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Shiodera et al.

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(54) **FIXING DEVICE AND IMAGE FORMING APPARATUS**

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CPC ***G03G 15/2025*** (2013.01)

(58) **Field of Classification Search**
CPC G03G 15/2025
See application file for complete search history.

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(57) **ABSTRACT**

A fixing device includes a rotator, a heater, a rotator support, a nip formation pad, lubricant, and a pressure rotator. The heater heats an inner circumferential surface of the rotator. The rotator support supports an end of the inner circumferential surface of the rotator in an axial direction of the rotator. The rotator slides on the rotator support. The nip formation pad is in contact with the inner circumferential surface of the rotator. One end of the nip formation pad in a longitudinal direction of the nip formation pad is separated from the rotator support with a clearance of 2 mm or more. The lubricant is between the rotator and the nip formation pad. The pressure rotator presses the nip formation pad via the rotator to form a nip between the rotator and the pressure rotator.

8 Claims, 14 Drawing Sheets

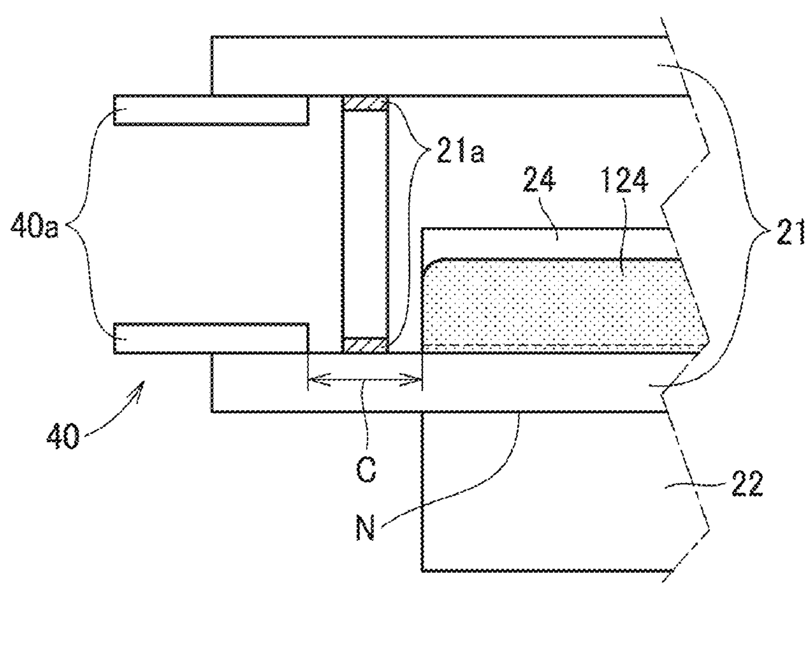

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FIG. 1

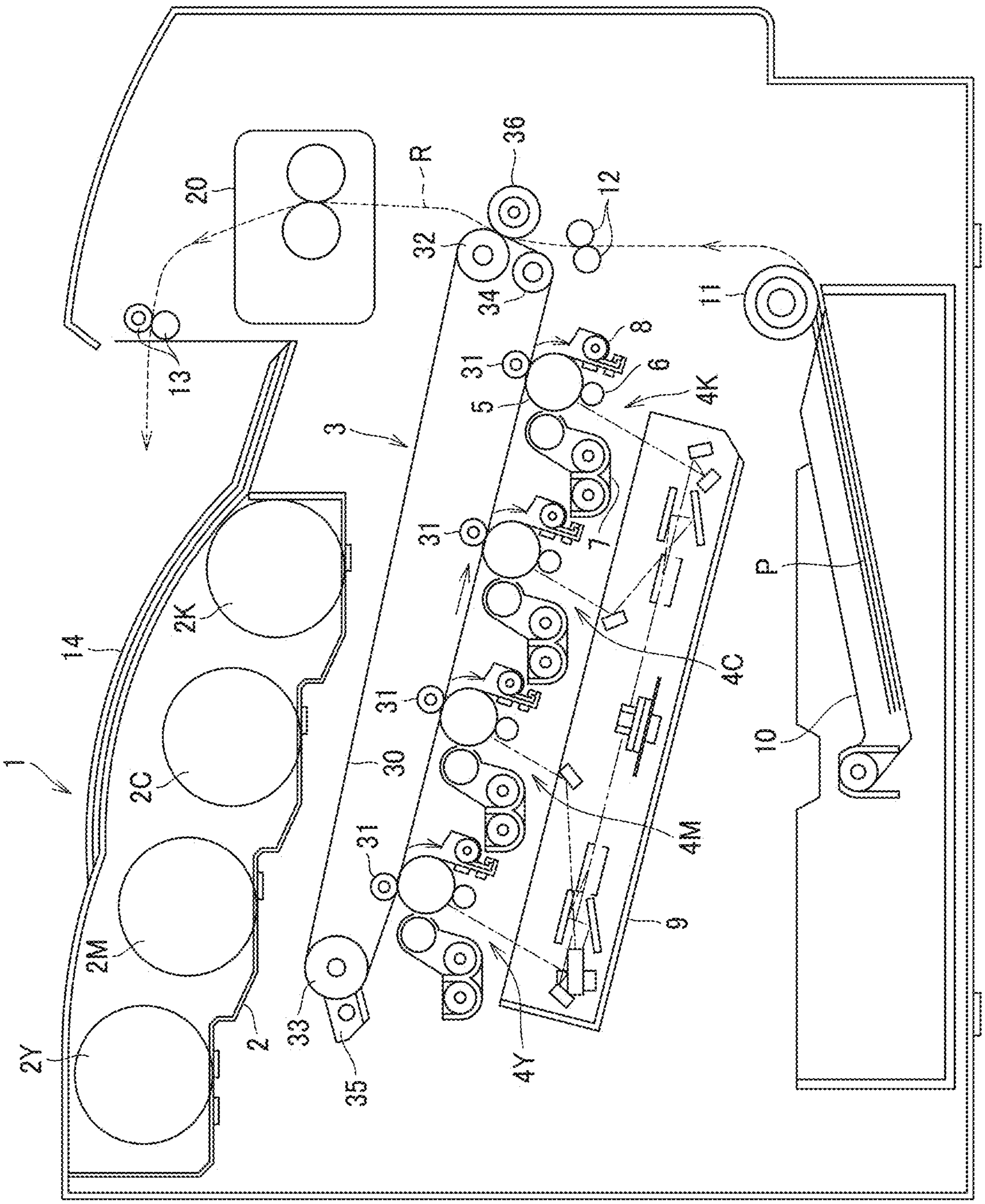

1
14
2
2Y
2M
2C
2K
3
30
31
32
33
34
35
36
20
R
13
12
11
10
P
9
4Y
4M
4C
4K
5
6
7
8

FIG. 2A

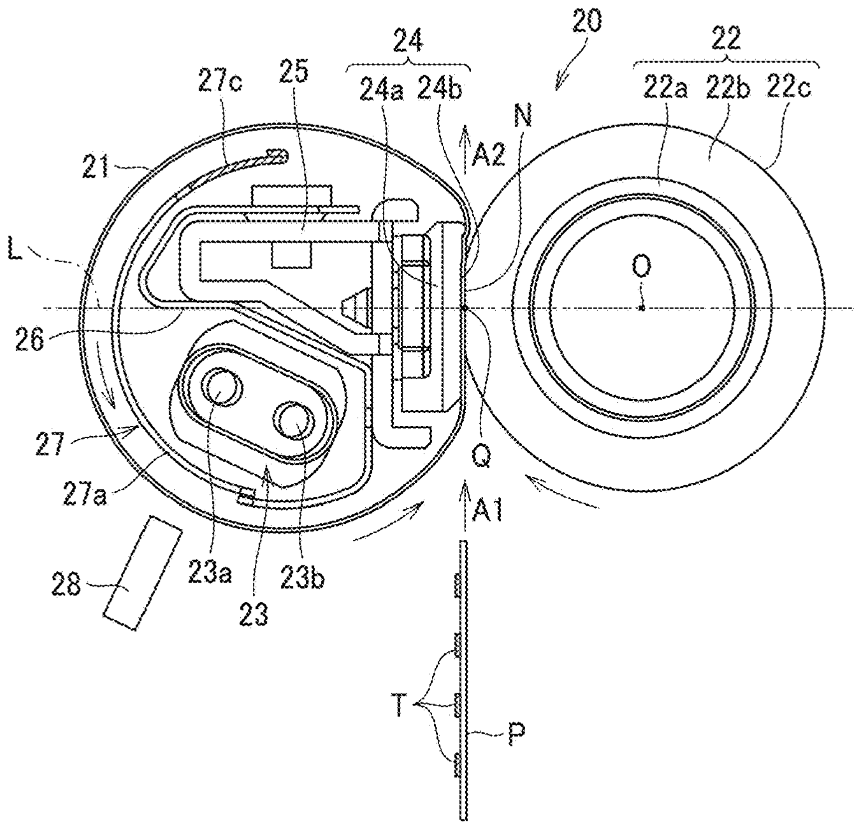

20
24
24a 24b
22
22a 22b 22c
27c
25
N
A2
21
L
O
26
Q
27
27a
A1
28
23a
23b
23
T
P

FIG. 2B

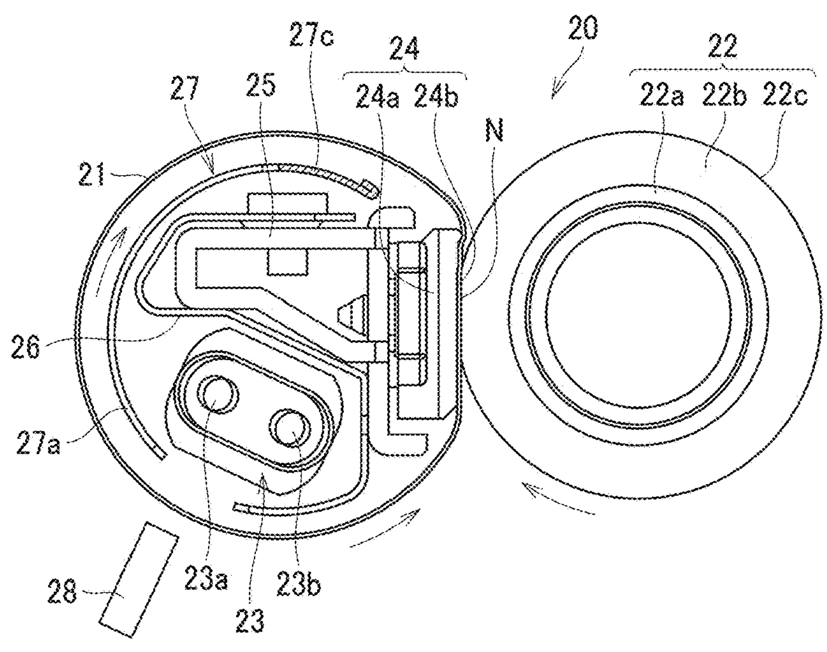

27c
24
20
22
27
25
24a 24b
22a 22b 22c
N
21
26
27a
28
23a
23b
23

FIG. 3

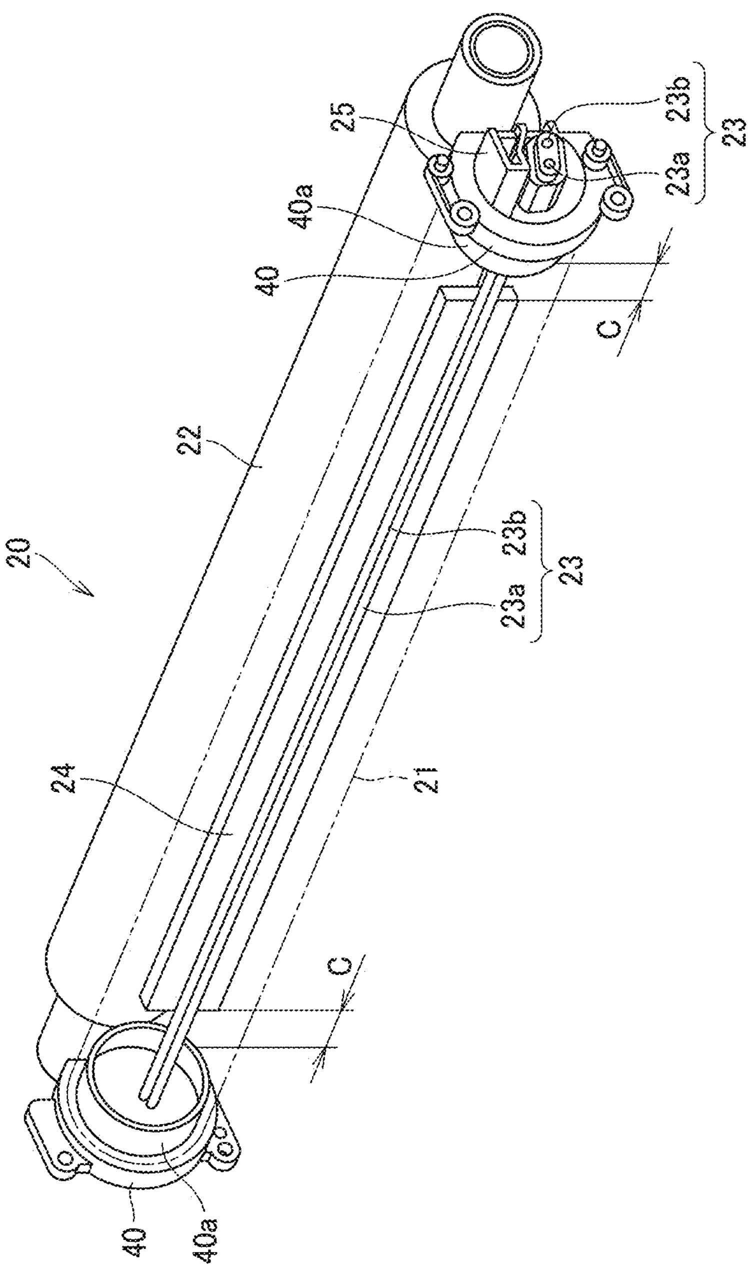


FIG. 4A

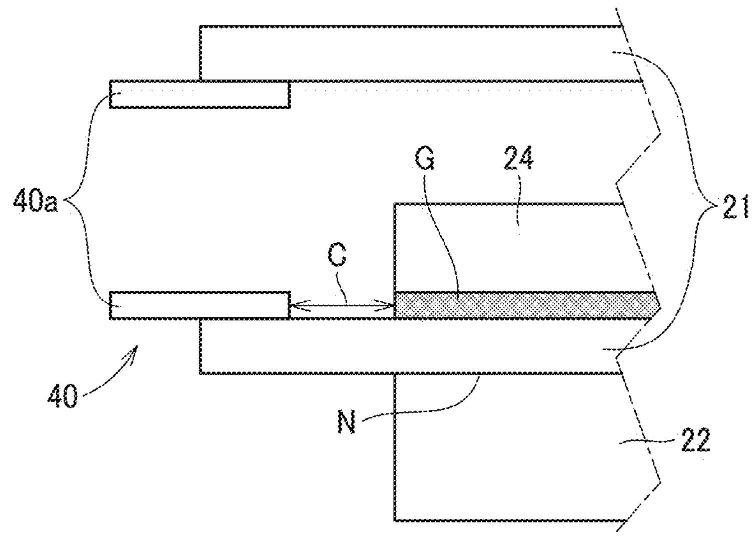


FIG. 4B

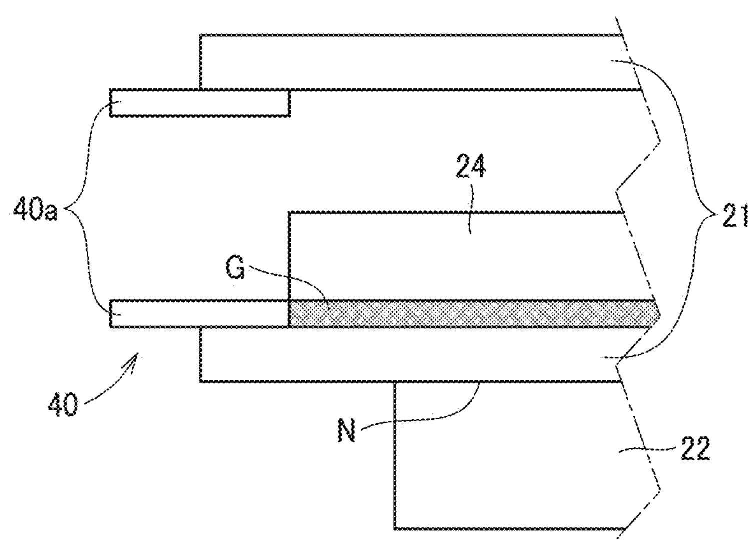


FIG. 5A

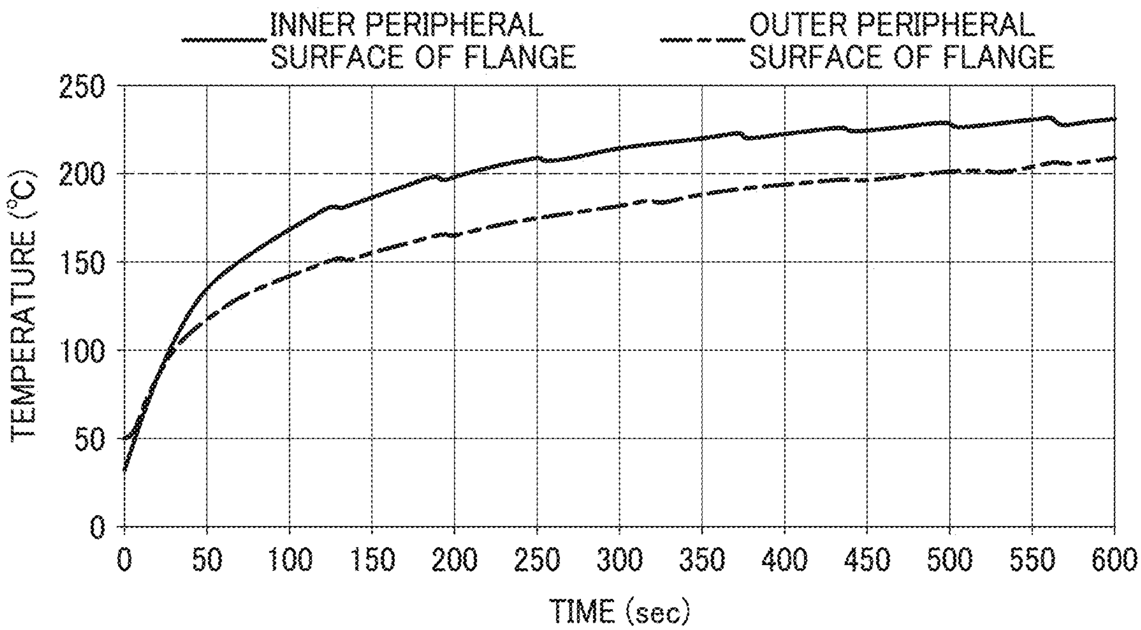

INNER PERIPHERAL SURFACE OF FLANGE
OUTER PERIPHERAL SURFACE OF FLANGE
TEMPERATURE (°C)
0
50
100
150
200
250
0
50
100
150
200
250
300
350
400
450
500
550
600
TIME (sec)

FIG. 5B

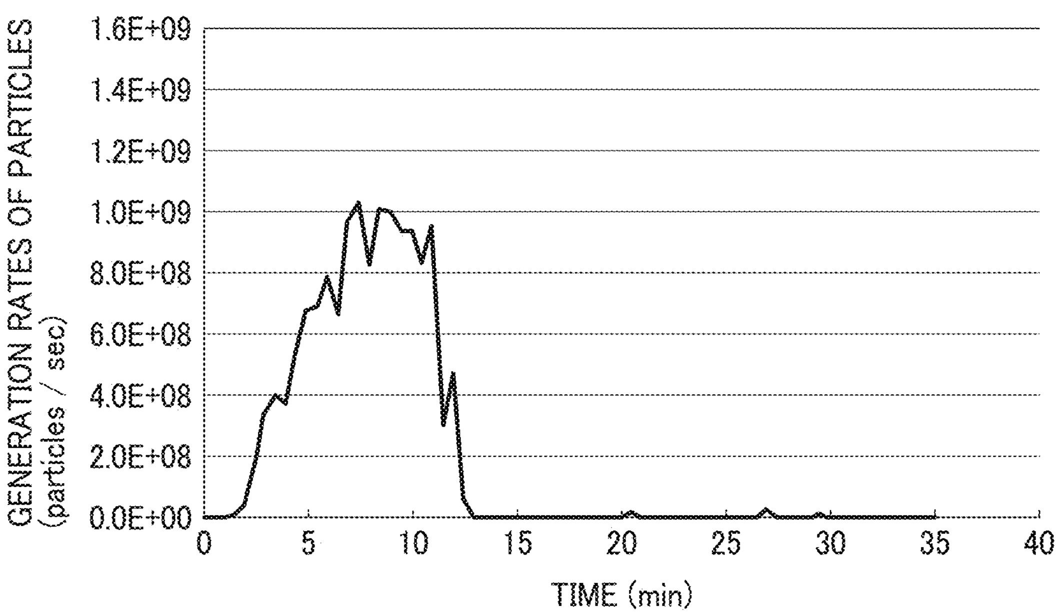

GENERATION RATES OF PARTICLES (particles / sec)
0.0E+00
2.0E+08
4.0E+08
6.0E+08
8.0E+08
1.0E+09
1.2E+09
1.4E+09
1.6E+09
0
5
10
15
20
25
30
35
40
TIME (min)

FIG. 5C

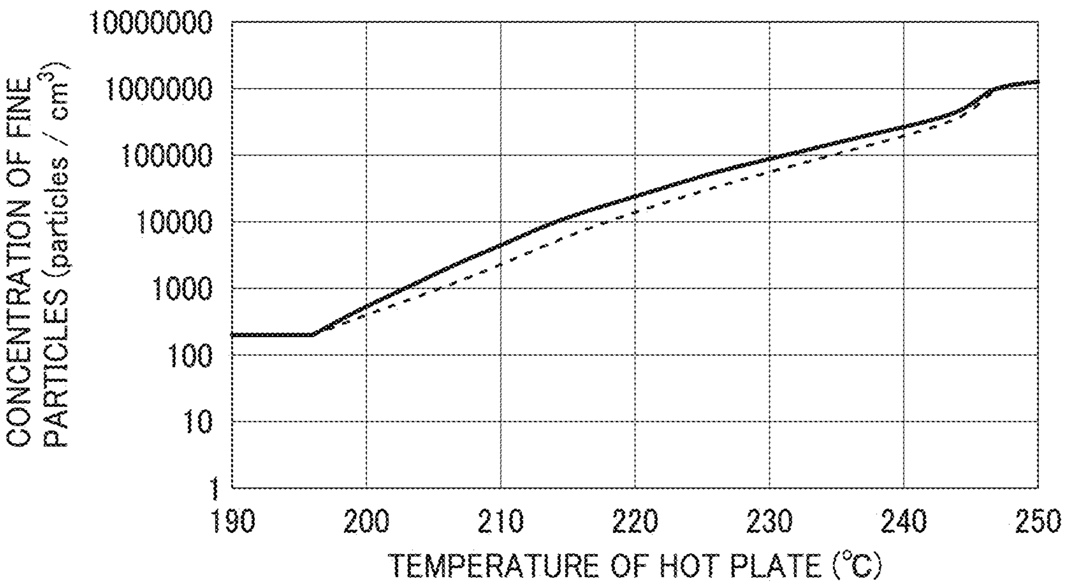

10000000
1000000
100000
10000
1000
100
10
1
CONCENTRATION OF FINE PARTICLES (particles / cm3)
190
200
210
220
230
240
250
TEMPERATURE OF HOT PLATE (°C)

