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(54) **Title**: INCLINED MOTOR IN AN INKJET PRINTER

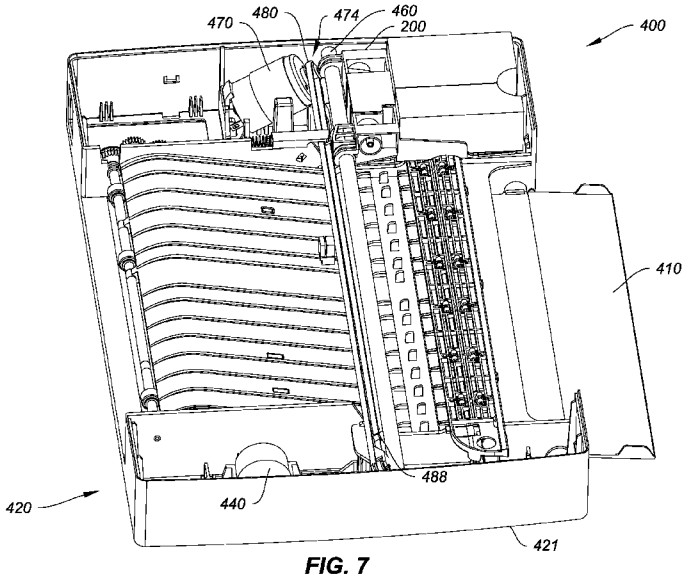


FIG. 7

(57) **Abstract**: A printing apparatus(400) includes a carriage for moving a printhead along a carriage (200) scan direction; a carriage guide (460) for guiding the carriage along the carriage scan direction; and a motor for moving the carriage, the motor (470) including a rotatable axle, wherein the motor is mounted in the printing apparatus such that when the printing apparatus is in its nominal operating position the rotatable axle (474) is inclined at an angle of between ten degrees and eighty degrees with respect to a horizontal plane.

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INCLINED MOTOR IN AN INKJET PRINTER

FIELD OF THE INVENTION

This invention pertains generally to carriage printer apparatus and more particularly to the motor that drives the carriage in a carriage printer.

BACKGROUND OF THE INVENTION

Many printers, including many inkjet printers, use a carriage-based architecture, which has advantages in size, performance, and cost. In the inkjet carriage printer, a printhead is mounted in a carriage that is moved back and forth across the region of printing. To print an image on a sheet of paper or other recording medium (sometimes generically referred to as paper herein), the recording medium is advanced a given distance along a recording medium advance direction and then momentarily stopped. While the recording medium is stopped and supported on a platen, the printhead carriage is moved along a carriage scan direction. The carriage scan direction extends substantially perpendicular to the recording medium advance direction. In the course of printhead travel along the carriage scan direction, controllable marking elements in the printhead record marks on the recording medium--for example by ejecting drops from an inkjet printhead. After the carriage has printed a swath of the image while traversing the recording medium, the recording medium is advanced incrementally, the carriage direction of motion is reversed, and marking is repeated with printhead movement in the reverse direction. By repeating this process a number of times, the printer forms the image onto the recording medium, swath by swath.

Internal printer components provide controlled movement of the recording medium in one direction, coordinated and synchronized with controlled movement of the printhead along the carriage scan direction. Providing this type of controlled movement requires a stable support structure for the various moving components and media. In addition, it is important to reduce sources of vibration of the carriage. Since the printhead prints as it is being moved by the carriage, vibration of the carriage can result in degraded print quality.

By way of example, FIG. 1 shows a portion of a prior art carriage printer 300, with some parts hidden so that other parts can be more clearly seen. Printer 300 has a printing region 303 across which a carriage 200 is moved back and forth along a carriage scan direction 305 that extends along the X axis between the right side 306 and the left side 307 of printer 300 while printing on recording medium that is supported by the platen that provides printing region 303. Carriage motor 380 moves a belt 384 attached to carriage 200 in order to move carriage 200 back and forth along carriage guide rail 382. In this way, carriage 200 is actuable to move along a carriage scan direction 305. Printhead 250 is mounted in carriage 200, and ink supplies 262 and 264 are mounted in the printhead 250. In this orientation of printhead 250, the droplets of ink are ejected downward onto the recording media in printing region 303 in the view of FIG. 1. Ink supply 262, in this example, contains five ink sources cyan, magenta, yellow, photo black, and colorless protective fluid, while ink supply 264 contains the ink source for text black.

Paper, or other recording medium is loaded along paper load entry direction 302 toward the front 308 of printer 300. Printed paper traveling from the rear 309 exits along direction 304. In this example, both the paper load entry direction 302 and the paper exit direction 304 are parallel to the Y axis. A feed roller 312 includes a feed roller shaft along its axis, and a feed roller gear 311 is mounted on the feed roller shaft. The motor that powers the paper advance rollers is not shown in FIG. 1, but a hole 310 in the framework at the right side 306 of the printer 300 is where the motor gear (not shown) protrudes through in order to engage feed roller gear 311, as well as the gear for the discharge roller (not shown). Bolt holes for attaching this paper advance motor are shown on both sides of hole 310. For normal paper pick-up and feeding, all rollers rotate in forward direction 313. Toward the left side 307 in the example of FIG. 1 is a maintenance station 330. Toward the rear 309 of the printer in this example is located an electronics board 390, which contains cable connectors 392 for communicating via cables (not shown) to the printhead carriage 200 and from there to the printhead. Also on the electronics board are typically mounted motor

controllers for the carriage motor 380 and for the paper advance motor, a processor and/or other control electronics for controlling the printing process, and an optional connector for a cable to a host computer.

In the prior art printer of FIG. 1, carriage guide rail 382 is part of a metal supporting structure that acts as a type of "backbone" 385 that extends from left side 307 to right side 306 of the printer for support and for attaching printer components. Carriage motor 380 is securely attached to backbone 385 near the left side 307 of the printer by a pair of screws 381 that attach to the face of carriage motor 380. The axle 383 around which belt 384 is looped also extends from the face of the carriage motor 380. Pulley 386 is attached to backbone 385 near the right side 306 of the printer. Axle 383 of carriage motor 380 is parallel to the Y axis. In normal operating orientation, printer 300 sits on a horizontal surface so that the XY plane is a horizontal plane. Since axle 383 is parallel to the XY plane, the mounting orientation of carriage motor 380 shown in FIG. 1 is sometimes referred to as a horizontal orientation. The plane of the belt 384 (i.e. the plane perpendicular to the thickness of the belt material) is also parallel to the horizontal XY plane, as is the rotational axis of pulley 386.

It is known that in order to keep carriage vibrations at a low level it is preferred to have the carriage axle and the belt substantially in a radial orientation from the axis of the carriage guide rail 382 that is parallel to carriage scan direction 305. This condition is satisfied in the prior art carriage printer 300 shown in FIG. 1. However, the size of the carriage motor 380 that is required in order to provide the required torque for accelerating and decelerating the carriage is such that the cylindrical casing of carriage motor 380 has a radius that is typically 2 to 3 centimeters. As a result, the cylindrical casing extends substantially above the carriage guide rail 382 as seen in FIG. 1. It is desirable to reduce the overall height of the printing apparatus, whether it is a stand-alone printer or part of a multifunction printer that also includes a scanner. A reduced height can lead to reduced manufacturing cost and reduced shipping cost, and also requires less room in the user's workspace.

In addition, the conventional backbone 385 is typically formed by a series of bends in sheet metal. Sheet metal bending tolerances make fabrication of the backbone to required tolerances difficult. Furthermore assembly of a carriage printer 300, or its multifunction printer counterpart, using the conventional backbone arrangement requires a number of fasteners (screws, bolts, clips, etc.) that complicate the assembly process.

What is needed is a printer that can provide high quality printing at lower cost, and with a reduced height of the printer. There is a recognized need to reduce the parts count and complexity of these systems and to simplify printer assembly while keeping carriage motion smooth and stable so that print quality is not degraded.

SUMMARY OF THE INVENTION

A printing apparatus comprising a carriage for moving a printhead along a carriage scan direction; a carriage guide for guiding the carriage along the carriage scan direction; and a motor for moving the carriage, the motor including a rotatable axle, wherein the motor is mounted in the printing apparatus such that when the printing apparatus is in its nominal operating position the rotatable axle is inclined at an angle of between ten degrees and eighty degrees with respect to a horizontal plane.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a perspective view showing components of a prior art carriage printer;

FIG. 2 is a perspective view that shows a multifunction printer according to an embodiment of the present invention;

FIG. 3 is a partially exploded view that shows elements of the multifunction printer of FIG. 2;

FIG. 4 is a perspective view that shows a printer chassis of FIG. 3;

FIG. 5 is a perspective view of the printer chassis of FIG. 4 populated with components;

FIG. 6 is a cross-section view of the multifunction printer of FIG. 2 that shows the media transport path for the printing apparatus;

FIG. 7 is a perspective view of a printing apparatus having an inclined carriage motor according to an embodiment of the invention;

FIG. 8 is a close-up view of a portion of the printing apparatus of FIG. 7;

FIG. 9 is an even closer view of the inclined motor of FIG. 7 and associated components;

FIG. 10 is a perspective view of the printer chassis of the printing apparatus of FIG. 7;

FIG. 11 is a close-up underside perspective view of a portion of the scanning apparatus of the multifunction printer of FIG. 2 including various features for securing components of the printing apparatus in position;

FIG. 12 is an underside perspective view of a the scanning apparatus of the multifunction printer of FIG. 2;

FIG. 13 is a perspective view of a paper advance motor;

FIG. 14 is a perspective view of a paper advance motor assembled into the printer chassis according to an embodiment of the invention;

FIG. 15 is a perspective view of mounting features in the printer chassis for mounting the paper advance motor according to an embodiment of the invention;

FIG. 16 is a perspective view of the paper advance motor, the inclined carriage motor and several of their associated components;

FIG. 17 is a perspective view looking downward toward the paper advance motor and its associated components mounted in the printer chassis;

FIG. 18 is a close-up view of a feed roller mounted in a printer chassis;

FIG. 19 is similar to FIG. 18 but with the feed roller assembly hidden in order to show a mounting feature in the printer chassis;

FIG. 20 is a perspective view of portions of the feed roller assembly, the turn roller assembly, a pick roller assembly and a drive shaft according to an embodiment of the invention;

FIG. 21 is a similar view as FIG. 20, but with the components mounted in the printer chassis; and

FIG. 22 is a perspective view (rotated relative to FIG. 20) of portions of the feed roller assembly the turn roller assembly and the drive shaft.

DETAILED DESCRIPTION OF THE INVENTION

FIG. 2 is a perspective view that shows a multifunction printer 100 according to an embodiment of the present invention. A scanning apparatus 500 is positioned atop a printing apparatus 400. Scanning apparatus 500 has a transparent platen 510, preferably glass, for supporting documents or other items to be scanned in order to convert an image into digitized data. Although the scanning apparatus preferably uses glass as the transparent member, any other suitable transparent member may also be used. An outer case 505 contains the various internal elements of the scanning apparatus 500. Mounted on case 505 are one or more operator controls 512, and optionally one or more indicators 514.

Embodiments of the present invention provide, within multifunction printer 100 (although applicable also in stand-alone printing apparatus architectures as well), a configuration for printing apparatus 400 that is assembled in a different manner from the "backbone"-based construction described previously with reference to FIG. 1. In embodiments of the present invention, a number of structural parts have been eliminated. Functions provided by the backbone in prior art printers, such as providing a support and attachment for motors, rollers, power supplies, carriage guides, and drive shafts, are described in further detail below. Embodiments also address desirable features such as reduced height and reduced noise.

Referring to the partially exploded view of FIG. 3, the case, the platen glass and most inner components (such as a scan bar and motor) of scanning apparatus 500 have been hidden, so that scanner base 520 can be seen more clearly. Scanner base 520 is shown removed from its assembled position, fitted against a printer chassis 420. Scanner base 520 can be formed of a single piece of plastic using injection molding, for example. At its top side it includes supports

522 for platen glass 510 (see FIG. 2). In other words, the top side of scanner base 520 faces platen glass 510. Also seen from the top perspective view of FIG. 3 is the scanner housing 525, which is formed as part of scanner base 520. An element of scanner housing 525 is rack 524 along which a scan bar (not shown) is used to scan documents that are placed on platen glass 510 (see FIG. 2). The bottom of scanner base 520 includes a first region 528 and a second region 529 that extends lower than the first region 528. The second region 529 extends lower in order to provide room for the rack 524 and the associated motor and gear of the scan bar (not shown). Even though ink supplies 262 and 264 (seen in the lower portion of FIG. 3) are the most upwardly extending parts of the printing apparatus 400, they are situated in an area corresponding to first region 528 of the bottom of scanner base 520. The circuit board 516 is attached to the scanner base 520 but is not an integral part of the scanner base 520.

A pinch roller assembly 530, shown separately in the exploded view of FIG. 3, is affixed to the bottom of scanner base 520, and extends into the media travel path, downward in the orientation of FIG. 3. Affixing of pinch roller assembly 530 can be done by snap fitting fingers 536 to scanner base 520 and attaching springs 538. Pinch rollers 532 are biased by springs 538 to press against the feed roller to form a nip 533 (see FIG. 6).

Some components of printing apparatus 400 are also shown in FIG. 3 and the close-up perspective view of FIG. 5, while the close-up perspective view of FIG. 4 shows the printer chassis 420 in isolation, empty of other components. Printer chassis 420 can be formed of a single piece of plastic using injection molding, for example. Printer chassis 420 includes a media input region 412 near door 410, a media support element 422, a printing region 424, and a discharge region 426. Various rollers are used to move recording medium along a media transport path as is described below relative to FIG. 6. A paper advance motor 440 provides power to rotate the rollers by various belts and gears that are shown in the example of FIG. 5, as discussed in further detail below. Media support element 422 can include a plurality of ribs 423 in order to reduce frictional drag on the moving recording medium. There can also be a plurality of ribs 425 in the printing region 424, as seen most clearly in FIG. 4. Ribs 425 support the paper in

the printing region and are positioned to avoid overspray of ink during borderless printing on recording media of standard sizes. A carriage guide 460 is mounted to printer chassis 420 and held in place by retainer 462 on side wall 428 of printer chassis 420 (shown in FIG. 4). A carriage 200 is slidably mounted on carriage guide 460 via carriage bearings 202 and 204, and is configured to move a printhead 250 (hidden behind the wall of printer chassis 420) and its ink supplies 262 and 264 in a carriage scan direction 305 along printing region 424 in order to print an image one swath at a time.

FIG. 6 shows a cross-sectional view of the multifunctional printer of FIG. 2. During printing, recording medium (not shown) is moved along a media transport path 430 (indicated as a dashed line) from media input region 412, across the media support element 422, then to the printing region 424, and finally to the discharge region 426. In particular, a pick roller 431 on pick arm 432 moves the recording medium from media input region 412 toward turn rollers 434 located in a turn region and to the media support element 422 that is located above media input region 412 when the multifunction printer 100 is oriented in its operating position. (A cleanout element that provides a curved guide surface to guide the recording medium upward from the pick roller 431 to the turn rollers 434 is not shown.) After the recording medium passes the turn rollers 434, the tendency of the recording medium to remain substantially straight causes the recording medium to contact the bottom of scanner base 520. In other words, the bottom surface 526 of scanner base 520, located above media support element 422, provides an upper guide for the recording medium as it passes through this region. As the recording medium continues to advance along media transport path 430, it passes below pinch roller assembly 530. In other words, the bottom surface 534 of pinch roller assembly 530, as well as the top of media support element 422, act as guides for the recording medium as it passes through this region. The recording medium is thus guided into the nip 533 formed by pinch rollers 532 that are biased by springs 538 against rotating feed roller 436, to move the recording medium across printing region 424 and over to discharge region 426. A discharge roller 438 (seen in FIGS. 5 and 6) drives the recording medium toward door 410.

A star wheel assembly 439 (seen in FIG. 3) positioned over the discharge roller pushes the paper into the discharge roller without smearing the ink on the freshly printed recording medium.

