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HIGH POWER ZOOM LENS

Abstract

A high power zoom lens including, in order from an object side: a first lens group that has a positive refractive power; a second lens group that has a negative refractive power; a third lens group that has a positive refractive power; a fourth lens group that has a positive refractive power; an L-th lens group that has a positive refractive power and is positioned at a position which is closest to an image side; in which, in a case of zooming from a wide-angle end to a telephoto end, a distance between the lens groups changes, the third lens group includes a lens group having a positive refractive power and a lens group having a negative refractive power, the fourth lens group includes a lens group having a positive refractive power and a lens group having a negative refractive power.

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Background/Summary

FIELD OF THE INVENTION

[0001] The present invention is suitable as a high power zoom lens having a zoom ratio of approximately more than 15 times among imaging lenses used in imaging devices such as a digital camera and a video camera.

BACKGROUND ART

[0002] In recent years, as a zoom lens used in an imaging apparatus, a zoom lens having a high zoom ratio, a high resolution, and a small size in entire system is required. In particular, in order to perform imaging in various scenes without changing the lens, there is a demand for a wider angle and a longer focal length even in a high power zoom lens.

[0003] In addition, particularly in the telephoto range, a mechanism for preventing an image blur caused by a vibration of the optical system due to camera shake or the like is required to be mounted.

[0004] In addition, a quick auto focus drive is required.

RELATED ART DOCUMENTS

Patent Documents

[0005] [Patent Document 1] JP 2021-12243 A1 [0006] [Patent Document 2] WO 2021/131370 A1

SUMMARY OF THE INVENTION

Problem that the Invention is to Solve

[0007] In Patent Document 1, a zoom lens that is small, has a large angle of view of about 40 degrees at a wide-angle end, and includes an image blur prevention mechanism is disclosed.

[0008] However, the zoom ratio is about 4 times, and there is a problem in increasing the focal length at the telephoto end.

[0009] In Patent Document 2, a zoom lens having a focal length of about 400 mm at a telephoto end is disclosed.

[0010] However, the zoom ratio is about 4 times, and there is a problem in increasing the angle of view at the wide-angle end. In addition, there is a problem that the total length is large.

[0011] The present invention provides a high-performance and small-sized optical system having a high zoom ratio of approximately 15 times or more and having favorable correction of various aberrations.

Means for Solving the Problem

[0012] In order to achieve the above object, the present invention provides a high power zoom lens including, in order from an object side: a first lens group G**1** that has a positive refractive power; a second lens group G**2** that has a negative refractive power; a third lens group G**3** that has a positive refractive power; a fourth lens group G**4** that has a positive refractive power; an L-th lens group GL that has a positive refractive power and is positioned at a position which is closest to an image side; in which, in a case of zooming from a wide angle end to a telephoto end, a distance between the lens groups changes, the third lens group G**3** includes a 3A lens group G**3**A having a positive refractive power and a 3B lens group G**3**B having a negative refractive power, image blur correction is performed by moving the 3B lens group G**3**B in a direction substantially perpendicular to an optical axis, the fourth lens group G**4** includes a 4A lens group G**4**A having a positive refractive power and a 4B lens group G**4**B having a negative refractive power, a focusing operation from an infinity state to a short distance is performed by moving the 4B lens group G**4**B from an object side to an image side in an optical axis direction, and the following conditional expressions are satisfied.

[00001] $0.25 < f1/fT < 0.66$ (1) $0.35 < ff/fr < 0.8$ (2) [0013] f1: focal length of first lens group G**1** [0014] fT: focal length of entire system in infinity state at telephoto end [0015] ff: combined focal length of the first lens group G**1** and the second lens group G**2** in the infinity state at the wide angle end [0016] fr: combined focal length from the third lens group G**3** to the L-th lens group GL in the infinity state at the wide-angle end

Advantage of the Invention

[0017] According to the present invention, it is possible to provide a high performance and compact optical system having a high zoom ratio of approximately 15 times or more and having favorable correction of various aberrations.

Description

BRIEF DESCRIPTION OF THE DRAWINGS

[0018] FIG. **1** is a lens configuration diagram at the wide angle end at infinity in Example 1 of a high power zoom lens of the present invention.

[0019] FIG. **2** is a longitudinal aberration diagram at the wide angle end of the high power zoom lens of Example 1 at infinity.

[0020] FIG. **3** is a longitudinal aberration diagram at an intermediate focal length of the high power zoom lens of Example 1 at infinity.

[0021] FIG. **4** is a longitudinal aberration diagram at the telephoto end of the high power zoom lens of Example 1 at infinity.

[0022] FIG. **5** is a lateral aberration diagram at the wide-angle end of the high power zoom lens of Example 1 at infinity.

[0023] FIG. **6** is a lateral aberration diagram at an intermediate focal length of the high power zoom lens of Example 1 at infinity.

[0024] FIG. **7** is a lateral aberration diagram at the telephoto end of the high power zoom lens of Example 1 at infinity.

[0025] FIG. **8** is a lateral aberration diagram in a case where a deflection angle of 0.3 degrees is corrected at the wide-angle end of the high power zoom lens of Example 1 at infinity during vibration reduction.

[0026] FIG. **9** is a lateral aberration diagram in a case where a deflection angle of 0.3 degrees is corrected at the intermediate focal length of the high power zoom lens of Example 1 at infinity during vibration reduction.

[0027] FIG. **10** is a lateral aberration diagram in a case where a deflection angle of 0.3 degrees is corrected at the telephoto end of the high power zoom lens of Example 1 at infinity during vibration reduction.

[0028] FIG. **11** is a lens configuration diagram at the wide-angle end at infinity according to Example 2 of the high power zoom lens of the present invention.

[0029] FIG. **12** is a longitudinal aberration diagram at the wide-angle end of the high power zoom lens of Example 2 at infinity.

[0030] FIG. **13** is a longitudinal aberration diagram at an intermediate focal length of the high power zoom lens of Example 2 at infinity.

[0031] FIG. **14** is a longitudinal aberration diagram at the telephoto end of the high power zoom lens of Example 2 at infinity.

[0032] FIG. **15** is a lateral aberration diagram at the wide-angle end of the high power zoom lens of Example 2 at infinity.

[0033] FIG. **16** is a lateral aberration diagram at an intermediate focal length of the high power zoom lens of Example 2 at infinity.

[0034] FIG. **17** is a lateral aberration diagram at the telephoto end of the high power zoom lens of

Example 2 at infinity.
[0035] FIG. **18** is a lateral aberration diagram in a case where a deflection angle of 0.3 degrees is corrected at the wide-angle end of the high power zoom lens of Example 2 at infinity during vibration reduction.
[0036] FIG. **19** is a lateral aberration diagram in a case where a deflection angle of 0.3 degrees is corrected at the intermediate focal length of the high power zoom lens of Example 2 at infinity during vibration reduction.
[0037] FIG. **20** is a lateral aberration diagram in a case where a deflection angle of 0.3 degrees is corrected at the telephoto end of the high power zoom lens of Example 2 at infinity during vibration reduction.
[0038] FIG. **21** is a lens configuration diagram at the wide-angle end at infinity according to Example 3 of the high power zoom lens of the present invention.
[0039] FIG. **22** is a longitudinal aberration diagram at the wide-angle end of the high power zoom lens of Example 3 in the infinity.
[0040] FIG. **23** is a longitudinal aberration diagram at an intermediate focal length of the high power zoom lens of Example 3 at infinity.
[0041] FIG. **24** is a longitudinal aberration diagram at the telephoto end of the high power zoom lens of Example 3 at infinity.
[0042] FIG. **25** is a lateral aberration diagram at the wide-angle end of the high power zoom lens of Example 3 at infinity.
[0043] FIG. **26** is a lateral aberration diagram at an intermediate focal length of the high power zoom lens of Example 3 at infinity.
[0044] FIG. **27** is a lateral aberration diagram at the telephoto end of the high power zoom lens of Example 3 at infinity.
[0045] FIG. **28** is a lateral aberration diagram in a case where a deflection angle of 0.3 degrees is corrected at the wide angle end of the high power zoom lens of Example 3 at infinity during vibration reduction.
[0046] FIG. **29** is a lateral aberration diagram in a case where a deflection angle of 0.3 degrees is corrected at the intermediate focal length of the high power zoom lens of Example 3 at infinity during vibration reduction.
[0047] FIG. **30** is a lateral aberration diagram in a case where a deflection angle of 0.3 degrees is corrected at the telephoto end of the high power zoom lens of Example 3 at infinity during vibration reduction.
[0048] FIG. **31** is a lens configuration diagram at the wide angle end at infinity according to Example 4 of the high power zoom lens of the present invention.
[0049] FIG. **32** is a longitudinal aberration diagram at the wide-angle end of the high power zoom lens of Example 4 at infinity.
[0050] FIG. **33** is a longitudinal aberration diagram at an intermediate focal length of the high power zoom lens of Example 4 at infinity.
[0051] FIG. **34** is a longitudinal aberration diagram at the telephoto end of the high power zoom lens of Example 4 at infinity.
[0052] FIG. **35** is a lateral aberration diagram at the wide-angle end of the high power zoom lens of Example 4 at infinity.
[0053] FIG. **36** is a lateral aberration diagram at an intermediate focal length of the high power zoom lens of Example 4 at infinity.
[0054] FIG. **37** is a lateral aberration diagram at the telephoto end of the high power zoom lens of Example 4 at infinity.
[0055] FIG. **38** is a lateral aberration diagram in a case where a deflection angle of 0.3 degrees is corrected at the wide-angle end of the high power zoom lens of Example 4 at infinity during vibration reduction.

