38.00665	12.863		
	3	-54.28519	1.850	1.80100	34.97
	4	95.00850	10.922	1.71300	53.87
	5	-67.98194	0.100		
	6	95.72298	6.765	2.00272	19.32
	7	-251.63874	1.000		
	8	-246.42407	6.991	1.80100	34.97
	9	-53.58723	1.610	1.69895	30.13
	10	99.80167	0.909		
	11	137.54054	10.681	1.62041	60.29
	12	-52.34651	2.010	1.60342	38.03
	13	-414.75790	0.100		
	14	143.20008	3.225	1.69680	55.53
	15	366.55185	0.462		
	16	51.74239	6.881	1.91082	35.25
	17	180.97539	0.260		
	18	35.24471	11.944	1.81600	46.62
	19	-93.14313	1.010	1.72825	28.46
	20	79.60733	0.642		
	21	118.00563	1.300	1.85896	22.73
	22	22.08603	7.000		
	23(St)	∞	DD[23]		
	*24	-18.33819	1.700	1.68948	31.02
	*25	-31.12948	0.100		
	26	111.28451	5.800	1.87070	40.73
	27	-25.06585	1.220	1.69895	30.13
					0.60298

TABLE 66-continued

Example 18						
Sn	R	D	Nd	vd	θgF	
28	182.89249	6.206	1.81600	46.62	0.55682	5
29	-28.43888	DD[29]				
30	-125.00563	1.300	1.51742	52.43	0.55649	
31	∞	11.118				
32	∞	2.150	1.54763	54.98	0.55247	
33	∞	1.317				
34	∞	0.700	1.49784	54.98	0.55000	
35	∞	1.000				

TABLE 67

Example 18		
f	32.025	
FNo.	1.03	
2ωmax	48.4	

TABLE 68

Example 18		
Infinity	0.4 m	
DD[23]	10.027	6.297
DD[29]	1.500	5.230

TABLE 69

Example 18		
Sn	24	25
KA	1.0000000E+00	1.0000000E+00
A4	7.6509788E-05	8.6420274E-05
A6	-1.2736248E-06	-6.0388926E-07
A8	5.0778640E-08	1.1474585E-08
A10	-1.3097284E-09	-7.5854198E-11
A12	2.0623870E-11	-1.6331770E-12
A14	-2.0059301E-13	3.9524334E-14
A16	1.1722812E-15	-3.5644909E-16
A18	-3.7566167E-18	1.5341315E-18
A20	5.0432936E-21	-2.6183645E-21

Example 19

FIG. 55 shows a cross-sectional configuration of the imaging lens of Example 19. The imaging lens of Example 19 consists of, in order from the object side, a first lens group G1 that has a positive refractive power, an aperture stop St, and a second lens group G2 that has a positive refractive power. During focusing from the object at infinity to the closest object, the first lens group G1 remains stationary with respect to the image plane Sim, and the second lens group G2 moves to the object side along the optical axis Z. The first lens group G1 consists of twelve lenses L1a to L1l in order from the object side. The second lens group G2 consists of four lenses L2a to L2d in order from the object side.

Regarding the imaging lens of Example 19, Table 70 shows basic lens data, Table 71 shows specification, Table 72 shows variable surface distances, Table 73 shows aspheric surface coefficients, and FIGS. 56 and 57 show aberration diagrams. In FIG. 56, the upper part shows

aberration diagrams in a state where the object at infinity is in focus, and the lower part shows aberration diagrams in a state where the object at the distance of 0.4 m (meter) from the object to the image plane Sim is in focus. FIG. 57 shows lateral aberration diagram in a state where the object at infinity is in focus.