FIG. 7 is a perspective view of printing apparatus 400, and shows printer chassis 420 populated with a number of the printer components (including carriage 200, carriage guide 460, carriage motor 470, belt 480, and paper advance motor 440), but rotated with respect to the views shown in FIGS. 3 and 5, such that the door 410 is to the right. In this view, carriage motor 470 is shown mounted in an inclined orientation relative to base 421 of printer chassis 420, according to an embodiment of the invention. Since the nominal operating position of printing apparatus 400 is such that the base 421 of printer chassis 420 rests in a substantially horizontal plane, it can also be said that carriage motor 470 is inclined with respect to a horizontal plane when the printing apparatus 400 is in its nominal operating position. Belt 480 is looped around rotatable motor axle 474 of carriage motor 470 near one end of carriage guide 460 and around idler pulley 488 (see also FIG. 16) near the opposite end of carriage guide element 460. Idler pulley 488 includes an axis of rotation that is configured to be parallel to the rotatable axle 474 of carriage motor 470.

FIG. 8 is a close-up perspective view of a portion of printing apparatus 400 together with a dashed line 521 that approximately represents the contour of the bottom of scanner base 520. As discussed relative to FIG. 3, scanner base 520 includes a first region 528 and a second region 529 that extends lower than first region 528. As seen in FIG. 8, carriage motor 470 is located near the second region 529 of the bottom of scanner base 520. If carriage motor 470 were horizontally mounted (as in prior art FIG. 1), its outer casing would interfere with the second region 529 of the bottom of scanner base 520. In order to reduce the height of printing apparatus 400 (and therefore the height of multifunction printer 100), in the embodiment shown in FIG. 8, carriage motor 470 is mounted to be inclined relative to horizontal base 421 (see FIG. 7). The upper edge 472 of carriage motor 470 is thus able to be about the same height as the upper rim 429 of the side wall 428 of printer chassis, and not interfere with the second region 529 of the bottom of scanner base 520. In addition, in order to keep carriage

vibrations at a low level, motor axle 474, and belt 480 are substantially radially oriented relative to the lengthwise axis of carriage guide 460, as shown in further detail below relative to FIG. 9. Carriage motor 470 is held in printer chassis 420 by inclined cradle 475 (see FIG. 10) that is molded as part of printer chassis 420. A holding feature 476 of inclined cradle 475 is shown in FIG. 8. Also shown in FIG. 8 is power supply 405 having a height that positions the top edge of power supply 405 near the upper rim 429 of side wall 428.

FIG. 9 shows a close-up perspective view of some of the components of printing apparatus 400 at approximately the same viewing angle as FIG. 8, but with printer chassis 420 hidden for clarity. Carriage 200 includes carriage bearings 202 and 204 that glide along carriage guide 460. Carriage motor 470 has an outer casing 471 including a cylindrical wall 477 that is substantially coaxial with rotatable motor axle 474 and a face 478 that is substantially perpendicular to rotatable motor axle 474. Outer casing 471 has a length L and a diameter D. In this example L is greater than D. As described above the diameter of the motor is sufficiently large that cylindrical wall 477 would interfere with second region 529 of scanner base 520 if the carriage motor were horizontally mounted. In addition, because the length L of the outer casing of carriage motor 470 is larger than its diameter D (not even counting the added length of the motor axle 474 and the electrical terminal(s) 479, mounting the carriage motor 470 with axis 473 of rotatable motor axle 474 pointing vertically upward would also cause interferences with the second region 529 of scanner base 520 (see FIG. 8). In other words, mounting the carriage motor 470 either horizontally or vertically would increase the height of printing apparatus 400 relative to the inclined orientation of the present invention. The preferred angle α of inclination of rotatable motor axle 474 from a line 402 that is parallel to the base 421 (see FIG. 7) depends on the overall length of carriage motor 470, the diameter of its outer casing 471, the position of belt attachment, etc. In the example shown in FIG. 9, the angle α of inclination of rotatable motor axle 474 from a line 402 that is parallel to the base 421 (i.e. the angle of inclination between rotatable motor axle 474 and a horizontal plane when the printing apparatus is in its nominal operating position) is 30 degrees. In general the preferred angle α of inclination is between

ten degrees and eighty degrees, and more preferably between twenty degrees and fifty degrees.

Motor axle 474 typically includes a toothed pulley having an outer rim 501 to keep the belt 480 engaged. Herein the term motor axle will also include the motor pulley. Belt 480 includes a first section 481 on one side of motor axle 474 and a second section 482 (substantially parallel to first section 481) on the other side of motor axle 474. In the example shown in FIG. 9, belt attachment 485 is on the first section 481. As the carriage 200 moves back and forth along carriage guide 460, different parts of belt 480 will be above or below motor axle 474. However, even at the extreme ends of travel of carriage 200, belt attachment 485 will not move from one side of motor axle 474 to the other side. Thus, the portion of first section 481 that includes belt attachment 485 is always on a predetermined side of motor axle 474, even if portions of the belt 480 move from one side of the motor axle 474 to the other side. Belt 480 includes a length direction L_B extending from the rotatable motor axle 474 to the idler pulley 488 (see FIG. 7), and a width direction W_B extending substantially parallel to the rotatable motor axle 474. In order to keep carriage vibration at a low level, the width direction W_B of belt 480 is disposed in a substantially radial orientation relative to an axis 464 of the carriage guide 460. This can be seen more clearly FIG. 9 relative to teeth 484 (a few of which are shown on the inner surface of the first section 481 of belt 480). Radial line 486 from carriage guide axis 464 extends along substantially the same direction as teeth 484, i.e. the teeth 484 on the first section 481 of belt 480 are oriented substantially radially relative to axis 464 of carriage guide 460. It can also be seen in FIG. 9 that first section 481 of belt 480 is positioned at a first distance from carriage guide 460, and section 482 is positioned at a second distance from carriage guide 460, where the first distance is less than the second distance.

FIG. 10 shows a perspective view of printer chassis 420 looking toward the region where the carriage motor would be mounted, but with no printer components assembled onto printer chassis 420. Inclined cradle 475 for supporting carriage motor 470 at an inclined orientation relative to base 421 of

printer chassis 420 can be seen. Also visible in FIG. 10 is retainer 462 (opposite the retainer 462 seen in FIG. 4) for holding carriage guide 460 in place. Ribs 425 for supporting recording medium in printing region 424 are also seen.

Inclined cradle 475 and holding feature 476 (see FIG. 8) perform part of the function of holding carriage motor 480 in place in printer chassis 420 using only parts that are molded together with printer chassis 420 and not requiring a separate support structure such as a backbone. In order to further secure the carriage motor 470 in its inclined position, a motor holding feature 540 is provided in second region 529 of the bottom of scanner base 520 as shown in FIG. 11. (The viewing angle of FIG. 11 is rotated with respect to the view of FIGS. 8 and 9.) During the assembly of multifunction printer 100, when scanner base 520 is mounted as an upper structure onto printer chassis 520, motor holding feature 540 engages carriage motor 470 near the upper edge 472 of carriage motor 470 (see FIG. 8) to hold carriage motor 480 against the inclined cradle 475 (see FIG. 10) and holding feature 476 (see FIG. 8) that serve as a motor support in printer chassis 420. In this embodiment, a first portion 541 of motor holding feature 540 contacts cylindrical wall 478 of outer casing 471 of carriage motor 480, and a second portion 542 of holding feature 540 contacts face 477 of the outer casing 471 of carriage motor 480.

When the multifunction printer 100 is fully assembled (see FIG. 2), the upper edge 472 of inclined carriage motor 480 is positioned near the base 520 of scanning apparatus 500, so that the overall height of multifunction printer 100 can be reduced relative to conventional multifunction printers. Additionally, the first section 481 that includes belt attachment 485 is oriented substantially radially relative to the carriage guide in order to keep carriage vibrations low for good print quality. Because inclined cradle 475 and holding feature 476 are integrally formed together with printer chassis 420 (e.g. during injection molding), and because motor holding feature 540 is likewise integrally formed with scanner base 520, no additional fasteners or assembled support structures are required, thereby simplifying assembly and reducing cost.

In other embodiments, the general approach of assembling a multifunction printer employed for the carriage motor is also used for assembling a variety of other components of the printing apparatus without using additional fasteners. For these embodiments, the printing apparatus 400 (for printing on recording medium) is provided that includes a printer chassis 420 having a support feature (such as inclined cradle 475 and holding feature 476) for holding a component of the printing apparatus. The component (such as carriage motor 470) is mounted onto the support feature. A scanning apparatus 500 (for converting an image into digitized data) is provided that includes a securing feature (such as motor holding feature 540 on scanner base 520). The scanning apparatus is then affixed to printer chassis 420 such that the securing feature of the scanning apparatus constrains a position of the component of the printing apparatus relative to the support feature of the printer chassis. In some instances, such as for the carriage motor, the securing feature can actually contact the component in order to hold it fixedly in place. For example, scanner base 520 can have a securing feature extending from scanner base 520 to contact power supply 405 (see FIG. 8) in order to hold it in place when scanner base 520 is assembled onto printer chassis 420. In other instances, the securing feature allows rotational motion of the component, but constrains translational motion. In some instances the securing feature of scanning apparatus 500 is brought nearly into contact, but not actually into contact with the component, so that an acceptable amount of motion of the component is allowed, but not an excessive amount of motion.

Assembly of carriage guide 460 is another example of this assembly approach that is used in some embodiments. In FIGS. 4 and 10, retainer features 462 (serving as support features for carriage guide 460) are shown on opposing side walls 428 of printer chassis 420. One or both of the opposing side walls 428 are somewhat flexible, so that at least the top portion of a side wall 428 can be bent outward, away from the inner region of the printer chassis 420. In the examples shown in FIGS. 4 and 10, retainer features 462 extend inwardly into printer chassis 420. Carriage guide 460 (see FIG. 5) is provided with open ends 461 (see FIG. 16) that can fit onto retainer features 462. When flexible side walls 428 are not bent, carriage guide 460 is longer than the distance between a

predetermined distance between the retainer features 462. By bending at least one of the flexible side walls 428 in an outward direction such that a distance between the two retainer features 462 is longer than the length of the carriage guide element, a first retainer feature 462 can be inserted into one open end 461 of the carriage guide, and the second retainer feature 462 can be inserted into the second open end 461 of the carriage guide. When the flexible side walls 428 are released, retaining features 462 hold carriage guide 460 in its mounted position in printer chassis 420. Interlocking features, such as attachment tabs 508 can be provided on outer case 505 of scanning apparatus 500, as shown in FIG. 12 to reduce the flexibility of the opposing flexible side walls 428 of printer chassis 420, so that when scanning apparatus 500 is affixed to printer chassis 420, carriage guide 460 becomes further secured with its position constrained. Lower rim 506 of outer case 505 can also engage with upper rim 429 (see FIG. 8) of side wall 428 of printer chassis 420 when scanning apparatus 500 is affixed to printer chassis 420. Interlocking complementary lips on upper rim 429 of side wall 428 and on lower rim 506 of outer case 505 can further reduce the flexibility of side walls 428 when the scanning apparatus 500 is affixed to printer chassis 420. Interlocking tongue and groove features (not shown) can also be provided. Such interlocking features - attachment tabs 508 and their attachment points (not shown) on printer chassis 420, complementary lips on upper rim 429 and lower rim 506, and interlocking tongue and groove features include both attachment features in the scanning apparatus 500 and mating features 420 that reduce the flexibility of the flexible side walls 428 when scanning apparatus 500 is affixed to printer chassis 420.

In addition to reducing the number of fasteners and not requiring an additional assembled structure, such as a backbone, a further advantage of attaching the carriage guide 460 to retaining features 462 that have been integrally formed with printer chassis 420 is improved dimensional tolerances. In particular, the distance from the printhead face to the recording medium in the printing region 424 is critically important. If this distance is too large, poorly performing jets that eject drops at an angle relative to their intended direction result in poor print quality. If the distance is too small, the printhead can strike the recording medium as the printhead is moved back and forth by the carriage, doing damage

to both the recording medium, and the printhead. By integrally forming retaining features 462 and ribs 425 in printing region 424 (see FIGS. 4 and 10), for example during injection molding of printer chassis 420, the spacing between printhead and recording medium is thereby well controlled.

Paper advance motor 440 is another example of a component that can be assembled onto support features in the printer chassis 420 and then secured in place when the scanning apparatus 500 of multifunction printer 100 is affixed to the printer chassis 420. As shown in FIG. 13, paper advance motor 440 includes a cylindrical wall 441 and a face 442 from which rotatable motor axle 444 extends. Motor axle 444 can include a toothed pulley having an outer rim (unlabelled) for embodiments where a toothed belt is used to transmit power from paper advance motor 440. Also extending from face 442 is a nonrotatable collar 443. Although bolt holes (unlabelled) are provided in the face 442 of a conventional paper advance motor 440 for attachment to a structural framework (as discussed in the background relative to prior art FIG. 1), attachment of paper advance motor 440 in embodiments of the invention does not require additional fasteners or separately assembled framework. As shown in the perspective view in FIG. 14, a cradle 445 and a collar holder 446 are integrally formed as part of printer chassis 420 (e.g. during injection molding of the printer chassis) as support features for paper advance motor 440. Collar holder 446 includes a slot 447 for holding collar 443. Collar holder 446 and slot 447 are shown more clearly in the perspective view of FIG. 15 without paper advance motor 440. Slot 447 has an open upper end 448 and a lower end 449 that is configured to hold collar 443 of paper advance motor 440. In this example, since collar 443 is circular, slot 447 has a rounded lower end 449. Also in this embodiment, slot 447 has a central axis (dashed line in the middle of slot 447) that is not vertical. Rather, in the view of FIG. 15 the central portion of the lower end 449 is offset to the left relative to the central portion of the upper end 448 of slot 447. During assembly of multifunction printer 100, cylindrical wall 441 of paper advance motor 440 is placed into cradle 445 and collar 443 is inserted into open upper end 448 of slot 447 and then lowered to fit

into lower end 449 of slot 447 of collar holder 446. Subsequently when scanning apparatus 500 is assembled onto printer chassis 420, curved securing feature 543 (see FIG. 12) holds cylindrical wall 441 of paper advance motor 440 in position. In some embodiments it is useful to perform tests on printing apparatus 400 prior to completion of the assembly, and it is in such embodiments that the nonvertical slot 447 (described above) can be useful. FIG. 16 shows a number of assembled components of printing apparatus 400, but with printer chassis 420 hidden for clarity. The viewing angle of FIG. 16 is rotated approximately 180 degrees relative to FIG. 15 so that items that point toward the left (such as the upper to lower dashed line indicating the central axis of slot 447) would point toward the right in FIG. 16. FIG. 16 shows paper advance motor 440 together with power transmission elements for driving the feed roller and the discharge roller. In particular, belt 450 is looped around rotatable motor axle 444 of paper advance motor 440 and also around pulley 451. Formed coaxially on the opposite side of pulley 451 is a pulley gear 455 (see FIG. 17) that engages feed roller driving gear 453. Formed coaxially on feed roller driving gear 453 is round projection 454, discussed in further detail below relative to the mounting of the feed roller. Feed roller 436 (see FIG. 6) is hidden by carriage guide 460 in the view of FIG. 16, but is assembled coaxially with feed roller driving gear 453. Feed roller driving gear 453 also transfers rotational power to idler gear 435 and from there to discharge roller gear 437, which rotates discharger roller 438 (see FIG. 6). During assembly of printing apparatus 400, pulley 451 and tensioning pulley 452 are respectively mounted on pulley mounting feature 414 and on axle mount 415 (see also FIG. 17), which are integrally formed on printer chassis 420 (see FIG. 15). When belt 450 is looped around motor axle 444, pulley 451 and tensioning pulley 452, the tension in belt 450 pulls motor axle 444 to the right in FIG. 16 (to the left in FIG. 15), thereby forcing collar 443 against the lower end of nonvertical slot 447. Thus, even before scanning apparatus 500 is assembled onto printer chassis 420, sufficient holding force is applied to paper advance motor 440 so that tests can be performed.

