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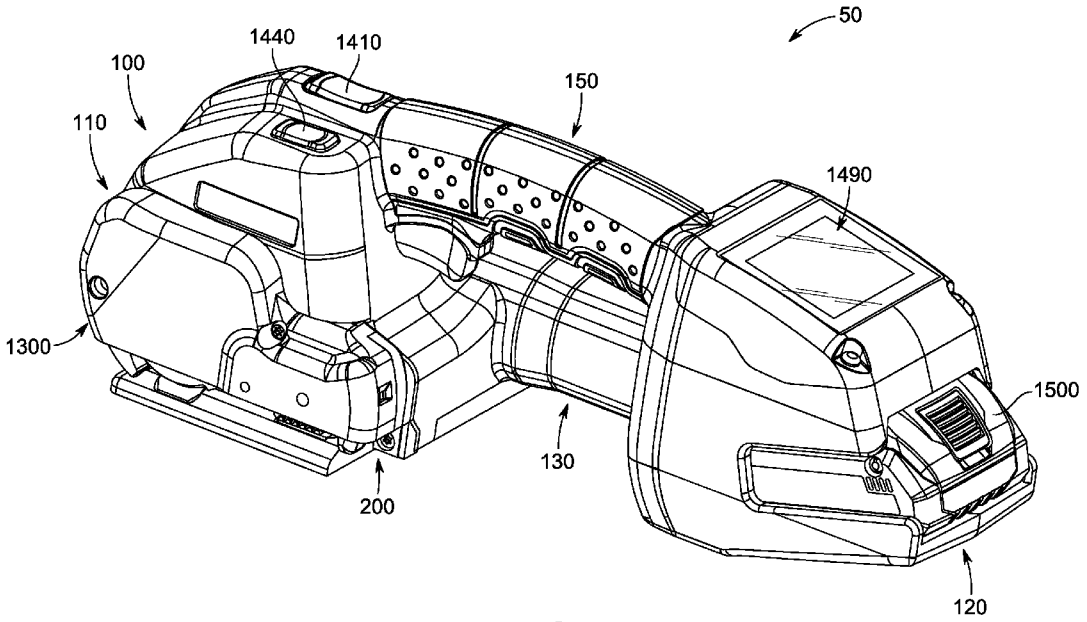

FIG. 1A

(57) Abstract: The present disclosure provides a strapping device including a support, a tensioning assembly, a sealing assembly, and a reset device. The support includes a tensioning plate and a weld plate. The tensioning assembly includes a tensioning wheel and is movable relative to the tensioning plate between a tensioning position and a strap-insertion position. The sealing assembly includes a weld arm and is switchable between a home configuration in which the weld arm is spaced from the weld plate and a sealing configuration in which the weld arm is closer to the weld plate. The tensioning assembly is operably connected to the reset device to move the reset device from a home position to an actuated position when the tensioning assembly moves from the tensioning position to the strap-insertion potion. This movement causes the reset device to switch the sealing assembly to the home configuration.

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[Continued on next page]

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STRAPPING DEVICE WITH SEALING-ASSEMBLY-RESET DEVICE

Priority

[0001] This application claims priority to and the benefit of U.S. Provisional Patent Application No. 63/387,370, filed December 14, 2022, the entire contents of which is incorporated herein by reference.

Field

[0002] The present disclosure relates to strapping devices, and more particularly to strapping devices configured to tension strap around a load and to attach overlapping portions of the strap to one another to form a tensioned strap loop around the load.

Background

[0003] Strapping devices are configured to tension strap around a load and to attach overlapping portions of the strap to one another to form a tensioned strap loop around the load. Battery-powered strapping devices are one type of strapping device. To use one of these strapping devices to form a tensioned strap loop around a load, an operator pulls strap leading end first from a strap supply, wraps the strap around the load, and positions the leading end of the strap below another portion of the strap. The operator then introduces one or more (depending on the type of strapping device) of these overlapped strap portions into the strapping device and actuates one or more buttons to initiate: (1) a tensioning cycle during which a tensioning assembly tensions the strap around the load; and (2) after completion of the tensioning cycle, a sealing cycle during which a sealing assembly attaches the overlapped strap portions to one another (thereby forming a tensioned strap loop around the load) and cuts the strap from the strap supply.

[0004] Since strapping device operators can use handheld strapping devices hundreds of times each day, there is a continuing need to make the strapping devices as easy-to-use as possible (without sacrificing performance) and to reduce operator fatigue.

Summary

[0005] Various embodiments of the present disclosure provide a strapping device including a support, a tensioning assembly, a sealing assembly, and a sealing-assembly-reset device. The support includes a tensioning plate and a weld plate. The tensioning assembly includes a tensioning wheel and is movable relative to the tensioning plate between a tensioning position and a strap-insertion position. The sealing assembly includes a weld arm and is switchable between a home configuration in which the weld arm is a first distance from the weld plate and a sealing configuration in which the weld arm is a second shorter distance from the weld plate. The sealing-assembly-reset device is movable between a home position and an actuated position. The tensioning assembly is operably connected to the sealing-assembly-reset device and configured to move the sealing-assembly-reset device from the home position to the actuated position when the tensioning assembly moves from the tensioning position to the strap-insertion potion. The sealing-assembly-reset device is positioned such that, when the sealing assembly is in the home configuration, movement of the sealing-assembly-reset device from the home position to the actuated position causes the sealing-assembly-reset device to switch the sealing assembly from the sealing configuration to the home configuration to release the strap joint after sealing.

Brief Description of the Figures

[0006] Figures 1A and 1B are perspective views of one example embodiment of a strapping device of the present disclosure.

[0007] Figure 1C is a block diagram of certain components of the strapping device of Figures 1A and 1B.

[0008] Figures 2A–2C are diagrammatic views of the strapping device of Figures 1A and 1B securing a load to a pallet.

[0009] Figure 2D is a perspective view of a friction-weld strap joint formed by the strapping device of Figure 1A to attach two overlapping portions of strap.

[0010] Figures 3A and 3B are perspective views of the working assembly of the strapping device of Figures 1A and 1B.

[0011] Figure 4A is a perspective view of the tensioning assembly of the working assembly of Figures 3A and 3B.

[0012] Figure 4B is an exploded perspective view of the tensioning assembly of Figure 4A.

[0013] Figure 4C is a cross-sectional perspective view of the tensioning assembly of Figure 4A taken along line 4C–4C of Figure 4A.

[0014] Figure 4D is a front elevational view of the rocker mover of the tensioning assembly of Figure 4A.

[0015] Figure 5A is a perspective view of the decoupling assembly of the working assembly of Figures 3A and 3B.

[0016] Figure 5B is an exploded perspective view of the decoupling assembly of Figure 5A.

[0017] Figure 5C is a cross-sectional perspective view of the decoupling assembly of Figure 5A taken along line 5C–5C of Figure 5A.

[0018] Figures 6A and 6B are perspective views of the actuating assembly of the working assembly of Figures 3A and 3B.

[0019] Figures 7A and 7B are perspective views of the cam-engaging assembly of the working assembly of Figures 3A and 3B with the actuating-assembly engager in its home and actuated positions, respectively.

[0020] Figures 8A–8G are side views of part of one side of the working assembly of Figures 3A and 3B showing the tensioning assembly moving from its tensioning position to its strap-insertion position and back to its tensioning position. Certain components of the working assembly are not shown for clarity.

[0021] Figures 9A–9G are side views of part of the opposite side of working assembly of Figures 3A and 3B that correspond to Figures 8A–8G. Certain components of the working assembly are not shown for clarity.

[0022] Figure 10A is a perspective view of part of the working assembly of Figures 3A and 3B.

[0023] Figure 10B is a cross-sectional perspective view of part of the working assembly of Figures 3A and 3B.

[0024] Figure 11A is a front elevational view of the working assembly of Figures 3A and 3B showing the sealing assembly of the working assembly in a sealing configuration and the sealing-assembly-reset device of the working assembly in a home position.

[0025] Figure 11B is a front elevational view similar to Figure 11A showing the sealing-assembly-reset device in an actuated position and the sealing assembly between the sealing configuration and a home configuration.

[0026] Figure 11C is a front elevational view similar to Figures 11A and 11B showing the sealing-assembly-reset device in the actuated position and the sealing assembly in the home configuration.

Detailed Description

[0027] While the systems, devices, and methods described herein may be embodied in various forms, the drawings show and the specification describes certain exemplary and non-limiting embodiments. Not all of the components shown in the drawings and described in the specification may be required, and certain implementations may include additional, different, or fewer components. Variations in the arrangement and type of the components; the shapes, sizes, and materials of the components; and the manners of connections of the components may be made without departing from the spirit or scope of the claims. Unless otherwise indicated, any directions referred to in the specification reflect the orientations of the components shown in the corresponding drawings and do not limit the scope of the present disclosure. Further, terms that refer to mounting methods, such as mounted, connected, etc., are not intended to be limited to direct mounting methods but should be interpreted broadly to include indirect and operably mounted, connected, and like mounting methods. This specification is intended to be taken as a whole and interpreted in accordance with the principles of the present disclosure and as understood by one of ordinary skill in the art.

[0028] Figures 1A–11C show one example embodiment of a strapping device of the present disclosure in the form of a battery-powered portable strapping device 50 and certain assemblies and components thereof. As shown in Figures 2A–2C, the strapping device 50 is configured to carry out a strapping cycle to tension and seal strap S (plastic strap in this example embodiment) around a load L on a pallet P to form a tensioned strap loop that secures the load L

to the pallet P. An operator pulls strap S from a strap supply (not shown) and wraps the strap around the load L and through the openings in the pallet P until a lower portion LP of the strap S (which includes the leading end of the strap S) is positioned below an upper portion UP of the strap S, as shown in Figure 2A. The operator then introduces the overlapped upper and lower portions UP and LP of the strap S into the strapping device 50 and actuates one or more buttons to initiate the strapping cycle. As shown in Figure 2B, a motor drives a tensioning assembly to carry out a tensioning cycle during which the strapping device 50 tensions strap S around the load L. Once a preset tension is reached in the strap S, as shown in Figure 2C, the motor drives a sealing assembly to carry out a sealing cycle during which the strapping device 50 connects the upper and lower portions UP and LP of the strap S to one another via friction welding to form a strap joint SJ, as shown in Figure 2D, and cuts the strap S from the strap supply.

[0029] The strapping device 50 includes a housing 100 (Figures 1A and 1B), a working assembly 200 (Figures 3A and 3B), a cover 1300 (Figure 1A), first and second pushbutton actuators 1410 and 1440 (Figures 1A–1C), a display assembly 1490 (Figures 1A–1C), a power supply 1500, a controller 1600 (Figure 1C), and one or more sensors 1700 (Figure 1C).

[0030] The housing 100, which is shown in Figures 1A and 1B, is formed from multiple components (not individually labeled) that collectively at least partially enclose and/or support some (or all) of the other assemblies and components of the strapping device 50. In this example embodiment, the housing 100 includes a front housing section 110, a rear housing section 120, a motor housing section 130, and a handle section 150. The front housing section 110 at least partially encloses and/or supports at least some of the components of the working assembly 200. The rear housing section 120 at least partially encloses and/or supports at least some of the components of the display assembly 1490 and defines a receptacle sized, shaped, and otherwise configured to receive and at least partially enclose and/or support the power supply 1500 and the controller 1600. The motor housing section 130 extends between and connects the bottoms of the front and rear housing sections 110 and 120 and at least partially encloses and/or supports at least some of the components of the working assembly 200, including the motor 1100. The handle housing section 150 extends between and connects the tops of the front and rear housing sections 110 and 120 and defines a handle used by the operator. This is merely one example, and in other embodiments the components of the strapping

device may be supported and/or enclosed by any suitable portion of the housing 100. The housing 100 may be formed from any suitable quantity of components joined together in any suitable manner. In this example embodiment, the housing 100 is formed from plastic, though it may be made from any other suitable material in other embodiments. The cover 1300 is attached to the front housing section 110 and covers part of the working assembly 200.

[0031] The working assembly 200, which is best shown in Figures 3A and 3B, includes the majority of the components of the strapping device 50 that are configured to carry out the strapping cycle to tension the strap around the load, attach the overlapping portions of the strap to one another, and cut the strap from the strap supply. The working assembly 200 includes a support 300, a tensioning assembly 400, a decoupling assembly 500, an actuating assembly 600, a cam-engaging assembly 700, a sealing assembly 900, a transmission 1000, a motor 1100, and a sealing-assembly-reset device 1200.

[0032] The support 300, which is best shown in Figures 3A and 3B, serves as a direct or indirect common mount for the tensioning assembly 400, the decoupling assembly 500, the actuating assembly 600, the cam-engaging assembly 700, the sealing assembly 900, the transmission 1000, the motor 1100, and the sealing-assembly-reset device 1200. The support 300 includes a base 300b, and a frame 300f extending from the base 300b. The base 300b supports a tension plate 312 below the tension wheel 400w of the tensioning assembly 400 (described below) and a weld plate 314 below the weld shoe 942 of the sealing assembly 900 (described below).

[0033] The tensioning assembly 400, which is best shown in Figures 4A–4D, is operable (with the motor 1100) to tension the strap around the load during the tensioning cycle and to move the tensioning assembly 400 relative to the support 300. The tensioning assembly 400 includes a rocker 400r, a rocker cover 400c, tensioning-assembly gearing, and a tension wheel 400w driven by the tensioning-assembly gearing. The tension wheel 400w is supported by the tensioning-assembly gearing, which is in turn supported by the rocker 400r.

[0034] The tensioning-assembly gearing includes: a driven shaft 410; a tensioning-assembly freewheel 412; a first set of planet gears 414a, 414b, and 414c; a gear cover 415; a rocker mover 420; a rollback ring gear 430; a rollback intermediate gear 431; a carrier 432; a second set of planet gears 434a, 434b, 434c, and 434d; a third set of planet gears 436a, 436b, and 436c; and bearings 405b1, 405b2, 405b3, and 405b4. Certain components of the tensioning-

assembly gearing are centered on, and certain components of the tensioning-assembly gearing are rotatable about, a tension-wheel rotational axis A400w. The driven shaft 410 includes a shaft portion 410a having a driven end 410a1 and a first sun gear 410b at the end opposite the driven end 410a1. The first set of planet gears 414a–414c are rotatably mounted (such as via respective bearings and mounting pins) to the rocker cover 400c and secured in place via the gear cover 415. The rollback ring gear 430 includes internal teeth 430it and external teeth 430ot. The carrier 432 includes a planet-gear carrier 432a to which the second set of planet gears 434a–434d are rotatably mounted (such as via respective bearings and mounting pins) and a second sun gear 432b rotatable with (and here integrally formed with) the planet-gear carrier 432a about the tension-wheel rotational axis A400w. The third set of planet gears 436a–436c are rotatably mounted to the rocker 400r (such as via respective bearings and mounting pins).

[0035] The rocker mover 420, which is best shown in Figure 4D, includes a ring gear 421 having internal teeth 421it and supporting an annular cam support 422 that includes angularly spaced first, second, and third cams 424, 426, and 428. The first cam 424 has a leading end 424le and a trailing end 424te connected by a convexly curved finger-engaging surface 424s. The finger-engaging surface 424s has an apex 424s' that corresponds to the point on the finger-engaging surface 424s furthest from the center of the cam support 422. The apex 424s' of the finger-engaging surface 424s is a distance Rmax from the center of the cam support 422, and the trailing end 424te of the cam 424 is a distance Rmin from the center of the cam support 422. Rmax is greater than Rmin such that the apex 424s' is further from the center of the cam support 422 than the trailing end 424te. The portion of the finger-engaging surface 424s extending between the apex 424s' and the trailing end 424te is curved such that the distance between the finger-engaging surface 424s and the center of the cam support 422 decreases moving from the apex 424s' to the trailing surface 424te. The second and third cams 426 and 428 are identical to the first cam 424 and are not separately described for brevity. Their components are identified herein with similar numbers as the components of the first cam 424, with the leading "424" being replaced with "426" and "428," respectively. The first, second, and third cams 424, 426, and 428 are equally angularly spaced apart such that each cam is spaced apart from the others by the same angle α, which is 120 degrees in this example embodiment. While the rocker mover includes three cams in this example embodiment, it may include any suitable quantity of one or more cams in other embodiments.

[0036] The shaft portion 410a of the driven shaft 410 extends through and is engaged by the tensioning-assembly freewheel 412, which is itself supported by and positioned within a bore defined through the cover 400c, which is attached to the rocker 400r. The tensioning-assembly freewheel 412 is configured to permit rotation of the driven shaft 410 relative to the rocker 400r in a tensioning rotational direction T—referred to as the tensioning direction T—and to prevent rotation of the driven shaft 410 in a rollback direction TREV, which is the rotational direction opposite the tensioning direction T. The first sun gear 410b of the driven shaft 410 meshes with and drivingly engages the first set of planet gears 414a–414c. The first set of planet gears 414a–414c mesh with the internal teeth 421it of the ring gear 421 of the rocker mover 420. The bearing 405b1 rotatably supports the rocker mover 420 and separates it from the rocker 400r and the cover 400c. The first sun gear 410b of the driven shaft 410 extends through the gear cover 415 and meshes with and drivingly engages the second set of planet gears 434a–434d. The second set of planet gears 434a–434d mesh with the internal teeth 430it of the rollback ring gear 430. The bearing 405b2 rotatably supports the carrier 432 such that the carrier 432 is rotatable relative to the rocker 400r. The second sun gear 432b of the carrier 432 meshes with and drivingly engages the third set of planet gears 436a–436c. The tension wheel 400w is rotatably mounted to the rocker 400r via bearings 405b3 and 405b4 such that the third set of planet gears 436a–436c mesh with internal teeth (not labeled) of the tension wheel 400w and therefore drivingly engage the tension wheel 400w. The tension wheel 400w is held in place longitudinally (in the direction of the tensioning-wheel axis A400w) via a suitable retainer and suitable fasteners (not shown for clarity).

[0037] The tensioning assembly 400 is movably mounted to the support 300 via the rocker 400r and a tensioning-assembly mounting shaft 395 (Figures 3A and 3B) and configured to pivot relative to the support 300—and particularly relative to the base 300b of the support 300—under control of the motor 1100 (as described below) and about a rocker-pivot axis A400r between a tensioning position (Figures 8A–8C and 8G) and a strap-insertion position (Figures 8D–8F). When the tensioning assembly 400 is in the tensioning position, the tension wheel 400w is adjacent to the tension plate 312 of the support 300 (or the upper surface of the upper portion of the strap if the strap has been inserted into the strapping device 50). When the tensioning assembly 400 is in the strap-insertion position, the tension wheel 400w is spaced-apart from the tension plate 312 to enable the overlapping upper and lower portions of the strap to be inserted

between the tension wheel 400w and the tension plate 312. The weight of the tensioning assembly 400 and one or more springs or other biasing elements (not shown) bias the tensioning assembly 400 to the tensioning position.

[0038] Specifically, the tensioning-assembly mounting shaft 395 extends through openings defined through the frame 300f of the support 300 and openings defined through first and second mounting ears 400r1 and 400r2 of the rocker 400r. The rollback intermediate gear 431 is rotatably mounted to the tensioning-assembly mounting shaft 395 and positioned between the mounting ears 400r1 and 400r2 of the rocker 400r such that teeth of the rollback intermediate gear 431 mesh with the external teeth 430ot of the rollback ring gear 430.

[0039] The decoupling assembly 500, which is best shown in Figures 5A–5C, controls whether the rollback ring gear 430 can rotate about the tensioning-wheel axis A400w. Generally, when the decoupling assembly 500 is in a coupled configuration, the decoupling assembly 500 prevents the rollback ring gear 430 from rotating about the tensioning-wheel axis A400w, which enables the motor 1100 to drive the tension wheel 400w to tension the strap and enables the tension wheel 400w to hold tension in the strap after the tensioning cycle is complete. Conversely, when the decoupling assembly 500 is in a release configuration, the rollback ring gear 430 is rotatable about the tensioning-wheel axis A400w such that the tension wheel 400w can release the held tension. The decoupling assembly 500 includes a decoupling-assembly shaft 510, a first engageable element 520, a second engageable element 530, an expandable element 540, a sleeve 550, a threaded fastener 560, a spacer 570, and a gear 580.

[0040] The decoupling-assembly shaft 510 includes a body 512 having a first end 512a having an irregular cross-section and second end 512b having radially extending teeth around its circumference. A first support 514 extends from the first end 512a. The first engageable element 520 comprises a tubular bushing having a cylindrical outer surface and an interior surface having a perimeter that matches the perimeter of the first end 512a of the body 512 of the decoupling-assembly shaft 510. The second engageable element 530 includes a tubular body 532 and an annular flange 534 at one end of the body 532. An opening 534o is defined through the flange 534. The expandable element 540 includes a torsion spring having a first end 540a and a second end 540b. The sleeve 550 includes a tubular body 552 having teeth 554 extending around its outer circumference. The body 552 defines an opening 554o.

[0041] As best shown in Figure 5C, the first engageable element 520 is mounted on the first end 512a of the body 512 of the decoupling-assembly shaft 510 for rotation therewith about a decoupling-assembly rotational axis A500. The second engageable element 530 circumscribes the first support 514 of the body 512 of the decoupling-assembly shaft 510 and is positioned such that the body 532 is adjacent and coaxial with the first engageable element 520. The expandable element 540 circumscribes the first engageable element 520 and the body 532 of the second engageable element 530. The outer diameters of the first engageable element 520 and the body 532 of the second engageable element 530 are substantially the same and are equal to or larger than the resting inner diameter of the expandable element 540. This means that when the decoupling assembly 500 is in a coupled configuration (described below), the expandable element 540 exerts a compressive force on the first engageable element 520 and the body 532 of the second engageable element 530 that prevents those components (and the decoupling-assembly shaft 510) from rotating relative to one another about the decoupling-assembly rotational axis A500. The second end 540b of the expandable element 540 is received in the opening 534o defined through the flange 534 of the second engageable element 530. At least part of the decoupling-assembly shaft 510, the first engageable element 520, the second engageable element 530, and the expandable element 540 are housed within and circumscribed by the sleeve 550. The first end 540a of the expandable element is received in the opening 554o defined through the body 552 of the sleeve 550. The gear 580 is mounted to the second end 512b of the body 512 of the decoupling-assembly shaft 510 such that the gear 580 is fixed in rotation with the decoupling-assembly shaft 510. The spacer 570 separates the first engageable element 520 and the gear 580.

[0042] As best shown in Figure 5C, the decoupling assembly 500 is mounted to the frame 300f of the support 300 and operatively connected to the tensioning-assembly gearing. More specifically, the decoupling assembly 500 is mounted to the frame 300f via the fastener 560, which fixes the second engageable element 530 in rotation relative to the frame 300f such that the second engageable element 530—and the second end 540b of the expandable element 540 received in the opening 534o of the flange 534 of the second engageable element 530—cannot rotate relative to the frame 300f about the decoupling-assembly rotational axis A500. The gear 580 operably connects the body 512 of the decoupling-assembly shaft 510 to rollback ring gear 430 of the tensioning-assembly gearing. Specifically, the teeth on the gear 580 mesh with

the teeth of the rollback intermediate gear 431, which in turn mesh with the external teeth 430ot of the rollback ring gear 430. In other embodiments, there is no rollback intermediate gear, and the teeth of the gear of the decoupling assembly mesh directly with the external teeth of the rollback ring gear.

[0043] The decoupling assembly 500 has a coupled configuration and a release configuration. Figure 5C shows the decoupling assembly 500 in the coupled configuration. When the decoupling assembly 500 is in the coupled configuration, the expandable element 540 exerts a compressive force on the first engageable element 520 and the body 532 of the second engageable element 530 that prevents them from rotating relative to one another about the decoupling-assembly rotational axis A500. Since the body 532 of the second engageable element 530 is fixed in rotation relative to the frame 300f of the support 300 and the decoupling-assembly shaft 510 is fixed in rotation with the first engageable element 520, the decoupling-assembly shaft 510—and thus the gear 580—is fixed in rotation relative to the frame 300f. Since the gear 580 meshes with the rollback intermediate gear 431, when in the coupled configuration the decoupling assembly 500 prevents the rollback intermediate gear 431 from rotating about the rocker axis A400r, which in turn prevents the rollback ring gear 430 from rotating about the tensioning-wheel axis A400w.

[0044] The decoupling assembly 500 is switchable (such as by the actuation assembly 600 as described below) from the coupled configuration to the release configuration to enable the first engageable element 520 and the decoupling-assembly shaft 510 to rotate relative to the second engageable element 530 about the decoupling-assembly rotational axis A500. As explained above, the second engageable element 530 and the second end 540b of the expandable element 540 (that is received in the opening 534o of the flange 534 of the second engageable element 530) are fixed in rotation relative to frame 300f. To switch the decoupling assembly 500 from the coupled configuration to the release configuration, the sleeve 550 is rotated about the decoupling-assembly rotational axis A500 from a coupled position to a release position in a release direction R550 relative to the frame 300f, the second end 540b of the expandable element 540, and the second engageable element 530. Since the first end 540a of the expandable element 540 is received in the opening 554o defined in the body 552 of the sleeve 550, the first end 540a rotates with the sleeve 550. As this occurs, the inner diameter of the expandable element 540 near its first end 540a begins expanding, and eventually expands enough (thereby reducing the

compression force or eliminating it altogether) to enable the first engageable element 520 and the decoupling-assembly shaft 510 to rotate about the decoupling-assembly rotational axis A500 relative to the second engageable element 530 (and the expandable element 540). When the sleeve 550 is released, the first end 540a of the expandable element 540 biases the sleeve 550 to rotate in a coupling direction C550 opposite the release direction R550 until the sleeve 550 reaches the coupled position (meaning the decoupling assembly 500 is back in its coupled configuration).

