US00RE35341E

United States Patent [19]

Kikuchi et al.

[11] E **Patent Number: Re. 35,341**

[45] **Reissued Date of Patent: Oct. 1, 1996**

[54] **SHEET FEED APPARATUS FOR IMAGE FORMING SYSTEM**

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[21] Appl. No.: **36,808**

[22] Filed: **Mar. 25, 1993**

Related U.S. Patent Documents

Reissue of:

[64] Patent No.: **5,002,266**
Issued: **Mar. 26, 1991**
Appl. No.: **288,143**
Filed: **Dec. 22, 1988**

[30] **Foreign Application Priority Data**

Dec. 26, 1987	[JP]	Japan	62-331141
Dec. 26, 1987	[JP]	Japan	62-331142
Dec. 26, 1987	[JP]	Japan	62-331144
Dec. 26, 1987	[JP]	Japan	62-331145

[51] **Int. Cl.**[6] **B65H 5/22**; B65H 1/22

[52] **U.S. Cl.** **271/3.14**; 271/109; 271/127; 271/164; 271/9.01

[58] **Field of Search** 271/3, 4, 6–10, 271/109, 114, 126, 127, 145, 157, 160, 162, 164, 272, 273, 3.14

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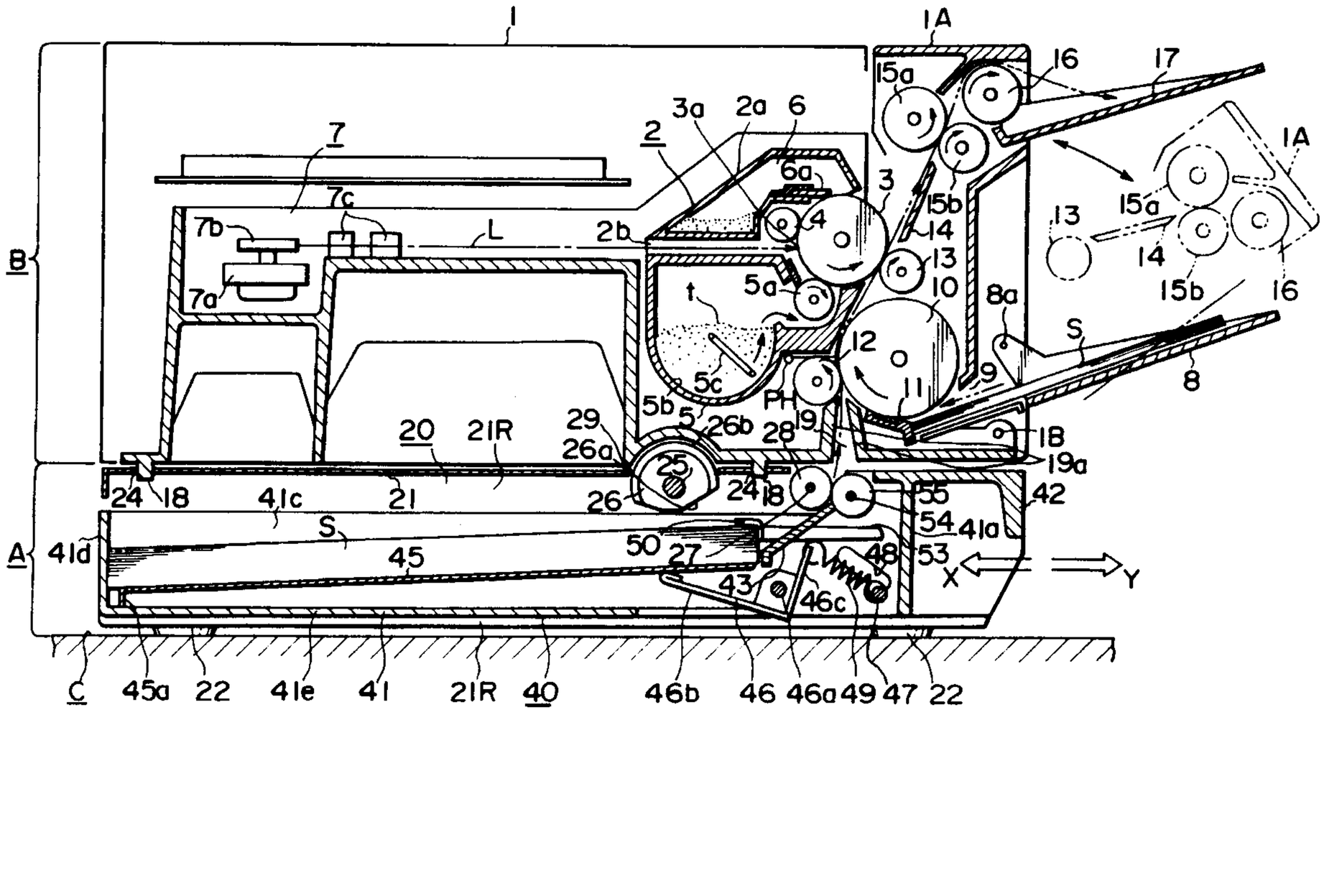
Primary Examiner—David H. Bollinger
Attorney, Agent, or Firm—Fitzpatrick, Cella, Harper & Scinto

[57] **ABSTRACT**

Image forming apparatus including sheet feeding apparatus, sheet conveying apparatus, sheet delivering apparatus, structure for supporting the sheet conveying apparatus and sheet delivering apparatus and having an opening side, sheet storing apparatus, and structure for guiding the sheet storing apparatus such that the sheet forming apparatus is detachable from the sheet feeding apparatus at the same opening side.

22 Claims, 14 Drawing Sheets



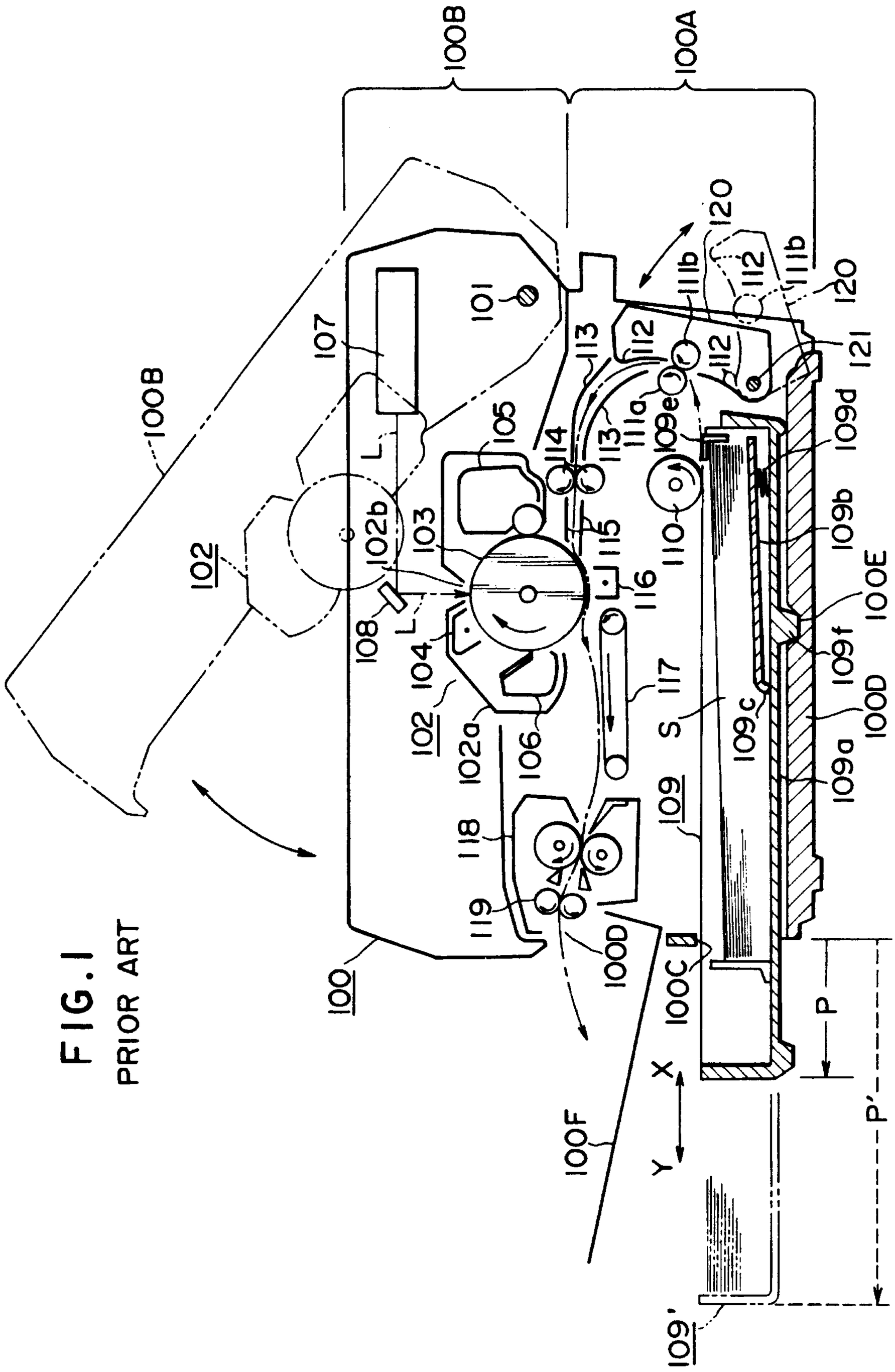
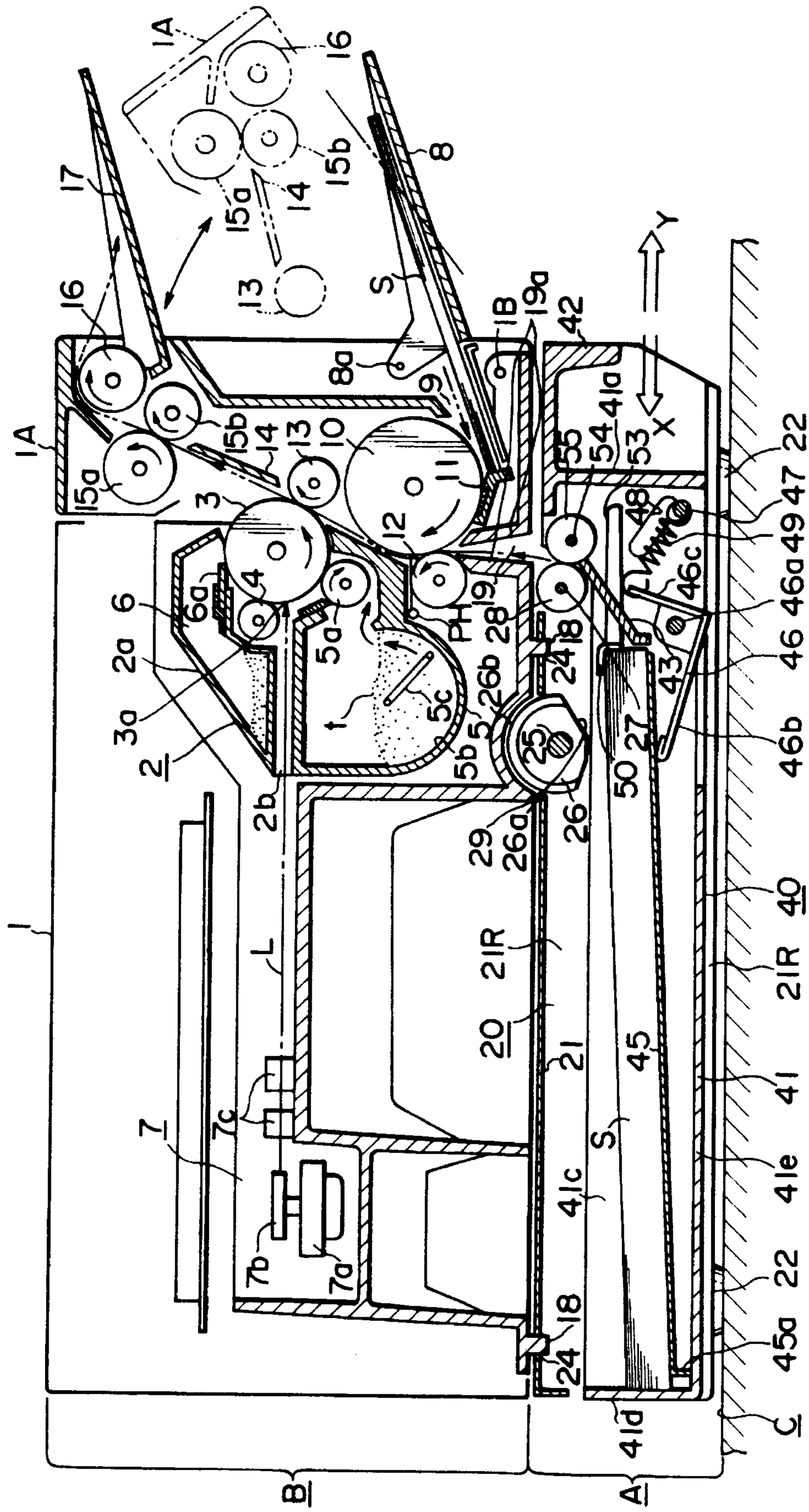


FIG. 1
PRIOR ART

FIG.2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16
17
15b
8
15a
14
13
S
16
8a
9
1B
19a
42
Y
X
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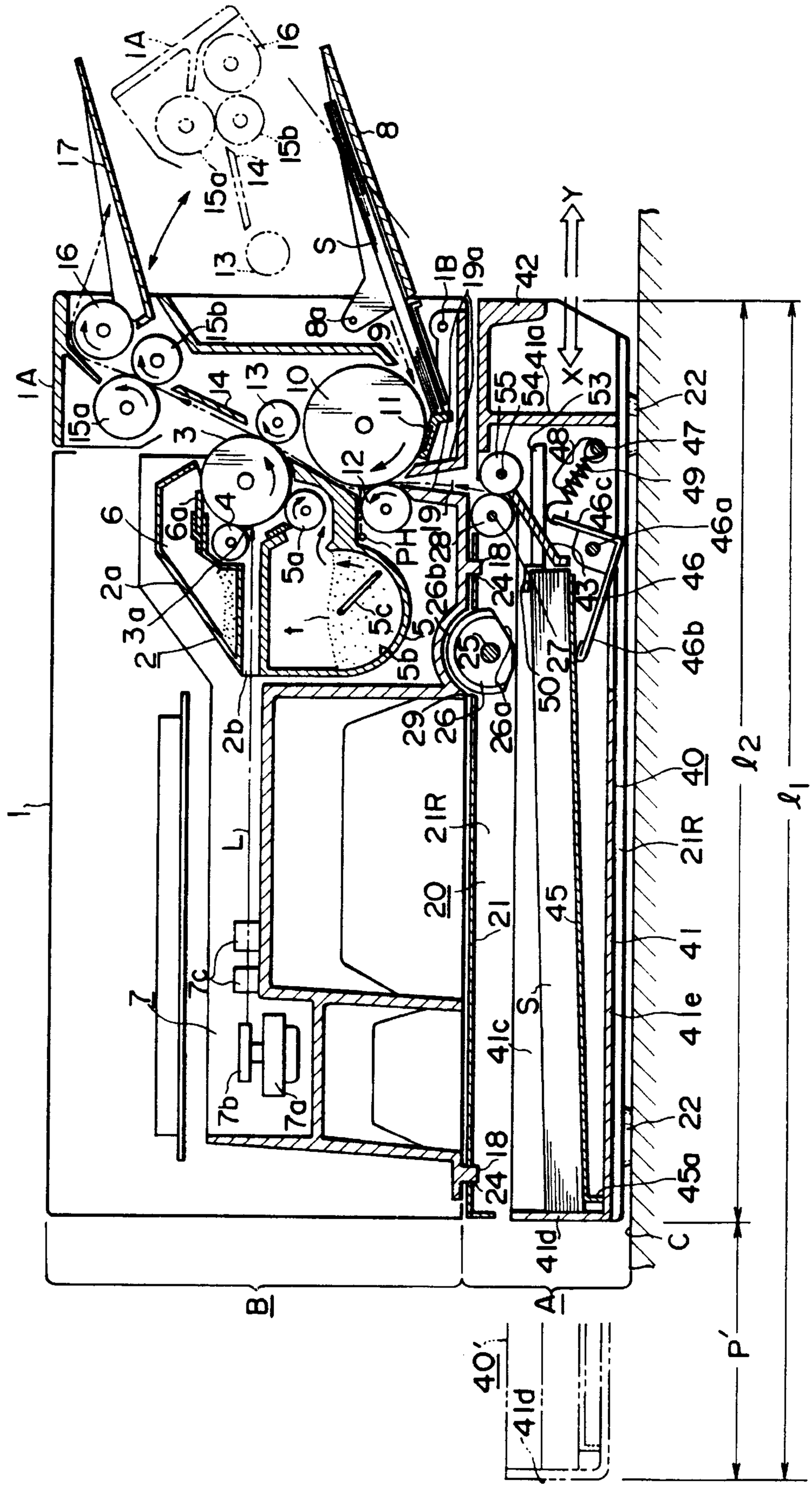
11
12
3
4
6
6a
2a
3a
2
2b
5a
5c
5b
5
26b
24
18
19
28
PH
25
26
29
26a
50
27
43
46c
48
49
47
22
46a
46
46b
54
55
53
41a
L
1
7
7c
7b
7a
20
21
45
41
41c
41e
41d
45a
40
21R
C
B
A

FIG. 3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16
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15b
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15a
14
13
S
18
19a
42
Y
X
15b
8a
9
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11
12
55
54
41a
53
22
47
49
46a
46
46b
46c
48
3
4
6
6a
2a
3a
2
5a
5c
5b
PH
9
28
26b
24
25
27
50
43
2b
29
26
26a
L1
2IR
20
21
45
41
40
l2
l1
7
7c
7b
7a
41c
41e
45a
41d
B
A
C
40'
P'