The feed roller assembly is yet another example of a component that can be assembled onto support features in the printer chassis 420 and then

secured in place when the scanning apparatus 500 of multifunction printer 100 is affixed to the printer chassis 420. The feed roller assembly includes feed roller 436, feed roller drive gear 453 that is coaxially mounted on a first end of feed roller 436 (see FIG. 17), and a power transmission gear 456 (see FIG. 18) that is coaxially mounted on a second end of feed roller 436. Power transmission gear 456 (which can be injection molded from acetal, for example) has a bearing surface 457. FIG. 19 shows the same perspective view as FIG. 18, but with feed roller 436 and power transmission gear 456 hidden in order to show feed roller support 406 that has been integrally formed with printer chassis 420, for example by injection molding. Feed roller support 406 includes a slot 407 having an open upper end 408 and a rounded lower end 409. When the feed roller assembly is assembled into printer chassis 420, the bearing surface 457 of power transmission gear 456 is inserted through the upper open end 408 of slot 407 and placed into contact with the rounded lower end 409 of slot 407. At the first end of the feed roller assembly, the round projection 454 (see FIG. 16) of feed roller drive gear 453 is inserted into a round hole 416 (see FIG. 15) in feed roller assembly support 417. The feed roller assembly is further secured when spring-biased pinch roller assembly 530 at pinch rollers 532 (see FIGS. 3 and 6), having already been assembled to scanner base 520, is pressed into contact with the rotatable feed roller assembly when the scanning apparatus 500 is assembled to the printer chassis 420, thereby constraining the bearing surface 457 of power transmission gear to be held against the rounded lower end 409 of slot 407.

Still another example of a component that can be assembled onto support features in the printer chassis 420 and then secured in place when the scanning apparatus 500 of multifunction printer 100 is affixed to the printer chassis 420 is drive shaft 490 that transmits power from power transmission gear 456 of the feed roller assembly to the turn roller assembly, as is described in further detail below and as shown in FIGS. 20-22. Drive shaft 490 is a rotatable shaft having bearing surfaces 492 and optionally one or more rings 494. FIG. 20 shows a portion of the feed roller assembly (including feed roller 436 and power transmission gear 456), turn roller assembly (including turn roller 438 and associated gears), pick roller assembly (including pick roller 431, pick arm 432

and associated gears) and drive shaft 490, but with printer chassis 420 hidden for clarity. FIG. 21 shows the same view but with printer chassis 420 shown. As shown in FIG. 21, integrally formed with printer chassis 420 (for example, by injection molding) are drive shaft supports 465, each including a slot (similar to slot 407 shown in FIG. 19, but sized to accommodate bearing surfaces 492 of drive shaft 490) having an open upper end 467 and a rounded lower end 468. Drive shaft supports 465 also include upper support surfaces 469. When assembling drive shaft 490 into printer chassis 420, bearing surfaces 492 are placed into contact with the rounded lower ends 468 of the slots 466 in drive shaft supports 465. Subsequently, when scanning apparatus 500 is assembled onto printer chassis 420, securing extension 544 (see FIG. 12) comes into contact with upper support surfaces 469 of one of the drive shaft supports 465, and securing extension 546 comes into contact, or nearly into contact with ring 494. Securing extension 544 does not quite come into contact with bearing surface 492, so that the position of drive shaft 490 is constrained but without additional frictional drag.

The function of drive shaft 490 and its interaction with the other portions of the paper feeding apparatus of printing apparatus 400 will next be described in further detail. The feed roller assembly including feed roller 436, feed roller drive gear 453 and power transmission gear 456, transmit power from paper advance motor 440 to rotate turn roller 434 and pick roller 431 as needed to advance recording medium toward the printing region. Power transmission gear 456 is a compound gear including bevel gear 458 and spur gear 459. When it is necessary to move a piece of recording medium from media input region 412 toward turn rollers 434 (see FIG. 6), a transmission mechanism (not shown) is engaged. Then power to pick roller 431 is transmitted from spur gear 459 through a gear train 418 having a gear that is engaged with spur gear 459 as well as a set of gears on one side of pick arm 432 and a set of gears on the other side of pick arm 432. Spur gears, having gear teeth that are parallel to the rotational axis of the gear are suitable for applications where the load to be driven (such as pick roller 431) requires substantial torque. However, a gear train having many gears tends to add to both the expense and the noise of the printing apparatus. Conventional

printers also use a gear train driven by the feed roller assembly to rotate turn roller 434. However, it has been found that drive shaft 490 having a bevel gear 491 at one end to engage with bevel gear 458 of power transmission gear 456 and another bevel gear 493 at the other end of drive shaft 490 to engage with a bevel gear 496 that is coupled to gears for rotating turn roller 434, is able to develop sufficient torque for the turn roller 434 to advance the recording medium through the turn region toward the feed roller 436 (see FIG. 6). Thus, using drive shaft 490 allows elimination of approximately seven gears (depending upon the configuration of the printer) and their associated expense and noise level. In particular, the turn roller assembly includes a compound gear 495 made up of bevel gear 496 and spur gear 497; a first pivot gear 498; a second pivot gear 499; an intermediate gear 489; a drive gear 487; and turn roller 434. Feed roller 436 can rotate either in forward direction 433 or in a reverse direction that is opposite to forward direction 433. Rotating feed roller 436 in forward direction 433 advances recording medium toward print region 424 (see FIG. 6). Feed roller 436 can also be rotated in the reverse direction to deskew the leading edge of recording medium as it approaches the feed roller. However, whether feed roller 436 is rotating in forward direction 433 or reverse direction, it is desired that turn roller 434 (when turning) should always rotate in forward direction 433. This is accomplished through first pivot gear 498, second pivot gear 499 and intermediate gear 487. Spur gear 497 of compound gear 495 is engaged with both first pivot gear 498 and second pivot gear 499. When spur gear 497 is rotated in one direction due to the rotation of feed roller 436, first pivot gear 498 is rotated to engage intermediate gear 489 (as in FIG. 22) which then causes drive gear 489 in forward direction 433. When spur gear 497 is rotated in the opposite direction due to the rotation of the feed roller 436, second pivot gear 499 is rotated to engage directly (i.e. without an intermediate gear) with drive gear 489 to rotate it in the forward direction 433.

A special case of the bevel gear is the miter gear where two meshing gears have equal numbers of teeth and shaft axes that are perpendicular to each other. The example shown in FIGS. 20 - 22 (the length axis of drive shaft

490 being perpendicular to the length axis of feed roller 436) use miter gears, but other bevel gear embodiments are contemplated.

The invention has been described in detail with particular reference to certain preferred embodiments thereof, but it will be understood that variations and modifications can be effected within the spirit and scope of the invention.

PARTS LIST

100	Multifunction printer
200	Carriage
202	Carriage bearing
204	Carriage bearing
250	Printhead
262	Ink supply
264	Ink supply
300	Printer
302	Load entry direction
303	Printing region
304	Direction
305	Carriage scan direction
306	Right side
307	Left side
308	Front
309	Rear
310	Hole
311	Feed roller gear
312	Feed roller
313	Forward direction
330	Maintenance station
380	Motor
381	Screw
382	Guide rail
383	Axle
384	Belt
385	Backbone
386	Rotational axis of pulley
390	Electronics board
392	Cable connectors

400 Printing apparatus
402 Line (parallel to base of printer chassis)
405 Power supply
406 Feed roller assembly support
407 Slot
408 Upper end (of slot)
409 Lower end (of slot)
410 Door
412 Media input region
414 Pulley mounting feature
415 Axle mount (for tensioning pulley)
416 Hole
417 Feed roller assembly support
418 Gear train (for pick roller)
420 Printer chassis
421 Base (of printer chassis)
422 Media support element
423 Ribs (on media support element)
424 Printing region
425 Ribs (in printing region)
426 Discharge region
428 Side wall
429 Upper rim (of side wall)
430 Media transport path
431 Pick roller
432 Pick arm
433 Forward rotation direction
434 Turn roller
435 Idler gear
436 Feed roller
437 Discharge roller gear
438 Discharge roller

439 Star wheel assembly
440 Paper advance motor
441 Cylindrical wall (of paper advance motor)
442 Face (of paper advance motor)
443 Collar (of paper advance motor)
444 Axle (of paper advance motor)
445 Cradle (for paper advance motor)
446 Collar holder (for paper advance motor)
447 Slot
448 Upper end (of slot)
449 Lower end (of slot)
450 Belt
451 Pulley
452 Tensioning pulley
453 Feed roller drive gear
454 Round projection
455 Pulley gear
456 Power transmission gear
457 Bearing surface
458 Bevel gear (of power transmission gear)
459 Spur gear (of power transmission gear)
460 Carriage guide
461 Open end (of carriage guide)
462 Retainer (for carriage guide)
464 Axis (of carriage guide)
465 Drive shaft support
466 Slot
467 Upper end
468 Lower end
469 Upper support surfaces
470 Carriage motor
471 Outer casing (of carriage motor)

472 Upper edge (of carriage motor)
473 Axis
474 Axle (of carriage motor)
475 Inclined cradle
476 Holding feature (of inclined cradle)
477 Cylindrical wall (of carriage motor)
478 Face (of carriage motor)
479 Electrical terminal(s)
480 Belt (for carriage)
481 First section (of belt)
482 Second section (of belt)
484 Teeth (of belt)
485 Belt attachment
486 Radial line (from axis of carriage guide)
487 Intermediate gear
488 Idler pulley
489 Drive gear (for turn roller assembly)
490 Drive shaft (for turn roller assembly)
491 Bevel gear (of drive shaft)
492 Bearing surface(s)
493 Bevel gear (of drive shaft)
494 Ring (of drive shaft)
495 Compound gear (of turn roller assembly)
496 Bevel gear (of compound gear)
497 Spur gear (of compound gear)
498 First pivot gear
499 Second pivot gear
500 Scanning apparatus
501 Outer rim
505 Case
506 Lower rim
508 Attachment tab(s)

510 Transparent platen
512 Control
514 Indicator
516 Printed circuit board
520 Scanner base
521 Dashed line representing contour of scanner base bottom
522 Supports (for platen glass)
524 Rack
525 Scanner housing
526 Bottom surface (of scanner base)
528 First region (of scanner base bottom)
529 Second region (of scanner base bottom)
530 Pinch roller assembly
532 Pinch rollers
533 Nip
534 Bottom surface (of pinch roller assembly)
536 Finger(s)
538 Spring(s)
540 Motor holding feature
541 First portion (of motor holding feature)
542 Second portion (of motor holding feature)
543 Curved securing feature
544 Securing extension
546 Securing extension

CLAIMS:

1 A printing apparatus comprising:

a carriage for moving a printhead along a carriage scan direction;

a carriage guide for guiding the carriage along the carriage scan direction; and

a motor for moving the carriage, the motor including a rotatable axle, wherein the motor is mounted in the printing apparatus such that when the printing apparatus is in its nominal operating position the rotatable axle is inclined at an angle of between ten degrees and eighty degrees with respect to a horizontal plane.

2. The printing apparatus of claim 1, the carriage guide including a first end and a second end, the printing apparatus further comprising a pulley including an axis of rotation, wherein the motor for moving the carriage is disposed proximate the first end of the carriage guide and the pulley is disposed proximate the second end of the carriage guide element, and wherein the axis of rotation of the pulley is substantially parallel to the rotatable axle of the motor.

3. The printing apparatus of claim 2 further comprising a belt that is looped around both the rotatable axle of the motor and the pulley.

4. The printing apparatus of claim 3, the belt including a first section and a second section that extend from the rotatable axle of the motor to the pulley, wherein the carriage is attached to a portion of the first section.

5. The printing apparatus of claim 4, the belt including a length direction extending from the rotatable axle of the motor to the pulley and a width direction extending substantially parallel to the rotatable axle of the motor, wherein the width direction of the first section of the belt is disposed in a substantially radial orientation relative to the carriage guide element.

6. The printing apparatus of claim 5, the belt including a plurality of teeth oriented along the width direction of the belt, and the carriage guide including an axis disposed between its first end and its second end, wherein the teeth on the first section of the belt are oriented substantially radially relative to the axis of the carriage guide element.

7. The printing apparatus of claim 4, wherein the first section of the belt is disposed at a first distance from the carriage guide and the second section of the belt is disposed at a second distance from the carriage guide element, and wherein the first distance is less than the second distance.

8. The printing apparatus of claim 1, wherein the rotatable axle is inclined at an angle of between twenty degrees and fifty degrees with respect to the horizontal plane.

9. A printing apparatus comprising:

a printer chassis including a base;

a carriage for moving a printhead along a carriage scan direction;

a carriage guide for guiding the carriage along the carriage scan direction; and

a motor for moving the carriage, the motor including a rotatable axle, wherein the motor is mounted in the printing apparatus such that the rotatable axle is inclined at an angle of between ten degrees and eighty degrees with respect to the base of the printer chassis.

10. The printing apparatus of claim 9, the printer chassis further including a motor support that is configured to hold the motor in an inclined orientation relative to the base of the printer chassis.

11. The printing apparatus of claim 10 further comprising an upper structure that is removably mountable on the printer chassis, the upper structure including a motor holding feature, wherein when the upper structure is mounted on the printer chassis, the motor holding feature of the upper structure holding the motor against the motor support of the printer chassis.

12. The printing apparatus of claim 11, the motor further including an outer casing having:

a cylindrical wall that is coaxial with the rotatable axle; and

a face that is substantially perpendicular to the rotatable axle, wherein the motor holding feature of the upper structure contacts the cylindrical wall.

13. The printing apparatus of claim 12, wherein the motor holding feature also contacts the face of the outer casing of the motor.

14. The printing apparatus of claim 9 further comprising:

a pulley having an axis of rotation that is substantially parallel to the rotatable axle of the motor; and

a belt that is looped around the rotatable axle of the motor and around the pulley, the belt including:

a) a first section that is attached to the carriage;

b) a second section that is substantially parallel to the first section; and

c) a width direction that is substantially parallel to the rotatable axle of the motor, wherein the width direction of the first section of the belt is oriented substantially radially relative to the carriage guide element.

15. A multifunction printer comprising:

a) a printing apparatus comprising:

i) a printer chassis including a base;

ii) a carriage for moving a printhead along a carriage scan direction;

iii) a carriage guide for guiding the carriage along the carriage scan direction; and

iv) a motor for moving the carriage, the motor including a rotatable axle, wherein the motor is mounted in the printing apparatus such that the rotatable axle is inclined at an angle of between ten degrees and eighty degrees with respect to the base of the printer chassis; and

b) a scanning apparatus to convert an image into digitized data, the scanning apparatus including a base that is affixed to the printer chassis, wherein the base of the scanning apparatus includes a motor holding feature to secure the motor of the printing apparatus in its inclined position.

16. The multifunction printer of claim 15, the inclined motor including an outer casing having:

a cylindrical wall that is coaxial with the rotatable axle;

a face that is substantially perpendicular to the rotatable axle, wherein the motor holding feature of the upper structure contacts the cylindrical wall; and

an upper edge between the cylindrical wall and the face, wherein the upper edge is disposed proximate the base of the scanning apparatus.

17. The multifunction printer of claim 16, wherein the motor holding feature of the base of the scanning apparatus contacts the face of the outer casing of the inclined motor.