[0056] FIG. **39** is a lateral aberration diagram in a case where a deflection angle of 0.3 degrees is corrected at the intermediate focal length of the high power zoom lens of Example 4 at infinity during the vibration reduction.
[0057] FIG. **40** is a lateral aberration diagram in a case where a deflection angle of 0.3 degrees is corrected at the telephoto end of the high power zoom lens of Example 4 at infinity during vibration reduction.
[0058] FIG. **41** is a lens configuration diagram at the wide-angle end at infinity according to Example 5 of the high power zoom lens of the present invention.
[0059] FIG. **42** is a longitudinal aberration diagram at the wide-angle end of the high power zoom lens of Example 5 at infinity.
[0060] FIG. **43** is a longitudinal aberration diagram of the high power zoom lens of Example 5 at an intermediate focal length at infinity.
[0061] FIG. **44** is a longitudinal aberration diagram at the telephoto end of the high power zoom lens of Example 5 at infinity.
[0062] FIG. **45** is a lateral aberration diagram at the wide angle end of the high power zoom lens of Example 5 at infinity.
[0063] FIG. **46** is a lateral aberration diagram at an intermediate focal length of the high power zoom lens of Example 5 at infinity.
[0064] FIG. **47** is a lateral aberration diagram at the telephoto end of the high power zoom lens of Example 5 at infinity.
[0065] FIG. **48** is a lateral aberration diagram in a case where a deflection angle of 0.3 degrees is corrected at the wide angle end of the high power zoom lens of Example 5 at infinity during vibration reduction.
[0066] FIG. **49** is a lateral aberration diagram in a case where a deflection angle of 0.3 degrees is corrected at the intermediate focal length of the high power zoom lens of Example 5 at infinity during vibration reduction.
[0067] FIG. **50** is a lateral aberration diagram in a case where a deflection angle of 0.3 degrees is corrected at the telephoto end of the high power zoom lens of Example 5 at infinity during vibration reduction.

EMBODIMENTS FOR CARRYING OUT THE INVENTION

[0068] Hereinafter, examples of the high power zoom lens according to embodiments of the present invention will be described in detail. The following description of Examples describes examples of the high power zoom lens according to the embodiments of the present invention, and the present invention is not limited to the present examples within a range not departing from the gist of the present invention.
[0069] The high power zoom lens according to the embodiments of the present invention includes, in order from the object side, as shown in lens configuration diagrams such as FIG. **1**, FIG. **11**, FIG. **21**, FIG. **31**, and FIG. **41**: a first lens group G**1** that has a positive refractive power; a second lens group G**2** that has a negative refractive power; a third lens group G**3** that has a positive refractive power; a fourth lens group G**4** that has a positive refractive power; an L-th lens group GL that has a positive refractive power and is positioned at a position which is closest to an image side; in which, in a case of zooming from a wide angle end to a telephoto end, a distance between the lens groups changes, the third lens group G**3** includes a 3A lens group G**3**A having a positive refractive power and a 3B lens group G**3**B having a negative refractive power, image blur correction is performed by moving the 3B lens group G**3**B in a direction substantially perpendicular to an optical axis, the fourth lens group G**4** includes a 4A lens group G**4**A having a positive refractive power and a 4B lens group G**4**B having a negative refractive power, a focusing operation from an infinity state to a short distance is performed by moving the 4B lens group G**4**B from an object side to an image side in an optical axis direction, and the following conditional expressions are satisfied.

[00002] $0.25 < f1 / fT < 0.66$ (1) $0.35 <$ .Math. ff / fr .Math. < 0.8 (2) [0070] f1: focal length of the first lens group G**1** [0071] fT: focal length of entire system in infinity state at telephoto end [0072] ff: combined focal length of the first lens group G**1** and the second lens group G**2** in the infinity state at the wide-angle end [0073] fr: combined focal length from the third lens group G**3** to the L-th lens group GL in the infinity state at the wide-angle end

[0074] As an optical system for obtaining a high zoom ratio, a zoom lens including a first lens group having a positive refractive power, a second lens group having a negative refractive power, a third lens group having a positive refractive power, and a plurality of rear groups in order from the object side, in which the rear group has a group for focusing, is generally known. In addition, for example, a zoom lens disclosed in Patent Document 1, which has a subgroup for performing image blur correction in the third lens group and reduces the size of the optical system, is known.

[0075] In addition, in a zoom lens including a first lens group having a positive refractive power, a second lens group having a negative refractive power, a third lens group having a positive refractive power, and a plurality of rear groups in order from the object side, since an on-axis ray in the third lens group passes through a high position in the entire zoom range, large spherical aberration or comatic aberration occurs in the third lens group. Accordingly, the high power zoom lens of the present invention adopts the configuration of the third lens group G**3** having a positive refractive power in which the distance changes during zooming and the fourth lens group G**4** having a positive refractive power. As a result, spherical aberration and comatic aberration can be suppressed in the entire zoom range, and aberrations of the entire optical system can be suppressed.

[0076] Conditional Expression (1) stipulates a ratio of the focal length of the first lens group G**1** to the focal length of the entire system in the infinity state at the telephoto end.

[0077] In a case where the upper limit of Conditional Expression (1) is exceeded and the refractive power of the first lens group G**1** decreases, the convergence action of the rays emerged from the first lens group G**1** decreases, and the diameter of the second lens group G**2** increases. As a result, the size of the optical system increases, which is not preferable.

[0078] It is not preferable that Conditional Expression (1) is below the lower limit and the refractive power of the first lens group G**1** is increased, because spherical aberration or comatic aberration increases mainly at the telephoto end.

[0079] In order to ensure the effect of Conditional Expression (1), it is preferable that the upper limit value is 0.55 and the lower limit value is 0.32.

[0080] Conditional Expression (2) stipulates a ratio of a combined focal length of the first lens group G**1** and the second lens group G**2** in the infinity state at the wide-angle end to a combined focal length of the third lens group G**3** to the L-th lens group GL in the infinity state at the wide-angle end. In order to obtain a large angle of view at the wide-angle end while achieving reduction in size of the entire system, it is necessary to appropriately set a retro focus type power arrangement at the wide angle end.

[0081] In a case where the upper limit of Conditional Expression (2) is exceeded and the combined refractive power of the first lens group G**1** and the second lens group G**2** in the infinity state at the wide angle end is weak, it is difficult to increase the angle of view of the entire system while maintaining the total lens length short. In addition, in a case where the upper limit of Conditional Expression (2) is exceeded and the combined refractive power of the third lens group G**3** to the L-th lens group GL in the infinity state at the wide-angle end increases, it is difficult to reduce spherical aberration and comatic aberration.

[0082] In a case where the combined refractive power of the first lens group G**1** and the second lens group G**2** in the infinity state at the wide-angle end is increased below the lower limit of Conditional Expression (2), it is difficult to reduce the astigmatism at the wide-angle end. Further, the effect of the oblique ray emerged from the second lens group G**2** is increased, and the diameter of the third lens group G**3** and subsequent lens groups is increased, which is not preferable. In addition, in a case where Conditional Expression (2) is lower than the lower limit, and the combined refractive power of the third lens group G**3** to the L-th lens group GL in the infinity state at the wide angle end is decreased, the total length is increased, which is not preferable.

[0083] In Conditional Expression (2), in order to ensure the effect, it is preferable that the upper limit value is 0.70 and the lower limit value is 0.45.

[0084] The present invention is further characterized in that the distance between the 4A lens group G**4**A and the 4B lens group G**4**B in the infinity state is constant during zooming.

[0085] By making the distance between the 4A lens group G**4**A and the 4B lens group G**4**B constant during zooming, a mechanism such as a cam can be simplified, and the product can be downsized. In addition, since a state where so-called zoom tracking for continuing to focus on the subject during zooming in the infinity state is satisfied, a quick and stable focusing operation can be performed.

[0086] The present invention is further characterized in that the distance between the 3A lens group G**3**A and the 3B lens group G**3**B is constant during zooming.