FIG. 4

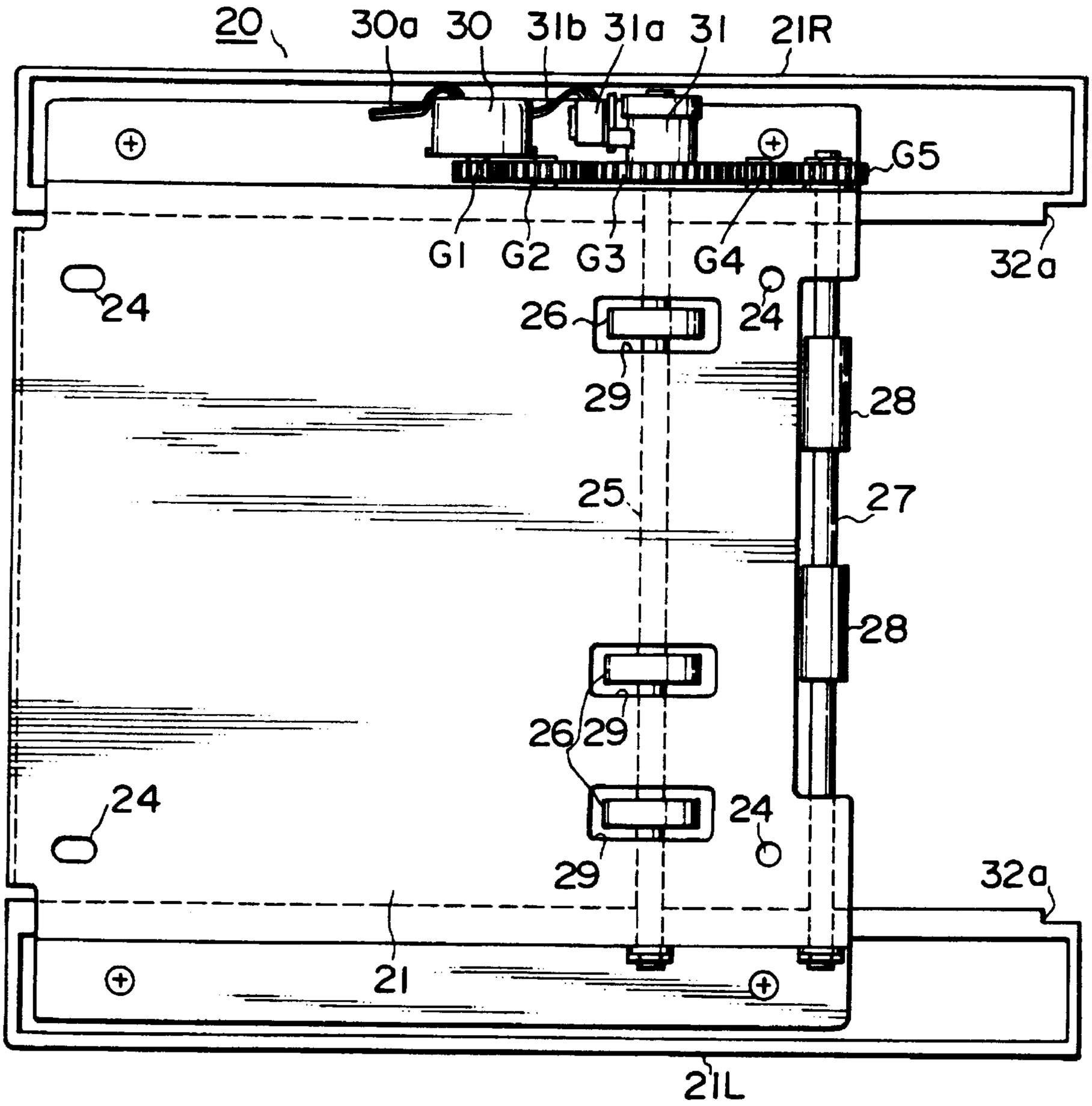

20
30a
30
31b
31a
31
21R
G5
G1
G2
G3
G4
32a
24
26
24
29
28
25
27
28
26
29
24
24
29
32a
21
21L

FIG.5

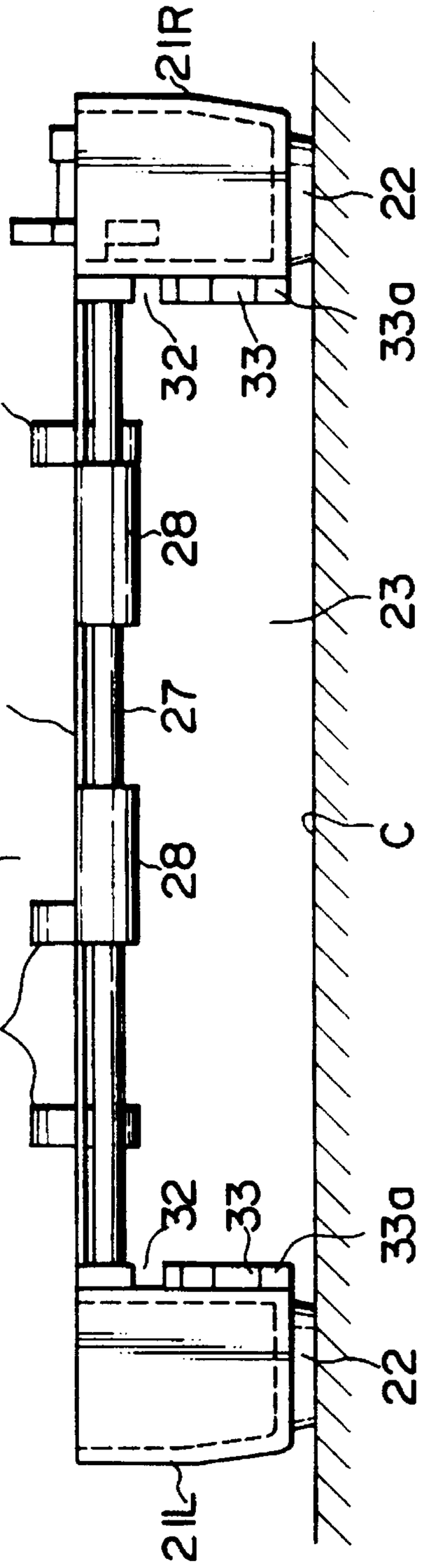
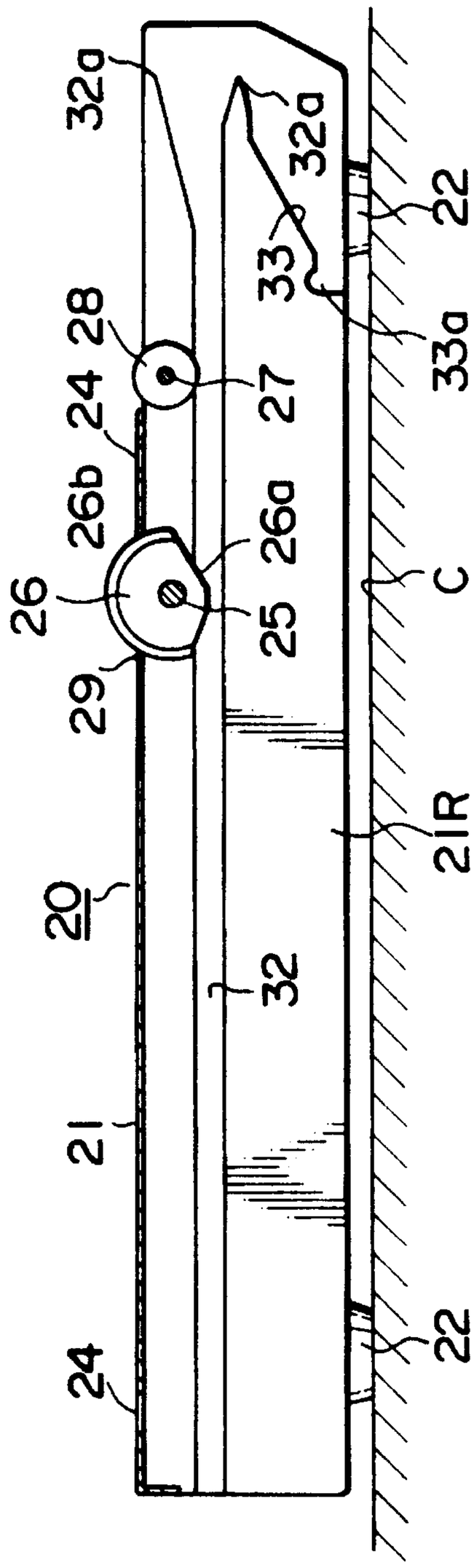

21R
22
33a
32
33
26
28
23
21
27
28
20
26
32
33
33a
22
21L

FIG.6


32a
32a
22
33
28
33a
24
27
26b
26a
C
26
25
29
21R
20
32
21
24
22

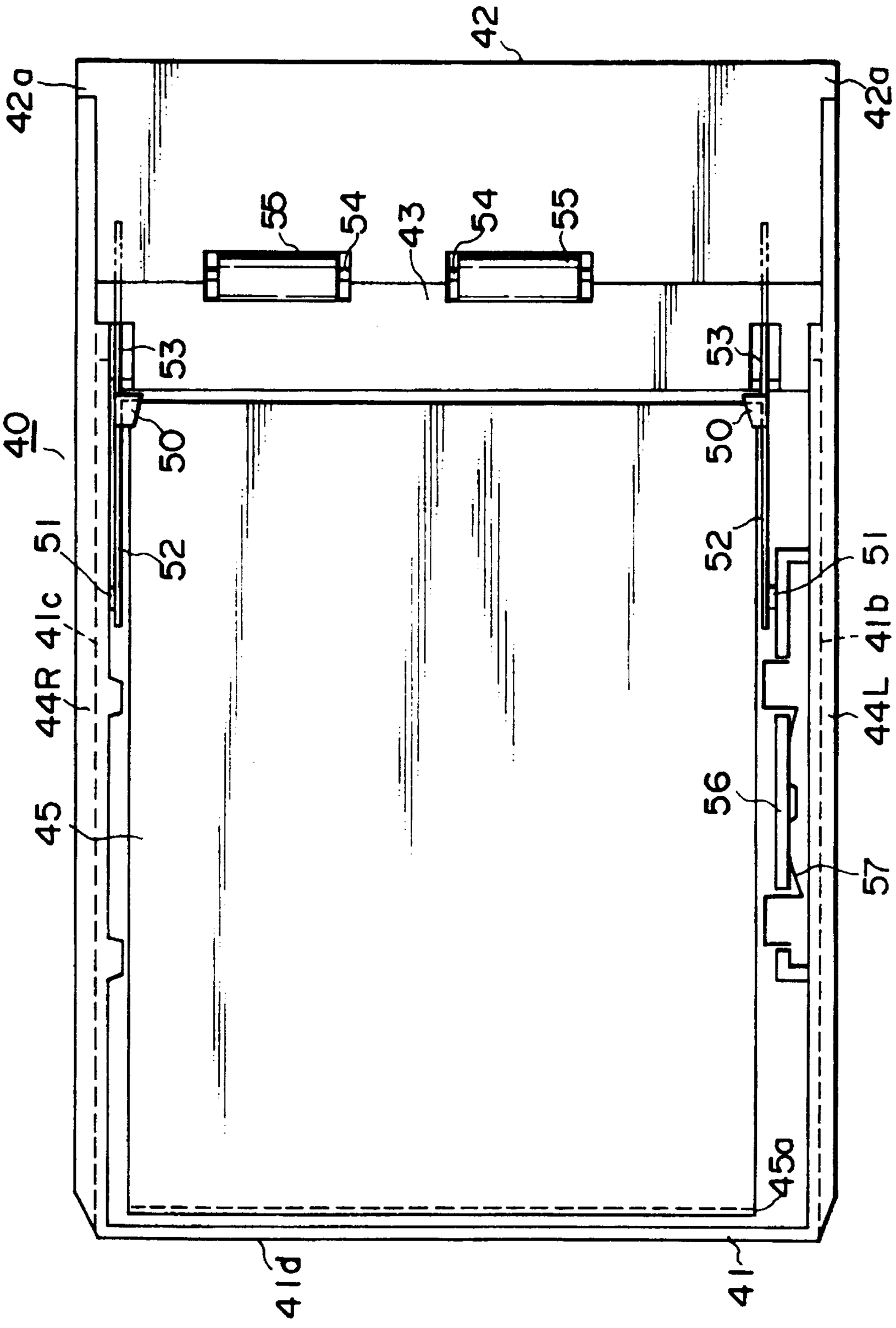
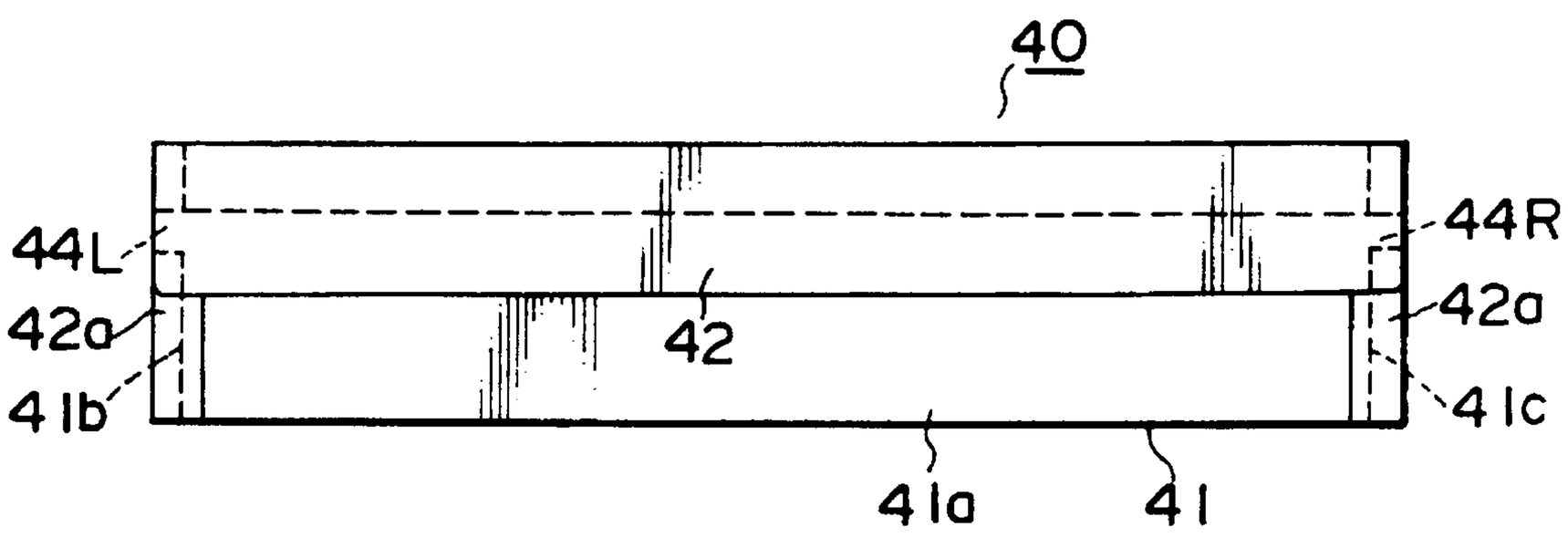

42
42a
42a
55
54
43
54
55
53
53
50
50
40
52
52
51
44R
41c
51
44L
41b
45
56
57
45a
41d
41

FIG. 7

FIG.8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44L
42a
41b
42
44R
42a
41c
41a
41

FIG.9

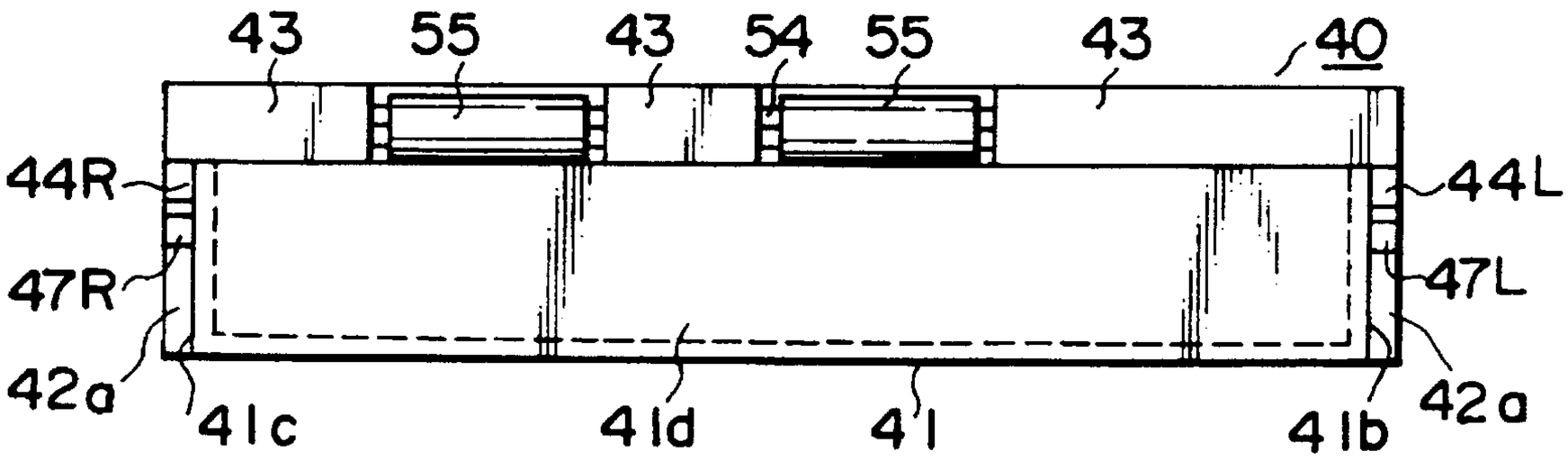
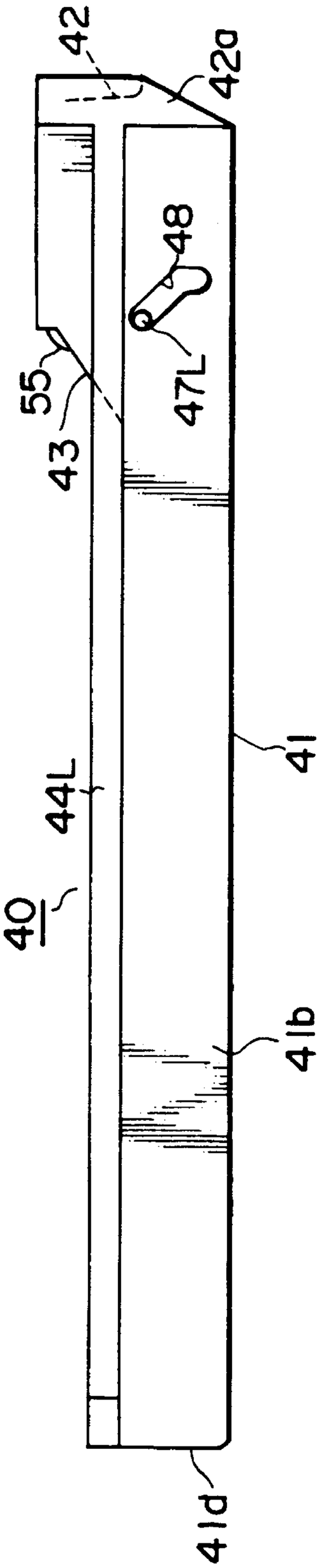