[0045] The actuating assembly 600, which is best shown in Figures 6A and 6B, is operably connected to the decoupling assembly 500 to switch it between the coupled and release configurations. The actuating assembly 600 includes an actuating-assembly body 610 and a decoupling-assembly actuator 620. The actuating-assembly body 610 includes a trigger 612, spaced-apart first and second mounting ears 614a and 614b extending from the trigger 612, a cam-engaging-assembly actuator 616 extending from the second mounting ear 614b, and an actuating rod 618 extending between the mounting ears 614a and 614b. Each mounting ear 614a and 614b defines a vertically extending slot therethrough. The decoupling-assembly actuator 620 includes an actuated arm 622, a gear arm 624 connected to the actuated arm 622, and a gear 626 at a free end of the gear arm 624.

[0046] The first and second mounting ears 614a and 614b of the actuating-assembly body 610 are pivotably mounted to frame 300f via pivots (such as pivot pins) (not labeled). The decoupling assembly actuator 620 is pivotably mounted to an actuator mounting pin 690 that extends through the slots defined through the first and second mounting ears 614a and 614b of the actuating-assembly body 610 and that is secured (such as via retaining rings) to the frame 300f. The actuated arm 622 of the decoupling assembly actuator 620 is positioned above the actuating rod 618.

[0047] The actuating-assembly body 610 is pivotable relative to the frame 300f about an actuating-assembly-body axis A610 between a home position (Figures 8A, 8F, and 8G) and an actuated position (Figures 8B–8E). A biasing element (not shown), such as a compression or torsion spring, biases the actuating-assembly body 610 to the home position. When the actuating-assembly body 610 is in the home position, the actuator mounting pin 690 is positioned at the top of the slots defined through the first and second mounting ears 614a and 614b of the actuating-assembly body 610. Conversely, when the actuating-assembly body 610 is in the

actuated position, the actuator mounting pin 690 is positioned at the bottom of the slots. The actuator mounting pin 690 and the slots therefore define the range of (pivoting) movement of the actuating-assembly body 610.

[0048] The decoupling-assembly actuator 620 is pivotable relative to the frame 300f about an actuator axis A620 between a home position (Figure 8A) and an actuated position (Figures 8B–8G). A biasing element 620b, which is a torsion spring in this example embodiment but may be any suitable biasing element, biases the decoupling-assembly actuator 620 to its home position. The actuating-assembly body 610 is operably connected to the decoupling-assembly actuator 620 to move the decoupling-assembly actuator 620 from its home position to its actuated position. Specifically, as the actuating-assembly body 610 moves from its home position toward its actuated position, the actuating rod 618 engages the actuated arm 622 of the decoupling-assembly actuator 620 and forces it to pivot about the actuator axis A620 until it (and the actuating-assembly body 610) reaches its actuated position.

[0049] The decoupling-assembly actuator 620 is positioned, oriented, and otherwise configured to control which configuration the decoupling assembly 500 is in. Specifically, when the decoupling-assembly actuator 620 is in its home position, as shown in Figure 8A, the decoupling assembly 500 is in its coupled configuration. The teeth of the gear 626 are unmeshed from the teeth 554 of the sleeve 550, and the sleeve 550 is in its coupled position. When the decoupling assembly actuator 620 moves from its home position to its actuated position, as shown in Figure 8B, the gear 626 meshes with the teeth 554 of the sleeve 550 and rotates the sleeve 550 in the release direction R550 until the sleeve 550 reaches its release position and the decoupling assembly 500 is in its release configuration. When the decoupling-assembly actuator 620 moves from its actuated position back to its home position, the gear 626 moves to enable the sleeve 550 to rotate in the coupling direction C550 back to its coupled position such that the decoupling assembly 500 is in its coupled configuration. In this embodiment, the gear 626 unmeshes from the teeth 554 of the sleeve 550 near the end of its movement.

[0050] The cam-engaging assembly 700, which is best shown in Figures 7A and 7B, is movable by the actuating assembly 600 into a position to be engaged by one of the cams 424, 426, and 428 of the rocker mover 420 of the tensioning assembly 400 to raise the tensioning assembly 400 from its tensioning position to its strap-insertion position. The cam-engaging assembly 700 includes a cam engager 710, an actuating-assembly engager 720, and a biasing

element 730. The cam engager 710 includes a cam-engager body 712 and a cam-engaging finger 714 extending from the cam-engager body 712. The actuating-assembly engager 720 includes an actuating-assembly-engager body 722, an actuator-engaging finger 724 extending from the actuating-assembly-engager body 722, and a stop 726. The actuating-assembly engager 720 is pivotably connected to the cam engager 710 such that the actuating-assembly engager 720 can pivot relative to the cam engager 710 about a cam-engaging-assembly rotational axis A700 between a home position (Figure 7A) and an actuated position (Figure 7B). The biasing element 730, which is a compression spring in this example embodiment but may be any other suitable biasing element, biases the actuating-assembly engager 720 to its home position.

[0051] As best shown in Figures 9A–9G, the cam-engaging assembly 700—and particularly the cam engager 710 and the actuating-assembly engager 720—are pivotably mounted to the tensioning-assembly mounting shaft 395 and configured to pivot about the rocker axis A400r relative to the support 300f between a home configuration (Figures 9A and 9G), a cam-engaging configuration (Figure 9B), and a stop configuration (Figures 9C–9G). When the cam-engaging assembly 700 is in the home configuration, the actuating-assembly engager 720 is in its home position relative to the cam engager 710, the actuator-engaging finger 724 is below the cam-engaging-assembly actuator 616, and the cam-engaging finger 714 is in a home position removed from the rotational path of the first, second, and third cams 424, 426, and 428 of the rocker mover 420. A biasing element, which is an extension spring or any other suitable spring, biases the cam-engaging assembly 700 to the home configuration. When the cam-engaging assembly 700 is in the cam-engaging configuration, the actuating-assembly engager 720 is in its home position relative to the cam engager 710 and the cam-engaging finger 714 is in a cam-engaging position and intersects the rotational path of the first, second, and third cams 424, 426, and 428 of the rocker mover 420. When the cam-engaging assembly 700 is in the stop configuration, the actuating-assembly engager 720 is in its home position relative to the cam engager 710 and the cam-engaging finger 714 is in a stop position and engages a stop 390 mounted to the frame 300f.

[0052] The sealing assembly 900, which is best shown in Figures 10A–11C, is configured to attach overlapping portions of the strap to one another to form a tensioned strap loop around the load during the sealing cycle via friction welding. The sealing assembly 900 includes a first link arm 910, a second link arm 920, a first sealing-assembly biasing element

930, a second a first sealing-assembly biasing element 932, a weld arm 940, a weld shoe 942, a cutter 944, and an eccentric shaft (not shown). The weld shoe 942 is slidably mounted to the weld arm 940 such that the weld shoe 942 can oscillate relative to the weld arm 940. The eccentric is operably connected to the weld shoe 942 and configured to, when rotated, cause the weld shoe 942 to oscillate. A toothed belt 900b operably connects the transmission 1000 to the eccentric to rotate the eccentric. The cutter 944 is removably mounted to the weld arm 940.

[0053] The weld arm 940 is pivotably mounted to the support 300 and is pivotable relative to the support 300 and the weld plate 314 about a weld-arm axis A940 between a home position (Figures 3A and 11C) in which the weld shoe 942 is spaced-apart from the weld plate 314 and a sealing position (Figures 10A, 11A, and 11B) in which the weld shoe 912 is adjacent to the weld plate 314 and positioned to weld the strap. The first and second link arms 910 and 920 operably connect the transmission 1000 to the weld arm 940 such that the transmission 1000 can move the weld arm 940 from the home position to the sealing position. The first link arm 910 is pivotably mounted to the support 300 via a first pivot 900p1 (such as a pivot pin). The second link arm 920 links the first link arm 910 to the weld arm 940. Specifically, one end of the second link arm 920 is pivotably connected to one end of the first link arm 910 via a second pivot 900p2 (such as a pivot pin), and the other end of the second link arm 920 is pivotably connected to the weld arm 940 via a third pivot 900p3 (such as a pivot pin). The first sealing-assembly biasing element 930 circumscribes the second link arm 920 and, as explained below, biases the sealing assembly 900 to its sealing configuration. The second sealing-assembly biasing element 932 biases the sealing assembly to its home configuration.

[0054] When the sealing assembly 900 is in the home configuration in which the weld arm 940 is in the home position—shown in Figures 3A and 11C—the first and second link arms 910 and 920 are oriented such that they form an angle greater than 0 degrees and less than 180 degrees (i.e., an acute or obtuse angle). When the sealing assembly 900 is in the sealing configuration in which the weld arm 940 is in the sealing position—shown in Figures 10A, 11A, and 11B—the first and second link arms 910 and 920 form an angle greater than 180 degrees and less than 360 degrees (i.e., a reflex angle). As described in detail below, the transmission 1000 is configured to switch the sealing assembly 900 from its home configuration to its sealing configuration, and the sealing-assembly-reset device 1200 is configured to switch the sealing

assembly 900 from its sealing configuration to its home configuration, both by manipulating the orientation of the first and second link arms 910 and 920.

[0055] The transmission 1000, which is best shown in Figures 3A and 3B, is driven by the motor 1100, is operably connected to the tensioning assembly 400 and configured to cause the tension wheel 400w to rotate in the tensioning direction T to tension the strap and to cause the tensioning assembly 400 to pivot to its strap-insertion position, and is operably connected to the sealing assembly 900 and configured to cause the sealing assembly 900 to attach the overlapping portions of the strap to one another. The transmission 1000 includes transmission gearing including a drive gear 1012 (which is a bevel pinion gear in this example embodiment) and a variable offset coupling 800 including a driven gear (which is a bevel wheel gear in this example embodiment). The transmission gearing and the variable offset coupling 800 are mounted to the support 300 such that the drive gear 1012 meshes with the driven gear.

[0056] The transmission gearing 1010 includes suitable components (such as gears, bearing, and freewheels) that transmit rotational movement of the output shaft of the motor 1100 in a first drive direction to the drive gear 1012 to rotate the drive gear 1012 (but not to drive any components of the sealing assembly 900 in this example embodiment). The drive gear 1012 drives the driven gear to rotate in the tensioning direction T, and the other components of the variable offset coupling 800 transmit the rotational movement of the driven gear 1022 to the driven shaft 410 of the tensioning assembly 400 to rotate the driven shaft 410 in the tensioning direction T.

[0057] The components of the transmission gearing 1010 transmit rotational movement of the output shaft of the motor 1100 in a second drive direction opposite the first drive direction to the sealing assembly 900 to switch the sealing assembly 900 from its home configuration to its sealing configuration and to drive the toothed belt 900b to rotate the eccentric and cause the weld shoe 942 to oscillate (but not to drive the drive gear 1012 in this example embodiment). More specifically, the transmission gearing 1010 includes a cam 1010c (Figure 11C) driven in rotation by the output shaft of the motor 1100 when the output shaft is rotated in the second drive direction. The cam 1010c engages the free end (not shown) of the first link arm 910 of the sealing assembly 900, which causes the first link arm 910 of the sealing assembly 900 to rotate clockwise about the first pivot 900p1 (from the viewpoint shown in Figures 11A–11C)

to raise the second pivot 900p2 and switch the sealing assembly 900 to the sealing configuration, thereby moving the weld arm 940 into its sealing position.

[0058] This is merely one example transmission assembly, and the strapping device may include any suitable transmission assembly or assemblies operably connecting one or more motors to the tensioning and sealing assemblies to drive those assemblies.

[0059] The motor 1100, which is best shown in Figures 3A and 3B, is operably connected to (via the transmission 1000) the tensioning assembly 400 and the sealing assembly 900 and is configured to drive those assemblies as explained herein. The motor 1100 includes the output shaft (not shown) referenced above. The motor 1100 is an electric motor in this example embodiment but may be any suitable motor.

[0060] The sealing-assembly-reset device 1200, which is best shown in Figures 10A–11C, is movable to switch the sealing assembly 900 from its sealing configuration to its home configuration. More specifically, the tensioning assembly 400 is operably connected to the sealing-assembly-reset device 1200 and configured to move the sealing-assembly-reset device 1200 to automatically switch the sealing assembly 900 from its sealing configuration to its home configuration when moving from the tensioning position to the strap-insertion position. The sealing-assembly-reset device 1200 includes a head 1210 and an actuated arm 1220 extending from the head 1210. The sealing-assembly-reset device 1200 is movably (here, pivotably) mounted to the support 300 and movable relative to the support 300, the tensioning assembly 400, and the sealing assembly 900 between a home position (Figures 10A–11A) and an actuated position (Figures 11B and 11C). A suitable spring or other biasing element biases the sealing-assembly-reset device to the home position. The sealing-assembly-reset device 1200 is positioned such that the head 1210 is adjacent to (here, above) the second pivot 900p2 and the actuated arm 1220 is engageable by part of the tensioning assembly 400 (the rocker cover 400c in this example embodiment). In this embodiment, the actuated arm 1220 is in constant engagement with the rocker cover 400c, though in other embodiments this may not be the case.

[0061] The position of the tensioning assembly 400 controls the position of the sealing-assembly-reset device 1200. Specifically, when the tensioning assembly 400 is in the tensioning position, the sealing-assembly-reset device 1200 is in the home position. When the sealing-assembly-reset device 1200 is in the home position, the head 1210 is disengaged from the sealing assembly 900 to enable the sealing assembly 900 to switch from the home

configuration to the sealing configuration without interference. Figure 11A shows the sealing-assembly-reset device 1200 in the home position and the sealing assembly 900 in the sealing configuration. When the tensioning assembly 400 moves from the tensioning position to the strap-insertion position, it (here, the rocker cover 400c) engages the actuated arm 1220 of the sealing-assembly-reset device 1200 and pivots the sealing-assembly-reset device 1200 from its home position to its actuated position. As shown in Figure 11B, this causes the head 1210 to move downward, engage the second link arm 920 of the sealing assembly 900 above the second pivot 900p2 (though in other embodiments it may engage the first link arm 920), and force the second pivot 900p2 downward. This switches the angle formed by the first and second link arms 910 and 920 from a reflex angle to an oblique angle, as shown in Figure 11B. Once this occurs, the second sealing-assembly biasing element 932 forces the sealing assembly 900 into its home configuration, as shown in Figure 11C. The tensioning assembly 400 is, therefore, operably connected to the sealing assembly 900 via the sealing-assembly-reset device 1200 to automatically switch the sealing assembly 900 from its sealing configuration to its home configuration as the tensioning assembly moves from its tensioning position to its strap-insertion position to release the strap joint after sealing.

[0062] This is merely one example of the sealing-assembly-reset device, and any other suitable configuration may be employed. For instance, the rocker may include a component positioned to engage and move the sealing-assembly-reset device as the tensioning assembly moves from its tensioning position to its strap-insertion position.

[0063] The display assembly 1490, which is shown in Figures 1A–1C, includes a suitable display screen 1492 with a touch panel 1494. The display screen 1492 is configured to display information regarding the strapping device 50 (at least in this embodiment), and the touch screen 1494 is configured to receive operator inputs such as a desired strap tension and desired weld cooling time. A display controller (not shown) may control the display screen 1492 and the touch panel 1494and, in these embodiments, is communicatively connected to the controller 1600 to send signals to the controller 1600 and to receive signals from the controller 1600. Other embodiments of the strapping device do not include a touch panel. Still other embodiments of the strapping device do not include a display assembly. Certain embodiments of the strapping device include a separate pushbutton panel instead of a touch panel beneath or integrated with the display screen.

[0064] The first and second pushbutton actuators 1410 and 1440 are operable to initiate the tensioning and/or sealing cycles as described below. Other embodiments of the strapping device 50 do not have pushbutton actuators and instead incorporate their functionality into the display assembly 1490. For instance, in one of these embodiments two areas of the touch panel define virtual buttons that have the same functionality as mechanical pushbutton actuators.

[0065] The controller 1600, which is shown in Figure 1C, includes a processing device (or devices) communicatively connected to a memory device (or devices). For instance, the controller may be a programmable logic controller. The processing device may include any suitable processing device such as, but not limited to, a general-purpose processor, a special-purpose processor, a digital-signal processor, one or more microprocessors, one or more microprocessors in association with a digital-signal processor core, one or more application-specific integrated circuits, one or more field-programmable gate array circuits, one or more integrated circuits, and/or a state machine. The memory device may include any suitable memory device such as, but not limited to, read-only memory, random-access memory, one or more digital registers, cache memory, one or more semiconductor memory devices, magnetic media such as integrated hard disks and/or removable memory, magneto-optical media, and/or optical media. The memory device stores instructions executable by the processing device to control operation of the strapping device 50. The controller 1600 is communicatively and operably connected to the motor 1100, the display assembly 1490, the pushbutton actuators 1410 and 1440, and the sensor(s) 1700 and configured to receive signals from and to control those components. The controller 1600 may also be communicatively connectable (such as via Wi-Fi, Bluetooth, near-field communication, or other suitable wireless communications protocol) to an external device, such as a computing device, to send information to and receive information from that external device.

[0066] The controller 1600 is configured to operate the strapping device in one of three operating modes to carry out the strapping cycle: (1) a manual operating mode; (2) a semi-automatic operating mode; and (3) an automatic operating mode. In the manual operating mode, the controller 1600 operates the motor 1100 to cause the tension wheel 400w to rotate responsive to the first pushbutton actuator 1410 being actuated and maintained in its actuated state. The controller 1600 operates the motor 1100 to cause the sealing assembly 900 to carry out the sealing cycle responsive to the second pushbutton actuator 1440 being actuated. In the semi-

automatic operating mode, the controller 1600 operates the motor 1100 to cause the tension wheel 400w to rotate responsive to the first pushbutton actuator 1410 being actuated and maintained in its actuated state. Once the controller 1600 determines that the tension in the strap reaches the (preset) desired strap tension, the controller 1600 automatically operates the motor 1100 to cause the sealing assembly 900 to carry out the sealing cycle (without requiring additional input from the operator). In the automatic operating mode, the controller 1600 operates the motor 1100 to cause the tension wheel 400w to rotate responsive to the first pushbutton actuator 1410 being actuated. Once the controller 1600 determines that the tension in the strap reaches the (preset) desired strap tension, the controller 1600 automatically operates the motor 1100 to cause the sealing assembly 900 to carry out the sealing cycle (without requiring additional input from the operator).

[0067] The sensors 1700 include any suitable sensors, such as microswitches, optical sensors, ultrasonic sensors, magnetic position sensors, and the like, configured to detect the position of certain components of the strapping device 50 and to send appropriate signals to the controller 1600. The sensors 1700 may include, for instance: one or more tensioning-assembly-position sensors configured to detect when the tensioning assembly 400 is in its tensioning position and/or its strap-insertion position; one or more trigger-position sensors configured to detect when the actuating-assembly body 610 is in its home position and/or its actuated position; and one or more actuating assembly sensors configured to detect actuation of the first and second pushbutton actuators 1410 and 1440.

[0068] The power supply 1500 is electrically connected to (via suitable wiring and other components) and configured to power several components of the strapping device 50, including the motor 1100, the display assembly 1490, the controller 1600, and the sensor(s) 1700. The power supply 1500 includes a rechargeable battery (such as a lithium-ion or nickel cadmium battery) in this example embodiment, though it may be any other suitable electric power supply in other embodiments. The power supply 1500 is sized, shaped, and otherwise configured to be received in the receptacle defined by the rear housing section 120 of the housing 100. The strapping device 50 includes one or more power-supply-securing devices (not shown) to releasably lock the power supply 1500 in place upon receipt in the receptacle. Actuation of a release device of the strapping device 50 or the power supply 1500 unlocks the power supply

1500 from the housing 100 and enables an operator to remove the power supply 1500 from the receptacle.

[0069] Use of the strapping device 50 to form a tensioned strap loop around a load is described below. Initially, the tensioning assembly 400 is in its tensioning position, the actuating-assembly body 610 is in its home position (meaning that the decoupling assembly 500 is in its coupled configuration), the cam-engaging assembly 700 is in its home configuration, and the sealing assembly 900 is in its home configuration, as shown in Figures, 8A, 9A, and 11C. The strapping device 50 is in the automatic mode for the purposes of this example.

[0070] The operator pulls the strap leading-end first from a strap supply (not shown), wraps the strap around the load, and positions the leading end of the strap S below another portion of the strap to form upper and lower portions of strap. The operator then pulls the trigger 612 and in doing so moves the actuating-assembly body 610 from the home position to the actuated position, as shown in Figures 8B and 9B. As this occurs, and as described above, the decoupling-assembly actuator 620 switches the decoupling assembly 500 from the coupled configuration to the release configuration. Additionally, the pivoting of the actuating-assembly body 610 causes the cam-engaging-assembly actuator 616 to engage the actuator-engaging finger 724 and force the cam-engaging assembly 700 to move to its cam-engaging configuration. Once one of the sensors 1700 detects that the actuating-assembly body 610 has reached the actuated position, the controller 1600 controls the motor 1100 to rotate the output shaft in the first drive direction.

[0071] As explained above, the transmission 1000 transmits this rotational movement of the output shaft to the drive shaft 410 of the tensioning assembly 400 and rotates it in the tensioning direction T. This causes the first sun gear 410b to rotate about the tension-wheel rotational axis A400w in the tensioning direction T. The first sun gear 410b drives the first set of planet gears 414a–414c. Since the first set of planet gears 414a–414c are fixed in rotation about the tensioning-wheel axis A400w, they drive the rocker mover 420 to rotate about the tension-wheel rotational axis A400w in the tensioning direction T. Eventually, the leading end of one of the cams 424, 426, and 428—here the leading end 424le of the first cam 424—engages the cam-engaging finger 714 and forces the cam-engaging finger 714 to pivot until it engages the stop 390, thereby moving the cam-engaging assembly 700 to its stop configuration, as shown in Figures 8C and 9C. Since the stop 390 prevents further pivoting of the cam-engaging finger 714

and the cam 424 bears against the cam-engaging finger 714, continued rotation of the rocker mover 420 forces the rocker 400r and the entire tensioning assembly 400 to pivot upward about the rocker axis A400r toward its strap-insertion position.

[0072] The first sun gear 410b also drives the second set of planet gears 434a–434d. Since the decoupling assembly 500 is in its release configuration, the rollback ring gear 430 is rotatable about the tension-wheel rotational axis A400w, and rotation of the second set of planet gears 434a–434d causes the rollback ring gear 430 to rotate about the tension-wheel rotational axis A400w in the tensioning direction T rather than causing the second carrier 430—and the tension wheel 400w—to rotate (though there may be a small amount of rotation due to drag torque). Once the controller 1600 determines that the tensioning assembly 400 has reached its strap-insertion position (such as based on feedback from one of the sensors 1700), as shown in Figures 8D and 9D, the controller 1600 controls the motor 1100 to stop rotating the output shaft. Generally, the apex 424s' of the finger-engaging surface 424s of the cam 424 engages the cam-engaging finger 714 when the tensioning assembly 400 is in its strap-insertion position. In other words, the bearing point of the cam 424 against the cam-engaging finger 714 is the apex 424s'. The tensioning-assembly freewheel 412 prevents the driven shaft 410 from reversing, ensuring the tensioning assembly 400 remains in the strap-insertion position. Accordingly, the tensioning-assembly gearing operatively connects the motor 1100 and the transmission 1000 to the tensioning assembly 400 to move the tensioning assembly 400 from its tensioning position to its strap-insertion position.

[0073] With the tensioning assembly 400 in its strap-insertion position and while continuing to pull the trigger 612 to hold the actuating-assembly body 610 in the actuated position, the operator introduces the overlapping upper and lower portions of the strap between the tension wheel 400w and the tension plate 312 and between the weld shoe 942 and the weld plate 314, as shown in Figures 8E and 9E. The operator then releases the trigger 612, enabling the appropriate biasing elements to force the actuating-assembly body 610 to return to its home position as shown in Figures 8F and 9F. A catch (not shown) engages the projection 622a of the actuated arm 622 of the decoupling assembly actuator 620 and holds it in place, holding the decoupling assembly 500 in its release configuration.

[0074] Once one of the sensors 1700 detects that the actuating-assembly body 610 has reached the home position (or has left the actuated position, depending on the embodiment),

the controller 1600 controls the motor 1100 to rotate the output shaft in the first drive direction. As explained above, this causes the rocker mover 420 to rotate about the tension-wheel rotational axis A400w in the tensioning direction T. As the rocker mover 420 rotates, the bearing point of the cam 424 against the cam-engaging finger 714 (i.e., the point of engagement between the finger-engaging surface 424s of the cam 424 that engages the cam-engaging finger 714) shifts from its apex 424s' toward the trailing end 424te of the cam 424. The curved shape and the orientation of the finger-engaging surface 424se causes the tensioning assembly 400 to gradually lower from its strap-insertion position toward its tensioning position while the cam engages the cam-engaging finger 714, as shown in Figures 8F and 9F. Continued rotation of the rocker mover 420 eventually causes the cam to disengage the cam-engaging finger 714, at which point suitable biasing elements force the tensioning assembly 400 to complete the movement to its strap-tensioning position and to move the cam-engaging assembly 700 back to its home position, as shown in Figures 8G and 9G. Once the controller 1600 determines that the tensioning assembly 400 has reached its tensioning position (such as based on feedback from one of the sensors 1700), the controller 1600 controls the motor 1100 to stop rotating the output shaft.