[0087] By making the distance between the third A lens group G**3**A and the third B lens group G**3**B constant, a mechanism such as a cam can be simplified, and the product can be downsized.

[0088] In the present invention, it is preferable that each of the three B lens groups G**3**B is a cemented lens including one positive lens and one negative lens.

[0089] In a case where the weight of the lens group that is driven during the vibration reduction increases, the actuator required for the driving also increases in size, which causes the mechanism to increase in size. In order to achieve good aberration correction during vibration reduction and downsizing of the mechanism at the same time, it is necessary to minimize the number of lenses used in the 3B lens group G**3**B. By configuring the 3B lens group G**3**B with one positive lens and one negative lens, it is possible to suppress the lateral chromatic aberration occurring in a case where the 3B lens group G**3**B is moved in a direction substantially perpendicular to the optical axis. In addition, since it is not necessary to generate a mechanism element such as a spacer by using the cemented lens, the weight can be further reduced.

[0090] In the present invention, the 4B lens group G**4**B is a cemented lens including: one negative lens, or one positive lens and one negative lens.

[0091] In order to simultaneously satisfy the achievement of the rapid driving during focusing and the downsizing of the mechanism, it is necessary to reduce the weight of the lens group used for focusing. By forming the 4B lens group G**4**B as a cemented lens including one negative lens or one positive lens and one negative lens, the weight of the 4B lens group G**4**B can be suppressed.

[0092] In the present invention, the L-th lens group GL positioned closest to the image side is fixed with respect to the image surface.

[0093] By fixing the L-th lens group GL, which is positioned closest to the image side, with respect to the image surface, a mechanism such as a cam can be simplified, and the product can be downsized.

[0094] In the present invention, it is further characterized in that the first lens group G**1** includes one negative lens and two positive lenses in order from the object side.

[0095] In order to achieve high imaging performance and downsizing at the same time, it is necessary to adopt an optimal configuration in which aberrations can be corrected while suppressing the number of lenses in the first lens group G**1**. By including the negative lens and the positive lens, it is possible to suppress the lateral chromatic aberration occurring in the first lens group G**1**. In addition, by using two positive lenses, it is possible to mainly reduce spherical aberration and comatic aberration occurring in the first lens group G**1** at the telephoto end.

[0096] In the present invention, the 4A lens group G**4**A further includes at least two positive lenses and one negative lens.

[0097] Since an on-axis ray passes through a high position in the 4A lens group G**4**A from the wide-angle end to the telephoto end, spherical aberration or comatic aberration is largely generated in the 4A lens group G**4**A. Since the aberration generated in the 4A lens group G**4**A is magnified by the 4B lens group G**4**B having a negative refractive power, it is necessary to suppress the aberration generated in the 4A lens group G**4**A in order to satisfactorily correct various aberrations from the infinity state to the short distance. Therefore, by forming the 4A lens group G**4**A with at least two or more positive lenses, spherical aberration and comatic aberration in the entire system can be satisfactorily corrected. In addition, by including a positive lens and a negative lens in the 4A lens group G**4**A, it is possible to satisfactorily correct the longitudinal chromatic aberration in the entire system.

[0098] The present invention further satisfies the following conditional expression.

[00003] $0.60 < |f4B/f4| < 1.8$ (3) [0099] f4B: focal length of 4B lens group G**4**B [0100] f4: focal length of fourth lens group G**4**

[0101] Conditional Expression (3) stipulates a ratio of a focal length of the fourth B lens group G**4**B to a focal length of the fourth lens group G**4**.

[0102] It is not preferable that the refractive power of the 4B lens group G**4**B exceeds the upper limit of Conditional Expression (3) and the refractive power of the 4B lens group G**4**B decreases because the distance of movement of the 4B lens group G**4**B during focusing increases and a quick focusing operation cannot be performed. On the other hand, in a case where the result of Conditional Expression (3) is greater than the upper limit and the refractive power of the fourth lens group G**4** increases, it is difficult to suppress the astigmatism.

[0103] It is not preferable that the value of Conditional Expression (3) is below the lower limit and the refractive power of the 4B lens group G**4**B increases because it is difficult to suppress the astigmatism generated in the 4B lens group G**4**B, and the change in astigmatism in the short range state from the infinity state is large. In addition, in a case where the value of Conditional Expression (3) is below the lower limit and the refractive power of the fourth lens group G**4** is decreased, the divergence of the off-axis ray emitted from the fourth lens group G**4** increases. Therefore, the diameter of the lens group closer to the image side than the fourth lens group G**4** increases, and the size of the optical system increases.

[0104] In Conditional Expression (3), in order to ensure the effect, it is preferable that the upper limit value is 1.60 and the lower limit value is 0.85.

[0105] The present invention further satisfies the following conditional expression.

[00004] $0.08 < FB/LT < 0.2$ (4) [0106] FB: back focus in air equivalent at wide angle end

[0107] LT: total optical length at wide angle end

[0108] Conditional Expression (4) stipulates a ratio of a back focus in terms of air equivalent at the wide angle end to a total optical length at the wide-angle end. Here, the back focus is a distance on the optical axis from the lens surface vertex of the L-th lens group GL closest to the image side to the image surface. By appropriately setting the back focus, it is possible to reduce the size of the entire system.

[0109] In a case where the upper limit of Conditional Expression (4) is exceeded and the back focus at the wide-angle end increases, it is difficult to suppress the total length of the optical system to be small, which is not preferable.

[0110] It is not preferable that the value of Conditional Expression (4) is lower than the lower limit and the back focus at the wide-angle end decreases because the angle of the off-axis ray emerged from the L lens group GL to the image surface increases and peripheral illumination decreases.

[0111] In Conditional Expression (4), in order to ensure the effect, it is preferable that the upper limit value is 0.18 and the lower limit value is 0.09.

[0112] The present invention further satisfies the following conditional expression.

[00005] $0.50 < f3/f4 < 5.$ (5) [0113] f3: focal length of third lens group G**3** [0114] f4: focal length of fourth lens group G**4**

[0115] Conditional Expression (5) stipulates a ratio of the focal length of the third lens group G**3** to

the focal length of the fourth lens group G**4**.
[0116] In the third lens group G**3** and the fourth lens group G**4**, both the on axis ray and the off-axis ray pass through a high position in the lens from the wide-angle end to the telephoto end. Therefore, in order to satisfactorily correct various aberrations such as spherical aberration, comatic aberration, and astigmatism while reducing the size of the optical system, it is important to appropriately set the refractive power of each group.
[0117] In a case where the upper limit of Conditional Expression (5) is exceeded and the refractive power of the third lens group G**3** decreases, the convergence action of the rays emerged from the third lens group G**3** is weakened, and the diameter of the fourth lens group G**4** increases. Therefore, it is difficult to reduce the product diameter. In addition, in a case where the refractive power of the fourth lens group G**4** is increased and exceeds the upper limit of Conditional Expression (5), it is difficult to suppress astigmatism.
[0118] In a case where the result of Conditional Expression (5) is lower than the lower limit and the refractive power of the third lens group G**3** increases, it is difficult to satisfactorily correct spherical aberration and comatic aberration. In addition, in a case where the value of Conditional Expression (5) is lower than the lower limit and the refractive power of the fourth lens group G**4** decreases, the divergence of the off-axis ray emerged from the fourth lens group G**4** increases. Therefore, the diameter of the lens group on the image side from the fourth lens group G**4** increases, and the size of the optical system increases.
[0119] In Conditional Expression (5), in order to ensure the effect, it is preferable that the upper limit value is 4.00 and the lower limit value is 1.00.
[0120] The present invention further satisfies the following conditional expression.
[00006] $0.010 < \Delta PgF\_3A < 0.073$ (6) [0121] ΔPgF_3A: largest one of anomalous dispersions of a g line and an F line of the positive lens included in the 3A lens group G**3**A
[0122] Conditional Expression (6) stipulates the largest value of the anomalous dispersions of the g line and the F line of the positive lens included in the 3A lens group G**3**A.
[0123] The anomalous dispersion of each lens included in the imaging optical system according to the embodiment of the present invention is stipulated by the following expression.
[00007] Pgf = PgF .Math. 0.64833 + 0.0018 * vd [0124] ΔPgF: anomalous dispersion of lens included in imaging optical system [0125] PgF: partial dispersion ratio of lens included in imaging optical system between g line and F line [0126] vd: Abbe number of lens included in imaging optical system at d line
[0127] It is not preferable that the anomalous dispersion of the positive lens included in the 3A lens group G**3**A is increased to exceed the upper limit of Conditional Expression (6) because the correction of the secondary spectrum is excessive and it is difficult to satisfactorily correct the longitudinal chromatic aberration from the wide-angle end to the telephoto end.
[0128] In a case where the result of Conditional Expression (6) is lower than the lower limit and the anomalous dispersion of the positive lens included in the 3A lens group G**3**A decreases, the second spectrum is insufficiently corrected, which is not preferable.
[0129] In Conditional Expression (6), in order to ensure the effect, it is preferable that the upper limit value is 0.058 and the lower limit value is 0.020.
[0130] The present invention further satisfies the following conditional expression.
[00008] $0.010 < \Delta PgF\_1 < 0.073$ (7) [0131] ΔPgF_1: largest one of the abnormal dispersions of a g line and an F line of the positive lens included in the first lens group G**1**
[0132] Conditional Expression (7) stipulates the largest value of the anomalous dispersions of the g line and the F line in the positive lenses included in the first lens group G**1**.
[0133] In a case where the anomalous dispersion of the positive lens included in the first lens group G**1** is increased and exceeds the upper limit of Conditional Expression (7), there is no appropriate glass material in the existing glass materials.