43
55
43
54
55
43
40
44R
47R
42a
41c
41d
41
41b
42a
44L
47L

FIG. 10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42a
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47L
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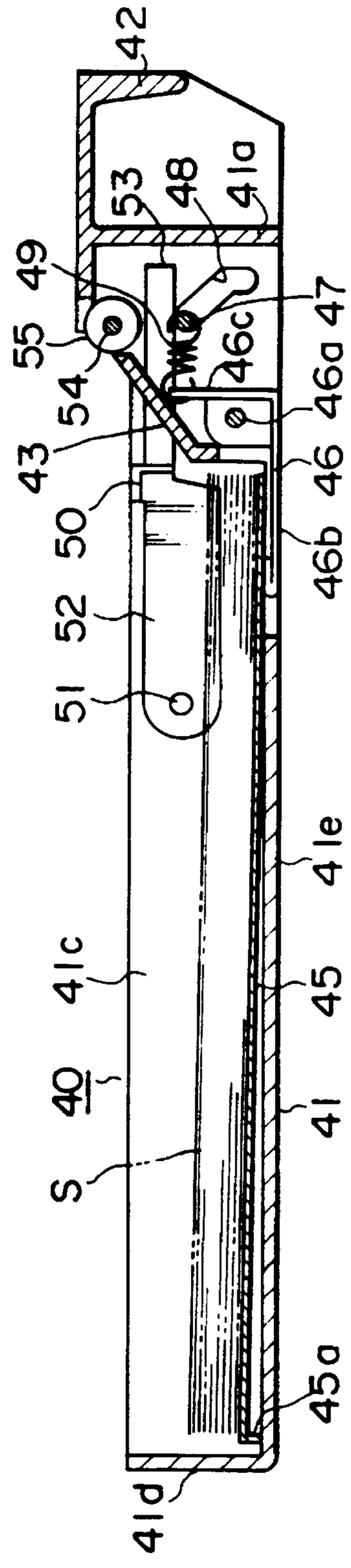
43
40
44L
41
41b
41d

FIG. 11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53
48
41a
49
55
54
47
46c
46d
43
50
46
46b
51
52
41e
41c
45
40
41
S
45a
41d

FIG. 12(A)

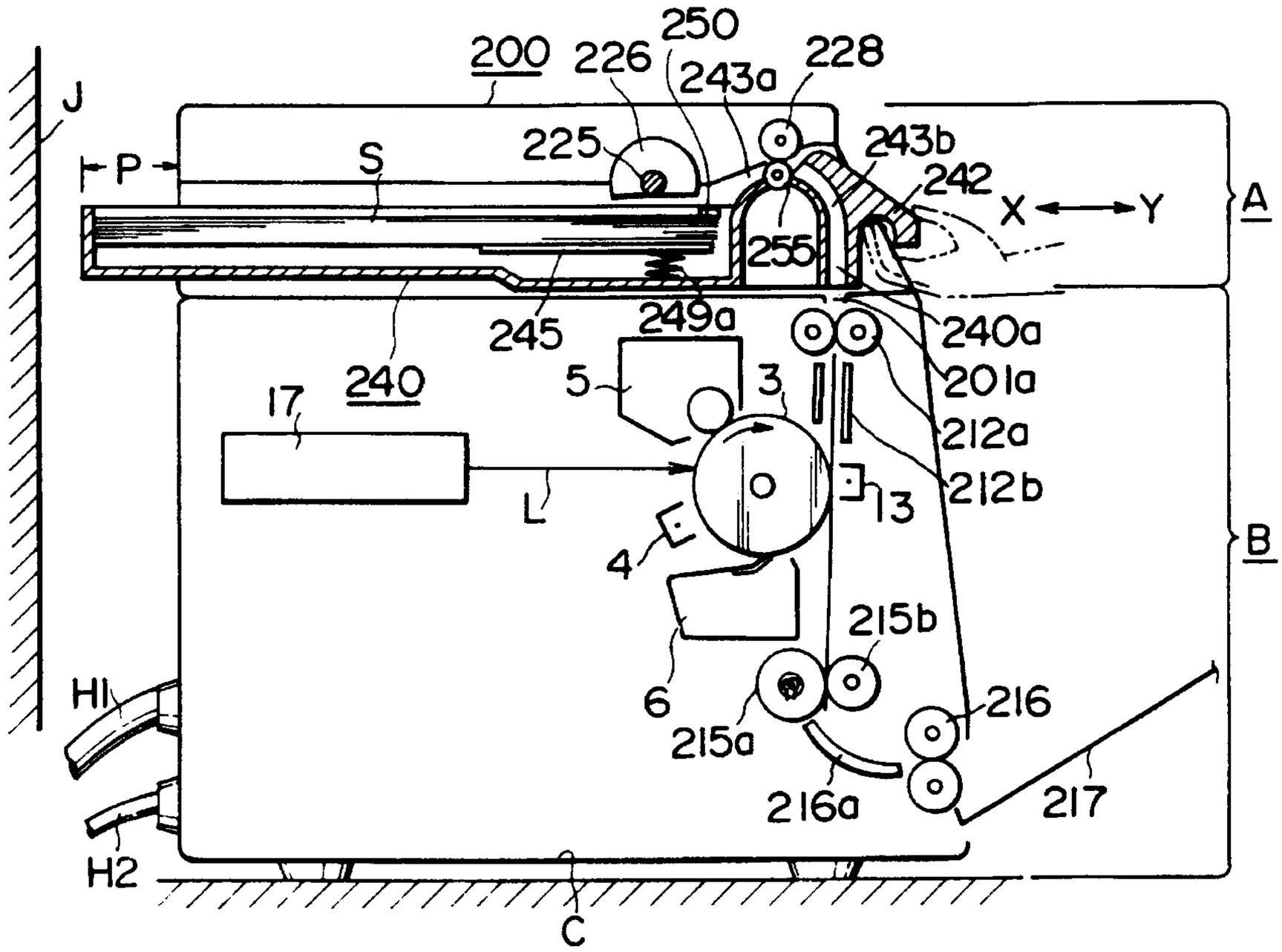


FIG. 12(B)

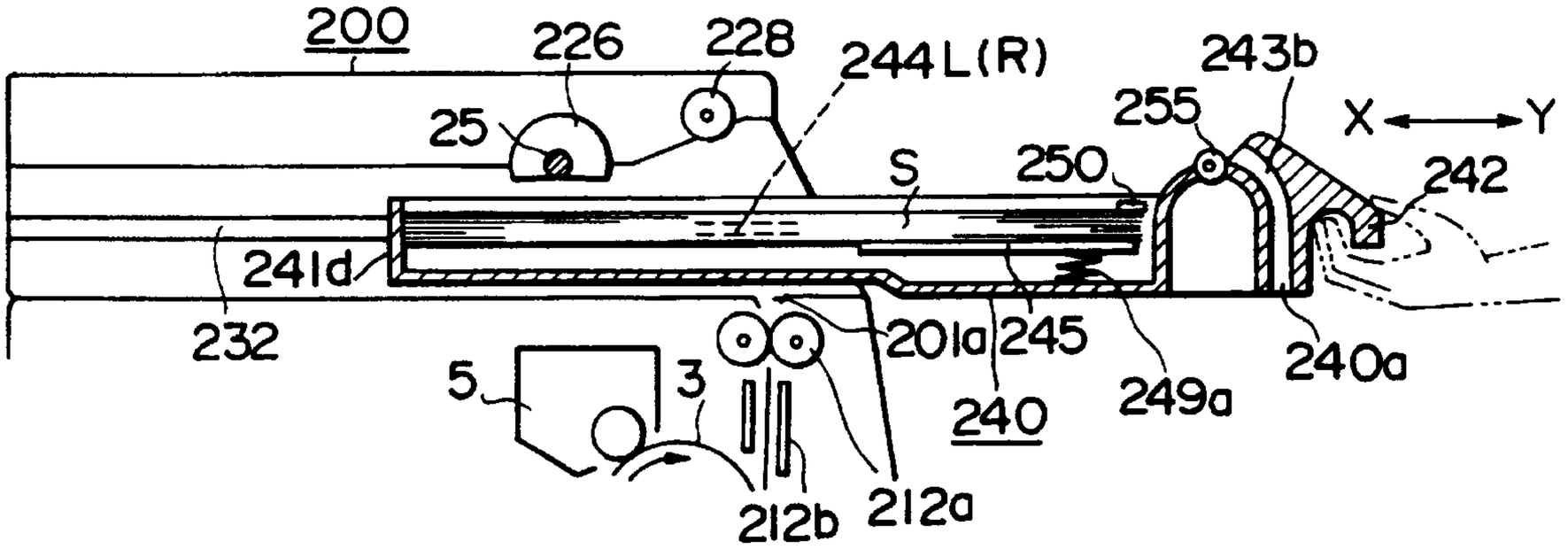


FIG. 12(C)

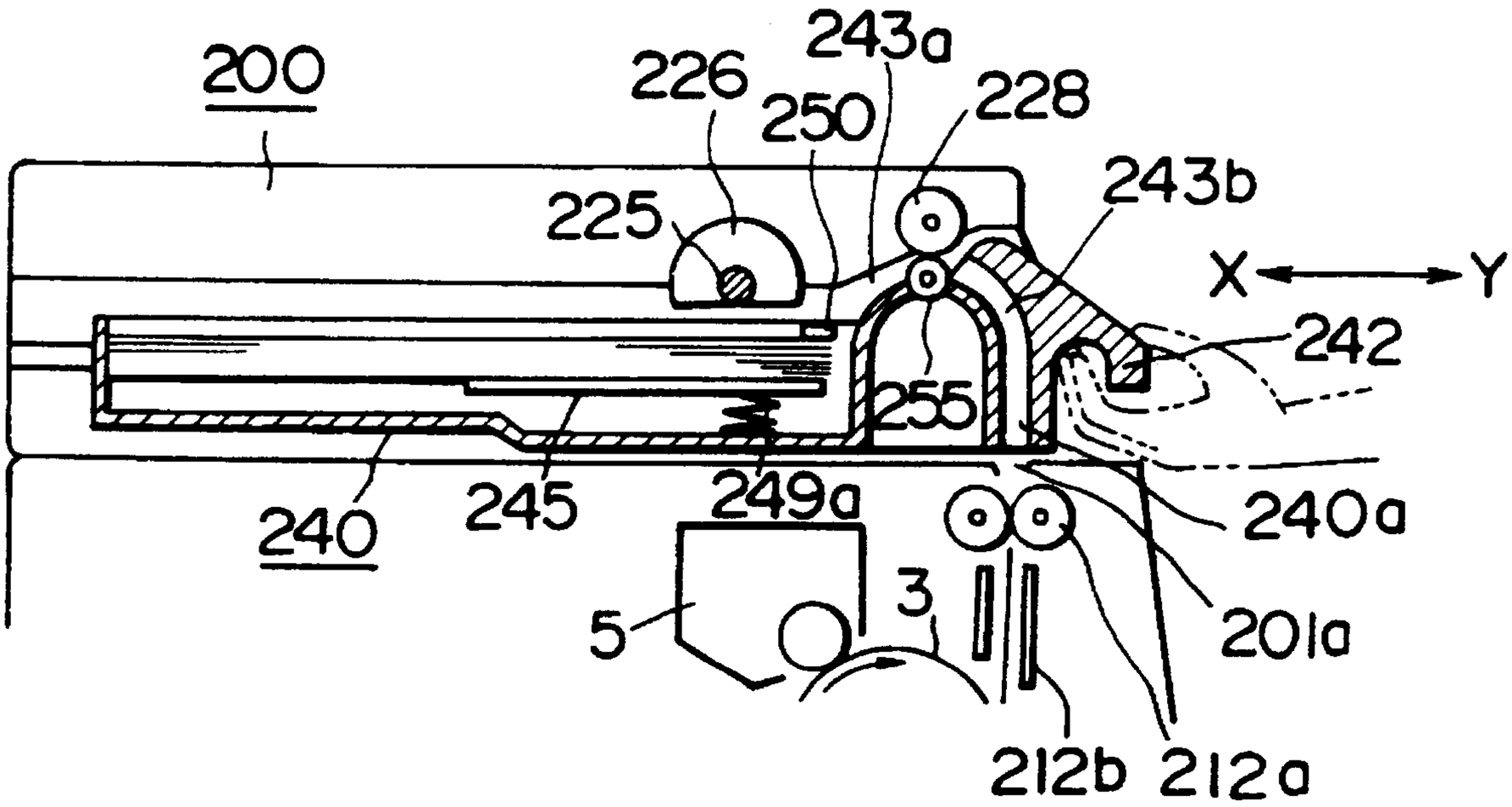

200
226
250
243a
228
243b
225
X
Y
242
255
240
245
249a
240a
3
5
201a
212b
212a

FIG. 13(A)

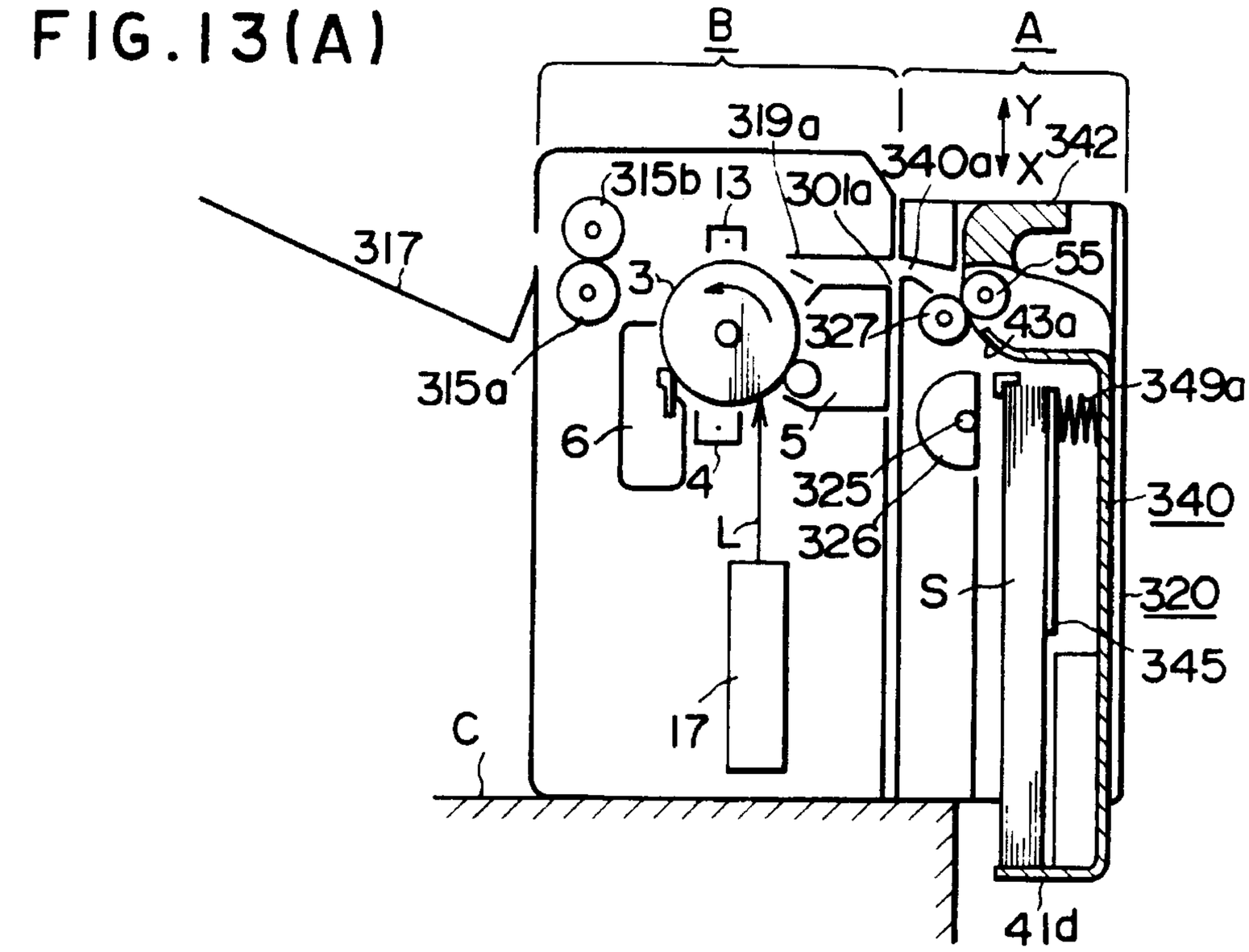


FIG. 13(B)