[0075] The operator then actuates the first pushbutton actuator 1410, which (via a pivoting lever) causes the catch to disengage the projection 622a of the actuated arm 622 of the decoupling assembly 620. As described above, this enables the decoupling assembly 500 to—via the biasing forces imparted by the expandable element 540 and the biasing element 620b—switch from its release configuration to its coupled configuration to enable the motor 1100 to operate to tension the strap S. Once one of the sensors 1700 detects the actuation of the first pushbutton actuator 1410, the controller 1600 initiates the strapping cycle. The controller 1600 starts the tensioning cycle by controlling the motor 1100 to rotate the output shaft in the first drive direction. As explained above, the transmission 1000 transmits this rotational movement of the output shaft to the drive shaft 410 of the tensioning assembly 400 and rotates it in the tensioning direction T. This causes the first sun gear 410b to rotate about the tension-wheel rotational axis A400w in the tensioning direction T. The first sun gear 410b drives the first set of planet gears 414a–414c. Since the first set of planet gears 414a–414c are fixed in rotation about the tensioning-wheel axis A400w, they drive the rocker mover 420 to rotate about the tension-wheel rotational axis A400w in the tensioning direction T. Since the cam-engaging assembly 700 is in its home configuration, the cam-engaging finger 714 is not in the rotational path of the cams

424, 426, and 428 of the rocker mover 420 and the tensioning assembly 400 does not pivot from its tensioning position.

[0076] The first sun gear 410b also drives the second set of planet gears 434a–434d. Since the decoupling assembly 500 is in its coupled configuration, it prevents the rollback ring gear 430 from rotating about the tension-wheel rotational axis A400w, and rotation of the second set of planet gears 434a–434d causes the carrier 432—including the second sun gear 432b—to rotate about the tension-wheel rotational axis A400w in the tensioning direction T. The second sun gear 432b drives the third set of planet gears 436a–436c, which causes the tension wheel 400w to rotate about the tension-wheel rotational axis A400w in the tensioning direction T. Accordingly, the tensioning-assembly gearing operatively connects the motor 1100 and the transmission 1000 to the tension wheel 400w to rotate the tension wheel 400w about the tension-wheel rotational axis A400w in the tensioning direction T.

[0077] As the tension wheel 400w rotates in the tensioning direction T, it pulls the upper portion of the strap S over the lower portion of the strap S, thereby tensioning the strap S around the load. Throughout the tensioning cycle, the controller 1600 monitors the current drawn by the motor 1100. When this current reaches a preset value that is correlated with the (preset) desired strap tension for this strapping cycle, the controller 1600 stops the motor 1100, thereby terminating the tensioning cycle. At this point, the strap exerts a torque on the tension wheel 400w in the rollback direction TREV. The tension wheel 400w transmits this torque to the third set of planetary gears 436a–436c, which transmit this torque to the second sun gear 432b of the carrier 432. The second set of planetary gears 434a–434d transmit this torque to the first sun gear 410b of the driven shaft 410 and to the rollback ring gear 430. The tensioning-assembly freewheel 412 prevents the driven shaft 410 from rotating in the rollback direction TREV. The decoupling assembly 500 is in its coupled configuration and prevents the rollback ring gear 430 from rotating in the rollback direction TREV. Accordingly, the torque the strap exerts on the tension wheel 400w is absorbed by components of the tensioning assembly 400 and the decoupling assembly 500, enabling the tension wheel 400w to hold tension in the strap without rotating in the rollback direction TREV.

[0078] After completion of the tensioning cycle, the controller 1600 automatically starts the sealing cycle by controlling the motor 1100 to begin rotating the output shaft in the second drive direction. This causes the transmission 1000 to drive the toothed belt 900b to begin

rotating the eccentric and oscillating the weld shoe 942 and switch the sealing assembly 900 from its home configuration to its sealing configuration, and in doing so pivot the weld arm 940 to its sealing position. As the weld arm 940 reaches the sealing position, the weld shoe 942 forces the overlapping upper and lower layers of strap against the weld plate 314 while the cutter 944 cuts the upper strap layer from the strap supply. The oscillating movement of the weld shoe 942 locally melts the portions of the upper and lower strap layers together. After a preset period of time or a preset quantity of rotations of the motor output shaft, the controller 1600 controls the motor 1100 to stop rotating the output shaft, completing the sealing cycle.

[0079] After the sealing cycle is complete, the operator again pulls the trigger 612, and in doing so moves the actuating-assembly body 610 from the home position to the actuated position. As this occurs, and as described above, the decoupling assembly actuator 620 switches the decoupling assembly 500 from the coupled configuration to the release configuration. After the sealing cycle is complete, the strap continues to exert the torque on the tension wheel 400w that acts in the rollback direction TREV. Switching the decoupling assembly 500 from the coupled configuration to the release configuration enables the tension wheel 400w to rotate in the rollback direction TREV to release that torque in a controlled manner.

[0080] Specifically, upon completion of the strapping process, the decoupling assembly 500 continues to prevent the rollback ring gear 430 of the tensioning-assembly gearing from rotating in the rollback direction TREV, which as explained above prevents the tension wheel 400w from rotating in the rollback direction TREV after tensioning so the tension wheel 400w can hold the tension in the strap. As the operator moves the actuating-assembly body 610 to its actuated position, the decoupling assembly actuator 620 begins rotating the sleeve 550 of the decoupling assembly 500 to its release position, and the inner diameter of the expandable element 540 of the decoupling assembly 500 begins expanding. Eventually, the torque the rollback ring gear 430 exerts on the decoupling-assembly shaft 510 of the decoupling assembly 500 (via the rollback intermediary gear 431 and the gear 580 of the of the decoupling assembly 500) exceeds the compression force the expandable element 540 exerts on the first engageable element 520. When this occurs, the rollback ring gear 430 begins rotating in the rollback direction TREV about the tension-wheel rotational axis A400w, enabling the second set of planetary gears 434a–434d and the carrier 432 to rotate in the rollback direction TREV about the tension-wheel rotational axis A400w. This causes the tension wheel 400w to rotate in the

rollback direction TREV about the tension-wheel rotational axis A400w to release the torque exerted by the tensioned strap.

[0081] Once one of the sensors 1700 detects that the actuating-assembly body 610 has reached the actuated position, the controller 1600 controls the motor 1100 to rotate the output shaft in the first drive direction to raise the tensioning assembly 400 to its strap-insertion position, as explained above. As the tensioning assembly 400 moves, it forces the sealing-assembly-reset device 1200 to pivot to its actuated position, and in doing so engage the sealing assembly 900 to force the sealing assembly 900 to switch to its home configuration and release the strap S, as shown in Figures 11B and 11C. The operator then removes the strapping device 50 from the tensioned strap loop.

[0082] Although the sealing assembly of the above-described example embodiment of the strapping device is configured to form a friction-welded strap joint, the sealing assembly may comprise other sealing mechanisms (such as notching jaw assembly, a crimping jaw assembly, a sealless joint assembly, an ultrasonic welding assembly, or a hot-knife assembly) in other embodiments configured to seal any suitable type of strap (such as metal, plastic, or paper strap).

[0083] The above-described example embodiment of the strapping device includes a single motor configured to drive both the tensioning assembly and the sealing assembly. In other embodiments, the strapping device includes separate motors configured to drive the respective tensioning and sealing assemblies and may include separate transmissions for each motor.

[0084] Other embodiments of the strapping device may include fewer assemblies, components, and/or features than those included in the strapping device 50 described above and shown in the Figures. In other words, while the strapping device 50 includes all of the assemblies, components, and features described above, they are independent of one another and may be independently included in other strapping devices.

[0085] While the strapping device described above is a handheld strapping device, the strapping device may be any other suitable strapping device in other embodiments, such as a standalone automatic or semi-automatic strapping machine.

Claims

1. A strapping device comprising:

a support comprising a tensioning plate and a weld plate;

a tensioning assembly comprising a tensioning wheel, the tensioning assembly movable relative to the tensioning plate between a tensioning position and a strap-insertion position;

a sealing assembly comprising a weld arm, the sealing assembly switchable between a first configuration in which the weld arm is a first distance from the weld plate and a second configuration in which the weld arm is a second distance from the weld plate, the second distance being shorter than the first distance; and

a sealing-assembly-reset device movable between a first position and an second position,

wherein the tensioning assembly is operably connected to the sealing-assembly-reset device and configured to move the sealing-assembly-reset device from the first position to the second position when the tensioning assembly moves from the tensioning position to the strap-insertion potion,

wherein the sealing-assembly-reset device is positioned such that, when the sealing assembly is in the first configuration, movement of the sealing-assembly-reset device from the first position to the second position causes the sealing-assembly-reset device to switch the sealing assembly from the second configuration to the first configuration.

2. The strapping device of claim 1, wherein the tensioning assembly is positioned to contact the sealing-assembly-reset device when moving from the tensioning position to the strap-insertion position to force the sealing-assembly-reset device to move from the first position to the second position.

3. The strapping device of claim 2, wherein the sealing-assembly-reset device comprises a head adjacent the sealing assembly and an actuated arm extending from the head, wherein the tensioning assembly is positioned to contact the actuated arm of the sealing-assembly-reset device when moving from the tensioning position to the strap-insertion position to force the sealing-assembly-reset device to move from the first position to the second position.

4. The strapping device of claim 3, wherein the tensioning assembly comprises tensioning-assembly gearing, a rocker housing the tensioning-assembly gearing, and a rocker cover attached to the rocker to at least partially enclose the tensioning-assembly gearing, wherein the tensioning assembly is positioned so the rocker cover contacts the actuated arm of the sealing-assembly-reset device when the tensioning assembly moves from the tensioning position to the strap-insertion position to force the sealing-assembly-reset device to move from the first position to the second position.

5. The strapping device of claim 2, wherein the sealing-assembly-reset device is pivotable between the first position and the second position.

6. The strapping device of claim 5, further comprising a biasing element biasing the sealing-assembly-reset device to the first position.

7. The strapping device of claim 1, wherein the sealing assembly further comprises:

a first linkage pivotably connected to the support via a first pivot; and

a second linkage pivotably connected to the first linkage via a second pivot and to the weld arm via a third pivot,

wherein the first linkage and the second linkage form an angle greater than 0 degrees and less than 180 degrees when the sealing assembly is in the first configuration,

wherein the first linkage and the second linkage form an angle greater than 180 degrees and less than 360 degrees when the sealing assembly is in the second configuration.

8. The strapping device of claim 7, wherein the sealing-assembly-reset device is positioned such that, when the sealing assembly is in the first configuration, movement of the sealing-assembly-reset device from the first position to the second position causes the sealing-assembly-reset device to move the second pivot to switch the sealing assembly from the second configuration to the first configuration.

9. The strapping device of claim 8, wherein the sealing-assembly-reset device is positioned such that, when the sealing assembly is in the first configuration, movement of the sealing-assembly-reset device from the first position to the second position causes the sealing-

assembly-reset device to move the second pivot downward to switch the sealing assembly from the second configuration to the first configuration.

10. The strapping device of claim 9, wherein the tensioning assembly is positioned to contact the sealing-assembly-reset device when moving from the tensioning position to the strap-insertion position to force the sealing-assembly-reset device to move from the first position to the second position.

11. The strapping device of claim 10, wherein the sealing-assembly-reset device comprises a head adjacent the second pivot and an actuated arm extending from the head, wherein the tensioning assembly is positioned to contact the actuated arm of the sealing-assembly-reset device when moving from the tensioning position to the strap-insertion position to force the sealing-assembly-reset device to move from the first position to the second position.

12. The strapping device of claim 11, wherein the tensioning assembly comprises tensioning-assembly gearing, a rocker housing the tensioning-assembly gearing, and a rocker cover attached to the rocker to at least partially enclose the tensioning-assembly gearing, wherein the tensioning assembly is positioned so the rocker cover contacts the actuated arm of the sealing-assembly-reset device when the tensioning assembly moves from the tensioning position to the strap-insertion position to force the sealing-assembly-reset device to move from the first position to the second position.

13. The strapping device of claim 12, wherein the sealing-assembly-reset device is pivotable between the first position and the second position, wherein the strapping device further comprises a biasing element biasing the sealing-assembly-reset device to the first position.

14. The strapping device of claim 9, wherein the sealing-assembly-reset device is pivotable between the first position and the second position.

15. The strapping device of claim 14, further comprising a biasing element biasing the sealing-assembly-reset device to the first position.

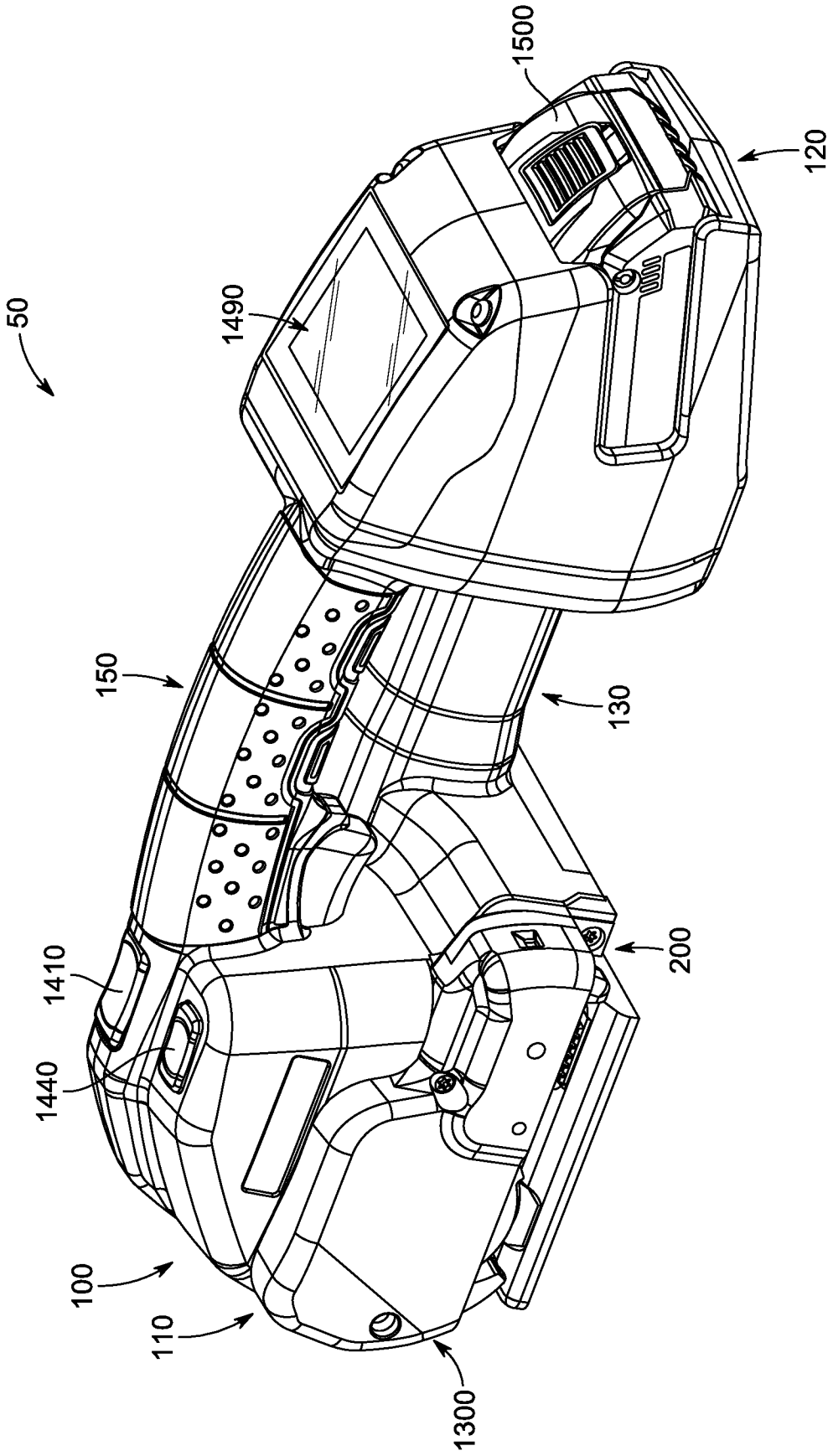


FIG. 1A

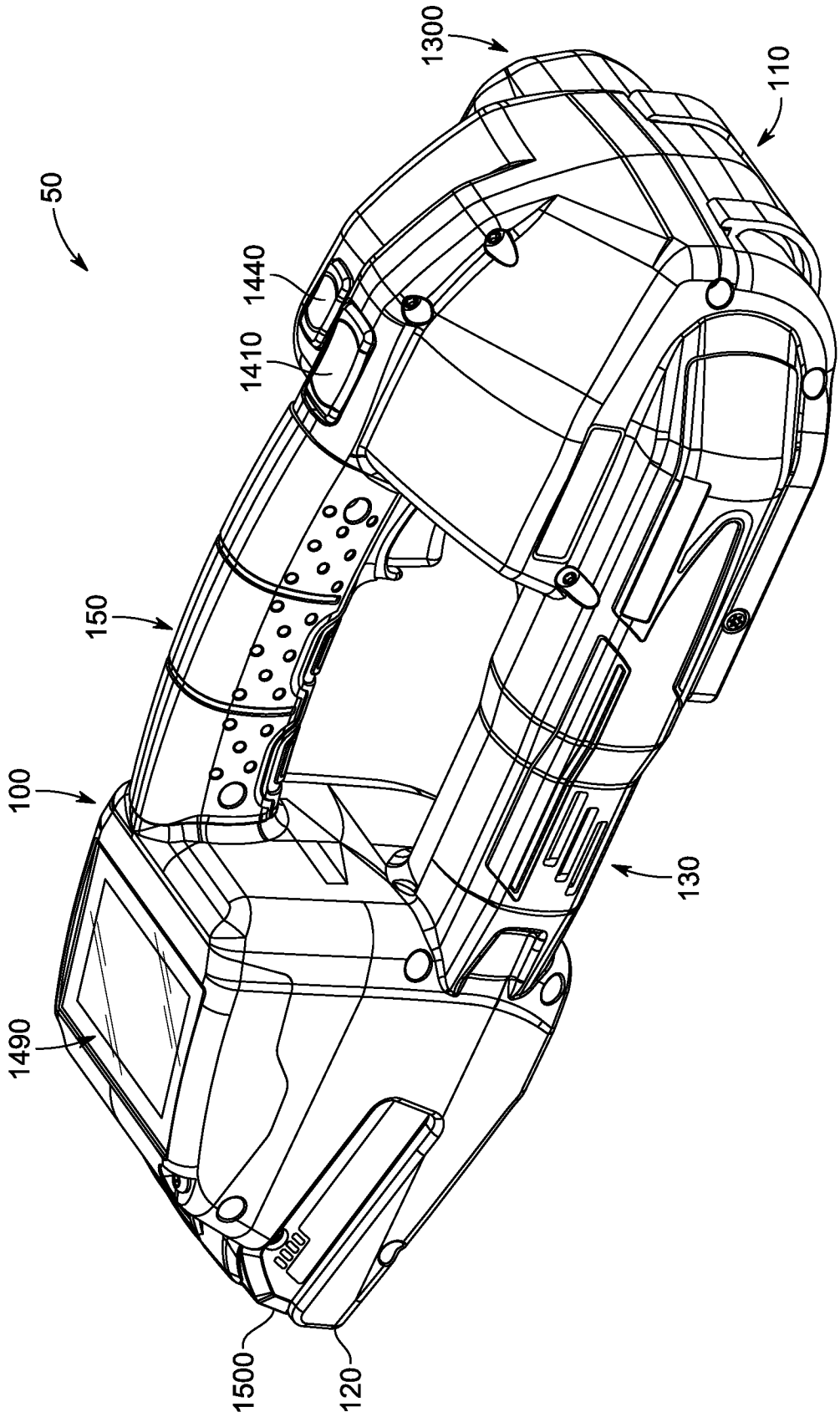


FIG. 1B

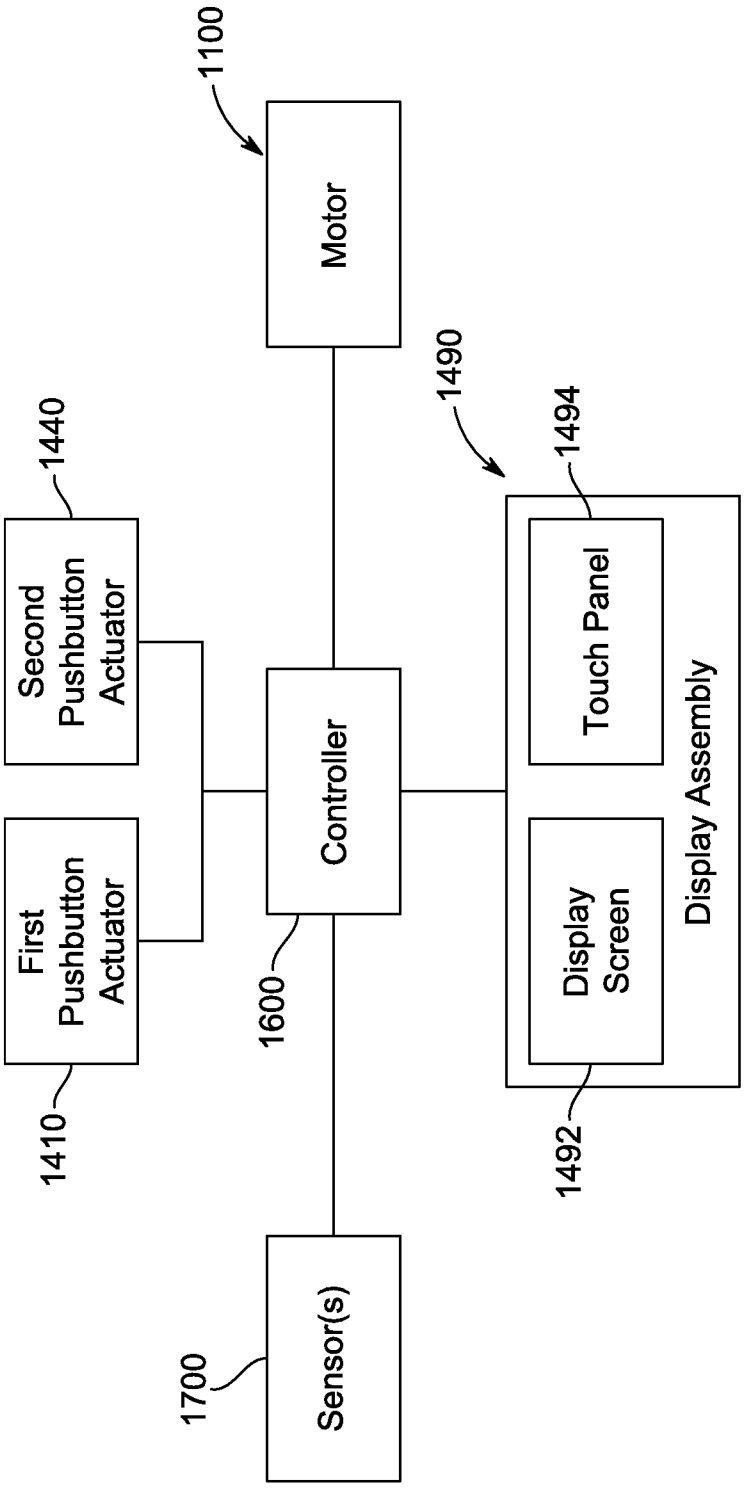

1100
Motor
1490
1494
1440
Second Pushbutton Actuator
Touch Panel
Display Assembly
Controller
First Pushbutton Actuator
Display Screen
1600
1410
1492
1700
Sensor(s)