TABLE 70

Example 19						
Sn	R	D	Nd	vd	θgF	
1	-158.58566	2.000	1.56926	62.34	0.54137	
2	45.50663	11.311				
3	-58.28419	1.860	1.82401	23.80	0.61679	
4	41.90339	13.828	1.88018	21.34	0.62618	
5	-101.81510	0.100				
6	98.28394	8.000	1.99999	15.00	0.65515	
7	-127.35841	0.100				
8	-132.35649	1.600	1.85117	22.44	0.62166	
9	84.30253	1.535				
10	137.70215	12.985	1.66628	58.19	0.54256	
11	-39.49589	2.000	1.86788	21.61	0.62483	
12	-124.45426	0.100				
13	73.44245	7.449	1.82042	45.96	0.55588	
14	-358.81915	0.000				
15	52.60700	4.584	1.71060	55.97	0.54269	
16	93.76319	0.250				
17	35.01559	11.718	1.81600	46.62	0.55682	
18	-112.02490	1.000	1.83429	23.29	0.61859	
19	45.38534	0.919				
20	60.40304	1.300	1.80688	24.66	0.61389	
21	21.37711	7.000				
22(St)	∞		DD[22]			
23	-24.07079	1.400	1.48001	58.75	0.54321	
24	352.80309	0.100				
25	39.97798	8.898	1.94001	31.43	0.59353	
26	-30.93442	1.210	1.76519	26.74	0.60732	
27	59.03069	1.000				
*28	53.18296	5.500	1.80610	40.73	0.56940	
*29	-44.23856		DD[29]			
30	∞	2.150	1.54763	54.98	0.55247	
31	∞	1.320				
32	∞	0.700	1.49784	54.98	0.55000	
33	∞	1.000				

TABLE 71

Example 19		
f	32.017	
FNo.	1.03	
2ωmax	49.0	

TABLE 72

Example 19		
Infinity	0.4 m	
DD[22]	10.229	5.964
DD[29]	11.831	16.096

TABLE 73

Example 19		
Sn	28	29
KA	1.0000000E+00	1.0000000E+00
A4	-1.0078045E-05	8.8298530E-06
A6	-3.5300117E-08	-1.8081425E-07
A8	-8.3277198E-10	5.3397794E-09

TABLE 73-continued

Sn	28	29
A10	4.3699816E-11	-9.6079166E-11
A12	-7.6172757E-13	1.0902419E-12
A14	6.9072493E-15	-7.9169687E-15
A16	-3.4626193E-17	3.6005727E-17
A18	9.0691746E-20	-9.3635343E-20
A20	-9.6047967E-23	1.0660537E-22

## Example 20

FIG. 58 shows a cross-sectional configuration of the imaging lens of Example 20. The imaging lens of Example 20 consists of, in order from the object side, a first lens group G1 that has a positive refractive power, an aperture stop St, a second lens group G2 that has a positive refractive power, and a third lens group G3 that has a positive refractive power. During focusing from the object at infinity to the closest object, the first lens group G1 and the third lens group G3 remain stationary with respect to the image plane Sim, and the second lens group G2 moves to the object side along the optical axis Z. The first lens group G1 consists of fourteen lenses L1a to L1n in order from the object side. The second lens group G2 consists of four lenses L2a to L2d in order from the object side. The third lens group G3 consists of one lens L3a.

Regarding the imaging lens of Example 20, Table 74 shows basic lens data, Table 75 shows specification, Table 76 shows variable surface distances, Table 77 shows aspheric surface coefficients, and FIGS. 59 and 60 show aberration diagrams. In FIG. 59, the upper part shows aberration diagrams in a state where the object at infinity is in focus, and the lower part shows aberration diagrams in a state where the object at the distance of 0.6 m (meter) from the object to the image plane Sim is in focus. FIG. 60 shows lateral aberration diagram in a state where the object at infinity is in focus.

TABLE 74

Sn	Example 20				
	R	D	Nd	vd	θgF
1	-69.40351	2.000	1.58913	61.13	0.54067
2	47.39750	10.135			
3	-65.36696	1.860	1.85896	22.73	0.62844
4	898.20220	6.892	1.88300	39.22	0.57295
5	-80.44512	0.100			
6	97.48909	5.741	1.98613	16.48	0.66558
7	-546.89782	2.000			
8	-171.12562	5.073	1.88300	39.22	0.57295
9	-63.25974	1.610	1.60342	38.03	0.58356
10	111.43989	1.962			
11	341.07330	13.611	1.62041	60.29	0.54266
12	-34.36799	2.010	1.59270	35.31	0.59336
13	-113.99006	0.100			
14	276.49914	3.956	1.59282	68.62	0.54414
15	-272.14204	0.100			
16	88.96039	4.616	1.59282	68.62	0.54414
17	546.58221	0.100			
18	109.73550	3.000	1.63854	55.38	0.54858
19	235.51602	0.000			
20	32.76798	13.753	1.75500	52.32	0.54737
21	-86.78027	1.010	1.74000	28.30	0.60790
22	46.97326	0.897			
23	62.86769	1.300	1.80518	25.42	0.61616
24	24.63660	7.000			