FIG. 6A

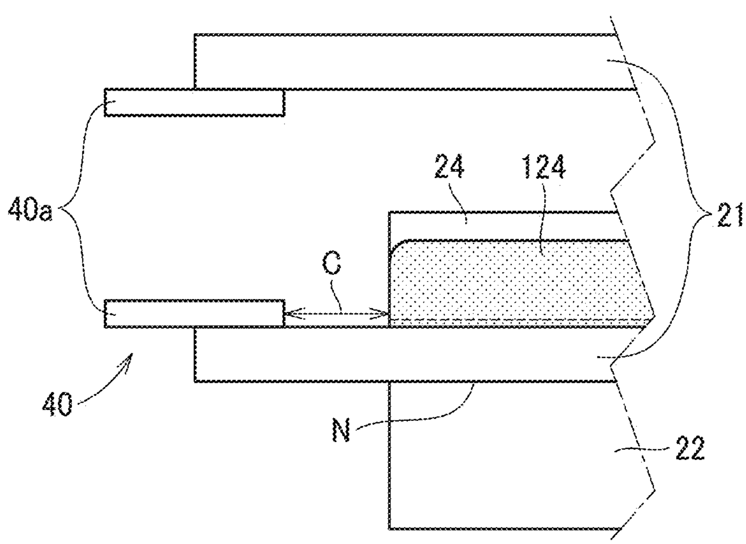

24
124
40a
21
C
40
N
22

FIG. 6B

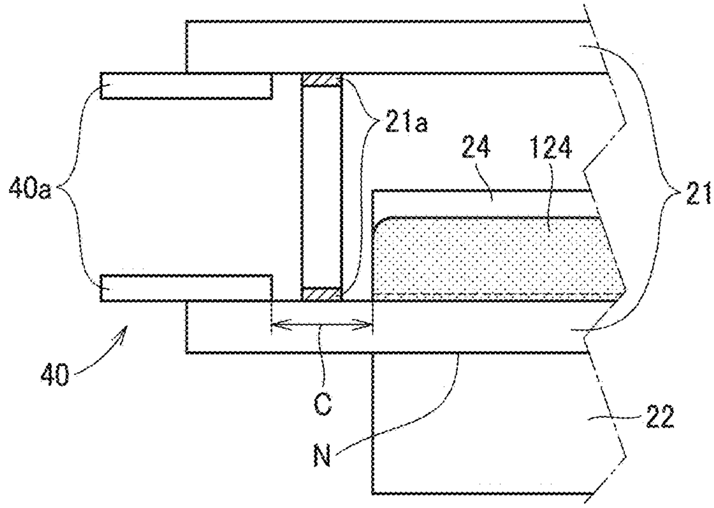


FIG. 6C

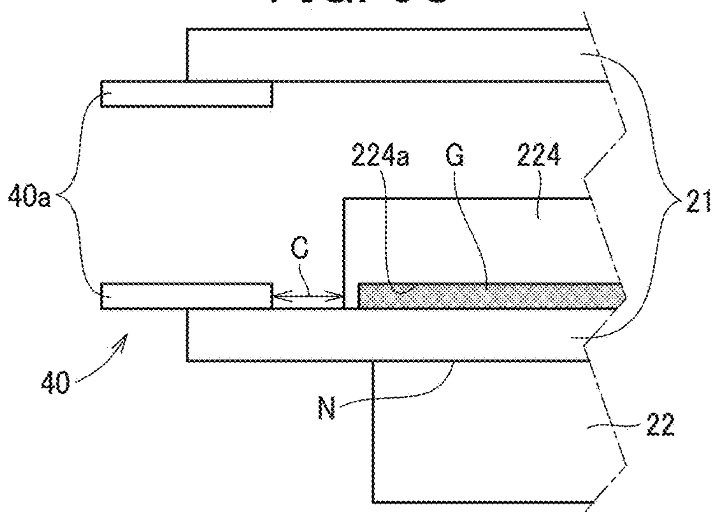


FIG. 6D

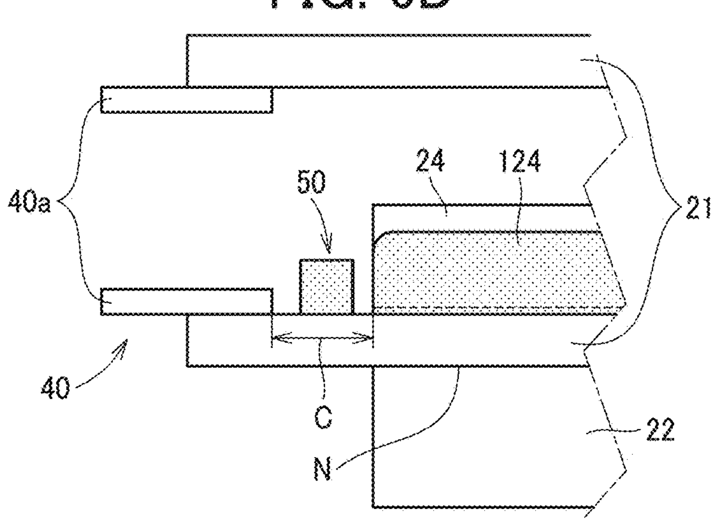


FIG. 6E

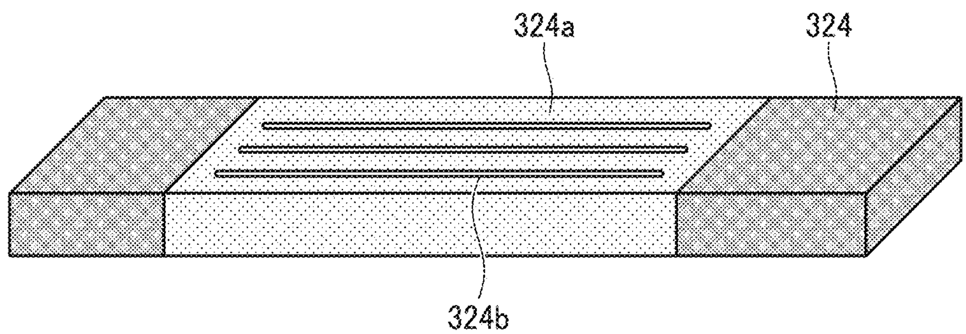


FIG. 6F

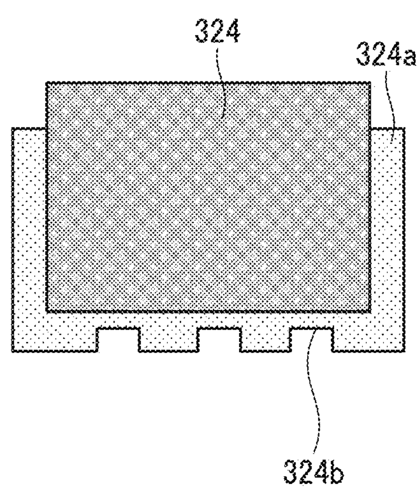


FIG. 7

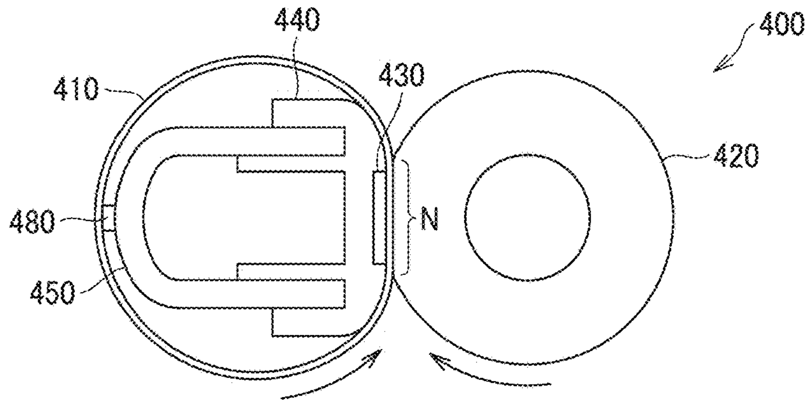

400
440
430
410
420
480
N
450

FIG. 8

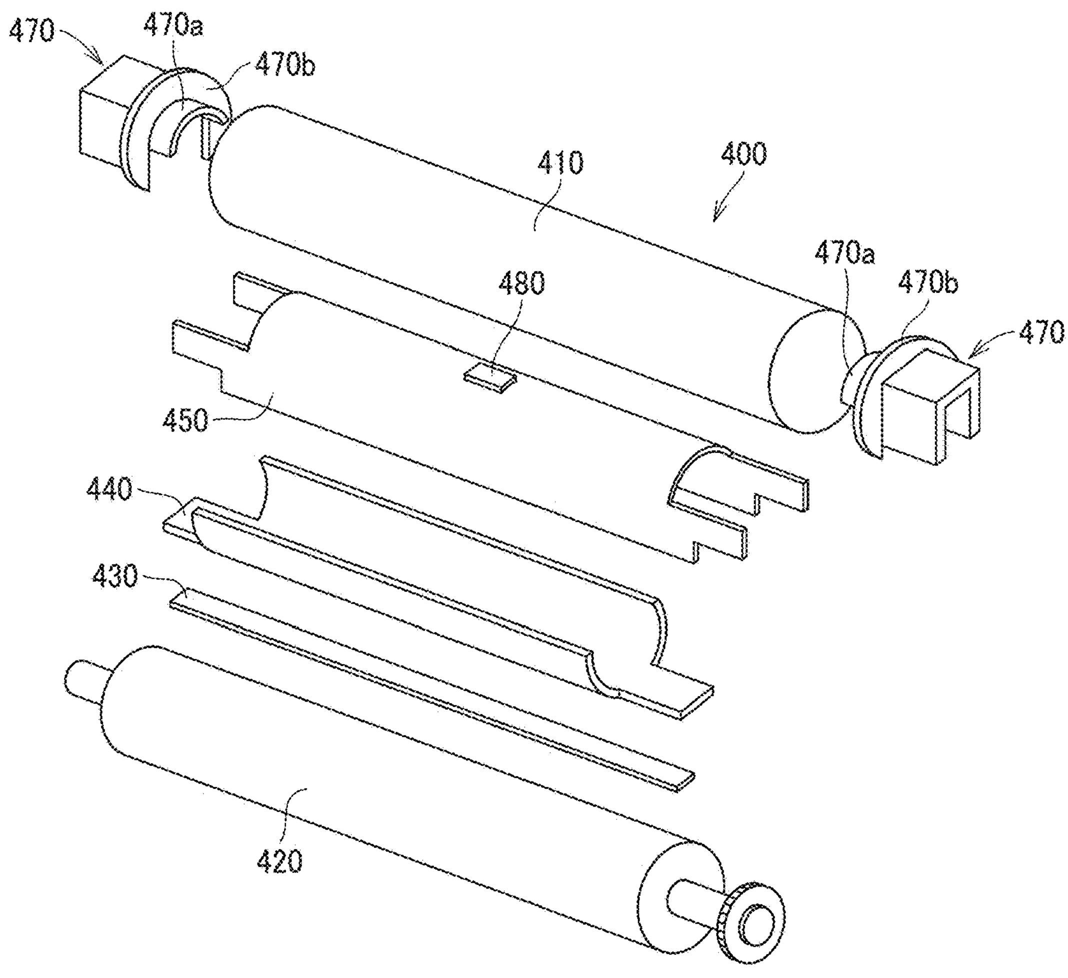

470
470a
470b
410
400
470a
470b
470
480
450
440
430
420

FIG. 9

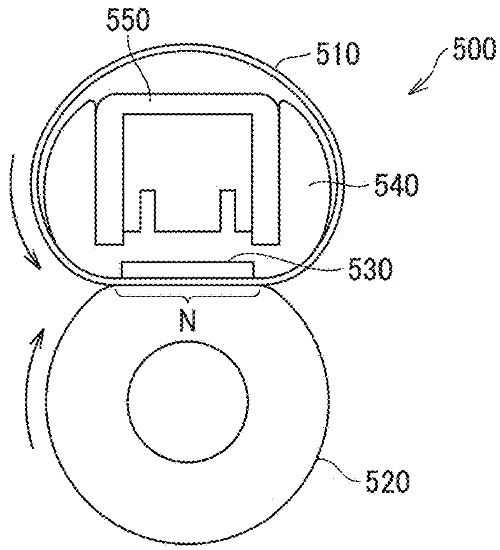

550
510
500
540
530
N
520

FIG. 10

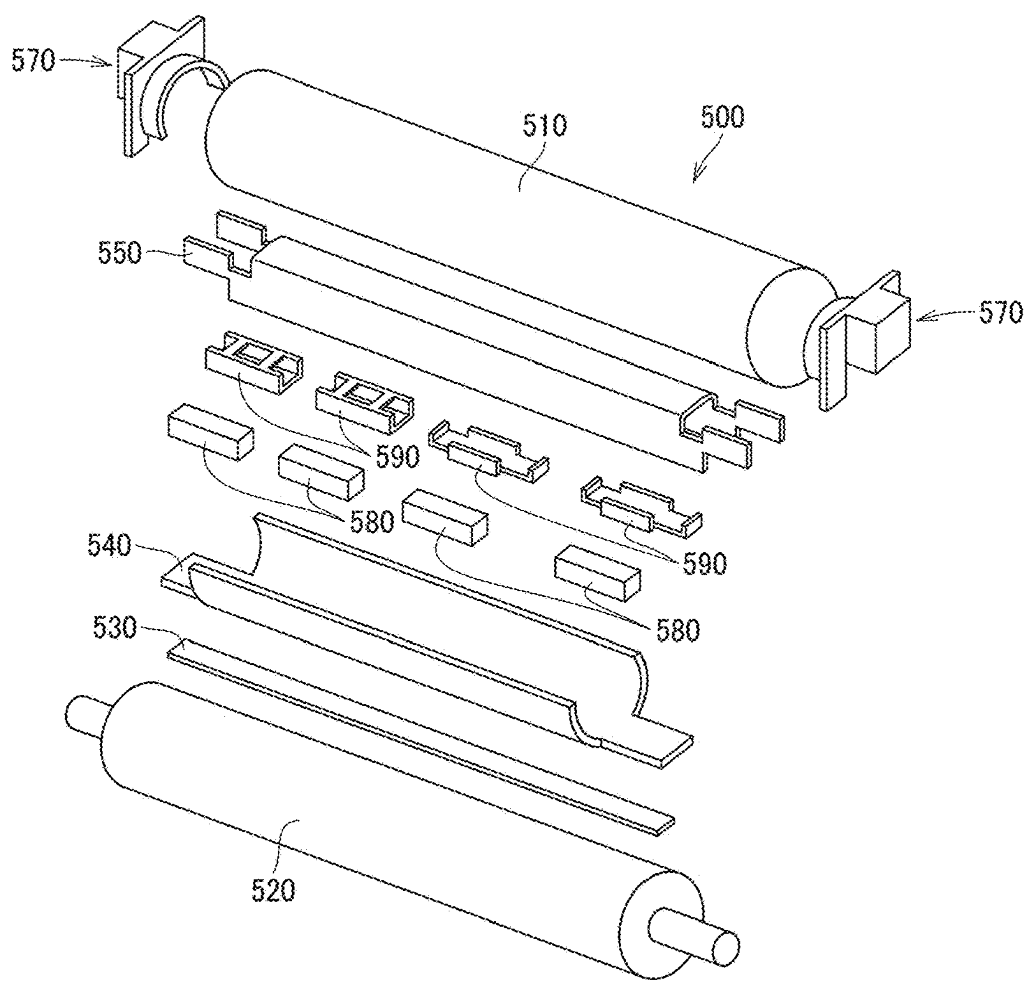

570
510
500
550
570
590
580
540
590
530
580
520

FIG. 11

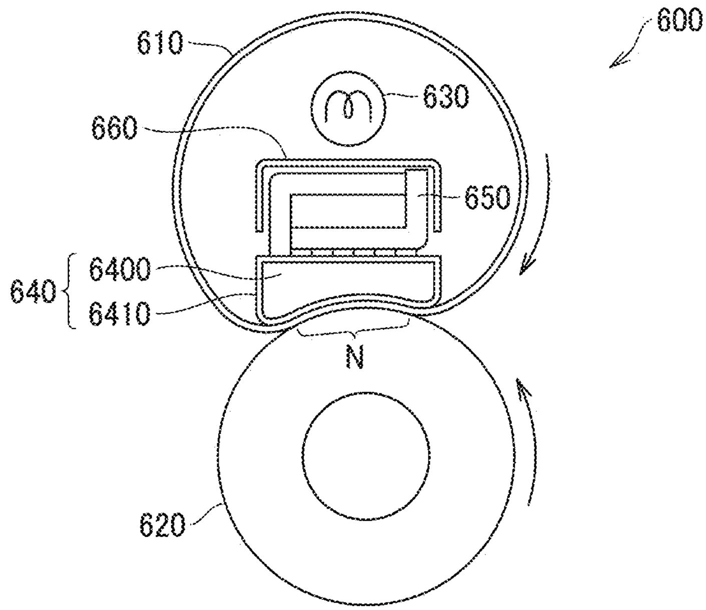

600
610
630
660
650
640
6400
6410
N
620

FIG. 12

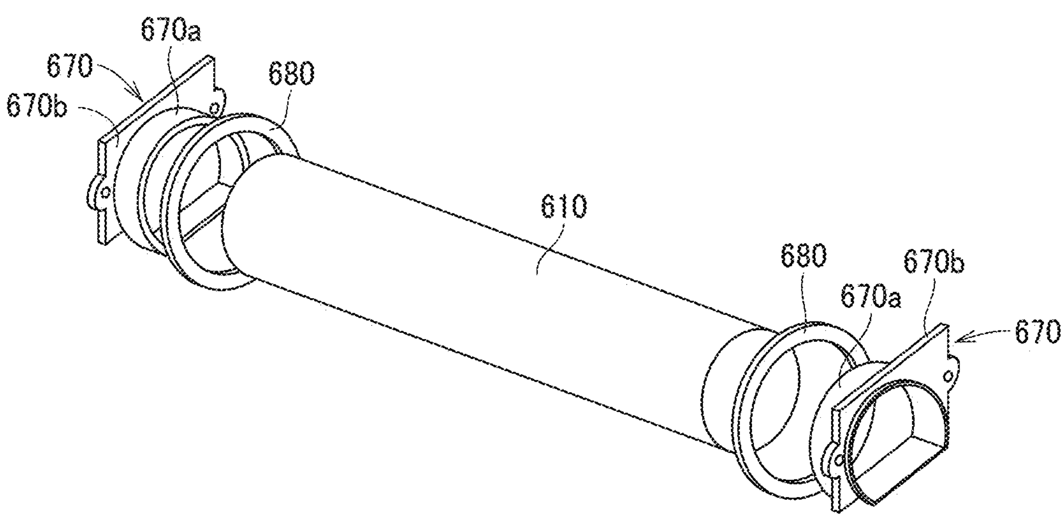

670a
670
670b
680
610
680
670b
670a
670

FIG. 13

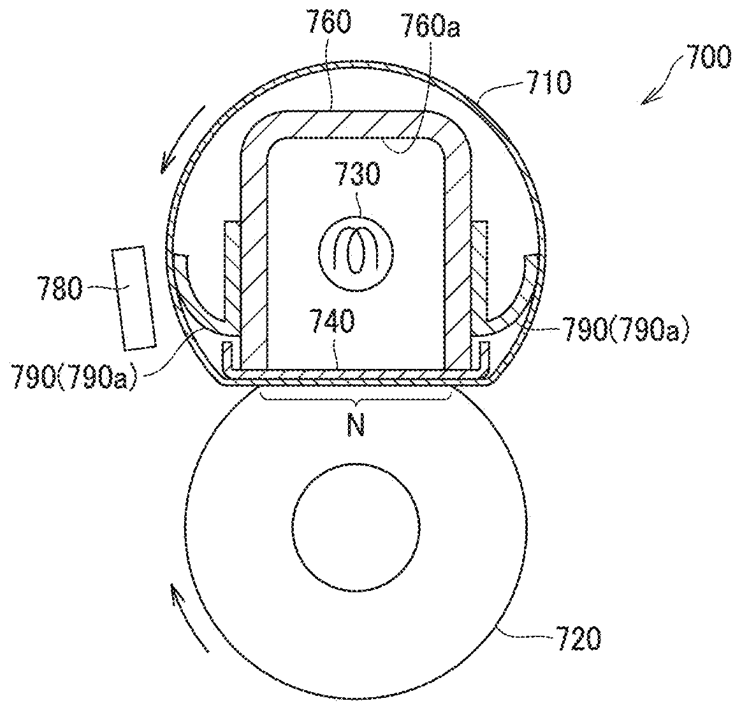

760
760a
700
710
730
780
740
790(790a)
790(790a)
N
720

FIG. 14

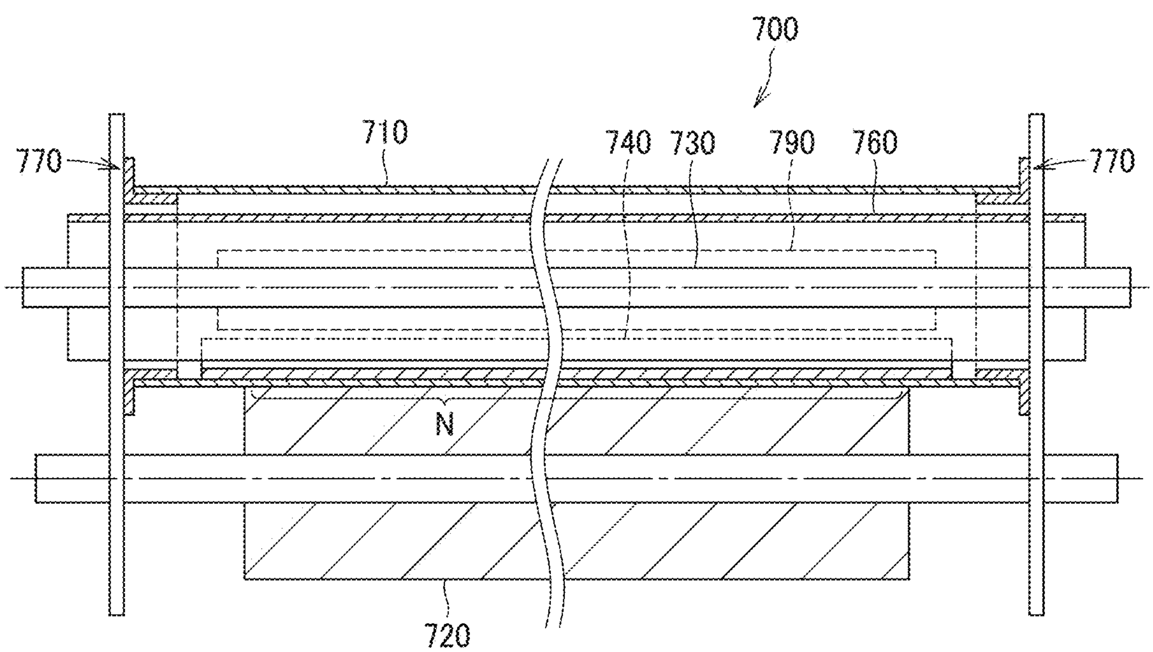

700
770
710
740
730
790
760
770
N
720

FIG. 15

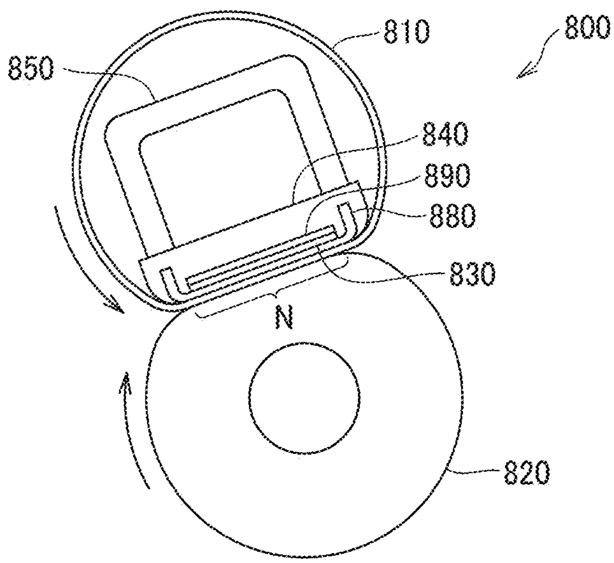


FIG. 16

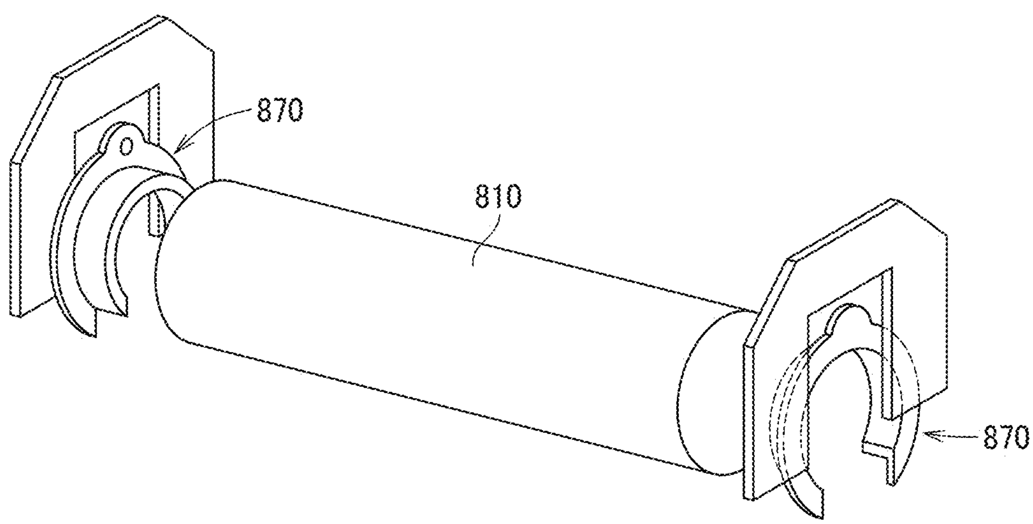


FIG. 17

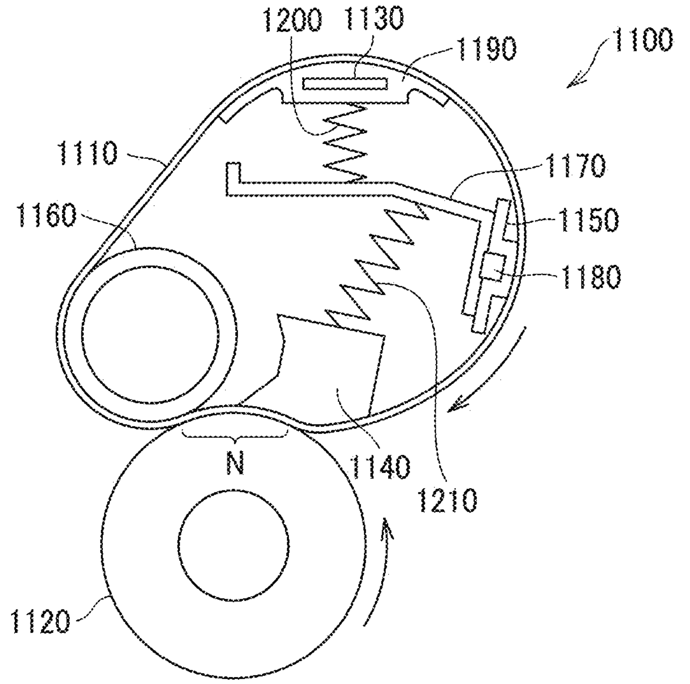
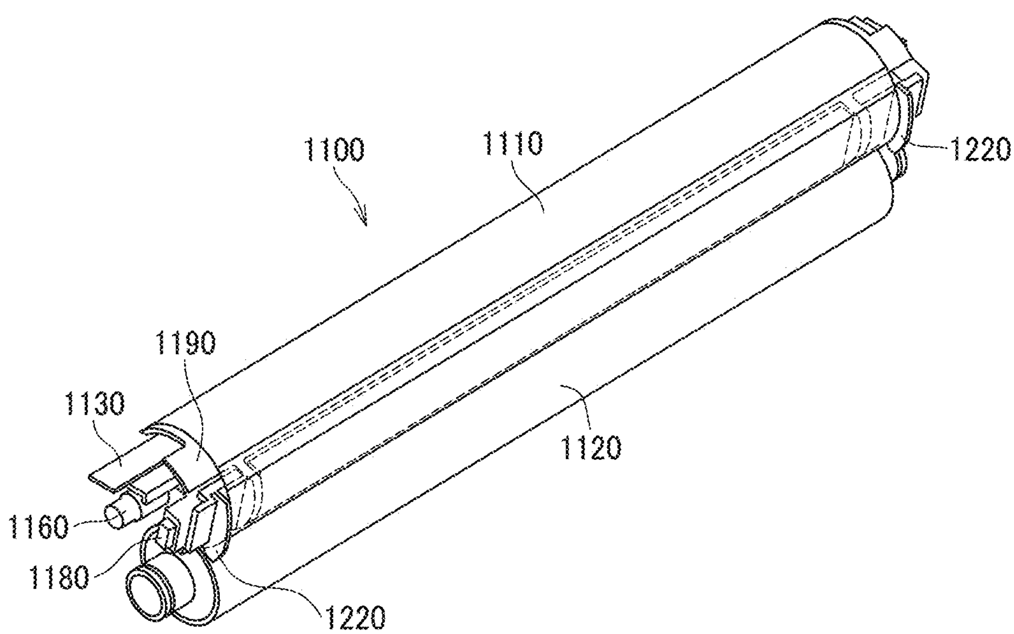

1200
1130
1190
1100
1110
1170
1160
1150
1180
N
1140
1210
1120

FIG. 18


1100
1110
1220
1190
1130
1120
1160
1180
1220

FIXING DEVICE AND IMAGE FORMING APPARATUS

CROSS-REFERENCE TO RELATED APPLICATIONS

This patent application is based on and claims priority pursuant to 35 U.S.C. § 119(a) to Japanese Patent Application No. 2022-043345, filed on Mar. 18, 2022, and No. 2022-152687, filed on Sep. 26, 2022, in the Japan Patent Office, the entire disclosures of which are hereby incorporated by reference herein.

BACKGROUND

Technical Field

Embodiments of the present disclosure relate to a fixing device including a rotator such as an endless belt and a heater heating an inner circumferential surface of the rotator and an image forming apparatus including the fixing device.

Related Art

In image forming apparatuses such as a copier, a printer, a facsimile machine, and a multifunction peripheral of them, one type of image forming apparatus includes a fixing device employing a surf system or a belt system. The surf system or the belt system includes a rotatable endless belt as a rotator. A heater such as a halogen heater heats the inner circumferential surface of the endless belt. Belt supports as rotator supports, such as flanges, support both ends of the inner circumferential surface of the endless belt in an axial direction of the endless belt so that the belt slides on the belt supports.

The fixing device includes a nip formation pad inside a loop of the endless belt and a pressure rotator. The pressure rotator contacts and presses the nip formation pad via the endless belt to form a nip. A conveyed medium such as a sheet passes through the nip. Lubricant is interposed between the endless belt and the nip formation pad in order to reduce frictional resistance and prevent the occurrence of abnormal noise.

SUMMARY

This specification describes an improved fixing device that includes a rotator, a heater, a rotator support, a nip formation pad, lubricant, and a pressure rotator. The heater heats an inner circumferential surface of the rotator. The rotator support supports an end of the inner circumferential surface of the rotator in an axial direction of the rotator. The rotator slides on the rotator support. The nip formation pad is in contact with the inner circumferential surface of the rotator. One end of the nip formation pad in a longitudinal direction of the nip formation pad is separated from the rotator support with a clearance of 2 mm or more. The lubricant is between the rotator and the nip formation pad. The pressure rotator presses the nip formation pad via the rotator to form a nip between the rotator and the pressure rotator.

This specification also describes an image forming apparatus including the fixing device.