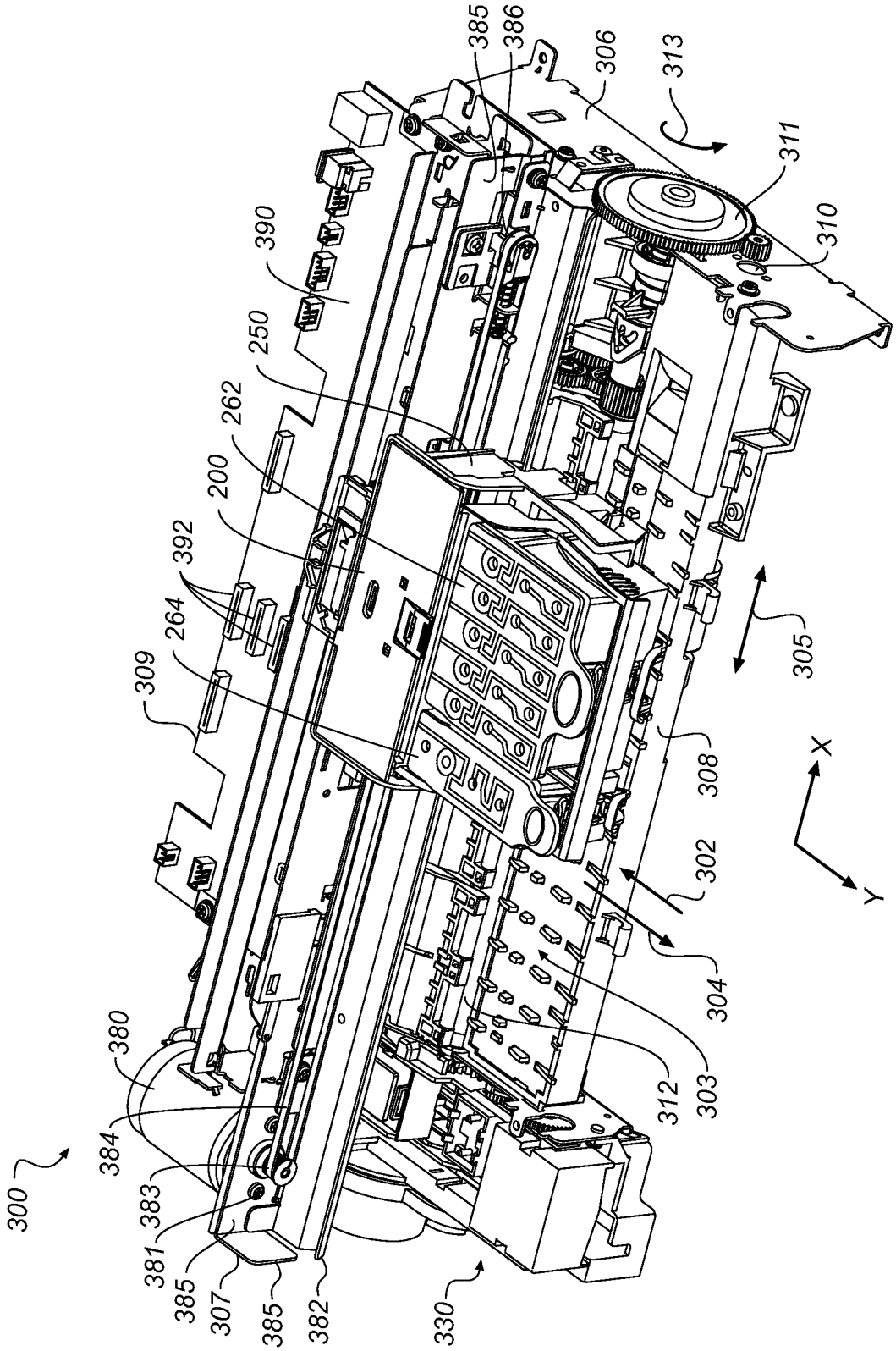


FIG. 1
(PRIOR ART)