FIG. 1C

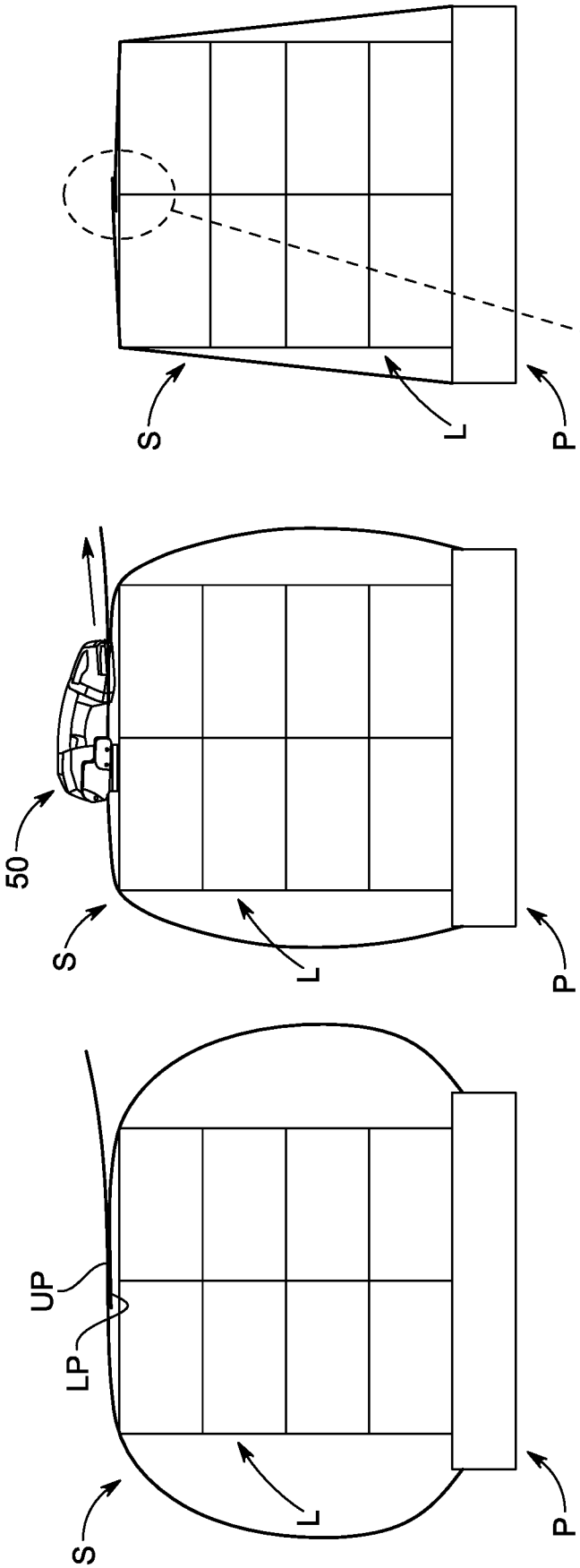


FIG. 2A

FIG. 2B

FIG. 2C

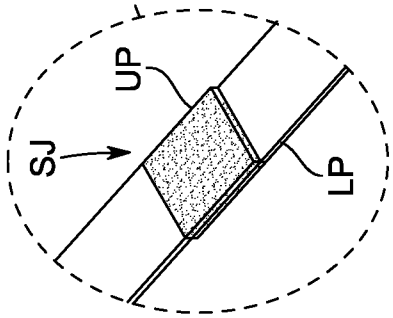


FIG. 2D

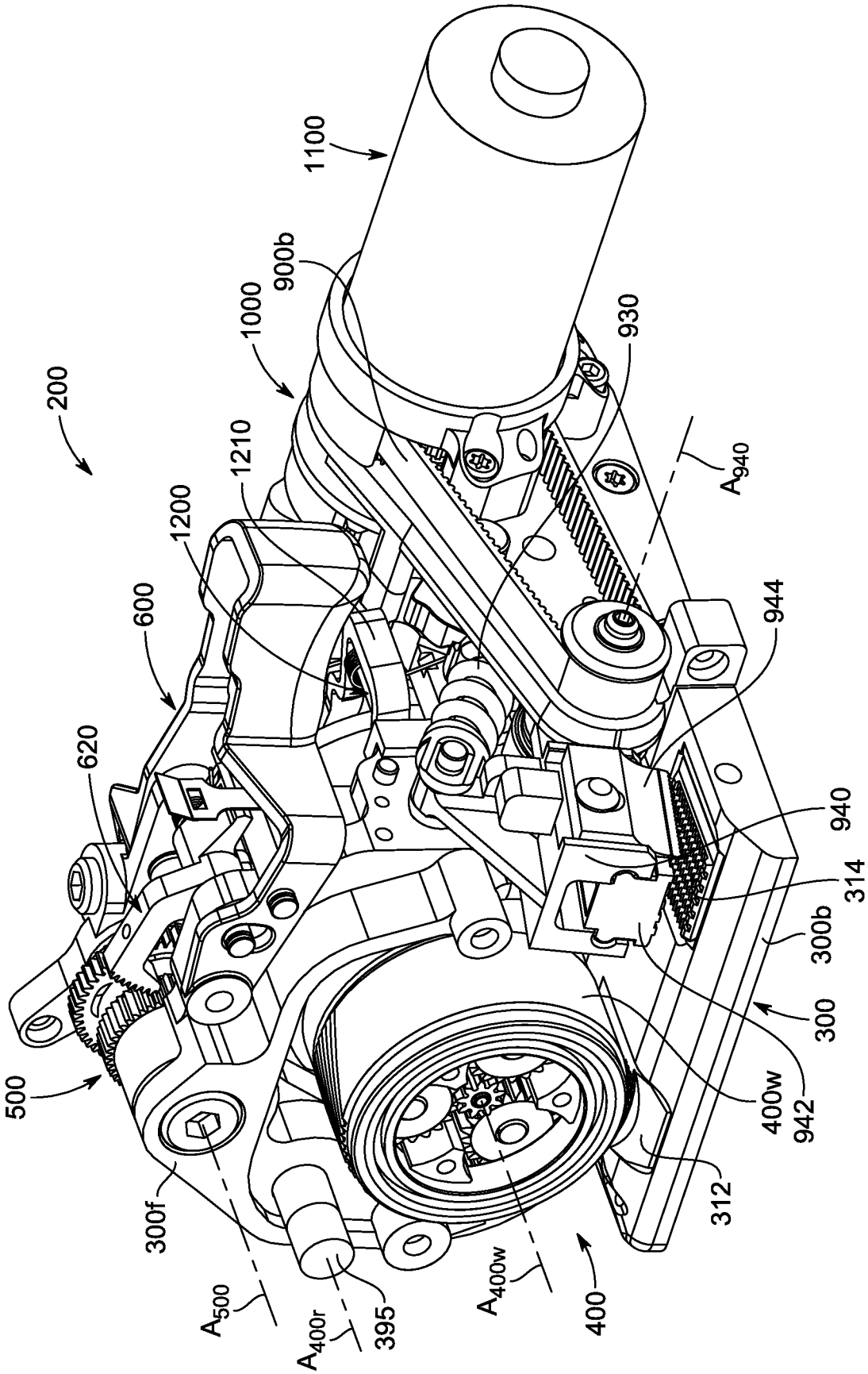
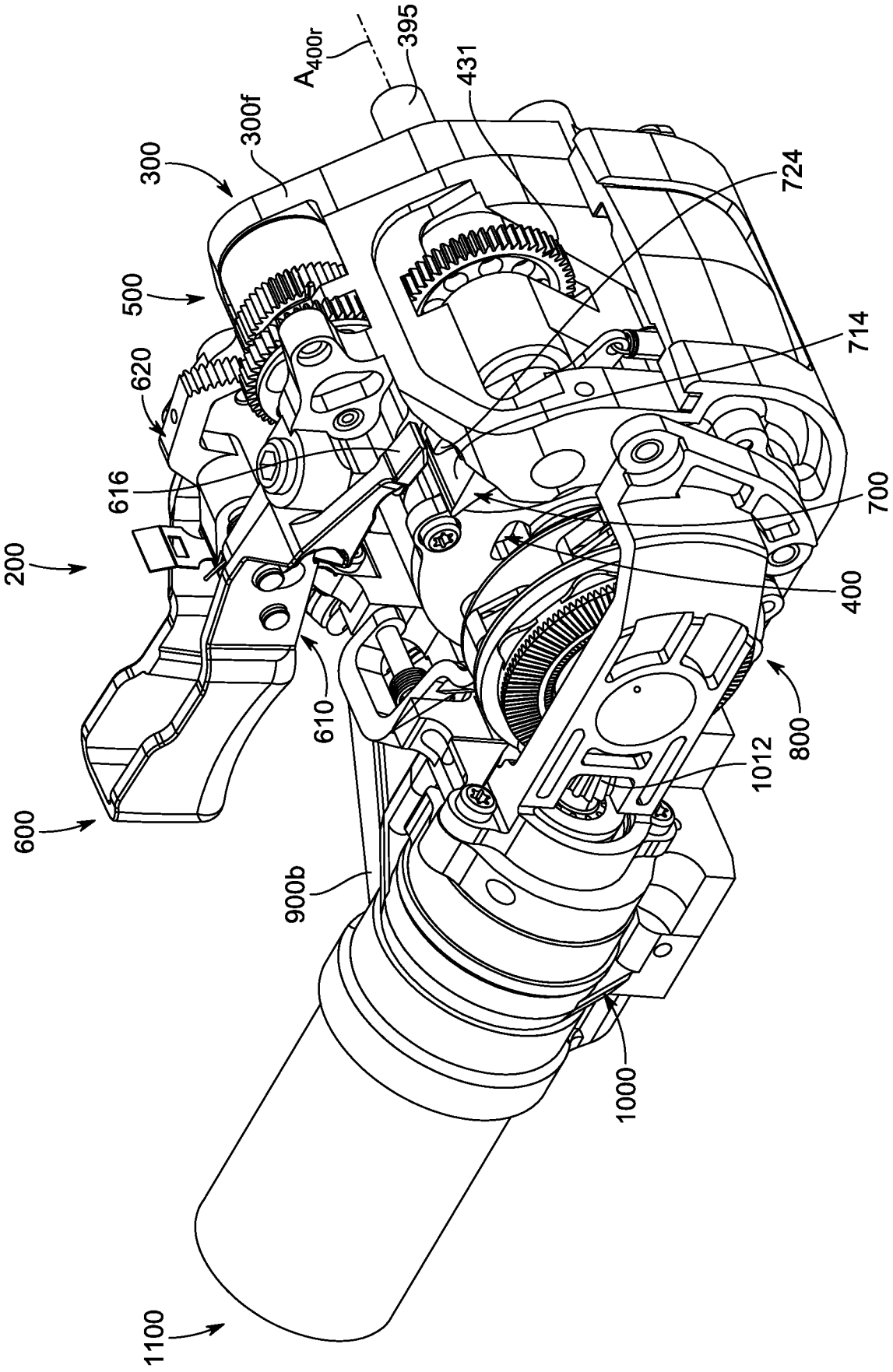

1100
900b
1000
930
200
1210
A_{940}
1200
944
600
620
940
314
300b
300
400w
942
312
500
300f
A_{500}
A_{400r}
395
A_{400w}
400

FIG. 3A


A_{400r}
395
431
300f
300
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500
714
620
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700
200
400
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800
1012
600
900b
1000
1100

FIG. 3B

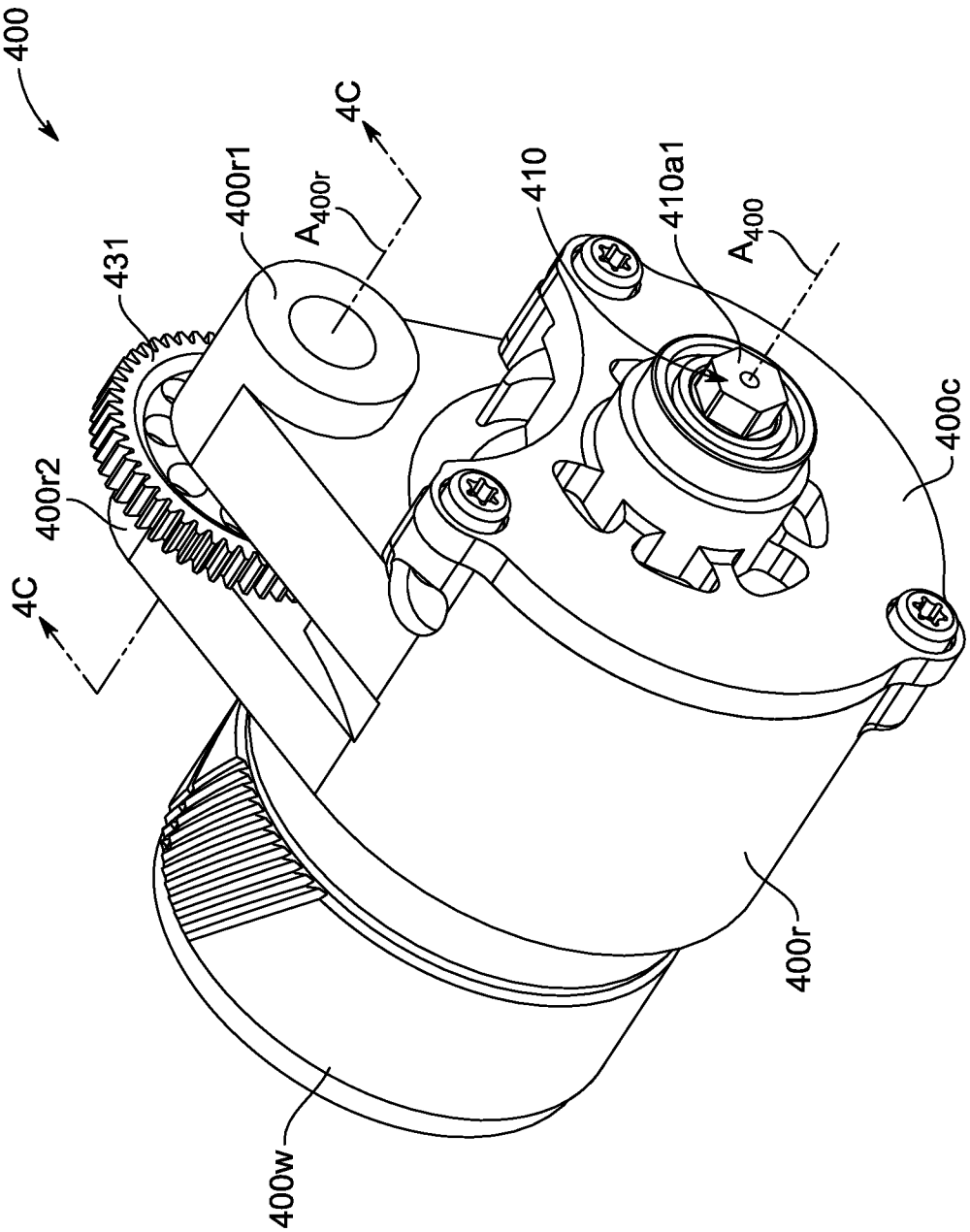
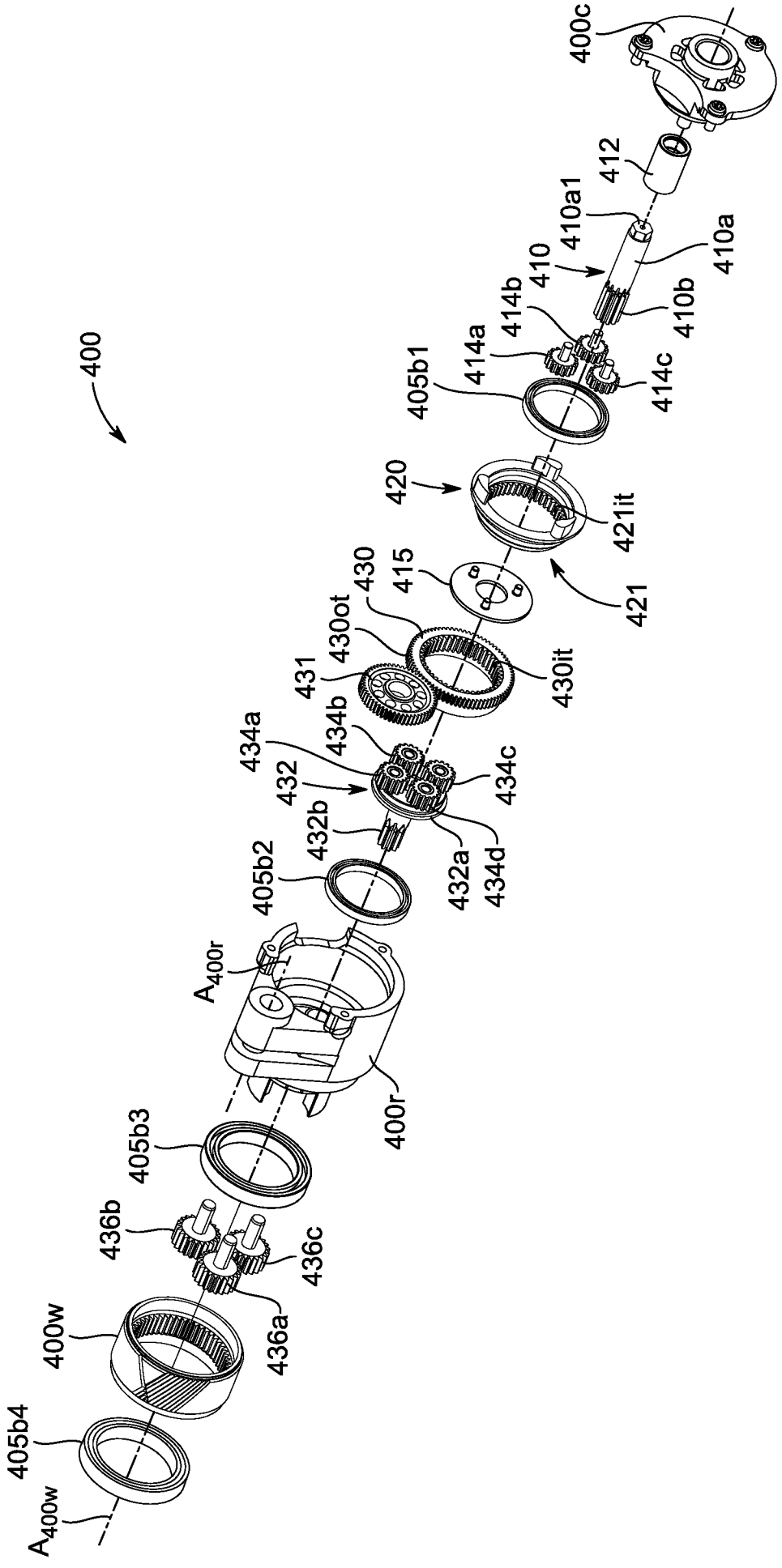


FIG. 4A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400c
412
410a1
410a
410
410b
414b
414a
414c
405b1
420
421it
421
415
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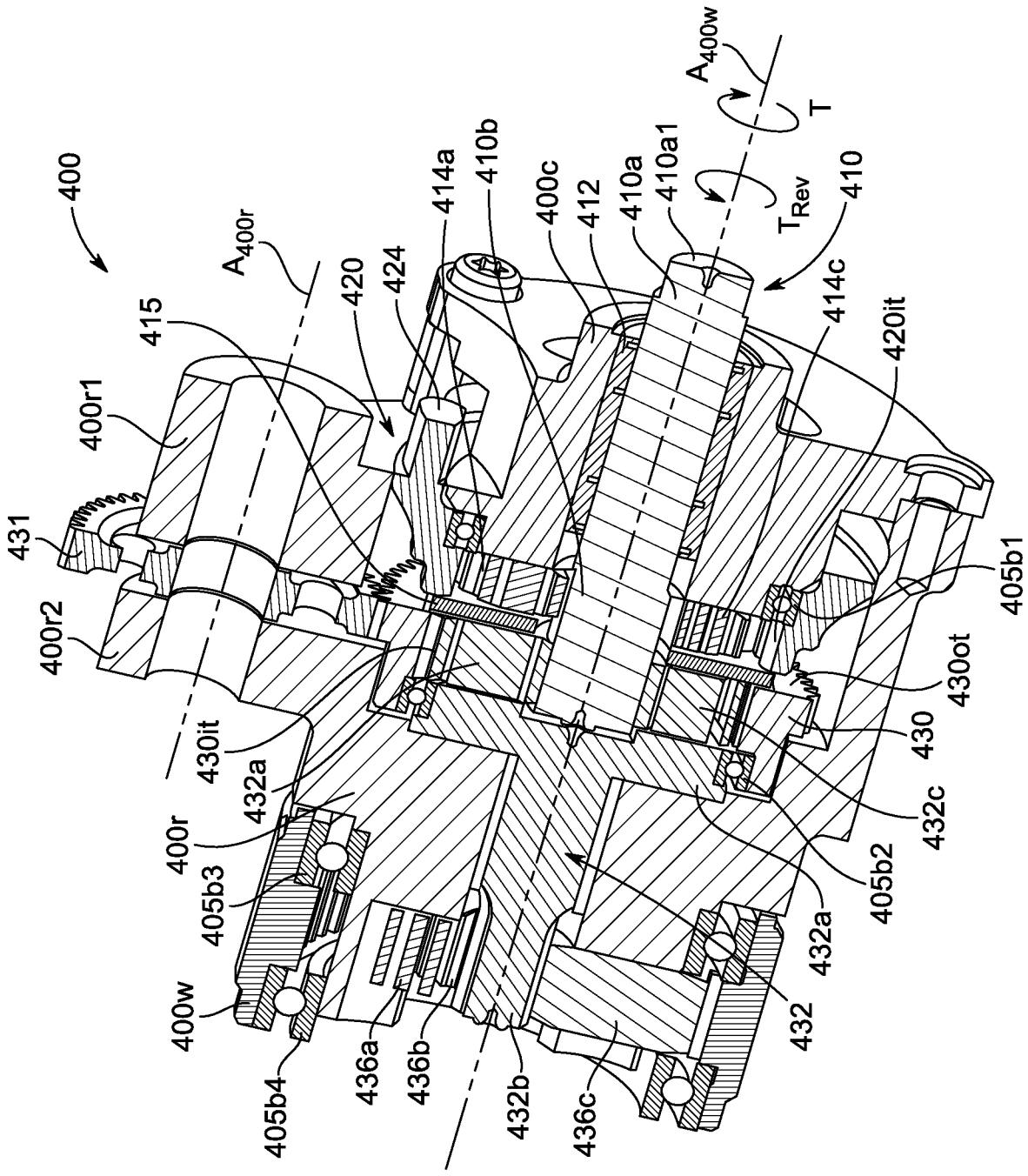
431
430it
434a
434b
434c
432
432b
432a
434d
405b2
A_{400r}
400r
405b3
436b
436c
436a
400w
405b4
A_{400w}

FIG. 4B


400
A400r
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420
424
414a
410b
400c
412
410a
410a1
A400w
T
TRev
410
414c
420it
400r1
431
400r2
430it
432a
400r
405b3
400w
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436c
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430ot
430
432c
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432a
432

FIG. 4C

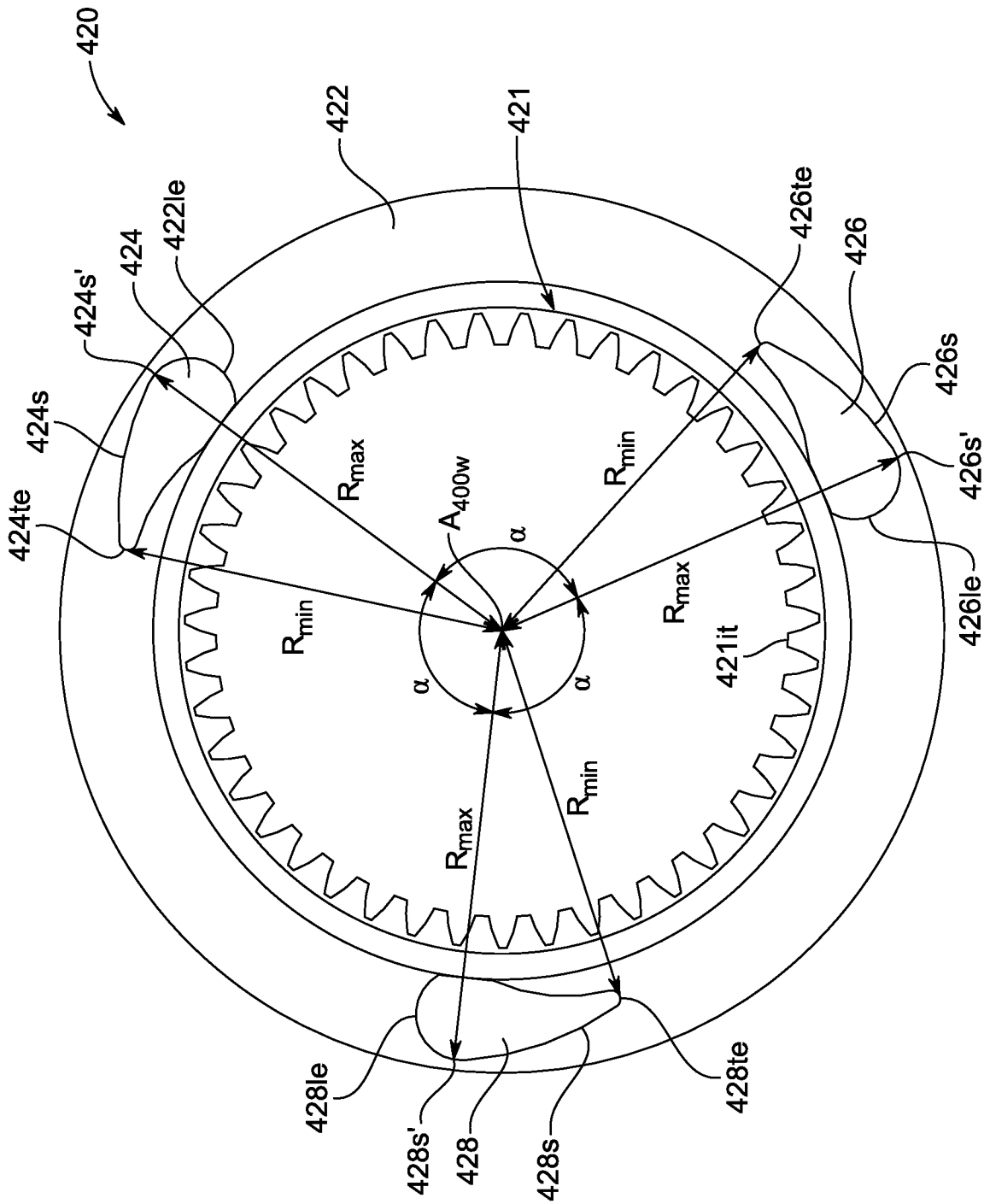

420
422
421
422le
424
424s'
424s
424te
426te
426
426s
426s'
426le
R_{max}
A_{400w}
α
R_{min}
R_{min}
R_{max}
421it
α
α
R_{max}
R_{min}
428le
428s'
428
428s
428te