[0134] In a case where the value of Conditional Expression (7) is lower than the lower limit and the anomalous dispersion of the positive lens included in the first lens group G**1** is decreased, the second spectrum at the telephoto end is insufficiently corrected, which is not preferable.
[0135] In Conditional Expression (7), in order to ensure the effect, it is preferable that the upper limit value is 0.058 and the lower limit value is 0.020.
[0136] Next, lens configurations of examples of the high power zoom lens according to the embodiment of the present invention will be described. In the following description, the lens configuration will be described in order from the object side to the image side.
[0137] In [Surface data], the surface number is a number of a lens surface or an aperture diaphragm S counted from the object side, r is a curvature radius of each surface, d is a distance between the surfaces, nd is a refractive index with respect to the d line (wavelength of 587.56 nm), vd is an Abbe number with respect to the d line, and PgF indicates a partial dispersion ratio with respect to the g line (wavelength of 435.8 nm) and the F line (wavelength of 486.1 nm).
[0138] An asterisk (*) attached to a surface number indicates that the lens surface shape is an aspherical shape. In addition, BF represents a back focus.
[0139] The (diaphragm) attached to the surface number indicates that the aperture diaphragm S is located at that position. A curvature radius with respect to the plane or the aperture diaphragm S is denoted by ∞ (infinity).
[0140] [Aspherical surface data] shows values of each coefficient for giving the aspherical shape of the lens surface denoted by * in [Surface data]. In a case where a displacement from the optical axis in a direction perpendicular to the optical axis is y, a displacement (sag) from an intersection of the optical axis and the aspherical surface in an optical axis direction is z, a curvature radius of a reference spherical surface is r, a conic coefficient is K, and aspherical coefficients of fourth order, sixth order, . . . , and twelfth order are A4, A6, . . . , and A12, respectively, coordinates of the aspherical surface are represented by the following expression.
[00009] $$z=\frac{(1/r)y^2}{1+\sqrt{1-(1+K)(y/r)^2}}+A4y^4+A6y^6+A8y^8+A10y^{10}+A12y^{12}$$
[0141] [Various types of data] indicate values such as a zoom ratio and a focal length in each focal length state.
[0142] The [Variable distance data] shows the variable distance and the BF value in each focal length state.
[0143] The [Lens group data] shows the surface number closest to the object side configuring each lens group and the total focal length of the entire group.
[0144] In addition, in the aberration diagrams corresponding to the respective examples, d, g, and C represent a d line, a g line, and a C line, respectively, and ΔS and ΔM represent a sagittal image surface and a meridional image surface, respectively.
[0145] In addition, in all the values of the specifications described below, unless otherwise noted, the units of the focal length f, the curvature radius r, the lens surface distance d, and other lengths are millimeters (mm), but the present invention is not limited thereto since the same optical performance can be obtained in both the proportional magnification and the proportional reduction in the optical system.
[0146] In addition, in the lens configuration diagram of each example, the arrows indicate paths of the lens groups during zooming from the wide angle end to the telephoto end, | indicates an image surface, and a one dot chain line passing through the center indicates an optical axis.
Example 1
[0147] FIG. **1** is a lens configuration diagram of a high power zoom lens of Example 1 of the present invention.
[0148] Example 1 includes, in order from the object side, a first lens group G**1** having a positive refractive power, a second lens group G**2** having a negative refractive power, an aperture diaphragm S, a third lens group G**3** having a positive refractive power, a fourth lens group G**4**

having a positive refractive power, and a fifth lens group G**5** having a positive refractive power. Further, the third lens group G**3** includes a 3A lens group G**3**A having a positive refractive power and a 3B lens group G**3**B having a negative refractive power, in order from the object side. Further, the fourth lens group G**4** includes a 4A lens group G**4**A having a positive refractive power and a 4B lens group G**4**B having a negative refractive power, in order from the object side. In addition, during the image blur correction during the vibration reduction, the 3B lens group G**3**B moves in a direction substantially perpendicular to the optical axis. Further, during focusing from the infinity to the short distance, the 4B lens group G**4**B moves to the image surface side. The fifth lens group G**5** corresponds to the L-th lens group GL positioned closest to the image side.

[0149] The first lens group G**1** includes, in order from the object side, a negative meniscus lens having a surface convex toward the object side, a positive meniscus lens having a surface convex toward the object side, and a positive meniscus lens having a surface convex toward the object side.

[0150] The second lens group G**2** includes, in order from the object side, a negative meniscus lens having a surface convex toward the object side, a cemented lens including a biconcave lens and a biconvex lens, and a negative meniscus lens having a surface convex toward the image side.

[0151] The third lens group G**3** includes, in order from the object side: a 3A lens group G**3**A including a biconvex lens, and a cemented lens including a biconvex lens and a biconcave lens; and a 3B lens group G**3**B including a cemented lens including a positive meniscus lens having a surface convex toward the image side and a biconcave lens.

[0152] The fourth lens group G**4** includes, in order from the object side: a 4A lens group 4A including a biconvex lens, a biconcave lens, and a biconvex lens; and a lens group 4B including a cemented lens including a positive meniscus lens having a surface convex toward the image side and a biconcave lens.

[0153] The fifth lens group G**5** includes, in order from the object side, a negative meniscus lens having a surface convex toward the object side, and a biconvex lens.

[0154] In addition, in the high power zoom lens of Example 1, during zooming from the wide-angle end to the telephoto end, the distance between the first lens group G**1** and the second lens group G**2** increases, the distance between the second lens group G**2** and the third lens group G**3** decreases, the distance between the third lens group G**3** and the fourth lens group G**4** decreases, and the distance between the fourth lens group G**4** and the fifth lens group G**5** increases. Further, the fifth lens group G**5** remains stationary with respect to the image surface during zooming.

[0155] The specification values of the high power zoom lens of Example 1 are shown below.

Numerical Example 1

TABLE-US-00001 Unit: mm [Surface data] Surface number r d nd vd PgF Object surface ∞ (d0) 1 109.3687 1.5500 1.80610 33.27 0.5884 2 66.0813 7.3019 1.43700 95.10 0.5336 3 917.2712 0.1500 4 82.8968 5.6553 1.59282 68.62 0.5440 5 1226.6732 (d5) 6 843.3064 0.9000 1.95375 32.32 7 17.1873 5.8777 8 −45.3866 0.9000 1.59282 68.62 9 38.8278 5.0211 1.80809 22.76 10 −36.1920 0.3622 11* −31.2704 1.0000 1.76450 49.09 12* −229.1745 (d12) 13 (diaphragm) ∞ 1.0001 14 28.4864 3.6144 1.57135 52.95 0.5553 15 −74.0294 0.1500 16 24.8293 3.7720 1.49700 81.61 0.5389 17 −153.8358 0.9000 2.00100 29.13 0.5995 18 74.5606 3.2487 19 −37.9845 2.1147 1.67270 32.17 20 −22.6649 0.9000 1.59201 67.02 21* 83.3308 (d21) 22 15.8733 6.5868 1.43700 95.10 23 −34.9701 0.1501 24 −71.3746 0.9000 2.00100 29.13 25 47.4713 0.3441 26* 41.9483 3.8875 1.59201 67.02 27* −28.4619 (d27) 28 −35.2496 2.6194 1.75211 25.05 29 −19.1229 0.9000 1.61881 63.85 30* 100.5407 (d30) 31 58.0854 0.9000 2.00100 29.13 32 34.6895 2.1291 33 49.4291 3.9521 1.51742 52.15 34 −537.8400 (BF) image surface ∞ [Aspherical surface data] Surface 11 Surface 12 Surface 21 Surface 26 Surface 27 Surface 30 K 0.00000 0.00000 0.00000 0.00000 0.00000 0.00000 A4 3.52436E−05 2.39096E−05 −6.52626E−06 −6.03584E−05 2.01084E−05 −2.94084E−06 A6 −2.46569E−07 −2.67116E−07 −1.29238E−08 −7.07509E−08 9.24124E−08 −5.49183E−08 A8 5.14679E−10 5.57472E−10 1.65231E−10 4.54929E−09 3.77026E−09 6.47510E−10 A10 0.00000E+00 0.00000E+00 −9.71037E−13 −7.71649E−12

0.00000E+00 1.74859E−12 Zoom ratio: 17.66 Wide angle Middle Telephoto [Various types of data] Focal length 16.48 73.48 291.00 F number 3.60 5.66 6.90 Total angle of view 2ω 87.13 20.95 5.41 Image height Y 14.20 14.20 Total length of lens 145.77 198.45 243.83 [Variable distance data] d0 ∞ ∞ ∞ d5 1.5000 45.2944 83.4890 d12 38.9747 13.8131 2.0000 d21 9.5180 4.1882 2.0000 d27 1.5000 1.5000 1.5000 d30 9.7861 49.0921 70.3574 BF 17.7003 17.7003 17.7003 [Lens group data] Group Starting surface Focal length G1 1 126.13 G2 6 −16.06 G3 13 55.71 G4 22 46.10 G5 31 4514.46 G3A 13 30.50 G3B 19 −46.75 G4A 22 27.04 G4B 28 −48.68

Example 2

[0156] FIG. **11** is a lens configuration diagram of a high power zoom lens of Example 2 of the invention.