TABLE 74-continued

Sn	Example 20				
	R	D	Nd	vd	θgF
25(St)	∞		DD[25]		
*26	-14.19913	1.700	1.68948	31.02	0.59874
*27	-19.92300	0.100			
30	217.66762	5.000	1.87070	40.73	0.56825
30	-32.97025	1.220	1.69895	30.13	0.60298
30	-98.98873	5.691	1.88300	39.22	0.57295
31	-31.65160		DD[31]		
32	300.00000	1.800	1.48749	70.24	0.53007
33	∞		11.121		
34	∞	2.150	1.54763	54.98	0.55247
35	∞	1.315			
36	∞	0.700	1.49784	54.98	0.55000
37	∞	1.000			

TABLE 75

Example 20	
f	32.027
FNo.	1.03
2ωmax	49.4

TABLE 76

Example 20	
Infinity	0.6 m
DD[25]	11.613
DD[31]	1.500

TABLE 77

Example 20	
Sn	26
KA	1.0000000E+00
A4	1.6825325E-04
A6	-2.4177276E-06
A8	9.3324700E-08
A10	-2.2900676E-09
A12	3.4816388E-11
A14	-3.2819139E-13
A16	1.8701820E-15
A18	-5.8954769E-18
A20	7.8960041E-21
	27

Tables 78 to 82 show values corresponding to Conditional Expressions (1) to (19) of the imaging lenses of Examples 1 to 20. In the example including a plurality of LA positive lenses LA, values are shown for all LA positive lenses LA. In Examples 1 to 20, the d line is set as the reference wavelength. Tables 78 to 82 show the values based on the d line. ΔθgFA, ΔθgFB, and ΔθgFn1 in Tables 78 to 82 represent the following values, respectively.

$$\Delta\theta gFA = \theta gFA + 0.00162 \times vda - 0.64159$$

$$\Delta\theta gFB = \theta gFB + 0.00162 \times vdb - 0.64159$$

$$\Delta\theta gFn1 = \theta gFn1 + 0.00162 \times vd1 - 0.64159$$

TABLE 78

Expression Number		Example 1	Example 2	Example 3	Example 4
(1)	NdA	2.00272	1.92286	1.95906	1.98613
(2)	vdA	19.32	20.88	17.47	16.48
(3)	vdB	90.19	81.61	68.62	68.62
(4)	vdn1	19.61	18.42	21.56	21.55
(5)	TL × FNo/f	2.246	2.417	2.293	2.225
(6)	vdC	68.62	81.61	68.62	68.62
(7)	Ndfm	1.45860	1.49700	1.59282	1.59282
(8)	Ndpr	1.93784	2.00100	1.88300	1.88300
(9)	Nd2p	1.95375	2.00100	1.88300	1.88300
(10)	f1/f	2.568	2.372	2.311	2.184
(11)	1/{tan(ωmax) × FNo}	3.555	3.375	3.448	3.330
(12)	f2 /f	0.795	0.721	0.705	0.699
(13)	f1/f2	3.231	3.288	3.281	3.122
(14)	(1 - β²) × βr²	0.692	0.822	0.813	0.790
(15)	Tf/TL	0.544	0.576	0.547	0.534
(16)	f/fm	0.859	0.803	0.872	0.825
(17)	ΔθgFA	0.03485	0.03124	0.04664	0.05069
(18)	ΔθgFB	0.03968	0.02949	0.01371	0.01371
(19)	ΔθgFn1	0.03718	0.04076	0.02842	0.02725

