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(54) **SCANNING OPTICAL DEVICE**

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(57) **ABSTRACT**

A scanning optical system receives a light beam deflected by an optical deflector and forms an image on an image surface. A window member transmits the light beam deflected by the optical deflector. An optical sensor detects the light beam that passes through the window member. A frame has a mount surface on which the optical deflector is mounted. The frame includes a first wall having a first opening and a second opening. The light beam directed from the optical deflector toward the scanning optical system passes through the first opening. The light beam directed from the optical deflector toward the optical sensor passes through the second opening. The first opening is closed by a closest scanning lens to the optical deflector in the scanning optical system. The second opening is closed by the window member.

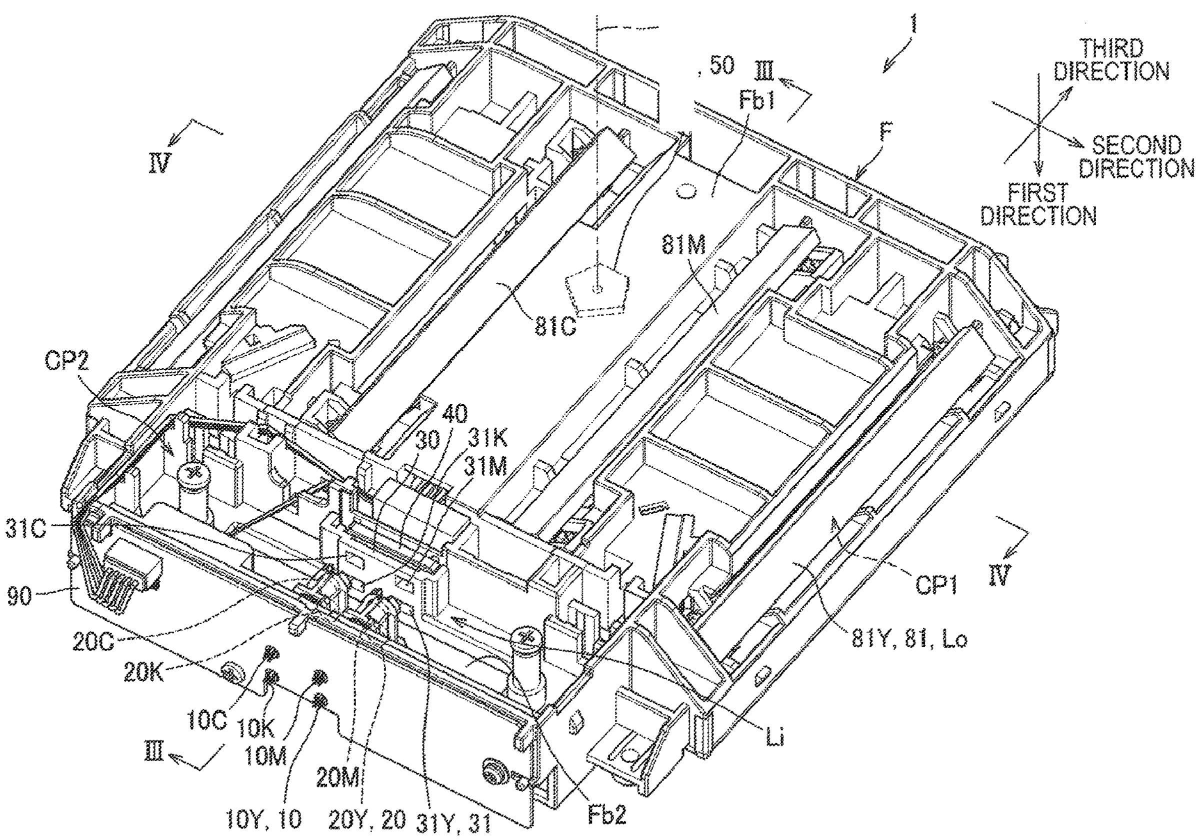
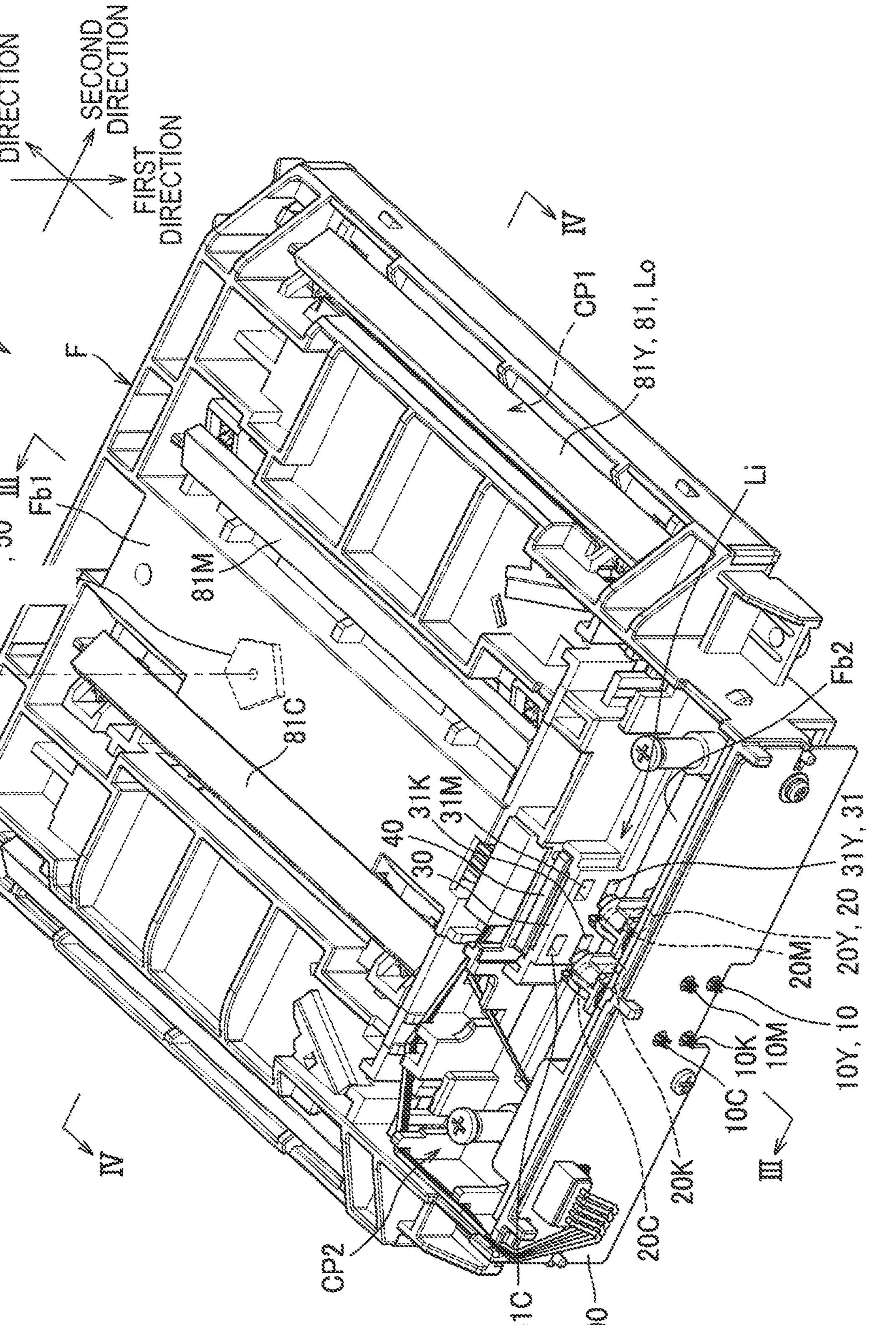


FIG. 1


THIRD DIRECTION
SECOND DIRECTION
FIRST DIRECTION
1
F
III
Fb1
50
IV
CP1
81Y, 81, Lo
81M
Li
81C
Fb2
31K
31M
40
30
31Y, 31
20Y, 20
20M
10Y, 10
10K
10M
10C
20K
20C
III
IV
CP2
31C
90