[0157] Example 2 includes, in order from the object side, a first lens group G**1** that has a positive refractive power, a second lens group G**2** that has a negative refractive power, an aperture diaphragm S, a third lens group G**3** that has a positive refractive power, a fourth lens group G**4** that has a positive refractive power, and a fifth lens group G**5** that has a positive refractive power. Further, the third lens group G**3** includes a 3A lens group G**3**A having a positive refractive power, and a 3B lens group G**3**B having a negative refractive power, in order from the object side. Further, the fourth lens group G**4** includes a 4A lens group G**4**A having a positive refractive power, and a 4B lens group G**4**B having a negative refractive power, in order from the object side. In addition, during the image blur correction during the vibration reduction, the 3B lens group G**3**B moves in a direction substantially perpendicular to the optical axis. Further, during focusing from the infinity to the short distance, the 4B lens group G**4**B moves to the image surface side. The fifth lens group G**5** corresponds to the L-th lens group GL positioned closest to the image side.

[0158] The first lens group G**1** includes, in order from the object side, a negative meniscus lens having a surface convex toward the object side, a positive meniscus lens having a surface convex toward the object side, and a positive meniscus lens having a surface convex toward the object side.

[0159] The second lens group G**2** includes: a negative meniscus lens having a surface convex toward the object side; a biconcave lens; and a cemented lens including a biconvex lens and a negative meniscus lens having a surface convex toward the image side, in order from the object side.

[0160] The third lens group G**3** includes, in order from the object side: a 3A lens group G**3**A including a biconvex lens, and a cemented lens including a biconvex lens and a biconcave lens; and a 3B lens group G**3**B including a cemented lens including a positive meniscus lens having a surface convex toward the image side and a biconcave lens.

[0161] The fourth lens group G**4** includes, in order from the object side: a 4A lens group G**4**A including a biconvex lens, and a cemented lens including a biconvex lens, and a biconcave lens; and a 4B lens group G**4**B including a cemented lens including a positive meniscus lens having a surface convex toward the image side, and a biconcave lens.

[0162] The fifth lens group G**5** includes, in order from the object side, a negative meniscus lens having a surface convex toward the object side, and a biconvex lens.

[0163] In the high power zoom lens of Example 2, during zooming from the wide-angle end to the telephoto end, the distance between the first lens group G**1** and the second lens group G**2** increases, the distance between the second lens group G**2** and the third lens group G**3** decreases, the distance between the third lens group G**3** and the fourth lens group G**4** decreases, and the distance between the fourth lens group G**4** and the fifth lens group G**5** increases. Further, the fifth lens group G**5** remains stationary with respect to the image surface during zooming.

[0164] The specification values of the high power zoom lens of Example 2 are shown below.

Numerical Example 2

TABLE-US-00002 Unit: mm [Surface data] Surface number r d nd vd PgF Object surface ∞ (d0) 1 103.2436 1.5500 1.80610 33.27 0.5884 2 63.7486 7.2211 1.43700 95.10 0.5336 3 538.7114 0.1500 4 81.4412 5.6792 1.59282 68.62 0.5440 5 1115.1717 (d5) 6 775.2282 0.9000 1.91082

35.25 7 16.4132 6.1565 8* −33.7624 1.0000 1.59201 67.02 9* 86.4689 0.1500 10 43.9493 4.5837 1.80809 22.76 11 −40.6567 0.9000 1.77250 49.63 12 5318.2571 (d12) 13 (diaphragm) ∞ 1.0000 14 26.2071 3.5822 1.54072 47.20 0.5678 15 −78.5508 0.1500 16 26.0109 3.6387 1.49700 81.61 0.5389 17 −102.4775 0.9000 2.00100 29.13 0.5995 18 79.2722 3.0937 19 38.2212 2.0136 1.68893 31.16 20 −23.4974 0.9000 1.59201 67.02 21* 82.1288 (d21) 22 32.0342 3.4958 1.43700 95.10 23 −329.5864 0.1500 24 19.8715 4.0085 1.49700 81.61 25 −392.2178 0.9000 2.00100 29.13 26 31.4569 0.8176 27* 34.7403 3.8014 1.59201 67.02 28* −37.1102 (d28) 29 −72.8134 2.2165 1.75211 25.05 30 −30.8578 0.9000 1.59201 67.02 31* 36.0524 (d31) 32 93.8380 0.9000 2.00100 29.13 33 40.1321 2.2375 34 65.3460 4.6222 1.60342 38.01 35 −77.0648 (BF) Image surface ∞ [Aspherical surface data] Surface 8 Surface 9 Surface 21 Surface 27 Surface 28 Surface 31 K 0.00000 0.00000 0.00000 0.00000 0.00000 0.00000 A4 5.39139E−05 4.06945E−05 −6.52360E−06 −3.31668E−05 2.06783E−05 −1.46682E−08 A6 −4.56671E−07 −5.16111E−07 −1.42896E−08 6.37360E−08 1.12194E−07 −8.98716E−08 A8 1.84445E−09 2.18662E−09 2.29825E−10 1.50461E−09 6.89367E−10 1.83802E−09 A10 −3.30429E−12 −4.02770E−12 −1.40717E−12 −4.52047E−12 0.00000E+00 −9.63256E−12 Zoom ratio: 17.66 Wide angle Middle Telephoto [Various types of data] Focal length 16.48 73.48 291.00 F number 3.60 5.66 6.90 Total angle of view 2ω 86.56 20.96 5.41 Image height Y 14.20 14.20 Total length of lens 146.79 200.14 245.06 [Variable distance data] d0 ∞ ∞ ∞ d5 1.5000 45.1776 83.4412 d12 39.4231 14.3069 2.0059 d21 8.7171 4.1048 2.0000 d28 1.5000 1.5000 1.5000 d31 11.1829 50.5497 71.6024 BF 16.8781 16.8781 16.8781 [Lens group data] Group Starting surface Focal length G1 1 126.48 G2 6 −16.57 G3 13 63.69 G4 22 43.57 G5 32 287.96 G3A 13 32.43 G3B 19 −47.10 G4A 22 26.55 G4B 28 −45.96

Example 3

[0165] FIG. **21** is a lens configuration diagram of a high power zoom lens of Example 3 of the invention.

[0166] Example 3 includes, in order from the object side, a first lens group G**1** having a positive refractive power, a second lens group G**2** having a negative refractive power, an aperture diaphragm S, a third lens group G**3** having a positive refractive power, a fourth lens group G**4** having a positive refractive power, and a fifth lens group G**5** having a positive refractive power. Further, the third lens group G**3** includes a 3A lens group G**3**A having a positive refractive power and a 3B lens group G**3**B having a negative refractive power, in order from the object side. Further, the fourth lens group G**4** includes a 4A lens group G**4**A having a positive refractive power and a 4B lens group G**4**B having a negative refractive power, in order from the object side. In addition, during the image blur correction during the vibration reduction, the 3B lens group G**3**B moves in a direction substantially perpendicular to the optical axis. Further, during focusing from the infinity to the short distance, the 4B lens group G**4**B moves to the image surface side. The fifth lens group G**5** corresponds to the L-th lens group GL positioned closest to the image side.

[0167] The first lens group G**1** includes, in order from the object side, a negative meniscus lens having a surface convex toward the object side, a biconvex lens, and a positive meniscus lens having a surface having a surface convex toward the object side.

[0168] The second lens group G**2** includes: a negative meniscus lens having a surface convex toward the object side; a biconcave lens; and a cemented lens including a biconvex lens and a negative meniscus lens having a surface convex toward the image side, in order from the object side.