FIG. 4D

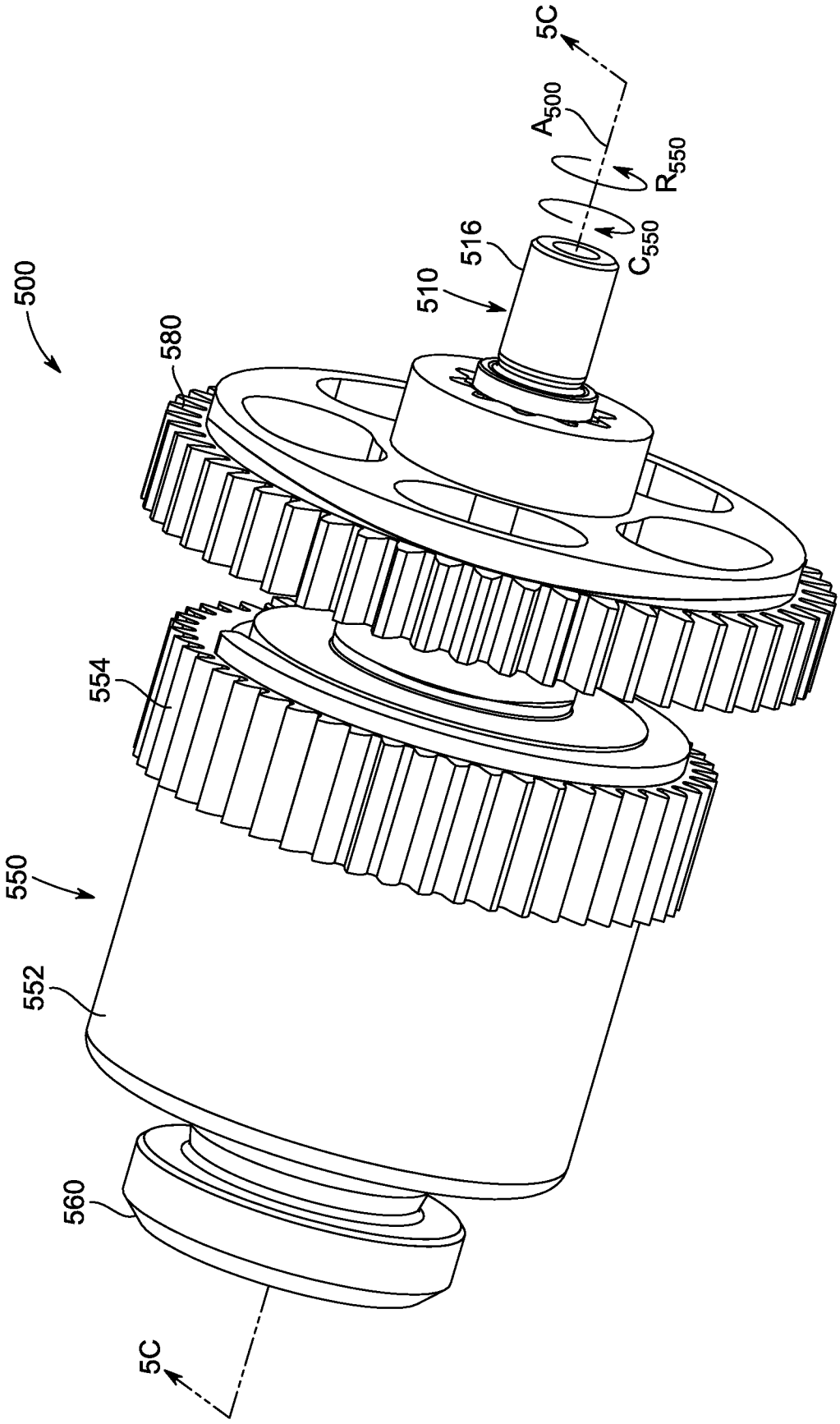
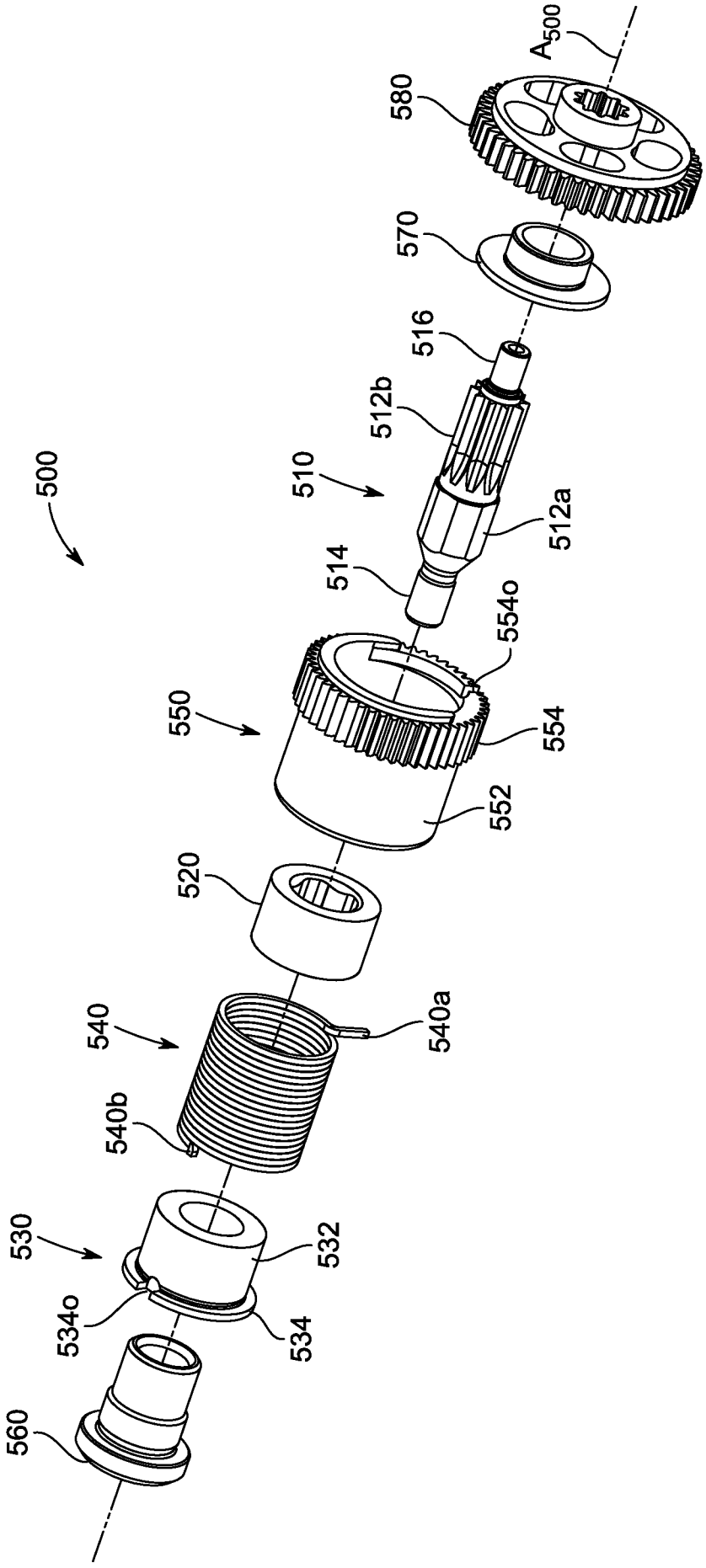


FIG. 5A


A500
580
570
516
512b
510
500
512a
514
554o
550
554
552
520
540
540a
540b
530
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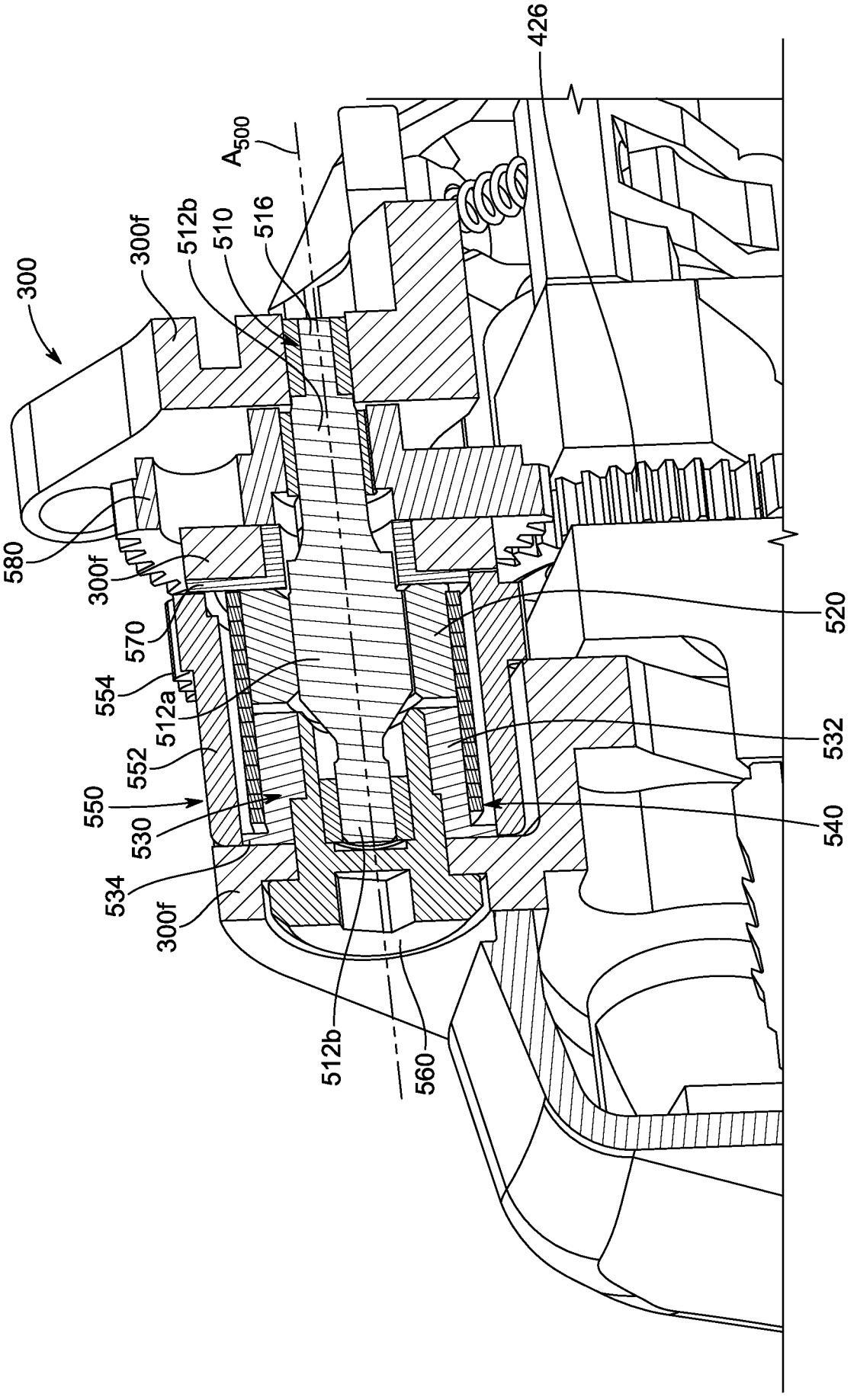
534o
534
560

FIG. 5B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A_{500}
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300f
512b
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554
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552
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530
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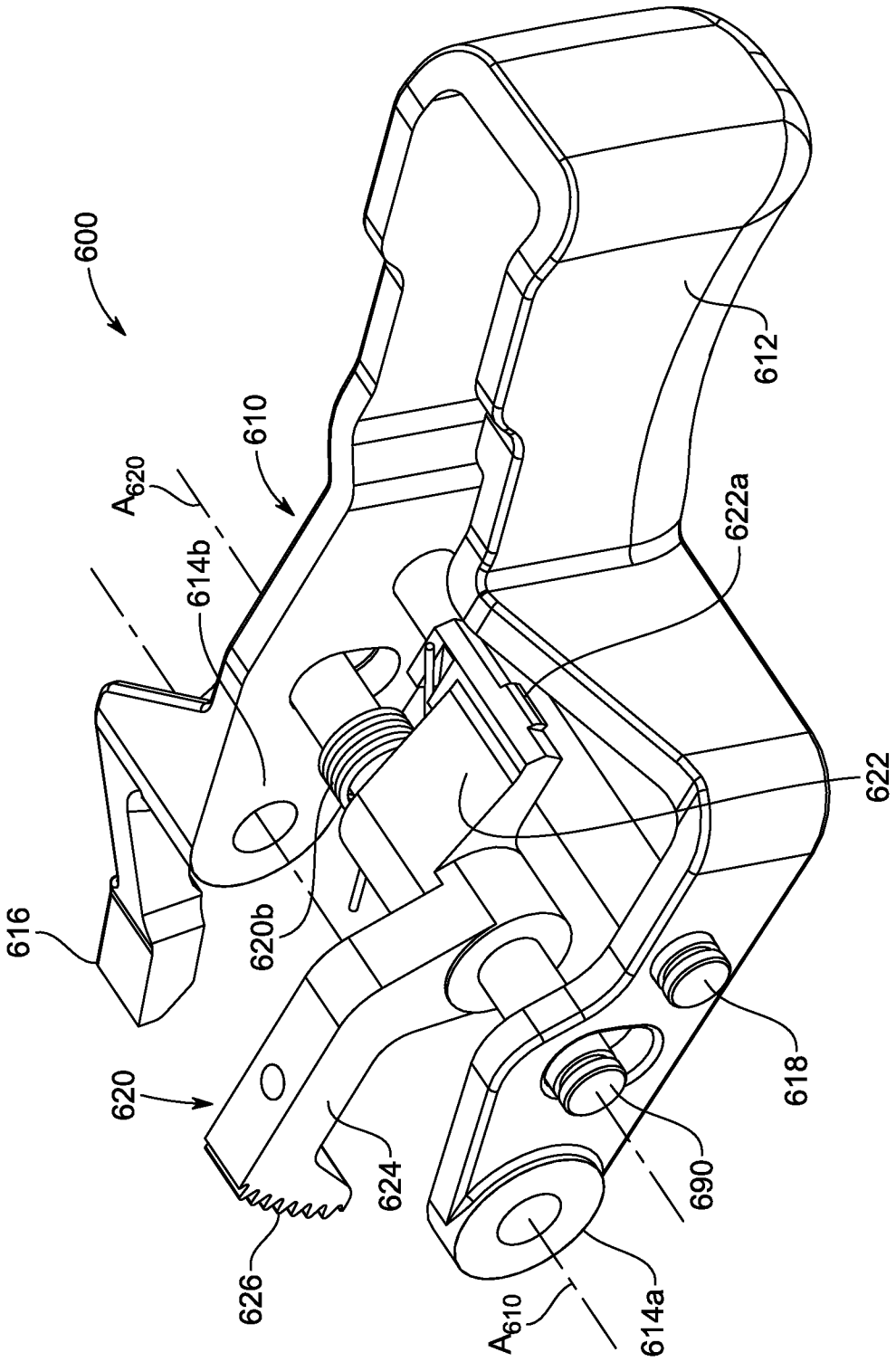
300f
512b
560
520
532
540

FIG. 5C


600
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A_{620}
614b
622a
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616
620b
620
624
626
618
690
A_{610}
614a

