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(54) **DEVELOPMENT DEVICE AND IMAGE FORMING APPARATUS INCORPORATING SAME**

(76) Inventors: **Hideo Yoshizawa**, Kanagawa (JP); **Kiyonori Tsuda**, Kanagawa (JP); **Takuzi Yoneda**, Tokyo (JP); **Emi Kita**, Kanagawa (JP); **Yutaka Takahashi**, Kanagawa (JP); **Yuki Oshikawa**, Kanagawa (JP); **Kohichi Utsunomiya**, Kanagawa (JP)

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(57) **ABSTRACT**

A development device includes a development casing, a developer bearer disposed facing a latent image bearer through an opening in the development casing to carry developer, a magnetic field generator disposed inside the developer bearer, a developer regulator extending in an axial direction of the developer bearer to adjust an amount of developer carried on the developer bearer, and a first axial end seal provided in an axial end portion of the development device outside an image range, in contact with an upstream face of the developer regulator to reduce a size of a clearance between the developer regulator and the development casing.

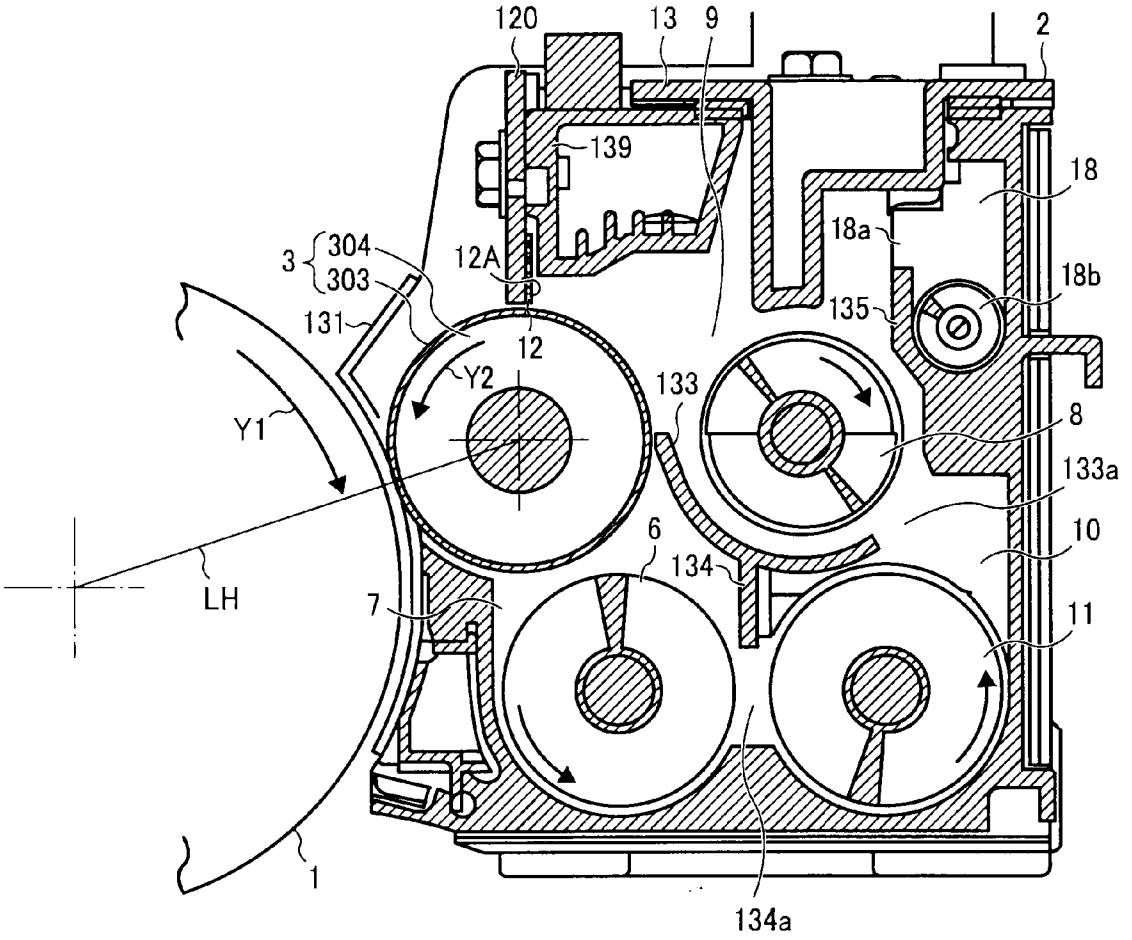


FIG. 1

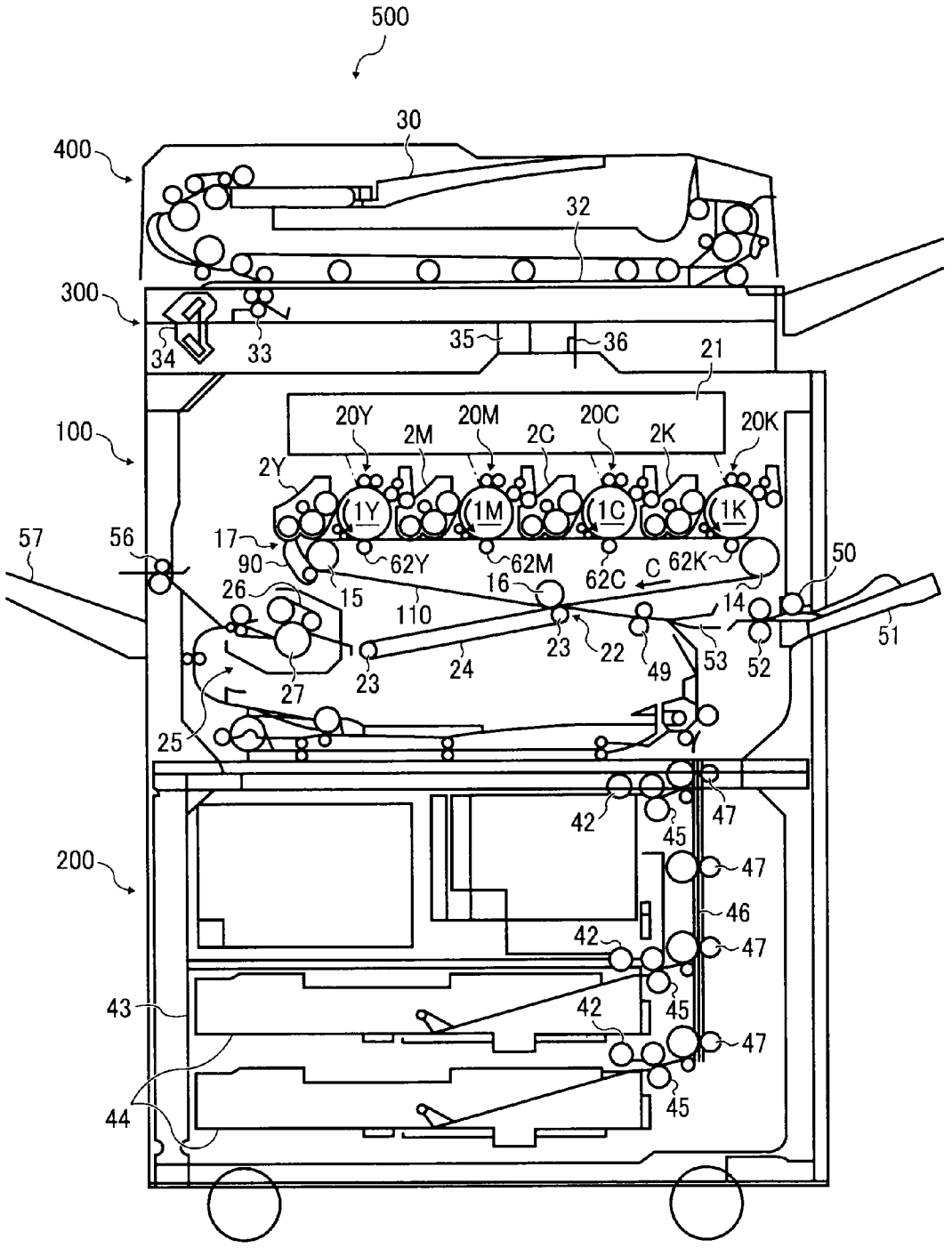

500
30
400
32
300
34
33
35
36
21
20Y
2M
20M
2C
20C
2K
20K
100
2Y
1Y
1M
1C
1K
57
56
17
90
62Y
62M
62C
C
62K
50
26
15
16
14
110
23
22
49
53
52
51
24
27
25
42
45
47
200
46
43
44