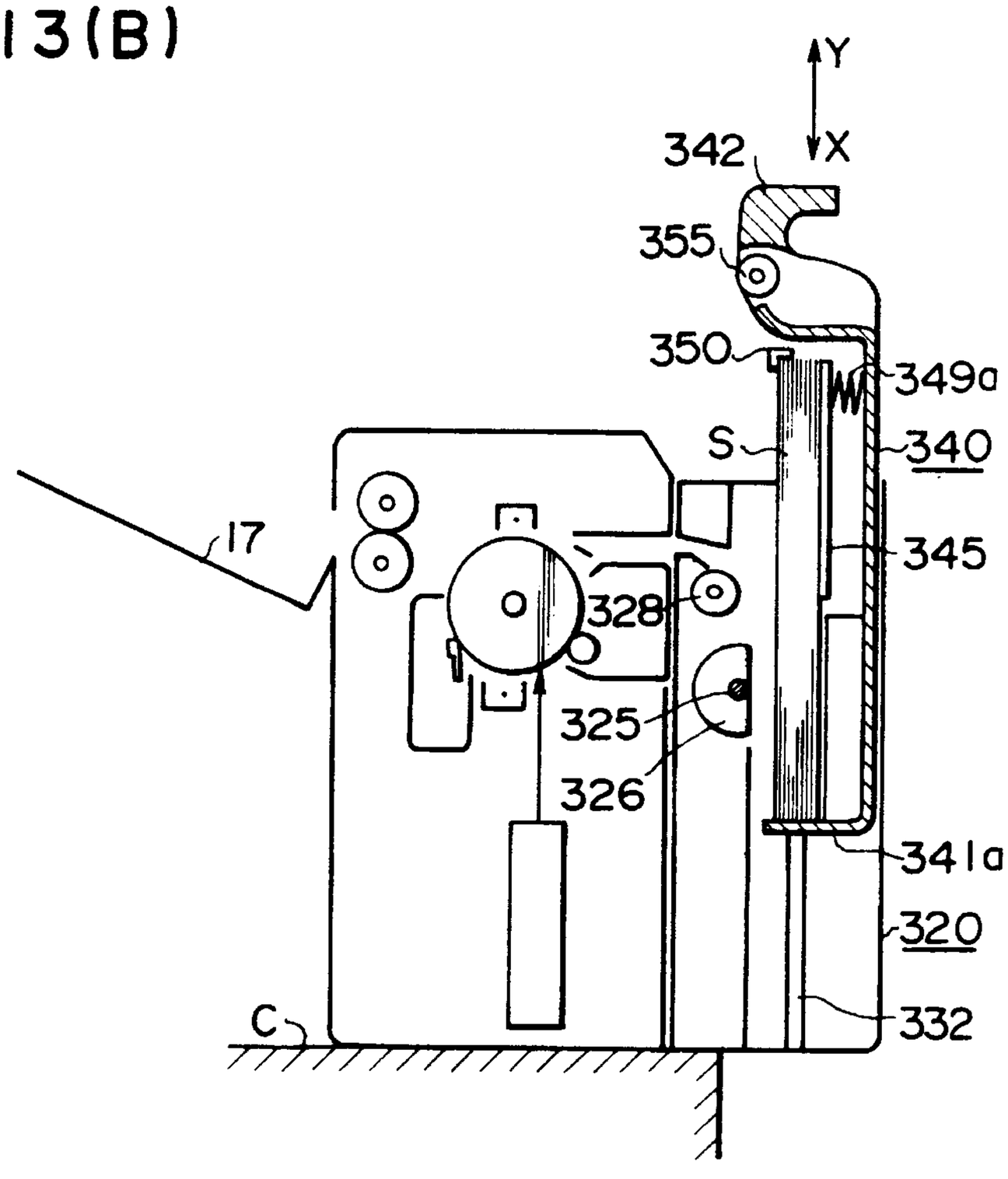


FIG.14

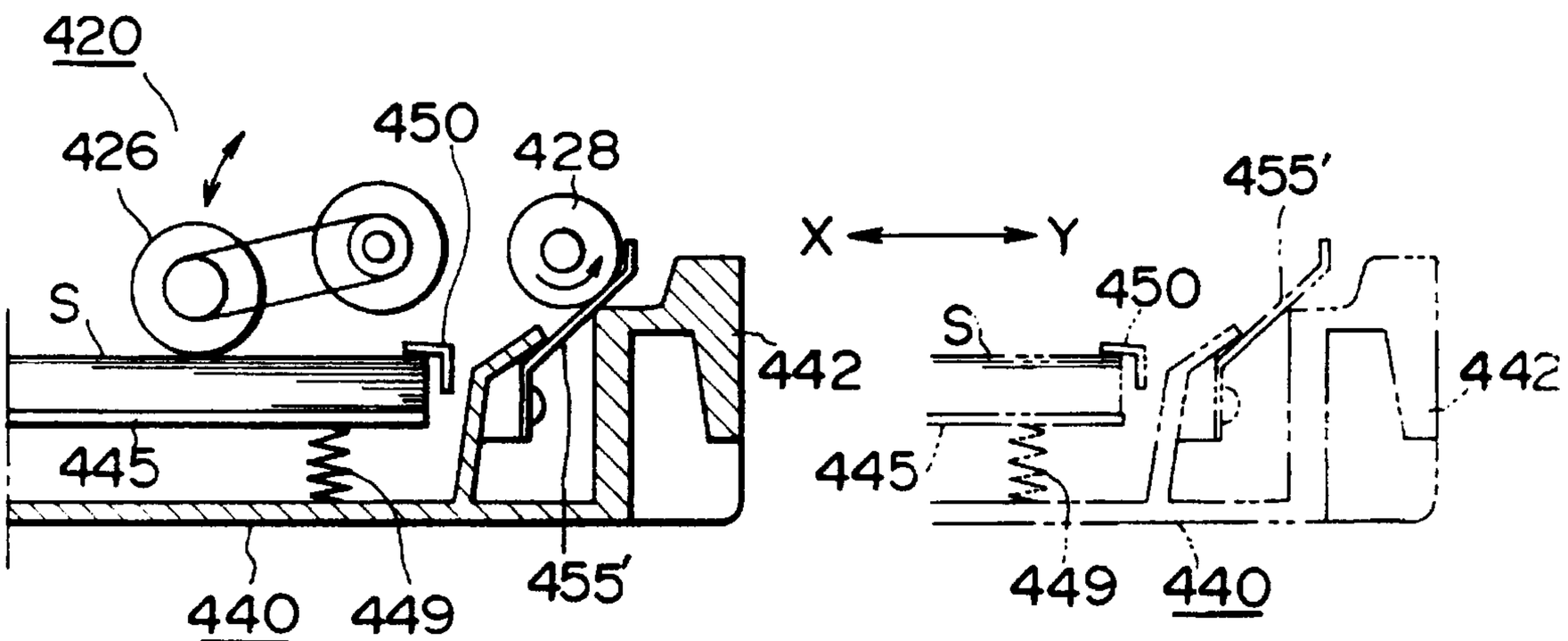


FIG. 15(A)

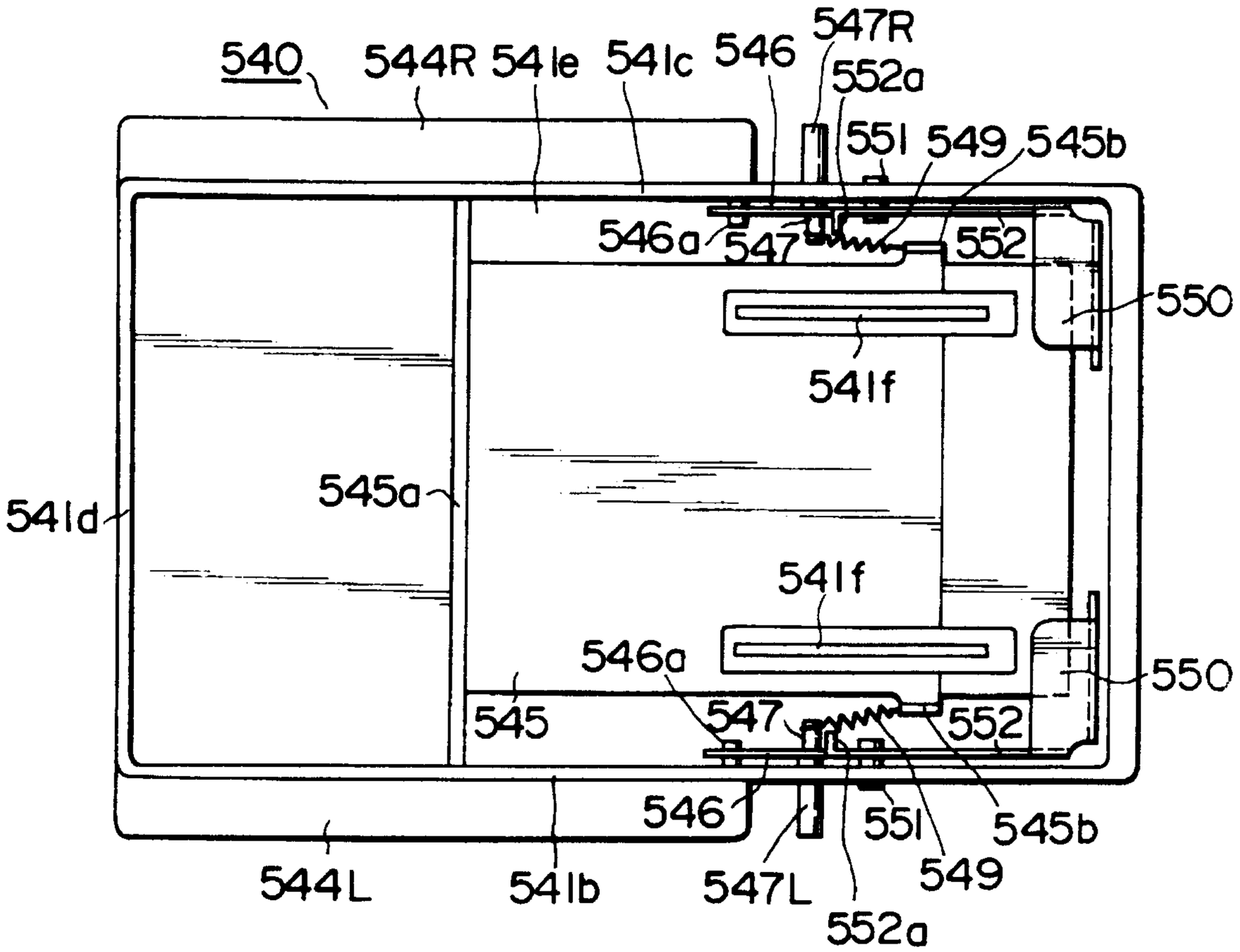
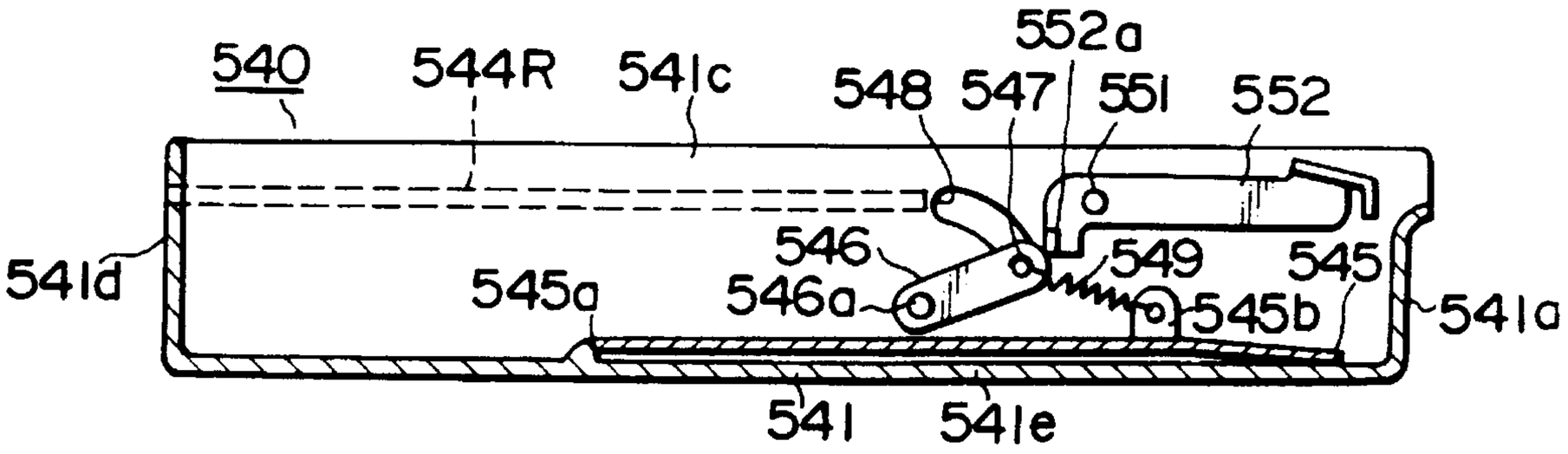


FIG. 15(B)



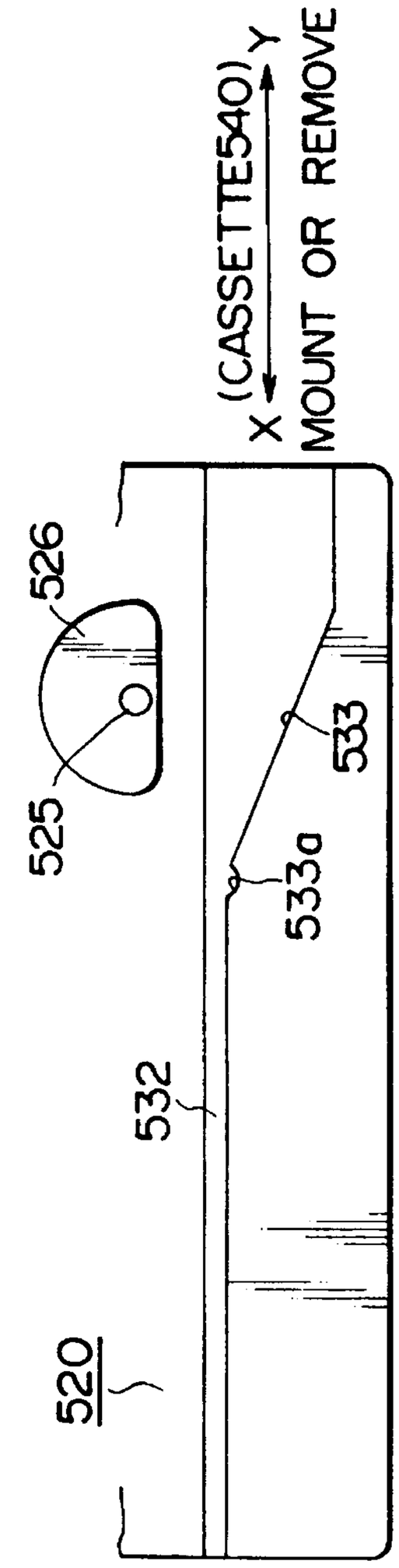


FIG. 15(C)

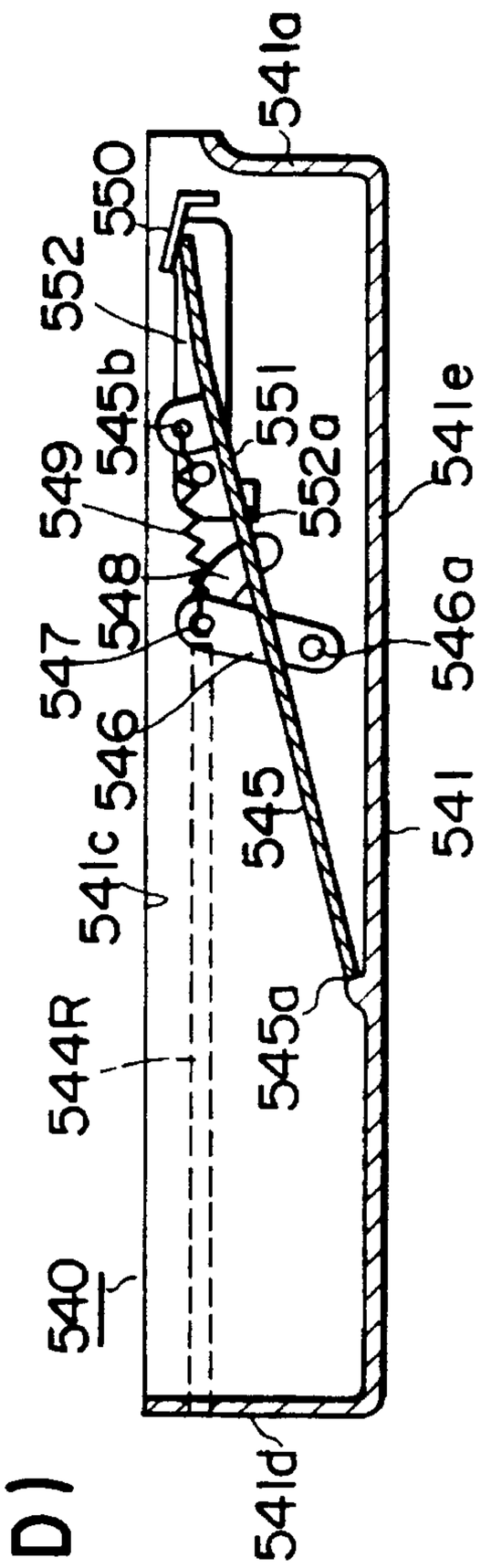


FIG. 15(D)