FIG. 6A

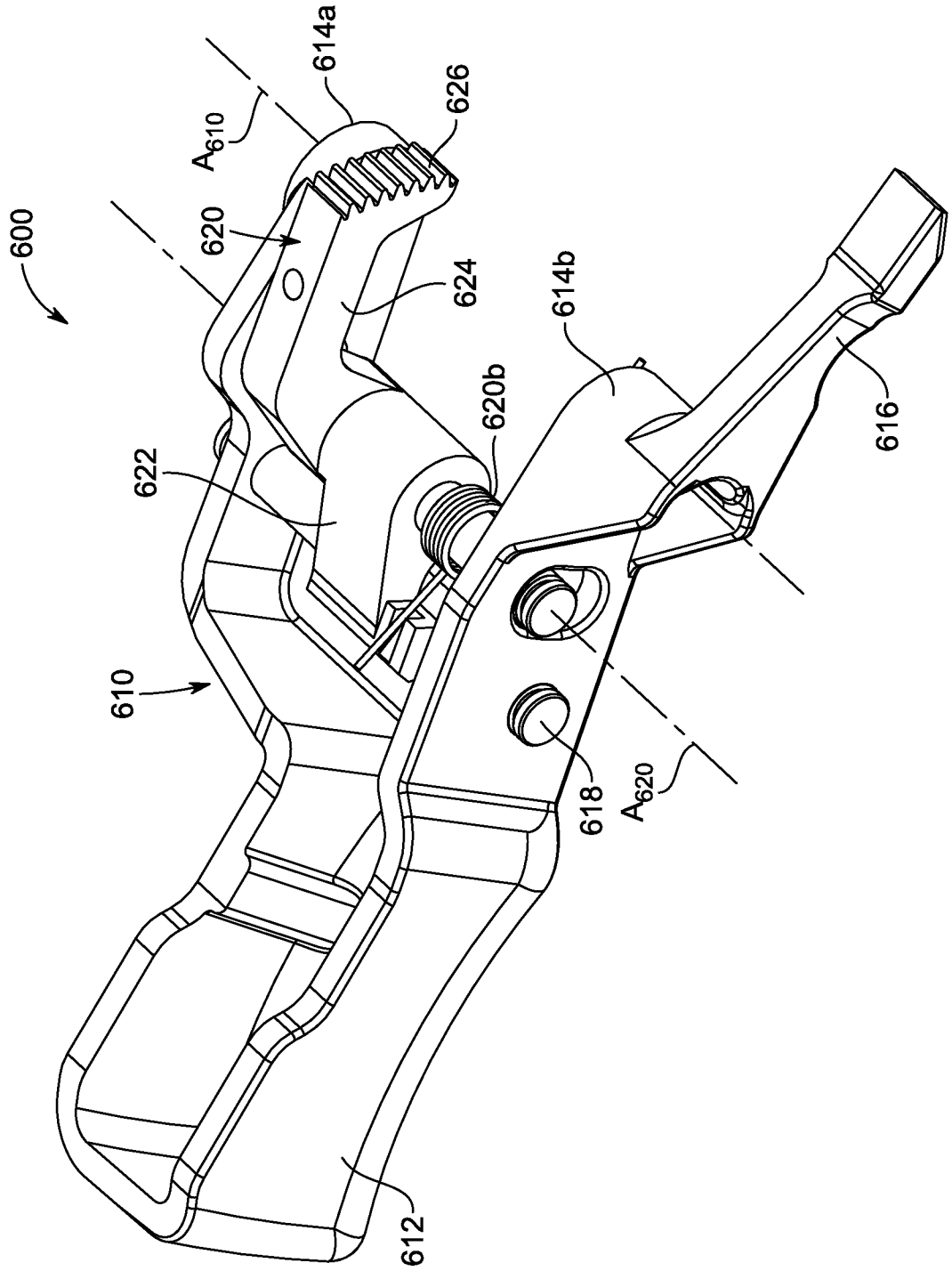


FIG. 6B

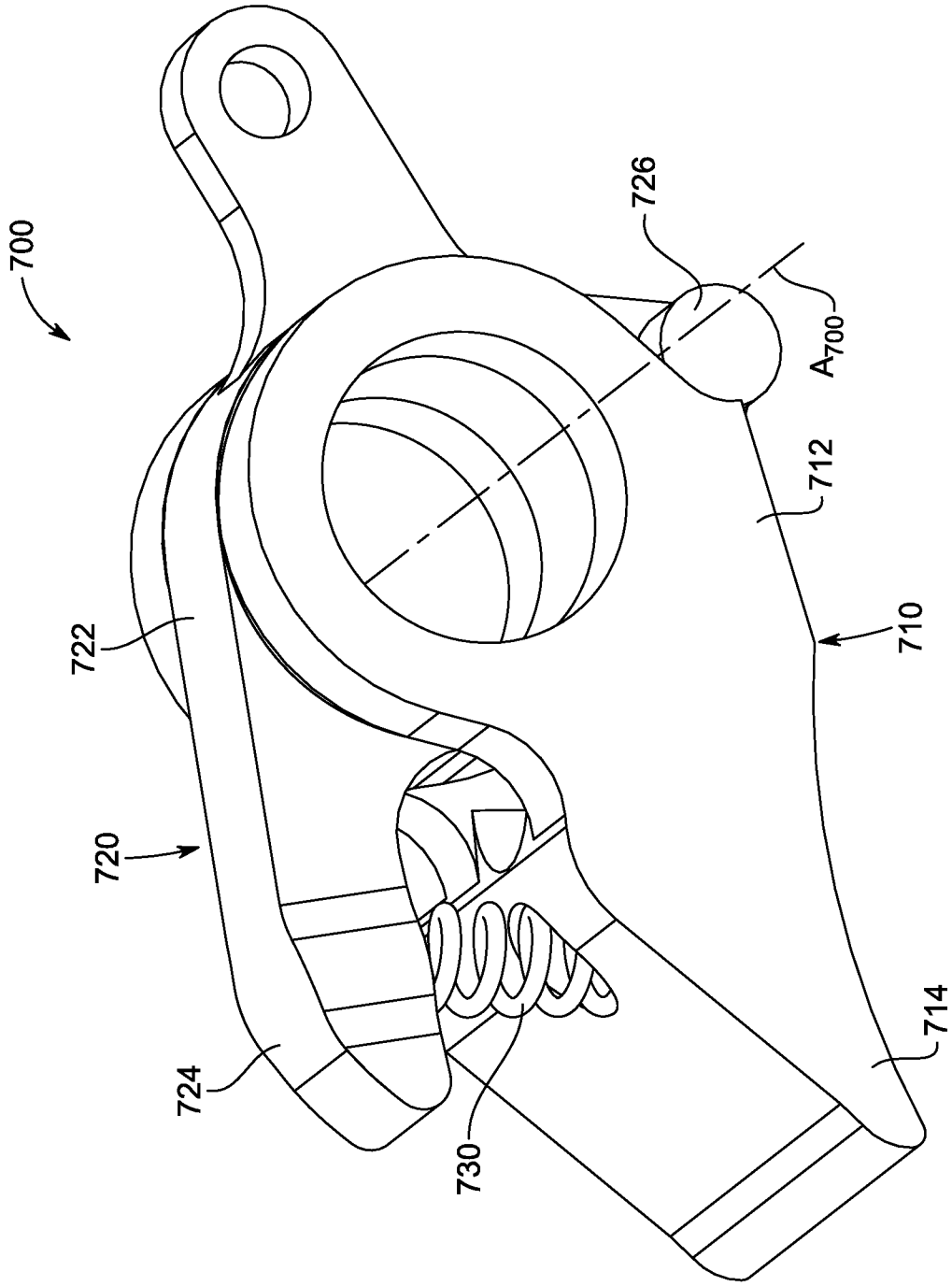


FIG. 7A

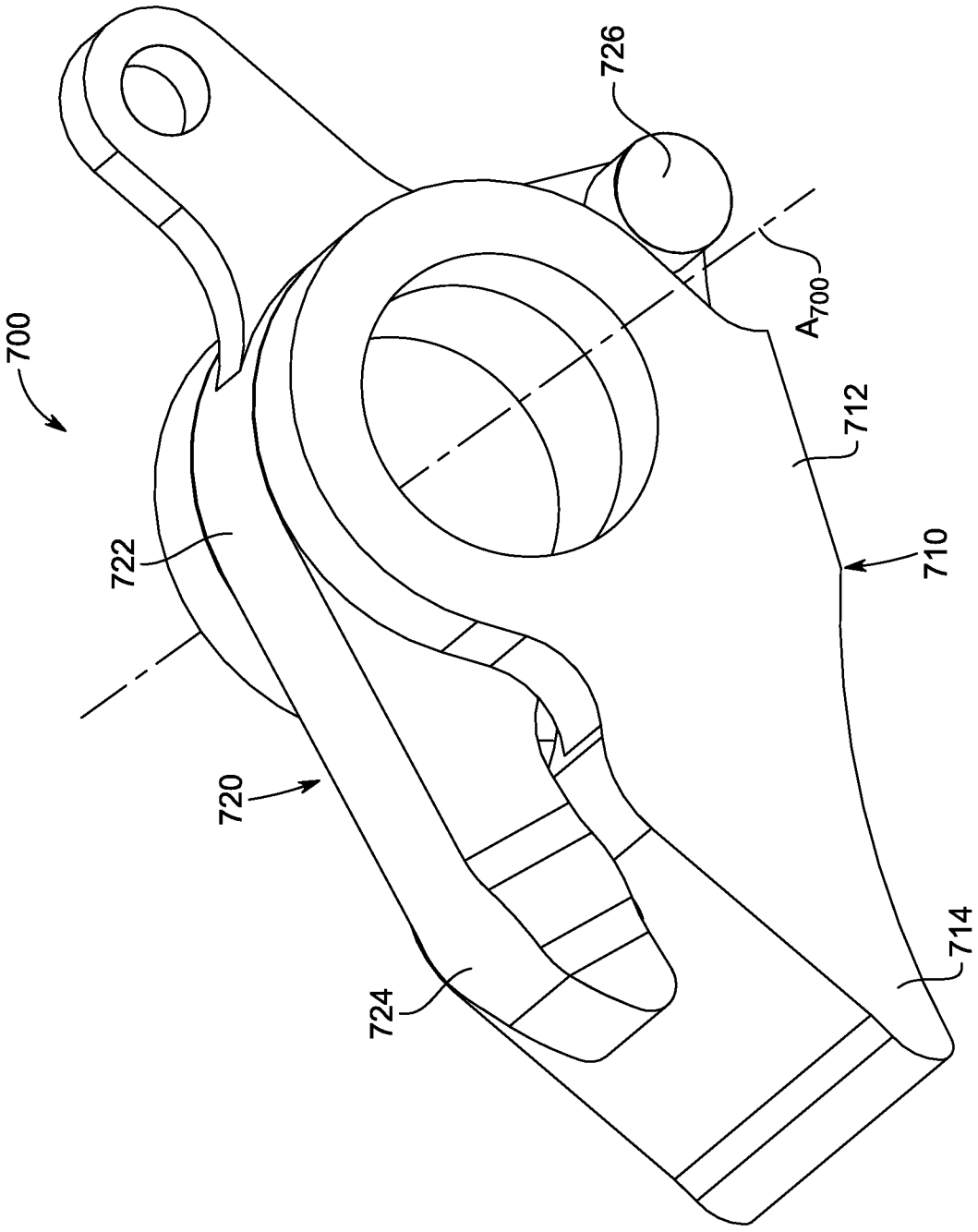


FIG. 7B

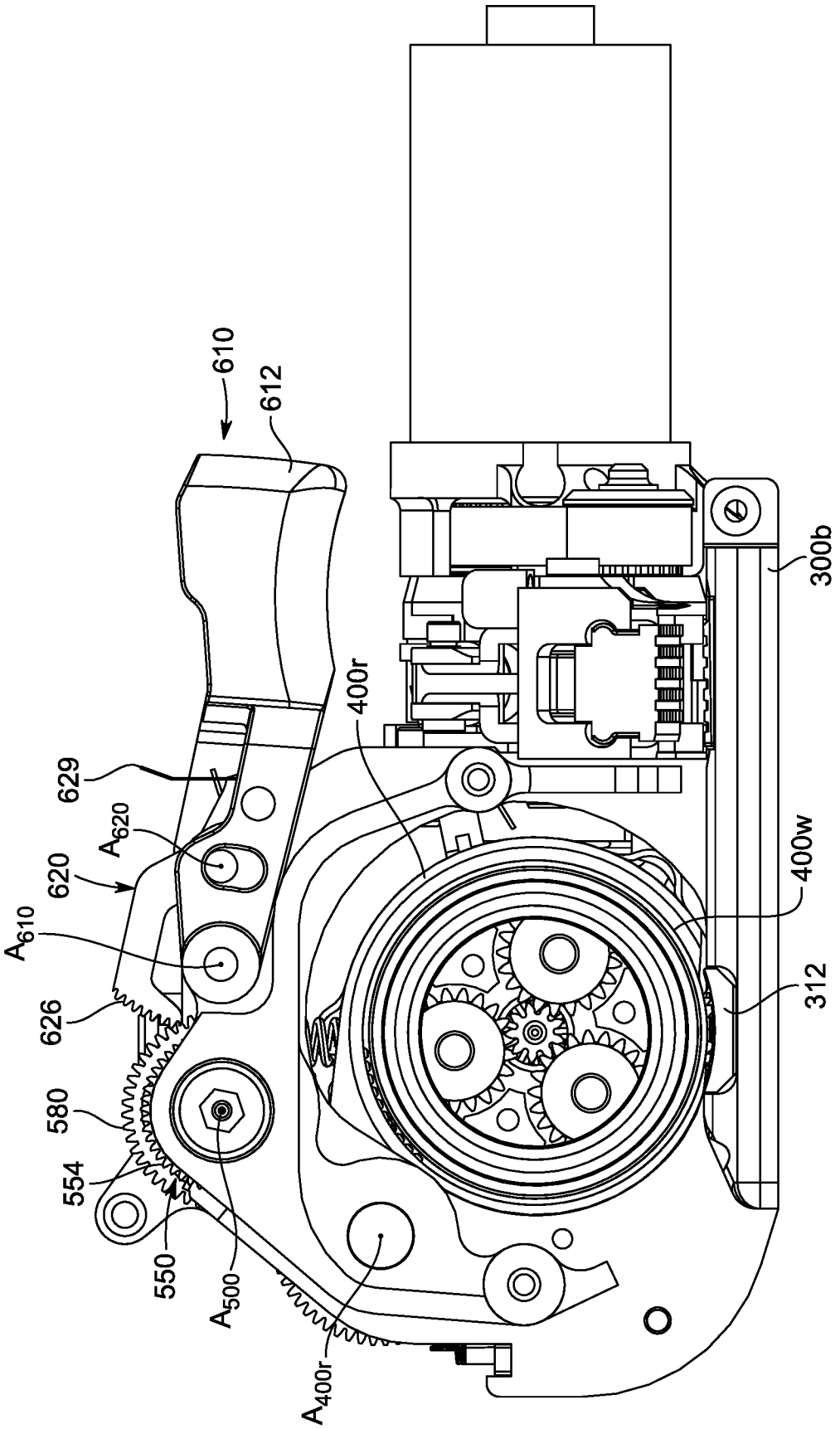

610
612
300b
400r
629
A_{620}
620
A_{610}
626
400w
312
580
554
550
A_{500}
A_{400r}