FIG. 2

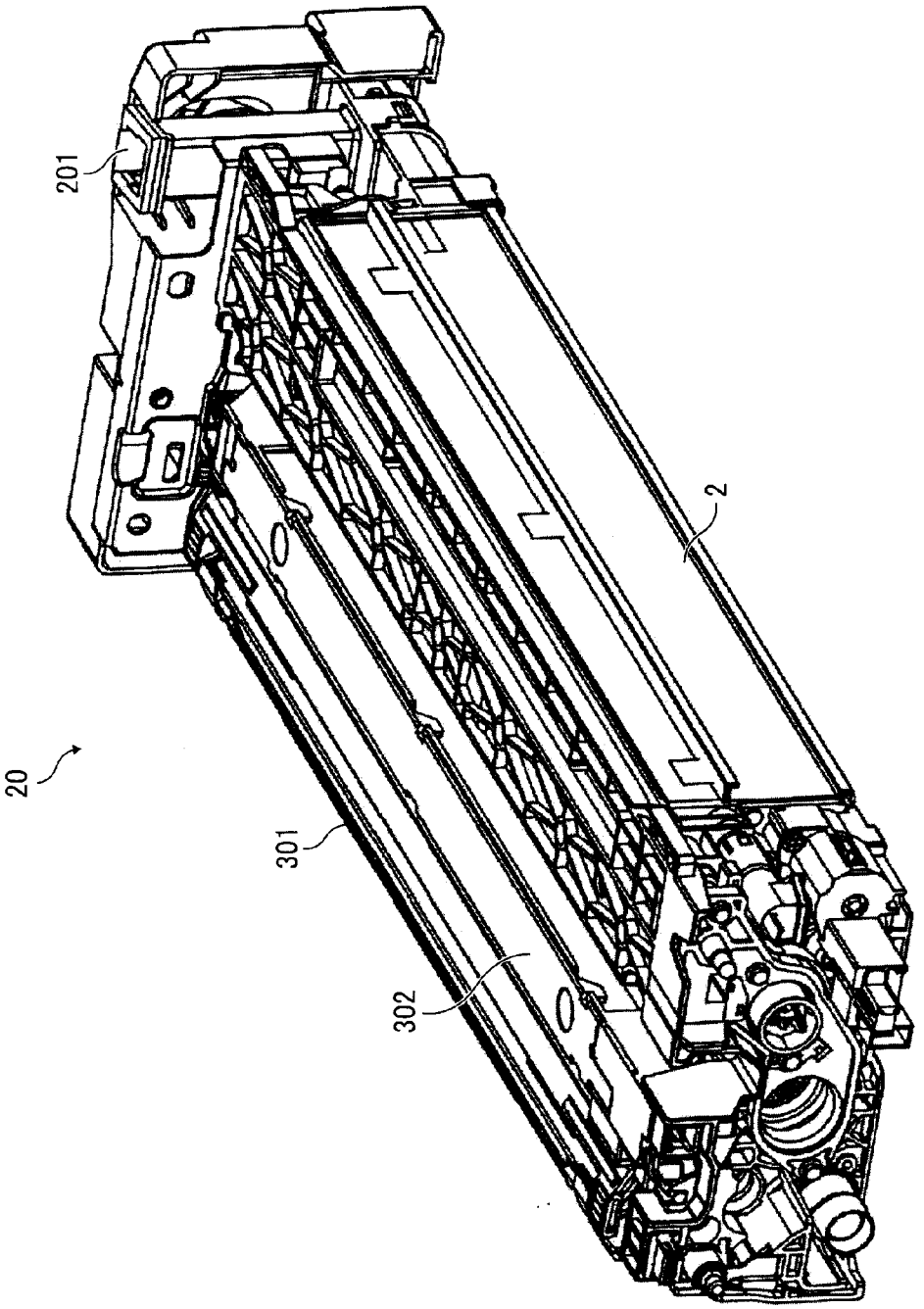


FIG. 3

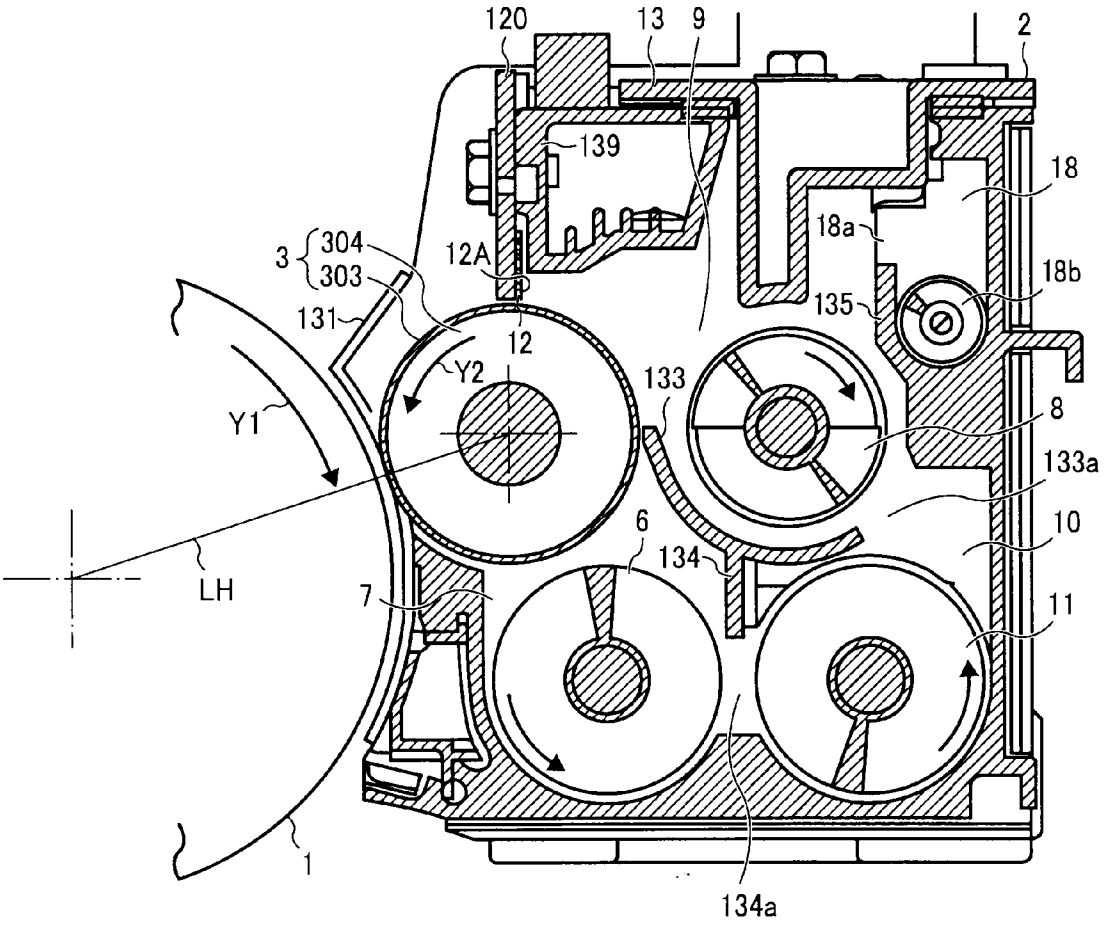

120
13
9
2
139
18
18a
18b
3
304
303
12A
131
135
12
Y2
133
Y1
8
133a
6
134
10
LH
7
11
1
134a