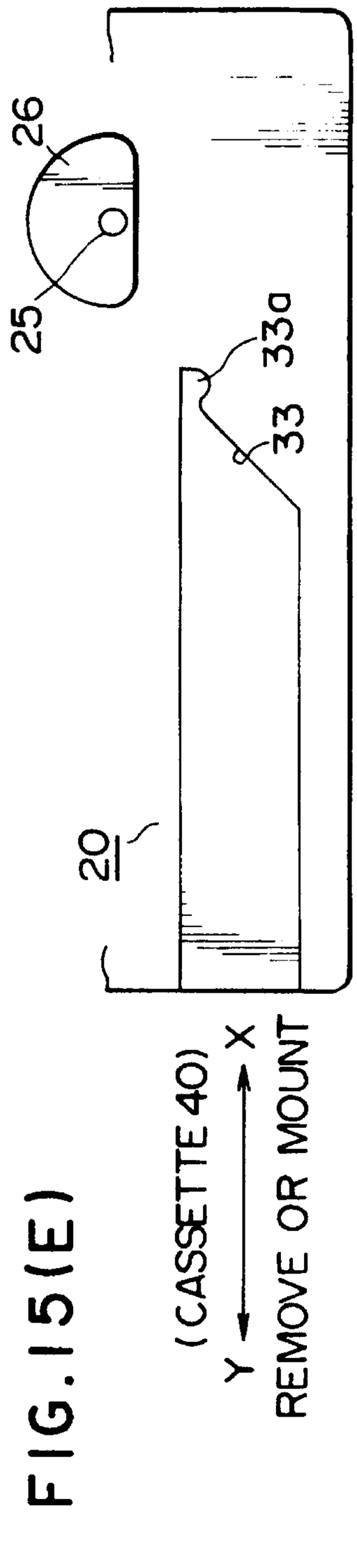


FIG. 15(E)

SHEET FEED APPARATUS FOR IMAGE FORMING SYSTEM

Matter enclosed in heavy brackets [ ] appears in the original patent but forms no part of this reissue specification; matter printed in italics indicates the additions made by reissue.

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates a sheet fed apparatus for an image forming system and, more particularly, to a sheet feed apparatus for feeding each sheet (i.e., a cut sheet such as a copying sheet, a transfer sheet, or a recording sheet) stored in a sheet storage unit to a main unit (e.g., a copying machine or printer) for receiving each sheet and performing predetermined processing such as image formation on the received sheet.

2. Related Background Art

A typical example of the main unit and sheet feed apparatus described above is shown in FIG. **1**. FIG. **1** shows a laser beam printer (LBP) from which a process cartridge and a sheet cassette are detachable.

The laser beam printer includes a printer housing **100**, and an image forming mechanism is incorporated in the printer housing **100**. The housing **100** is divided into upper and lower halves **100**B and **100**A. The upper half **100**B can be pivoted about a rear end hinge shaft **101** upward with respect to the lower half **100**A and can be open, as indicated by the alternate long and short dashed line. The upper half **100**B can be pivoted downward and can be closed with respect to the lower half **100**A, as indicated by the solid line in FIG. **1**.

The upper half **100**B is always biased by a spring means (not shown) toward an open direction. When the upper half **100**B is completely closed with respect to the lower half **100**A against the biasing force of the spring means, a locking mechanism (not shown) is operated to lock the upper half **100**B with the lower half **100**A. As a result, a closed state can be appropriately maintained, as indicated by the solid line.

When the locking mechanism is released, the upper half **100**B is opened by the biasing force of the spring means, as indicated by the alternate long and short dashed line and is held at a predetermined open angle. Most of the interior of the printer can be observed by an operator.

The upper half **100**B is raised as described above to largely expose the interior of the printer so as to mount a process cartridge **102** in the printer and perform inspection and maintenance of the interior of the printer.

An open side (left end face in FIG. **1**) of the upper half **100**B of the printer is its front side. The hinge shaft **101** is located at the rear side (i.e., the right end face in FIG. **1**) of the printer.

The process cartridge **102** has a cartridge housing **102**a which contains four process units, i.e., a photosensitive drum **103**, a charger **104**, a developing unit **105**, and a cleaner **106**. The process cartridge **102** is detachable from a predetermined storage section at about the central portion of the upper half **100**B. The cartridge **102** is mechanically and electrically connected to the printer such that mechanical drive and electrical circuit systems of the cartridge and the printer are connected through a coupling member (not shown). A laser scanner unit **107** and a laser reflecting mirror **108** are arranged at predetermined positions inside the upper half **100**B.

A sheet cassette **109** is defined as a sheet storage unit. The cassette leading end of the sheet cassette **109** is inserted from a cassette insertion opening **100**C formed at the lower front end face of the lower half **100**A of the printer. When the sheet cassette **109** is sufficiently inserted in the X direction inside the lower half **100**A along a base plate **100**D in the lowere half **100**A, a boss **109**f formed on the outer bottom surface of the cassette is engaged with an engaging recess **100**E formed on the upper surface of the base plate **100**D, so that the cassette **109** is positioned and mounted in the printer. When the sheet cassette **109** is pulled against the engaging force of the boss **109**f and the recess **100**E in the Y direction, the cassette **109** can be pulled outside the printer.

The sheet cassette **109** includes a main case **109**a and an intermediate plate **109**b located inside the case **109**a. The rear side of the intermediate plate **109**b is biased by a spring **109**d to pivot upward about a pivot portion **109**c. Sheets (i.e., transfer sheets) S are stacked on and stored in the main case **109**a. The sheet S extend on the upper surface of the intermediate plate **109**b and the inner bottom surface of the main case **109**a. The level of the upper surface of the stack of sheets S is kept unchanged regardless of a decrease in sheets upon feeding of each sheet S or the number of stacked sheets since the intermediate plate **109**b is basied upward by the spring **109**d.

A separation pawl **109**e is engaged with the leading ends of the upper surfaces of the sheets S to separate one sheet from the stacked sheets.

A sheet feed system includes a sheet pickup roller **110**, a pair of convey rollers **111**a and **111**b for conveying the sheet picked up by the sheet pickup roller **110**, sheet guide plates **112**, **113**, and **115**, a pair of registration rollers **114**, a transfer charger **116**, a sheet conveyor belt **117**, and a pair of sheet delivery rollers **110**. The printer also includes a fixing unit **118**. The members **110** to **119** are located at predetermined positions in the lower half **100**A.

A sheet delivery opening **100**D is formed in the upper front surface of the lower half **100**A. The pair of sheet delivery rollers **119** oppose the opening **100**D. A delivery sheet tray **100**F is mounted in the printer.

When the upper half **100**B in which the process cartridge **102** is mounted is closed with respect to the lower half **100**A, as indicated by the solid line, the lower surface of the photosensitive drum **103** on the process cartridge **102** side opposes at a normal position the transfer charger **116** mounted in the lower half **100**A and is spaced apart therefrom by a predetermined distance. When the sheet cassette **109** is normally mounted in the lower half **100**A, the upper surface of the leading end of the stack of sheets S opposes the lower position of the sheet pickup roller **110**.

When the image formation start signal is input to a printer control system, the photosensitive drum **103** is rotated at a predetermined peripheral velocity in a direction indicated by an arrow. The outer surface of the photosensitive drum **103** is uniformly charged by the charger **104** to a predetermined polarity (i.e., a positive or negative polarity).

The laser scanner unit **107** generates a pixel laser beam L corresponding to a timer-serial electrical pixel signal of image information input from an original image photoelectric reading unit (not shown), a word-processor (not shown), or a computer (not shown).

The laser scanner unit **107** then scan a surface of the photoelectric drum **103**. That is, the uniformly charged surface of the rotating photosensitive drum **103** is sequentially scanned with the laser beam L from the laser scanner unit **107** through the mirror **108** and an exposure window

102b formed in the cartridge housing **102**a in the axial direction of the drum. Therefore, a latent image corresponding to image information is formed on the photosensitive drum **103**.

The formed latent image is visualized as a tone image by the developing unit **105**, and the toner image is transferred to the sheet S fed to a position of the transfer charger **116** between the photosensitive drum **103** and the charger **116**.

A convey force is applied to the uppermost sheet S stored in the sheet cassette **109** upon counterclockwise rotation of the pickup roller **110**. The leading side of the sheet is moved from a position below the separation pawl **109**e to a position above the separation pawl **109**e. Only the upermost sheet is picked up and fed in the same direction as the mounting direction of the cassette **109**. The sheet is guided by the guide plate **112** and is relayed and conveyed by the pair of convey rollers **111**a and **111**b. The sheet is then U-turned toward the registration rollers **114** located above the sheet pickup roller **110** in a direction (i.e., from right to left in the printer) opposite to the direction for picking up the sheet from the cassette **109**. The U-turned sheet is fed by the registration rollers **114** between the photosensitive drum **103** and the transfer charger **116** through the guide plate **115** from the right in synchronism with rotation of the photosensitive drum **103**. Therefore, the toner image formed on the photosensitive drum **103** is transferred to this sheet.

The sheet which received the toner image during feeding of the sheet between th photosensitive drum **103** and the charger **116** from the right to the left is separated from the surface of the photosensitive drum **103** by a separating means (not shown). the sheet is then conveyed in the fixing unit **118** by the conveyor belt **117**, and the toner image is fixed. The sheet is then delivery as an image-formed product (print) on the tray **100**F through the pair of delivery rollers **119** and the delivery opening **100**D. After toner image transfer, a residual toner on the surface of the photosensitive drum **103** is removed by the cleaner **106**, and the drum surface is cleaned to prepare for the next image formation cycle.

A rear surface plate **120** of the lower half **100**A of the printer can be pivoted downward about a hinge portion **121**, as indicated by the alternate long and two short dashed line in FIG. **1**. The curved guide plate **112** and the roller **111**b of the pair od sheet convey rollers **111**a and **111**b are disposed inside the rear surface plate **120**. When the sheet is jammed in a U-turned sheet path from the sheet pickup roller **110** to the registration roller **114**, the rear surface plate **120** is moved down and opened to remove the jammed sheet.

The conventional laser printer described above has the following problems.

(1) Since the feed direction of the sheet S picked up by the sheet pickup roller **110** from the sheet cassette **109** serving as a sheet storage unit inserted in the printer as the main unit is the same as a direction X for inserting the sheet cassette **109** into the printer, the position of the sheet with respect to the cassette is the cassette insertion/mounting leading end. The size of the cassette **109** varies depeneding on different lengths of sheet S. An extended portion of each cassette from the cassette insertion/removal opening **100**C toward the front surface of the printer varies depending on different cassette sizes, resulting in poor appearance.

When a cassette **109**' (indicated by the alternate long and two short dashed line) which stores longer sheets in the feed direction is mounted in the printer, an extended length P' of the rear end portion of the cassette is increased, and the space for installing the printer is undesirably increased.

(2) Since the sheet S in the cassette **109** is fed from the cassette insertion/mounting direction leading end in a cassette insertion/mounting direction, the fed sheet is U-turned in a direction opposite to the sheet pickup direction and is conveyed to the transfer unit as a sheet processing unit through the sheet guide plates **112** and **113**. The frequency of occurrence of jamming in the U-turn guide plates **112** and **113** is higher than that in other portions in practise. In addition, since the U-turn guide plates **112** and **113** are located in the rear portion of the printer, an operator must walk to the rear side of the printer to open the rear surface plate **120** so as to eliminate jamming upon occurence of jamming in the U-turn guide plates **112** and **113**, resulting in inconvenience.

(3) The upper sheets S stored in the cassette may be separated above the separation pawl **109**e by a shock upon mounting of the cassette **109** in the printer. These sheets are undesirably moved from the cassette front end in the sheet feed direction which is the same as the cassette insertion/mounting direction. This causes a feed error of the sheet and double sheet feeding.

(4) The sheet pickup roller **110**, the pair of convey rollers **111**a and **111**b, and the guide plates **112** and **113** which constitute a sheet feeder unit feeding the sheet S from the sheet cassette **109** as the sheet storage unit to a predetermined unit (transfer unit) of the printer as the main unit are permanetly mounted in the lower half of the printer. If a sheet cassette except for a standard cassette and a paper deck are required due to sheets except for standard sheets, the lower unit including the above members must be replaced with a unit corresponding to the paper size.

SUMMARY OF THE INVENTION

It is an object of the present invention to solve the problems described above and to provide a sheet feed apparatus which can be made compact and has excellent operability, and which can appropriately feed a sheet.

In the sheet feed apparatus according to the present invention, the sheets stacked in the sheet storage unit mounted in the sheet feeder unit are fed in a direction opposite to a direction for mounting the sheet storage unit in the feeder unit and are fed to the main unit. Therefore, problems (1), (2) and (3) posed by the conventional system wherein the sheets stored in the sheet storage unit are fed in the same direction as the sheet storage unit mounting direction can be solved.

The sheet feeder unit can be detachable from the main unit, and therefore, problem (4) can also be solved.

Since the sheet storage unit which is mounted in or removed from the sheet feeder unit includes a sheet convey member, continuous conveyance of the sheet picked up from the sheet storage unit can be assured. Therefore, jamming of the sheet immediately after pickup of the sheet can be greatly reduced.

Even if jamming occurs, the sheet storage unit can be pulled from the feeder unit. The sheet convey member is pulled together with the sheet storage unit. Therefore, an operation for eliminating jamming can be facilitated.

The above-mentioned conventional printer has the following drawback. As previously described, the sheet stored in the cassette **109** serving as the sheet storage unit is picked up forward from the cassette **109** by the sheet pickup roller **110**. The sheet is guided by the curved guide plate **112** supported by the rear surface plate which can be pivoted about the hinge portion **121**. The sheet is then guided to the

sheet convey rollers **111**a and **111**b. A gap is formed in a sheet transfer portion between the front end serving as a sheet outlet of the cassette **109** and the curve convey guide plate **112**. The curved guide plate **112** is supported by the member **120** pivoted about the hinge portion **121**. It is therefore difficult to appropriately position the sheet. Jamming often occurs due to a transfer error in the transfer portion between the front end of the cassette **109** and the guide plate **112**.

This sheet transfer portion is located in the rear portion of the printer as the main unit. The operator must walk to the rear side of the printer to eliminate jamming in the sheet transfer portion, resulting in inconvenience. This inconvenience can be eliminated by the arrangement of the present invention. A maximum distance, l_1 for inserting the sheet storage unit into the sheet feeder unit is larger than a size l_2 of the sheet feeder unit in the sheet storage unit inserting/mounting direction (FIG. **3**). In a normal state wherein the sheet storage unit is sufficiently inserted into the sheet feeder unit, the front end face of the sheet storage unit is almost aligned with the front end face of the main unit. In the normal state of the sheet storage portion mounted in the sheet feeder unit, no extended portion of the sheet storage unit from the main unit is present regardless of different lengths of the sheet storage unit since the front end face of the sheet storage unit is almost aligned with the front end face of the main unit. Therefore, unlike the conventional case (FIG. **1**) wherein rear end portions of the cassette **109** serving as the sheet storage units are extended as the extended portions P and P' on the front side of the printer serving as the main unit, the outer appearance of the printer can be improved.

The distance (maximum insertion stroke) l_1 for inserting the sheet storage unit into the sheet feeder unit is larger than the size l_2 of the sheet feeder unit in the sheet storage unit mounting direction. Therefore, longer sheet storage unit having a length larger than the size l_2 can be inserted into the sheet storage unit. In a normal state wherein the sheet storage unit is mounted in the sheet feeder unit, the rear end portion serving as the insertion leading end of the sheet storage unit extends from the rear end face of the rear portion of the feeder unit or main unit. However, as compared with the front-end outer appearance of FIG. **1**, the outer appearance of the present invention can be much improved.

The sheet storage unit includes a vertically pivotal intermediate plate on which sheets are stacked, a spring member for biasing the intermediate plate upward, and a transmission member for transmitting the biasing force of the spring member to the intermediate plate. When the intermediate plate receives the biasing force of the spring member through the transmission member, the intermediate plate is urged upward. However, when the intermediate plate does not receive the biasing force, the intermediate plate is located at the lowermost position by its own weight, so that a large distance is set between the intermediate plate and the one-sheet separation member. During replenishment of the sheet storage unit with sheets, the sheet storage unit must be kept in a state wherein no biasing force is applied to the intermediate plate. In this state, the intermediate plate is kept at the lowermost position, and the distance between the intermediate plate and the one-sheet separation member can be kept to be large. Therefore, the sheets can be quickly replenished without being interfered by a biasing force and the separation member.

Since a biasing spring member is not arranged below the intermediate plate, a low-profile sheet storage unit can be provided.

As compared with the above arrangement, the conventional case has the following drawback.

In the conventional printer as previously described, the separation pawl **109**e of the cassette **109** serving as a sheet storage unit is stabilized in a state wherein the separation pawl **109**e is urged upward to the highest level at the leading end (or leading end of the sheet on the intermediate plate) of the intermediate plate **109**b always biased upward by the spring **109**d. In order to replenish the main case **109**a with sheets S, the operator must move the intermediate plate **109**b downward against the biasing force of the biasing spring **109**d while offsetting thr leading ends of the sheets S from the separation pawl **109**e.