BRIEF DESCRIPTION OF THE DRAWINGS

A more complete appreciation of the disclosure and many of the attendant advantages and features thereof can be

readily obtained and understood from the following detailed description with reference to the accompanying drawings, wherein:

FIG. **1** is a schematic cross-sectional view of an image forming apparatus according to an embodiment of the present disclosure;

FIG. **2**A is a schematic cross-sectional view of a fixing device including a shield that is moved to a light-shielding position;

FIG. **2**B is a schematic cross-sectional view of the fixing device including the shield that is moved to a retracted position;

FIG. **3** is a perspective view of a part of the fixing device of FIGS. **2**A and **2**B;

FIG. **4**A is a schematic view of a main part of the fixing device according to the embodiment;

FIG. **4**B is a schematic view of a main part of the fixing device according to a comparative embodiment;

FIG. **5**A is a graph illustrating a relation between an operating time of the fixing device and the temperature of an inner circumferential surface of a flange and a relation between the operating time and temperature of an outer circumferential surface of the flange;

FIG. **5**B is a graph illustrating a relation between the operating time of the fixing device and a generation rate of fine particles;

FIG. **5**C is a graph illustrating a relation between temperature of a hot plate and a concentration of fine particles;

FIG. **6**A is a schematic view of a main part of the fixing device according to a first embodiment;

FIG. **6**B is a schematic view of a main part of the fixing device according to a second embodiment;

FIG. **6**C is a schematic view of a main part of the fixing device according to a third embodiment;

FIG. **6**D is a schematic view of a main part of the fixing device according to a fourth embodiment;

FIG. **6**E is a perspective view of a nip formation pad of the fixing device according to a fifth embodiment;

FIG. **6**F is a schematic cross-sectional view of the nip formation pad of the fixing device according to the fifth embodiment;

FIG. **7** is a schematic cross-sectional view of a fixing device that is different from the fixing device of FIG. **2** but applicable to the above-described embodiments;

FIG. **8** is an exploded perspective view of the fixing device illustrated in FIG. **7**;

FIG. **9** is a schematic cross-sectional view of a fixing device that is different from the fixing devices of FIGS. **2** and **7** but applicable to the above-described embodiments;

FIG. **10** is an exploded perspective view of the fixing device illustrated in FIG. **9**;

FIG. **11** is a schematic cross-sectional view of a fixing device that is different from the fixing devices of FIGS. **2**, **7**, and **9** but applicable to the above-described embodiments;

FIG. **12** is an exploded perspective view of the fixing device illustrated in FIG. **11**;

FIG. **13** is a schematic cross-sectional view of a fixing device that is different from the fixing devices of FIGS. **2**, **7**, **9**, and **11** but applicable to the above-described embodiments;

FIG. **14** is a cross-sectional view of the fixing device illustrated in FIG. **13**, taken along a longitudinal direction of a fixing belt included in the fixing device;

FIG. **15** is a schematic cross-sectional view of a fixing device that is different from the fixing devices of FIGS. **2**, **7**, **9**, **11**, and **13** but applicable to the above-described embodiments;

FIG. **16** is an exploded perspective view of the fixing device illustrated in FIG. **15**;

FIG. **17** is a schematic cross-sectional view of a fixing device that is different from the fixing devices of FIGS. **2**, **7**, **9**, **11**, **13**, and **15** but applicable to the above-described embodiments; and

FIG. **18** is a perspective view of a part of the fixing device illustrated in FIG. **17**.