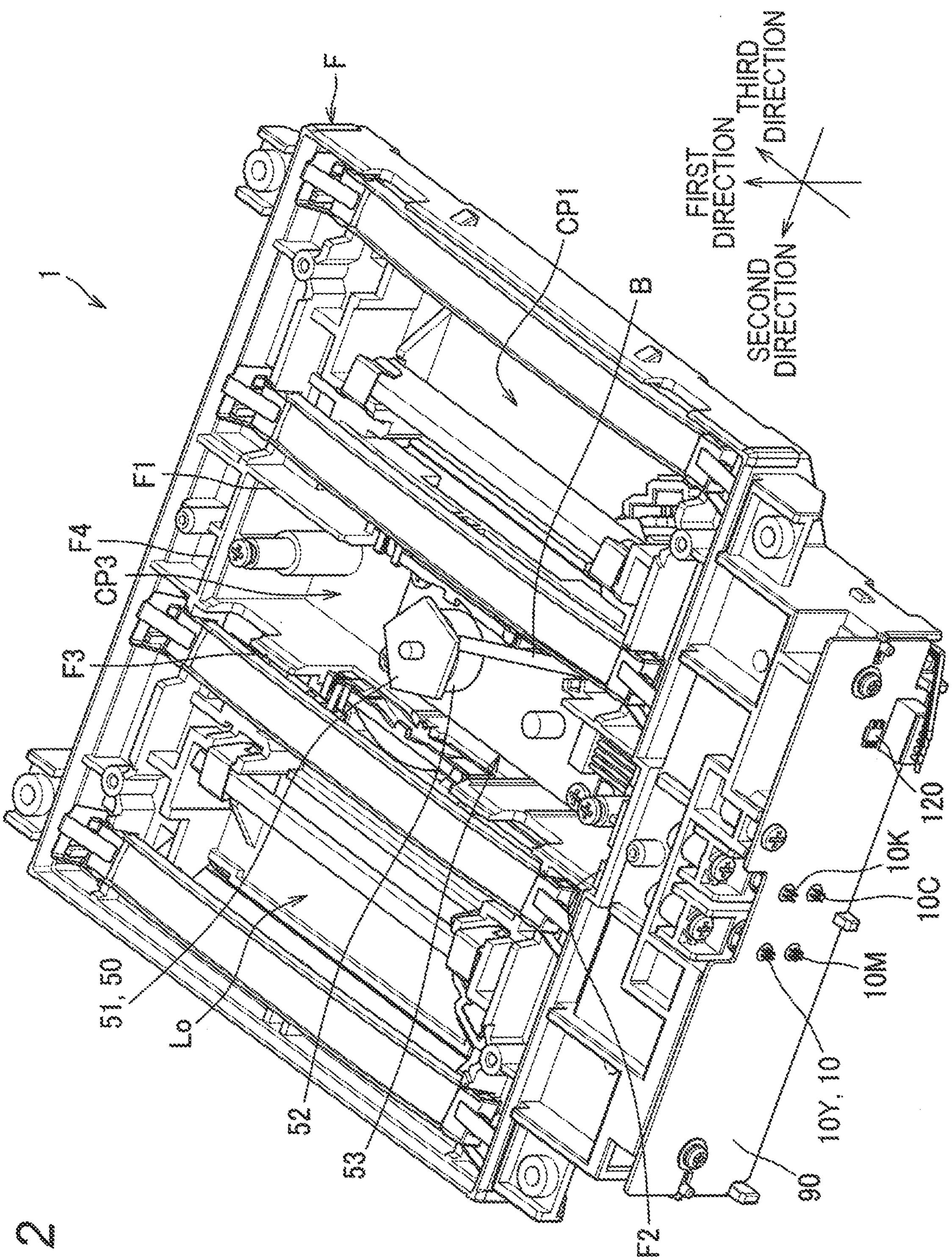

1
F
CP1
B
F1
F4
CP3
F3
51, 50
Lo
52
53
F2
90
10Y, 10
10M
10C
10K
120
FIRST DIRECTION
THIRD DIRECTION
SECOND DIRECTION

FIG. 2

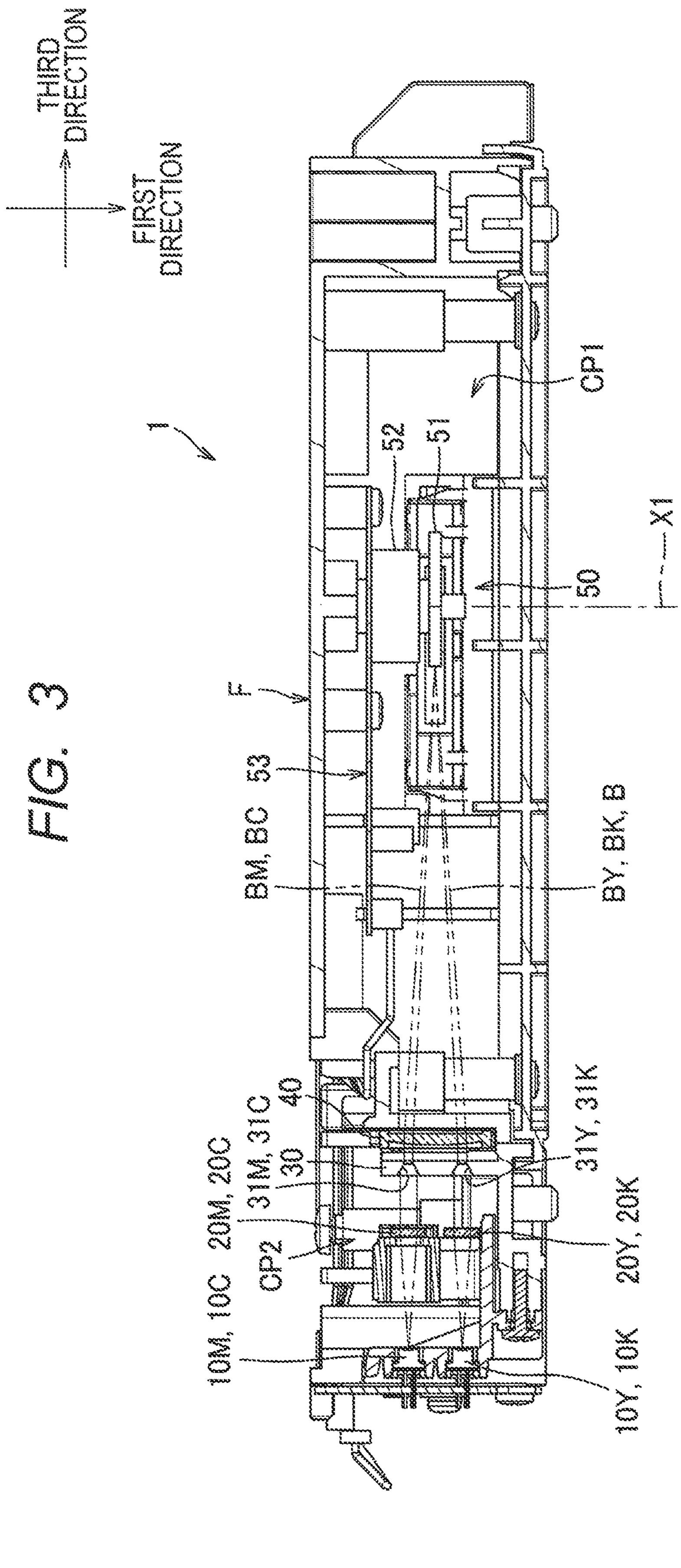

THIRD DIRECTION
FIRST DIRECTION
1
F
CP1
52
51
50
X1
BM, BC
53
BY, BK, B
40
30
31M, 31C
31Y, 31K
20M, 20C
20Y, 20K
CP2
10M, 10C
10Y, 10K