FIG. 4

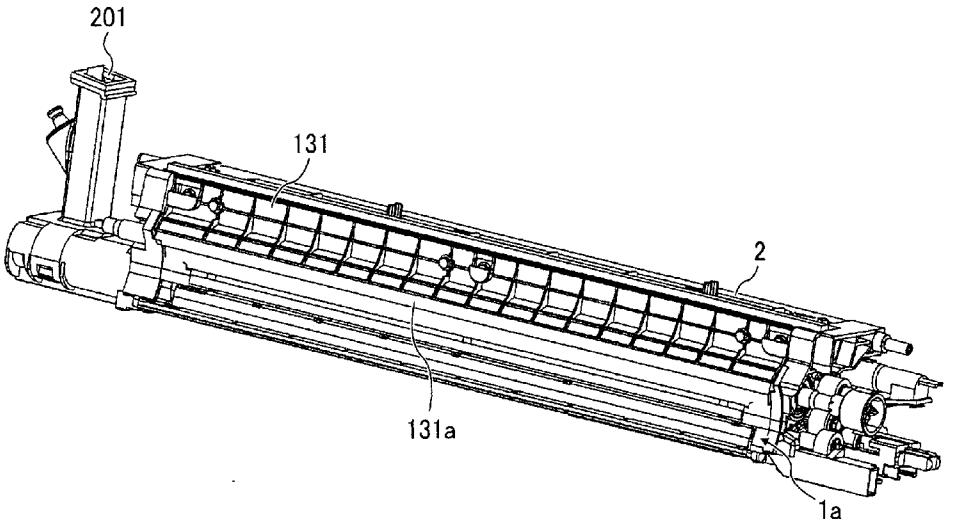

201
131
2
131a
1a

FIG. 5

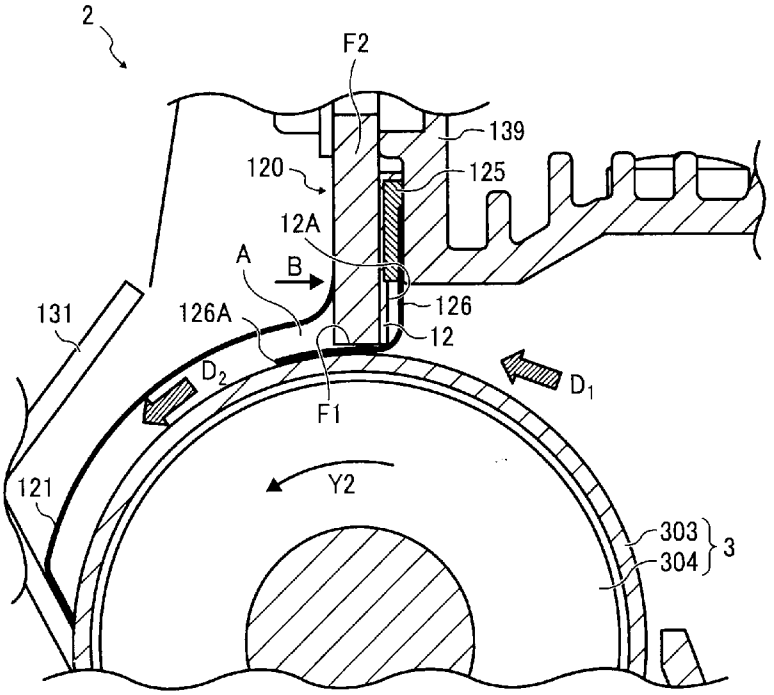

2
F2
139
120
125
12A
A
B
131
126A
126
12
D2
D1
F1
Y2
121
303
304
3

FIG. 6

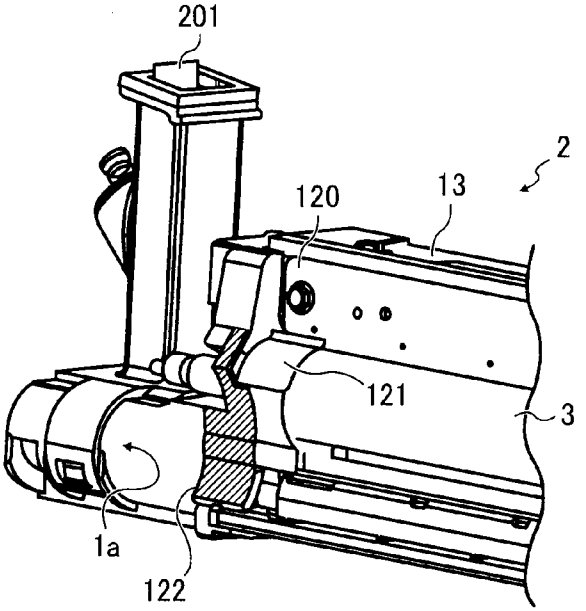


FIG. 7

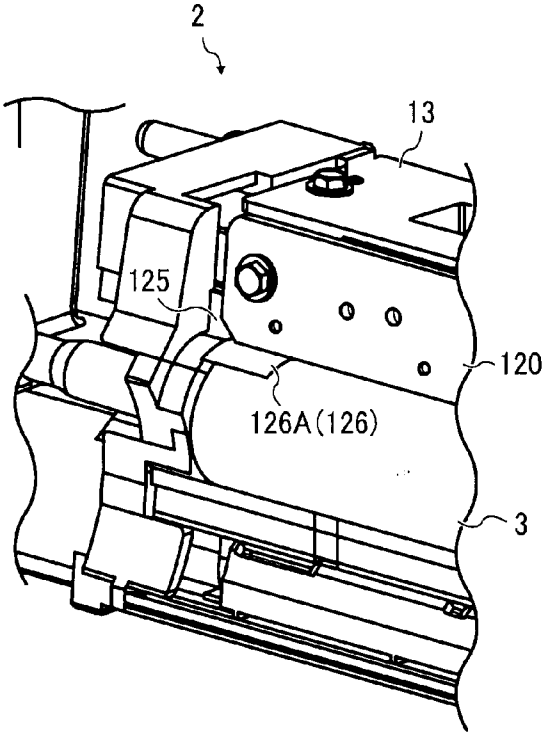


FIG. 8

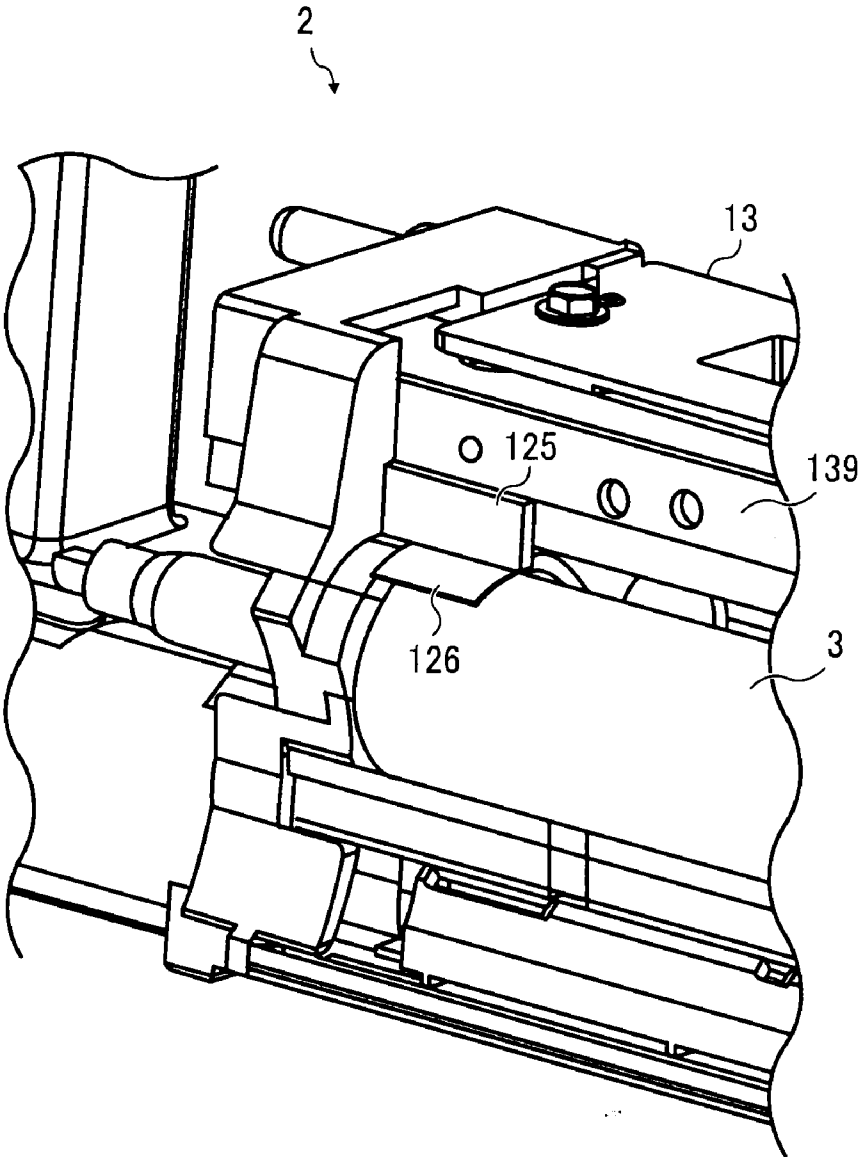


FIG. 9A

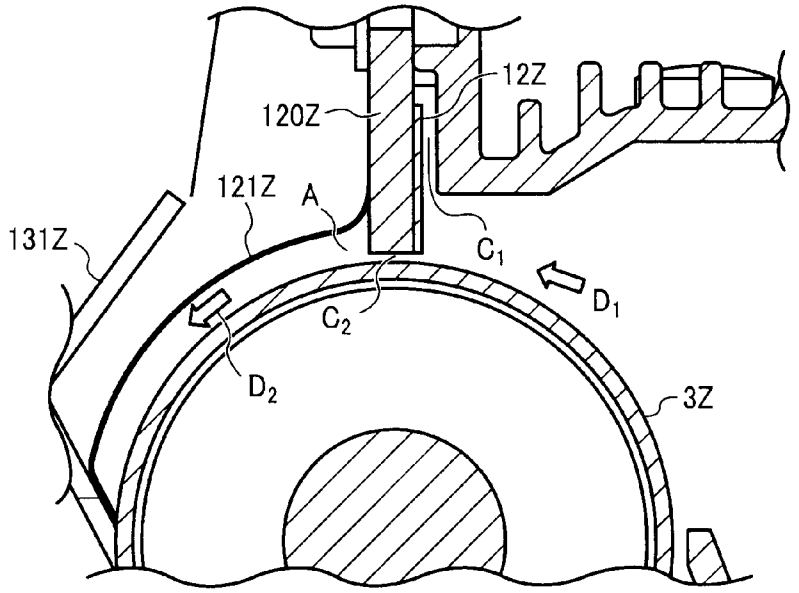

12Z
120Z
121Z
A
131Z
C1
D1
C2
D2
3Z

FIG. 9B

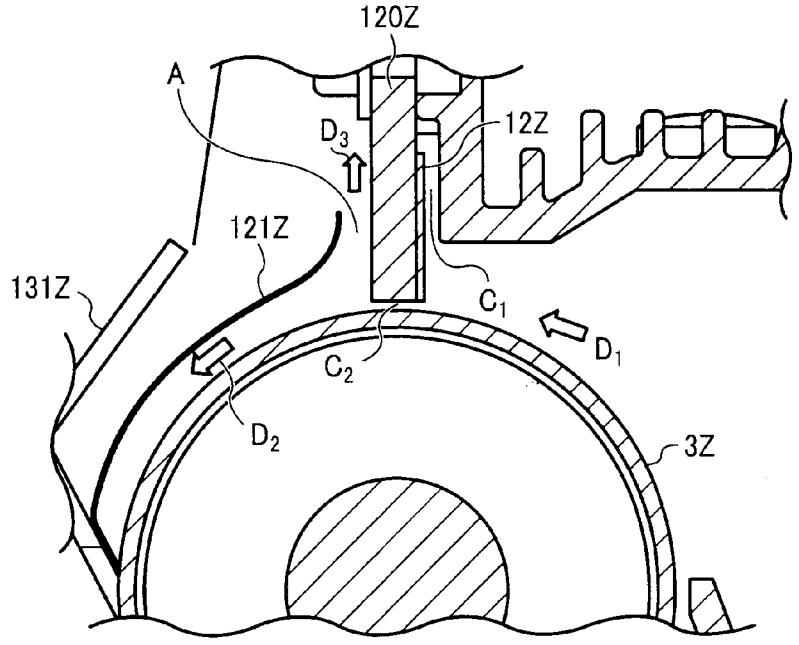

120Z
A
D3
12Z
121Z
131Z
C1
D1
C2
D2
3Z

FIG. 10

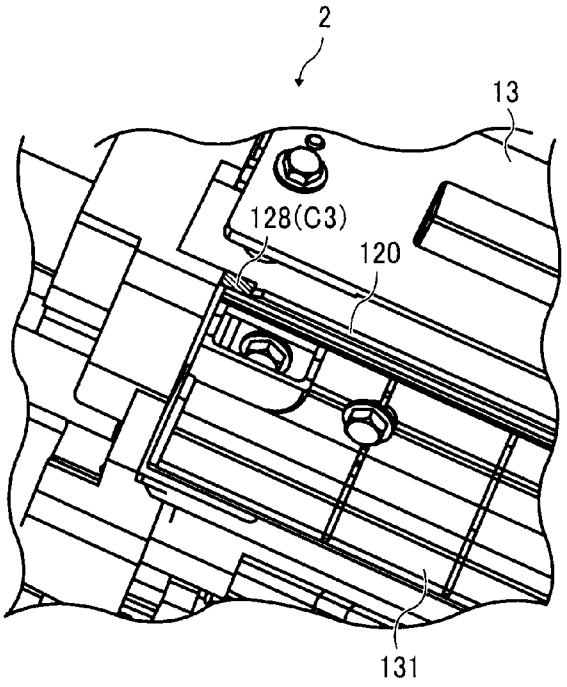
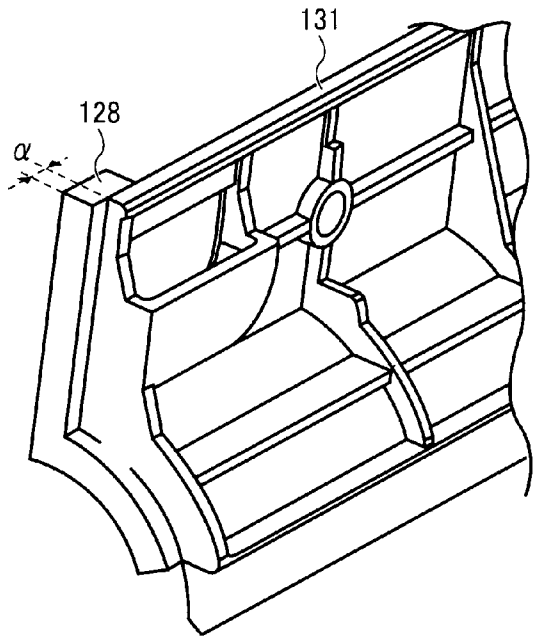


FIG. 11



DEVELOPMENT DEVICE AND IMAGE FORMING APPARATUS INCORPORATING SAME

CROSS-REFERENCE TO RELATED APPLICATION

[0001] This patent application is based on and claims priority pursuant to 35 U.S.C. §119 to Japanese Patent Application No. 2011-097637, filed on Apr. 25, 2011, in the Japan Patent Office, the entire disclosure of which is hereby incorporated by reference herein.

FIELD OF THE INVENTION

[0002] This invention generally relates to a development device used in an image forming apparatus, such as a copier, a printer, a facsimile machine, and a multifunction machine including at least two of these functions, and an image forming apparatus including the development device.

BACKGROUND OF THE INVENTION

[0003] Typical development devices include a developer bearer inside which a magnetic field generator is provided to carry developer on the surface of the developer bearer and a developer regulator to adjust the amount of developer carried on the developer bearer. Developer is carried on the surface of the developer bearer due to the magnetic force exerted by the magnetic field generator and conveyed to a development range as the developer bearer rotates. The developer regulator extends in a width direction perpendicular to the direction of rotation of the developer bearer and is disposed with a tip thereof facing the surface of the developer bearer across a predetermined clearance (i.e., a regulation gap). The developer regulator regulates the amount of developer passing through the regulation gap, carried on the developer bearer.

[0004] Typically, the magnetic field generator does not present in end portions in the width direction (i.e., axial end portions) of the developer bearer outside an image area because the end portions do not need to carry the developer. Although the axial end portions of the developer bearer are not designed to carry developer, in practice, among the developer conveyed toward the regulation gap, the developer blocked by the developer regulator is pushed to the axial end portion.

[0005] The developer that has reached the axial ends then inevitably moves through the gap between the developer regulator and the developer bearer. In the axial end portions, the effects of the magnetic force exerted by the magnet roller are small. Accordingly, it is possible that the developer leaves the surface of the developer bearer and scatters. The scattering developer can adhere to other components, resulting in contamination inside the apparatus or adhere to sheets of recording media, thus degrading image quality.

BRIEF SUMMARY OF THE INVENTION

[0006] In view of the foregoing, one embodiment of the present invention provides a development device that includes a development casing, a developer bearer disposed facing a latent image bearer through an opening formed in the development casing, a magnetic field generator disposed inside the developer bearer, a developer regulator to adjust an amount of developer carried on the developer bearer, and a first axial end seal provided in an axial end portion of the development device outside an image range. The developer bearer carries by rotation two-component developer including toner and carrier. The developer regulator extends in an axial direction of the developer bearer perpendicular to a direction of rotation of the developer bearer, and an end face of the developer regulator faces the developer bearer across a predetermined regulation gap. The first axial end seal is disposed in contact with an upstream face of the developer regulator in the direction of rotation of the developer bearer to reduce a size of a clearance (C_1) between the developer regulator and the development casing.

[0007] In another embodiment, an image forming apparatus includes a latent image bearer, a latent image forming unit to form a latent image on the latent image bearer, and the development device described above.

BRIEF DESCRIPTION OF THE DRAWINGS

[0008] A more complete appreciation of the disclosure and many of the attendant advantages thereof will be readily obtained as the same becomes better understood by reference to the following detailed description when considered in connection with the accompanying drawings, wherein:

[0009] FIG. **1** is a schematic diagram illustrating an image forming apparatus according to an embodiment;

[0010] FIG. **2** is a perspective view illustrating an image forming unit;

[0011] FIG. **3** is an end-on axial view of a development device;

[0012] FIG. **4** is a perspective view of the development device shown in FIG. **3**;

[0013] FIG. **5** is an enlarged view illustrating a development regulator and the adjacent portion in the development device according to an embodiment;

[0014] FIG. **6** is a perspective view illustrating the development device from which a rim portion of the development casing enclosing the opening (i.e., an opening rim) is removed;

[0015] FIG. **7** is a perspective view illustrating the development device shown in FIG. **6** from which a photoreceptor seal member and a development-side seal are removed;

[0016] FIG. **8** is a perspective view illustrating the development device from which the developer regulator is removed;

[0017] FIG. **9**A is an enlarged view illustrating a configuration around a developer regulator in a comparative development device in which a development-side seal and the developer regulator are in contact with each other;

[0018] FIG. **9**B is an enlarged view illustrating the comparative development device in which the development-side seal and the developer regulator are away from each other;

[0019] FIG. **10** is an enlarged perspective view illustrating a development device including a seal member provided to the rim portion of the development casing enclosing an opening formed in the development casing; and

[0020] FIG. **11** is an enlarged view illustrating an axial end portion of the development device shown in FIG. **10**.

DETAILED DESCRIPTION OF THE INVENTION

[0021] In describing preferred embodiments illustrated in the drawings, specific terminology is employed for the sake of clarity. However, the disclosure of this patent specification is not intended to be limited to the specific terminology so selected, and it is to be understood that each specific element

includes all technical equivalents that operate in a similar manner and achieve a similar result.

[0022] Referring now to the drawings, wherein like reference numerals designate identical or corresponding parts throughout the several views thereof, and particularly to FIG. **1**, a multicolor image forming apparatus according to an embodiment of the present invention is described.

[0023] It is to be noted that the suffixes Y, M, C, and K attached to each reference numeral indicate only that components indicated thereby are used for forming yellow, magenta, cyan, and black images, respectively, and hereinafter may be omitted when color discrimination is not necessary.

[0024] FIG. **1** is a schematic diagram that illustrates a configuration of an image forming apparatus **500** according to the present embodiment.

[0025] The image forming apparatus **500** shown in FIG. **1** can be, for example, a copier, and includes a printer unit **100**, a sheet feeder **200** on which the printer unit **100** is mounted, and a scanner **300** fixed above the printer unit **100**. The image forming apparatus **500** further includes an automatic document feeder (ADF) **400** fixed on the scanner **300**.

[0026] The printer unit **100** includes four image forming units **20**Y, **20**M, **20**C, and **20**K for forming yellow (Y), magenta (M), cyan (M), and black (K) images. The image forming apparatus **500** further includes an optical writing unit **21**, an intermediate transfer unit **17**, a secondary transfer device **22**, a pair of registration rollers **49**, and a belt-type fixing device **25**.

[0027] The optical writing unit **21** includes a light source, a polygon mirror, an f-θ lens, and reflection mirrors, and is configured to direct a laser beam onto surfaces of four photoreceptors **1** according to image data.

[0028] FIG. **2** is a perspective view of one of the four image forming units **20** as viewed from the bask side of the paper on which FIG. **1** is drawn.

[0029] In each image forming unit **20**, the drum-shaped photoreceptor **1** and the components, such as a charging device **302**, a development device **2**, a drum cleaning unit **301**, and a discharger, provided around the photoreceptor **1** may be supported by a common frame (supporter), forming a process cartridge (modular unit) removably installable in a main body (e.g., printer unit **100**) of the image forming apparatus **500**. The printer unit **100** of the image forming apparatus **500** according to the present embodiment includes four process cartridges arranged in parallel to each other.