Operability for replenishing the sheets S into the cassette is thus poor.

In addition, since the spring **109**d is present below the intermediate plate **109**b, at least a space for minimum height of the spring **109**d and a thickness (generally 3 mm or more) of the molded wall of the cassette main case **109**a is required. In practice, the spring **109**d cannot be compressed to its minimum height due to its fatigue. Therefore, a sufficient margin must be assured to fail to provide a low-profile cassette **40**.

The above problem can be solved by the arrangement of the present invention.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a longitudinal sectional side view showing a conventional sheet feed apparatus;

FIG. **2** is a longitudinal sectional view showing a sheet feed apparatus according to an embodiment of the present invention and a printer (LBP) serving as a main unit combined with the sheet feed apparatus;

FIG. **3** is an longitudinal sectional side view showing a relationship between a cassette size and an extension length in an image forming apparatus shown in FIG. **2**;

FIG. **4** is a plan view of a sheet feeder;

FIG. **5** is a front view of the sheet feeder shown in FIG. **4**;

FIG. **6** is a longitudinal sectional side view of the sheet feeder shown in FIG. **4**;

FIG. **7** is a plan view of a sheet cassette;

FIG. **8** is a front view of the sheet cassette shown in FIG. **7**;

FIG. **9** is a rear view of the sheet cassette shown in FIG. **7**;

FIG. **10** is aleft side view of the sheet cassette shown in FIG. **7**;

FIG. **11** is a longitudinal sectional side view of the sheet cassette shown in FIG. **7**;

FIG. **12**(A), **12**(B), AND **12**(C) are views showing a sheet feed apparatus according to another embodiment of the present invention;

FIGS. **13**(A) and **13**(B) are views showing a sheet feed apparatus according to still another embodiment of the present invention;

FIG. **14** is a longitudinal sectional view showing a main part of a structure of a convey roller;

FIGS. **15**(A) to **15**(D) show another arrangement of a spring member for biasing an intermediate plate upward, in which FIG. **15** (A) is a plan view of a cassette, FIG. **15** (B) is a longitudinal sectional side view of the cassette, FIG. **15**

(C) is a longitudinal section side view of cassette insertion portion, and FIG. **15** (D) is a longitudinal sectional side view showing a state wherein the cassette is inserted into the insertion portion; and

FIG. **15** (E) is a longitudinal sectional side view showing another arrangement of the cassette insertion portion.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

FIG. **2** is a longitudinal sectional side view showing an arrangement including a sheet feed apparatus A according to an embodiment of the present invention and a laser beam printer B serving as a main unit and combined with the sheet feed apparatus A according to the present invention.

The sheet feed apparatus A is prepared separately from the printer B as the main unit and serves as an optional unit which is detachable from the printer B. The sheet feed apparatus A is placed on a base C, and the printer B as the main unit is placed on the sheet feed apparatus A. Projections **18** extending on the lower surface of the printer B are fitted in recesses **24** formed in an upper surface plate **21** of the sheet feed apparatus A, thereby combining the sheet feed apparatus A with the printer B.

A sheet inlet **19** is formed in the bottom surface of the printer B and corresponds to a nip position between a sheet pickup roller **10** and a sheet convey roller **12**, both of which are located inside the printer B. When the printer B is positioned on the sheet feed apparatus A as described above, the sheet inlet **19** of the sheet feed apparatus A is located above a pair of sheet convey rollers **28** and **55** located at the front side portion of the upper surface plate **21** of the sheet feed apparatus A.

The respective components of the present invention will be described below.

I. Printer B

An arrangement and image forming operations of the printer B will be described below. The printer B has a housing **1**. The right end face in FIG. **2** is the front surface of the printer B. The housing **1** includes a front surface **1**A. the front surface plate **1**A can be pivoted about a hinge shaft **1**B mounted on the lower side of the housing **1** and is open, as indicated by the alternate long and two short dashed line. The front surface plate **1**A can be closed, as indicated by the solid line. The front surface plate **1**A is open to largely expose the interior of the printer B in order to mount a process cartridge **2** into the printer B or remove it therefrom or to perform inspection and maintenance.

The process cartridge **2** includes a cartridge housing **2**a which contains four image processing units, i.e., a photosensitive drum **3**, a charging roller **4**, a developing unit **5**, and a cleaner **6**. The front surface plate **1**A is open, as indicated by the alternate long and two short dashed line, to be detachably mounted in a predetermined storage portion in the printer housing **1**. When the cartridge **2** is normally mounted in the printer B, mechanical driving systems and electrical driving systems of the cartridge and the printer are mechanically and electrically coupled through a coupling member (not shown).

A laser beam scanner **7** is located deep in the housing **1**. The laser beam scanner **7** comprises a semiconductor laser, a scanner motor **7**a, a polygonal mirror **7**b, and a lens system **7**c. A laser beam L from the scanner **7** almost horizontally propagates into the housing **2**a through an exposure window **2**b formed in the cartridge housing **2**a mounted in the printer B. The laser beam L passes through an optical path formed between the cleaner **6** and the developing unit **5** formed in the upper and lower positions in the housing. The laser beam L scans and exposes the surface of the photosensitive drum in its axial direction.

A multifeed tray **8** is attached to the lower end side of the front surface plate **1**A so as to extend outward and inclined upward from its proximal end to its distal end. A plurality of sheets S can be simultaneously set on the multifeed tray **8**. The tray **8** can be folded about a hinge shaft **8**a at the proximal end of the tray **8** to come close to the front surface plate **1**A when it is not used. An opening **9** is formed at the lower side of the printer front surface plate **1**A. The proximal end of the multifeed tray **8** corresponds to this opening.

A sheet pickup roller **10** is disposed in the lower portion inside the front surface plate **1**A. A sheet separation pad **11** is located in contact with the lower side of the sheet pickup roller **10**. A convey roller **12** is in contact with the left side of the sheet pickup roller **10**. the convey roller **12** is disposed in the printer **1**. A transfer roller **13** is located above the pickup roller **10** inside the front surface plate **1**A. A pair of fixing rollers **15**a and **15**b are disposed in the upper portion inside the front surface plate **1**A. A sheet guide plate **14** is located between the transfer roller **13** and the pair of fixing rollers **15**a and **15**b. A sheet delivery roller **16** is located at the sheet outlet. A tray **17** is located at the sheet outlet.

The members **8** to **11** and **13** to **17** are located on the side of the printer front surface plate **1**A. In a closed state of the front surface plate **1**A with respect to the printer housing **1**, as indicated by the solid line, the sheet pickup roller **10** is in contact with the sheet convey roller **12** disposed in the printer housing **1**, and the transfer roller **13** is in contact with the right side of the photosensitive drum **3** in the process cartridge **2** mounted in the printer housing **1**.

When an image formation start signal is input to a printer control system, the photosensitive drum **3** is rotated counterclockwise as indicated by an arrow at a predetermined peripheral velocity. The outer surface of the photosensitive drum **3** is uniformly charged by the charging roller **4** to a predetermined polarity (i.e., a positive or negative polarity). The charging roller **4** is a conductive member to which a predetermined voltage is applied. The photosensitive drum **3** is charged by this roller in accordance with so-called contact (or direct) charging scheme. The charging roller **4** may be driven by the photosensitive drum **3** or may be rotated in a direction opposite to that of the photosensitive drum **3**. Alternatively, the charging roller **4** need not be rotated, or may comprise a friction charging member or a corona charger.

A pixel laser beam L corresponding to a time-serial electrical pixel signal of image information output from on the laser beam scanner **7** is incident on a uniformly charged exposed portion **3**a of the photosensitive drum **3**. Main scanning with the laser beam L is performed on the surface of the drum **3** in the axial direction, thereby forming a latent image of the image information on the surface of the photosensitive drum **3**.

The latent image on the surface of the drum **3** is converted into a toner image by a developing agent carried by a developing sleeve (or roller) **5**a of the developing unit **5**.

The developing unit **5** includes a hopper **5**b for storing a developing agent (toner) t, and a developing agent stirring/convey member **5**c which is rotated in a direction of an arrow to stir the developing agent t in the hopper **5**a and continuously supply the developing agent to the developing sleeve **5**a.

Of the sheets (transfer sheets) S set on the multifeed tray **8**, the uppermost sheet is separated from other sheets by the pickup roller **10** which is rotated clockwise and the separation pad **11**. The sheet is then fed in the printer through the opening **9**. The leading end of the sheet is clamped at the nip portion between the pickup roller **10** and the convey roller **12** and is conveyed toward a contact portion (transfer unit) between the photosensitive drum **3** and the transfer roller **13** at the same speed as the peripheral velocity of the photosensitive drum **3**. During feeding, the leading end of the sheet is detected by a sheet sensor PH located at a predetermined position in a sheet path between the pickup roller **10** an the transfer roller **13**. The laser beam scanner **7** starts exposure and scanning (image information write operation) the surface of the photosensitive drum **3** in accordance with image information in response to the sheet leading end detection signal.

During feeding between the photosensitive drum **3** and the transfer roller **13**, a toner image on the photosensitive drum **3** is transferred to the sheet at the transfer unit by a voltage (i.e., a voltage having a polarity opposite to that of the toner) applied to the transfer roller **13** and a pressure between the transfer roller and the photosensitive drum **3**. In this case, the voltage is applied to the transfer roller **13** when the leading end of the sheet reaches the contact portion (transfer unit) between the photosensitive drum **3** and the transfer roller **13**. The transfer roller **13** may be a corona charger.

the sheet which has passed through the transfer unit is separated from the surface of the photosensitive drum **3** and is guided to the guide plate **14**. The sheet is then guided to the pair of fixing rollers **15**a and **15**b. Of the pair of fixing rollers **15**a and **15**b, the roller **15**a which is brought into contact with the image surface of the sheet comprises a heating roller incorporating a halogen heater. The roller **15**b which is brought into contact with a non-image surface of the sheet comprises an elastic press roller. During feeding of the image-transferred sheet between the pair of rollers **15**a and **15**b, the toner image is fixed on the sheet surface by heat and pressure. The image-formed product (print) is delivered by the delivery roller **16** onto the tray **17**.

A residual toner and other contaminants on the surface of the photosensitive drum **3** are cleaned by a cleaning blade **6**a of the cleaner **6**, and the photosensitive drum **3** is ready for the next image formation cycle.

II. Sheet Feed Apparatus A

The sheet feed apparatus A comprises a sheet feeder including at least a sheet feed means and its driving means, and a sheet cassette **40** serving as a sheet storage unit detachable from the sheet feeder **20**.

(1) Sheet Feeder **20**

FIG. **4** is plan view of the sheet feeder **20**, FIG. **5** is a front view thereof, and FIG. **6** is a longitudinal sectional side view thereof.

Referring to FIGS. **4**, **5**, and **6**, the sheet feeder **20** includes a feeder upper surface plate **21**, elongated hollow right and left stands **21**R and **21**L which are mounted on the right and left sides of the upper surface plate **21** so as to be parallel to each other, and pads **22** attached to the lower surfaces of the stands **21**R and **21**L. When the feeder **20** is placed on a horizontal base C, a sheet cassette storage space **23** (FIG. **5**) is defined by the lower surface of the feeder upper surface plate **21**, the upper surface of the base C, and the inner side surfaces of the right and left stands **21**R and **21**L.

Holes (recesses) **24** formed in the feeder upper surface plate **21** are engaged with the corresponding projections **18** (FIG. **2**) formed on the lower surface of the printer B to position the printer B on the feeder **20**. Therefore, the sheet feed apparatus A is combined with the printer B.

A sheet feed roller shaft **25** is rotatably supported between the stands **21**R and **21**L through bearings. Rollers **26** are mounted on the shaft **25** and spaced part from each other at predetermined intervals. The rollers **26** serve as three sheet feeding means. Each roller **26** comprises a roller (D-shaped roller) having a sector-shaped section. Each roller **26** is normally stopped such tat its notched portion **26**a is directed downward (FIGS. **2** and **6**). A sheet convey roller shaft **27** is rotatably supported between the right and left stands **21**R and **21**L through bearings. Sheet convey rollers **28** are mounted on the shaft **27**.

The sheet feed roller shaft **25** is substantially parallel to the sheet convey roller shaft **27**. The convey roller shaft **27** is located at the front end portion of the feeder upper surface plate **21** at a position nearer to the upstream side in the sheet feed direction. Arcuated portions **26**b opposite to the notched portions of the rollers **26** mounted onthe shaft **25** are partially exposed above the upper surface plate **21** through corresponding through holes **29** formed in the upper surface plate **21**.

A stepping motor **30** (FIG. **4**) is arranged inside the right stand **21**R to drive the feed rollers **26** and the convey rollers **28**. A gear train is constituted by gears G**1** to G**5** which are meshed with each other. The gear G**1** is an output gear of the motor **30**. The gear G**2** serves as an idler gear. The gear G**3** is a clutch gear loosely fitted on the right end of the sheet feed roller shaft **25**. Engagement/disengagement of the gear G**3** is controlled by a one-revolution spring clutch **31**. The gear G**4** serves as an idler gear. The gear G**5** is a convey roller shaft gear integrally mounted on the right end of the sheet convey roller shaft **27**.

Upon energization of the motor **30**, the output gear G**1** is rotated counterclockwise. The gears G**2** and G**5** interlocked with the gear G**1** and then rotated. The idler gears G**2** and G**4** are rotated clockwise, while the clutch gear G**3** and the convey roller shaft gear G**4** are rotated counterclockwise. Upon deenergization of a solenoid plunger **31**a of the spring clutch **31**, the clutch gear G**3** is disengaged from the shaft **25** and idles on the shaft **25**. In this state, a rotational force is not transmitted to the sheet feed roller shaft **25**, and the feed rollers **26** are kept stopped. When the solenoid plunger **31**a is temporarily energized, the clutch **31** is actuated and the clutch gear G**3** is engaged with the shaft **25**. The shaft **25** is rotated counterclockwise. Therefore, the sheet feed rollers **26** are rotated counterclockwise (FIG. **6**). Upon one revolution of the shaft **25**, i.e., the rollers **26**, the clutch is disengaged, i.e., the shaft **25** and therefore the rollers **26** are stopped.

The sheet convey roller shaft **27** and therefore the sheet convey rollers are kept rotated counterclockwise through the gears G**1** to G**5** regardless of ON-OFF control of the spring clutch **31** while the motor **30** is kept driven.

Energization lead wires **30**a and **31**b are connected to the motor **30** and the solenoid plunger **31**a, respectively. When the printer B is normally set on the sheet feed apparatus A, electrical coupling members (not shown) of the sheet feed apparatus A and the printer B are coupled to each other. The motor **30** and the solenoid plunger **31**a are connected to a control circuit (not shown) in the printer B through the lead

wires **30**a and **31**b. Alternatively, a plug (not shown) connected to the terminals of the lead wires **30**a and **31**b may be inserted into a socket (not shown) in the printer B to connect the motor **30** and the solenoid plunger **31**a to the control circuit of the printer B when the printer B is normally set on the sheet feed apparatus A.

Guide grooves **32** (FIGS. **5** and **6**) are symmetrically formed on the inner surfaces of the right and left stands **21**R and **21**L to mount a sheet cassette into the printer or remove it therefrom. Cam grooves **33** are symmetrically formed on the inner surfaces of the front end portions of the right and left stands **21**R and **21**L.

(2) Sheet Cassette **40**

FIG. **7** is a plan view of the sheet cassette, FIG. **8** is front view thereof, FIG. **9** is a rear view thereof, FIG. **10** is left side view thereof, and FIG. **11** is a longitudinal sectional side view thereof.

The cassette **40** includes a main case **41** having an open upper surface and a rectangular section. The case **41** includes a front wall **41**a, a left side wall **41**b, a right side wall **41**c, a rear wall **41**d, and a bottom plate **41**e. A handle **42** is attached to the outer surface of the front wall **41**a. A sheet guide plate **43** is mounted on the inner surface of the front wall **41**a and inclined upward from its proximal end to its distal end. Elongated flanges **44**L and **44**R extend outward from the upper sides of the left and right side walls **41**b and **41**c of the case along the longitudinal direction of the walls **41**b and **41**c. The case **41** (**41**a and **41**e), the handle **42**, the guide plate **43**, the left and right elongated flanges **44**L and **44**R are constituted by a single resin molder member.

An intermediate plate **45** is stored in the case **41**. The front end of the intermediate plate **41** can be vertically pivoted about a rear side **45**a. The sheets are stacked on the intermediate plate **45** and are stored in the case **41**.

An L-shaped pressure lever **46** (FIGS. **2** and **11**) srves as a pressure transmitting member for vertically pivoting the intermediate plate **45**. The level **46** can be pivoted about a shaft **46**a mounted at the front end of the intermediate plate **45**. One horizontal arm **46**b is located below the lower surface of the front end portion of the intermediate plate **45**. When the lever **46** is pivoted clockwise about the shaft **46**a, the horizontal arm **46**b is raised, and the intermediate plate **45** is pivoted upward about the rear side **45**a (from a state in FIG. **11** to a state in FIG. **2**).

A pressure shaft **47** is located in front of the level **46**. The left and right ends of the shaft **47** are fitted in symmetrical oblique slots **48** formed in left and right side walls **41**b and **41**c of the case, respectively. Left and right end portions **47**L and **47**R (FIGS. **9** and **10**) of the shaft **47** are exposed outside the left and right side walls. A tension coil spring **49** is hooked between the pressure shaft **47** and a vertical arm **46**c of the lever **46**.