FIG. 3

FIG. 4

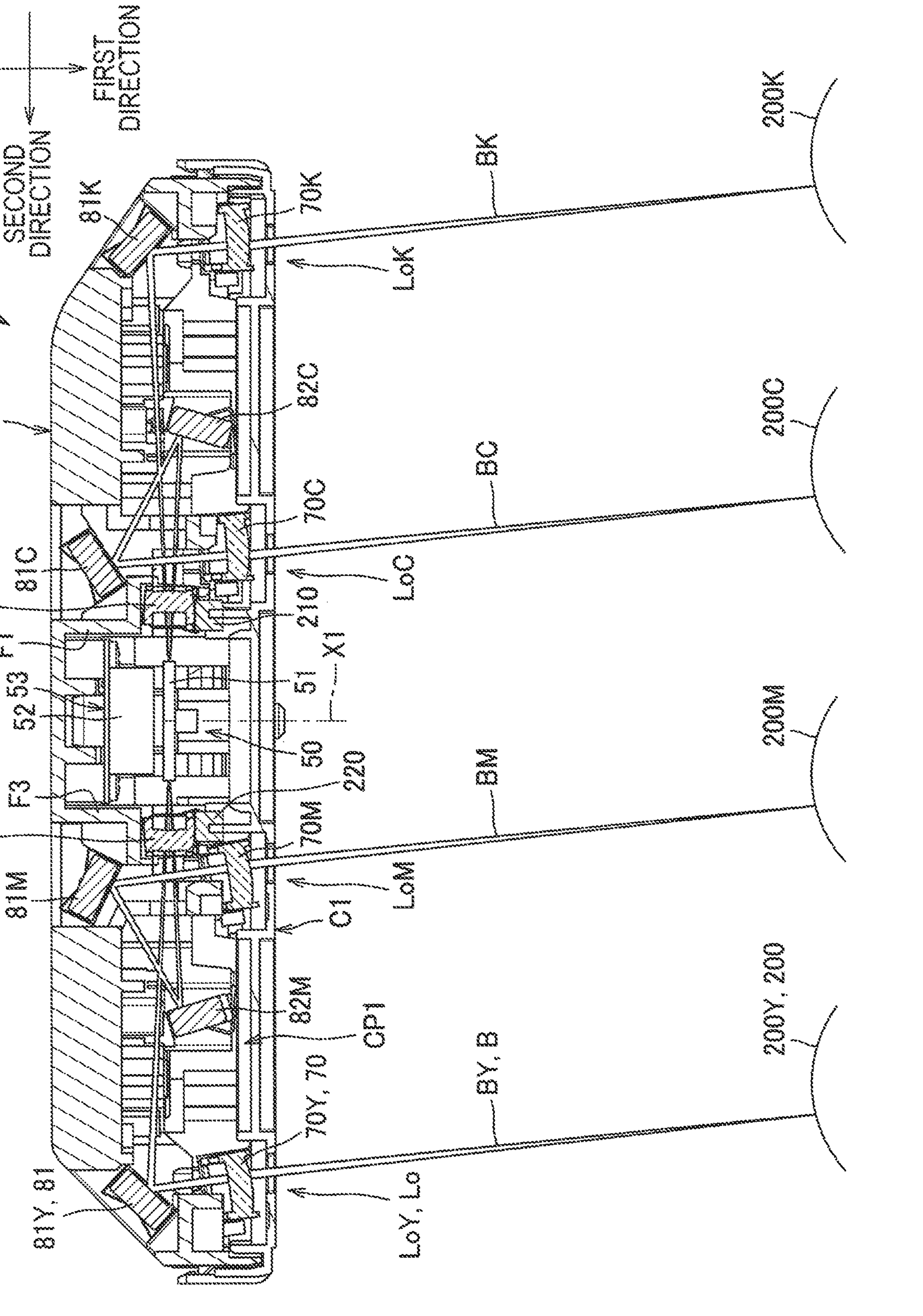
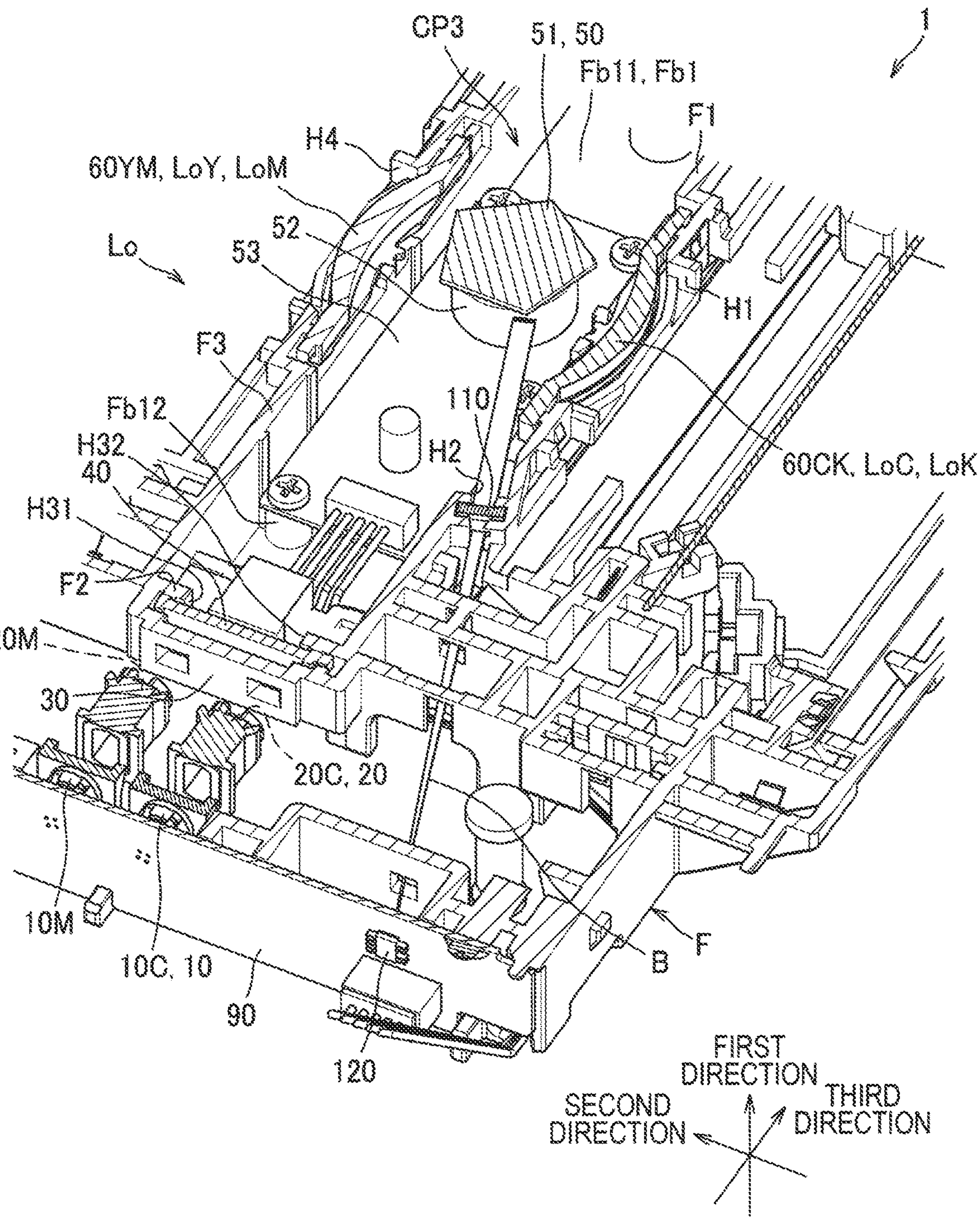

SECOND DIRECTION
FIRST DIRECTION
1
F
81K
70K
LoK
BK
200K
82C
70C
BC
200C
81C
60CK
LoC
210
F1
X1
53
52
51
50
200M
220
BM
60YM, 60
F3
70M
81M
LoM
C1
82M
CP1
200Y, 200
70Y, 70
BY, B
81Y, 81
LoY, Lo

FIG. 5



1
CP3
51, 50
Fb11, Fb1
F1
H4
60YM, LoY, LoM
Lo
52
53
H1
F3
Fb12
110
H32
H2
60CK, LoC, LoK
40
H31
F2
20M
30
20C, 20
10M
10C, 10
90
120
B
F
FIRST DIRECTION
SECOND DIRECTION
THIRD DIRECTION