The accompanying drawings are intended to depict embodiments of the present invention and should not be interpreted to limit the scope thereof. The accompanying drawings are not to be considered as drawn to scale unless explicitly noted. Also, identical or similar reference numerals designate identical or similar components throughout the several views.

DETAILED DESCRIPTION

In describing embodiments illustrated in the drawings, specific terminology is employed for the sake of clarity. However, the disclosure of this 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 have a similar function, operate in a similar manner, and achieve a similar result.

Referring now to the drawings, embodiments of the present disclosure are described below. As used herein, the singular forms "a," "an," and "the" are intended to include the plural forms as well, unless the context clearly indicates otherwise.

With reference to drawings, descriptions are given below of embodiments of the present disclosure. In the drawings illustrating the following embodiments, the same reference numbers are allocated to elements having the same function or shape, and redundant descriptions thereof are omitted below.

With reference to FIG. **1**, the following describes a schematic configuration and operation of an image forming apparatus **1** including a fixing device **20** according to an embodiment of the present disclosure and next describes details of the fixing device **20**.

FIG. **1** is a schematic view of the image forming apparatus **1**. In the present embodiment, the image forming apparatus **1** is a color laser printer. The image forming apparatus **1** includes four image forming devices **4Y**, **4M**, **4C**, and **4K** in a center portion of a body of the image forming apparatus **1**. The image forming devices **4Y**, **4M**, **4C**, and **4K** have substantially the same configuration except for containing different color developers (e.g., toners) of yellow (Y), magenta (M), cyan (C), and black (K), respectively, corresponding to color separation components of color images.

Specifically, each of the image forming devices **4Y**, **4M**, **4C**, and **4K** includes, e.g., a photoconductor **5** having a drum shape and serving as a latent image bearer, a charger **6** that charges the surface of the photoconductor **5**, a developing device **7** that supplies toner to the surface of the photoconductor **5**, and a cleaner **8** that cleans the surface of the photoconductor **5**. FIG. **1** illustrates reference numerals assigned to the photoconductor **5**, the charger **6**, the developing device **7**, and the cleaner **8** of the image forming device **4K** that forms a black toner image. However, reference numerals for the image forming devices **4Y**, **4C**, and **4M** that form yellow, cyan, and magenta toner images, respectively, are omitted for convenience.

An exposure device **9** is disposed below the image forming devices **4Y**, **4M**, **4C**, and **4K** and exposes the outer circumferential surfaces of the respective photoconductors **5** with laser beams. The exposure device **9** includes a light source, a polygon mirror, an f-θ lens, and a reflection mirror to irradiate the surface of the photoconductor **5** with the laser beam according to image data.

A transfer device **3** is disposed above the image forming devices **4Y**, **4M**, **4C**, and **4K**. The transfer device **3** includes an intermediate transfer belt **30** serving as an intermediate transferor and four primary transfer rollers **31** serving as primary transfer devices.

The transfer device **3** also includes a secondary transfer roller **36** as a secondary transfer device and a secondary transfer backup roller **32**. In addition, the transfer device **3** includes a cleaning backup roller **33**, a tension roller **34**, and a belt cleaner **35**.

The intermediate transfer belt **30** is an endless belt stretched taut across the secondary transfer backup roller **32**, the cleaning backup roller **33**, and the tension roller **34**. In the present embodiment, as a driver drives and rotates the secondary transfer backup roller **32** in a counterclockwise direction, the intermediate transfer belt **30** rotates in a direction indicated by an arrow in FIG. **1** by friction therebetween.

The four primary transfer rollers **31** sandwich the intermediate transfer belt **30** together with the four photoconductors **5**, forming four primary transfer nips between the intermediate transfer belt **30** and the photoconductors **5**, respectively. Each primary transfer roller **31** is connected to a power supply. The power supply applies a predetermined direct current (DC) voltage and/or alternating current (AC) voltage to each of the primary transfer rollers **31**.

The intermediate transfer belt **30** is interposed between the secondary transfer roller **36** and the secondary transfer backup roller **32** to form a secondary transfer nip. Similar to the primary transfer rollers **31**, the secondary transfer roller **36** is connected to a power supply that applies a predetermined direct current (DC) voltage and/or alternating current (AC) voltage to the secondary transfer roller **36**.

The belt cleaner **35** includes a cleaning brush and a cleaning blade that contact an outer circumferential surface of the intermediate transfer belt **30**. A waste toner conveyance tube extends from the belt cleaner **35** to an inlet of a waste toner container to convey waste toner collected from the intermediate transfer belt **30** by the belt cleaner **35** to the waste toner container.

A bottle holder **2** disposed in an upper portion of the image forming apparatus **1** accommodates four toner bottles **2Y**, **2C**, **2M**, and **2K** detachably attached to the bottle holder **2**. The toner bottles **2Y**, **2C**, **2M**, and **2K** contain fresh yellow, cyan, magenta, and black toners to be supplied to the developing devices **7** of the image forming devices **4Y**, **4C**, **4M**, and **4K**, respectively. The fresh toner is supplied from the toner bottles **2Y**, **2M**, **2C**, and **2K** to the respective developing devices **7** through toner supply tubes connected between the toner bottles **2Y**, **2M**, **2C**, and **2K** and the respective developing devices **7**.

In a lower portion of the body of the image forming apparatus **1**, a sheet feeding tray and a sheet feeding roller **11** are disposed. The sheet feeding tray **10** contains sheets P as recording media. The sheet feeding roller **11** feeds the sheet P from the sheet feeding tray **10**. The sheets P as the recording media may be plain paper, thick paper, postcards, envelopes, thin paper, coated paper, art paper, tracing paper, overhead projector (OHP) transparencies, and the like. Additionally, a bypass tray may be attached to the image forming apparatus **1** to place such recording media thereon.

The image forming apparatus **1** includes a conveyance path R to convey the sheet P from the sheet feeding tray **10** to a sheet ejection roller pair **13** via the secondary transfer nip. The sheet ejection roller pair **13** ejects the sheet P outside the image forming apparatus **1**. In the conveyance path R, a pair of timing rollers **12** is disposed upstream from the secondary transfer nip in a direction in which the sheet P is conveyed (hereinafter simply referred to as a sheet conveyance direction). The pair of timing rollers **12** sends out the sheet P fed from the sheet feeding roller **11** toward the secondary transfer nip at a predetermined time.

The fixing device **20** is disposed downstream from the secondary transfer roller **36** in the sheet conveyance direction. The fixing device **20** receives the sheet P bearing a toner image and fixes the toner image onto the sheet P. On the conveyance path R downstream from the fixing device **20** in the sheet conveyance direction, the sheet ejection roller pair **13** is disposed. The sheet ejection roller pair **13** ejects the sheet P onto an output tray **14**. To stack the sheet P ejected outside the image forming apparatus **1**, the output tray **14** is disposed on a top surface of the image forming apparatus **1**.

Next, a basic operation of the image forming apparatus **1** (illustrated as the laser printer) according to the present embodiment is described below with reference to FIG. **1**. When an image forming operation is started, a driver drives and rotates the photoconductor **5** in each of the image forming devices **4**Y, **4**M, **4**C, and **4**K clockwise in FIG. **1**, and the charger **6** uniformly charges the surface of the photoconductor **5** in a predetermined polarity.

The exposure device **9** emits laser beams onto the charged outer circumferential surfaces of the photoconductors **5**, respectively, thus forming electrostatic latent images on the photoconductors **5**. The image data used to expose the respective photoconductors **5** is monochrome image data produced by decomposing a desired full color image into yellow, cyan, magenta, and black image data. The developing devices **7** supply yellow, cyan, magenta, and black toners to the electrostatic latent images formed on the photoconductors **5**, visualizing the electrostatic latent images as yellow, cyan, magenta, and black toner images, respectively.

Simultaneously, as the image forming operation is started, the secondary transfer backup roller **32** is driven and rotated counterclockwise in FIG. **1**, rotating the intermediate transfer belt **30** in the direction indicated by the arrow in FIG. **1** by friction therebetween. The power supply applies a constant voltage or a constant current control voltage having a polarity opposite the polarity of the toner to the primary transfer roller **31**, creating a transfer electric field at each primary transfer nip formed between the photoconductor **5** and the primary transfer roller **31**.

When the yellow, magenta, cyan, and black toner images formed on the photoconductors **5** reach the primary transfer nips, respectively, in accordance with rotation of the photoconductors **5**, the transfer electric fields generated at the primary transfer nips transfer the yellow, magenta, cyan, and black toner images from the photoconductors **5** onto the intermediate transfer belt **30**, respectively, such that the yellow, magenta, cyan, and black toner images are superimposed successively on the intermediate transfer belt **30**. Thus, a full color toner image is formed on the outer circumferential surface of the intermediate transfer belt **30**.

After the primary transfer of the yellow, cyan, magenta, and black toner images from the photoconductors **5** onto the intermediate transfer belt **30**, residual toner that is not transferred onto the intermediate transfer belt **30** remains on each of the photoconductors **5**. Each of the cleaners **8** removes the residual toner from each of the photoconductors **5**. Thereafter, a discharger removes the charge on the outer circumferential surface of the photoconductor **5** to ready the photoconductor **5** for the next image formation.

On the other hand, the sheet feeding roller **11** disposed in the lower portion of the image forming apparatus **1** is driven and rotated to feed the sheet P from the sheet feeding tray toward the pair of timing rollers **12** through the conveyance path R. When the sheet P comes into contact with the pair of timing rollers **12**, the pair of timing rollers **12** temporarily stops conveying the sheet P.

Thereafter, the pair of timing rollers **12** is rotated at a predetermined time to convey the sheet P to the secondary transfer nip in synchronization with the full-color toner image formed on the intermediate transfer belt **30** reaching the secondary transfer nip. The power supply applies a transfer voltage to the secondary transfer roller **36**. The transfer voltage has the polarity opposite the polarity of the charged toner contained in the full-color toner image formed on the intermediate transfer belt **30**. As a result, a transfer electric field is generated at the secondary transfer nip.

The transfer electrical field transfers the full-color toner image from the intermediate transfer belt **30** onto the sheet P at a time. After the secondary transfer of the full color toner image from the intermediate transfer belt **30** onto the sheet P, residual toner that is not transferred to the sheet P remains on the intermediate transfer belt **30**. The belt cleaner **35** removes the residual toner from the intermediate transfer belt **30**. The removed toner is conveyed and collected into the waste toner container disposed inside the image forming apparatus **1**.

Thereafter, the sheet P bearing the full color toner image is conveyed to the fixing device **20** that fixes the full color toner image on the sheet P. The sheet P bearing the fixed full-color toner image is ejected by the sheet ejection roller pair **13** onto the outside of the image forming apparatus **1** and is stacked on the output tray **14**.

The above describes the image forming operation of the image forming apparatus **1** to form the full-color toner image on the sheet P. Alternatively, the image forming apparatus **1** may form a monochrome toner image by using any one of the four image forming devices **4**Y, **4**C, **4**M, and **4**K or may form a bicolor toner image or a tricolor toner image by using two or three of the image forming devices **4**Y, **4**C, **4**M, and **4**K.

With reference to FIGS. **2**A and **2**B, the following describes the fixing device **20**. FIGS. **2**A and **2**B are schematic cross-sectional views of the fixing device **20**. The fixing device **20** is one example of a nip forming unit. The fixing device **20** includes a fixing belt **21** and a pressure roller **22** as an opposed rotator in contact with the outer circumferential surface of the fixing belt **21**.

The fixing device **20** also includes a halogen heater **23**, a nip formation pad **24**, a stay **25**, a reflector **26**, a shield **27**, and a temperature sensor **28**. The halogen heater serves as a heat source to heat the fixing belt **21**. The nip formation pad **24** is in contact with the inner circumferential surface of the fixing belt **21**. The pressure roller **22** presses the fixing belt **21** against the nip formation pad **24** to form a fixing nip N. The stay **25** supports the nip formation pad **24**. The halogen heater **23** radiates radiant heat, and the reflector **26** reflects the radiant heat to the fixing belt **21**. The shield **27** shields the radiant heat radiated from the halogen heater **23**. The temperature sensor **28** serves as a temperature detector to detect the temperature of the fixing belt **21**.

The fixing belt **21** is a thin, flexible, endless belt (which may be a film). Specifically, the fixing belt **21** includes a base layer forming the inner circumferential surface of the fixing belt **21**. The base layer is made of metal such as nickel or steel use stainless (SUS) or resin such as polyimide (PI).

The fixing belt **21** includes a release layer made of tetrafluoroethylene-perfluoroalkylvinylether copolymer (PFA), polytetrafluoroethylene (PTFE) or the like. The release layer is an outermost layer. Optionally, an elastic layer made of rubber such as silicone rubber, silicone rubber foam, and fluoro rubber may be interposed between the base layer and the release layer.