[0030] It is to be noted that reference numeral **201** shown in FIG. **2** represents a toner supply inlet formed in the development device **2**.

[0031] The image forming units **20** are described in further detail below using the image forming unit **20** for yellow.

[0032] The surface of the photoreceptor **1**Y is uniformly charged by the charging device **302**Y. Then, the optical writing unit **21** directs the laser beam, which is modulated and deflected, to the charged surface of the photoreceptor **1**Y. The laser beam (exposure light) attenuates the electrical potential of the portion of the photoreceptor **1**Y thus exposed, forming an electrostatic latent image for yellow thereon. Then, the development device **2**Y develops the electrostatic latent image formed on the photoreceptor lY with developer into a yellow toner image. The yellow toner image is primarily transferred from the photoreceptor **1**Y onto the intermediate transfer belt **110**.

[0033] Subsequently, the drum cleaning unit **301**Y removes toner remaining on the surface of the photoreceptor **1**Y. Further, the discharger removes electrical potential remaining on the photoreceptor **1**Y, after which the charging device **302**Y uniformly charges the surface of the photoreceptor **1**Y, thus initializing the photoreceptor **1**Y The above-described processes are also performed in other image forming units **20** similarly.

[0034] Next, the intermediate transfer unit **17** is described below.

[0035] The intermediate transfer unit **17** includes the intermediate transfer belt **110**, a belt cleaning unit **90**, a tension roller **14**, a driving roller **15**, a backup roller **16**, and four primary-transfer bias rollers **62**. The intermediate transfer belt **110** is stretched around multiple rollers including the tension roller **16** and rotates clockwise in FIG. **1** as the driving roller **15** rotates, driven by a belt driving motor. The four primary-transfer bias rollers **62** are disposed in contact with an inner circumferential surface of the intermediate transfer belt **110** and receive a primary transfer bias from a power source.

[0036] The four primary-transfer bias rollers **62** press the intermediate transfer belt **110** against the respective photoreceptors **1** from the inner circumferential side, forming primary-transfer nips therebetween. The primary transfer bias causes a primary-transfer electrical field between the photoreceptor **1** and the primary-transfer bias roller **62** in each primary-transfer nip. The yellow toner image is transferred from the photoreceptor **1**Y onto the intermediate transfer belt **110** with the effects of the primary-transfer electrical field and the nip pressure. Subsequently, magenta, cyan, and black toner images are transferred from the photoreceptors **1**M, **1**C, and **1**K and superimposed one on another on the yellow toner image. Thus, a superimposed four-color toner image is formed on the intermediate transfer belt **110**.

[0037] The four-color toner image formed on the intermediate transfer belt **110** is transferred in a secondary-transfer nip onto a sheet (recording medium) transported from the sheet feeder **200** (secondary-transfer process). The belt cleaning unit **90** is provided downstream from the secondary-transfer nip in a direction in which the sheet is transported (hereinafter "sheet conveyance direction"), pressing against the driving roller **15** via the intermediate transfer belt **110**. The belt cleaning unit **90** removes any toner remaining on the intermediate transfer belt **110** after the secondary transfer process.

[0038] The secondary transfer device **22** is described in further detail below.

[0039] The secondary transfer device **22** is disposed beneath the intermediate transfer unit **17** in FIG. **1** and includes a conveyance belt **24** looped around two tension rollers **23**. The conveyance belt **24** rotates counterclockwise in FIG. **1** as at least one of the two tension rollers **23** rotates. The intermediate transfer belt **110** and the conveyance belt **24** are nipped between the backup roller **16** and the tension roller **23** on the right in FIG. **1**. Thus, the intermediate transfer belt **110** is in contact with the conveyance belt **24**, forming the secondary-transfer nip.

[0040] A secondary-transfer bias whose polarity is opposite to the polarity of toner is applied to the tension roller **23** on the right from a power source. The secondary-transfer bias causes a secondary-transfer electrical field in the secondary-transfer nip to electrically transfer the four-color toner image from the intermediate transfer belt **110** toward the tension roller **23**. Timed to coincide with transferring of the four-color toner image, the registration rollers **49** forward the sheet

to the secondary-transfer nip, and the four-color toner image is secondarily transferred on the sheet. It is to be noted that, instead of applying the secondary-transfer bias to one of the tension rollers **23**, a contactless charger to charge the sheet may be provided.

[0041] The sheet feeder **200** disposed beneath the main body of the apparatus includes a paper bank **43** in which multiple sheet cassettes **44** are arranged vertically. Each sheet cassette **44** contains multiple sheets stacked on top of another. Each sheet cassette **44** is provided with a feed roller **42** pressed against the sheet on the top in the sheet cassette **44**. As the feed roller **42** rotates, the sheet is conveyed to a feeding path **46**.

[0042] Multiple pairs of conveyance rollers **47** are provided along the feeding path **46**, and the pair of registration rollers **49** is provided at an end portion of the feeding path **46**. The sheet is conveyed toward the registration rollers **49** and then clamped in the nip between the registration rollers **49**.

[0043] Meanwhile, the four-color toner image formed on the intermediate transfer belt **110** is transported to the secondary-transfer nip as the intermediate transfer belt **110** rotates. The registration rollers **49** forward the sheet clamped therebetween so that it can contact the four-color image in the secondary-transfer nip. Thus, the four-color toner image is transferred onto the sheet in the secondary-transfer nip, forming a full-color image on the while sheet. As the conveyance belt **24** rotates, the sheet carrying the full-color toner image is discharged from the secondary-transfer nip and conveyed to the fixing device **25**.

[0044] The fixing device **25** includes a belt unit to rotate a fixing belt **26** looped around two rollers as well as a pressure roller **27** pressed against one of the two rollers of the belt unit. The fixing belt **26** and the pressure roller **27** press against each other, forming a fixing nip therebetween, and the sheet conveyed by the conveyance belt **24** is clamped in the fixing nip. A heat source to heat the fixing belt **26** is provided inside the roller against which the pressure roller **27** presses. With the heat and pressure, the toner image is fixed on the sheet in the fixing nip (fixing process).

[0045] After the fixing process, discharge rollers **56** discharge the sheet to a stack tray **57** protruding from a side (on the left in FIG. **1**) of the housing of the image forming apparatus **500**. Alternatively, the sheet is conveyed again to the secondary-transfer nip for duplex printing.

[0046] To make copies of a bundle of originals, users can place the bundle of originals, for example, on a document table **30** of the ADF **400**. It is to be noted that, if the bundle of originals is bound like a book on one side (side-stitched documents), the bundle is placed on an exposure glass **32** of the scanner **300**. Specifically, the user lifts the ADF **400** to expose the exposure glass **32** of the scanner **300**, sets the bundle on the exposure glass **32**, and then lowers the ADF **400** so as to hold the bundle with the ADF **400**.

[0047] Then, the user presses a copy start switch, and the scanner **300** starts reading image data of the originals. When the originals are set on the ADF **400**, the ADF **400** automatically conveys the originals to the exposure glass **32** before reading of image data. In reading of image data, the first and second carriages **33** and **34** start moving, and the first carriage **33** directs an optical beam from the light source onto the original. Subsequently, the optical beam reflected from a surface of the original is reflected by the mirror of the second carriage **34**, passes through the imaging lens **35**, and then enters the reading sensor **36**. Thus, the reading sensor **36** obtains the image data of the original document.

[0048] In parallel to reading of image data, components of the respective image forming units **20**, the intermediate transfer unit **17**, the secondary transfer device **22**, and the fixing device **25** start operating. According to the image data obtained by the reading sensor **36**, the optical writing unit **21** is driven, and yellow, magenta, cyan, and black toner images are formed on the photoreceptors **1**Y, **1**M, **1**C, and **1**K, respectively.

[0049] Additionally, almost simultaneously with the start of image data reading, the sheet feeder **200** starts feeding sheets. Specifically, one of the feed rollers **42** is selectively rotated, and the sheets are fed from the corresponding sheet cassette **44**. The sheets are fed one by one to the feeding path **46**, separated by a separation roller **45**, after which the pairs of conveyance rollers **47** convey the sheet to the secondary-transfer nip. Instead of the sheet cassette **44**, the sheets may be fed from a side tray (external tray) **51** projecting from the side of the apparatus. In this case, a feed roller **50** is rotated to feed the sheets from the side tray **51**, and a separation roller **52** forwards the sheets one by one to a feed path **53** inside the printer unit **100**.

[0050] When multicolor toner images are formed, the intermediate transfer belt **110** is disposed with its upper portion substantially horizontal so that the photoreceptors **1**Y, **1**M, **1**C, and **1**K are in contact with the upper side of the intermediate transfer belt **110**. By contrast, when monochrome images (black toner images) are formed, the left side of the intermediate transfer belt **110** in FIG. **1** is lowered, thus disengaging the intermediate transfer belt **110** from the photoreceptors **1**Y, **1**M, and **1**C. Then, only the photoreceptor **1**K among the four photoreceptors **1** is rotated counterclockwise in FIG. **1**. At that time, not only the photoreceptor **1** but also the development device **2** is stopped in each of the image forming units **20**Y, **20**M, and **20**C to prevent wear of the photoreceptors **1** or waste of developer.

[0051] Although not shown in FIG. **1**, the image forming apparatus **500** further includes a controller for controlling operations of respective parts thereof and an operation panel including a display and various keys. Regarding simplex printing to form an image on only one side of the sheet, the image forming apparatus **500** can offer three different modes: a direct discharge mode, a reverse discharge mode, and a reverse decal discharge mode. The user can select one of these modes by sending a command to the controller from the operation panel.