FIG. 6

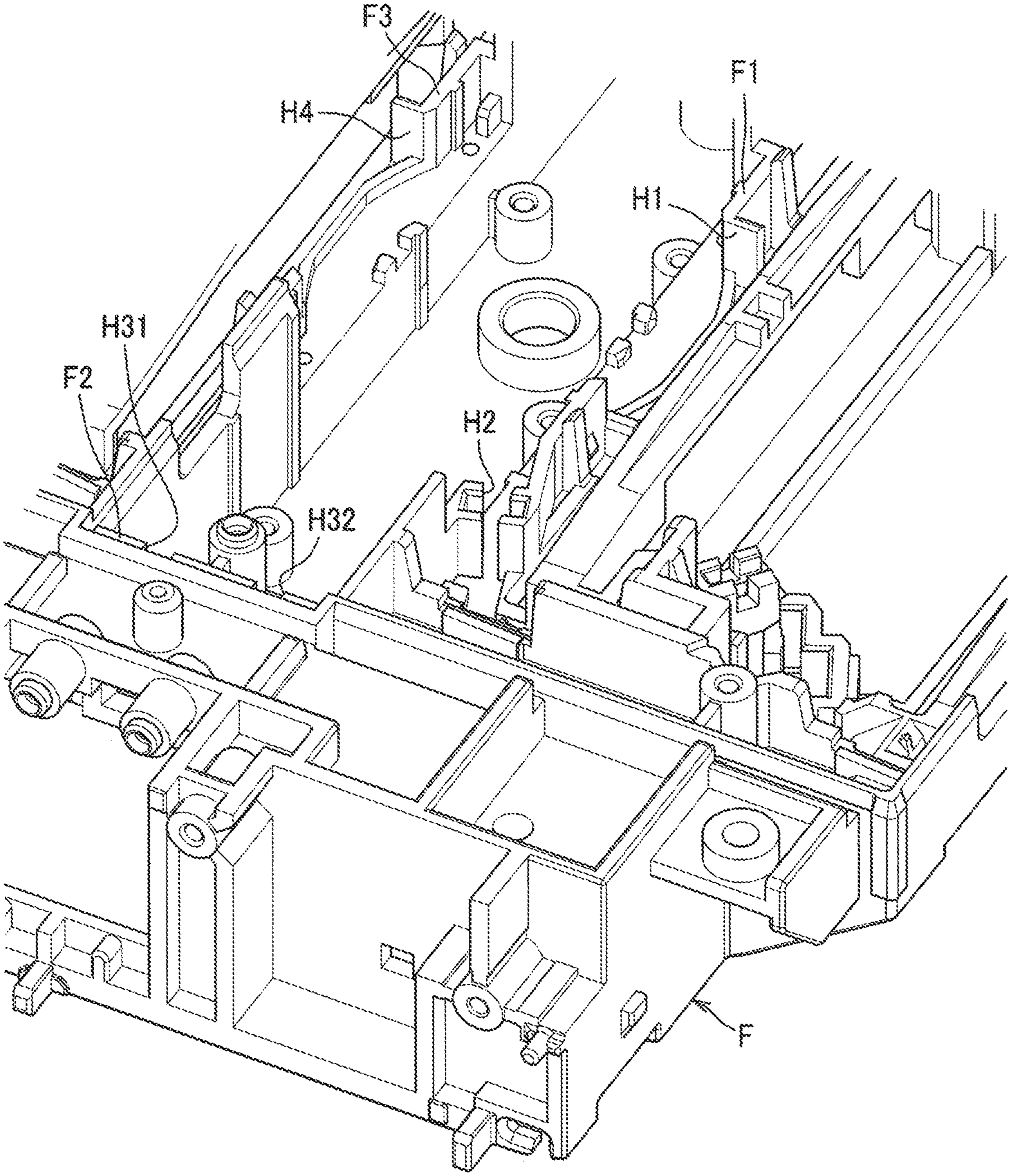


FIG. 7

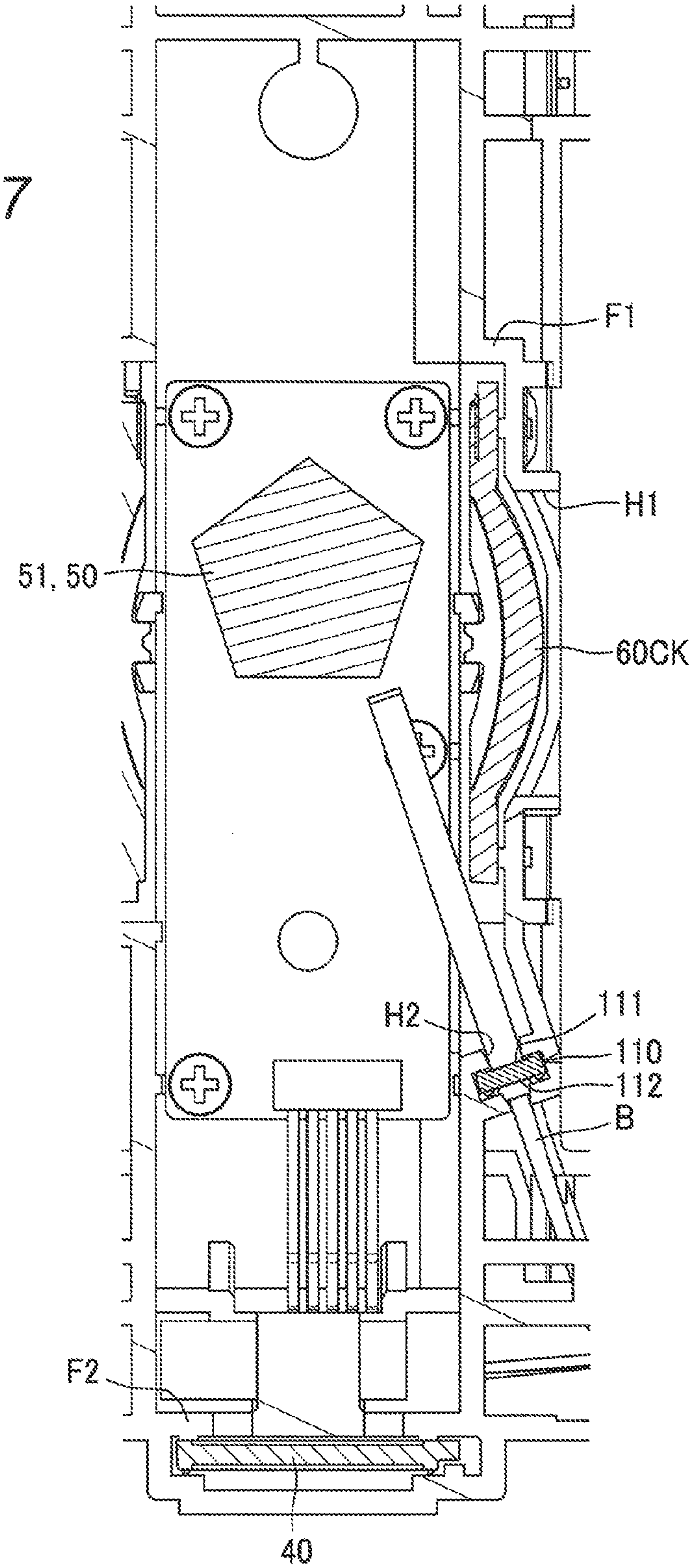


FIG. 8

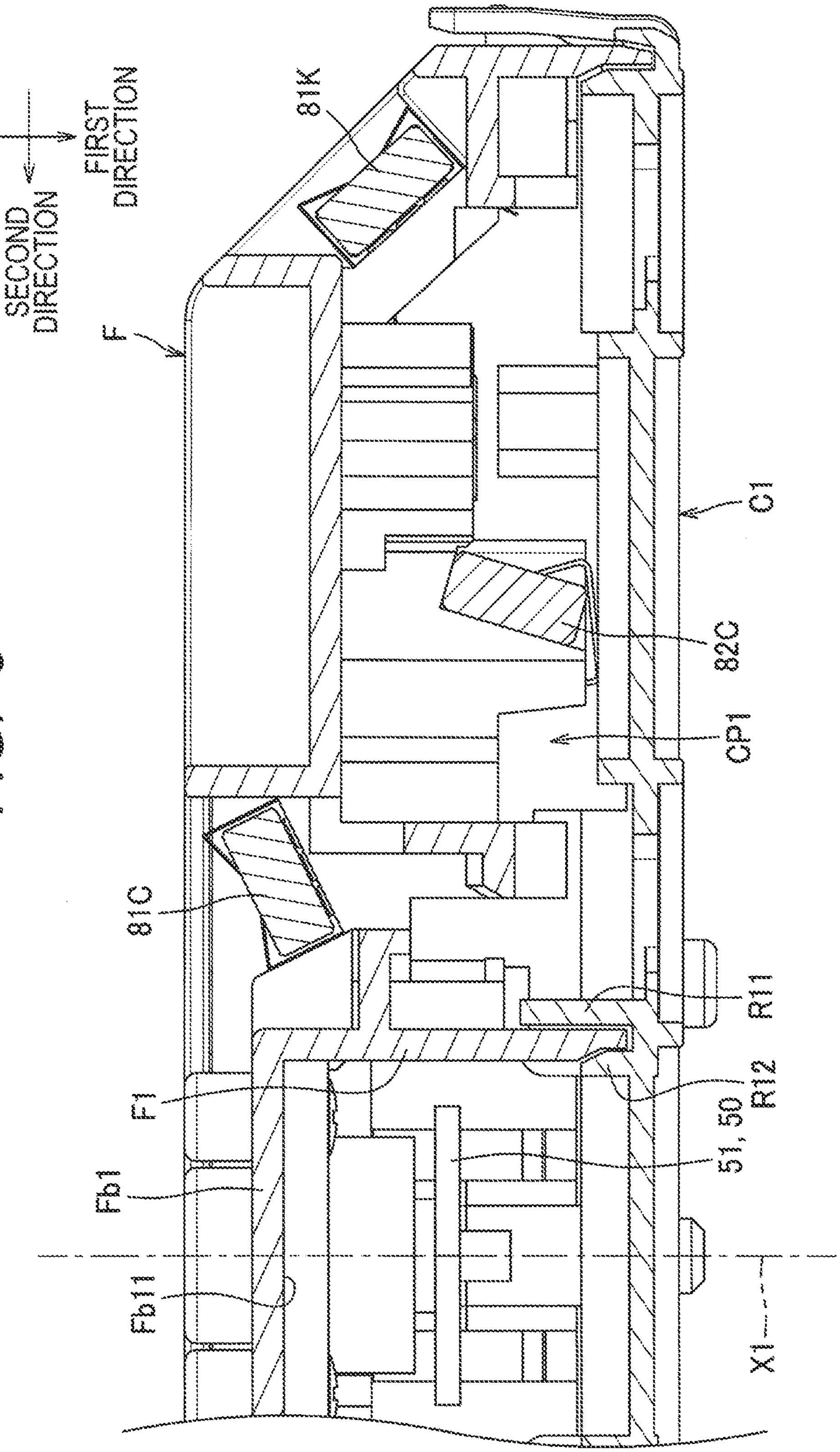
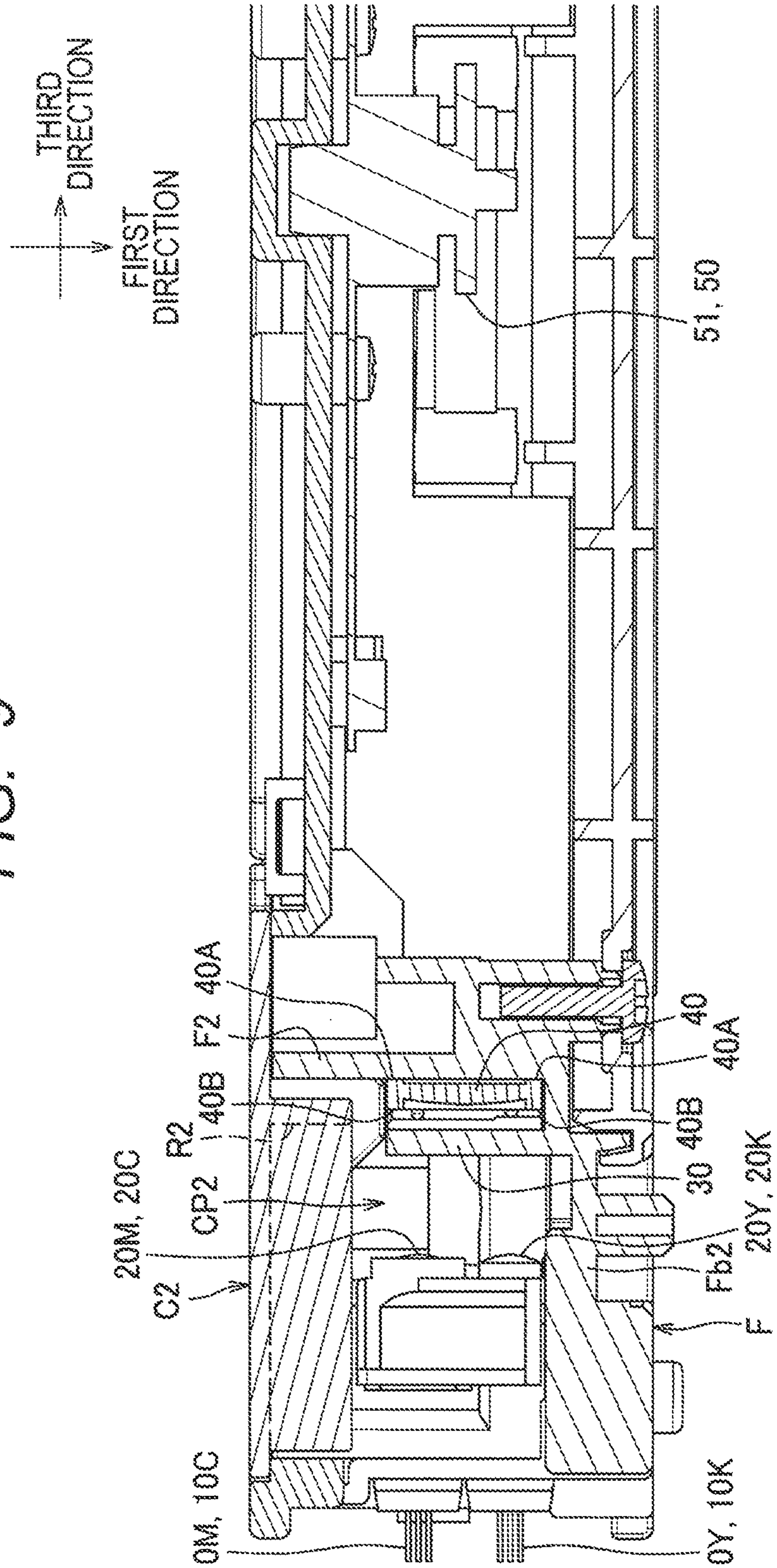