[0169] The third lens group G**3** includes, in order from the object side: a 3A lens group G**3**A including a biconvex lens and a cemented lens including a biconvex lens and a biconcave lens; and a 3B lens group G**3**B including a cemented lens including a positive meniscus lens having a surface convex toward the image side, and a biconcave lens.

[0170] The fourth lens group G**4** includes, in order from the object side: a 4A lens group G**4**A including a biconvex lens, a cemented lens including a biconvex lens and a biconcave lens; and a

4B lens group G**4**B including a cemented lens including a positive meniscus lens having a surface convex toward the image side and a biconcave lens.

[0171] The fifth lens group G**5** includes, in order from the object side, a negative meniscus lens having a surface convex toward the object side, and a biconvex lens.

[0172] In the high power zoom lens of Example 3, during zooming from the wide-angle end to the telephoto end, the distance between the first lens group G**1** and the second lens group G**2** increases, the distance between the second lens group G**2** and the third lens group G**3** decreases, the distance between the third lens group G**3** and the fourth lens group G**4** decreases, and the distance between the fourth lens group G**4** and the fifth lens group G**5** increases. Further, the fifth lens group remains stationary with respect to the image surface during zooming.

[0173] The specification values of the high power zoom lens of Example 3 are shown below.

Numerical Example 3

TABLE-US-00003 Unit: mm [Surface data] Surface number r d nd vd PgF Object surface ∞ (d0) 1 118.8841 1.5500 1.80610 33.27 0.5884 2 70.0228 7.4863 1.43700 95.10 0.5336 3 −2402.5913 0.1500 4 80.3410 5.8476 1.59282 68.62 0.5440 5 675.7919 (d5) 6 485.6242 0.9000 1.95375 32.32 7 16.7430 5.8285 8* −43.1161 1.0000 1.59201 67.02 9* 64.4976 0.2815 10 52.7306 5.4828 1.75211 25.05 11 −22.5163 0.9000 1.72916 54.67 12 −408.4979 (d12) 13 (diaphragm) ∞ 1.0000 14 30.9666 3.4000 1.54072 47.20 0.5678 15 −63.5513 0.1517 16 25.0482 3.5271 1.49700 81.61 0.5389 17 −79.0529 0.9000 2.00100 29.13 0.5995 18 92.9187 2.9833 19 −40.5363 2.0695 1.69895 30.05 20 −22.8952 0.9000 1.59201 67.02 21* 60.7550 (d21) 22 24.9347 3.5949 1.55032 75.50 23 −174.0996 0.1500 24 37.0230 2.8841 1.59282 68.62 25 −445.9978 0.9000 2.00100 29.13 26 29.5861 0.3434 27* 24.7835 4.0436 1.59201 67.02 28* −48.7516 (d28) 29 −410.3724 2.0910 1.76182 26.61 30 −54.9954 0.9000 1.59201 67.02 31* 23.0380 (d31) 32 70.2250 0.9000 1.95375 32.32 33 26.9449 0.1500 34 26.0345 6.2541 1.58144 40.89 35 −194.4494 (BF) Image surface ∞ [Aspherical surface data] Surface 8 Surface 9 Surface 21 Surface 27 Surface 28 Surface 31 K 0.00000 0.00000 0.00000 0.00000 0.00000 0.00000 A4 2.23406E−05 5.87171E−06 −7.05642E−06 −2.34043E−05 2.38348E−05 1.44502E−06 A6 −5.92061E−07 −5.76131E−07 5.82547E−09 2.41225E−08 9.84370E−08 −2.10702E−07 A8 4.90497E−09 4.84268E−09 9.78902E−11 1.51538E−09 9.01072E−10 4.22508E−09 A10 −1.50741E−11 −1.50530E−11 −1.20622E−12 −2.49357E−12 0.00000E+00 −3.95449E−11 A12 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 1.65036E−13 Zoom ratio 17.65 Wide angle Middle Telephoto [Various types of data] Focal length 16.48 73.48 291.00 F number 3.61 6.03 6.90 Total angle of view 2ω 86.28 20.96 5.43 Image height Y 14.20 14.20 14.20 Total length of lens 146.31 202.49 238.32 [Variable distance data] d0 ∞ ∞ ∞ d5 1.3000 45.3108 82.8571 d12 36.5543 14.0107 1.8000 d21 9.9515 4.8856 1.8000 d28 1.5000 1.5000 1.5000 d31 12.6529 52.4418 65.9970 BF 17.8001 17.8001 17.8001 [Lens group data] Group Starting surface Focal length G1 1 122.57 G2 6 −16.33 G3 13 72.36 G4 22 40.97 G5 32 274.29 G3A 13 33.10 G3B 19 −44.46 G4A 22 24.87 G4B 28 −40.82

Example 4

[0174] FIG. **31** is a lens configuration diagram of a high power zoom lens of Example 4 of the invention.

[0175] Example 4 includes, in order from the object side, the first lens group G**1** having a positive refractive power, the second lens group G**2** having a negative refractive power, the aperture diaphragm S, the third lens group G**3** having a positive refractive power, the fourth lens group G**4** having a positive refractive power, and the fifth lens group G**5** having a positive refractive power. Further, the third lens group G**3** includes a 3A lens group G**3**A having a positive refractive power and a 3B lens group G**3**B having a negative refractive power, in order from the object side. Further, the fourth lens group G**4** includes a 4A lens group G**4**A having a positive refractive power and a 4B lens group G**4**B having a negative refractive power, in order from the object side. In addition, during the image blur correction during the vibration reduction, the 3B lens group G**3**B moves in a direction substantially perpendicular to the optical axis. Further, during focusing from the infinity to the short distance, the 4B lens group G**4**B moves to the image surface side. The fifth lens group G**5** corresponds to the L-th lens group GL positioned closest to the image side.

[0176] The first lens group G**1** includes, in order from the object side, a negative meniscus lens having a surface convex toward the object side, a biconvex lens, and a positive meniscus lens having a surface having a surface convex toward the object side.

[0177] The second lens group G**2** includes: a negative meniscus lens having a surface convex toward the object side; a biconcave lens; and a cemented lens including a biconvex lens, and a negative meniscus lens having a surface convex toward the image side, in order from the object side.

[0178] The third lens group G**3** includes, in order from the object side: a 3A lens group G**3**A including a biconvex lens, and cemented lens including a biconvex lens and a negative meniscus lens having a surface convex toward the image side; and a 3B lens group G**3**B including a cemented lens including a positive meniscus lens having a surface convex toward the image side, and a biconcave lens.

[0179] The fourth lens group G**4** includes, in order from the object side: a fourth A lens group G**4**A including a biconvex lens, a biconvex lens, and a cemented lens including a negative meniscus lens having a surface convex toward the object side, a biconvex lens; and a fourth B lens group G**4**B including a negative meniscus lens having a surface convex toward the object side.

[0180] The fifth lens group G**5** includes a cemented lens including a biconvex lens and a negative meniscus lens having a surface convex toward the image side in order from the object side.

[0181] In the high power zoom lens of Example 4, during zooming from the wide-angle end to the telephoto end, the distance between the first lens group G**1** and the second lens group G**2** increases, the distance between the second lens group G**2** and the third lens group G**3** decreases, the distance between the third lens group G**3** and the fourth lens group G**4** decreases, and the distance between the fourth lens group G**4** and the fifth lens group G**5** increases. Further, the fifth lens group G**5** remains stationary with respect to the image surface during zooming.

[0182] The specification values of the high power zoom lens according to Example 4 are shown below.

Numerical Example 4

TABLE-US-00004 Unit: mm [Surface data] Surface number r d nd vd PgF Object surface ∞ (d0) 1 116.3748 1.5500 1.77047 29.74 0.5951 2 68.3039 6.9297 1.55032 75.50 0.5401 3 −2997.5168 0.1500 4 87.1562 4.4452 1.59282 68.62 5 302.8455 (d5) 6 529.8137 0.9000 2.00100 29.13 7 17.4115 5.9157 8* −52.6206 1.0000 1.59201 67.02 9* 43.9475 0.3972 10 47.5334 6.2138 1.84666 23.78 11 −24.0353 0.7000 1.87070 40.73 12 −207.0889 (d12) 13 (diaphragm) ∞ 1.0000 14 39.0214 2.9898 1.56732 42.82 0.5731 15 −56.7981 0.1500 16 31.9627 3.1470 1.43700 95.10 0.5336 17 −49.0264 0.9000 2.00100 29.13 0.5995 18 −1059.6443 2.9815 19 −32.2654 1.7584 1.80518 25.46 20 −21.1686 0.9000 1.59201 67.02 21* 72.6089 (d21) 22* 25.7264 4.0290 1.55332 71.69 23* −45.7796 0.1500 24 63.7008 2.4029 1.43700 95.10 25 −281.8985 0.1500 26 80.8058 0.9000 2.00100 29.13 27 21.0580 4.9262 1.59410 60.47 28 −140.2849 (d28) 29* 39.7565 0.9000 1.59201 67.02 30* 17.3521 (d30) 31 147.0748 4.7991 1.64769 33.84 32 −78.3862 0.7000 2.00069 25.46 33 −251.1533 (BF) Image surface ∞ [Aspherical surface data] Surface 8 Surface 9 Surface 20 Surface 21 K 0.00000 0.00000 0.00000 0.00000 A4 2.36411E−05 4.77811E−06 0.00000E+00 −6.54233E−06 A6 −4.60758E−07 −4.51453E−07 0.00000E+00 −7.46116E−09 A8 3.04297E−09 2.98017E−09 0.00000E+00 3.43006E−10 A10 −8.64361E−12 −8.20791E−12 0.00000E+00 −1.84406E−12 A12 0.00000E+00 0.00000E+00 0.00000E+00 0.00000E+00 [Aspherical surface data] Surface 22 Surface 23 Surface 29 Surface 30 K 0.00000 0.00000 0.00000 0.00000 A4 −1.81016E−05 1.29457E−05 −9.01196E−07 −9.63943E−06 A6 −5.68522E−08 −9.37840E−08 −8.94787E−10 −2.05196E−08 A8 3.37094E−10 4.66364E−10 9.63729E−12 5.09093E−10 A10 0.00000E+00 0.00000E+00 6.55361E−13 −1.10749E−11 A12