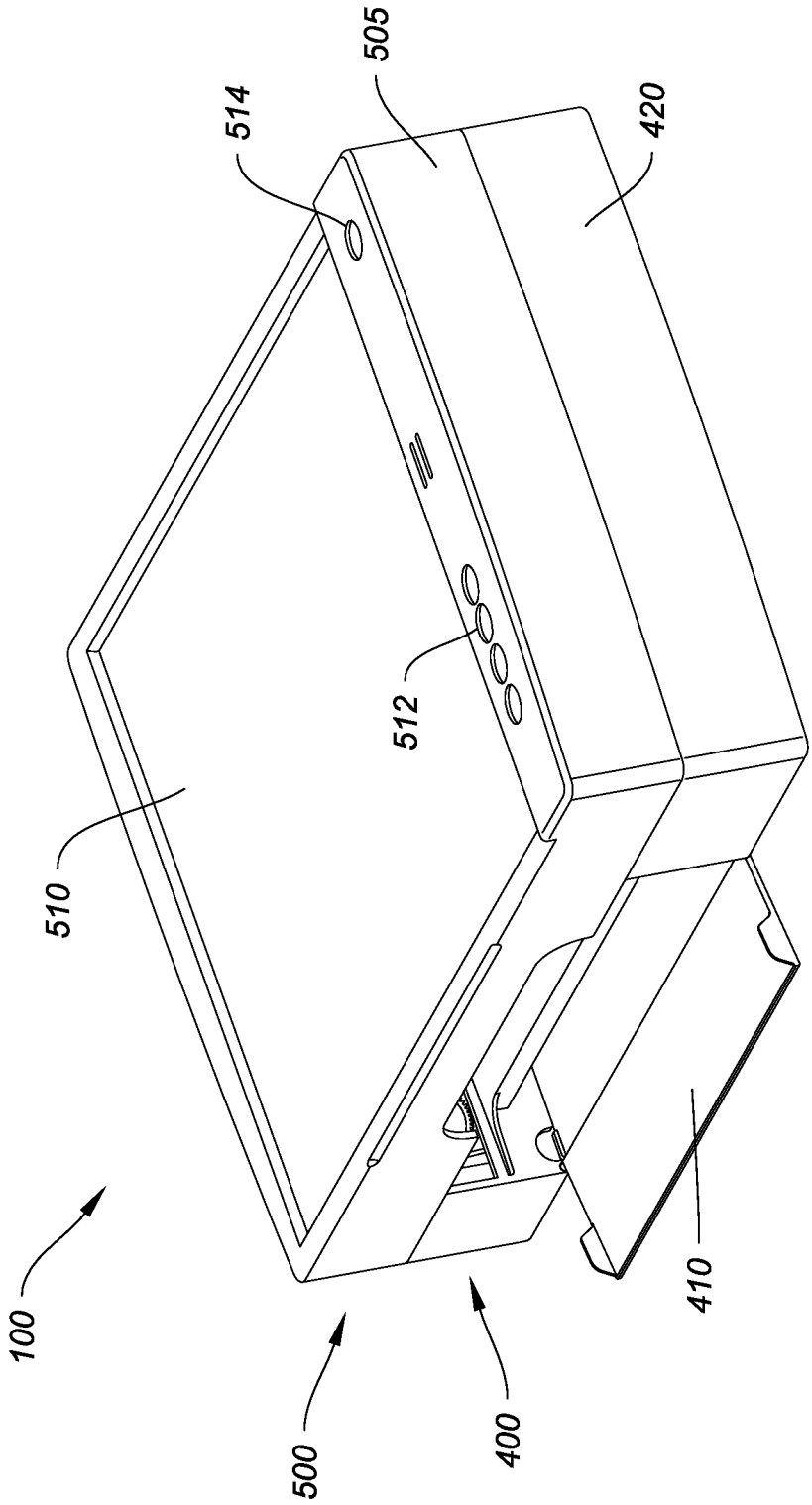


FIG. 2

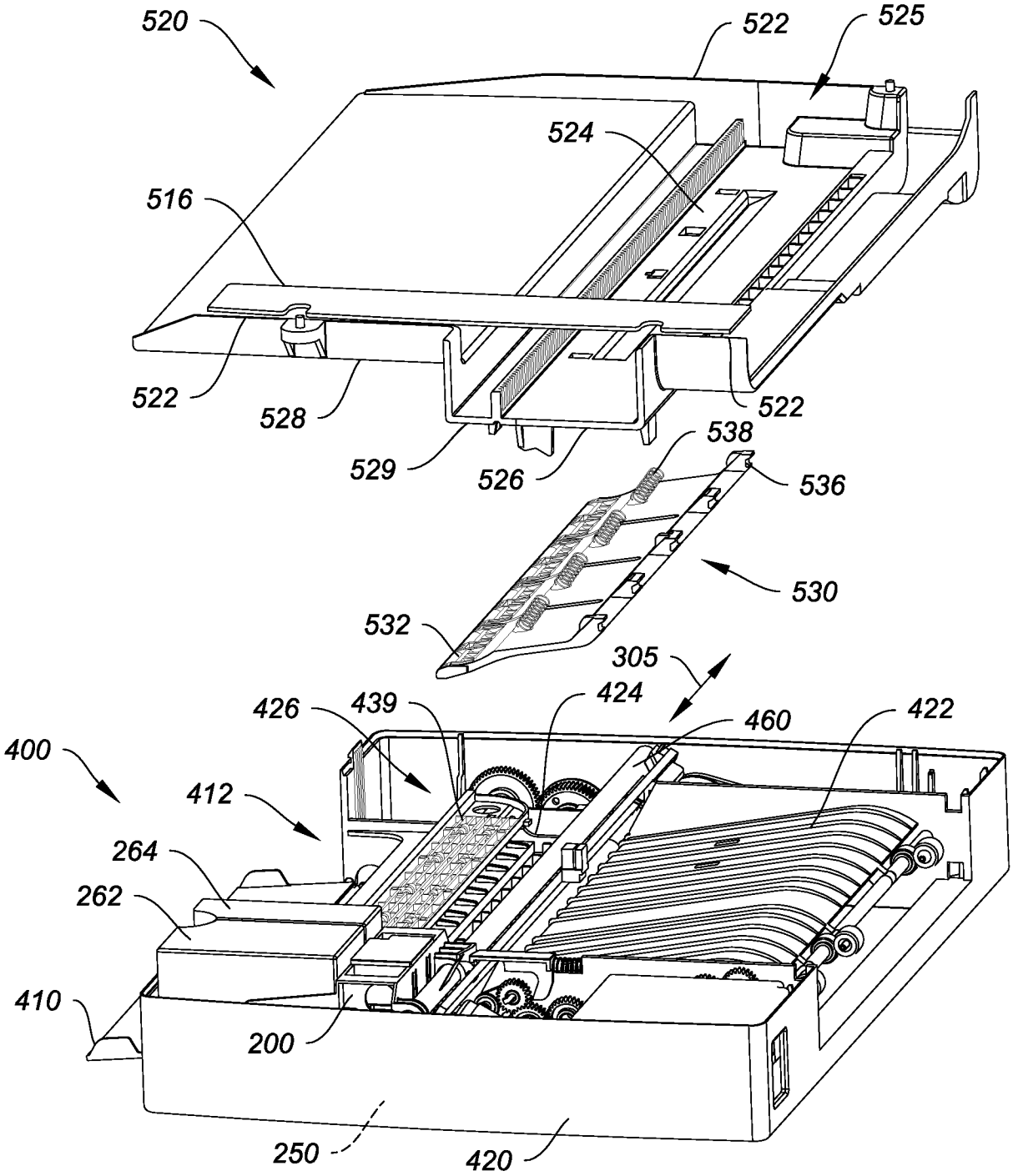

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FIG. 3

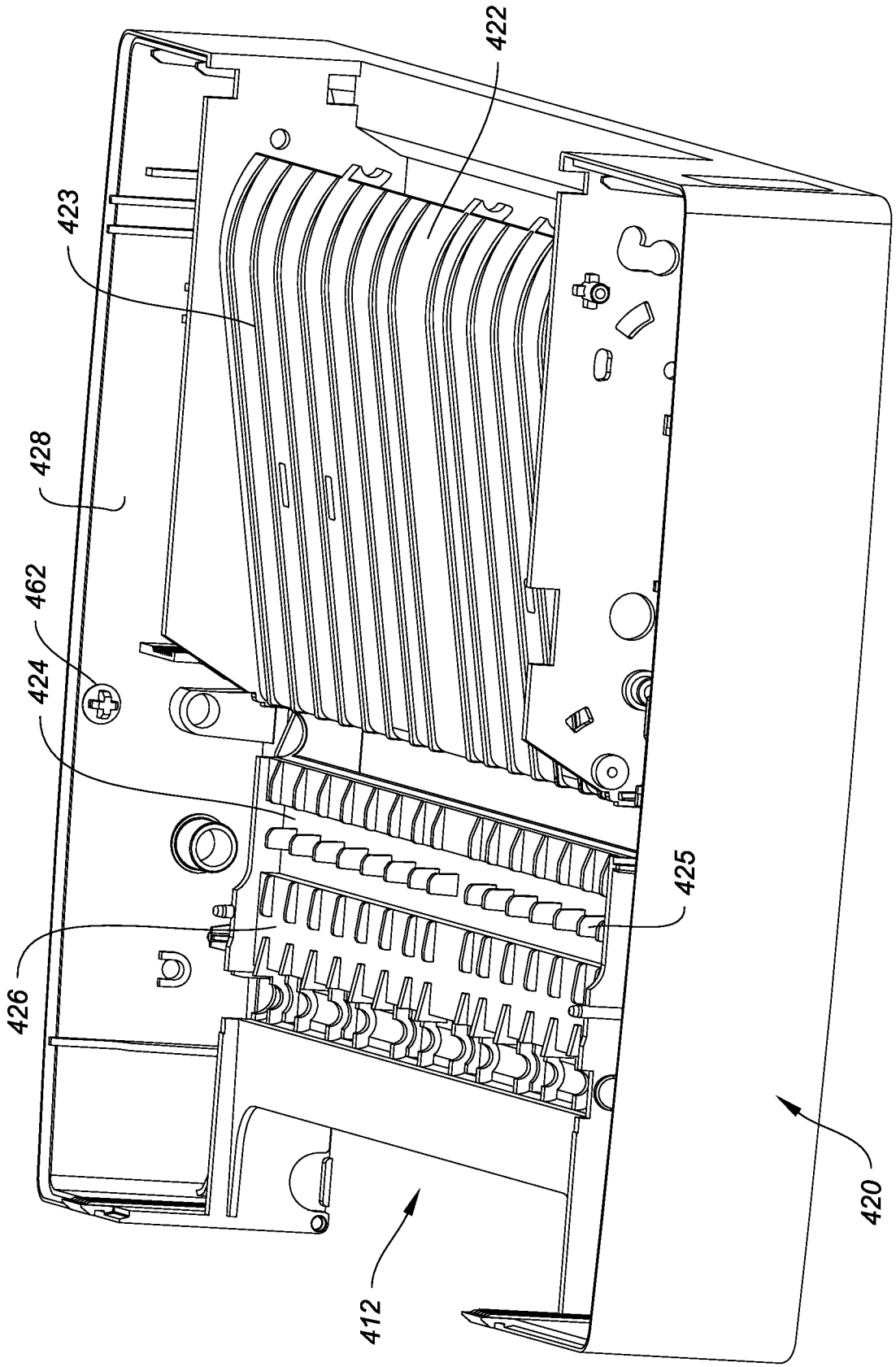


FIG. 4

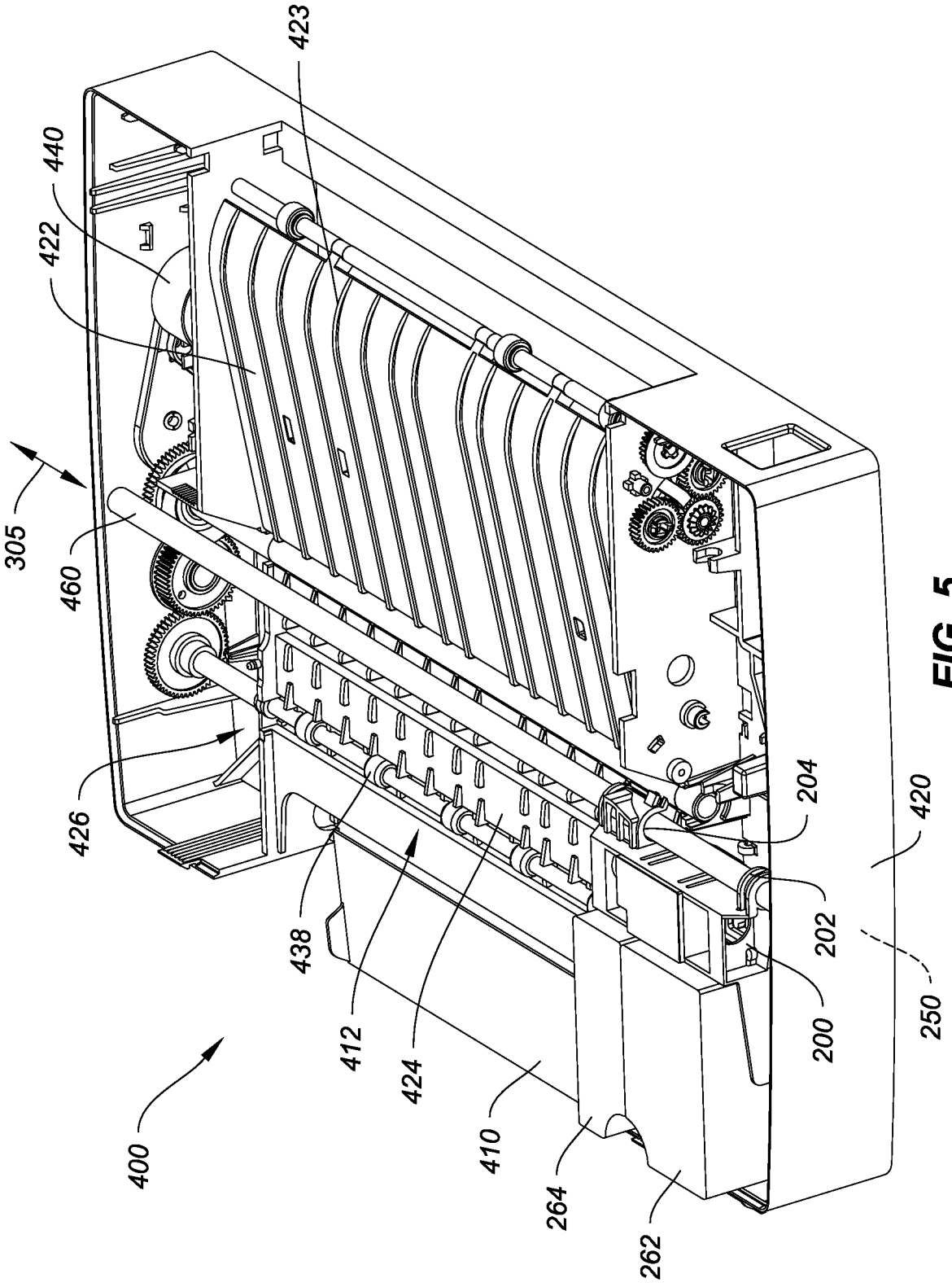

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FIG. 5

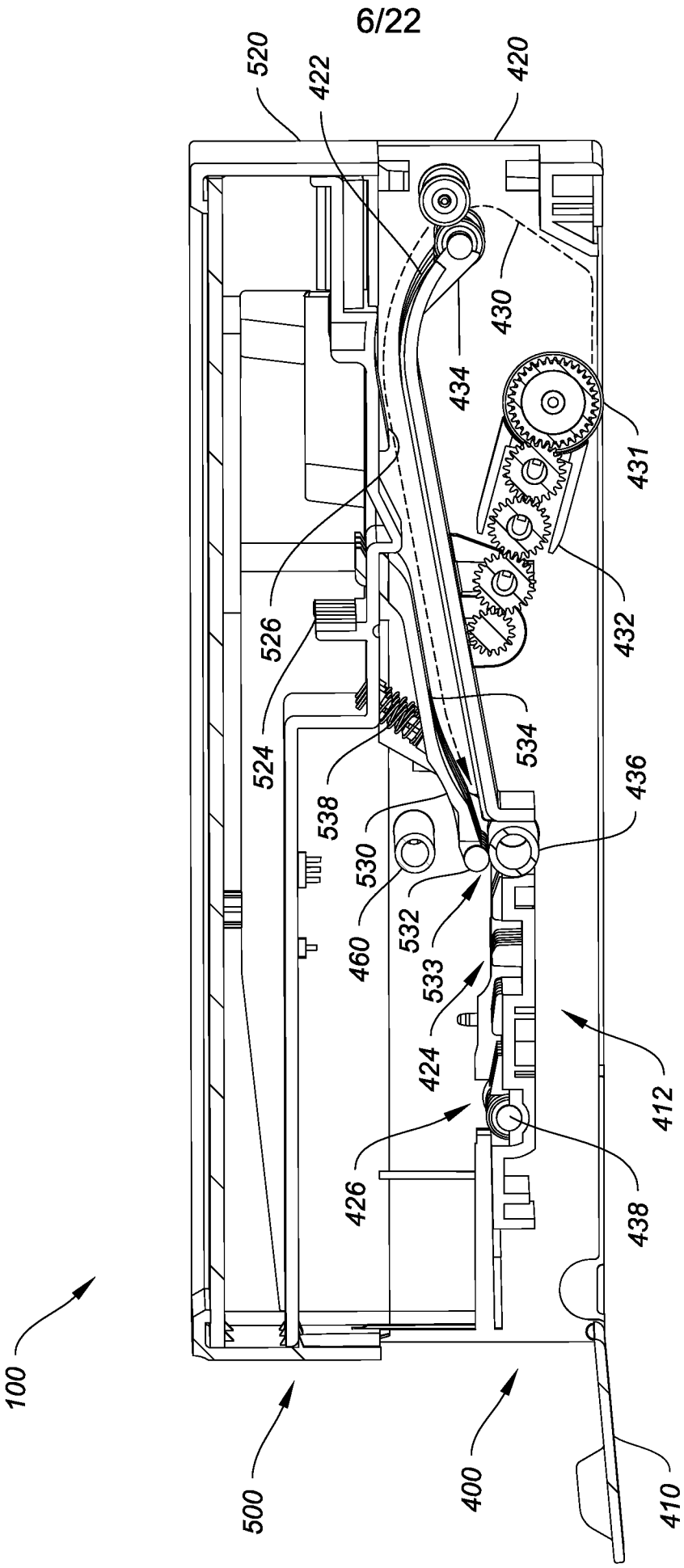

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FIG. 6

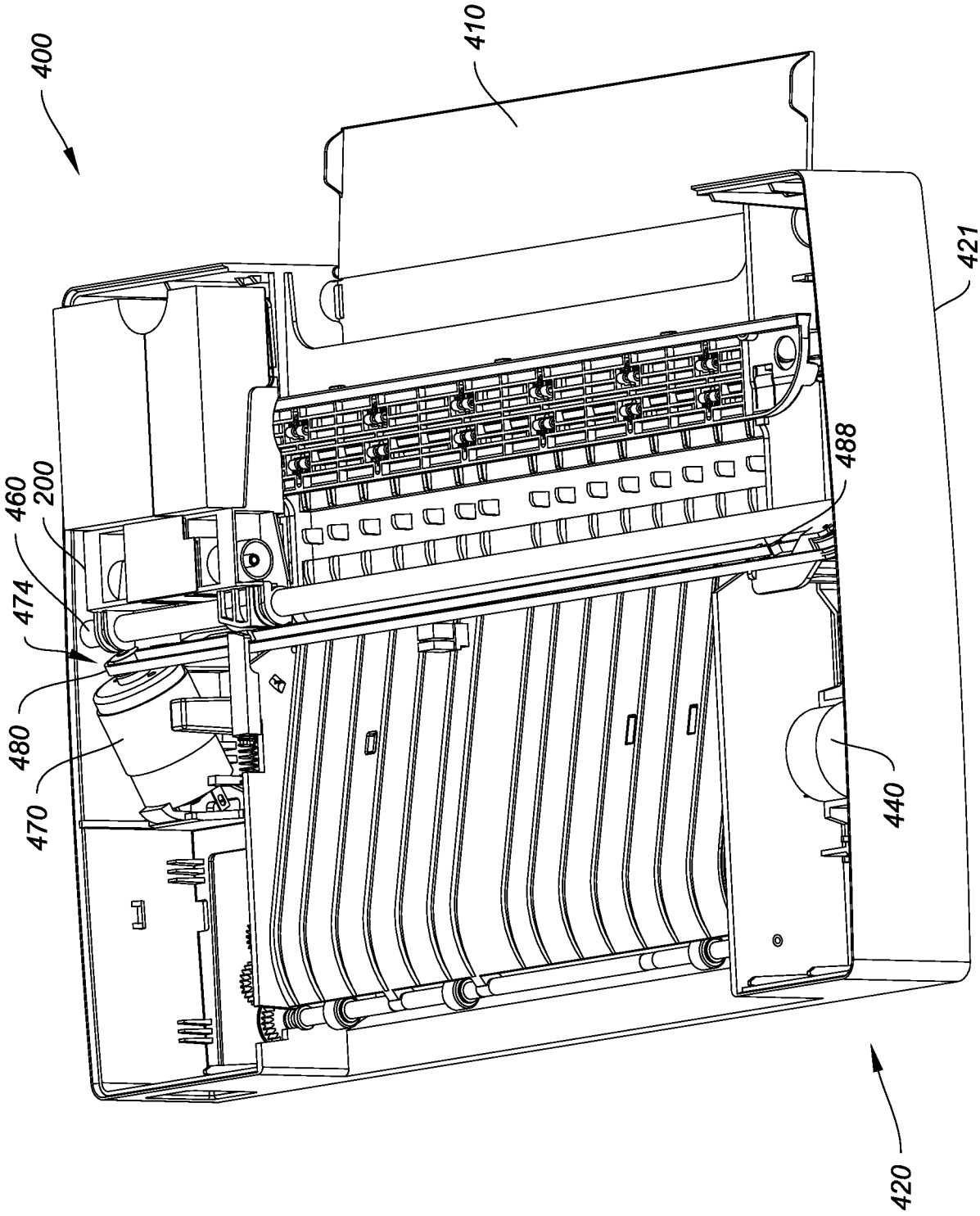


FIG. 7

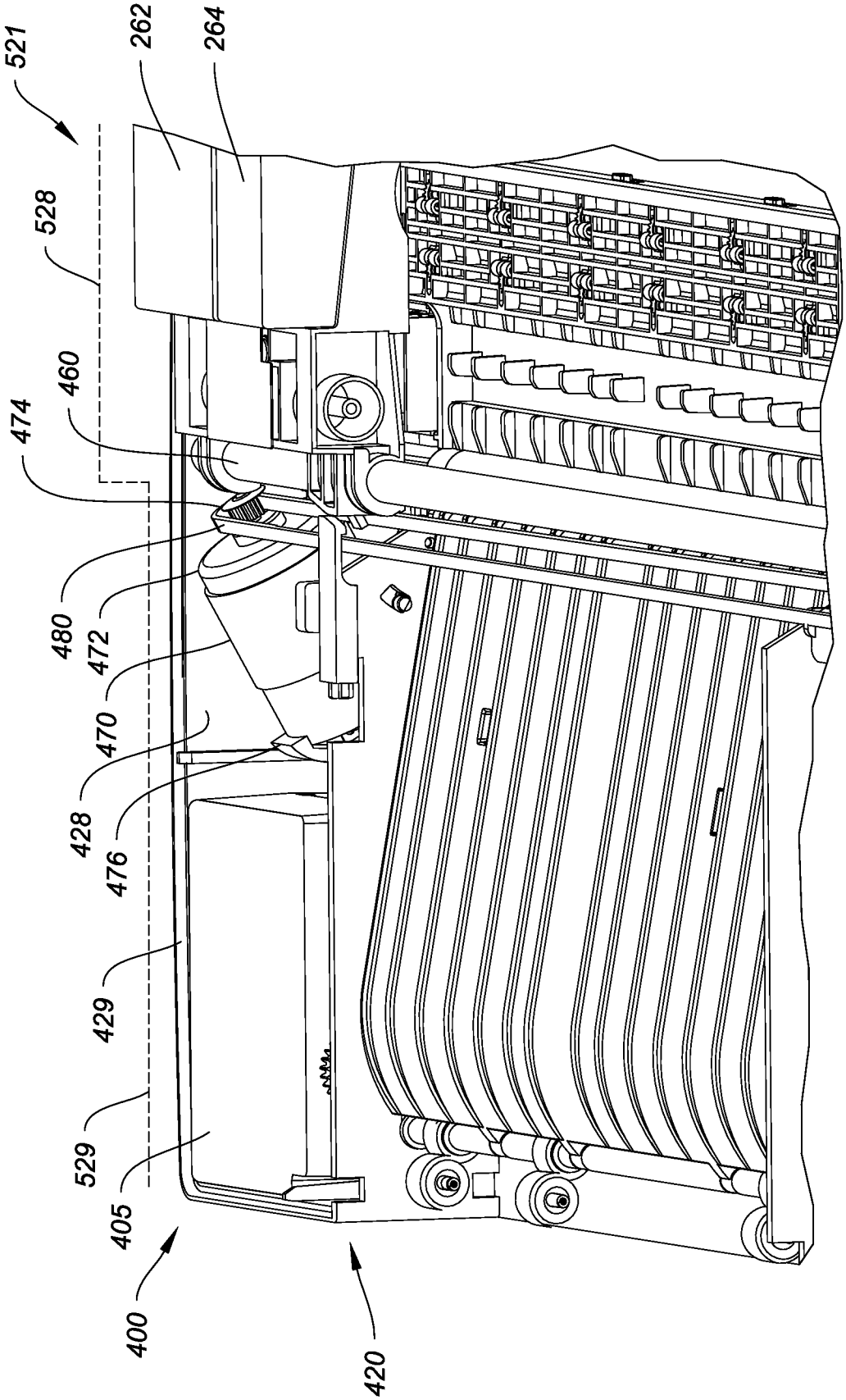


FIG. 8

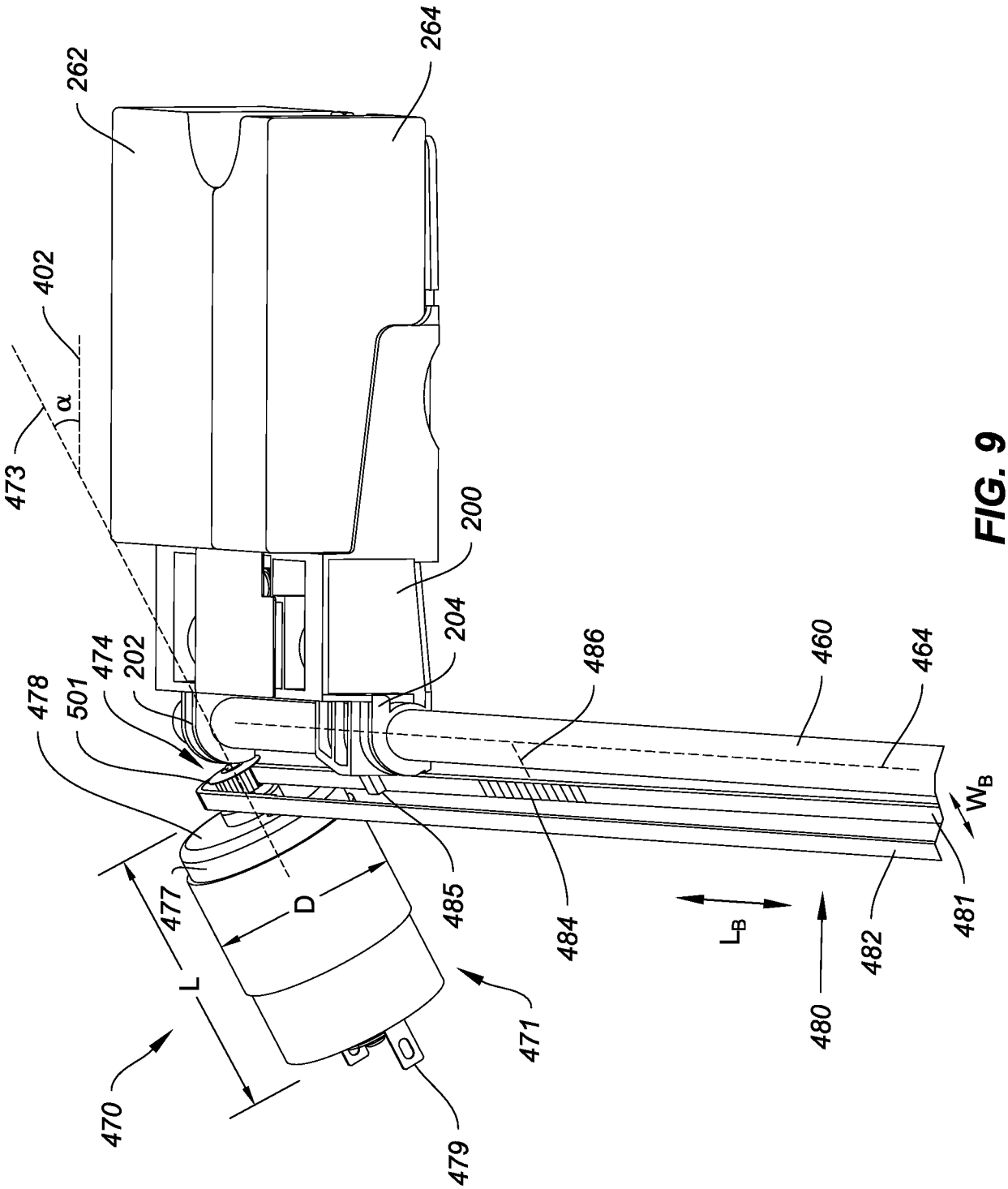

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FIG. 9

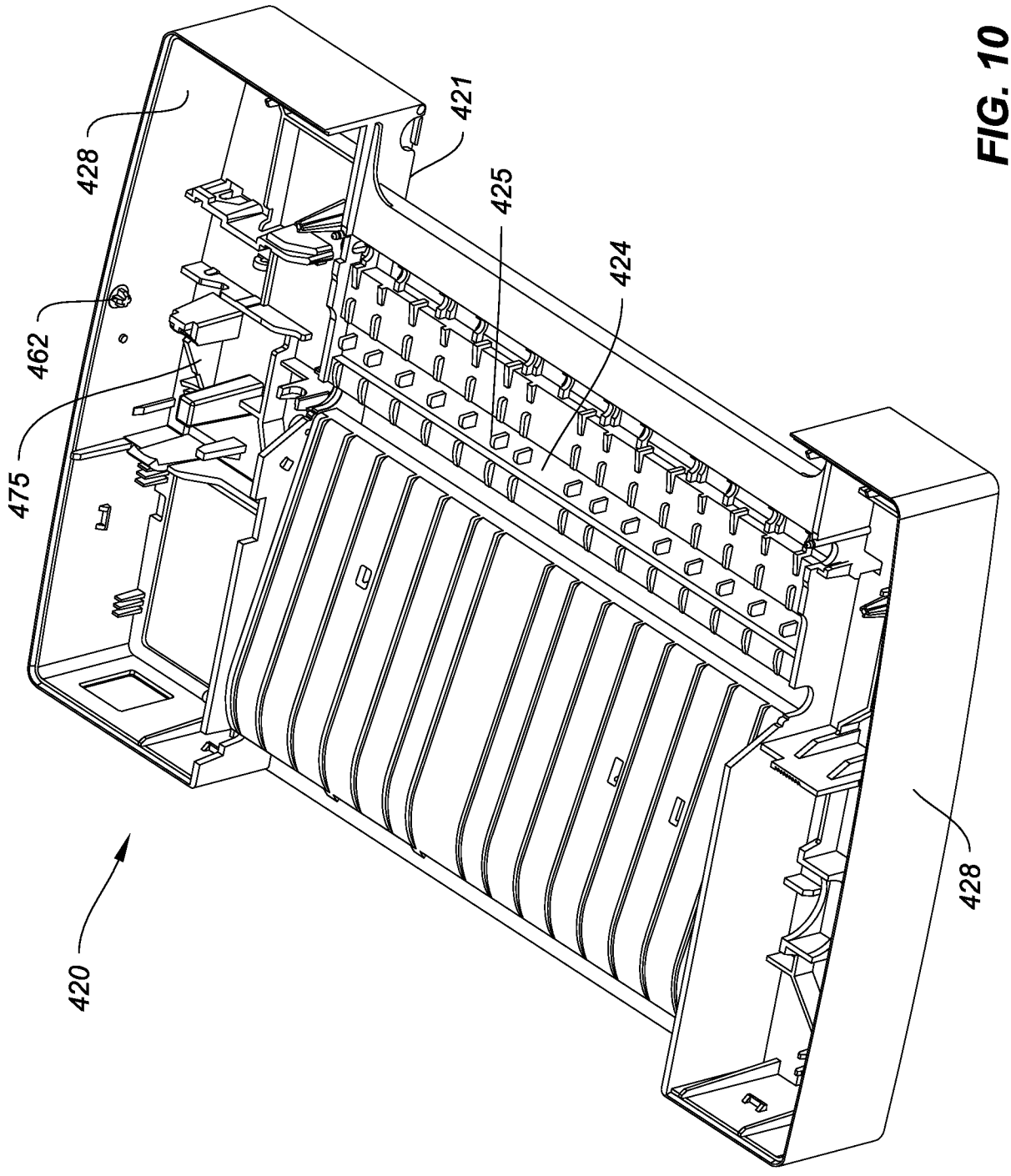


FIG. 10

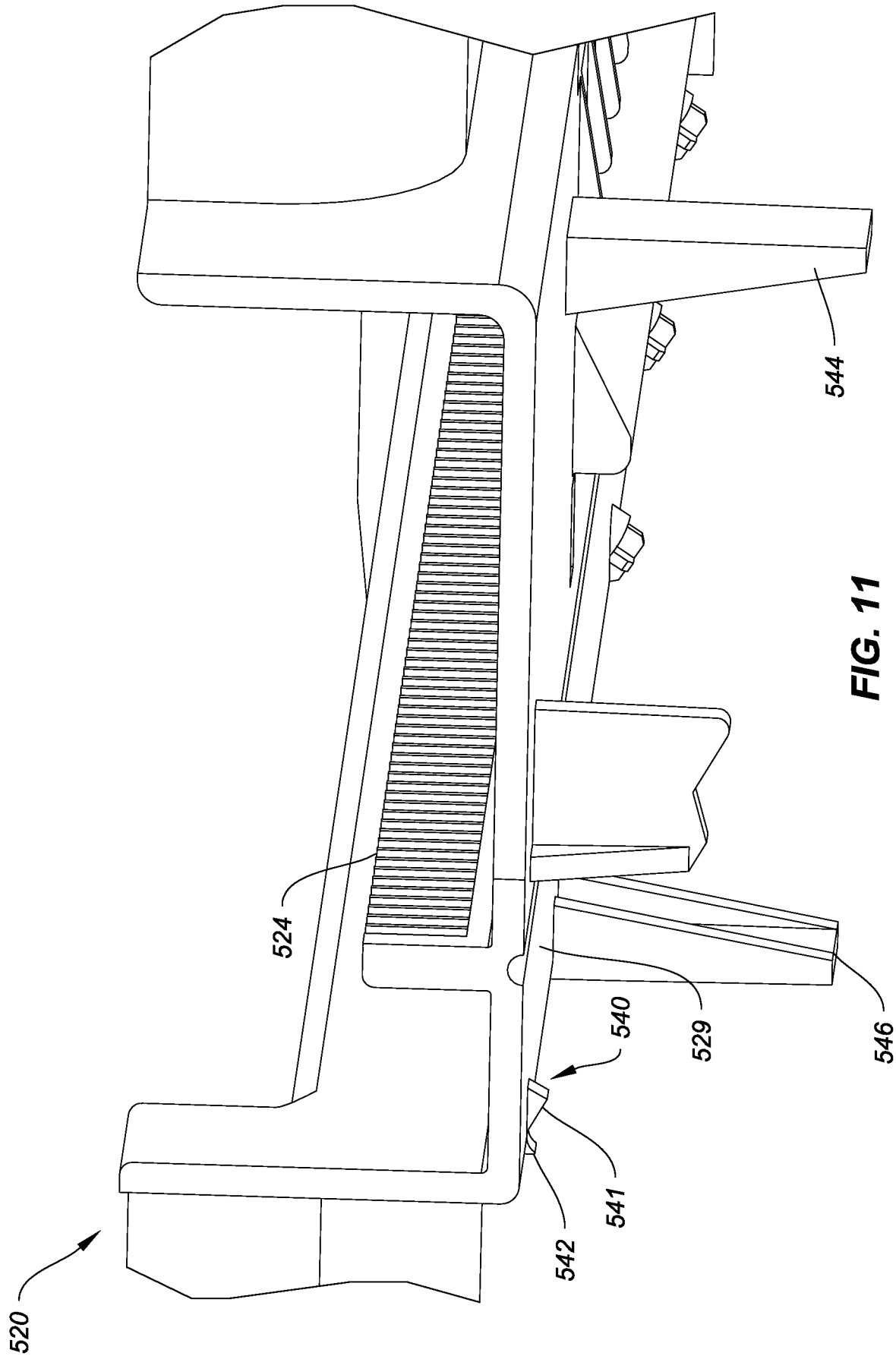


FIG. 11

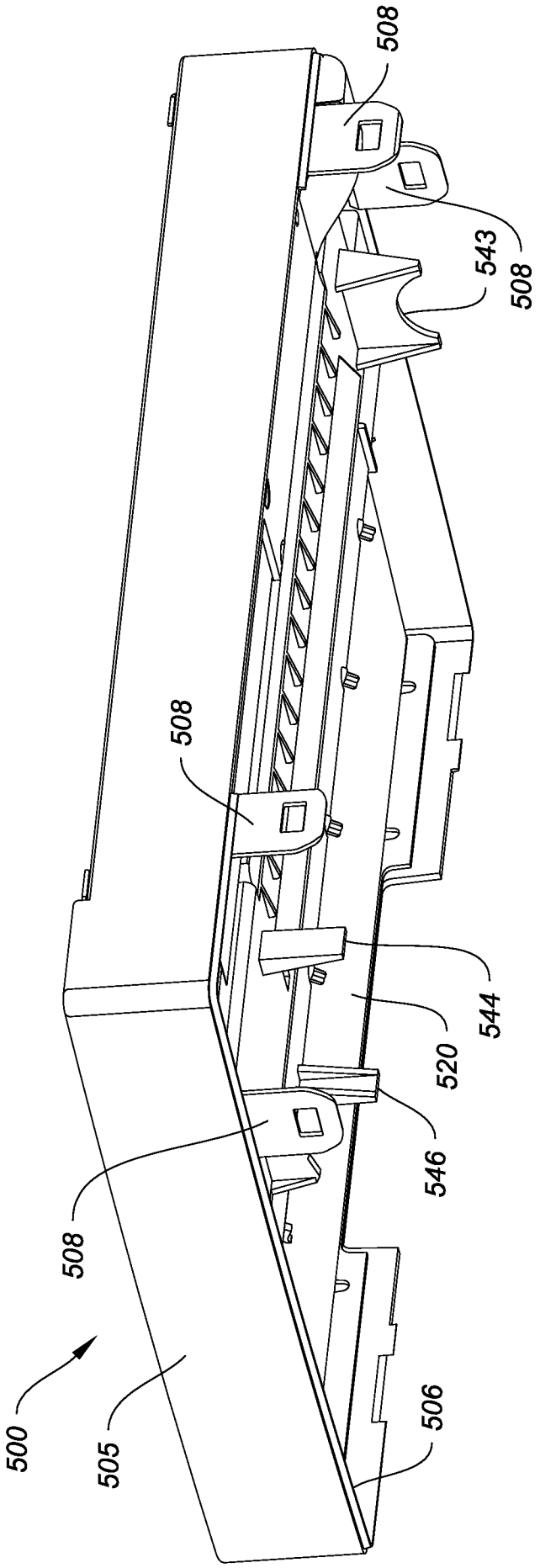