SECOND DIRECTION
FIRST DIRECTION
81K
F
C1
82C
CP1
81C
R11
R12
51, 50
F1
Fb1
Fb11
X1

FIG. 9


THIRD DIRECTION
FIRST DIRECTION
51, 50
40A
F2
40B
R2
CP2
20M, 20C
C2
10M, 10C
40
40A
40B
30
20Y, 20K
Fb2
F
10Y, 10K

SCANNING OPTICAL DEVICE

REFERENCE TO RELATED APPLICATIONS

[0001] This application claims priority from Japanese Patent Application No. 2022-140800 filed on Sep. 5, 2022. The entire content of the priority application is incorporated herein by reference.

BACKGROUND ART

[0002] A scanning optical device including a polygon mirror is known.

DESCRIPTION

[0003] A polygon mirror may be damaged by dust and so on contained in the surrounding air hitting the rotating mirror, and reflectance may decrease. It is considered that a scanning optical device has a seal that prevents dust from entering around the polygon mirror. In this technique, a scanning lens seals a hole formed in a wall arranged on the output side of the polygon mirror.

[0004] In the above technique, a light beam directed to an optical sensor for detecting the light beam passes through the scanning lens. Thus, the scanning lens need to have a region for passing the light beam directed to the optical sensor, which may increase the size of the scanning lens.

[0005] In view of the foregoing, an example of an object of this disclosure is to suppress dust and so on entering around a polygon mirror while suppressing an increase in the size of a scanning lens.

[0006] According to one aspect, this specification discloses a scanning optical device. The scanning optical device includes a semiconductor laser, a coupling lens, an optical deflector, a scanning optical system, a window member, an optical sensor, and a frame. The semiconductor laser is configured to emit light. The coupling lens is configured to convert the light emitted by the semiconductor laser into a light beam. The optical deflector includes a polygon mirror configured to deflect, in a main scanning direction, the light beam converted by the coupling lens. The scanning optical system is configured to receive the light beam deflected by the optical deflector and to form an image on an image surface. The window member is configured to transmit the light beam deflected by the optical deflector. The optical sensor is configured to detect the light beam that passes through the window member. The frame has a mount surface on which the optical deflector is mounted. The frame includes a first wall having a first opening and a second opening. The light beam directed from the optical deflector toward the scanning optical system passes through the first opening. The light beam directed from the optical deflector toward the optical sensor passes through the second opening. The first opening is closed by a closest scanning lens to the optical deflector in the scanning optical system. Thus, the scanning lens suppresses dust and so on entering around the polygon mirror through the first opening. The second opening is closed by the window member. Thus, the window member suppresses dust and so on entering around the polygon mirror through the second opening. Further, since the light beam directed toward the optical sensor passes through the window member different from the scanning lens, it is unnecessary to provide the scanning lens with an area for allowing the light beam directed toward the optical sensor to pass through. This suppresses an increase in the size of the scanning lens.

[0007] FIG. **1** is a perspective view of a scanning optical device viewed from an other side in a first direction.

[0008] FIG. **2** is a perspective view of the scanning optical device viewed from one side in the first direction.

[0009] FIG. **3** is a cross-sectional view taken along a line in FIG. **1**.

[0010] FIG. **4** is a cross-sectional view taken along a line IV-IV in FIG. **1**.

[0011] FIG. **5** is an enlarged perspective view showing a structure around an optical deflector of the scanning optical device cut along a plane perpendicular to the first direction and passing through a window member.

[0012] FIG. **6** is an enlarged perspective view showing a structure around a first wall of a frame.

[0013] FIG. **7** is a cross-sectional view showing a structure around the optical deflector of the scanning optical device taken along a plane perpendicular to the first direction and passing through the window member.

[0014] FIG. **8** is a cross-sectional view showing a relationship between the first wall and a first cover.

[0015] FIG. **9** is a cross-sectional view showing a relationship between a second wall and a second cover.

[0016] As shown in FIGS. **1** and **2**, a scanning optical device **1** includes a frame F, an incident optical system Li, an optical deflector **50**, and a scanning optical system Lo. In this embodiment, the scanning optical device **1** is applied to an electrophotographic image forming apparatus. The image forming apparatus includes four photosensitive drums **200** (see FIG. **4**).

[0017] In the following description, a direction parallel to a rotation axis X**1** of a polygon mirror **51** described later is referred to as a "first direction". A direction perpendicular to the first direction and in which the polygon mirror **51** and a first scanning lens **60** (see FIG. **4**) are arranged is referred to as a "second direction". A direction perpendicular to the first direction and the second direction is referred to as a "third direction". The third direction corresponds to a main scanning direction, and the first direction corresponds to a sub-scanning direction of the incident optical system Li. It is assumed that an arrow showing each direction in drawings indicates one side in each direction.

[0018] The incident optical system Li includes four semiconductor lasers **10**, four coupling lenses **20**, an aperture plate **30**, and a condenser lens **40**.

[0019] The semiconductor lasers **10** are devices that emit light. Four semiconductor lasers **10** are provided corresponding to the four photosensitive drums **200** (see FIG. **4**) that are scanned and exposed by the scanning optical device **1**. Toner images of different colors are formed on the photosensitive drums **200**.

[0020] In this embodiment, a first color is "yellow (Y)", a second color is "magenta (M)", a third color is "cyan (C)", and a fourth color is "black (K)". In the following description, the name of the part corresponding to the first color may be prefixed with "first" and the part corresponding to the first color may be distinguished by adding "Y" to the end of the reference numeral. Similarly, the parts corresponding to the second, third, and fourth colors are prefixed with "second," "third," and "fourth," and suffixed with "M, "C", and "K" may be used for distinguishing.

[0021] The semiconductor lasers **10** include a first semiconductor laser **10**Y corresponding to yellow, a second semiconductor laser **10**M corresponding to magenta, a third semiconductor laser **10**C corresponding to cyan, and a fourth semiconductor laser **10**K corresponding to black. The first semiconductor laser **10**Y is arranged with an interval in the first direction from the second semiconductor laser **10**M. The first semiconductor laser **10**Y is located on one side in the first direction with respect to the second semiconductor laser **10**M.

[0022] The third semiconductor laser **10**C is arranged with an interval in the second direction from the second semiconductor laser **10**M. The third semiconductor laser **10**C is located on the other side in the second direction with respect to the second semiconductor laser **10**M. The fourth semiconductor laser **10**K is arranged with an interval in the first direction from the third semiconductor laser **10**C, and is arranged with an interval in the second direction from the first semiconductor laser **10***y*.

[0023] The coupling lens **20** is a lens that converts light from the semiconductor laser **10** into a light beam. The coupling lenses **20**Y, **20**M, **20**C and **20**K for respective colors are arranged at positions facing corresponding semiconductor lasers **10**Y, **10**M, **10**C and **10**K.