TABLE 79

Expression Number		Example 5	Example 6	Example 7	Example 8
(1)	NdA	1.89286	1.92286	2.10420	2.00069
(2)	vdA	20.36	18.90	17.02	25.46
(3)	vdB	67.73	74.70	94.66	75.50
(4)	vdn1	23.02	22.62	20.89	24.40
(5)	TL × FNo/f	2.230	2.443	2.660	2.262
(6)	vdC	67.73	74.70	94.66	75.50
(7)	Ndfm	1.59522	1.53775	1.43875	1.55032
(8)	Ndpr	1.90043	1.85067	1.84786	1.86725
(9)	Nd2p	1.90043	1.85067	1.84786	1.86725
(10)	f1/f	2.366	2.003	2.051	2.513
(11)	1/{tan(ωmax) × FNo}	3.462	3.329	3.279	3.512
(12)	f2 /f	0.684	0.715	0.730	0.661
(13)	f1/f2	3.457	2.800	2.808	3.800
(14)	(1 - β²) × βr²	0.821	0.751	0.762	0.842
(15)	Tf/TL	0.540	0.589	0.620	0.550
(16)	f/fm	0.860	0.822	0.796	0.933
(17)	ΔθgFA	0.03083	0.03863	0.04909	0.01330
(18)	ΔθgFB	0.01239	0.01878	0.04578	0.02073
(19)	ΔθgFn1	0.02068	0.01986	0.02360	0.01811

TABLE 80

Expression Number		Example 9	Example 10	Example 11	Example 12
(1)	NdA	1.92119	2.05090	1.95375	1.92119
(2)	vdA	23.96	26.94	32.32	23.96
(3)	vdB	81.61	68.62	94.66	75.50
(4)	vdn1	23.02	22.73	27.01	24.10
(5)	TL × FNo/f	2.244	2.709	2.685	2.740
(6)	vdC	81.61	68.62	90.19	67.73
(7)	Ndfm	1.49700	1.56883	1.43875	1.55032
(8)	Ndpr	1.88300	1.73630	1.82897	1.78517
(9)	Nd2p	1.88300	1.79841	1.93835	1.83756
(10)	f1/f	2.380	0.872	1.076	1.050
(11)	1/{tan(ωmax) × FNo}	3.482	3.302	3.395	3.309
(12)	f2 /f	0.679	0.583	0.851	0.786
(13)	f1/f2	3.503	—	—	—
(14)	(1 - β²) × βr²	0.823	1.294	0.821	0.875
(15)	Tf/TL	0.546	0.285	0.335	0.339
(16)	f/fm	0.856	—	0.925	0.955
(17)	ΔθgFA	0.01748	0.00724	0.00092	0.01748
(18)	ΔθgFB	0.02949	0.01371	0.04578	0.02073
(19)	ΔθgFn1	0.02068	0.02367	0.01127	0.01848

TABLE 81

Expression Number		Example 13	Example 14	Example 15	Example 16
(1)	NdA	2.00069 1.95906 —	2.00001 1.99166 2.00001	2.00001 1.98542 2.00000	2.10420 1.92286 —
(2)	vdA	25.46 17.47 —	16.35 26.42 15.00	16.89 25.79 15.00	17.02 20.88 —
(3)	vdB	94.66	94.66	94.66	60.47
(4)	vdnl	26.87	22.80	24.57	22.14
(5)	TL × FNo/f	4.077	4.677	4.548	4.012
(6)	vdC	81.54	67.73	67.73	—
(7)	Ndfm	1.43875	1.43875	1.43875	1.59410
(8)	Ndpr	1.84950	1.64162	1.82040	1.79175
(9)	Nd2p	1.81272	1.71964	1.80692	1.81305
(10)	f1/f	3.011	2.883	2.441	2.818
(11)	1/{tan(ωmax) × FNo}	2.132	1.939	2.021	2.248
(12)	f2 /f	1.395	1.501	1.493	1.281
(13)	f1/f2	2.158	1.921	1.634	2.200
(14)	(1 - β²) × βr²	0.890	0.880	0.832	0.900
(15)	TFTL	0.696	0.713	0.713	0.691
(16)	f/fm	0.589	0.588	0.630	0.689
(17)	ΔθgFA	0.01330 0.04664	0.03483 0.01225	0.03363 0.01358	0.04909 0.03124
(18)	ΔθgFB	0.04578	0.04578	0.04578	0.01153
(19)	ΔθgFn1	0.02590	0.01910	0.01733	0.03186