In a state (FIG. **11**) wherein the sheet cassette **40** is removed from the sheet feeder **20**, the lever **46** receives a force by the weight of the intermediate plate **45** and the sheets S stacked thereon. By this force, the lever **46** tends to be pivoted counterclockwise about the shaft **46**a, and the horizontal arm **46**b is almost laid in the horizontal direction. At the same time the intermediate plate **45** also laid on the inner bottom surface of the case **41**. In this state, the pressure shaft **47** receives a tension from the vertical arm **46**c of the lever **46** through the coil spring **49**, and the left and right ends **47**L and **47**R are held at the upper end points of the oblique slots **48**.

A pair of right and left separation pawls **50** separate the uppermost sheet from the remaining sheets and are mounted on the distal end portions of levers **52** which can be vertically pivoted about shafts **51**. The pair of right and left separation pawls **50** correspond to the right and left corners of the leading end of the uppermost one of the sheets S stacked on the intermediate plate **45** in the case **41**. Lever extended portions **53** are formed by extending the distal end portions of the levers **52** over the positions of the separation pawls **50**, respectively. The extended portions **53** are located above the pressure shaft **47**. In the state (FIG. **11**) wherein the sheet cassette **40** is removed from the sheet feeder **20**, the extended portions **53** are placed on the pressure shaft **47** whose end portions are pulled to the upper end positions of the oblique slots **48**. The levers **52** are held to be almost horizontal, and their downward pivotal movement is prevented. As a result, downward movement of the pawls **50** is also prevented.

Rollers **55** serving as sheet convey members and located on the side of the upper side of the sheet guide plate **43** are rotatable about a shaft **54**. The sheet convey rollers **55** are driven rollers which are paired with the sheet convey rollers **28** serving as driving rollers (FIG. **2**) on the feeder **20** side. When the sheet cassette **40** is sufficiently inserted and mounted in the feeder **20**, the sheet convey rollers **55** are located at positions corresponding to the sheet convey rollers **28** in the feeder **20** and are brought into contact therewithy. In this case, the rollers **55** are biased by a biasing means (not shown) toward the rollers **28** and are threfore in contact with the rollers **28** at a predetermined pressure.

A stacked sheet side press member **56** (FIG. **7**) is mounted inside the left side wall **41**b of the case **41**, and a biasing spring plate **57** urges the side press member **56** against the side surfaces of the stacked sheets at a predetermined pressure.

(3) Storage of Sheets in Cassette **40**

Stacking and storage (to be described in detail later) of the sheets S in the sheet cassette **40** are performed through the upper surface opening of the case **41** after the cassette **40** is removed from the feeder **20**. In the state (FIG. **11**) wherein the cassette **40** is removed from the feeder **20**, the intermediate plate **45** in the case **41** is laid on the inner bottom surface, i.e., located at the lowermost pivotal position, as described above. The extended portions **53** of the levers **52** having the separation pawls **50** are supported on the pressure shaft which is pulled upward to the upper end positions of the oblique slots **48**. The levers **52** are kept almost horizontal and their downward movement is prevented. Therefore, the levers **52** are located near the upper surface opening of the case **41**. Spaces between the front end of the intermediate plate **45** and the separation pawls **50** are kept large, and the sheets S can be quickly stored into the case **41**.

In the conventional cassette **109** shown in FIG. **1**, the separation pawl **109**e is stabilized at the uppermost level at the front end of the intermediate plate **109**b or the leading end of the sheet S which is always biased upward by the sping **109**d. The sheets S are replenished into the case **109**a while the intermediate plate **109**b is moved downward against the biasing force of the spring **109**d so as to offset the separation pawl **109**e. Operability for sheet replenishment is degraded, as previously described.

The cassette **40** of the present invention can eliminate this drawback.

(4) Mounting of Cassette **40**

The sheet cassette **40** is mounted in the feeder **20** as follows. The cassette **40** inserted (a direction of an arrow X in FIG. **1**) from the front surface of the feeder **20** into the sheet cassette storage space **23** (FIG. **5**) defined by the lower

surface of the upper surface plate **21**, the upper surface of the base C, and the inner side surfaces of the right and left stands **21**R and **21**L of the feeder **20**. In this case, the rear surface wall **41**d of the cassette **40** is a leading end during insertion, and the elongated flanges **44**R and **44**L at the right and left sides of the cassette are fitted in the corresponding guide grooves **32** formed on the inner surfaces of the right and left stands **21**R and **21**L.

When the cassette **40** is sufficiently inserted into the feeder **20**, lower surfaces of projections **42**a of the handle **42** on the front surface of the cassette abut against distal end portions **32**a (FIGS. **4** and **6**) of the guide grooves **32**, and further insertion of the cassette **40** can be prevented. The cassette **40** can be set in the feeder **20** at a proper insertion position. In this mounting state, the front end (i.e., the trailing end) of the cassette **40** is almost aligned with the front surface of the printer B, and an extended portion of the cassette **40** outside the printer B can be eliminated. The extended portions P and P' of the trailing ends of the conventional cassettes in FIG. **1** toward the front side of the printer can be eliminated, thereby improving the outer appearance.

As shown in FIG. **3**, the maximum insertion distance l_1 of the cassette **40** into the feeder **20** is set to be larger than the size l_2 of the feeder **20** in the cassette mounting direction. The cassette **40'** having a length larger than the size l_2 can be inserted and mounted in the feeder **20**. In this case, in the state wherein the cassette **40'** is normally mounted in the feeder **20**, the rear end (i.e., the leading end) of the cassette **40'** appears as indicated by the alternate long and short dashed line in FIG. **3**, thus exposing the extending portion P' outside the rear portion of the feeder **20** or the printer B serving as the main unit. As previously described, unlike the extended portions P and P' of the cassettes **109** in the conventional case, the outer appearance can be improved.

The sheet feed rollers **26** located on the side of the upper surface plate **21** of the feeder **20** are rollers (D-shaped rollers) each having a sector-shaped section. Each roller **26** is stopped while its notched portion **26**a is directed downward. Therefore, when the cassette **40** is inserted into the feeder **20**, the upper side of the rear wall **41**d of the case **41** passes under the notched portions **26**a of the sheet feed rollers **26** and is not in contact therewith.

The intermediate plate **45** does not receive an upward pivotal force from the pressure level **46** until the cassette **40** is sufficiently inserted into the feeder **20** and normally mounted therein. The intermediate plate **45** is kept laid on the inner surface of the bottom plate **41**e of the case **41**, as shown in FIG. **11**. The sheets S on the intermediate plate **45** are horizontally stored in the case **41**. During insertion of the cassette **40** into the feeder **20**, the upper surface of the uppermost sheet of the sheets S stacked in the case **41** is spearated from the notches portions **26**a of the sheet feed roller **26**. No interference between the upper surface of the uppermost sheet S in the cassette **40** and the feed rollers **26** occurs.

The feed rollers **26** in the feeder **20** are constituted by rollers each having a sector-shaped section, and the notches **26**a are normally directed downward. Therefore, the sheet cassette storage space **23** defined by the lower surface of the upper surface plate **21**, the upper surface of the base C, and the inner side surfaces of the right and left stands **21**R and **21**L can have a sufficient height. Therefore, the capacity for storing the sheet cassette **40** can be increased.

The right and left end portion **47**R and **47**L of the pressure shaft **47** extending outward from the right and left side walls **41**c and **41**b of the cassette **40** are respectively engaged with the cam grooves **33** formed on the inner surfaces of the right and left stands **21**R and **21**L of the feeder **20** immediately before the cassette **40** is normally mounted in the feeder **20** upon insertion of the cassette **40** into the feeder **20**. The right and left end portions **47**R and **47**L of the pressure shaft **47** receive a downward force by the insertion force of the cassette **40** along the cam grooves **33**. The shaft **47** is moved downward since its both ends fitted in the oblique slots **48** are moved from the upper end points to the lower end points. Upon downward movement of the pressure shaft **47**, the pressure lever **46** is pivoted clockwise about the shaft **46**a through the tension coil spring **49**. The horizontal arm **46**b of the lever **46** is raised, and the intermediate plate **45** which supports the sheets S is pivoted about the rear side **45**a so as to be inclined from the rear side to the front side.

When the cassette **40** is sufficiently inserted and normally mounted in the feeder **20**, both the ends of the pressure shaft **47** reach the lower end points. More specifically, the right and left end portions **47**R and **47**L are held by lower ends **33**a (FIG. **5**) of the cam grooves **33**.

Since the pressure shaft **47** which supports the extended portions **53** of the separation pawl levers **52** is moved downward along the slots **48**, the levers **52** are pivoted downward (clockwise) about the shafts **51** at the initial period of downward movement. However, the separation pawls **50** are received by the corners of the leading end of the sheets S moved upward by upward pivotal movement of the front end of the intermediate plate **45** upon further downward movement of the pressure shaft **47**. Therefore, further downward movement of the levers **52** is prevented, and the pressure shaft **57** is separated from the lever extended portions **53**. The separation pawls **50** are placed on the stacked sheets S by their own weight since the extended portions **53** are separated form the pressure shaft **57**. Therefore, each pawl is operated as a one-sheet separation pawl.

The sheet convey rollers **55** in the cassette **40** are respectively in contact (FIG. **2**) with the front sides of the sheet convey rollers **28** in the feeder **20** when the cassette **40** is completely mounted in the feeder **20**.

FIG. **2** shows positions and states of the respective members of the sheet feed apparatus A when the cassette **40** is perfectly mounted in the feeder **20**.

(5) Operation of Feeder **20**

When a mode for using the sheet feed apparatus A is selected at the console of the printer B serving as the main unit and an image formation start signal is input to a control circuit in the printer B, the stepping motor **30** in the feeder **20** is energized and is rotated. Upon rotation of the motor **30**, the gears G**1** to G**5** are rotated, and the sheet convey rollers **28** are rotated counterclockwise in FIG. **2**.

The sheet convey rollers **55** of the cassette **40** which ar brought into contact with the rollers **28** and paired therewith are driven. The sheet feed rollers **26** are kept stopped since the one-revolution spring clutch **31** is kept in a disengaged state. Thereafter, when the solenoid plunger **31**a of the feeder **20** is temporarily energized from the control circuit of the printer in accordance with a sheet feed start signal, the spring clutch **31** is engaged, and the sheet feed rollers **26** are rotated clockwise (FIG. **2**) by one revolution. Upon one revolution of the feed rollers **26**, the arcuated portions **26**a of the rollers **26** are brought in contact with the upper surface of the uppermost sheet of the sheets stacked on the intermediate plate **45**. A feed force in a direction opposite to the direction X for mounting the cassette **40** in the feeder **20** acts on the upper surface of the uppermost sheet. The uppermost

sheet is separated from other sheets s by the separation pawls **50** and is fed in a direction of the front wall **41**a of the cassette **40**.

The leading end of the fed sheet is guided by the guide plate **43** and gripped by the nip portion between the pair of sheet feed rollers **27** and **55** from the lower direction. The sheet is then conveyed upward and is fed in the printer B through the sheet inlet **19**. The sheet fed in the printer is gripped by the nip portion between the feed and convey rollers **10** and **12** in the printer B through a guide plate **19**a. The sheet is then fed to the transfer roller **13**. An image formation operation in the printer B is the same as that in the sheet feed mode from the multifeed tray **8**, as previously described.

Upon every revolution of the sheet feed rollers **26** in the feeder **20**, each sheet stored in the cassette **40** mounted in the feeder **20** is fed to the printer B, and an image is formed on the fed sheet.

When the number of sheets S stacked on the cassette **40** is decreased, the intermediate plate **45** is pivoted upward upon clockwise pivotal movement of the pressure lever **46** by a charged force of the tension coil spring **49**. The vertical level of the uppermost sheet S on the intermediate plate **45** at the leading end of the sheet is kept at a predetermined level. Therefore, stable separation and feeding of each sheet can be performed.

(6) Removal of the Cassette **40**

In order to remove the cassette **40** from the feeder **20**, fingers are hooked to the handle **42** at the front end face of the cassette to pull the cassette **40** from the feeder **20** in a direction opposite to the cassette mounting direction X as indicated by an arrow Y in FIG. **2**.

In an initial period of removal of the cassette **40**, the right and left end portions **47**R and **47**L of the pressure shaft **47** in the cassette **40** are respectively disengaged from the cam grooves **33** on the inner side surfaces of the right and left stands **21**R and **21**L of the feeder **20**. In this state, the pressure shaft **47** can be freely moved. A clockwise biasing force is released from the pressure lever **46**. The lever **46** is pivoted counterclockwise by the weight of the intermediate plate **45** and the sheets S stacked thereon. As shown in FIG. **11**, the intermediate plate **45** is laid on the inner bottom surface of the case **41** again. The pressure shaft **47** is returned to the initial state wherein both the end portions of the shaft **47** are kept at the upper end positions. The extended portions **53** are supported on the pressure shaft **47** which is returned to the upper end point and is kept almost horizontal.

The sheet feed apparatus A of this embodiment is prepared as an optional unit which can be detachably added to the main unit B such as a printer or copying machine, as needed. Each sheet feed roller **26** has a sector-shaped section to allow longer sliding of the sheet cassette **40** in the feeder **20**. Therefore, the sheet feed apparatus B can be entirely set below the main unit B. Furthermore, the sheet feed apparatus A can be mounted into the feeder or removed therefrom from the front side of the main unit which is a manipulation side of the main unit B. According to the sheet feed apparatus A, the height of the main unit B is only slightly increased, and an extended portion of the cassette **40** outside the front side of the main unit can be eliminated even in an optional arrangement. Operability of the sheet feed apparatus is equivalent to that of the main unit B, and the sheet feed apparatus is matched with the main unit B in view of design, thereby providing excellent operability and design.

The feed direction of the sheet stacked on the cassette **40** mounted in the feeder **20** is opposite to the direction for mounting the cassette **40** in the feeder **20**. Therefore, the cassette **40** can be easily mounted into the main unit B from the front side or removed therefrom, and the operator need not walk to the rear side of the main unit B even upon occurrence of jamming, thus resulting in convenience.

Although the sheet feed apparatus A consisting of the feeder **20** and the cassette **40** is located below the main unit B, jamming troubleshooting and other troubleshooting operations can be performed on the front side even if the cassette **40** has a long mounting stroke. This can be realized because the mounting direction of the cassette **40** into the feeder is opposite to the feed direction of the sheet.

Since the sheet feed apparatus A consisting of the feeder **20** and the cassette **40** is located below the main unit B, the height of the system is only slightly increased by the number of sheets S stacked and stored in the cassette **40**. The main unit B is not adversely affected by this arrangement. That is, design flexibility can be facilitated, and system expansion can be achieved by slightly modifying the design specifications.

When the cassette is inserted into and mounted in the main unit in the same convey direction of the sheet as in the conventional system, the leading end of the sheet is extended from the front end of the cassette by an inertia generated by a shock upon mounting of the cassette. If a separation pawl type cassette is used, a strong force acts on the separation pawls to deform them, or movement of the separation pawl is degraded. However, when the cassette is inserted into the main unit in a direction opposite to the feed direction of the sheet, the above inertia acts in the opposite direction, thereby eliminating the conventional drawback described above.

The sheet convey rollers **55** in the cassette **40** may comprise driving rollers as in the rollers **28** in the feeder **20**.

In addition, the spring force for lifting the intermediate plate **45** is used to confirm a click at the end of mounting of the cassette **40** or to prevent the cassette **40** from removal. An additional spring and a cassette removal mechanism need not be arranged in the cassette **40** and the feeder **20**, thus realizing a low-cost arrangement.

When the cassette **40** is removed from the feeder **20**, the spring **49** for lifting the intermediate plate **45** receives almost no load, and the service life of the spring **49** is also prolonged.

A space is assured in the cassette **40** in the feed direction and is utilized as the handle **42**. In this case, the spring **49** may be arranged at the front end portion of the cassette in the sheet feed direction to minimize the thickness of the cassette **40**. Therefore, the sheet feed apparatus A and hence the main unit B can be made compact.

III Other Embodiments

(1) FIGS. **12**(A), **12**(B), and **12**(C)

In this embodiment, a sheet feed apparatus A is placed on a printer B serving as a main unit.

The sheet feed apparatus A comprises a sheet feeder **200** and a sheet cassette **240** which can be detachably mounted in the sheet feeder **200** through elongated flanges **244**R and **244**L and guide grooves **232**. The cassette **240** can be inserted into the feeder **200** and can be removed therefrom from the front side. FIG. **12**(A) shows a state wherein the sheet cassette **240** is mounted in the feeder **200**, and FIG. **12**(B) shows a state wherein the sheet cassette **240** is being mounted in the feeder **200** or removed therefrom.

Sheets S are stacked on an intermediate plate **245** in the cassette **240**. The front end of the intermediate plate **245** is lifted by a spring **249**a. Separation pawls **250** are provided at the right and left corners of the leading end of the uppermost sheet of the stacked sheets S.

In the state wherein the cassette **240** is mounted in the feeder **200**, as shown in FIG. **12**(A), sheet feed rollers **226** of the feeder **200** are rotated counterclockwise by one revolution, and the uppermost sheet of the sheets stacked in the cassette **240** is fed in a direction opposite to a direction X for mounting the cassette **240** into the feeder **200**. Therefore, the sheet is guided by a guide **243**a and gripped by the nip portion between sheet convey rollers **228** of the feeder **220** and rollers **255** of the cassette **240**, and is guided downward by a downwardly curved guide **243**b.

The sheet is fed in the printer from a sheet outlet **240**a in the bottom surface of the cassette to a sheet inlet **201**a formed in the upper surface of the printer B. The sheet fed in the printer is subjected to image transfer by an image transfer unit (i.e., a corona charger) **13** of a photosensitive drum **3** through a path from registration rollers **212**a and guide plates **212**b and is then delivered onto a delivery tray **217** through a pair of fixing rollers **215**a and **215**b, a guide plate **216**a, and a pair of delivery rollers **216**.