[0024] The aperture plate **30** has stop apertures **31** through which the light beam from the coupling lens **20** passes. In this embodiment, the aperture plate **30** is formed integrally with the frame F. The aperture plate **30** is located between the coupling lens **20** and the condenser lens **40**. Four stop apertures **31** are provided corresponding to the four semiconductor lasers **10** and coupling lenses **20**.

[0025] The condenser lens **40** is a lens that condenses the light beam from the coupling lens **20** onto a mirror surface of the polygon mirror **51** in the sub-scanning direction. The condenser lens **40** is located on the side opposite to the coupling lens **20** with respect to the aperture plate **30**.

[0026] As shown in FIG. **3**, the optical deflector **50** is a device that deflects the light beam from the coupling lens **20** in the main scanning direction (third direction), and includes the polygon mirror **51**, a motor **52**, and a motor circuit board **53**. The polygon mirror **51** rotates to deflect the light beam in the main scanning direction. The polygon mirror **51** has five mirror surfaces provided at equal distances from the rotation axis X1 (see also FIG. **1**). The motor **52** is a motor for rotating the polygon mirror **51**. The motor circuit board **53** is provided with the motor **52**. The motor circuit board **53** is fixed to the frame F.

[0027] As shown in FIG. **4**, the scanning optical system Lo is an optical system that forms an image of the light beam deflected by the optical deflector **50** on the surface of the photosensitive drum **200** serving as an image surface. Each component constituting the scanning optical system Lo is fixed to the frame F. The scanning optical system Lo includes a first scanning optical system LoY corresponding to yellow, a second scanning optical system LoM corresponding to magenta, a third scanning optical system LoC corresponding to cyan, and a fourth scanning optical system LoK corresponding to black.

[0028] The first scanning optical system LoY and the second scanning optical system LoM are arranged on one side of the polygon mirror **51** in the second direction. The third scanning optical system LoC and the fourth scanning optical system LoK are arranged on the other side of the polygon mirror **51** in the second direction. A light beam from the optical deflector **50** is incident on each of the scanning optical systems LoY, LoM, LoC, and LoK.

[0029] The first scanning optical system LoY includes a first scanning lens **60**YM, a second scanning lens **70**Y, and a reflecting mirror **81**Y. The first scanning lens **60**YM is the closest optical component to the optical deflector **50** among the optical components that constitute the first scanning optical system LoY. Specifically, with respect to the distance along the optical path of the light beam passing through the center in the main scanning direction in the first scanning optical system LoY, the first scanning lens **60**YM is the closest optical component to the optical deflector **50**.

[0030] The first scanning lens **60**YM is a lens that refracts light beams BY and BM deflected by the optical deflector **50** in the main scanning direction and forms images on the photosensitive drums **200**Y and **200**M. The first scanning lens **60**YM has an fθ characteristic that causes the light beams BY and BM scanned at a constant angular velocity by the optical deflector **50** to have a constant velocity on the photosensitive drums **200**Y and **200**M.

[0031] The reflecting mirror **81**Y is a mirror that reflects the light beam BY from the first scanning lens **60**YM toward the photosensitive drum **200**Y.

[0032] The second scanning lens **70**Y is a lens that refracts the light beam BY reflected by the reflecting mirror **81**Y in the sub-scanning direction and forms an image on the photosensitive drum **200**Y. In the scanning optical system Lo, the sub-scanning direction corresponds to the direction perpendicular to the main scanning direction and a light beam traveling direction. The second scanning lens **70**Y is arranged on one side of the polygon mirror **51** in the first direction.

[0033] The second scanning optical system LoM includes the first scanning lens **60**YM, a second scanning lens **70**M, a reflecting mirror **81**M, and a mirror **82**M. The first scanning lens **60**YM is the closest optical component to the optical deflector **50** among the optical components that constitute the second scanning optical system LoM.

[0034] The first scanning lens **60**YM is shared with the first scanning optical system LoY. The mirror **82**M is a mirror that reflects the light beam BM from the first scanning lens **60**YM to the reflecting mirror **81**M. The second scanning lens **70**M and the reflecting mirror **81**M have similar functions to the second scanning lens **70**Y and the reflecting mirror **81**Y of the first scanning optical system LoY. That is, the reflecting mirror **81**M reflects the light beam BM reflected by the mirror **82**M toward the photosensitive drum **200**M, and the second scanning lens **70**M refracts the light beam BM reflected by the reflecting mirror **81**M in the sub-scanning direction and forms an image on the photosensitive drum **200**M.

[0035] The third scanning optical system LoC has a structure that is substantially symmetrical with the second scanning optical system LoM with respect to the rotation axis X1 of the polygon mirror **51**. Specifically, the third scanning optical system LoC includes a first scanning lens **60**CK, a second scanning lens **70**C, a reflecting mirror **81**C, and a mirror **82**C that have functions similar to the members of the second scanning optical system LoM. The first scanning lens **60**CK is the closest optical component to the optical deflector **50** among the optical components that constitute the third scanning optical system LoC.

[0036] The first scanning lens **60**CK refracts light beams BC and BK deflected by the optical deflector **50** in the main scanning direction to form images on the photosensitive drums **200**C and **200**K. The mirror **82**C reflects the light beam BC from the first scanning lens **60**CK to the reflecting mirror **81**C. The reflecting mirror **81**C reflects the light beam BC reflected by the mirror **82**C toward the photosensitive drum **200**C. The second scanning lens **70**C refracts the light beam BC reflected by the reflecting mirror **81**C in the sub-scanning direction to form an image on the photosensitive drum **200**C.

[0037] The fourth scanning optical system LoK has a structure that is substantially symmetrical with the first scanning optical system LoY with respect to the rotation axis X**1** of the polygon mirror **51**. Specifically, the fourth scanning optical system LoK includes the first scanning lens **60**CK, a second scanning lens **70**K, and a reflecting mirror **81**K that have functions similar to the members of the first scanning optical system LoY. The first scanning lens **60**CK is the closest optical component to the optical deflector **50** among the optical components that constitute the fourth scanning optical system LoK.

[0038] The reflecting mirror **81**K reflects a light beam BK from the first scanning lens **60**CK toward the photosensitive drum **200**K. The second scanning lens **70**K refracts the light beam BK reflected by the reflecting mirror **81**K in the sub-scanning direction to form an image on the photosensitive drum **200**K.

[0039] As shown in FIG. **3**, the light emitted from each of the semiconductor lasers **10**Y, **10**M, **10**C and **10**K passes through the corresponding coupling lenses **20**Y, **20**M, **20**C and **20**K to be converted into light beams BY, BM, BC and BK. The light beams BY, BM, BC, and BK pass through the corresponding stop apertures **31**Y, **31**M, **31**C and **31**K of the aperture plate **30**, pass through the condenser lens **40**, and are incident on the polygon mirror **51**. The condenser lens **40** is a lens through which all of the light beams BY, BM, BC, and BK pass, and has a cylindrical entrance surface and a flat exit surface.

[0040] As shown in FIG. **4**, the polygon mirror **51** deflects the light beams BY, BM, BC and BK toward the corresponding scanning optical systems LoY, LoM, LoC and LoK. The light beam BY directed toward the first scanning optical system LoY passes through the first scanning lens **60**YM, is reflected by the reflecting mirror **81**Y, passes through the second scanning lens **70**Y, and is emitted toward the photosensitive drum **200**Y on one side in the first direction. The light beam BY is emitted from the second scanning lens **70**Y at a particular angle with respect to the first direction. The light beam BY is imaged on the surface of the first photosensitive drum **200**Y and is scanned in the main scanning direction.

[0041] The light beam BM directed toward the second scanning optical system LoM passes through the first scanning lens **60**YM, is reflected by the mirror **82**M and the reflecting mirror **81**M, passes through the second scanning lens **70**M, and is emitted toward the photosensitive drum **200**M on one side in the first direction. The light beam BM is emitted from the second scanning lens **70**M at a particular angle with respect to the first direction. The light beam BM is imaged on the surface of the second photosensitive drum **200**M and is scanned in the main scanning direction. The light beams BC and BK are similarly emitted toward the photosensitive drums **200**C and **200**K on one side in the first direction by the corresponding scanning optical systems LoC and LoK, and are imaged on the surfaces of the corresponding photosensitive drums **200**C and **200**K and are scanned in the main scanning direction.

[0042] The frame F is made of resin and integrally formed by molding. The frame F has a first recess CP**1** shown in FIG. **2** and a second recess CP**2** shown in FIG. **1**. The first recess CP**1** opens on one side in the first direction. The second recess CP**2** opens on the other side in the first direction. As shown in FIG. **4**, the optical deflector **50** and part of the scanning optical system Lo are arranged in the first recess CP**1**. Specifically, the members of the scanning optical system Lo other than the reflecting mirrors **81** are arranged in the first recess CP**1**. As shown in FIG. **1**, the coupling lens **20**, the aperture plate **30**, and the condenser lens **40** are arranged inside the second recess CP**2**. The second recess CP**2** is arranged on the other side in the third direction with respect to the first recess CP**1**.

[0043] The frame F includes a first base wall Fb**1** located at the bottom of the first recess CP**1** and a second base wall Fb**2** located at the bottom of the second recess CP**2**.