The fixing belt **21** not including the elastic layer has a small thermal capacity that improves a fixing property. However, as the pressure roller **22** and the fixing belt **21** sandwich and press the unfixed toner image T on the sheet P passing through the fixing nip N, slight surface asperities of the fixing belt **21** may be transferred onto the toner image T on the sheet P, resulting uneven gloss of the solid toner image T. To address this circumstance, preferably, the fixing belt **21** includes the elastic layer no thinner than 80 μm. The elastic layer not thinner than 80 μm elastically deforms to absorb the slight surface asperities in the fixing belt **21**, thus preventing uneven gloss of the toner image on the sheet P.

In order to decrease the thermal capacity of the fixing belt **21**, the fixing belt **21** in the present embodiment is thin and has a decreased loop diameter. For example, the base layer of the fixing belt **21** is designed to have a thickness of from 20 μm to 50 μm, the elastic layer is designed to have a thickness of from 80 μm to 300 μm, and the release layer is designed to have a thickness of from 3 μm to 50 μm. Thus, the fixing belt **21** is designed to have a total thickness not greater than 1 mm.

The loop diameter of the fixing belt **21** is set in a range of 20 mm to 40 mm. In order to further decrease the thermal capacity of the fixing belt **21**, preferably, the fixing belt **21** may have a total thickness not greater than 0.20 mm and more preferably not greater than 0.16 mm. Preferably, the loop diameter of the fixing belt **21** may be 30 mm or less.

The pressure roller **22** includes a cored bar **22***a*, an elastic layer **22***b* disposed on the surface of the cored bar **22***a*, and a release layer **22***c* disposed on the surface of the elastic layer **22***b*. The elastic layer **22***b* is made of foamed silicone rubber, silicon rubber, or fluoro-rubber. The release layer **22***c* is made of PFA or PTFE. A biasing member such as a spring presses the pressure roller **22** against the nip formation pad **24** via the fixing belt **21**. Thus, the pressure roller **22** abuts on the nip formation pad **24** via the fixing belt **21**. At a portion at which the pressure roller **22** contacts and presses the fixing belt **21**, deformation of the elastic layer **22***b* of the pressure roller **22** forms the fixing nip N having a predetermined width in the sheet conveyance direction.

A driver such as a motor disposed inside the image forming apparatus **1** drives and rotates the pressure roller **22**. As the driver drives and rotates the pressure roller **22**, a driving force of the driver is transmitted from the pressure roller **22** to the fixing belt **21** at the fixing nip N, thus rotating the fixing belt **21** in accordance with rotation of the pressure roller **22** by friction between the fixing belt **21** and the pressure roller **22**. As described later with reference to FIG. **3**, flanges **40** as belt supports are inserted into both ends of the fixing belt **21** to rotatably hold the fixing belt **21**. However, in the fixing nip N, the flanges **40** do not support both ends of the fixing belt **21**.

In the present embodiment, the pressure roller **22** is a solid roller. Alternatively, the pressure roller **22** may be a hollow roller. In a case in which the pressure roller **22** is the hollow roller, a heat source such as the halogen heater may be disposed inside the pressure roller **22**.

The elastic layer **22***b* of the pressure roller **22** may be made of solid rubber. Alternatively, if no heater is disposed inside the pressure roller **22**, the elastic layer of the pressure roller **22** may be made of sponge rubber. The sponge rubber is preferable to the solid rubber because the sponge rubber has enhanced thermal insulation that draws less heat from the fixing belt **21**.

The halogen heater **23** is disposed inside the loop of the fixing belt **21** and upstream from the fixing nip N in the sheet conveyance direction. Specifically, as illustrated in FIG. **2**A, the halogen heater **23** is disposed, in the sheet conveyance direction, upstream from an imaginary line L passing through the center Q of the fixing nip N in the sheet conveyance direction and the rotation center O of the pressure roller **22**, that is, in a lower portion from the line L in FIG. **2**A.

A power supply situated inside the image forming apparatus **1** supplies power to the halogen heater **23** so that the halogen heater **23** generates heat. A controller operatively connected to the halogen heater **23** and the temperature sensor **28** controls the halogen heater **23** based on the temperature of the outer circumferential surface of the fixing belt **21**, which is detected by the temperature sensor **28**.

Such heating control of the halogen heater **23** adjusts the temperature of the fixing belt **21** to a desired fixing temperature. Instead of the temperature sensor **28** that detects the temperature of the fixing belt **21**, a temperature sensor that detects the temperature of the pressure roller **22** may be disposed, and the controller may predict the temperature of the fixing belt **21** based on the temperature of the pressure roller **22** detected by the temperature sensor.

In the present embodiment, two halogen heaters **23** are disposed in the loop of the fixing belt **21**, but one halogen heater **23** or three or more halogen heaters **23** may be disposed in the loop of the fixing belt **21** based on the size of the sheet P used in the image forming apparatus **1**. However, when the cost of the halogen heater **23** itself, a space inside the loop of the fixing belt **21**, and the like are considered, a desirable number of the halogen heaters **23** is two or less. The radiant heat radiated from the heater heats the fixing belt **21**. The heater may be a resistive heat generator or carbon heater instead of the halogen heater.

The nip formation pad **24** includes a base pad **24***a* and a sliding sheet **24***b* disposed on the surface of the base pad **24***a*, the surface facing the fixing belt **21**. The sliding sheet **24***b* is a low friction member. The base pad **24***a* extends in the axial direction of the fixing belt **21** or the axial direction of the pressure roller **22**.

The sliding sheet **24***b* is not always necessary. The surface of the base pad **24***a* itself having a good sliding performance with the fixing belt **21** enables omitting the sliding sheet **24***b*.

The base pad **24***a* receives a pressing force from the pressure roller **22** and determines a shape of the fixing nip N. In the present embodiment, the shape of the fixing nip N is a flat shape but may be a concave shape or another shape.

The sliding sheet **24***b* is disposed to reduce sliding friction when the fixing belt **21** rotates. The base pad **24***a* itself made of a low-friction member enables a configuration not including the sliding sheet **24***b*.

The base pad **24***a* is made of a heat-resistant material having a heat-resistant temperature of 200° C. or more to prevent deformation of the nip formation pad **24** due to heat in the toner fixing temperature range, thereby ensuring a stable state of the fixing nip N and stabilizing qualities in the image on the ejected sheet P. The material of the base pad **24***a* may be general heat-resistant resins such as polyethersulfone (PES), polyphenylene sulfide (PPS), liquid crystal polymer (LCP), polyethernitrile (PEN), polyamide-imide (PAI), and polyetheretherketone (PEEK).

The stay **25** supports and fixes the base pad **24***a*. The stay **25** prevents the nip formation pad **24** from being bent by the pressure from the pressure roller **22** to form the fixing nip having a uniform width along the axial direction of the pressure roller **22**.

Preferably, the stay **25** is made of metal having an increased mechanical strength, such as stainless steel and iron, to prevent bending of the nip formation pad **24**. The base pad **24***a* is preferably made of a rigid material to ensure the strength of the base pad **24***a*. The material of the base pad **24***a* may be resins such as liquid crystal polymers (LCP), metals, ceramics, or the like.

The reflector **26** is fixed and supported by the stay **25** so as to face the halogen heater **23**. The reflector **26** reflects the radiant heat and light emitted from the halogen heater **23** toward the fixing belt **21** to prevent the heat from being transmitted to the stay **25** and the like, thereby efficiently heating the fixing belt **21** and saving energy.

The material of the reflector **26** may be aluminum, stainless steel, or the like. In particular, the reflector made of an aluminum base on which silver having low emissivity (in other words, high reflectivity) is evaporated improves the heating efficiency of the fixing belt **21**.

A surface of the reflector **26** facing the halogen heater **23** is formed to spread over the inner circumferential surface of the fixing belt **21**. As illustrated in FIG. **2**A. the reflector **26** has a portion facing a lower portion of the halogen heater **23** and extending along a circumferential direction of the fixing belt **21** to shield radiant heat radiated from both ends of the halogen heater **23**. The above-described portion of the reflector **26** does not extend over the entire length of the reflector **26** in the longitudinal direction of the reflector **26**.

The shield **27** is made of a metal plate such as a SUS plate having heat resistance and a thickness of 0.1 mm to 1.0 mm so as to have a cross-sectional shape along the inner circumferential surface of the fixing belt **21**. In FIGS. **2**A and **2**B, the cross-sectional shape of the shield **27** has ends and is not a ring closed in the circumferential direction. Specifically, the cross-sectional shape of the shield **27** is an arc.

The shield **27** is rotatable around the halogen heater **23**. In the present embodiment, the shield **27** is rotatable along the circumferential direction of the fixing belt **21**. Specifically, a circumferential region of the fixing belt **21** has a directly heated region directly facing the halogen heater **23** and heated by the halogen heater **23**. In addition, the circumferential region of the fixing belt **21** has a non-directly heated region in which a member other than the shield **27**, such as the reflector **26**, the stay **25**, or the nip formation pad **24** exists between the halogen heater **23** and the fixing belt **21**.

When the shield **27** thermally shields between the halogen heater **23** and the fixing belt **21**, the shield **27** is disposed at a shielding position facing the directly heated region as illustrated in FIG. **2**A. When the shield **27** does not thermally shield between the halogen heater **23** and the fixing belt **21**, the shield **27** is moved to a retracted position facing the non-directly heated region as illustrated in FIG. **2**B.

In other words, the shield **27** is retracted to a space above upper portions of the reflector **26** and the stay **25**. The shield **27** is preferably made of ceramic or metal such as aluminum, iron, or SUS because the shield **27** requires heat resistance.

FIG. **3** is a perspective view of a part of the fixing device **20** according to the present embodiment. FIG. **3** omits the sliding sheet **24***b*, the stay **25**, the shield **27**, and the like. As illustrated in FIG. **3**, cylindrical portions **40***a* of the flanges **40** are inserted into loops of both ends of the fixing belt **21**, respectively.

The cylindrical portions **40***a* of the flanges **40** come into contact with both ends of the inner circumferential surface of the fixing belt **21** in the axial direction of the fixing belt **21**, respectively, and both ends of the inner circumferential surface of the fixing belt **21** slide on the cylindrical portions **40***a* of the flanges **40**. As a result, the cylindrical portions **40***a* of the flanges **40** rotatably hold the fixing belt **21**. The fixing device **20** includes a pair of side plates that supports and fixes left and right flanges **40**, the halogen heater **23**, the nip formation pad **24** in FIG. **3**, and the stay **25** in FIGS. **2**A and **2**B.

With continued reference to FIGS. **2**A and **2**B, the following describes a fixing operation of the fixing device **20** according to the present embodiment. As the image forming apparatus **1** illustrated in FIG. **1** is powered on, power is supplied to the halogen heater **23**, and the driver starts driving and rotating the pressure roller **22** clockwise in FIGS. **2**A and **2**B. The rotation of the pressure roller **22** drives the fixing belt **21** to rotate counterclockwise in FIGS. **2**A and **2**B by friction between the fixing belt **21** and the pressure roller **22**.

Thereafter, the sheet P bearing the unfixed toner image T formed in the image forming processes described above is conveyed in the sheet conveyance direction A**1** in FIG. **2**A while guided by a guide plate and enters the fixing nip N formed between the fixing belt **21** and the pressure roller **22** pressed against the fixing belt **21**. The toner image T is fixed onto the sheet P under heat from the fixing belt **21** heated by the halogen heater **23** and pressure exerted between the fixing belt **21** and the pressure roller **22**.

The sheet P bearing the fixed toner image T is sent out from the fixing nip N and conveyed in a direction indicated by an arrow A**2** in FIG. **2**A. As a leading edge of the sheet P contacts a front edge of the separator, the separator separates the sheet P from the fixing belt **21**. The sheet P separated from the fixing belt **21** is ejected by the sheet ejection roller pair **13** depicted in FIG. **1** to the outside of the image forming apparatus **1** and stacked on the output tray **14**.

The following describes a configuration of the fixing device **20**.

The fixing device **20** includes the fixing belt **21**, the halogen heater **23**, the pressure roller **22**, the nip formation pad **24**, and the flanges **40**.

The nip formation pad **24** and the flanges **40** may be made of a heat-resistant resin such as liquid crystal polymer. As illustrated in FIG. **3**, a clearance C is formed between the cylindrical portion **40***a* of the flange **40** and each of both ends of the nip formation pad **24** in the longitudinal direction of the nip formation pad **24**.

FIG. **4**A is a schematic view of a main part of the fixing device illustrating the clearance C in an easy-to-understand manner. As illustrated in FIG. **4**A, the feature of the fixing device according to the present embodiment is the clearance C having a predetermined size between the nip formation pad **24** and the cylindrical portion **40***a* of the flange **40**. The size of the clearance C is at least equal to or larger than 2 mm in the longitudinal direction of the nip formation pad **24**. The reason why the size of the clearance C is equal to or larger than 2 mm is described later.

Increasing the clearance C decreases the length of the nip formation pad **24** in the longitudinal direction thereof. The upper limit of the clearance C is determined by the nip formation pad **24** having the same length as the pressure roller **22** in the longitudinal direction as illustrated in FIG. **4**A.

Lubricant G is interposed between the nip formation pad **24** and the fixing belt **21**. The pressure applied to the nip N causes the lubricant G to flow outward in the longitudinal direction of the nip formation pad **24**.

A fixing device according to a comparative embodiment illustrated in FIG. **4**B includes the nip formation pad **24** having both ends in contact with the cylindrical portions **40***a* of the flanges **40** in the longitudinal direction of the nip formation pad **24**. In the fixing device having no clearance between the nip formation pad **24** and the flange **40** as described above, the lubricant G between the nip formation pad **24** and the fixing belt **21** easily flows to the inner peripheral surface and the outer peripheral surface of the cylindrical portion **40***a* of the flange **40**.

In contrast, the fixing device according to the present embodiment has the clearance C between the nip formation pad **24** and the cylindrical portion **40***a* of the flange **40** as illustrated in FIG. **4**A. Therefore, the lubricant G is unlikely to flow to the inner peripheral surface and the outer peripheral surface of the cylindrical portion **40***a* of the flange **40**. Even if a part of the lubricant G overflows into the clearance C, the clearance C functions as a lubricant reservoir and holds the lubricant G in the clearance C.

The following describes how ultrafine particles are generated in the fixing device.

To examine how the ultrafine particles are generated in the fixing device, the image forming apparatus including the fixing device according to the comparative embodiment as illustrated in FIG. **4**B performed a continuous printing test for ten minutes. As the lubricant G, fluorine grease 70 mg and silicone oil 35 mg were used.