The feeder **200** in the sheet feed apparatus A may be permanently mounted on the upper surface plate of the printer B serving as a main unit. Alternatively, the feeder **200** may be prepared as an optional unit and detachably mounted on the upper surface plate. In this case, various types of sheets can be fed by replacing the feeders **200**.

Since the sheet is guided by the guide **243**b from the cassette **240** to the printer B serving as the main unit in a substantially vertical direction, a sheet path can be shortened as compared with a conventional arrangement. The substantially vertical guide **243**b is formed in the cassette **240** which is detachably mounted in the feeder **220**. During jamming troubleshooting operation, the cassette **240** is pulled from the feeder **200** to open the sheet path, thereby facilitating the processing.

The cassette **240** is inserted into and mounted in the feeder **200** by using the feeder front surface side as a reference side. When a cassette having a given length in the sheet feed direction is used and mounted in the feeder **200**, the rear end portion of the cassette **240** extends outside the rear end surface of the feeder **200** or the printer B serving as the main unit. However, since a power source cord H**1**, an interface cord H**2**, and the like extend from the rear end face of the printer B serving as the main unit, no problem is posed. The rear surface of the printer B cannot be brought into contact with a wall surface J or the like due to the presence of cords and the like on the rear surface of the printer B. A given distance is required between the rear surface of the printer B and the wall surface J, and therefore an extended portion P of the rear end portion of the cassette **240** will not reduce the effective installation space. To the contrary, an extended portion can be eliminated from the front side, thus improving front-side design and operability.

Regarding the extending portion P of the rear end portion of the cassette **240**, assume that a sheet feed apparatus having a maximum feed capacity corresponding to a width LTR (width: 8.5") is used. If the rear end portions of LTR (length: 11") and A**4** (length: 297 mm) cassettes are set not to be extended from the rear end face of the feeder **200**, but only a rear end portion of an LGL (length: 14") cassette is extended outside from the rear end face of the feeder **200**, the LTR and A**4** cassettes are frequently used. Therefore, the rear end portions of the cassettes do not appear outside the rear end portion of the feeder **200**, thus providing a good outer appearance, as shown in FIG. **12**(C).

(2) FIGS. **13**(A) and **13**(B)

A sheet feed apparatus A is located at the side of a printer B serving as a main unit.

The sheet feed apparatus A comprises a sheet feeder **320**, and a sheet cassette **340** which can be mounted into the feeder **320** or removed therefrom by engaging elongated flanges **344**R and **344**L of the cassette **340** with guide grooves **332** formed in the feeder **320**. The cassette **340** is mounted into a cassette storage space of the feeder **320** or removed therefrom. In this case, the storage space has an upper opening. FIG. **13**(A) shows a state wherein the cassette **340** is mounted in the feeder **320**, and FIG. **13**(B) shows a state wherein the cassette **340** is being mounted in the feeder **320** or removed therefrom. The weight of sheets S in the cassette in a vertical state is received by a sheet trailing end regulating member which is constituted by an inner surface of the rear wall of the cassette.

In the state (FIG. **13**(A)) in which the cassette **340** is mounted, sheet feed rollers **326** in the feeder **320** are rotated counterclockwise by one revolution, and one sheet in the cassette **340** on the side of the feed rollers **326** is fed in a direction opposite to the direction X for mounting the cassette **340** in the feeder **320**. The sheet is conveyed by a guide **343**a and clamped by a nip portion between sheet convey rollers **327** of the feeder **320** and rollers **355** of the cassette **340**. The sheet is then fed in the printer B through communication ports **340**a and **301**a between the feeder **320** and the printer B. The sheet fed in the printer B is guided to an image transfer unit **13** at a photosensitive drum **3** through a guide plate **319**a. An image formed on the photosensitive drum **3** is transferred to the sheet. The sheet is then delivered onto a delivery tray **317** through a pair of fixing rollers **15**a and **15**b.

When the cassette is inserted and mounted in the same direction as the sheet feed direction as in the conventional case, the leading end of the sheet jumps beyond the front end of the cassette upon mounting of the cassette into the feeder due to an inertia, or a strong force acts on the separation pawls to deform the pawls if a separation pawl type cassette is used. In the latter case, smooth movement of the separation pawls cannot be assured. However, when the cassette is inserted and mounted in a direction opposite to the sheet feed direction, the inertia acts in the opposite direction, thus eliminating the above conventional drawback. When the cassette **340** is vertically inserted and mounted in the feeder, rigidity of a sheet trailing end position regulating member **341**d which supports the trailing ends of the sheets is increased to prevent misalignment of the trailing ends of the sheets.

(3) FIG. **14**

An elastic plate member such as a leaf spring, a molded member, or a Mylar sheet, or a sheet member **455**' is used in place of the rollers **55** (first embodiment) which serve as sheet convey members arranged in a cassette **440**. When the cassette **440** is sufficiently inserted into a feeder **420**, the elastic plate or sheet member **455**' which serves as the sheet convey member in the cassette **440** is brought into contact with sheet convey rollers **428** in the feeder **420**. One or both of sheet guide members in front of and behind the sheet convey roller may be utilized.

A sheet S fed from the cassette **440** upon rotation of sheet feed rollers **426** of the feeder **420** is introduced into a contact portion between the convey rollers **428** and the elastic sheet

member or sheet member **455'** and is guided by the member **455'**. The sheet S is then conveyed in a substantially vertical direction.

The arrangement of this embodiment is inexpensive, and downstream and upstream guide operations with respect the sheet convey rollers **428** can be assured.

In this case, each convey roller **426** need not be a roller having a sector-shaped section, but can be a roller having a circular section and controlled to be brought into contact with or separated from the sheet S as in this embodiment.

(4) FIGS. **15**(A) to **15**(E)

FIGS. **15**(A) to **15**(E) show still another embodiment of the present invention, in which FIG. **15**(A) is a plan view thereof, FIG. **15**(B) is a longitudinal side section view, and FIG. **15**(C) is a view showing an upward cam surface and a back-and-forth guide groove.

An intermediate plate **545** in a main case **541** of a cassette **540** is vertically pivotal about its rear end **545**a. A spring mechanism **545**b is arranged at each of the right and left side of the intermediate plate **545**. Pressure levers **546** vertically pivotal about shaft **546**a are mounted on inner surfaces of right and left side walls **541**c and **541**b of the main case **541**, respectively. Pressure shaft **547** are fixed to distal end portions of the right and left pressure levers **546**. Outer end portions (cam followers) **547**R and **547**L of the pressure shaft **547** are exposed outside the right and left side walls **541**c and **541**b of the main case **41** through arcuated slots **548** having shafts **546**a of the levers **546** as their centers.

One end of each coil spring **549** is hooked to a corresponding one of the spring mechanism **545**b of the intermediate plate **545**, and the other end of the spring **549** is locked by the corresponding pressure shaft **547** (or pressure lever **546**). A pair of right and left sheet separation pawls **550** are mounted on distal end portions of levers **552** vertically pivotal about shafts **551** on the inner surfaces of the right and left side walls **541**c and **541**b of the case **541**. Each separation pawl lever **550** is biased downward (clockwise in FIG. **15**(B)) about the shaft **551** by its own weight or a biasing spring (not shown). The pawls **550** are located at the right and left corners of the leading end of the uppermost one of the sheets stacked on the intermediate plate **545**.

FIGS. **15**(A) and **15**(B) show a state wherein the cassette **540** is removed from a feeder **520**. In this state, the pressure shafts **547** can be freely moved. For this reason, the intermediate plate **545** is laid on the inner bottom surface of the case **541** by its own weight. The pressure levers **546** are pivoted downward (clockwise in FIG. **15**(B)) about the shafts **546**a by the laid intermediate plate **545** through the coil springs **549** and the pressure shafts **547**. Therefore, the pressure shafts **547** are stopped at the lower end positions of the slots **548**. The distal end portions of the pressure levers **546** pivoted downward abut against engaging portions **552**a of the separation pawl levers **552**. An upward pivotal force (counterclockwise in FIG. **15**(B)) about the shafts **551** acts on the separation pawl levers **552**. Downward pivotal movement of the separation pawls held at the uppermost positions can be prevented.

A large space is formed between the front end of the intermediate plate **545** and each separation pawl **550**, and sheets can be easily stored in the cassette main case. The sides of the sheets stacked on the intermediate plate **545** are regulated by width regulating plates **541**f.

Elongated flanges **544**R and **544**L of the cassette **540** are engaged with corresponding guide grooves **532** formed in the feeder **520** (FIG. **15**(C)) to insert the cassette **540** into the feeder **520**. The end portions **547**R and **547**L serving as cam followers on the cassette **540** are engaged with upward cam surfaces **533** formed in the feeder **520** immediately before mounting of the cassette **540** into the feeder **520** is completed. When the cassette **540** is further inserted, the end portions **547**R and **547**L are moved upward along the arcuated slots **548** toward the upper end positions. When the cassette **540** is inserted in the feeder **520** and is perfectly mounted therein, the end portions **547**R and **547**L are stabilized in recesses **533**a of the cam surfaces **533**.

Upon upward movement of the end portions **547**R and **547**L, the pressure levers **546** are pivoted upward about the shafts **546**a. The intermediate plate **545** receives a tensile force through the coil springs **549** and is moved upward at a predetermined pressure. The distal end portions of the pressure levers **546** are separated upward from the engaging portions **552**a of the separation pawl levers **552**, and the separation pawl lever **552** can be freely pivoted. FIG. **15**(D) shows a state wherein the cassette **540** is perfectly mounted in the feeder **520**.

When a sufficient space can be assured in the cassette **540** in a direction perpendicular to the sheet feed direction, the springs **549** and the like are arranged in its side areas, and the thickness of the cassette **540** can be minimized. The construction of the sheet feed apparatus A and hence the main unit B can be made compact.

As shown in FIG. **15**(E), even if the cassette is inserted into the feeder in the same direction as the sheet feed direction as in the conventional case, pressure shafts **547** (**547**R and **547**L) are engaged with or disengaged from cam surfaces **533** directed toward the main unit, thereby performing mounting/removal of the cassette in the same manner as described above.

The cassette includes a means for urging the sheet toward the feed rollers. When the sheet size or the type of sheet is changed, the urging means can be set to correspond to each cassette currently mounted in the main unit, and an optimal feed pressure can advantageously act on the sheet.

The sheet urging means of the cassette also serves as a locking means for locking the cassette when the cassette is perfectly mounted in the feeder as main unit. Therefore, the feeder only has a simple cam mechanism. No locking means need be arranged in the feeder, and a low-cost, compact cassette feeder can be obtained.

What is claimed is:

1. An image forming apparatus including means for feeding a sheet, means for conveying a fed sheet to an image forming section, and means for delivering the sheet processed by the image forming section, comprising:

means for partially supporting said conveying means and said delivering means and having an opening side relative to a housing of said image forming apparatus, *said conveying means and said delivering means being arranged at a side portion of said image forming apparatus*;

sheet storing means for storing therein sheets to be processed; and

means for guiding said sheet storing means so that said sheet storing means is detachable from said feeding means at the same side of said image forming apparatus as the opening side of said supporting means,

wherein said feeding means feeds the sheet in a direction opposite to a direction for mounting said sheet storing means.

2. An apparatus according to claim **1**, wherein part of said sheet conveying means also serves as another feeding means for feeding the sheet.

3. An apparatus according to claim **2**, wherein said sheet conveying means comprises a roller which opposes another roller at a convey section thereof and a frictional member at a feed section thereof.

4. An apparatus according to claim **3**, further including a sheet path for guiding a sheet separated by said frictional member to said convey section, said sheet path being located in a downstream side of said feed section.

5. An apparatus according to claim **4**, further including a sheet delivery tray in an upstream side of said feed section.

6. An apparatus according to claim **5**, wherein said feeding means and said guiding means are constituted by a unit structure with respect to a housing of said image forming apparatus.

7. A sheet feed apparatus used in an image forming apparatus including means for conveying a sheet fed by feeding means to an image forming section, and means for delivering the sheet processed by said image forming section, comprising:

a sheet feed unit as a single unit comprising said feeding means and means for guiding sheet storing means; and

sheet storing means comprising means for stacking the sheets and means for conveying the sheet, said conveying means being located in a downstream side of said stacking means, and said sheet storing means being detachable from said sheet feed unit.

8. An apparatus according to claim **7**, wherein said feeding means feeds the sheet in a direction opposite to a direction for mounting said sheet storing means.

9. An apparatus according to claim **8**, wherein said conveying means guides the sheet to said image forming apparatus housing through an opening formed in a bottom portion of a housing of said image forming apparatus.

10. An apparatus according to claim **7**, further including spring means for biasing said stacking means toward said feeding means, and means for biasing said spring means upon mounting of said sheet storing means in said sheet feed unit.

11. An apparatus according to claim **10**, wherein said sheet feed unit comprises a cam surface, said sheet storing means comprises a cam follower which is engaged with said cam surface of said sheet feed unit when said sheet storing means is mounted in said sheet feed unit, and said spring means for biasing said stacking means upward has one end coupled to said cam follower and the other end coupled to said stacking means through a transmission member, so that said stacking means is moved vertically upward through said transmission member by a charged force of said spring means which is obtained by engagement of said cam follower with said cam surface when said sheet storing means is mounted in said sheet feed unit.

12. An apparatus according to claim **11**, wherein said sheet storing means comprises a one-sheet separation pawl engaged with a leading end of an uppermost one of the sheets, said one-sheet separation pawl being provided with an engaging portion interlocked with said cam follower, and said stacking means is located in a lowermost position by its own weight when said sheet storing means is not mounted in said sheet feed unit so that said one-sheet separation pawl is moved upward to an uppermost position from said stacking means through said transmission member, said spring member, and said cam follower.

13. An apparatus according to claim **7**, wherein a maximum distance l_1 for inserting said sheet storing means into said sheet feed unit is larger than a size l_2 of said sheet feed unit in a direction for inserting said sheet storing means into said sheet feed unit, and a front surface of said sheet storing means is substantially aligned with a front surface of a housing of said image forming apparatus when said sheet storing means is perfectly inserted and normally mounted into said sheet feed unit.

14. An apparatus according to claim **7**, wherein the sheet fed from said sheet storing means by said feeding means of said sheet feed unit is conveyed in a direction substantially perpendicular to the sheet stored in said sheet storing means.

15. An image forming apparatus including sheet feeding means for feeding the sheet and transporting means for transporting the sheet fed by said sheet feeding means through an image forming section to an outlet section, comprising:

means for partially supporting said transporting means, said supporting means having an opening side relative to a housing of said image forming apparatus, said transporting means being arranged at a side portion of said image forming apparatus;

sheet storing means for storing therein sheets to be processed; and

means for guiding said sheet storing means so that said sheet storing means is detachable from said feeding means at the same side of said image forming apparatus as the opening side of said supporting means,

wherein said feeding means feeds the sheet in a direction opposite to a direction for mounting said sheet storing means.

16. An image forming apparatus according to claim 15, wherein said supporting means is pivoted at a side portion of said image forming apparatus, and said transporting means is arranged to transport the sheet in a direction substantially perpendicular to the direction for mounting said sheet storing means.

17. An image forming apparatus according to claim 15, wherein said transporting means comprises means for conveying the fed sheet to said image forming section, image forming means, means for delivering the sheet processed at said image forming section to said outlet section, and guide means for guiding the fed sheet and the processed sheet.

18. An apparatus according to claim 17, wherein part of said sheet conveying means also serves as another feeding means for feeding the sheet.

19. An apparatus according to claim 18, wherein said sheet conveying means comprises a roller which opposes another roller at a conveying section thereof and a frictional member at a feeding section thereof.

20. An apparatus according to claim 19, further comprising a sheet path for guiding a sheet separated by said frictional member to said conveying section, said sheet path being located in a downstream side of said feeding section.

21. An apparatus according to claim 20, further comprising a sheet delivery tray in an upstream side of said feeding section.

22. An apparatus according to claim 21, wherein said feeding means and said guiding means for said sheet storing means are constituted by a unit structure with respect to a housing of said image forming apparatus.

* * * * *

UNITED STATES PATENT AND TRADEMARK OFFICE

CERTIFICATE OF CORRECTION

PATENT NO. : Re. 35,341
DATED : October 1, 1996
INVENTOR(S) : YUTAKA KIKUCHI, ET AL.

It is certified that error appears in the above-indentified patent and that said Letters Patent is hereby corrected as shown below:

Title page, item [56]"198529 4/1989 Japan" should read --1-98529 4/1989 Japan--.

Column 2,
line 34, "rollers 110." should read --rollers 119.--.

Column 3,
line 13, "upermost" should read --uppermost--;
line 28, "th" should read --the--;
line 31, "the sheet" should read --The sheet--; and
line 44, "od" should read --of--.

Column 5,
line 15, "size 1_2" should read --size ℓ_2--.

Column 6,
line 12, "thr" should read --the--.

Column 7,
line 1, "section" should read --sectional--; and
line 43, "the" should read --The--.

Column 8,
line 20, "printer" should read --printer housing--.

Column 10,
line 14, "tat" should read --that--.

Column 11,
line 35, "srves" should read --serves--.

UNITED STATES PATENT AND TRADEMARK OFFICE

CERTIFICATE OF CORRECTION

PATENT NO. : Re. 35,341
DATED : October 1, 1996
INVENTOR(S) : YUTAKA KIKUCHI, ET AL.

It is certified that error appears in the above-indentified patent and that said Letters Patent is hereby corrected as shown below:

Column 12,
line 25, "therewithy." should read --therewith.--.
Column 14,
line 52, "ar" should read --are--.
Column 21,
line 59, "unit" should read --unit,--.

Signed and Sealed this

Twentieth Day of May, 1997

Attest:

BRUCE LEHMAN

Attesting Officer

Commissioner of Patents and Trademarks