TABLE 82

Expression Number		Example 17	Example 18	Example 19	Example 20
(1)	NdA	2.00069 1.95906 —	2.00272 — 19.32	1.88018 1.99999 21.34	1.98613 — 16.48
(2)	vdA	25.46 17.47 —	— 15.00	— —	— —
(3)	vdB	94.66	60.29	58.19	68.62
(4)	vdnl	26.43	25.60	22.03	24.08
(5)	TL × FNo/f	4.728	4.324	4.310	4.269
(6)	vdC	68.62	—	—	68.62
(7)	Ndfm	1.43875	1.62041	1.66628	1.59282
(8)	Ndpr	1.87685	1.84335	1.87306	1.74707
(9)	Nd2p	1.82640	1.84335	1.87306	1.87685
(10)	f1/f	2.675	1.780	1.921	1.685
(11)	1/{tan(ωmax) × FNo}	2.127	2.145	2.132	2.107
(12)	f2 /f	1.611	0.985	1.099	1.208
(13)	f1/f2	1.660	1.806	1.748	1.395
(14)	(1 - β²) × βr²	0.860	0.822	0.729	0.595
(15)	TFTL	0.705	0.677	0.669	0.669
(16)	f/fm	—	—	—	—
(17)	ΔθgFA	0.01330 0.04664	0.03485 —	0.01916 0.03786	0.05069 —
(18)	ΔθgFB	0.04578	-0.00126	-0.00476	0.01371
(19)	ΔθgFn1	0.01694	0.01795	0.01734	0.01971

The F numbers of the imaging lenses of Examples 1 to 20 are smaller than 2. In particular, the F numbers of the imaging lenses of Examples 1 to 9 are smaller than 1.2. The imaging lens of Examples 1 to 20 have such a small F number, reduction in size is achieved, and various aberrations are satisfactorily corrected, whereby high optical performance is achieved.

Next, an imaging apparatus according to an embodiment of the present disclosure will be described. FIGS. 61 and 62 are external views of a camera 30 which is the imaging apparatus according to the embodiment of the present disclosure. FIG. 61 is a perspective view of the camera 30 viewed from the front side, and FIG. 62 is a perspective view of the camera 30 viewed from the rear side. The camera 30 is a so-called mirrorless type digital camera, and the inter-

changeable lens 20 can be detachably attached thereto. The interchangeable lens 20 includes the imaging lens 1, which is housed in a lens barrel, according to an embodiment of the present disclosure.

The camera 30 comprises a camera body 31, and a shutter button 32 and a power button 33 are provided on an upper surface of the camera body 31. Further, an operation section 34, an operation section 35, and a display section 36 are provided on a rear surface of the camera body 31. The display section 36 displays a captured image and an image within an angle of view before imaging.

An imaging aperture, through which light from an imaging target is incident, is provided at the center on the front surface of the camera body 31. A mount 37 is provided at a position corresponding to the imaging aperture. The inter-

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changeable lens 20 is mounted on the camera body 31 with the mount 37 interposed therebetween.

In the camera body 31, there are provided an imaging element, a signal processing circuit, a storage medium, and the like. The imaging element such as a charge coupled device (CCD) or a complementary metal oxide semiconductor (CMOS) outputs a captured image signal based on a subject image which is formed through the interchangeable lens 20. The signal processing circuit generates an image through processing of the captured image signal which is output from the imaging element. The storage medium stores the generated image. The camera 30 is able to capture a still image or a video by pressing the shutter button 32, and is able to store image data, which is obtained through imaging, in the storage medium.

The technology of the present disclosure has been hitherto described through embodiments and examples, but the technology of the present disclosure is not limited to the above-mentioned embodiments and examples, and may be modified into various forms. For example, values such as the radius of curvature, the surface distance, the refractive index, the Abbe number, and the aspheric surface coefficient of each lens are not limited to the values shown in the numerical examples, and different values may be used therefor.

Further, the imaging apparatus according to the embodiment of the present disclosure is not limited to the above example, and may be modified into various forms such as a camera other than the mirrorless type, a film camera, and a video camera.