[0044] The first base wall Fb**1** and the second base wall Fb**2** are walls that cross the first direction. Specifically, the first base wall Fb**1** and the second base wall Fb**2** are walls whose thickness direction is along the first direction. That is, the first base wall Fb**1** and the second base wall Fb**2** are walls having flat surfaces perpendicular to the first direction.

[0045] The second base wall Fb**2** is located at a position shifted to one side in the first direction with respect to the first base wall Fb**1**. As shown in FIG. **5**, the optical deflector **50** is attached to the first base wall Fb**1**. Specifically, the motor circuit board **53** is fixed to the first base wall Fb**1** with screws from one side in the first direction. Part of the scanning optical system Lo, more specifically, the members of the scanning optical system Lo excluding the reflecting mirrors **81** are attached to the first base wall Fb**1** on one side in the first direction. The optical deflector **50** and part of the scanning optical system Lo are located on one side in the first direction with respect to the first base wall Fb**1**. As shown in FIG. **1**, the semiconductor laser **10**, the coupling lens **20**, and the aperture plate **30** are located on the other side in the first direction with respect to the second base wall Fb**2**. The condenser lens **40** and the reflecting mirrors **81** are also located on the other side in the first direction with respect to second base wall Fb**2**.

[0046] The reflecting mirrors **81** are arranged near the first base wall Fb**1** and are exposed on the other side in the first direction with respect to the first base wall Fb**1**. In other words, the first base wall Fb**1** does not have a portion located on the other side of the reflecting mirrors **81** in the first direction. With this configuration, the reflecting mirrors **81** are exposed on the other side in the first direction without being hidden by the first base wall Fb**1**, and are attachable to the frame F from the other side in the first direction.

[0047] As shown in FIG. **5**, the frame F has a mount surface Fb**11** on which the optical deflector **50** is mounted. The motor circuit board **53** of the optical deflector **50** is fixed to a boss Fb**12** protruding from the mount surface Fb**11**.

[0048] The scanning optical device **1** further includes a window member **110**, an optical sensor **120**, and a laser circuit board **90**. The window member **110** is a member that transmits a light beam B deflected by the optical deflector **50**. In this embodiment, the window member **110** is a lens that converges the light beam B onto the optical sensor **120**.

[0049] As shown in FIG. **7**, the window member **110** has a flat-shaped entrance surface **111**. The entrance surface **111**

is perpendicular to an optical path of the light beam B directed from the optical deflector **50** toward the optical sensor **120**. The window member **110** has an exit surface **112** that converges light in the main scanning direction and the sub-scanning direction. The exit surface **112** is an anamorphic surface having different powers in the main scanning direction and the sub-scanning direction.

[0050] As shown in FIG. **5**, the optical sensor **120** is a sensor for determining a writing position of the light beam B with respect to the photosensitive drum **200**, and detects the light beam B that has passed through the window member **110**. Specifically, a controller (not shown) determines the writing position of the light beam B on the photosensitive drum **200**, based on the timing at which the light beam B is detected by the optical sensor **120**.

[0051] The laser circuit board **90** is located at the end of the frame F on the other side in the third direction. The laser circuit board **90** is located on the side opposite to the polygon mirror **51** with respect to the coupling lens **20** in the third direction. As shown in FIGS. **2** and **5**, the semiconductor lasers **10**Y, **10**M, **10**C, and **10**K and the optical sensor **120** are mounted to the laser circuit board **90**.

[0052] The frame F includes a first wall F**1**, a second wall F**2**, a third wall F**3**, and a fourth wall F**4**. The first wall F**1**, the second wall F**2**, the third wall F**3** and the fourth wall F**4** form a third recess CP**3** in which the optical deflector **50** is accommodated. The third recess CP**3** is located at a center of the first recess CP**1** in the second direction.

[0053] The optical deflector **50** is located between the first wall F**1** and the third wall F**3** in the second direction. The optical deflector **50** is located between the second wall F**2** and the fourth wall F**4** in the third direction. The second wall F**2** and the fourth wall F**4** are connected to the first wall F**1** and the third wall F**3**.

[0054] The first wall F**1** is a wall that partitions the optical deflector **50** from part of the third scanning optical system LoC and the fourth scanning optical system LoK. Specifically, the first wall F**1** partitions the optical deflector **50** from the members of the third scanning optical system LoC and the fourth scanning optical system LoK other than the first scanning lens **60**CK.

[0055] As shown in FIGS. **5** and **6**, the first wall F**1** has a first opening H**1** and a second opening H**2**. The first opening H**1** is an opening through which the light beam BC, BK directed from the optical deflector **50** to the third scanning optical system LoC or the fourth scanning optical system LoK passes. The second opening H**2** is an opening through which the light beam B directed from the optical deflector **50** to the optical sensor **120** passes. The first scanning lens **60**CK closes the first opening H**1**. The window member **110** closes the second opening H**2**. Specifically, the first scanning lens **60**CK (the closest scanning lens to the optical deflector **50** in the scanning optical system Lo) is fixed in the first opening H**1** to close the first opening H**1**, and the window member **110** is fixed in the second opening H**2** to close the second opening H**2**.

[0056] As shown in FIG. **5**, the second wall F**2** has two third openings H**31** and H**32**. The third openings H**31** and H**32** are openings through which the light beam B directed from the coupling lens **20** to the optical deflector **50** passes. The third openings H**31** and H**32** are formed in slit shapes elongated in the first direction and penetrate in the third direction. The light beam BY, BM passes through the third opening H**31**. The light beam BC, BK passes through the third opening H**32**.

[0057] As shown in FIGS. **5** and **6**, the third wall F**3** has a fourth opening H**4**. The fourth opening H**4** is an opening through which the light beam BY, BM directed from the optical deflector **50** to the first scanning optical system LoY or the second scanning optical system LoM passes. The first scanning lens **60**YM closes the fourth opening H**4**.

[0058] The condenser lens **40** closes the third openings H**31** and H**32**. The condenser lens **40** is sandwiched between the second wall F**2** and the aperture plate **30**.

[0059] As shown in FIG. **9**, the condenser lens **40** has a rib **40**A protruding from the exit surface to one side of the third direction, that is, in the traveling direction of the light beam B incident on the condenser lens **40**. The rib **40**A is in contact with the second wall F**2**. The condenser lens **40** also has a rib **40**B protruding from the entrance surface to the other side in the third direction. The rib **40**B is in contact with the aperture plate **30**. Specifically, each end of the rib **40**B in the second direction is in contact with the aperture plate **30** (see FIG. **1**). The ribs **40**A and **40**B are configured to surround the periphery of the exit surface and the entrance surface, which are optical surfaces of the condenser lens **40**. This allows the condenser lens **40** to close the third openings H**31** and H**32** without bringing the optical surfaces of the condenser lens **40** into direct contact with the second wall F**2** and the aperture plate **30**.

[0060] As shown in FIG. **8**, the scanning optical device **1** further includes a first cover C**1** (an example of a deflector cover). The first cover C**1** covers the optical deflector **50** from the side opposite to the mount surface Fb**11**. Specifically, the first cover C**1** covers the first recess CP**1**.

[0061] The first cover C**1** has two first ribs R**11** and R**12**. Each of the first ribs R**11** and R**12** overlaps the first wall F**1** when viewed from the traveling direction of the light beam B incident on the first scanning lens **60**CK (see FIG. **4**), more specifically from the second direction. Each of the first ribs R**11** and R**12** extends in the third direction. The distance between the first wall F**1** and each of the first ribs R**11** and R**12** in the second direction is smaller than the thickness of the first wall F**1**. The two first ribs R**11** and R**22** sandwich the first wall F**1** in the second direction. Of the two first ribs, the first rib R**11** farther from the polygon mirror **51** protrudes further toward the first base wall Fb**1** than the first rib R**12** which is closer to the polygon mirror **51**. The two first ribs R**11** and R**12** are similarly provided on the third wall F**3** on one side of the polygon mirror **51** in the second direction.

[0062] As shown in FIG. **4**, the scanning optical device **1** further includes two seal members **210** and **220**. One seal member **210** is located between the first scanning lens **60**CK and the first cover C**1**. The one seal member **210** closes the first opening H**1** together with the first scanning lens **60**CK. Further, the one seal member **210** is located between the window member **110** and the first cover C**1**. The one seal member **210** closes the second opening H**2** together with the window member **110**. The other seal member **220** is located between the first scanning lens **60**YM and the first cover C**1**. The other seal member **220** closes the fourth opening H**4** together with the first scanning lens **60**YM. The seal members **210** and **220** are made of an elastic member such as sponge.

[0063] As shown in FIG. **9**, the scanning optical device **1** further includes a second cover C**2** (an example of a coupling-lens cover). The second cover C**2** covers the coupling lens **20**. Specifically, the second cover C**2** covers the second recess CP**2**.

[0064] The second cover C**2** includes a second rib R**2**. The second rib R**2** overlaps the second wall F**2** when viewed from the traveling direction of the light beam B incident on the condenser lens **40**, specifically from the third direction. The distance in the third direction between the second rib R**2** and the second wall F**2** is smaller than or equal to the thickness of the second wall F**2**.

[0065] As described above, according to this embodiment, the following effects are obtained.