[0052] FIG. **3** is an end-on axial view illustrating a schematic configuration of the development device **2** provided in the image forming unit **20**. FIG. **3** is a cross-sectional view illustrating an end portion on the back side of the paper on which FIG. **2** is drawn (front side of the paper on which FIG. **1** is drawn).

[0053] FIG. **4** is a perspective view of the development device **2** without other components, such as the photoreceptor **1**, of the image forming unit **20**. When the development device **2** is incorporated in the image forming unit **20**, the photoreceptor **1** is positioned at a position 1a shown in FIG. **4**.

[0054] Referring to FIG. **3**, the development device **2** includes a development casing **13** for containing two-component developer consisting essentially of toner and magnetic carrier and a development roller **3** serving as a developer bearer to carry thereon the developer. An opening is formed in the development casing **13** at a position facing the photore-

ceptor **1**, which rotates clockwise in FIG. **3** as indicated by arrow Y**1**, and the development roller **3** is partly exposed from the opening. The development roller **3** rotates counterclockwise in FIG. **3** as indicated by arrow Y**2**. The development roller **3** is disposed so that a minute clearance is kept between the exposed surface thereof and the surface of the photoreceptor **1**.

[0055] The development roller **3** includes a cylindrical development sleeve **303** constructed of an electroconductive, nonmagnetic material and a magnet roller **304** disposed inside the development sleeve **303**. The magnet roller **304** includes multiple stationary magnetic poles. The development sleeve **303** serves as a developer bearer, and the magnet roller **304** serves as the magnetic field generator to generate a magnetic field at least in the portion facing a developer doctor **120**.

[0056] The development sleeve **303** rotates, thus moving relatively to the magnet roller **304**, in a direction following the direction of rotation of the photoreceptor **1** indicated by arrow Y**1**. Further, a power source is connected to the development sleeve **303** to apply a development bias thereto. When the development bias is applied to the development sleeve **303**, an electrical field (i.e., development field) is formed between the surface of the development roller **3** and the surface of the photoreceptor **1** in a development range where the development roller **3** faces the photoreceptor **1**.

[0057] The development field causes toner contained in the developer carried on the surface of the development roller **3** to adhere to the electrostatic latent image formed on the photoreceptor **1**, thus developing it into a toner image. In image development, the magnetic field formed by the magnet roller **304** causes the magnetic carrier in the developer to stand on end on the development sleeve **303** in the development range, thus forming a magnetic brush.

[0058] The development device **2** further includes the developer doctor **120** (i.e., a doctor blade) and a magnetic plate **12**. The developer doctor **120** and the magnetic plate **12** together form a developer regulator that adjusts the amount of developer carried to the development range, carried on the surface of the development roller **3**. The developer regulator formed by the developer doctor **120** and the magnetic plate **12** has an end face F**1** facing the development roller **3** across the predetermined gap (i.e., a regulation gap).

[0059] The magnetic plate **12** is fixed to an upstream face of the developer doctor **120** in the direction of rotation of the development roller **3**. The developer doctor **120** is fixed to an upper casing **139**, which forms a part of the development casing **13**, and accordingly the magnetic plate **12** is fixed to the upper casing **139** via the developer doctor **120**. The developer doctor **120** and the magnetic plate **12** extend in the width direction perpendicular to the direction of rotation of the development roller **3** and in parallel to the surface of the development roller **3**.

[0060] It is to be noted that reference character **12**A (shown in FIG. **3**) represents an upstream face of the magnetic plate **12** in the direction of rotation of the development roller **3**, and LH (shown in FIG. **3**) represents a line passing through axial centers of the development roller **3** and the photoreceptor **1**.

[0061] The development casing **13** further includes an opening rim **131** positioned downstream from the developer doctor **120** in the direction of rotation of the development roller **3** and extends to the opening (development range), thus covering the downstream side of the developer doctor **120**. The opening rim **131** serves as a rim portion adjacent to the opening, and an opening seal **131***a* is bonded to the opening rim **131** as shown in FIG. **4**.

[0062] The developing device **2** further includes a supply screw **8** and a collecting screw **6** positioned downstream from the development range where the development roller **3** faces the photoreceptor **1** in the direction of rotation of the development roller **3**. The supply screw **8** transports the developer to the back side of the paper on which FIG. **2** is drawn while supplying the developer to the development roller **3**. The collecting screw **6** collects the developer that has passed through the development range and transports the collected developer in the direction identical to the direction in which the supply screw **8** transports the developer (hereinafter "developer conveyance direction"). The development roller **3** and a supply compartment **9** in which the supply screw **8** is provided are arranged laterally, and a collecting compartment **7** in which the collecting screw **6** is provided is positioned beneath the development roller **3**. The development device **2** further includes an agitation compartment **10** beneath the supply compartment **9** and in parallel to the collecting compartment **7**. In the agitation compartment **10**, an agitation screw **11** is provided to transport the developer toward the front side of the paper on which FIG. **2** is drawn while agitating the developer. The agitation screw **11** transports the developer in the direction opposite the developer conveyance direction of the supply screw **8**.

[0063] The development device **2** further includes a first separation wall **133** that includes a portion separating the supply compartment **9** from the agitation compartment **10**.

[0064] Although separated by the first separation wall **133**, the supply compartment **9** and the agitation compartment **10** communicate with each other in both axial end portions, which are respectively on the front side and the back side of the paper on which FIG. **3** is drawn. Additionally, a second separation wall **134** that includes a portion separating the agitation compartment **10** from the collecting compartment **7** is provided. Although separated by the second separation wall **134**, an opening **134***a* is formed in an end portion of the second separation wall **134**, which is on the back side of the paper on which FIG. **3** is drawn, and thus the agitation compartment **10** communicates with the collecting compartment **7**. It is to be noted that the supply compartment **9** and the collecting compartment **7** are separated by the first partition **133** as well, and no opening is formed in that portion of the first partition **133**. Thus, the supply compartment **9** does not communicate with the collecting compartment **7**.

[0065] After being used in image development, developer is collected in the collecting compartment **7** and then is conveyed to the back side of the paper on which FIG. **2** is drawn. The collected developer is further conveyed through the opening **134***a* formed in the second separation wall **134**, in a non-image area, to the agitation compartment **10**. It is to be noted that premixed toner, in which toner and carrier are mixed, is supplied to the agitation compartment **10** through the toner supply inlet **201** (shown in FIG. **2**) formed on an upper side of an upstream end portion of the agitation compartment **10**.

[0066] The supply compartment **9** includes a discharge path **18** to discharge the developer from the supply compartment **9** outside the development device **2** when the amount of developer inside the development device **2** becomes excessive resulting from the supply of premixed toner or the like. The developer is discharged through a discharge opening **18***a*

to the discharge path **18**, and a discharge screw **18***b* is provided in the discharge path **18**. Specifically, the discharge path **18** is formed by a partition **135** and the development casing **13** and is positioned on the side of the supply compartment **9** via the partition **135**. The discharge opening **18***a* is formed in an end portion of the partition **135** on the downstream side in the developer conveyance direction in the supply compartment **9** (on the back side in FIG. **2** and the same position as the cross section shown in FIG. **3**). That is, the discharge opening **18***a* serves as a communication portion between the supply compartment **9** and the discharge path **18**.

[0067] Next, circulation of developer inside the three compartments formed in the development casing **13** (i.e., a developer container) is described below.

[0068] In the supply compartment **9**, the supply screw **8** transports the developer supplied from the agitation compartment **10** downstream while supplying it to the development roller **3**. The developer that is not supplied to the development roller **3** but is transported to the downstream end portion of the supply compartment **9** (i.e., excessive developer) is transported through an opening **133***a* for excessive developer formed in the first separation wall **133** to the agitation compartment **10**. The developer collected from the development roller **3** in the collecting compartment **7** is transported by the collection screw **6** to a downstream end portion of the collecting compartment **7**, after which the collected developer is transported to the agitation compartment **10** through the opening **134***a* formed in the second separation wall **134**. In the agitation compartment **10**, the excessive developer and the collected developer are mixed together and transported by the agitation screw **11** to a downstream end portion of the agitation compartment **10**, which is on the upstream side in the conveyance direction of the supply screw **8**. Then, the developer is transported through the opening formed in the first separation wall **133** to the supply compartment **9**.

[0069] In the agitation compartment **10**, the agitation screw **11** transports the collected developer, the excessive developer, and toner supplied through the toner supply inlet **201** as required in the direction opposite the direction in which the developer is transported in the collecting compartment **7** as well as the supply compartment **9**. Subsequently, the developer is transported from the downstream end portion of the agitation compartment **10** to an upstream end portion of the supply compartment **9** through the opening. It is to be noted that a toner concentration detector is provided beneath the agitation compartment **10**, and premixed toner is supplied by a toner supply device from a toner container according to outputs from the toner concentration detector.

[0070] In the above-described development device **2**, the used developer does not directly enter the supply compartment **9** because supply and collection of developer are performed in the supply compartment **9** and the collecting compartment **7**, respectively. Therefore, decreases in toner concentration in the developer supplied to the development roller **3** on the downstream side in the supply compartment **9** can be prevented or reduced. Additionally, collection and agitation of developer are performed in different developer conveyance compartments, namely, the collecting compartment **7** and the agitation compartment **10**, which can prevent the used developer from being supplied to the development roller **3** during agitation. Therefore, only sufficiently agitated developer is allowed to enter the supply compartment **9**. In other words, decreases in concentration of toner in the developer in the supply compartment **9** can be prevented or alleviated, and accordingly image density can be kept constant.