FIG. 12

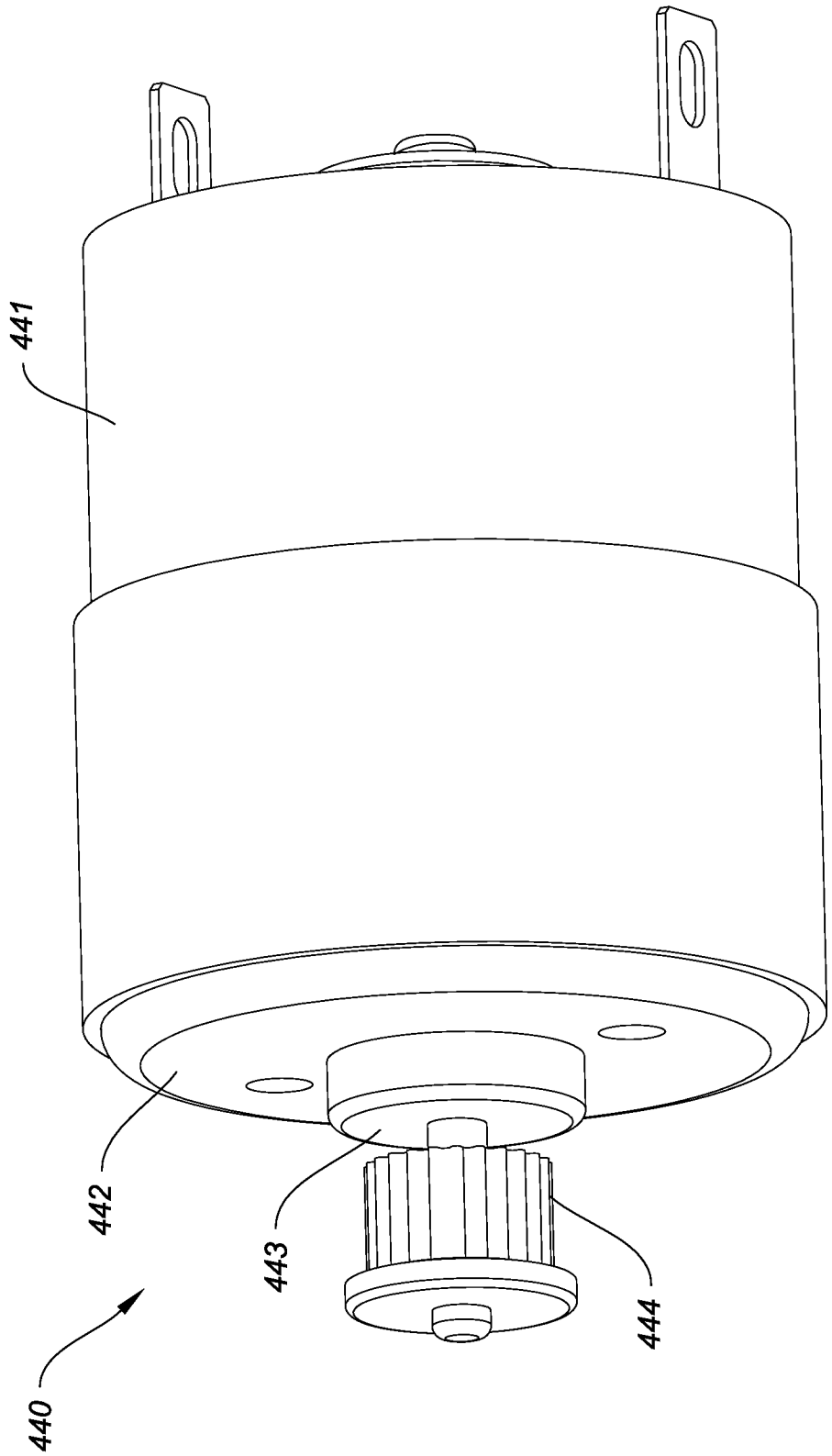


FIG. 13

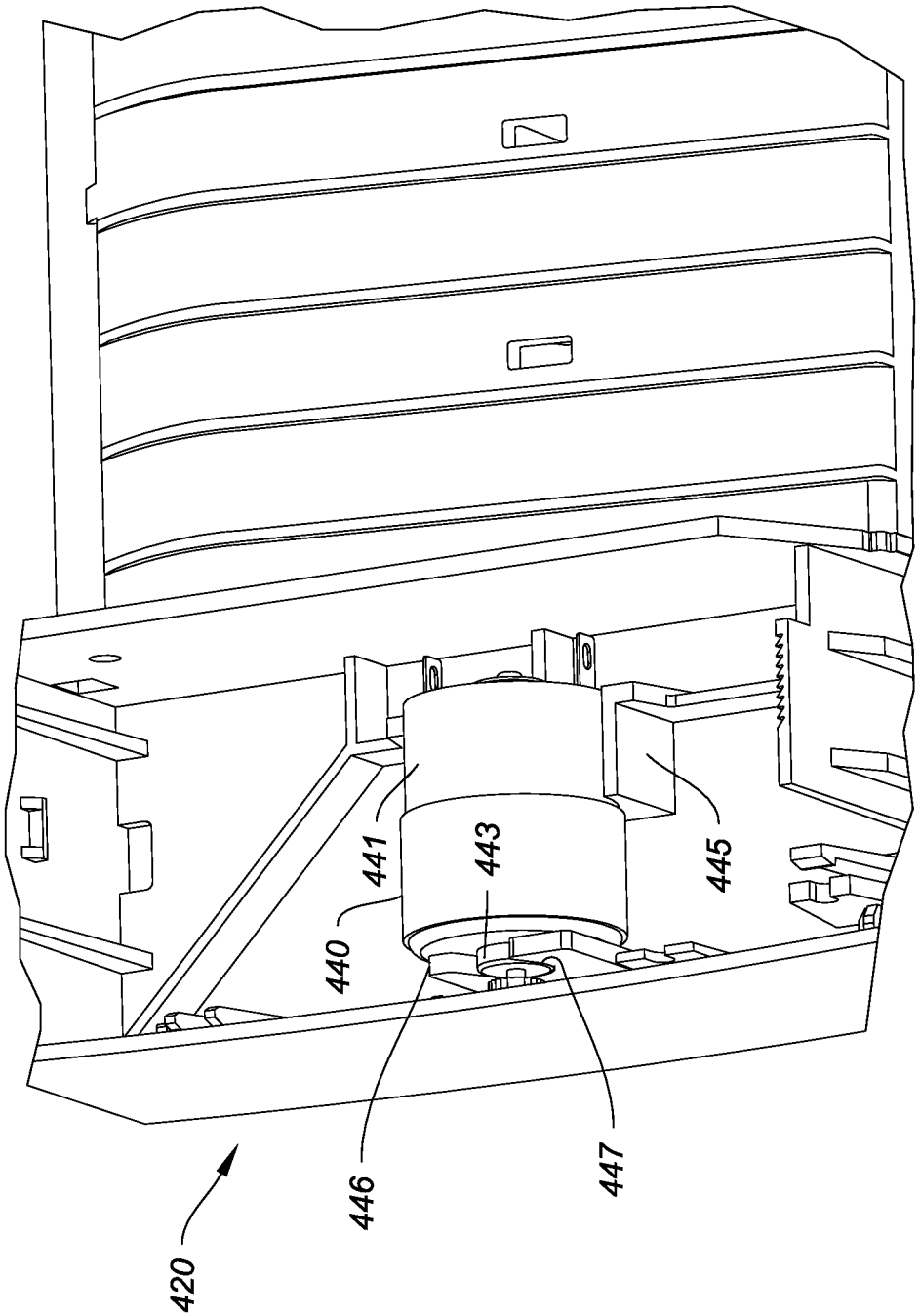


FIG. 14

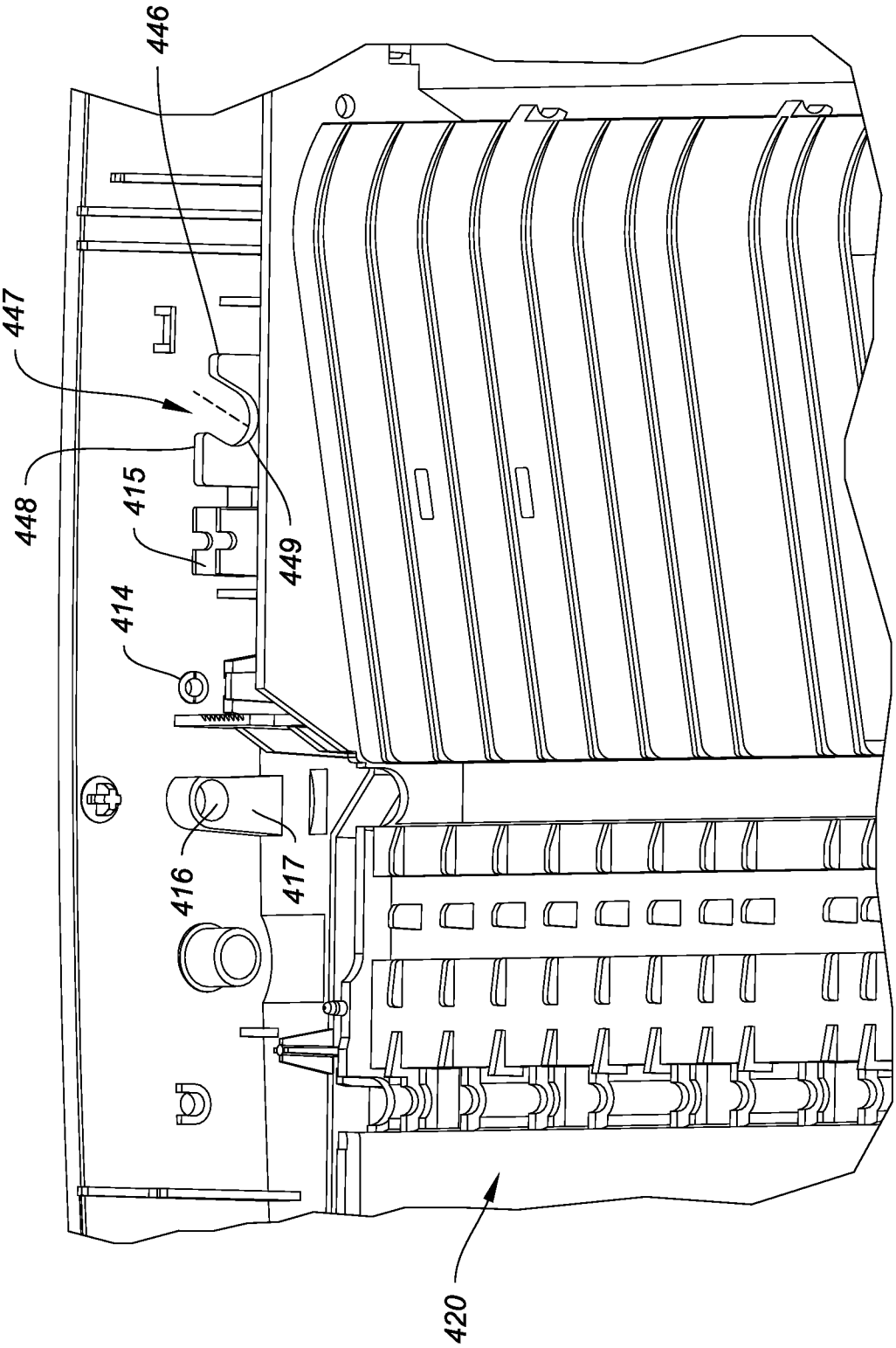


FIG. 15

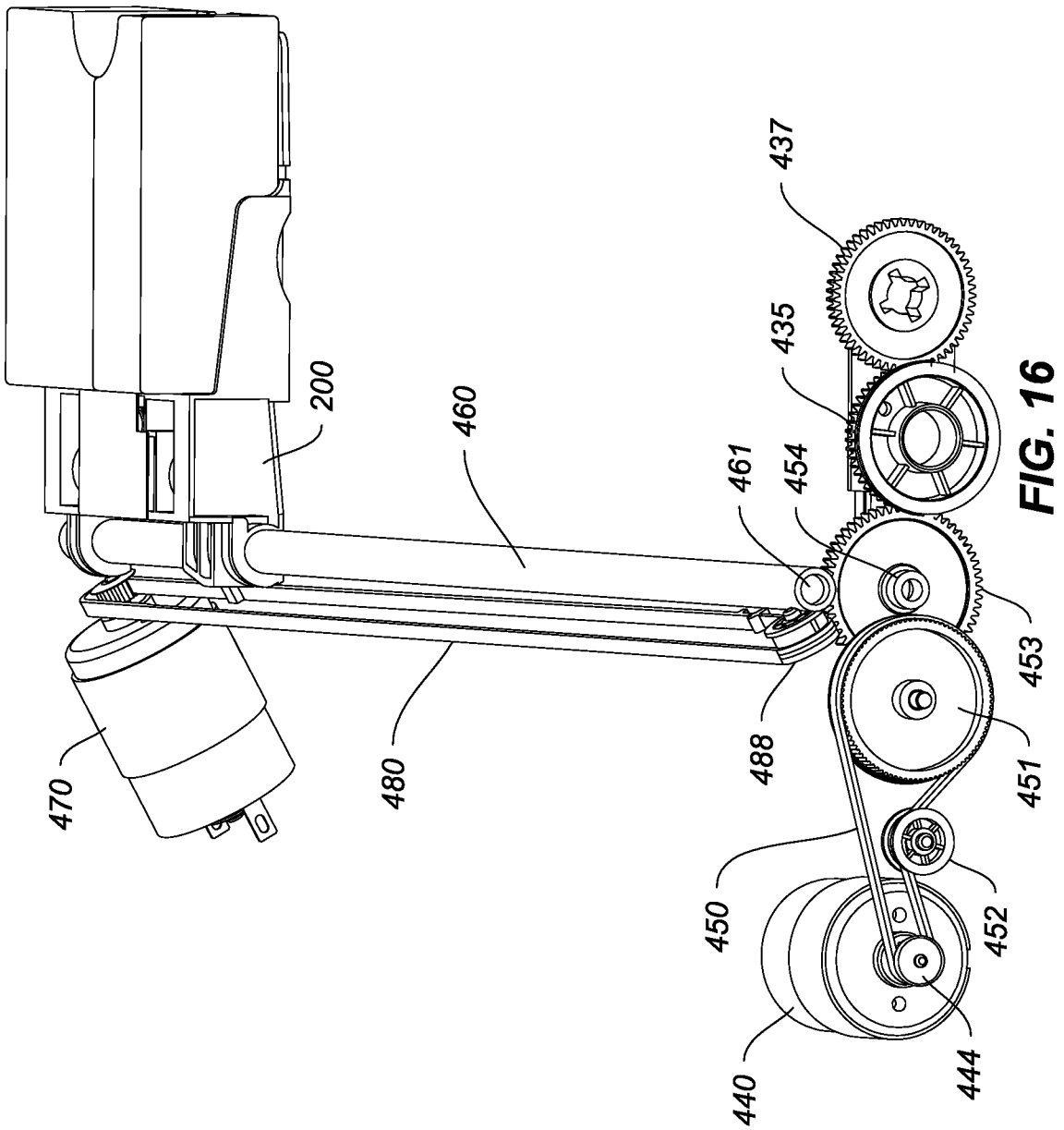


FIG. 16

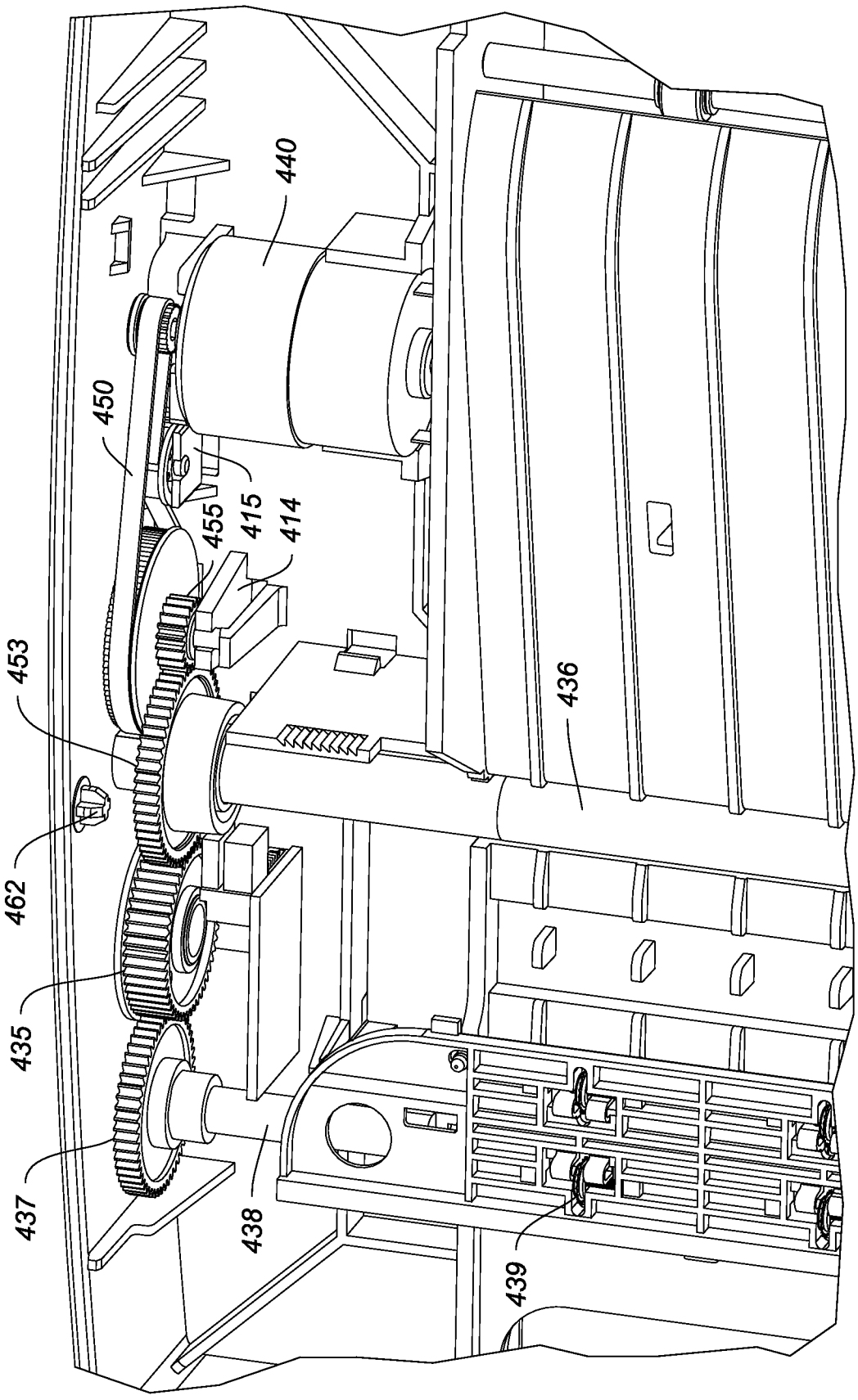


FIG. 17

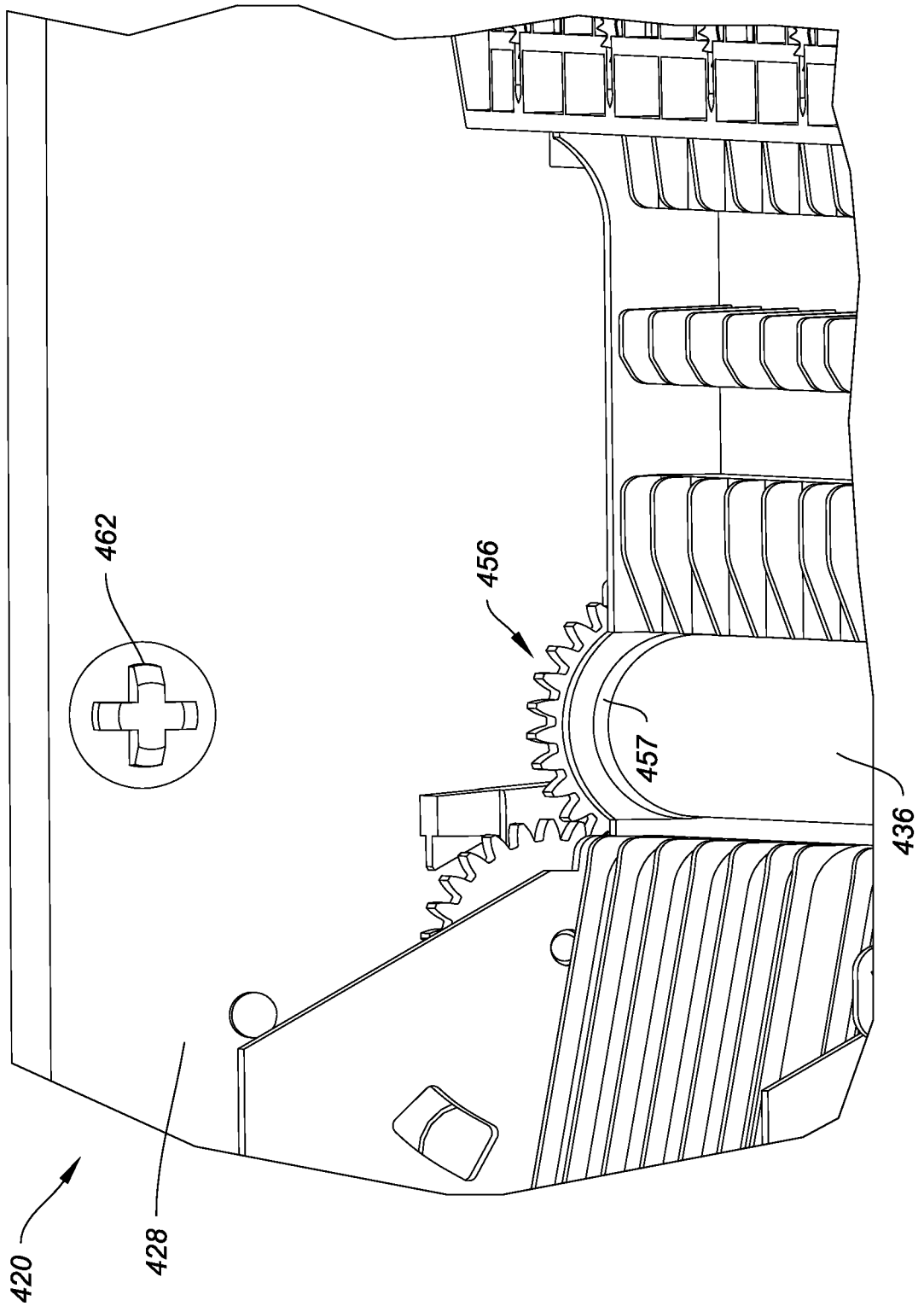


FIG. 18

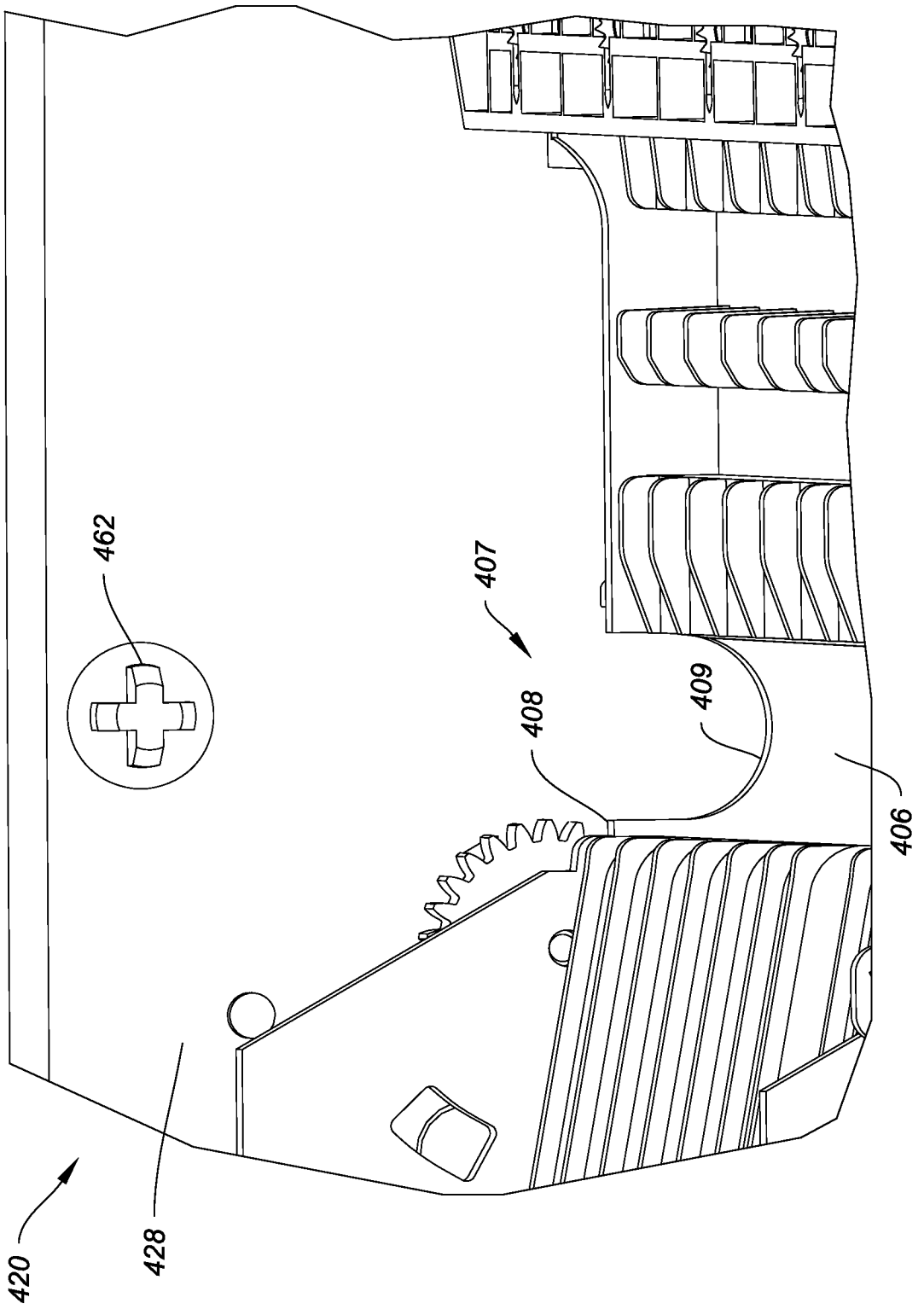


FIG. 19

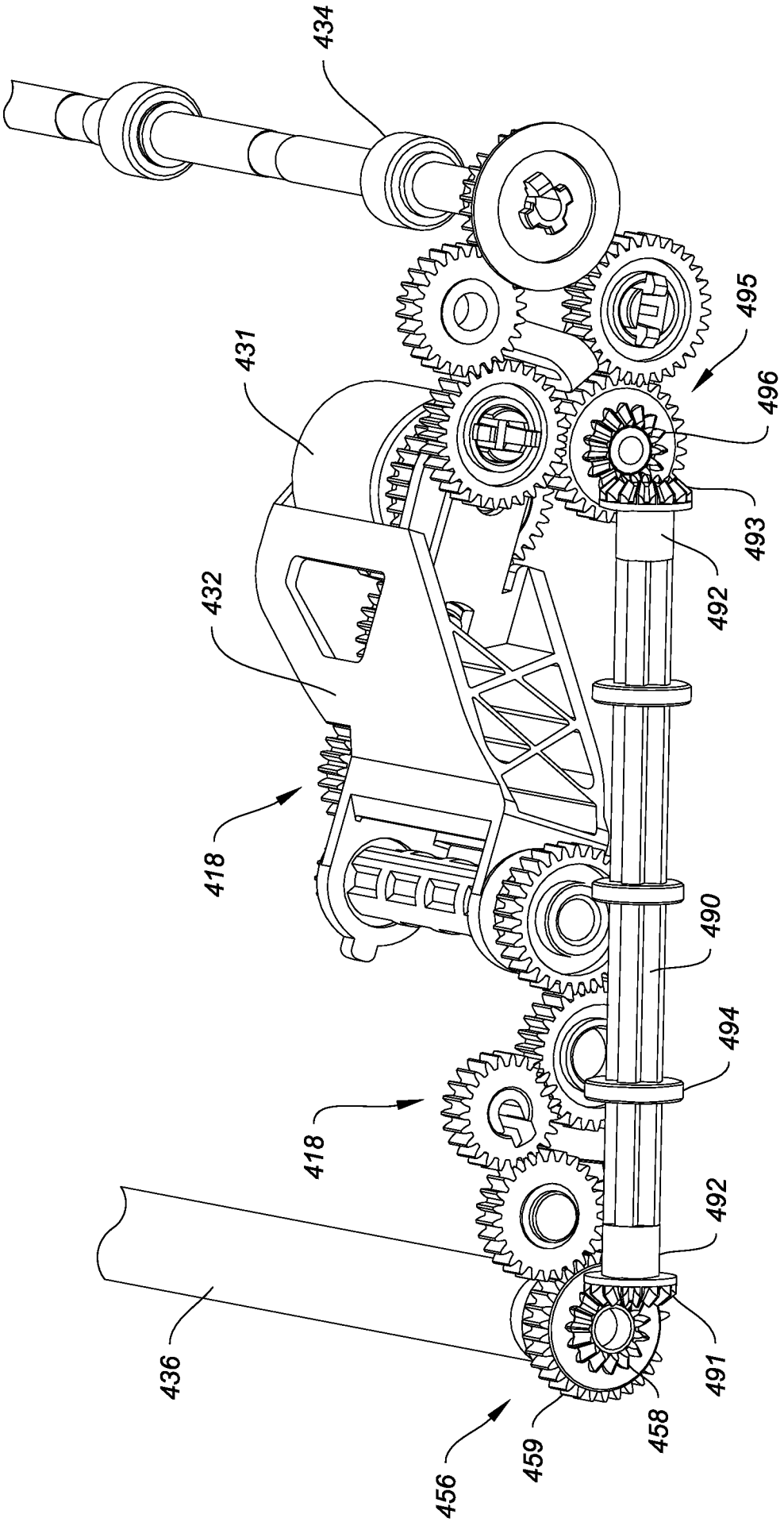

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FIG. 20

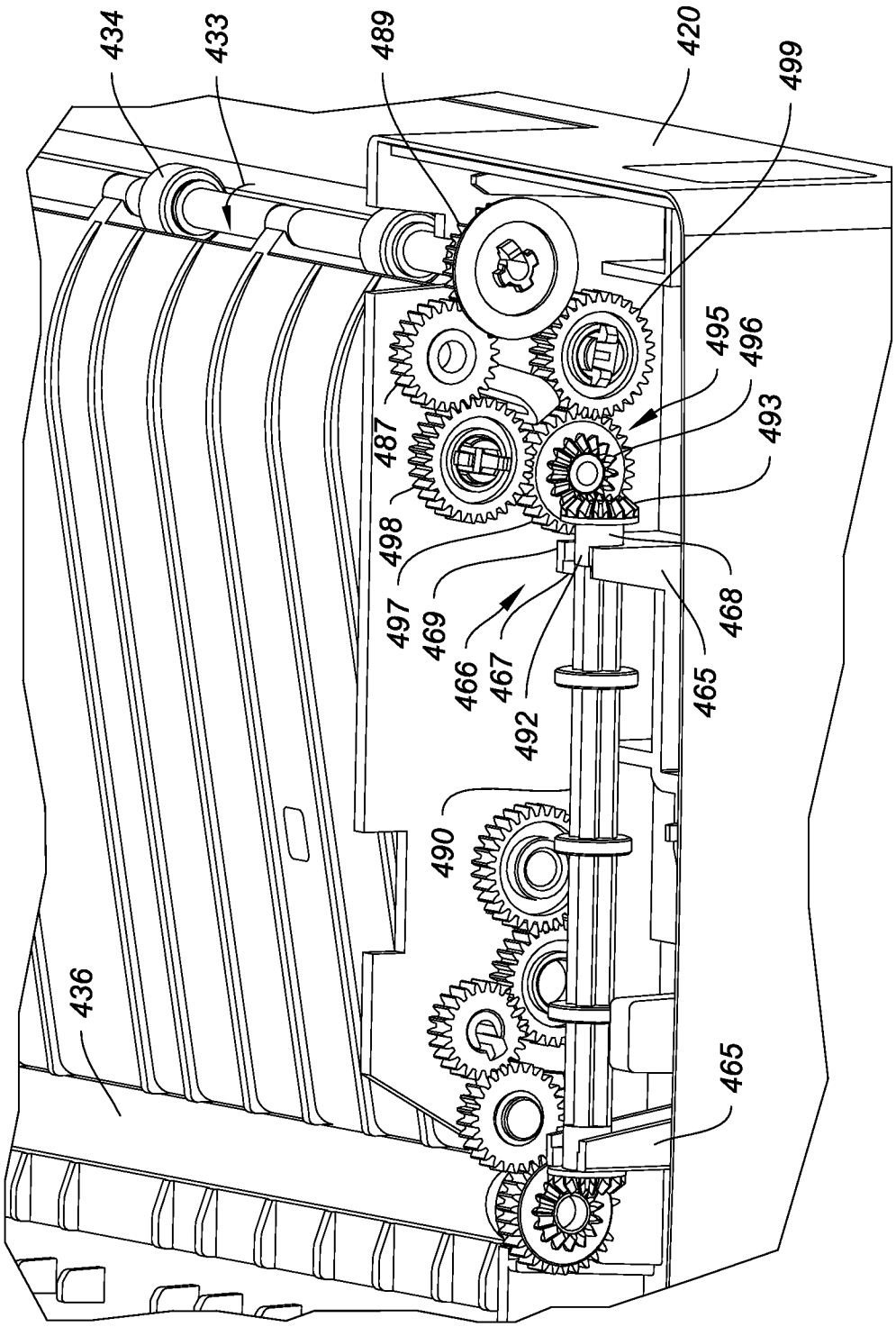

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FIG. 21

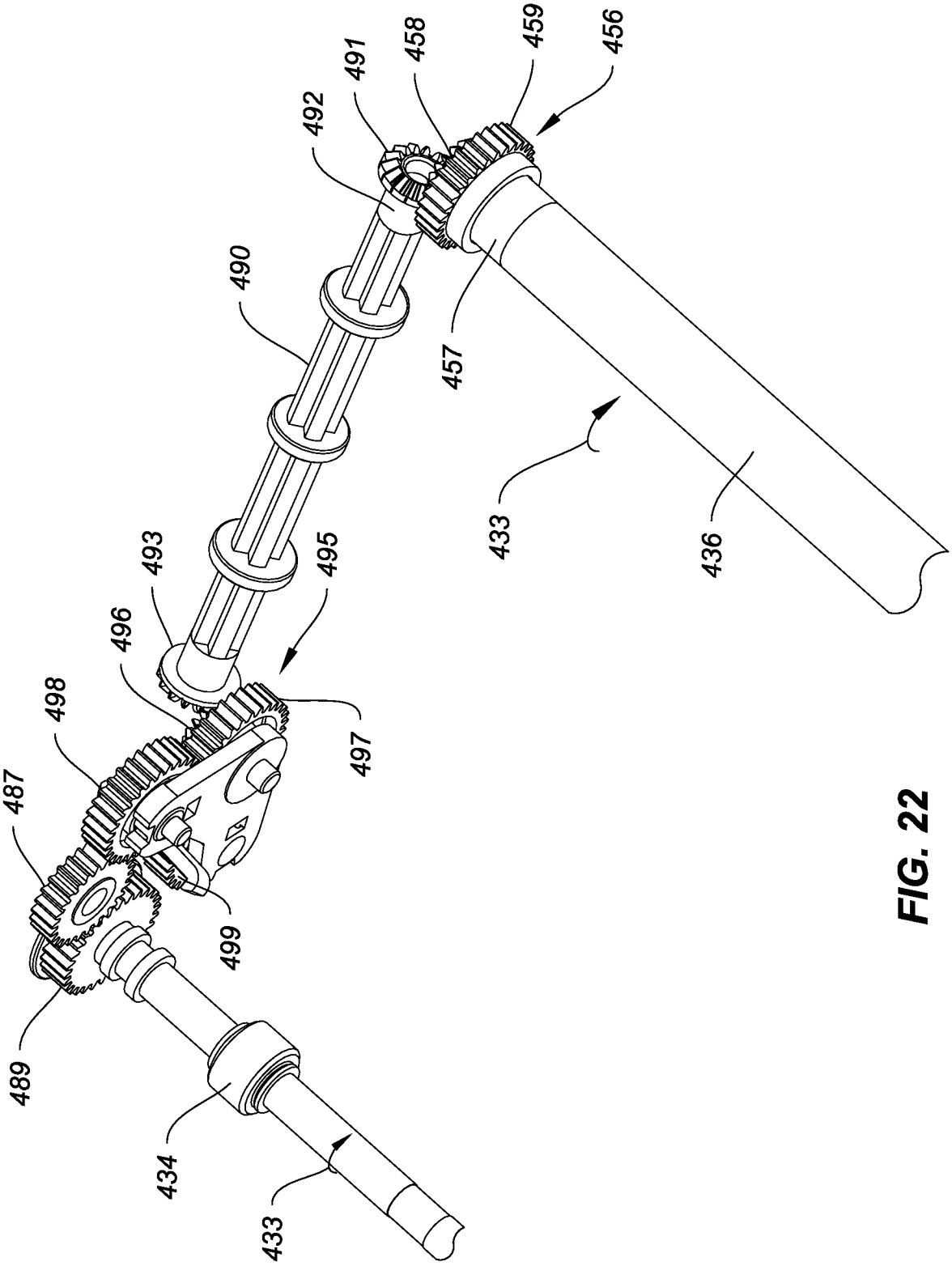

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FIG. 22

INTERNATIONAL SEARCH REPORT

International application No
PCT/US2011/056820

A. CLASSIFICATION OF SUBJECT MATTER
INV. B41J19/00 B41J19/20
ADD.

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
B41J

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)
EPO-Internal

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 5 608 430 A (JONES MICHAEL E [US] ET AL) 4 March 1997 (1997-03-04) column 8, line 15 - line 29; figures 7,8 column 9, line 8 - line 24	1,8-13, 15-17
A	JP 60 183180 A (CANON KK) 18 September 1985 (1985-09-18) abstract; figures 1-4	1-17
A	US 3 951 249 A (NERBAS DIETER ET AL) 20 April 1976 (1976-04-20) the whole document	1-17
A	US 2001/017435 A1 (YOSHIDA FUTOSHI [JP]) 30 August 2001 (2001-08-30) paragraph [0059] - paragraph [0068]; figure 4	1-17

-/--

[X] Further documents are listed in the continuation of Box C.

[X] See patent family annex.

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"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

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"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
18 January 2012	26/01/2012

Name and mailing address of the ISA/	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016	João, César

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C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 5 668 588 A (MORIZUMI YOSHIAKI [JP] ET AL) 16 September 1997 (1997-09-16) column 7, line 10 - column 8, line 24; figure 1 -----	1-17

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No
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