[0066] As shown in FIG. **5**, the first opening H**1** of the first wall F**1** is closed by the first scanning lens **60**CK, and the second opening H**2** is closed by the window member **110**. Thus, the first scanning lens **60**CK and the window member **110** suppress dust and so on entering around the polygon mirror through the first opening H**1** and the second opening H**2**. Further, since the light beam B directed toward the optical sensor **120** passes through the window member **110** different from the first scanning lens **60**CK, it is unnecessary to provide the first scanning lens **60**CK with an area for allowing the light beam B directed toward the optical sensor **120** to pass through. This suppresses an increase in the size of the first scanning lens **60**CK.

[0067] Since the window member **110** is a lens that converges the light beam B onto the optical sensor **120**, the number of parts is reduced compared to a structure in which a lens for the optical sensor is provided separately from the window member.

[0068] The entrance surface **111** of the window member **110** is perpendicular to the optical path of the light beam B directed from the optical deflector **50** to the optical sensor **120**. Thus, compared with a structure in which the entrance surface of the window member is inclined with respect to the optical path, the loss of light quantity is reduced and the size of the second opening H**2** is reduced.

[0069] As shown in FIG. **8**, the first cover C**1** includes the first ribs R**11** and R**12** that overlap the first wall F**1** when viewed from the second direction. Thus, the first ribs R**11** and R**12** suppresses dust and so on entering around the polygon mirror **51** through the gap between the first wall F**1** and the first cover C**1**.

[0070] As shown in FIG. **5**, the third openings H**31** and H**32** of the second wall F**2** are closed by the condenser lens **40**. Thus, the condenser lens **40** suppresses dust and so on entering around the polygon mirror **51** through the third openings H**31** and H**32**.

[0071] As shown in FIG. **9**, the second cover C**2** includes the second rib R**2** that overlaps the second wall F**2** when viewed from the third direction. Thus, the second rib R**2** suppresses dust and so on entering around the polygon mirror **51** though the gap between the second wall F**2** and the second cover C**2**.

[0072] By sandwiching the condenser lens **40** between the second wall F**2** and the aperture plate **30**, the condenser lens **40** is brought into close contact with the second wall F**2**. This further suppresses dust and so on entering around the polygon mirror **51** through the third openings H**31** and H**32**.

[0073] As shown in FIG. **4**, the seal member **210**, **220** is located between the first scanning lens **60**YM, **60**CK and the first cover C**1**. Thus, the seal member **210**, **220** suppresses dust and so on entering around the polygon mirror **51** through the gap between the first scanning lens **60**YM, **60**CK and the first cover C**1**.

[0074] As shown in FIG. **9**, the condenser lens **40** includes the ribs **40**A that protrude in the third direction and contact the second wall F**2**. This enables the condenser lens **40** to seal the third openings H**31** and H**32** without bringing the optical surface of the condenser lens **40** into contact with the second wall F**2**.

[0075] While the invention has been described in conjunction with various example structures outlined above and illustrated in the figures, various alternatives, modifications, variations, improvements, and/or substantial equivalents, whether known or that may be presently unforeseen, may become apparent to those having at least ordinary skill in the art. Accordingly, the example embodiments of the disclosure, as set forth above, are intended to be illustrative of the invention, and not limiting the invention. Various changes may be made without departing from the spirit and scope of the disclosure. Thus, the disclosure is intended to embrace all known or later developed alternatives, modifications, variations, improvements, and/or substantial equivalents. Some specific examples of potential alternatives, modifications, or variations in the described invention are provided below.

[0076] The window member may be a member that simply transmits a light beam and does not have a lens function. In this case, a lens for condensing the light beam on the optical sensor may be provided separately from the window member.

[0077] The condenser lens may be integral with the coupling lens.

[0078] In the above embodiment, part of the scanning optical system Lo is attached to one side of the first base wall Fb**1** in the first direction, but the present disclosure is not limited to this. For example, the entire scanning optical system may be attached to one side of the first base wall in the first direction.

[0079] In the above-described embodiment, the frame F has substantially rectangular frame-shaped side walls surrounding each of the recesses CP**1** and CP**2**. At least one of the frame-shaped side walls may be provided at the first cover or the second cover.

[0080] The first cover may cover at least a portion of the frame where the optical deflector is arranged. For example, a cover that covers the optical deflector and a cover that covers a part of the scanning optical system may be separate. The cover may cover the entire scanning optical system. For example, in a case where the entire scanning optical system is accommodated in the first recess, the cover may cover the entire scanning optical system.

[0081] The number of the first ribs and the second ribs is not limited to the above embodiment, and may be any number. Further, two second ribs may be provided and the second wall may be sandwiched between the two second ribs.

[0082] The semiconductor laser **10** may be configured to have a plurality of light emitting points. With this configuration, a plurality of light beams emitted from the semiconductor laser **10** may be converted into a plurality of light beams by one coupling lens **20**, and the plurality of light beams may be imaged on the surface of the photosensitive drum **200** by the corresponding scanning optical system Lo.

When configured in this manner, each of the light beams BY, BM, BC, and BK of the above embodiment includes a plurality of light beams.

[0083] In the above-described embodiment, the scanning optical device applied to a color image forming apparatus is exemplified. However, the scanning optical device may be applied to a monochrome image forming apparatus that scans one light beam.

[0084] In the above embodiment, the window member **110** has the flat-shaped entrance surface **111**, but the entrance surface **111** may be a surface having power instead of a flat surface. In the above embodiment, the exit surface **112** is an anamorphic surface, but the exit surface may be an axisymmetric surface.

[0085] The elements described in the above-described embodiment and modifications may be implemented in any combination.

What is claimed is:

1. A scanning optical device comprising:
a semiconductor laser configured to emit light;
a coupling lens configured to convert the light emitted by the semiconductor laser into a light beam;
an optical deflector including a polygon mirror configured to deflect, in a main scanning direction, the light beam converted by the coupling lens;
a scanning optical system configured to receive the light beam deflected by the optical deflector and to form an image on an image surface;
a window member configured to transmit the light beam deflected by the optical deflector;
an optical sensor configured to detect the light beam that passes through the window member; and
a frame having a mount surface on which the optical deflector is mounted,
the frame including a first wall having a first opening through which the light beam directed from the optical deflector toward the scanning optical system passes and a second opening through which the light beam directed from the optical deflector toward the optical sensor passes,
the first opening being closed by a closest scanning lens to the optical deflector in the scanning optical system,
the second opening being closed by the window member.

2. The scanning optical device according to claim **1**, wherein the window member is a lens configured to condense the light beam on the optical sensor.

3. The scanning optical device according to claim **1**, wherein the window member has a flat-shaped entrance surface; and
wherein the entrance surface is perpendicular to an optical path of the light beam directed from the optical deflector toward the optical sensor.

4. The scanning optical device according to claim **1**, further comprising a deflector cover configured to cover the optical deflector on a side opposite to the mount surface,
wherein the deflector cover includes a rib overlapping the first wall when viewed from a traveling direction of the light beam that is incident on the scanning lens.

5. The scanning optical device according to claim **1**, further comprising a condenser lens configured to condense the light beam from the coupling lens in a sub-scanning direction,
wherein the frame includes a second wall having a third opening through which the light beam directed from the coupling lens toward the optical deflector passes; and
wherein the third opening is closed by the condenser lens.

6. The scanning optical device according to claim **5**, further comprising a coupling-lens cover configured to cover the coupling lens,
wherein the coupling-lens cover includes a rib overlapping the second wall when viewed from a traveling direction of the light beam that is incident on the condenser lens.

7. The scanning optical device according to claim **5**, wherein the frame includes an aperture plate located between the coupling lens and the condenser lens, the aperture plate having a stop aperture through which the light beam passes; and
wherein the condenser lens is sandwiched between the second wall and the aperture plate.

8. The scanning optical device according to claim **5**, wherein the condenser lens includes a rib protruding in a traveling direction of the light beam that is incident on the condenser lens, the rib being in contact with the second wall.

9. The scanning optical device according to claim **1**, further comprising:
a deflector cover configured to cover the optical deflector on a side opposite to the mount surface; and
a seal member located between the scanning lens and the deflector cover.

10. The scanning optical device according to claim **1**, wherein the frame includes:
a first base wall crossing a first direction along a rotation axis of the polygon mirror, the optical deflector being attached to the first base wall; and
a second base wall crossing the first direction, the second base wall being located at a position shifted to one side in the first direction with respect to the first base wall;
wherein the optical deflector is located on the one side in the first direction with respect to the first base wall; and
wherein the coupling lens is located on an other side in the first direction with respect to the second base wall.

11. The scanning optical device according to claim **10**, wherein the frame has a first recess and a second recess, the first recess opening on one side in the first direction, the second recess opening on an other side in the first direction,
wherein the polygon mirror is disposed in the first recess; and
wherein the coupling lens is disposed in the second recess.

12. The scanning optical device according to claim **1**, wherein the image surface is a circumferential surface of a photosensitive drum provided in an image forming apparatus; and
wherein the optical sensor is for determining a writing position of the light beam with respect to the photosensitive drum.

13. The scanning optical device according to claim **1**, further comprising a laser circuit board located on a side opposite to the polygon mirror with respect to the coupling lens in the main scanning direction,
wherein the semiconductor laser and the optical sensor are mounted to the laser circuit board.

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