[0071] FIG. **5** is an enlarged cross-sectional view illustrating a configuration in the axial end portion adjacent to the developer doctor **120** (on the same cross section as shown in FIG. **3**). FIG. **6** is an enlarged cross-sectional view of the axial end portion of the development device **2** (on the left in FIG. **4**) from which the opening rim **131** is removed.

[0072] It is to be noted that, in FIG. **5**, reference character A represents an area downstream from the developer doctor **120** in the direction of rotation of the development roller **3**, and arrows D_1 and D_2 represent flow of developer.

[0073] As shown in FIGS. **5** and **6**, a development-side seal **121** (cover) is provided in an axial end portion and downstream from the developer doctor **120** in the direction of rotation of the development roller **3** indicated by arrow Y**2**. The development-side seal **121** is a flexible elastic member, and a lower end portion thereof is fixed to the development casing **13**. Due to the elasticity thereof, an upper end portion of the development-side seal **121** presses, as indicated by arrow B shown in FIG. **5**, a downstream face of the developer doctor **120** in the direction of rotation of the development roller **3**. The development-side seal **121** is designed to prevent scattering of developer downstream from the regulation gap.

[0074] Additionally, as shown in FIG. **6**, a photoreceptor seal member **122** is provided in an axial end portion of the position **1***a* where the photoreceptor **1** is disposed. The photoreceptor seal member **122** is provided between the photoreceptor **1** and the development casing **13** to shield the photoreceptor **1**. As shown in FIG. **6**, the photoreceptor seal member **122** is disposed to hold a lower side of the development-side seal **121**. The development-side seal **121** and the photoreceptor seal member **122** may be provided in either axial end portion.

[0075] Next, a distinctive feature of the present embodiment is described below with reference to FIG. **5**.

[0076] The development device **2** further includes a doctor end seal **125** (first axial end seal) constructed of an elastic material such as sponge and disposed in contact with the upstream face **12**A of the magnetic plate **12** in the direction of rotation of the development roller **3**. The upstream face **12**A of the magnetic plate **12** stands vertically from an upstream edge of the end face F**1** of the developer regulator (developer doctor **120** and the magnetic plate **12**). The doctor end seal **125** is positioned in an axial end portion that is a non-image area outside the image area where an image can be formed on the photoreceptor **1**. Specifically, in the image area positioned in an axial center portion (a center portion in the width direction), the amount of developer carried on the development sleeve **303** due to the magnetic force exerted by the magnet roller **304** is adjusted with the regulation gap, and an appropriate amount of developer is conveyed to the development range.

[0077] Additionally, a flexible sheet member **126** (second axial end seal) constructed of, for example, urethane is provided with a first end portion thereof interposed between the doctor end seal **125** and the upper casing **139**, thus being fixed to the development casing **13**, and a second end portion **126**A thereof not fixed (i.e., a free end). The second end portion **126**A of the flexible sheet member **126** contacts the surface of the development roller **3** in the axial end portion.

[0078] The second end portion **126**A of the flexible sheet member **126** follows rotation of the development roller **3** and is positioned downstream in the direction of rotation of the

development roller **3** from the regulation gap between the developer doctor **120** and the development roller **3**. The development-side seal **121** serves as a cover for the second end portion **126**A of the flexible sheet member **126** (second axial end seal).

[0079] It is to be noted that two doctor end seals **125** and two flexible sheet members **126** may be provided in the respective axial end portions.

[0080] Next, a procedure of installation of the doctor end seals **125** and the seal members **126** is described below.

[0081] FIG. **7** is a perspective view illustrating the development device **2** from which the photoreceptor seal members **122** and the development-side seals **121** are removed. FIG. **8** is a perspective view illustrating the development device **2** from which the developer doctor **120** is removed.

[0082] Referring to FIG. **7**, initially, the first end portion of the flexible sheet member **126** is fixed to the upper casing **139**, and the free end, namely, the second end portion **126**A (shown in FIG. **7**), of the flexible sheet member **126** is disposed downstream (to the front side of the paper on which FIG. **8** is drawn) from the first end portion thereof in the direction of rotation of the development roller **3** and hung over the development roller **3**. Additionally, the doctor end seal **125** is fixed to the upper casing **139** to cover a portion of the flexible sheet member **126** that is in contact with the upper casing **139**.

[0083] Subsequently, referring to FIG. **7**, the developer doctor **120** is fixed to the upper casing **139**. In the present embodiment, the sum of a thickness of the flexible sheet member **126** and a thickness of the doctor end seal **125** is greater than a thickness of a clearance C_1 (shown in FIGS. **9**A and **9**B) between the magnetic plate **12** and the upper casing **139** (e.g., length in the direction of rotation of the development roller **3**). With this configuration, as shown in FIG. **5**, the doctor end seal **125** can be disposed to contact the upstream face **12**A of the magnetic plate **12** in the direction of rotation of the development roller **3**.

[0084] Next, scattering of developer in a comparative development device is described below with reference to FIGS. **9**A and **9**B.

[0085] FIGS. **9**A and **9**B are enlarged views illustrating a configuration around a developer doctor **120**Z facing a development roller **3**Z in the comparative development device. In FIG. **9**A, a development-side seal **121**Z and the developer doctor **120**Z are in contact with each other, whereas, in FIG. **9**B, the development-side seal **121**Z and the developer doctor **120**Z are away from each other.

[0086] As shown in FIGS. **9**A and **9**B, also in the comparative development device, the development-side seals **121**Z serving as covers or seal members are provided downstream from the regulation gap in the direction of rotation of the development roller **3**Z to cover axial end portions of the development roller **3**Z and the developer doctor **120**Z outside the image area. The development-side seals **121**Z are designed to prevent scattering of developer that has passed through clearances C_2 at the axial ends of the regulation gap between the development roller **3**Z and the developer doctor **120**Z.

[0087] It is to be noted that, in this specification, the regulation gap and the clearances C_2 respectively mean the axial center portion (in the image area) and the axial end portions of the clearance between the developer bearer and the developer regulator.

[0088] However, it is preferred to prevent passage of the developer through the clearances C_2 itself

[0089] More specifically, magnetic members forming the magnet roller are not present outside the development range in the axial direction, and it is not designed to convey developer through clearances C_2 between the development roller **3**Z and the developer doctor **120**Z in the axial end portions. In practice, however, among the developer conveyed toward the regulation gap as indicated by arrow D_1, the developer that is prevented from passing through the regulation gap by the developer doctor **120**Z is pushed to the axial ends long the magnetic plate **12**Z.

[0090] The developer that is pushed to the axial end portions moves through the clearance C_1, shown in FIGS. **9**A and **9**B, between the development casing and the magnetic plate **12**Z. The developer that has reached the axial ends then inevitably moves through the clearances C_2 between the development roller **3**Z and the developer doctor **120**Z. In the axial end portions, the developer can easily leave the surface of the development roller **3**Z because the effects of the magnetic force exerted by the magnet roller are small. Accordingly, it is still possible that the developer scatters outside the comparative development device even through the development-side seals **121**Z can inhibit it to some extent.

[0091] Additionally, to supply developer to the development roller **3**Z, the conveyance screw (supply screw **8**) conveys the developer in the longitudinal direction (width direction) of the development roller **3**Z while agitating toner and carrier in the developer. Therefore, the developer is more likely to scatter in the downstream end portion in the direction in which the supply screw conveys the developer.

[0092] Moreover, in the area where the magnets of the magnet roller present, the developer carried on the surface of the development roller **3**Z is retained along the magnetic force lines, thus inhibited from moving in the thrust direction (width direction). By contrast, in the axial end portions of the development roller **3**Z, there are magnetic force lines heading further to the ends in the thrust direction from the axial ends of the magnets of the magnet roller. Accordingly, some developer moves in the thrust direction through the clearance C_2 between the development roller **3**Z and the developer doctor **120**Z.

[0093] Although it is preferred that the developer be retained along the magnetic force lines, doing so is difficult because the development roller **3**Z rotates, resulting in scattering of developer.

[0094] In view of the foregoing, in the development device **2** according to the present embodiment, the doctor end seals **125** are provided in the respective axial end portions outside the image area and disposed in contact with the upstream face **12**A of the magnetic plate **12** in the direction of rotation of the development roller **3**. The doctor end seals **125** can fill in the clearance C_1 shown in FIGS. **9**A and **9**B and prevent the developer moving through the clearance C_1 to the axial end portions outside the image area. This configuration can inhibit the developer from moving through the clearances C_2 between the development roller **3** and the developer doctor **120** in the area where the effects of the magnetic force exerted by the magnet roller **304** is smaller. Thus, scattering of developer can be gap inhibited.

[0095] Referring again to FIGS. **9**A and **9**B, another inconvenience in the comparative development device is described below.

[0096] If developer passes through the axial end portions, the developer can accumulate in an area A shown in FIGS. **9**A and **9**B. Then, it is possible that the developer pushes away the upper end portion of the development-side seal **121**Z as indicated by arrow D_3 shown in FIG. **9**B, creating a clearance between the development-side seal **121**Z and the developer doctor **120**Z. Additionally, the second end portion (downstream end portion) of the development-side seal **121**Z is fixed at a position downstream from the developer doctor **120**Z in the direction of rotation of the development roller **3**Z, and the first end portion (upstream end portion) is in contact with the developer doctor **120**Z due to this elasticity. Accordingly, if the developer conveyed by rotation of the development roller **3**Z comes into contact with the development-side seal **121**Z, the developer disengages the development-side seal **121**Z from the developer doctor **120**Z, defying the elasticity of the development-side seal **121**Z.