FIG. 8A

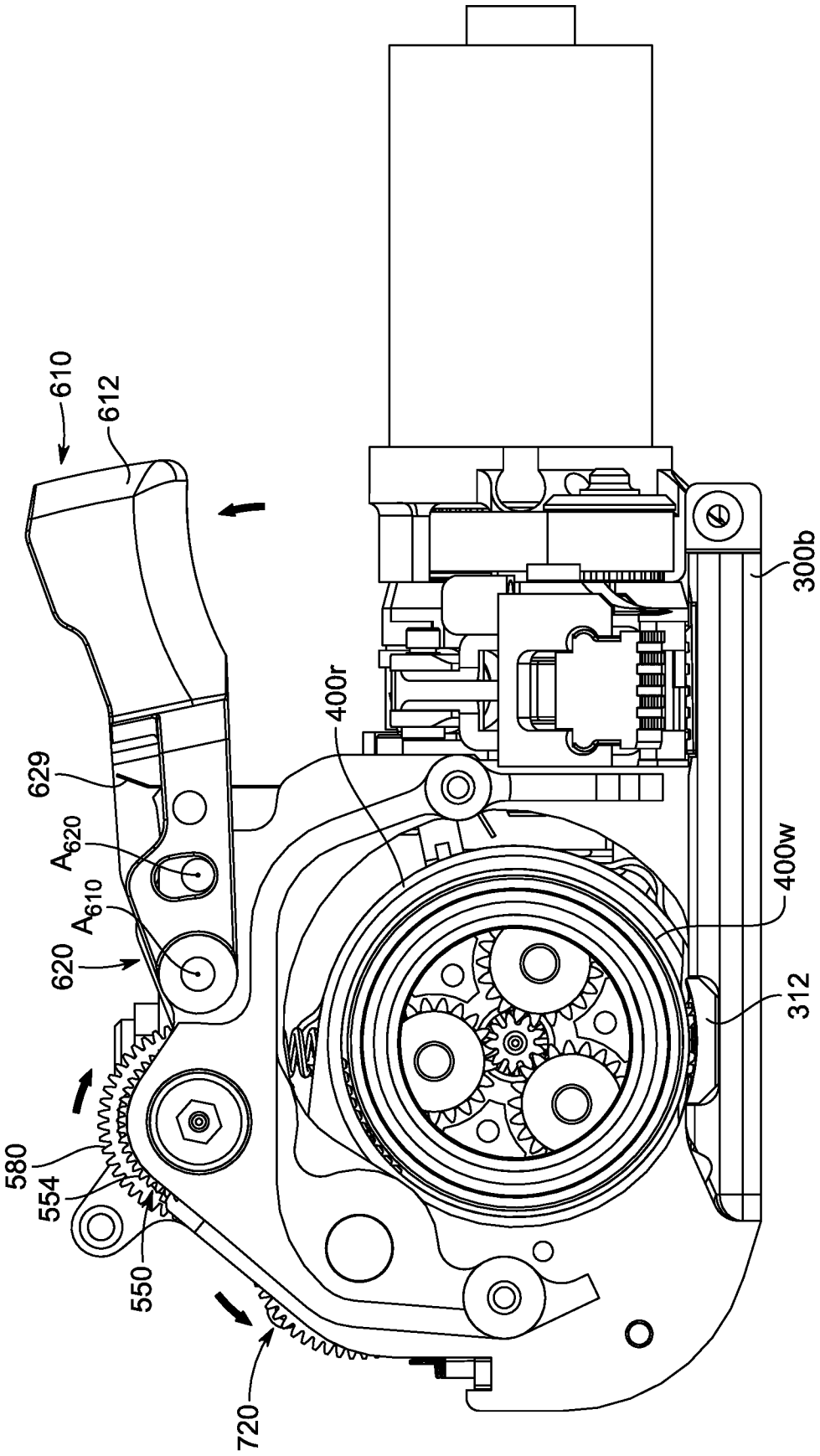


FIG. 8B

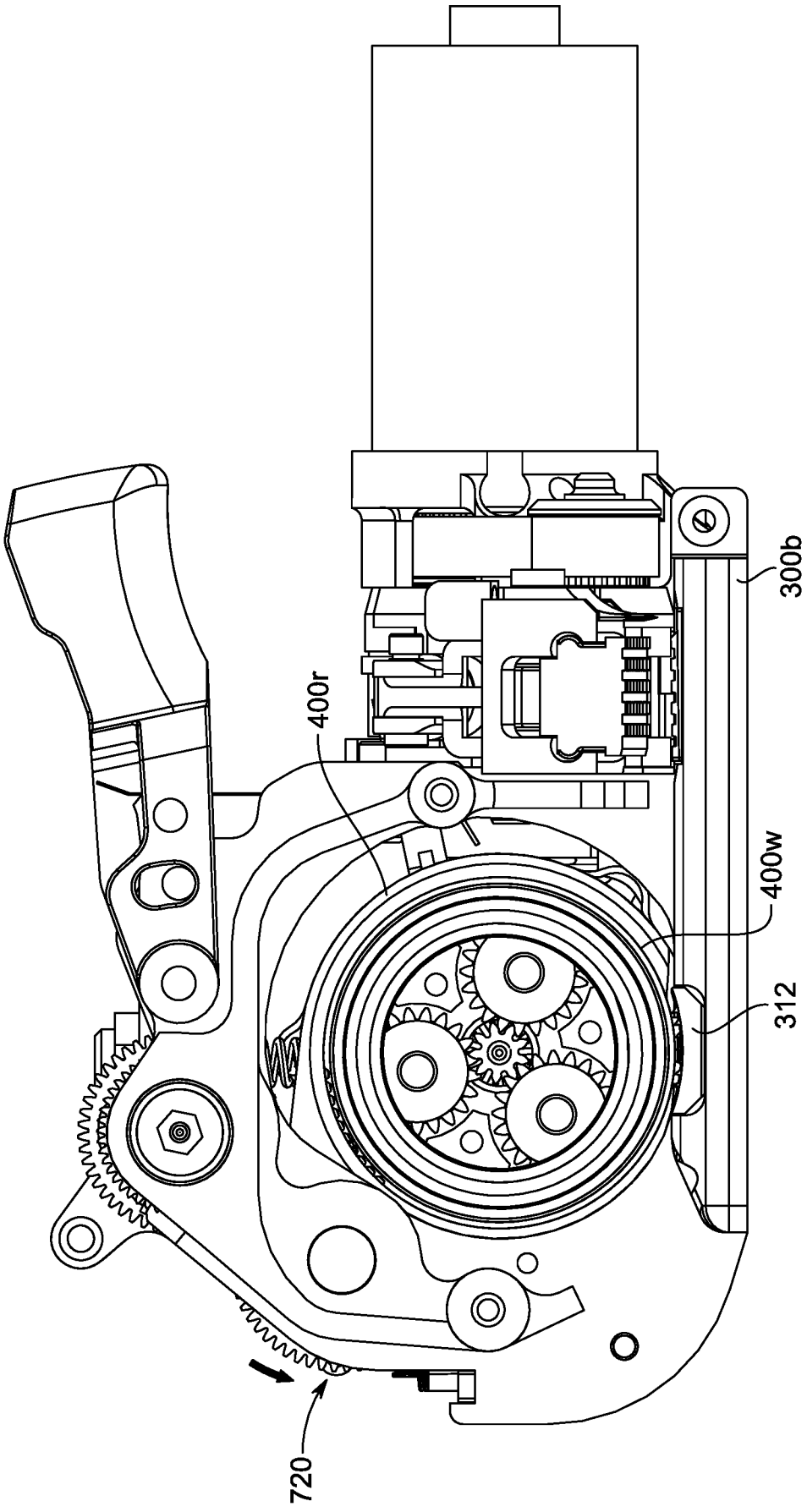


FIG. 8C

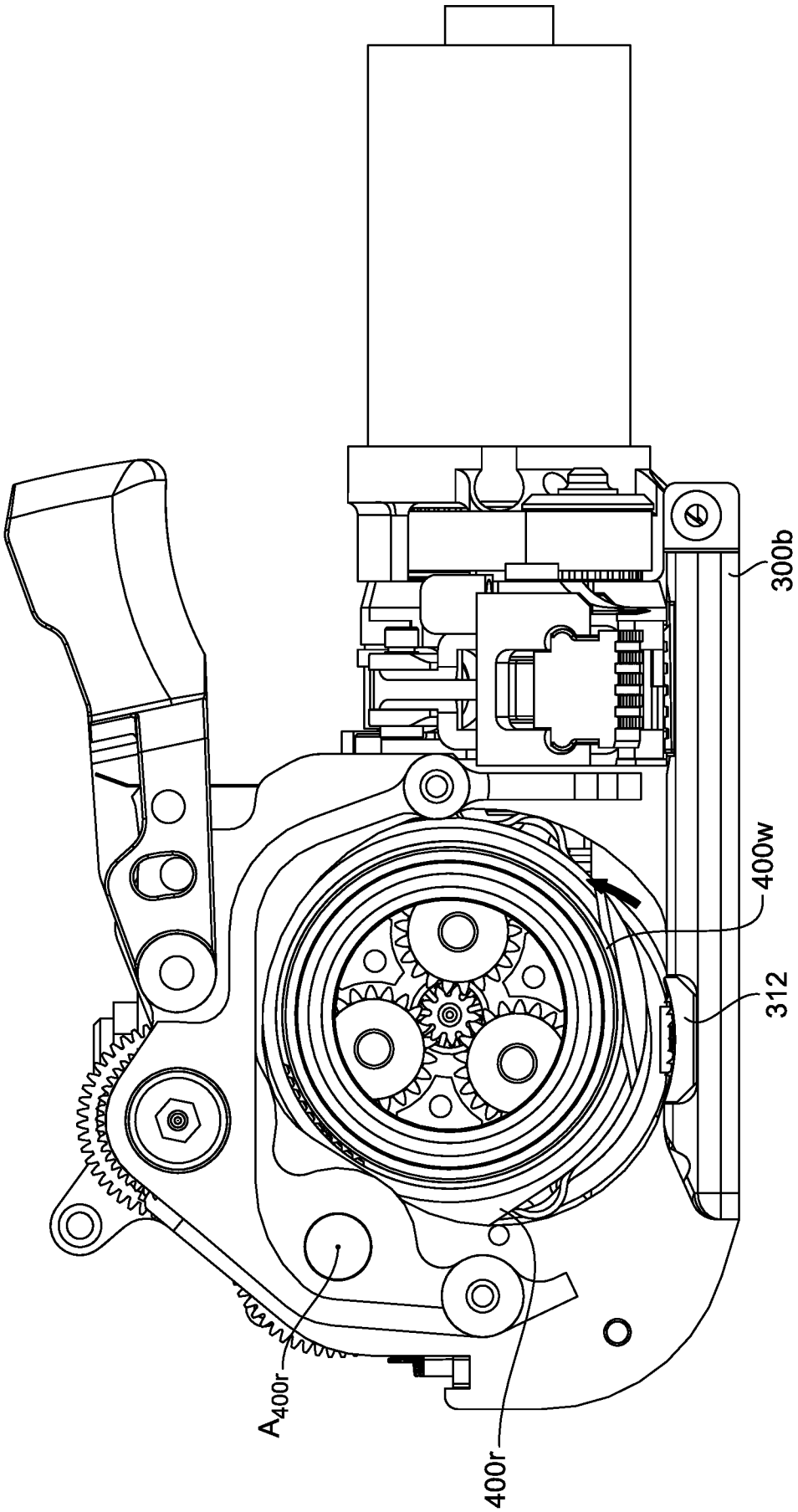


FIG. 8D

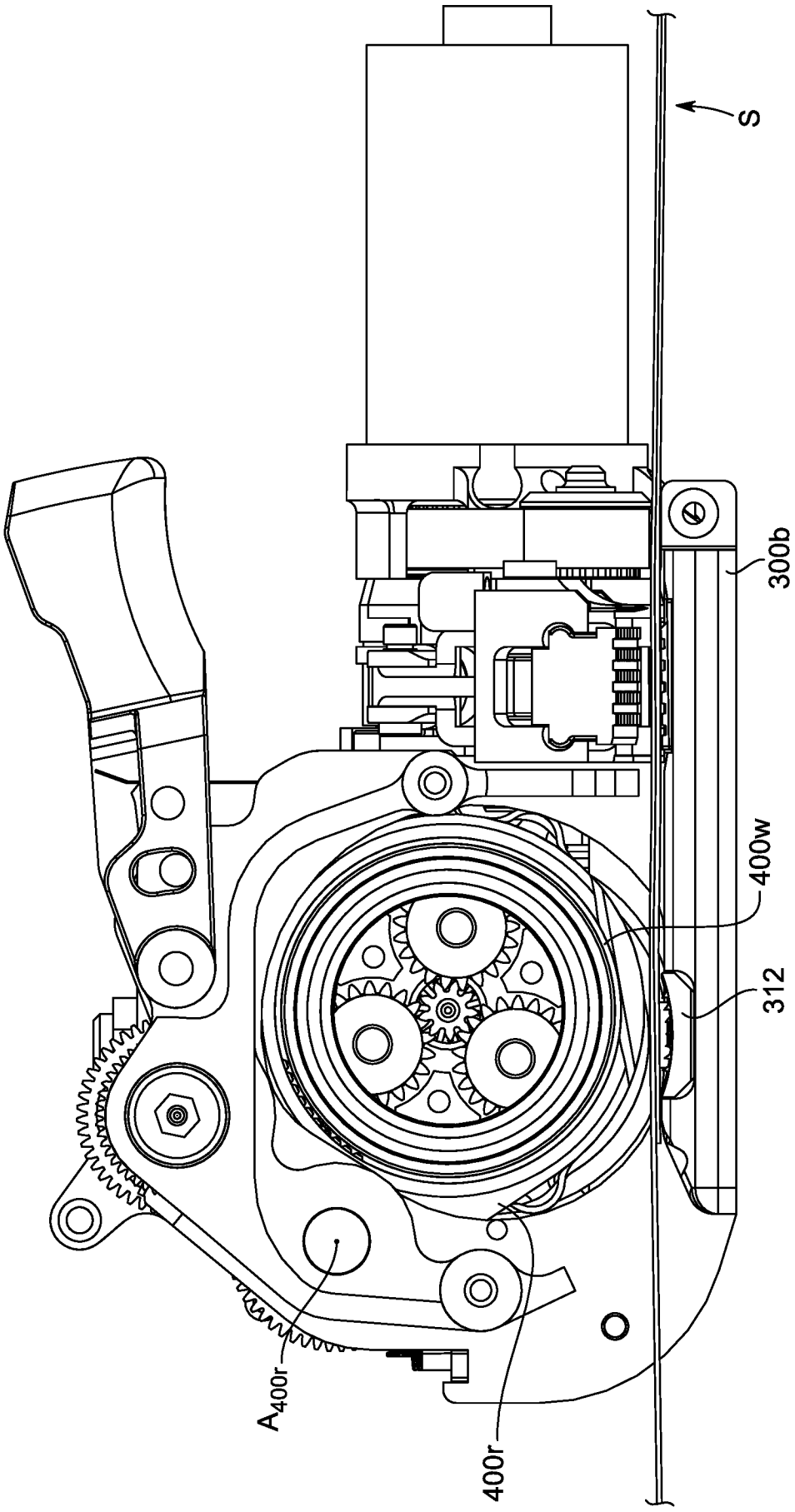


FIG. 8E

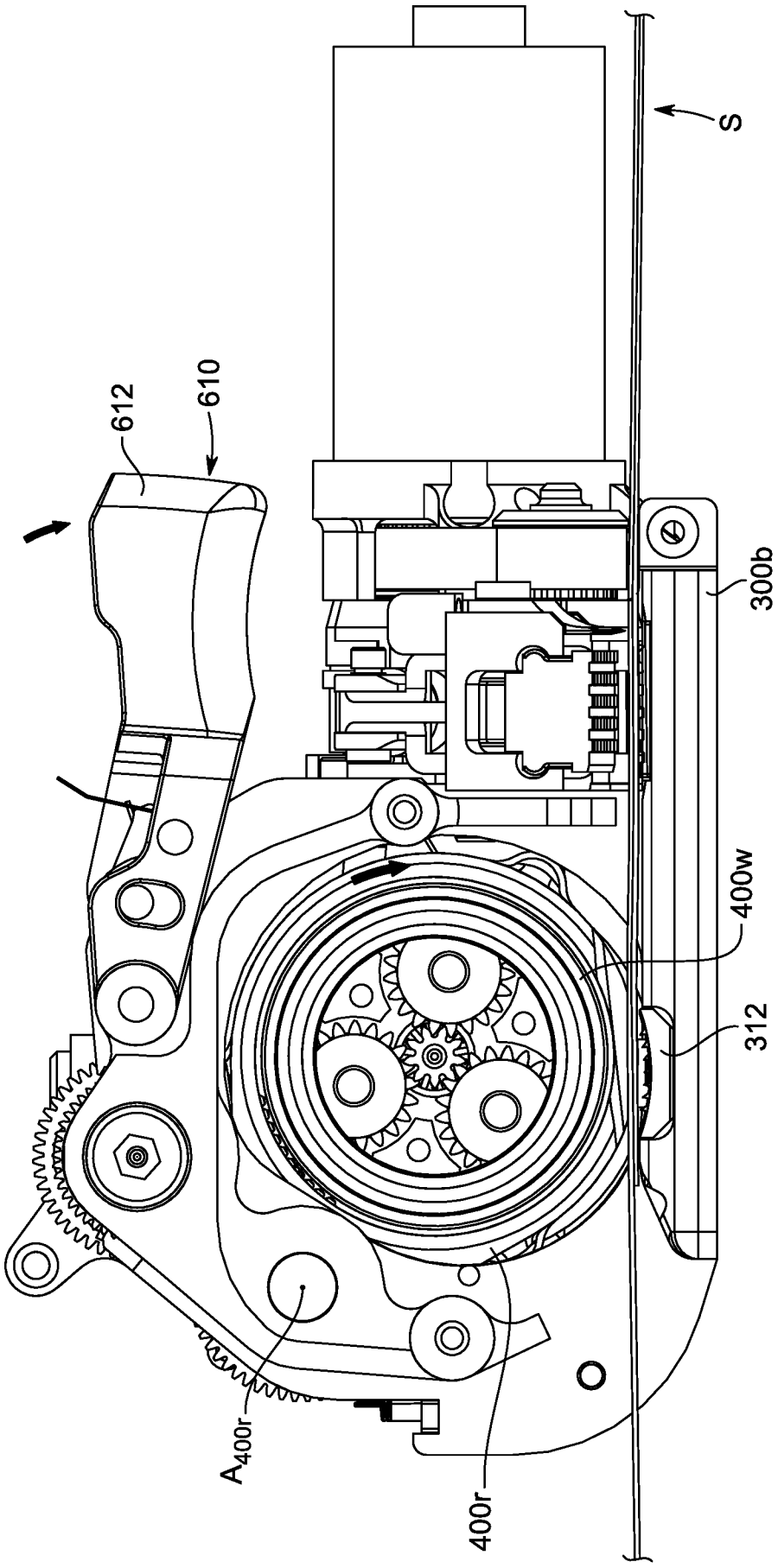


FIG. 8F

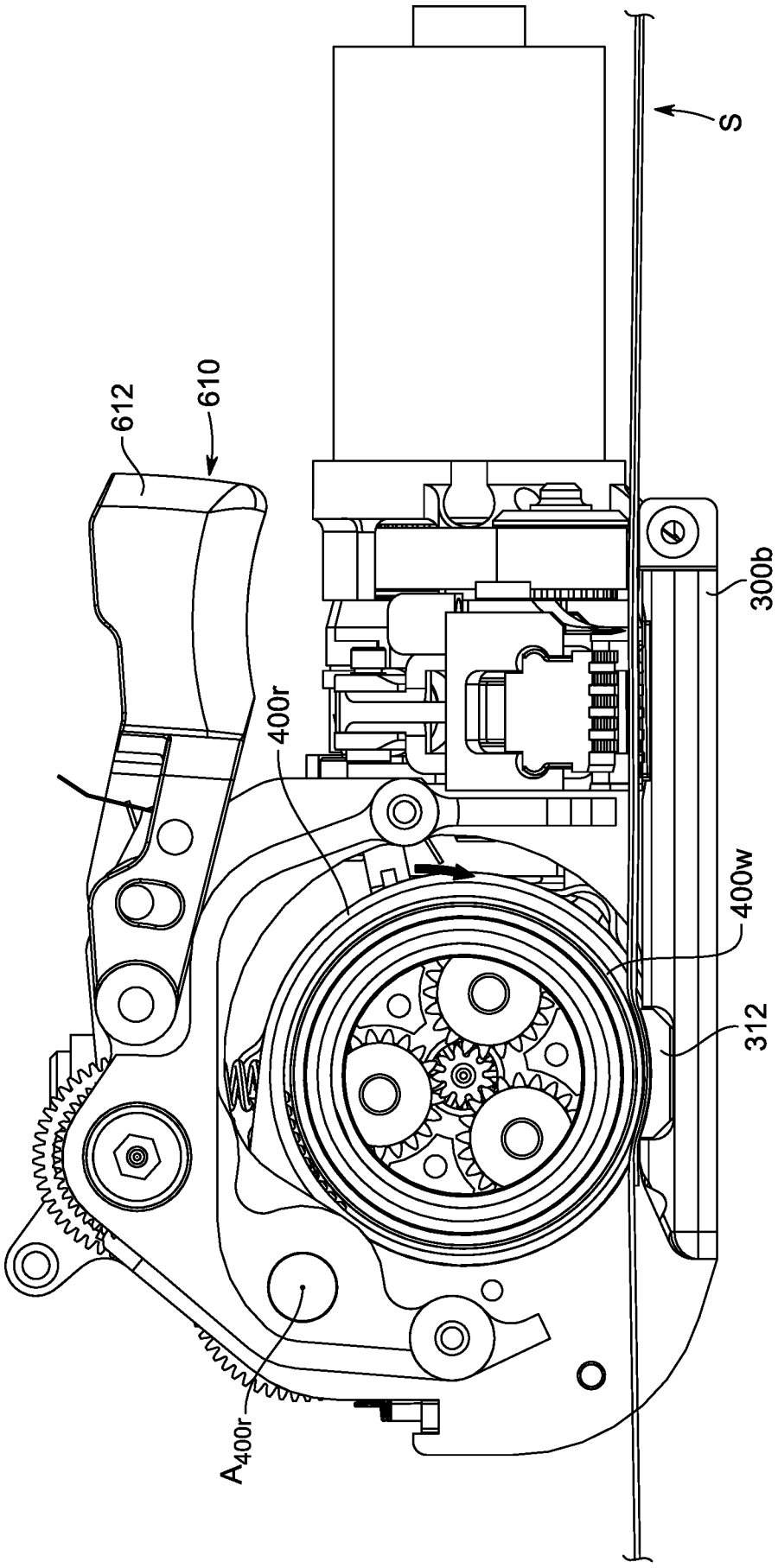
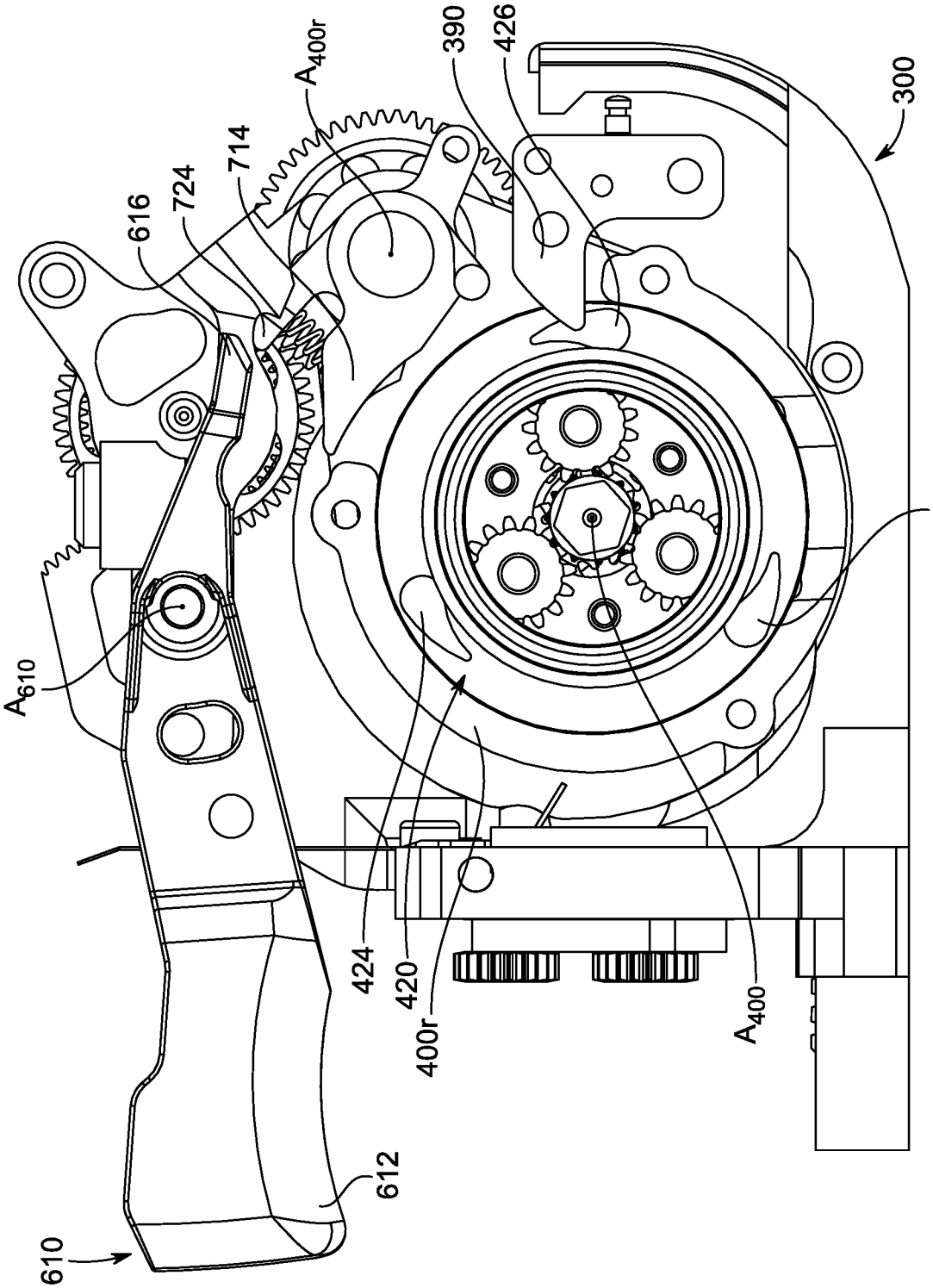


FIG. 8G


300
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428
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420
400r
A_{400}
612
610