What is claimed is:

1. An imaging lens comprising, as lens groups, only three lens groups consisting of, in order from an object side to an image side: a first lens group that has a positive refractive power; a second lens group that has a refractive power; and a third lens group that has a refractive power,

wherein during focusing from an object at infinity to a closest object, only the second lens group moves along an optical axis,

during focusing, a distance between the first lens group and the second lens group changes, a distance between the second lens group and the third lens group changes, and mutual distances between all lenses in the first lens group, mutual distances between all lenses in the second lens group, and mutual distances between all lenses in the third lens group are constant,

the first lens group includes, successively in order from a position closest to the object side to the image side, a first lens as a single lens of which an image side lens surface is concave, a second lens as a single lens of which an object side lens surface is convex, a third lens as a single lens of which an object side lens surface is convex, and a fourth lens of which an object side lens surface is convex,

at least two negative lenses are disposed in the first lens group,

a cemented lens, in which a lens of which an object side lens surface is convex and a biconvex lens are cemented in this order from the object side to the image side, is disposed in the first lens group,

the second lens group includes a negative lens of which an object side lens surface is concave at a position closest to the object side,

an object side lens surface of a lens closest to the image side in the second lens group is concave,

the imaging lens includes, within the lens groups, successively in order from a position closest to the image

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side to the object side, a first image side lens as a single lens that is a biconcave lens, a second image side lens as a single lens that is a biconvex lens, a third image side lens as a negative lens of which an object side lens surface is concave, a fourth image side lens as a positive lens of which an image side lens surface is convex, and a fifth image side lens as a biconvex lens, a stop is disposed closer to the image side than the second lens and closer to the object side than the fourth image side lens, and

assuming that:

a distance on the optical axis from a lens surface closest to the object side to the stop in a state where the object at infinity is in focus is  $Tf$ , and

a sum of a distance on the optical axis from the lens surface closest to the object side to a lens surface closest to the image side and a back focal length at an air-converted distance in the state where the object at infinity is in focus is  $TL$ ,

Conditional Expression (15) is satisfied, which is represented by

$$0.2 < Tf/TL < 0.65 \quad (15).$$

2. The imaging lens according to claim 1,

wherein the second lens group has a negative refractive power, and

the third lens group has a positive refractive power.

3. The imaging lens according to claim 2, wherein the number of lenses disposed closer to the object side than the stop is eight or less.

4. The imaging lens according to claim 2, wherein the number of lenses disposed closer to the object side than the stop is seven or less.

5. The imaging lens according to claim 2,  
wherein the first lens is a positive meniscus lens,  
the second lens is a meniscus lens,  
the third lens is a meniscus lens, and  
the fourth lens is a meniscus lens.

6. The imaging lens according to claim 1, wherein Conditional Expression (15-3) is satisfied, which is represented by

$$0.285 \leq Tf/TL \leq 0.65 \quad (15-3).$$

7. The imaging lens according to claim 6, wherein the number of lenses disposed closer to the object side than the stop is eight or less.

8. The imaging lens according to claim 6, wherein the number of lenses disposed closer to the object side than the stop is seven or less.

9. The imaging lens according to claim 6,  
wherein the first lens is a positive meniscus lens,  
the second lens is a meniscus lens,  
the third lens is a meniscus lens, and  
the fourth lens is a meniscus lens.

10. The imaging lens according to claim 1, wherein the number of lenses disposed closer to the object side than the stop is eight or less.

11. The imaging lens according to claim 10,  
wherein the first lens is a positive meniscus lens,  
the second lens is a meniscus lens,  
the third lens is a meniscus lens, and  
the fourth lens is a meniscus lens.

12. The imaging lens according to claim 1, wherein the number of lenses disposed closer to the object side than the stop is seven or less.

13. The imaging lens according to claim 12,  
wherein the first lens is a positive meniscus lens,

the second lens is a meniscus lens,  
the third lens is a meniscus lens, and  
the fourth lens is a meniscus lens.

**14.** The imaging lens according to claim 1,  
wherein the first lens is a positive meniscus lens, 5  
the second lens is a meniscus lens,

the third lens is a meniscus lens, and  
the fourth lens is a meniscus lens.

**15.** An imaging apparatus comprising the imaging lens  
according to claim 1. 10

**16.** The imaging lens according to claim 1,  
wherein the first lens is a positive meniscus lens, the  
second lens is a meniscus lens, the third lens is a  
meniscus lens, the fourth lens is a meniscus lens, the  
first lens group includes, a fifth lens as a biconvex lens 15  
disposed adjacent to the image side of the fourth lens,  
and a sixth lens that has a negative refractive power and  
is disposed adjacent to the image side of the fifth lens.

\* \* \* \* \*