0.00000E+00 0.00000E+00 0.00000E+00 5.50621E−14 Zoom ratio 14.71 Wide angle Middle Telephoto [Various types of data] Focal length 16.48 64.00 242.50 F number 3.61 5.56 6.90 Total angle of view 2ω 86.52 23.97 6.54 Image height Y 14.20 14.20 14.20 14.20 Total length of lens 146.00 192.15 236.33 [Variable distance data] d0 ∞ ∞ ∞ d5 1.5716 40.7114 74.5819 d12 33.5376 12.5729 1.8000 d21 13.4937 6.6573 1.8000 d28 1.8556 1.8556 1.8556 d30 12.0037 46.8095 72.7524 BF 22.5947 22.5548 22.5548 [Lens group data] Group Starting surface Focal length G1 1 119.17 G2 6 −17.06 G3 13 100.30 G4 22 37.86 G5 31 256.97 G3A 13 35.56 G3B 19 −43.37 G4A 22 26.13 G4B 28 −52.80

Example 5

[0183] FIG. **41** is a lens configuration diagram of a high power zoom lens of Example 5 of the invention.

[0184] Example 5 includes, in order from the object side, the first lens group G**1** having a positive refractive power, the second lens group G**2** having a negative refractive power, the aperture diaphragm S, the third lens group G**3** having a positive refractive power, the fourth lens group G**4** having a positive refractive power, and the fifth lens group G**5** having a positive refractive power. Further, the third lens group G**3** includes a 3A lens group G**3**A having a positive refractive power and a 3B lens group G**3**B having a negative refractive power, in order from the object side. Further, the fourth lens group G**4** includes a 4A lens group G**4**A having a positive refractive power and a 4B lens group G**4**B having a negative refractive power, in order from the object side. In addition, during the image blur correction during the vibration reduction, the 3B lens group G**3**B moves in a direction substantially perpendicular to the optical axis. Further, during focusing from the infinity to the short distance, the 4B lens group G**4**B moves to the image surface side. The fifth lens group G**5** corresponds to the L-th lens group GL positioned closest to the image side.

[0185] The first lens group G**1** includes, in order from the object side, a negative meniscus lens having a surface convex toward the object side, a positive meniscus lens having a surface convex toward the object side, and a positive meniscus lens having a surface convex toward the object side.

[0186] The second lens group G**2** includes, in order from the object side, a negative meniscus lens having a surface having a surface convex toward the object side, a biconcave lens, and a cemented lens including a biconvex lens and a biconcave lens.

[0187] The third lens group G**3** includes, in order from the object side: a 3A lens group G**3**A including a biconvex lens and a cemented lens including a biconvex lens and a biconcave lens; and a 3B lens group G**3**B including a cemented lens including a positive meniscus lens having a surface convex toward the image side and a biconcave lens.

[0188] The fourth lens group G**4** includes, in order from the object side: a 4A lens group G**4**A including a biconvex lens, a biconvex lens, and a cemented lens including a negative meniscus lens having a surface convex toward the object side, and a biconvex lens; and a 4B lens group G**4**B including a cemented lens including a positive meniscus lens having a surface convex toward the image side and a biconcave lens.

[0189] The fifth lens group G**5** includes a cemented lens including a positive meniscus lens having a surface convex toward the image side and a negative meniscus lens having a surface convex toward the image side in order from the object side.

[0190] In the high power zoom lens of Example 5, during zooming from the wide-angle end to the telephoto end, the distance between the first lens group G**1** and the second lens group G**2** increases, the distance between the second lens group G**2** and the third lens group G**3** decreases, the distance between the third lens group G**3** and the fourth lens group G**4** decreases, and the distance between the fourth lens group G**4** and the fifth lens group G**5** increases. Further, the fifth lens group G**5** remains stationary with respect to the image surface during zooming.

[0191] The specification values of the high power zoom lens according to Example 5 are shown below.

Numerical Example 5

TABLE-US-00005 Unit: mm [Surface data] Surface number r d nd vd PgF Object surface ∞ (d0) 1 106.8386 1.5500 1.80610 33.27 0.5884 2 59.4803 7.4150 1.55032 75.50 0.5401 3 522.9275 0.1500 4 72.0349 5.7699 1.59282 68.62 0.5440 5 373.5800 (d5) 6 269.1183 0.9000 2.05090 26.94 7 16.6261 5.0616 8* −135.4091 1.0000 1.59201 67.02 9* 32.4548 0.5198 10 38.8520 7.6536 1.84666 23.78 11 −16.2500 0.7000 1.87070 40.73 12 239.2102 (d12) 13 (diaphragm) ∞ 1.0000 14 27.5698 3.0480 1.61772 49.81 0.5603 15 −125.3575 0.1500 16 31.3132 3.1224 1.49700 81.61 0.5389 17 −67.3797 0.9000 1.92119 23.96 0.6202 18 158.1299 2.7973 19 −39.1978 1.6622 1.69895 30.05 20* −22.3292 0.9000 1.59201 67.02 21* 63.5739 (d21) 22* 25.9286 3.9242 1.55332 71.69 23* −45.2119 0.1500 24 170.7771 2.2122 1.49700 81.61 25 −98.7406 0.1500 26 253.4673 0.9000 2.00100 29.13 27 23.2142 4.5718 1.59282 68.62 28 −45.6031 (d28) 29 −95.6450 2.1788 1.72825 28.32 30 −25.5817 0.7000 1.59349 67.00 31 31.3175 (d31) 32 −390.7541 5.1449 1.54814 45.82 33 −26.9478 0.7000 2.00100 29.13 34 −53.8103 (BF) Image surface ∞ [Aspherical surface data] Surface 8 Surface 9 Surface 20 Surface21 Surface 22 Surface 23 K 0.00000 0.00000 0.00000 0.00000 0.00000 0.00000 A4 7.14491E−05 4.55732E−05 0.00000E+00 −6.65377E−06 −2.01094E−05 2.11553E−05 A6 9.70874E−07 −1.03416E−06 0.00000E+00 −3.73114E−08 −4.52995E−08 −4.39308E−08 A8 5.48008E−09 5.80657E−09 0.00000E+00 4.11200E−10 −5.20971E−10 −6.17686E−10 A10 −1.21178E−11 −1.32370E−11 0.00000E+00 −4.62914E−13 0.00000E+00 0.00000E+00 Zoom ratio 18.81 Wide angle Middle Telephoto [Various types of data] Focal length 16.50 69.25 310.35 F number 4.11 5.46 6.88 Total angle of view 2ω 84.80 22.20 5.09 Image height Y 14.20 14.20 14.20 Total length of lens 146.00 196.20 235.00 [Variable distance data] d0 ∞ ∞ ∞ d5 1.3000 42.4639 75.5228 d12 35.4332 14.2582 1.9297 d21 10.6484 6.5999 1.8000 d28 1.6708 1.6708 1.6708 d31 13.6658 47.9249 70.7963 BF 18.3800 18.3493 18.3487 [Lens group data] Group Starting surface Focal length G1 1 113.68 G2 6 −14.81 G3 13 66.24 G4 22 41.30 G5 32 1916.27 G3A 13 31.38 G3B 19 −44.44 G4A 22 25.91 G4B 28 −46.63

[0192] The following shows a list of corresponding values of the conditional expressions in each of the above examples.