During the printing test, temperatures were measured in the inner peripheral surface and the outer peripheral surface of the flange **40** of the fixing device. FIG. **5**A illustrates measurement results. In addition, generation rates (particles/second) of particles including fine particles (FP) and the ultrafine particles (UFP) were measured according to the measurement method specified in Blue Angel Standard. FIG. **5**B illustrates measurement results of the generation rates. The concentration of generated fine particles including the ultrafine particles was measured with a fast mobility particle sizer (FMPS3091 manufactured by Tokyo Dylec Corp.).

As illustrated in FIG. **5**B, the fine particles including the ultrafine particles started to come out all at once after about 3 minutes from the start of printing, gradually increased, and continued to be generated until the end of printing. The number of generated fine particles greatly exceeded the Blue Angel standard value of 3.5×10^{11} particles.

In FIG. **5**B, the timing at which the fine particles including the ultrafine particles rapidly increase is about 3 minutes from the start of printing. This timing (that is, about 3 minutes from the start of printing) substantially coincides with the time at which the inner peripheral surface of the flange illustrated in FIG. **5**A reaches 200° C. or more.

On the other hand, the lubricant G was heated by a hot plate, and concentrations of generated fine particles including ultrafine particles were measured in temperatures from 190° C. to 250° C. FIG. **5**C is a graph illustrating the results of the measurements. From the results of the measurements, it can be seen that the fine particles including the ultrafine particles start to come out all at once at 200° C. or more.

Based on the above-described results, the present inventors found that the inner peripheral surface of the flange is the place in which the fine particles including the ultrafine particles are generated. The outer peripheral surface of the flange also reaches 200° C. in about 9 minutes, but before that, fine particles have already been generated. As a result, applying the present embodiment to the fixing device including the flange **40** whose temperature reaches 200° C. or more can reduce an amount of fine particles including the ultrafine particles generated in the fixing device.

The following describes the reason why the size of the clearance C is equal to or larger than 2 mm.

The present inventors made three fixing devices each having the configuration as illustrated by the schematic view of FIG. **4**A. The three fixing devices had three clearances C, 2 mm, 1.5 mm, and 1.0 mm, respectively. The present inventors set each of the fixing devices in the image forming apparatus and performed continuous printing tests for ten minutes similar to the above-described printing test.

In a result of the continuous printing test of the fixing device having the clearance C=1.0 mm, the adhesion of the lubricant G to the flange **40** was remarkably recognized. In a result of the continuous printing test of the fixing device having the clearance C=1.5 mm, the adhesion of the lubricant G to the flange **40** was slightly recognized.

In a result of the continuous printing test of the fixing device having the clearance C=2.0 mm, the adhesion of the lubricant G to the flange **40** was not recognized. In addition, generation of the fine particles including the ultrafine particles was not observed. After the continuous printing test of the image forming apparatus including the fixing device with the clearance C=2.0 mm, the fixing device was disassembled, and the fixing belt **21** was cut open to observe the inner circumferential surface of the fixing belt corresponding to the clearance C, and the diameters φ of the droplets of the lubricant G adhering to the inner circumferential surface of the fixing belt corresponding to the clearance C were checked. As a result, φ≈1 mm.

Based on the above results, the present inventors found that the clearance C having at least equal to or larger than 2 mm can prevent the lubricant G that are droplets having the diameter φ≈1 mm from flowing to the flange **40** outside the nip formation pad **24** in the longitudinal direction of the nip formation pad **24** and adhering to the flange **40**. To balance the pressure between the fixing belt **21** and the pressure roller **22** and ensure the fixing property of the toner to the sheet, a desired upper limit of the clearance C is a length from a position at which an inner end of the flange **40** is in contact with the inner circumferential surface of the fixing belt **21** to a position facing an end of the pressure roller **22** on the inner circumferential surface of the fixing belt **21**.

The above-described configuration illustrated in FIG. **4**A is a basic configuration of the fixing device according to the present disclosure. Various embodiments are possible as long as the fixing device has the clearance C between the nip formation pad **24** and the cylindrical portion **40***a* of the flange **40**.

FIGS. **6**A to **6**D are schematic views of main parts of the fixing devices according to four embodiments, that is, the first to fourth embodiments. It goes without saying that these embodiments are examples and do not limit the present disclosure.

The first embodiment is described below with reference to FIG. **6**A.

The fixing device according to the first embodiment illustrated in FIG. **6**A includes a sliding sheet **124** covering a lower surface and side surfaces of the nip formation pad **24**. The sliding sheet **124** has a low friction characteristic to reduce friction with the fixing belt **21** and a high lubricant holding capacity.

The sliding sheet **124** may be an elongated rectangular sheet-like material in which resin fibers such as PTFE are woven. The sliding sheet **124** may be configured to have a shape having an opening in a vertical cross-section perpendicular to the longitudinal direction of the sliding sheet **124**. Specifically, both end regions of the sliding sheet **124** in the sliding direction are bent at a substantially right angle with respect to a nip surface (that is a sliding surface), and the sliding sheet **124** has a substantially U-shape in the vertical cross-section perpendicular to the longitudinal direction. The sliding sheet **124** covers an entire nip formation surface of the nip formation pad **24**, and a surface of the sliding sheet **124** corresponds to the nip surface.

The sliding sheet **124** may be a PFA sheet or a PTFE sheet each having a low frictional resistance. Alternatively, the sliding sheet **124** may be made by coating a sheet having high frictional resistance with a material having a low friction coefficient.

The lubricant G held in an impregnated state in the sliding sheet **124** is unlikely to flow outward in the longitudinal direction. Even if a part of the lubricant G protrudes into the clearance C, the lubricant G is held in the clearance C as it is.

A second embodiment is described below with reference to FIG. **6**B.

The fixing device according to the second embodiment illustrated in FIG. **6**B includes an annular projection **21***a* formed on the inner circumferential surface of the fixing belt **21** as a flow preventer that prevents the lubricant G on the inner circumferential surface of the fixing belt **21** from moving outward in addition to the configuration illustrated in FIG. **6**A.

Since rotating the fixing belt **21** generates a centrifugal force that acts on the lubricant G, the annular projection **21***a* can prevent the lubricant G from flowing out to the outside of the annular projection **21***a* after the lubricant G flows to the clearance C.

The shape of the flow preventer is not limited to the shape of the annular projection **21***a* illustrated in FIG. **6**B. The cross-sectional shape of the annular projection **21***a* is not limited to a horizontally long rectangle but may be a vertically long rectangle. The cross-sectional shape of the annular projection **21***a* may be a complicated shape having a large surface area such as an L-shape, a T-shape, or a W-shape. Increasing the surface area of the flow preventer in this way enhances the ability to retain the lubricant G, and the lubricant G is less likely to flow to the flange **40**.

A third embodiment is described below with reference to FIG. **6**C.

The fixing device according to the third embodiment illustrated in FIG. **6**C includes a nip formation pad **224** having a storage space **224***a* in the bottom of the nip formation pad **224**. The storage space **224***a* can store the lubricant G. The storage space **224***a* may be a groove having one line shape or a plurality of grooves having a plurality of line shapes, extending in the longitudinal direction of the nip formation pad **224**. Holding the lubricant G in the storage space **224***a* enables preventing the lubricant G from moving to the outside of the nip formation pad **224** in the axial direction.

A fourth embodiment is described below with reference to FIG. **6**D.

The fixing device according to the fourth embodiment illustrated in FIG. **6**D includes a lubricant absorber **50** disposed in the clearance C in addition to the configuration illustrated in FIG. **6**A. The annular projection **21***a* is formed, for example, by attaching a ring made of urethane rubber having a width of 1 mm and a height of 2 mm to the inner circumferential surface of the fixing belt **21**. The ring may be made by using a mold or by cutting a urethane rubber plate. Preferably, the annular projection **21***a* is disposed at the center of clearance C as illustrated in FIG. **6**B. The lubricant absorber **50** may have the same width as the width of the nip formation pad **24** that is a length of the nip formation pad **24** in a direction perpendicular to the paper surface of FIG. **6**D. The lubricant absorber **50** may be positioned by being connected to an arm portion extending from the nip formation pad **24**. The lubricant absorber **50** is made of, for example, sponge or cloth.

A fifth embodiment is described below with reference to FIGS. **6**E and **6**F. The fixing device according to the fifth embodiment illustrated in FIGS. **6**E and **6**F includes a sliding sheet **324***a* covering a lower surface and side surfaces of the nip formation pad **324**. The sliding sheet **324***a* has a storage space **324***b*. The storage space **324***b* is under the bottom of the nip formation pad **224**. The storage space **224***a* can store the lubricant G. FIG. **6**E is a perspective view of the nip formation pad **324**. In FIG. **6**E, the storage space **324***b* can be seen. FIG. **6**F is a cross-sectional view of of the nip formation pad **324** that is cut so as to see the storage space **324***b*. After the nip formation pad **324** is assembled to the fixing device, the configuration including the storage space **324***b* is as illustrated in FIGS. **6**A and **6**C. The storage space **324***b* may be a groove having one line shape or a plurality of grooves having a plurality of line shapes, extending in the longitudinal direction of the nip formation pad **324**. Holding the lubricant G in the storage space **324***b* enables preventing the lubricant G from moving to the outside of the nip formation pad **324** in the axial direction. The sliding sheet **324***a* may be the PFA sheet or the PTFE sheet each having the low frictional resistance. Alternatively, the sliding sheet **324***a* may be made from a sheet having a high frictional resistance and including the storage space **324***b* for the lubricant. Coating the sheet with material having a low friction coefficient produces the sliding sheet **324***a*.

Even if a part of the lubricant G moves to the clearance C, the lubricant absorber **50** absorbs and holds the lubricant G. As a result, the lubricant absorber **50** can prevent the lubricant G from flowing to the flange **40**. In addition, clearances adjacent to both ends of the lubricant absorber **50** hold the lubricant G. Therefore, the lubricant G is more unlikely to flow to the flange **40**.

Next, other types of fixing devices are described.

According to the embodiments of the present disclosure, the configuration of the fixing device is not limited to the configuration described above. The embodiments of the present disclosure may be applied to fixing devices having various configurations. A description is now given of some examples of the configuration of the fixing device to which the embodiments of the present disclosure are applicable.

A fixing device **400** illustrated in FIGS. **7** and **8** includes a fixing belt **410** as a first rotator, a pressure roller **420** as a second rotator, a heater **430** as a heat source, a heater holder **440** as a heat source holder, a pressure stay **450** as a support, a thermistor **480** as a temperature sensor, and flanges **470** (see FIG. **8**) as rotator holders.

Functions and configurations of the fixing belt **410** and the pressure roller **420** illustrated in FIG. **7** are basically the same as those of the fixing belt **21** and the pressure roller **22** illustrated in FIGS. **2**A and **2**B.

The heater **430** is a ceramic heater including a plate-like substrate and a resistive heat generator disposed on the substrate. Flowing an electric current through the resistive heat generator causes the resistive heat generator to generate heat. The heater **430** is disposed so as to be in contact with the inner circumferential surface of the fixing belt **410**, and the heater **430** generates heat to heat the inner circumferential surface of the fixing belt **410**. In addition, the heater **430** also functions as a nip formation pad that forms the fixing nip N by sandwiching the fixing belt **410** with the pressure roller **420**.

The heater holder **440** is the heat source holder that holds the heater **430**. The heater holder **440** is made of, for example, a heat-resistant resin. The heater holder **440** has a half circle cross-sectional shape formed along the inner circumferential surface of the fixing belt **410** to restrict a rotational orbit of the fixing belt **410**.

The pressure stay **450** is the support to support the heater holder **440**. Since the pressure stay **450** supports the heater holder **440**, the pressure stay **450** prevents bending of the heater holder **440** and the heater **430** due to pressure applied by the pressure roller **420** to form the fixing nip N having a uniform width between the pressure roller **420** and the fixing belt **410**. The pressure stay **450** is preferably made of metal such as SUS in order to ensure rigidity.

The thermistor **480** as the temperature sensor is disposed on the pressure stay **450**. The thermistor **480** faces the inner circumferential surface of the fixing belt **410** in a contact or non-contact manner to detect the temperature of the fixing belt **410**.

Similar to the above-described flanges **40**, the flanges **470** are a pair of holders holding both ends of the fixing belt **410** in the longitudinal direction of the fixing belt **410**. The flange **470** has a backup portion **470*a*** as an insertion portion to be inserted into the fixing belt **410** and a flange portion **470*b*** as a regulator to regulate the movement of the fixing belt **410** in the longitudinal direction. A biasing member such as a spring presses the flange **470** against the end of the fixing belt **410** to hold the flange **470** inserted into the loop of the fixing belt **410**.

In the fixing device **400** having the above-described configuration, when the heater **430** generates heat, the temperature of the flange **470** increases, and the temperature of the lubricant adhering to the flange **470** increases, which may cause the generation of the fine particles including the ultrafine particles. Accordingly, applying the present embodiments to the fixing device **400** illustrated in FIGS. **7** and **8** also enables preventing the lubricant from moving to the flange to reduce the occurrence of fine particles including ultrafine particles.

Next, a fixing device **500** illustrated in FIGS. **9** and **10** is described. Similar to the fixing device **400** illustrated in FIGS. **7** and **8**, the fixing device **500** includes the ceramic heater (that is a heater **530**). The fixing device **500** illustrated in FIGS. **9** and **10** includes a fixing belt **510** as the first rotator, a pressure rotator **520** as the second rotator, the heater **530** as the heat source, a heater holder **540** as the heat source holder, a reinforcement **550** as the support, belt holders **570** (see FIG. **10**) as the rotator holders, heat-sensitive members **580** (see FIG. **10**) as the temperature sensors, and covers **590** (see FIG. **10**).

Functions and configurations of the fixing belt **510**, the pressure rotator **520**, the heater **530**, the heater holder **540**, the reinforcement **550**, and the belt holders **570** illustrated in FIGS. **9** and **10** are basically the same as those of the fixing belt **410**, the pressure roller **420**, the heater **430**, the heater holder **440**, the pressure stay **450**, and the flanges **470** illustrated in FIGS. **7** and **8**.

The heat-sensitive members **580** are disposed on a side of the heater holder **540** that is opposite to a side of the heater holder **540** to hold the heater **530** and detects the temperature of the heater **530** via the heater holder **540**. Based on the temperature detected by the heat-sensitive members **580**, heat generation of the heater **530** is controlled so that the fixing belt **510** is maintained at a predetermined fixing temperature.

The covers **590** are box-shaped members made of heat-resistant resin. Each cover **590** is disposed so as to face the heater holder **540** via the heat-sensitive member **580** inside the loop of the fixing belt **510** to cover the corresponding heat-sensitive member **580**.