[0097] The clearance between the developer doctor **120**Z and the development-side seal **121**Z is not desirable because it encourages scattering of developer.

[0098] By contrast, in the development device **2** according to the present embodiment, as shown in FIG. **5**, the flexible sheet member **126** is provided in the clearance C_2 between the development roller **3** and the developer doctor **120** to eliminate or reduce the clearance C_2 outside the image area, thereby inhibiting the developer from moving directly to the area A shown in FIG. **5**.

[0099] Although the doctor end seal **125** is fixed to the upper casing **139** in the present embodiment, the portion to which the doctor end seal **125** is attached in not limited thereto as long as it contacts the axial end portions of the upstream face **12**A of the magnetic plate **12** in the direction of rotation of the development roller **3**. For example, the doctor end seal **125** may be fixed on the side of the developer doctor **120**. Additionally, the portion to which the flexible sheet member **126** is attached in not limited to the upper casing **139** as long as the flexible sheet member **126** can be provided in the clearance C_2 between the development roller **3** and the developer doctor **120**.

[0100] As described above, the development device **2** according to the present embodiment includes the development roller **3** serving as the developer bearer, the developer doctor **120**, the magnetic plate **12**, and the doctor end seals **125** serving as the first axial end seals disposed in contact with the upstream face **12**A of the developer regulator (developer doctor **120** and the magnetic plate **12**) on the upstream side in the direction of rotation of the development roller **3**.

[0101] Specifically, the doctor end seals **125** contact the respective axial end portions of the upstream face **12**A of the developer doctor **120** and the magnetic plate **12** to fill in the clearances C_1 shown in FIGS. **9**A and **9**B, thereby inhibiting the developer from moving further to the respective axial end portions. Thus, being blocked by the doctor end seal **125**, the developer, which tends to move along the surface of the magnetic plate **12** to the axial end portions, can be prevented from moving toward the clearances C_2 that are at the axial ends of the regulation gap between the developer doctor **120** and the development roller **3**. Consequently, scattering of developer can be inhibited.

[0102] The development device **2** further includes the flexible sheet member **126** that extends from the first end portion fixed to the doctor end seal **125** downstream from the regulation gap in the direction of rotation of the development roller **3** through the clearance C_2. The seal members **126** can reduce the size of the clearances C_2 at the axial ends of the regulation gap, thereby inhibiting passage of developer therethrough. The flexible sheet member **126** passing though the clearance C_2 at the axial end of the regulation gap can inhibit accumulation of developer in the area A adjacent to the position where the development-side seal **121** contacts the developer doctor **120**, thereby preventing creating of clearance between the developer doctor **120** and the development-side seal **121**.

[0103] Additionally, the second end portion **126**A of the flexible sheet member **126** is positioned upstream in the direction of rotation of the development roller **3** from the development range where development roller **3** faces the photoreceptor **1**, or upstream from the line LH (shown in FIG. **3**) passing through axial centers of the development roller **3** and the photoreceptor **1**. Thus, the length of the flexible sheet member **126** in the circumferential direction of the development roller **3** is designed not to reach the development range, where the distance between the development roller **3** and the photoreceptor is shortest. Thus, it does not reduce the gap with the development-side seal **121**.

[0104] Additionally, the flexible sheet member **126** and the development-side seal **121** are similar in length in the width direction (axial direction of the development roller **3**). Accordingly, the area A can be covered with the flexible sheet member **126** entirely in the width direction.

[0105] Additionally, the image forming apparatus **500** according to the present embodiment includes the photoreceptor **1** serving as the latent image bearer, the charging device **302** to charge the photoreceptor **1**, the optical writing unit **21** to form a latent image on the photoreceptor **1**, the development device **2** to develop the latent image, and the drum cleaning unit **301** to remove toner remaining on the photoreceptor **1** after image transfer. The image forming apparatus **500** can inhibit contamination inside the apparatus and scattering of toner on output images.

[0106] Next, a variation of the above-described development device **2** is described below with reference to FIGS. **10** and **11**.

[0107] In the variation, another seal member is provided to an axial end portion of the opening rim **131** to prevent scattering of developer from the axial end portions of the developer doctor **120**.

[0108] FIG. **10** is an enlarged perspective view illustrating an axial end portion of the development device **2** according to the variation in which a casing-side seal **128** (third axial end seal) is provided to the opening rim **131** as viewed from above. FIG. **11** is an enlarged view of an axial end portion (on the left in FIG. **4**) of the opening rim **131** to which the casing-side seal **128** is provided.

[0109] As described above, the developer that is prevented from passing through the regulation gap is pushed to the axial ends long the magnetic plate **12**. When the developer reaches the axial end portions of the developer doctor **120**, it is possible that, even if the clearance C_2 is very small, the developer urged by the pushing force can pass through the clearance C_2 between the development casing **13** and the end portion of the developer doctor **120** and scatter.

[0110] In view of the foregoing, in the configuration shown in FIGS. **10** and **11**, the casing-side seals **128** are provided to the axial end portions of the developer doctor **120** to prevent scattering of developer. The casing-side seal **128** are fixed to the axial end portion of the opening rim **131** and may be in contact with the side face or axial end face F**2** (shown in FIG.

5) of the developer doctor **120** at the axial end, thus filling in a clearance C**3** between the side face F**2** of the developer doctor **120** and the development casing **13**. The clearance C**3** between the developer doctor **120** and a side plate of development casing **13** can be thus filled in, and developer can be prevented from moving in the thrust direction.

[0111] Additionally, the casing-side seal **128** are fixed to the opening rim **131** with an axial end portion a projecting beyond the axial end of the opening rim **131** (in the width direction). The projecting portion a may be folded along the side face of the development casing **13**. Thus, the clearance between the opening rim **131** and the side face of the development casing **13** can be filled in, preventing scattering of developer therefrom, and clearances created between the adjacent components, namely, the opening rim **131**, the development casing **13**, and the developer doctor **120**, can be covered better.

[0112] It is to be noted that various aspects of this specification can adapt to any image forming apparatus, such as a printer or a facsimile machine, that includes a development device not limited to copiers.

[0113] Numerous additional modifications and variations are possible in light of the above teachings. It is therefore to be understood that, within the scope of the appended claims, the disclosure of this patent specification may be practiced otherwise than as specifically described herein.

What is claimed is:

1. A development device comprising:
- a development casing;
- a developer bearer to carry by rotation two-component developer including toner and carrier, the developer bearer disposed facing a latent image bearer through an opening formed in the development casing;
- a magnetic field generator disposed inside the developer bearer;
- a developer regulator to adjust an amount of developer carried on the developer bearer, the developer regulator extending in an axial direction of the developer bearer perpendicular to a direction of rotation of the developer bearer and disposed with an end face thereof facing the developer bearer across a predetermined regulation gap; and
- a first axial end seal provided in an axial end portion of the development device outside an image range, the first axial end seal disposed in contact with an upstream face of the developer regulator in the direction of rotation of the developer bearer to reduce a size of a clearance (C_1) between the developer regulator and the development casing.

2. The development device according to claim **1**, further comprising:
- a flexible second axial end seal having a first end portion fixed to the first axial end seal and a second end portion disposed downstream from the regulation gap in the direction of rotation of the developer bearer, the second axial end seal passing through a clearance (C_2) at an axial end of the regulation gap between the development bearer and the developer regulator; and
- a cover disposed downstream from the developer regulator in the direction of rotation of the developer bearer to cover the second end portion of the second axial end seal.

3. The development device according to claim **2**, wherein the second end portion of the second axial end seal is positioned upstream from the development range in the direction of rotation of the developer bearer.

4. The development device according to claim **2**, wherein the second axial end seal and the cover are similar in length in the axial direction of the developer bearer.

5. The development device according to claim **2**, wherein the first axial end seal is elastic, and a sum of a thickness of the first axial end seal and a thickness of the second axial end seal is greater than a thickness of the clearance (C_1) between the developer regulator and the development casing.

6. The development device according to claim **1**, further comprising a third axial end seal to fill in a clearance (C**3**) between an axial end face of the developer regulator and the development casing, wherein the development casing comprises a rim portion adjacent to the opening, the rim portion covering a downstream side of the developer regulator in the direction of rotation of the developer bearer, and the third axial end seal is fixed to an axial end portion of the rim portion of the development casing and disposed in contact with the axial end face of the developer regulator.

7. The development device according to claim **6**, wherein the third axial end seal is fixed to the rim portion of the development casing with an outer end portion of the third axial end seal projecting beyond an axial end of the rim portion of the development casing.

8. An image forming apparatus comprising:
- a latent image bearer;
- a latent image forming unit to form a latent image on the latent image bearer; and
- a development device to develop the latent image, the development device including:
  - a development casing;
  - a developer bearer to carry by rotation two-component developer including toner and carrier, the developer bearer disposed facing the latent image bearer through an opening formed in the development casing;
  - a magnetic field generator disposed inside the developer bearer;
  - a developer regulator to adjust an amount of developer carried on the developer bearer, the developer regulator extending in an axial direction of the developer bearer perpendicular to a direction of rotation of the developer bearer and disposed with an end face thereof facing the developer bearer across a predetermined regulation gap; and
  - a first axial end seal provided in an axial end portion of the development device outside an image range, the first axial end seal disposed in contact with an upstream face of the developer regulator in the direction of rotation of the developer bearer to reduce a size of a clearance (C_1) between the developer regulator and the development casing.

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