TABLE-US-00006 [Conditional Expression Corresponding Value] Conditional Expressions EX1 EX2 EX3 EX4 EX5 (1) 0.43 0.43 0.42 0.49 0.37 (2) 0.58 0.57 0.59 0.61 0.57 (3) 1.06 1.06 1.00 1.39 1.13 (4) 0.12 0.11 0.12 0.15 0.13 (5) 1.21 1.46 1.77 2.65 1.60 (6) 0.037 0.056 0.056 0.027 0.027 (7) 0.056 0.037 0.037 0.056 0.037

OTHER EMBODIMENTS

[0193] The technology disclosed in the present example is not limited to the description of the above-described embodiment and examples, and various modification implementations can be made. The shape and numerical value of each part shown in each of the above-described numerical examples are merely an example for carrying out the present technology, and the technical scope of the present technology is not limited thereto.

[0194] The present technology can have the following configuration.

[1]

[0195] A high power zoom lens including, in order from an object side: a first lens group G**1** that has a positive refractive power; a second lens group G**2** that has a negative refractive power; a third lens group G**3** that has a positive refractive power; a fourth lens group G**4** that has a positive refractive power; an Loth lens group GL that has a positive refractive power and is positioned at a position which is closest to an image side; in which, in a case of zooming from a wide angle end to a telephoto end, a distance between the lens groups changes, the third lens group G**3** includes a 3A lens group G**3**A having a positive refractive power and a 3B lens group G**3**B having a negative refractive power, image blur correction is performed by moving the 3B lens group G**3**B in a direction substantially perpendicular to an optical axis, the fourth lens group G**4** includes a 4A lens group G**4**A having a positive refractive power and a 4B lens group G**4**B having a negative refractive power, a focusing operation from an infinity state to a short distance is performed by moving the 4B lens group G**4**B from an object side to an image side in an optical axis direction, and the following conditional expressions are satisfied.

[00010] $0.25 < f1/fT < 0.66$ (1) $0.35 < ff/fr < 0.8$ (2) [0196] f1: focal length of first lens group G**1** [0197] fr: focal length of entire system in infinity state at telephoto end [0198] ff: combined focal length of the first lens group G**1** and the second lens group G**2** in the infinity state at the wide angle end [0199] fr: combined focal length from the third lens group G**3** to the L-th lens group GL in the infinity state at the wide-angle end

[2]

[0200] The high power zoom lens according to [1], in which a distance between the 4A lens group G**4**A and the 4B lens group G**4**B in the infinity state is constant during zooming.

[3]

[0201] The high power zoom lens according to [1] or [2], in which a distance between the 3A lens group G**3**A and the 3B lens group G**3**B is constant during zooming.

[4]

[0202] The high power zoom lens according to any one of [1] to [3], in which each of the three B lens groups G**3**B is a cemented lens including one positive lens and one negative lens.

[5]

[0203] The high power zoom lens according to any one of [1] to [4], in which the 4B lens group G**4**B is one negative lens or a cemented lens including one positive lens and one negative lens.

[6]

[0204] The high power zoom lens according to any one of [1] to [5], in which the L-th lens group GL positioned closest to the image side is fixed with respect to an image surface.

[7]

[0205] The high power zoom lens according to any one of [1] to [6], in which the first lens group G**1** includes one negative lens and two positive lenses in order from the object side.

[8]

[0206] The high power zoom lens according to any one of [1] to [7], in which the 4A lens group G**4**A further includes at least two positive lenses and one negative lens.

[9]

[0207] The high power zoom lens according to any one of [1] to [8], in which the high power zoom lens further satisfies the following conditional expression.

[00011] $0.60 < f4B/f4 < 1.8$ (3) [0208] f4B: focal length of 4B lens group G**4**B [0209] f4: focal length of fourth lens group G**4**

[10]

[0210] The high power zoom lens according to any one of [1] to [9], in which the high power zoom lens further satisfies the following conditional expression.

[00012] $0.08 < FB/LT < 0.20$ (4) [0211] FB: back focus in air equivalent at wide-angle end [0212] LT: total lens length at wide-angle end

[11]

[0213] The high power zoom lens according to any one of [1] to [10], in which the high power zoom lens further satisfies the following conditional expression.

[00013] $0.50 < f3/f4 < 5.$ (5) [0214] f3: focal length of the third lens group G**3** [0215] f4: focal length of the fourth lens group G**4**

[12]

[0216] The high power zoom lens according to any one of [1] to [11], in which the high power zoom lens further satisfies the following conditional expression.

[00014] $0.010 < \Delta PgF\_3A < 0.073$ (6) [0217] ΔPgF_3A: largest one of anomalous dispersions of a g line and an F line of the positive lens included in the 3A lens group G**3**A

[13]

[0218] The high power zoom lens according to any one of [1] to [12], in which the high power zoom lens further satisfies the following conditional expression.

[00015] $0.010 < \Delta PgF\_1 < 0.073$ (7) [0219] ΔPgF_1: largest one of the abnormal dispersions of a g line and an F line of the positive lens included in the first lens group G**1**

DESCRIPTION OF REFERENCE NUMERALS AND SIGNS

[0220] G**1**: first lens group [0221] G**2**: second lens group [0222] G**3**: third lens group [0223] G**4**: fourth lens group [0224] G**5**: fifth lens group [0225] GL: L-th lens group [0226] S: aperture diaphragm [0227] I: image surface

Claims

1. A high power zoom lens comprising, in order from an object side: a first lens group G**1** that has a positive refractive power; a second lens group G**2** that has a negative refractive power; a third lens group G**3** that has a positive refractive power; a fourth lens group G**4** that has a positive refractive power; an L-th lens group GL that has a positive refractive power and is positioned at a position which is closest to an image side; wherein in a case of zooming from a wide-angle end to a telephoto end, a distance between the lens groups changes, the third lens group G**3** includes a 3A lens group G**3**A having a positive refractive power, and a 3B lens group G**3**B having a negative refractive power, image blur correction is performed by moving the 3B lens group G**3**B in a direction substantially perpendicular to an optical axis, the fourth lens group G**4** includes a 4A lens group G**4**A having a positive refractive power, and a 4B lens group G**4**B having a negative refractive power, a focusing operation from an infinity state to a short distance is performed by moving the 4B lens group G**4**B from an object side to an image side in an optical axis direction, and the following conditional expressions are satisfied: $0.25 < f1 / fT < 0.66$ (1)

$0.35 < |ff / fr| < 0.8$ (2) f1: focal length of first lens group G**1** fT: focal length of entire system in infinity state at telephoto end ff: combined focal length of the first lens group G**1** and the second lens group G**2** in the infinity state at the wide-angle end fr: combined focal length from the third lens group G**3** to the L-th lens group GL in the infinity state at the wide-angle end.

2. The high power zoom lens according to claim 1, wherein a distance between the 4A lens group G**4**A and the 4B lens group G**4**B in the infinity state is constant during zooming.

3. The high power zoom lens according to claim 1, wherein a distance between the 3A lens group G**3**A and the 3B lens group G**3**B is constant during zooming.

4. The high power zoom lens according to claim 1, wherein each of the three B lens groups G**3**B is a cemented lens including one positive lens and one negative lens.

5. The high power zoom lens according to claim 1, wherein the 4B lens group G**4**B is one negative lens or a cemented lens including one positive lens and one negative lens.

6. The high power zoom lens according to claim 1, wherein the L-th lens group GL positioned closest to the image side is fixed with respect to an image surface.

7. The high power zoom lens according to claim 1, wherein the first lens group G**1** includes one negative lens and two positive lenses in order from the object side.

8. The high power zoom lens according to claim 1, wherein the 4A lens group G**4**A further includes at least two positive lenses and one negative lens.

9. The high power zoom lens according to claim 1, wherein the high power zoom lens further satisfies the following conditional expression: $0.60 < |f4B / f4| < 1.8$ (3) f4B: focal length of the 4B lens group G**4**B f4: focal length of the fourth lens group G**4**.

10. The high power zoom lens according to claim 1, wherein the high power zoom lens further satisfies the following conditional expression: $0.08 < FB / LT < 0.20$ (4) FB: back focus in air equivalent at wide-angle end LT: total lens length at wide-angle end.

11. The high power zoom lens according to claim 1, wherein the high power zoom lens further satisfies the following conditional expression: $0.50 < f3/f4 < 5.$ (5) f3: focal length of the third lens group G**3** f4: focal length of the fourth lens group G**4**.

12. The high power zoom lens according to claim 1, wherein the high power zoom lens further satisfies the following conditional expression: $0.010 < \text{PgF\_3}A < 0.073$ (6) ΔPgF_3A: largest one of anomalous dispersions of a g line and an F line of the positive lens included in the 3A lens group G**3**A.

13. The high power zoom lens according to claim 1, wherein the high power zoom lens further satisfies the following conditional expression: $0.010 < \Delta\text{PgF\_1} < 0.073$ (7) ΔPgF_1: largest one of the abnormal dispersions of a g line and an F line of the positive lens included in the first lens group G**1**.