As described above, the fixing device to which the present disclosure is applied may include the heat-sensitive member **580** that detects the temperature of the heater **530** and the cover **590** that covers the heat-sensitive member **580**.

Subsequently, a fixing device **600** illustrated in FIGS. **11** and **12** is described. Similar to the fixing device **20** illustrated in FIGS. 2A, 2B, and **3**, the fixing device **600** includes the halogen heater (that is a heater **630**). Specifically, the fixing device **600** illustrated in FIGS. **11** and **12** includes a fixing belt **610** as the first rotator, a pressure roller **620** as the second rotator, the heater **630** as the heat source, a nip formation pad **640**, a support **650** as the support, a reflector **660** as the reflector, retention frames **670** (see FIG. **12**) as the rotator holders, and rings **680** (see FIG. **12**) as a slide.

Functions and configurations of the fixing belt **610**, the pressure roller **620**, the heater **630**, the nip formation pad **640**, the support **650**, the reflector **660**, and the retention frames **670** illustrated in FIGS. **11** and **12** are basically the same as those of the fixing belt **21**, the pressure roller **22**, the heater **23**, the nip formation pad **24**, the stay **25**, the reflector **26**, and the flanges **40** illustrated in FIGS. 2A, 2B, and **3**. The nip formation pad **640** includes a metal base pad **6400** and a fluororesin sliding sheet **6410** that is interposed between the base pad **6400** and an inner circumferential surface of the fixing belt **610**.

The ring **680** is mounted on an outer circumferential surface of a cylindrical portion **670*a*** as an insertion portion of the retention frame **670** that is inserted into the loop formed by the fixing belt **610**. The ring **680** is interposed between a longitudinal edge of the fixing belt **610** and a fixing plate **670*b*** as a restraint of the retention frame **670**. As the fixing belt **610** rotates, the ring **680** rotates together with the fixing belt **610**, or the fixing belt **610** slides over the low-friction ring **680**. Thus, the sliding friction that is generated between the fixing belt **610** and the retention frame **670** is reduced.

According to one or more embodiments of the present disclosure, the fixing device may include the rings **680** as described above.

Subsequently, a fixing device **700** illustrated in FIGS. **13** and **14** is described. Similar to the fixing device **20** illustrated in FIGS. 2A, 2B, and **3**, the fixing device **700** includes the halogen heater that is a heater **730** as the heat source. Specifically, the fixing device **700** illustrated in FIGS. **13** and **14** includes a fixing belt **710** as the first rotator, a pressure roller **720** as the second rotator, a halogen heater **730** as the heat source, a nip formation pad **740**, a reflector **760**, belt supports **770** (see FIG. **14**) as the rotator holders, a temperature sensor **780** as the temperature sensor, and guides **790**.

The fixing belt **710**, the pressure roller **720**, the halogen heater **730**, the nip formation pad **740**, the reflector **760**, the belt supports **770**, and the temperature sensor **780** that are illustrated in FIGS. **13** and **14** are basically the same in function as the fixing belt **21**, the pressure roller **22**, the heater **23**, the nip formation pad **24**, the reflector **26**, the flanges **40**, and the temperature sensor **28**, respectively, illustrated in FIGS. 2A, **2**B, and **3**.

However, the reflector **760** illustrated in FIGS. **13** and **14** reflects the radiant heat (infrared rays) emitted from the halogen heater **730** mainly to the nip formation pad **740**, not to the fixing belt **710**. The reflector **760** has a U-shaped cross-section to cover the outside of the halogen heater **730**. The reflector **760** has an inner face **760***a* facing the halogen heater **730** and serving as a reflecting surface having a relatively high reflectance. The inner face **760***a* as the reflecting surface of the reflector **760** reflects the radiant heat emitted from the halogen heater **730** to the nip formation pad **740**.

As a result, the nip formation pad **740** is heated by the radiant heat emitted from the halogen heater **730** toward the nip formation pad **740** and the radiant heat reflected by the reflector **760** to the nip formation pad **740**. The heat is conducted from the nip formation pad **740** to the fixing belt **710** at the fixing nip N.

In this case, the nip formation pad **740** that forms the nip N functions as a heat conductor that conducts heat to the fixing belt **710** at the fixing nip N. To conduct heat, the nip formation pad **740** is made of metal having good thermal conductivity such as copper or aluminum.

The reflector **760** also functions as a support (in other words, a stay) that supports the nip formation pad **740**. Since the reflector **760** supports the nip formation pad **740** throughout the length of the fixing belt **710**, the reflector **760** prevents the nip formation pad **740** from bending to form the fixing nip N having a uniform width between the fixing belt **710** and the pressure roller **720**. The reflector **760** is preferably made of metal having relatively high rigidity such as SUS or Steel Electrolytic Cold Commercial (SECC) to ensure the function as the support.

The guides **790** are disposed inside the loop of the fixing belt **710** to guide the inner circumferential surface of the fixing belt **710** rotating. Each of the guides **790** has a guide face **790***a* curving along the inner circumferential surface of the fixing belt **710**. As the fixing belt **710** is guided along the guide face **790***a*, the fixing belt **710** smoothly rotates without being largely deformed.

According to one or more embodiments of the present disclosure, the fixing device may conduct heat from the halogen heater **730** via the nip formation pad **740** having good thermal conductivity to heat the fixing belt **710** as described above.

Subsequently, a fixing device **800** illustrated in FIGS. **15** and **16** is described. Similar to the fixing device **400** illustrated in FIGS. **7** and **8**, the fixing device **800** includes the ceramic heater (that is a heater **830**). The fixing device **800** illustrated in FIGS. **15** and **16** includes a fixing belt **810** as the first rotator, a pressure roller **820** as the second rotator, the heater **830** as the heat source, a holder **840** as the heat source holder, a stay **850** as the support, arc-shaped guides **870** (see FIG. **16**) as the rotator holders, a heat diffuser **880** as a heat conductor, and a heat retaining plate **890** as a heat insulator.

Functions of the fixing belt **810**, the pressure roller **820**, the heater **830**, the holder **840**, the stay **850**, and the arc-shaped guides **870** illustrated in FIGS. **15** and **16** are basically the same as the functions of the fixing belt **410**, the pressure roller **420**, the heater **430**, the heater holder **440**, the pressure stay **450**, and the flanges **470** illustrated in FIGS. **7** and **8**, respectively. In addition to the heater **830**, the holder **840** holds the heat diffuser **880** and the heat retaining plate **890** that are overlaid.

The heat diffuser **880** is made of metal such as stainless steel, aluminum alloy, or iron. The heat diffuser **880** is disposed so as to be in contact with the inner circumferential surface of the fixing belt **810**, transmits heat generated by the heater **830** to the fixing belt **810**, and is in contact with the pressure roller **820** via the fixing belt **810** to form the fixing nip N.

Thermal conductive grease is applied between the heater **830** and the heat diffuser **880** to improve heat transfer efficiency from the heater **830** to the heat diffuser **880**. On the other hand, the heat retaining plate **890** is disposed on a side of the heater **830** that is opposite to a side of the heater **830** facing the heat diffuser **880** to prevent the heat of the heater **830** from being transmitted to the holder **840** and the stay **850**.

Since the fixing belt **810** rotates and slides on the heat diffuser **880**, lubricant is applied between the fixing belt **810** and the heat diffuser **880** to improve sliding performance. A slide surface of the heat diffuser **880** in contact with the fixing belt **810** is formed with a surface layer such as a glass coating layer or a hard chromium plating layer each having low friction and wear resistance.

In the fixing device **800** having the above-described configuration, when the heater **830** generates heat, the temperature of the arc-shaped guide **870** increases, and the temperature of the lubricant adhering to the arc-shaped guide **870** increases, which may cause the generation of the fine particles including the ultrafine particles. Therefore, applying present embodiments can prevent the occurrence of the fine particles including the ultrafine particles.

The embodiments of the present disclosure are applicable to a fixing device **1100** illustrated in FIGS. **17** and **18**.

The fixing device **1100** illustrated in FIGS. **17** and **18** includes a fixing belt **1110** as the first rotator, a fixing roller **1160**, a pressure roller **1120** as the second rotator, a heater **1130** as the heat source, a pressing pad **1140** as the nip formation pad, a guide **1150**, a support **1170**, a temperature sensor **1180** as the temperature sensor, a heat transferor **1190**, and belt holders **1220** (see FIG. **18**) as the rotator holders.

The fixing belt **1110** illustrated in FIG. **17** is wound around the fixing roller **1160**, the pressing pad **1140**, the guide **1150**, and the heat transferor **1190**. The fixing roller **1160** is rotated by the rotation of the pressure roller **1120**.

The heater **1130** is a planar heater or a plate-shaped heater such as a ceramic heater and disposed in the heat transferor **1190**. The heat transferor **1190** is interposed between the heater **1130** and the fixing belt **1110** to transfer the heat of the heater **1130** to the fixing belt **1110**. A spring **1200** attached to the support **1170** biases the heat transferor **1190** against the fixing belt **1110** so that the heat transferor **1190** comes into contact with the inner circumferential surface of the fixing belt **1110**.

Another spring **1210** attached to the support **1170** biases the pressing pad **1140** against the fixing belt **1110** so that the pressing pad **1140** comes into contact with the inner circumferential surface of the fixing belt **1110**. As a result, the pressing pad **1140** is pressed against the pressure roller **1120** via the fixing belt **1110** to form the nip N between the fixing belt **1110** and the pressure roller **1120**.

The guide **1150** is attached to and supported by the support **1170**. A temperature sensor **1180** is attached to the guide **1150** and detects the temperature of the fixing belt **1110**.

Since the fixing device **1100** as illustrated in FIG. **17** also includes the belt holders **1220** that hold both ends of the fixing belt **1110** in the longitudinal direction, heating the fixing belt **1110** increases the temperature of the lubricant adhering to the belt holders **1220**, which may cause the occurrence of fine particles including the ultrafine particles. Accordingly, applying the present embodiments of the present disclosure to the above-described fixing device **1100** can also effectively prevent the occurrence of the fine particles including the ultrafine particles similar to the above-described embodiments.

The above-described embodiments are illustrative and do not limit this disclosure. It is therefore to be understood that within the scope of the appended claims, numerous additional modifications and variations are possible to this disclosure otherwise than as specifically described herein. For example, the image forming apparatus to which the features of this disclosure are applied is not limited to the printer illustrated in FIG. **1** but may be other types of printers, copiers, facsimile machines, or multifunction machines having these capabilities.

The following describes preferred aspects of the present disclosure.

First Aspect

In a first aspect, a fixing device includes a rotator, a heater, a rotator support, a nip formation pad, lubricant, and a pressure rotator. The heater heats an inner circumferential surface of the rotator. The rotator support supports an end of the inner circumferential surface of the rotator in an axial direction of the rotator. The rotator slides on the rotator support. The nip formation pad is in contact with the inner circumferential surface of the rotator. One end of the nip formation pad in a longitudinal direction of the nip formation pad is separated from the rotator support with a clearance of 2 mm or more. The lubricant is between the rotator and the nip formation pad. The pressure rotator presses the nip formation pad via the rotator to form a nip between the rotator and the pressure rotator.

Second Aspect

In a second aspect, the fixing device according to the first aspect further includes a flow preventer in contact with the inner circumferential surface of the rotator between the nip formation pad and the rotator support that form the clearance.

Third Aspect

In a third aspect, the fixing device according to the first aspect further includes a lubricant absorber in contact with the inner circumferential surface of the rotator between the nip formation pad and the rotator support that form the clearance.

Fourth Aspect

In a fourth aspect, the fixing device according to any one of the first to third aspects further includes a sliding sheet impregnated with lubricant. The sliding sheet is disposed between the nip formation pad and the rotator.

Fifth Aspect

In a fifth aspect, the nip formation pad in the fixing device according to any one of the first to fourth aspects has a space between the rotator and the nip formation pad to store lubricant.

Sixth Aspect

In a sixth aspect, an image forming apparatus includes the fixing device according to any one of the first to fifth aspects.

The above-described embodiments are illustrative and do not limit the present invention. Thus, numerous additional modifications and variations are possible in light of the above teachings. For example, elements and/or features of different illustrative embodiments may be combined with each other and/or substituted for each other within the scope of the present invention.

What is claimed is:

1. A fixing device comprising:

a rotator configured to rotate;

a heater configured to heat an inner circumferential surface of the rotator;

a rotator support including a base portion and a cylindrical wall extending from the base portion, the cylindrical wall supporting a first end of the inner circumferential surface of the rotator extending from a nip in a longitudinal direction of a nip formation pad, and supporting a second end of the inner circumferential surface of the rotator facing the first end, the base portion defining a base opening, and the cylindrical wall defining an extension opening;

the nip formation pad in contact with the inner circumferential surface of the rotator, the nip formation pad having one end in a longitudinal direction of the nip formation pad, the one end laterally separated from the first end of the rotator support contacting the inner circumferential surface of the rotator with a clearance of 2 mm or more;

lubricant between the rotator and the nip formation pad;

a pressure rotator configured to press the nip formation pad via the rotator to form a nip between the rotator and the pressure rotator; and

a flower preventer in contact with the inner circumferential surface of the rotator at a same level as the cylindrical wall contacting the inner circumferential surface of the rotator, the flower preventer separated from and between the nip formation pad and the rotator support that form the clearance forming a lubricant gap exposing the inner circumferential surface of the rotator between the flower preventer and the nip formation pad,

the cylindrical wall having a side surface facing the nip formation pad.

2. The fixing device according to claim **1**,

wherein the flow preventer has an O-shape in an axial direction along the inner circumferential surface of the rotator.

3. The fixing device according to claim **1**, further comprising

a lubricant absorber in contact with the inner circumferential surface of the rotator between the nip formation pad and the rotator support that form the clearance, the lubricant absorber om the nip formation pad.

4. The fixing device according to claim **1**, further comprising

a sliding sheet impregnated with lubricant and disposed between the nip formation pad and the rotator.

5. The fixing device according to claim **1**,

wherein the nip formation pad has a space between the rotator and the nip formation pad to store lubricant.

6. The fixing device according to claim **5**, wherein

the nip formation pad includes a groove,

the groove and the rotator cooperatively define the space, and

the space is a closed space configured to prevent lubricant from moving outside of the nip formation pad in an axial direction.

7. An image forming apparatus comprising the fixing device according to claim **1**.

8. The fixing device according to claim **1**,

wherein the rotator support includes a portion having an outer circumference equal to an inner circumference of the inner circumferential surface of the rotator.

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