FIG. 9A

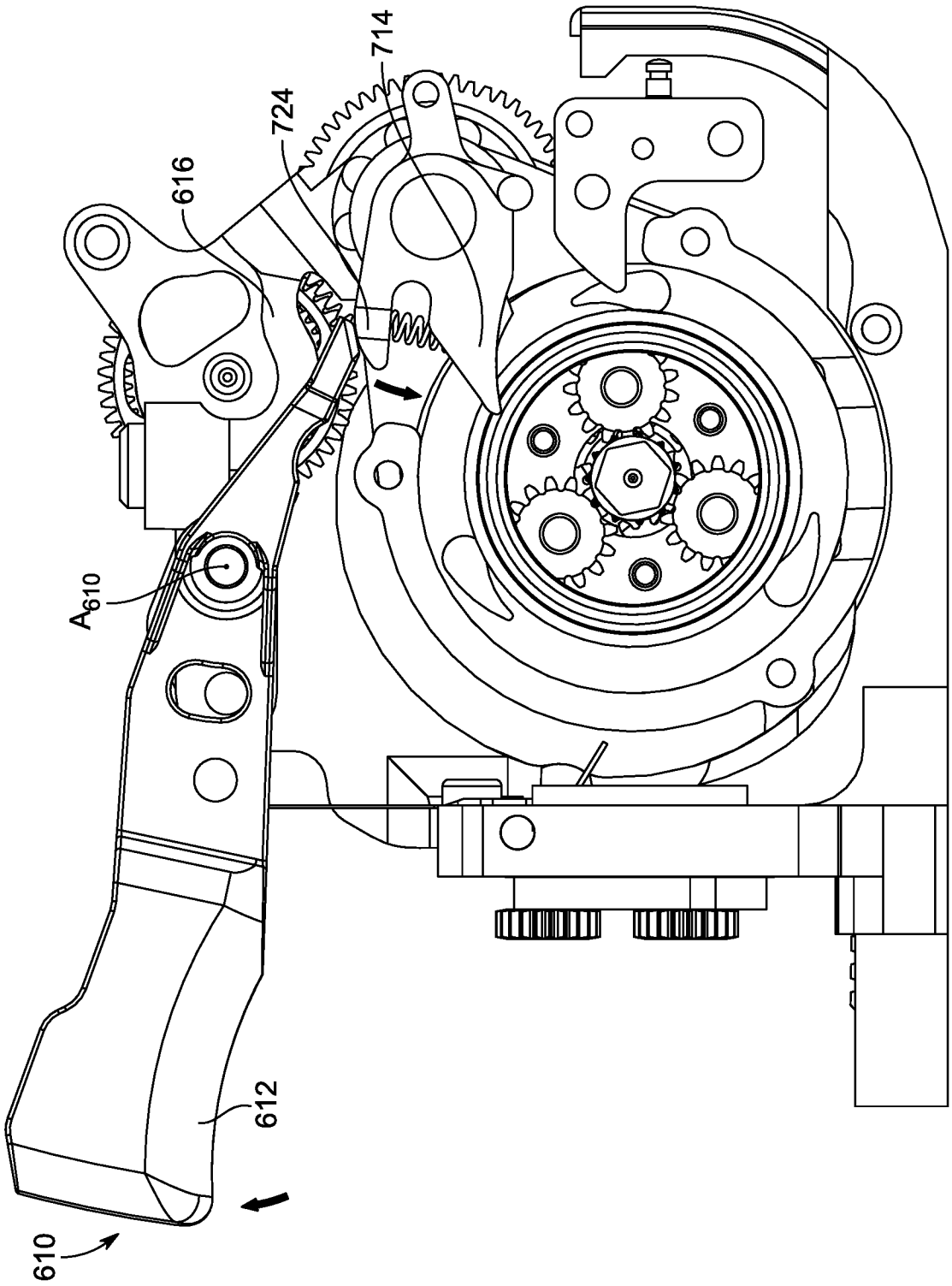


FIG. 9B

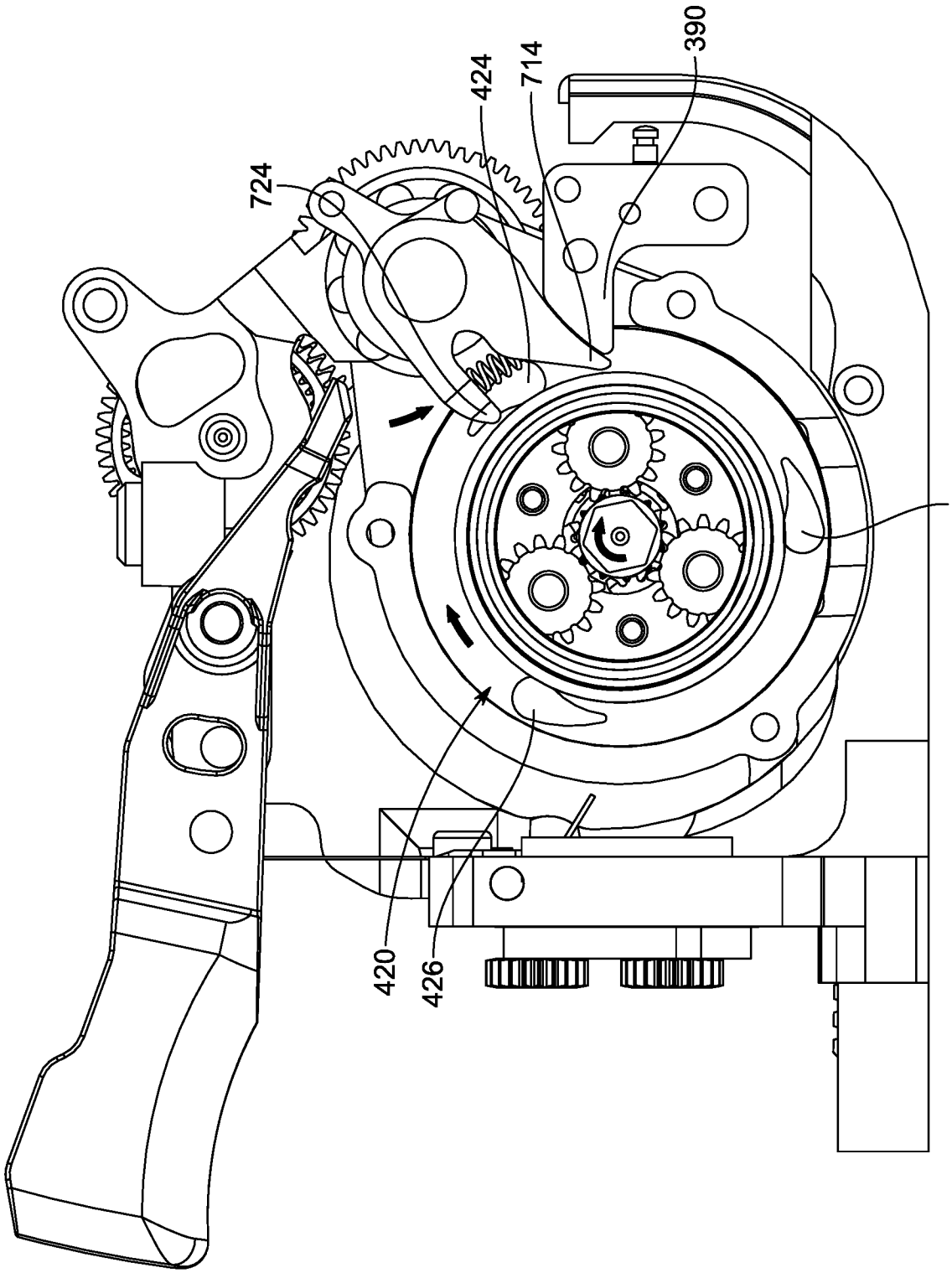


FIG. 9C

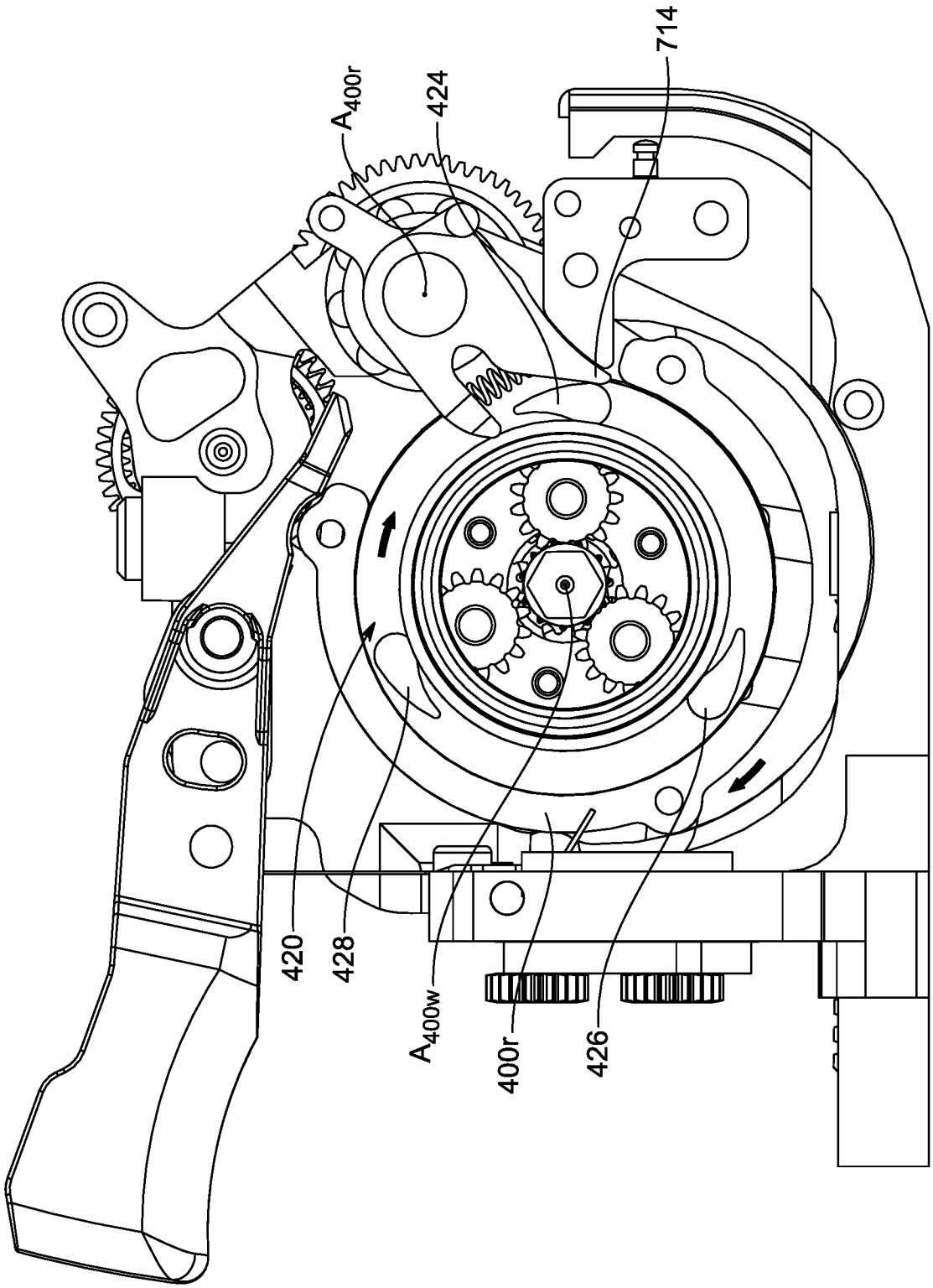


FIG. 9D

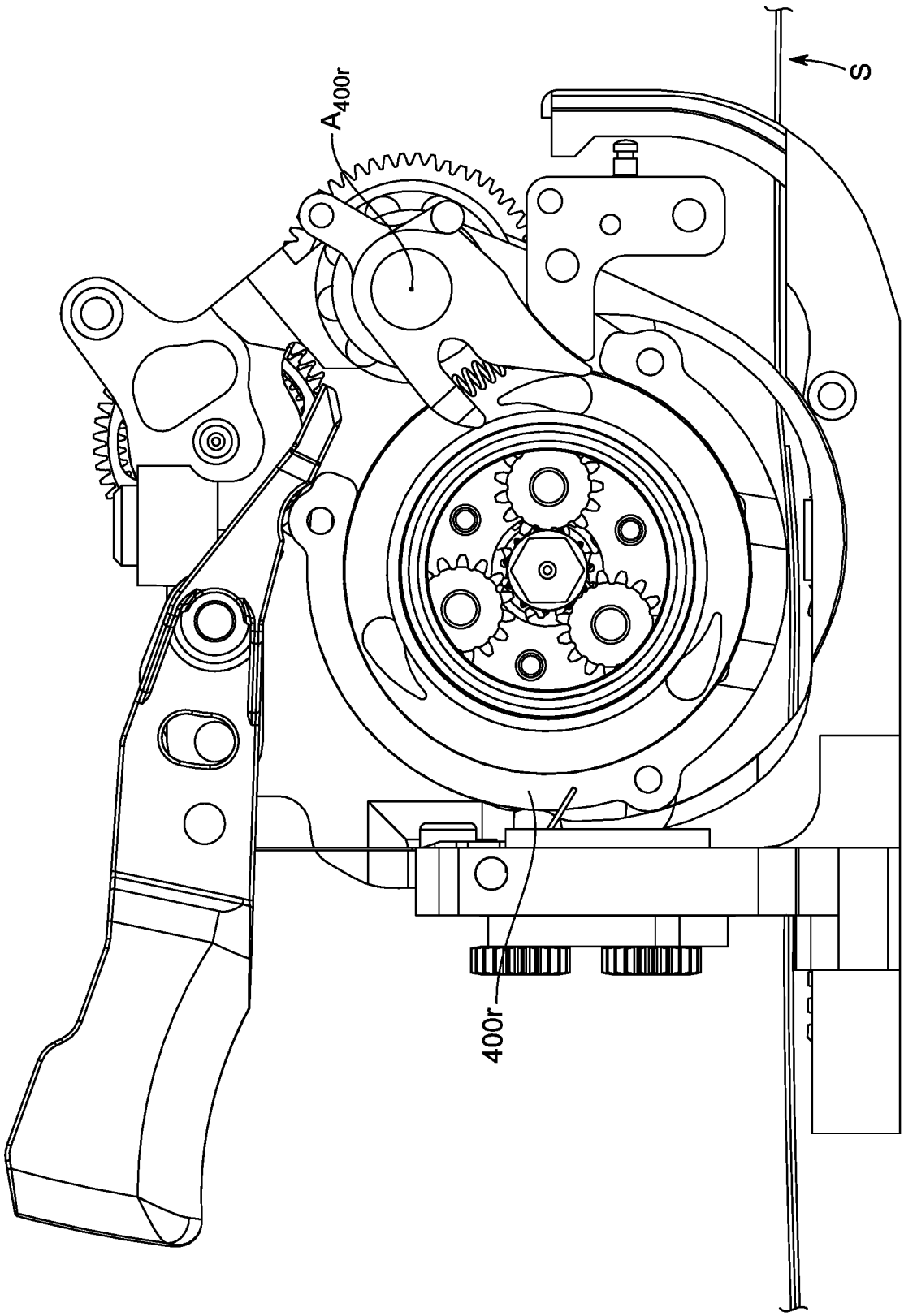


FIG. 9E

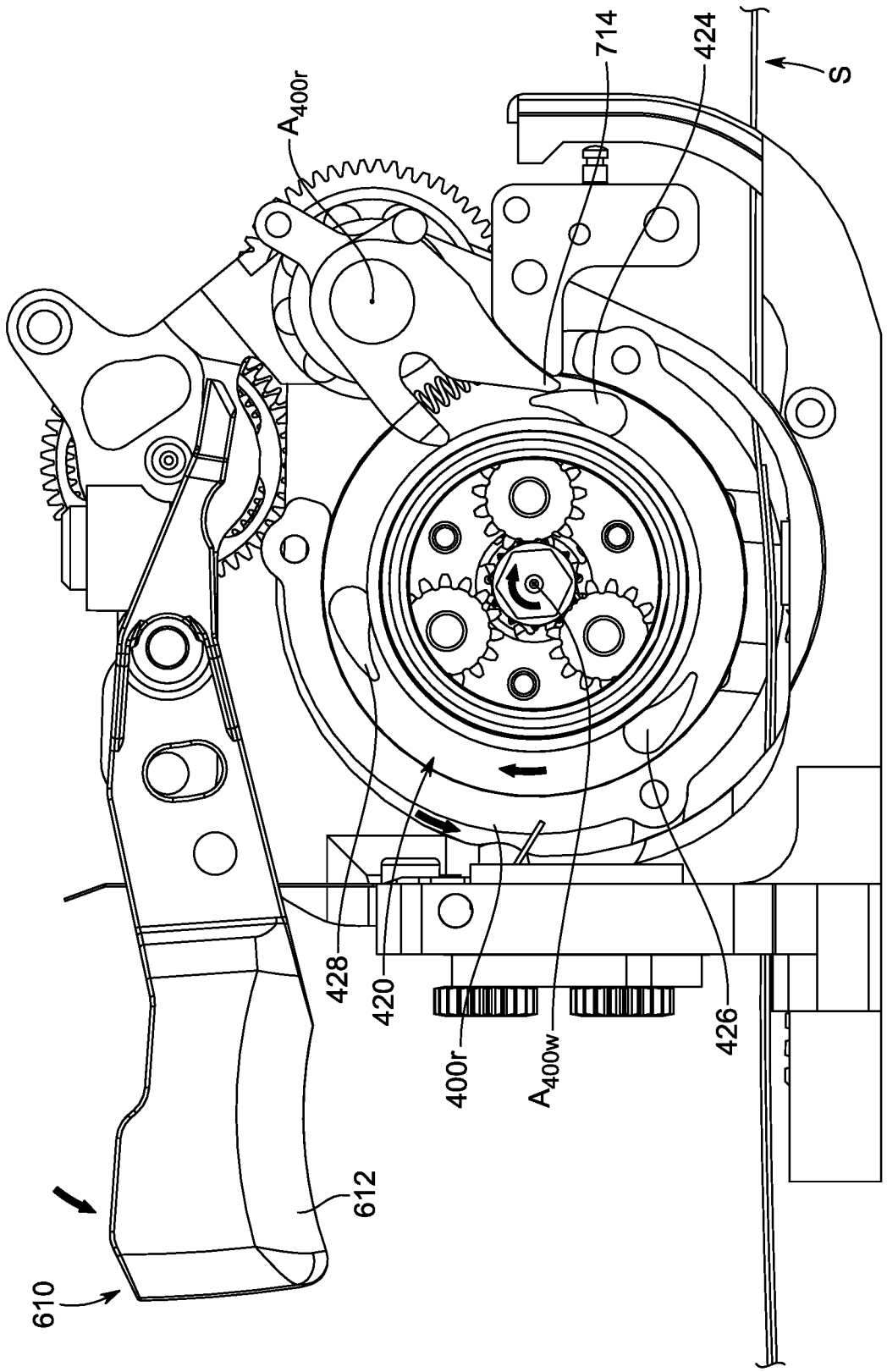


FIG. 9F

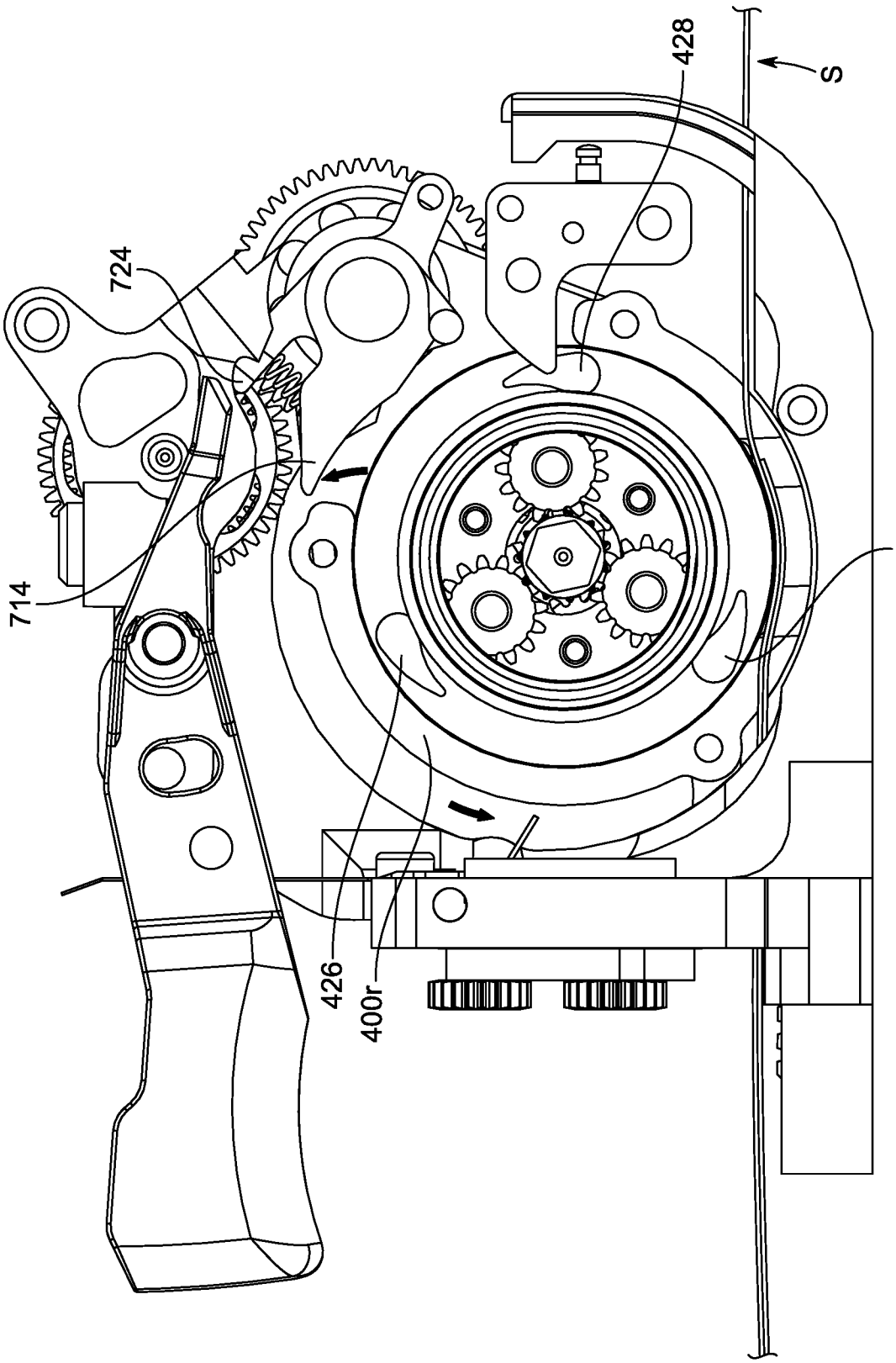


FIG. 9G

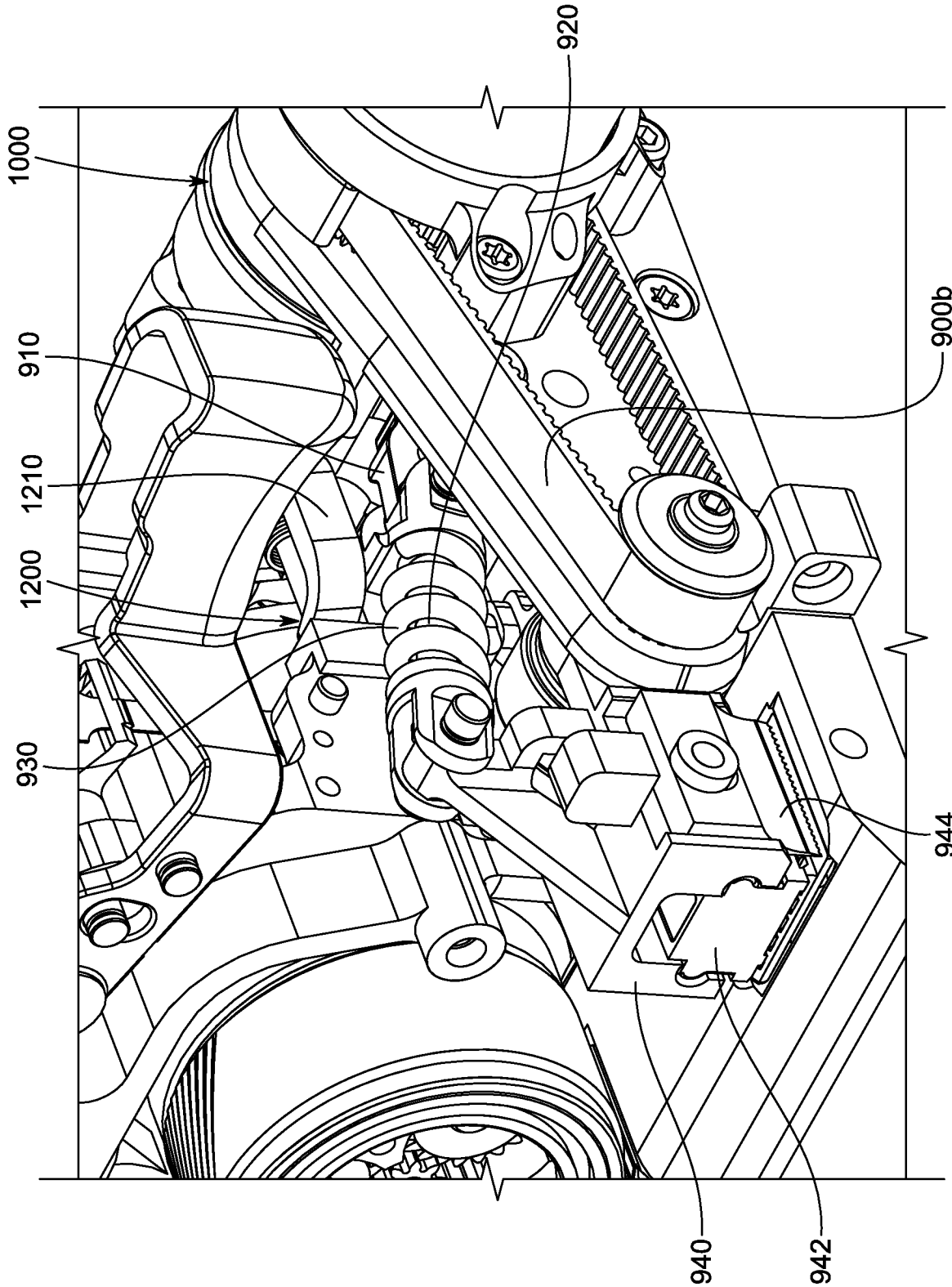


FIG. 10A

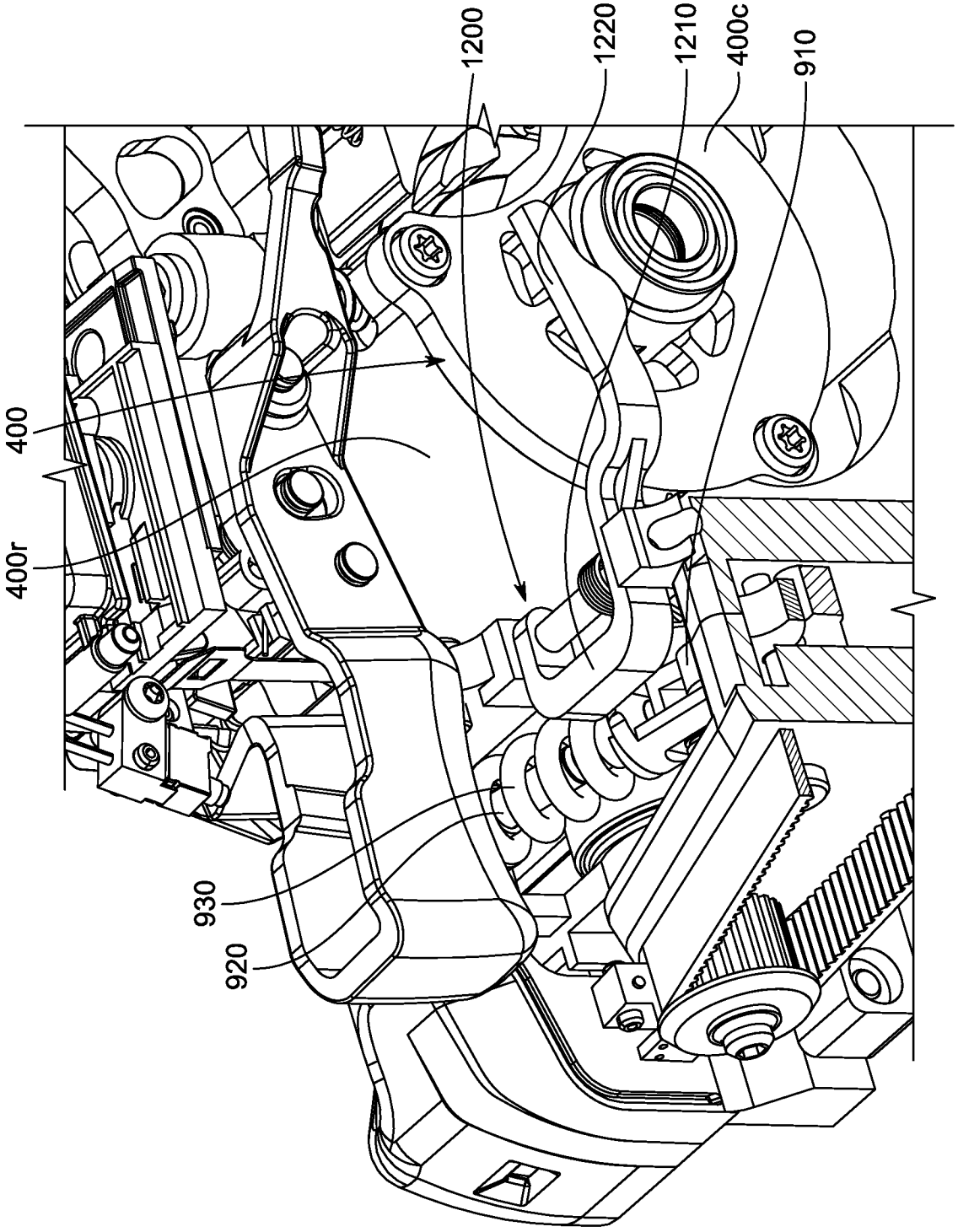
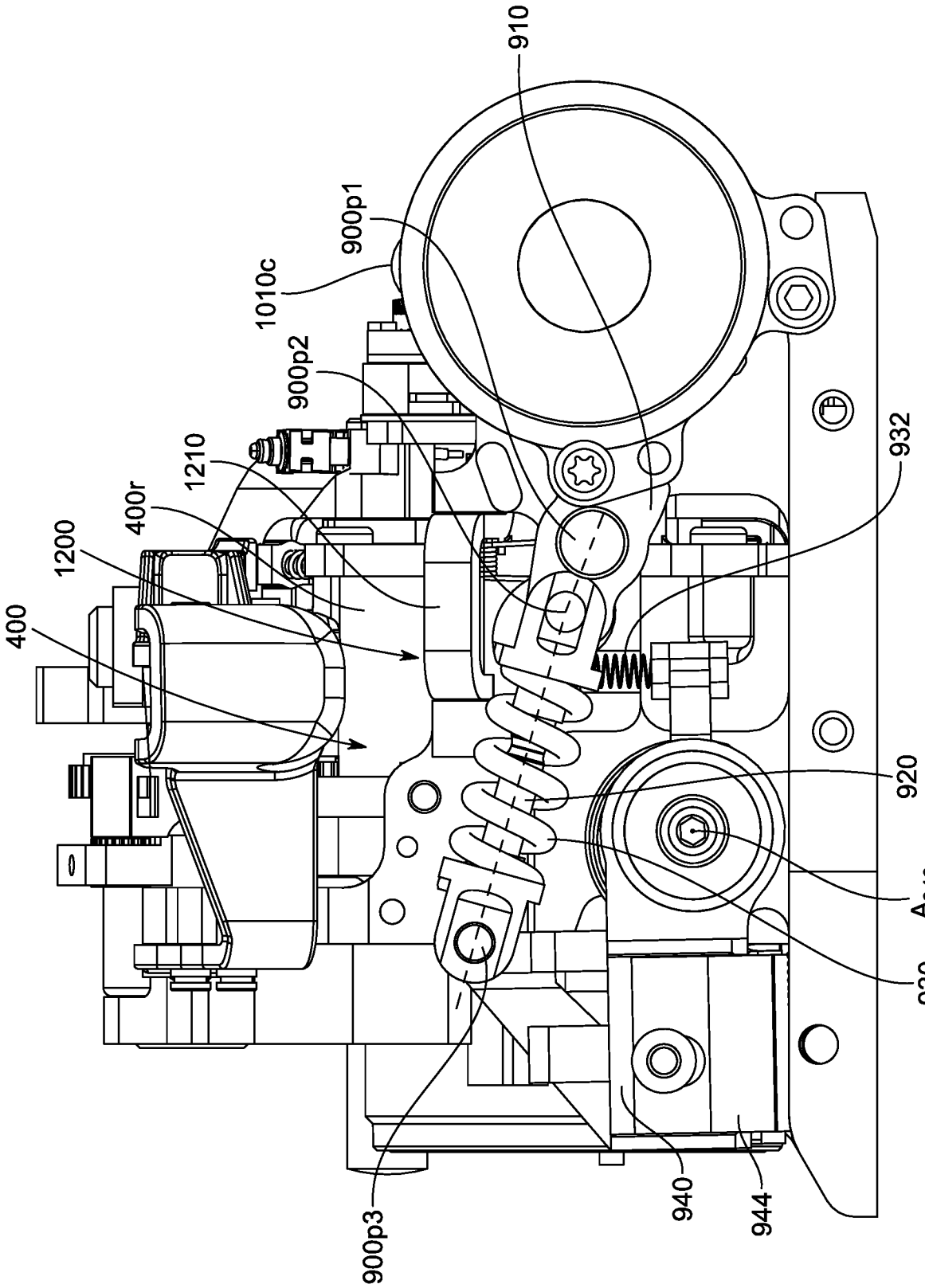


FIG. 10B


910
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A_{940}
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900p3
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944

FIG. 11A

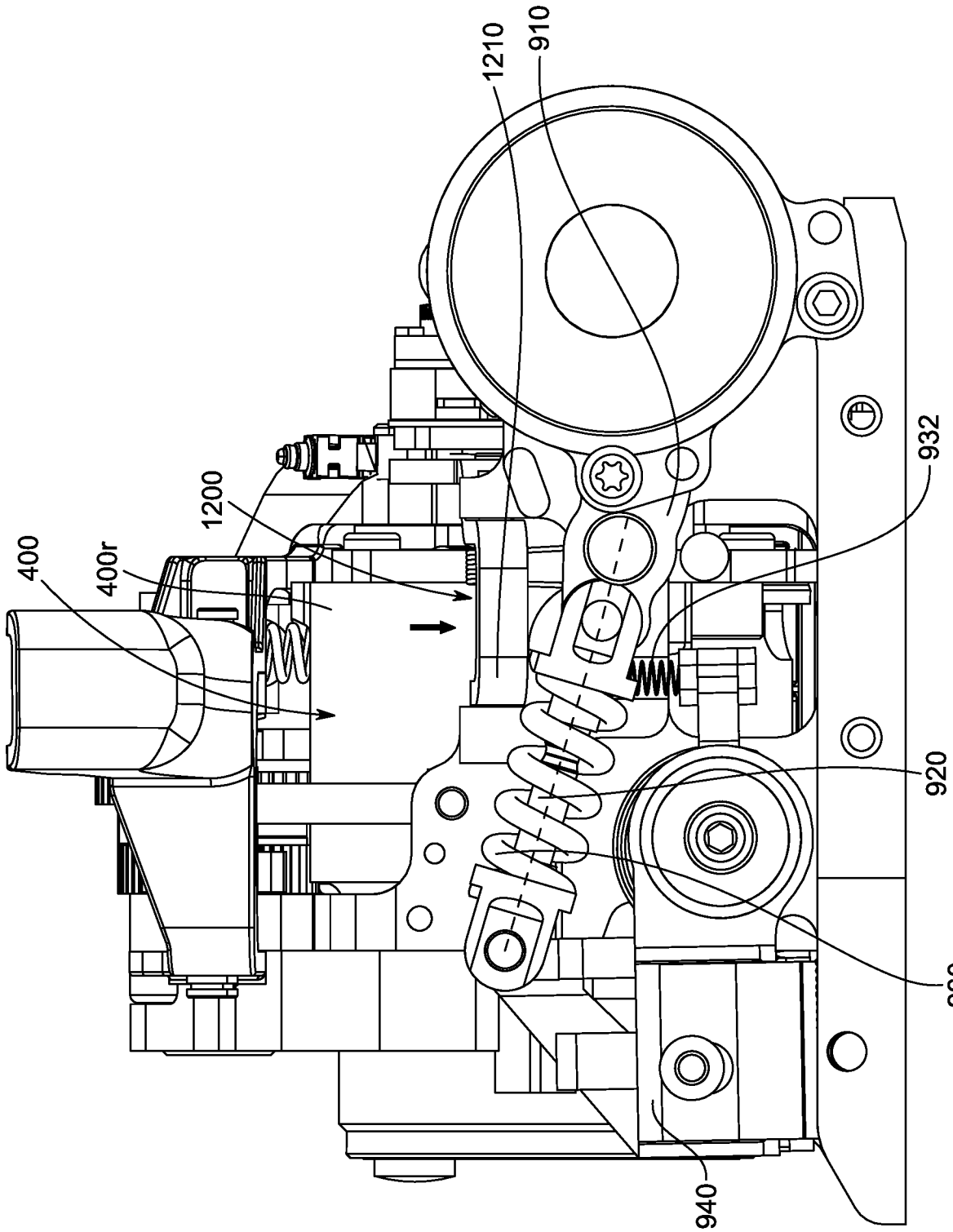

FIG. 11B

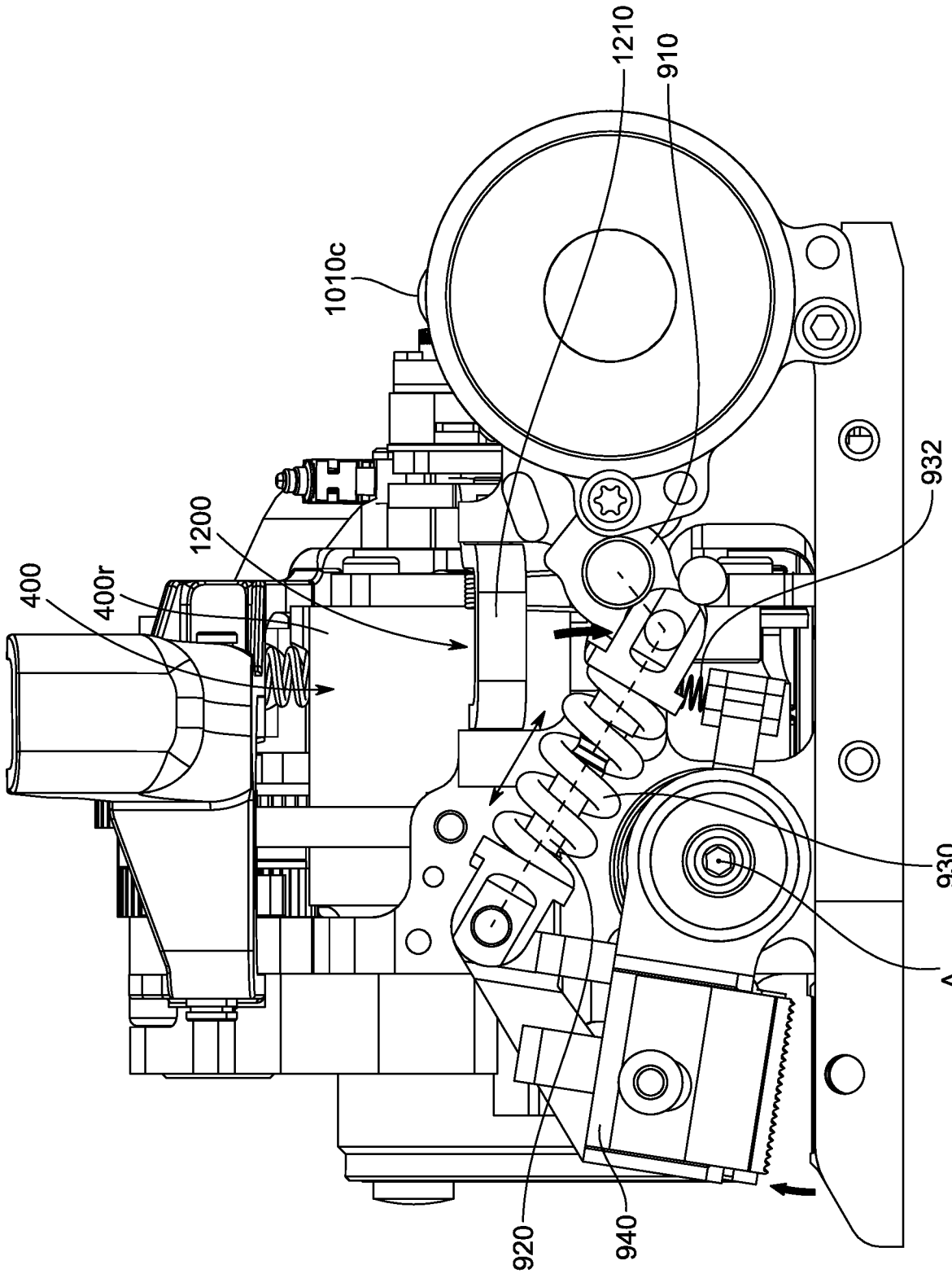

FIG. 11C

INTERNATIONAL SEARCH REPORT

International application No
PCT/US2023/082859

A. CLASSIFICATION OF SUBJECT MATTER
INV. B65B13/02 B65B13/18 B65B13/22
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)
B65B

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 practicable, search terms used)
EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 2011/056390 A1 (NEESER MIRCO [CH] ET AL) 10 March 2011 (2011-03-10) paragraph [0051] - paragraph [0057]	1-15
X	CA 3 189 194 A1 (SIGNODE IND GROUP LLC [US]) 20 January 2022 (2022-01-20) paragraph [0054] - paragraph [0159]	1
A	US 9 403 609 B2 (SIAT S P A [IT]; SIAT S P A [IT]) 2 August 2016 (2016-08-02) the whole document	1-15
A	US 2020/354094 A1 (KELLER ANDREAS [CH] ET AL) 12 November 2020 (2020-11-12) the whole document	1-15
A	US 3 211 186 A (HAROLD BUSHMAN JULIUS) 12 October 1965 (1965-10-12) the whole document	1-15

☐ Further documents are listed in the continuation of Box C.

☒ See patent family annex.

* Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier application or patent but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"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

"X" document of particular relevance;; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

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