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(71) Applicant: **Illinois Tool Works Inc.**
Glenview IL 60025 (US)

(72) Inventors:
- **LUCON, Michele**
  Glenview, 60025 (US)
- **CABRELE, Federico**
  Glenview, 60025 (US)
- **GAWEDA, Waldemar**
  Glenview, 60025 (US)
- **PONTINI, Mattia**
  Glenview, 60025 (US)
- **CROSIO, Pietro**
  Glenview, 60025 (US)
- **BASSETTI, Marco**
  Glenview, 60025 (US)

(74) Representative: **HGF**
HGF Limited
1 City Walk
Leeds LS11 9DX (GB)

(54) A BINDING TOOL

(57) The present invention provides for an automatic tool for distributing, tensioning and severing a binding strap. The tool comprises a pistol-shaped housing, having a barrel portion extending between a distal housing end portion and a proximal housing end portion along a longitudinal axis, and a handle portion extending away from said barrel portion in a direction different to said longitudinal axis; a reel magazine assembly, configured to retainingly receive at least one strap reel and provide for a rotation of the at least one strap reel about a strap reel centre axis, wherein said rotation is directed so as to wind up a strap coiled up onto the at least one strap reel; a feeder mechanism, provided within said barrel portion and configured to receive an end portion of the strap from the at least one strap reel and move the strap in a direction along said longitudinal axis; a locking heads magazine assembly, provided within said barrel portion and configured to store a plurality of locking heads and supply one locking head at the time for use with the strap; a cut-off mechanism, provided within said barrel portion, configured to cut the strap and receive and move said one locking head from said locking heads magazine assembly into a loading position ready for engagement with the strap, and a drive unit, configured to drive said feeder mechanism so as to selectively move the strap towards said distal housing end portion or towards said reel magazine assembly, and actuate said cut-off mechanism at a predetermined condition.

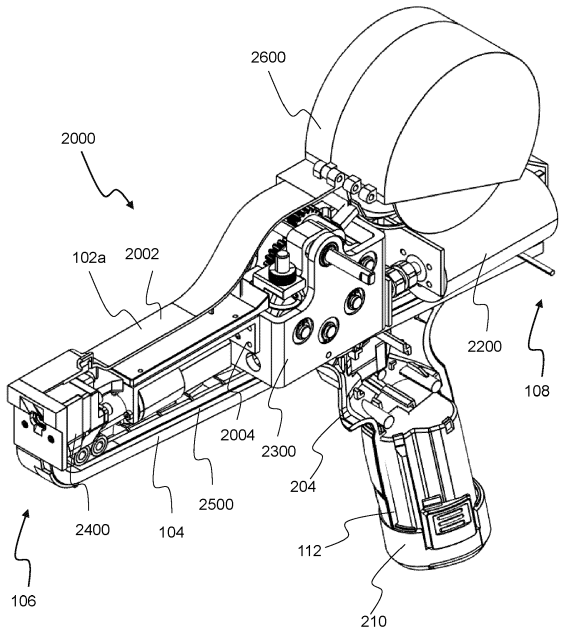


FIG. 21(b)

EP 4 488 185 A1

Description

Technical Field of Invention

[0001] The present invention relates generally to hand-held tensioning and cutting tools and in particular, to an improved hand tool including a magazine and feeder mechanism for a continuous strap and relevant locking heads for binding, fastening and bundling cables, tubes, conduits or any other strap-like structure. Even more particularly, the present invention relates to automatic hand-held binding and cutting tools.

Background

[0002] Cable ties, also known as zip ties or hose ties, are widely used in a variety of environments and applications. For example, cable ties may be used to securely bundle a plurality of wires, cables or conduits such as those found in the automotive industry. Also, cable ties may be used to secure articles to rigid structures (e.g. a chassis) but may also be utilised as hose clamps. Typically, a cable tie comprises a tie head portion and a tie tail portion of various lengths that is integrally formed with the head portion. During use, the tie tail is threaded through the tie head so as to encircle the articles to be bound or secured. The tie tail section is usually provided with teeth that engage with a pawl provided in the tie head and forming a ratchet so that, as the free end of the tie tail is pulled, the cable tie tightens and does not come undone. Once the tie tail of the cable tie has been pulled through the tie head and past the ratchet, it is prevented from being pulled back, thus, the resulting loop may only be pulled tighter. Some cable ties may include a tab that can be depressed to release the ratchet so that the cable tie can be loosened or be removed and possibly reused.

[0003] A cable tie tensioning device, also known as cable tie tool or cable tie gun (or a strap-binding tool), may be used to install cable ties and apply a predefined degree of tension, as well as, cut off the extra tail. Preferably, the cut tie tail should be flush with the tie head portion so as to avoid sharp edges, which might otherwise cause injuries or damages to cables, conduits, or other components. Manually operated light-duty tools may be operated by simply and repeatedly squeezing the handle and trigger with the fingers until a desired tension of the cable tie has been reached to then cut off the tail section of the tightened cable tie. Heavy-duty or automated tools may be powered, for example, by electricity, compressed air or a solenoid (i.e. actuator) to assist the user when operating the tool. In addition, other binding or bundling tools including a magazine or magazines that comprise(s) a plurality of either separate cable ties including heads, or a long reeled up cable strap and separate locking heads to be used with the strap exist. Such known tools, for example the ones using reeled cable straps, can have relatively complicated mechanisms utilising either electronically operated and/or manually operated components in order to tension and cut a desired length of cable tie or strap that is used to secure or bundle up one or more structures. Also, currently available binding or bundling tools, driven manually or electronically, can be relatively inaccurate or limited for using in narrow or confined spaces due to the clamping "beak" design. Further, some of these tools are known to only dispense a limited, predefined length of strap material thus, limiting the application of such tools in various environments and applications. Moreover, when only dispensing pre-dimensioned cable ties, this can result in a relatively high amount of waste (cable tails). In addition, when using mechanical tensioning and cut-off tools with pre-dimensioned cable ties, inherent inaccuracies of the hand-operated tensioning of the cable tie can produce incorrectly closed cable tie bundles that may fail prematurely, for example, due to over-tensioning. Even more, the currently available cable tie tools are fairly inaccurate when cutting the cable ties, thus, producing sharp burrs that can cause injuries to the user, or damage other components.

[0004] Furthermore, available *"magazine'ed"* binding and bundling tools typically require relatively large electric power sources or power connectors, thus, making the tool rather weighty and cumbersome. As a result, the relatively complicated and cumbersome tools are difficult to handle, more expensive to manufacture and are more likely to fail or break from during use.

[0005] Moreover, currently available cable tie tools, especially when hand operated, are not able to produce a reproduceable accuracy of a desired tension when installing the cable tie, potentially causing or risking damage to the one or more structures that are secured or bundled up. This is typically caused by over-squeezing the tool trigger, such that, for example, thin walled cables can be easily damaged .

[0006] Accordingly, it is an object of the present invention to provide an improved, as well as, a simplified automatic binding tool for bundling and fastening cables, conduits or any other structures, using a continuous strap, provided from a strap magazine, and a locking heads magazine, housing a plurality of locking heads to be used with the strap without the need to load individual and pre-dimensioned cable ties for each use. Further, it is an object of the present invention to provide a binding tool with improved accuracy for tensioning, cutting and dispensing a fastening strap. It is yet another object of the present invention to provide an automatic binding tool with improved ease of use and compact dimensions, allowing an improved and faster handling by the user, thus, minimising time and costs.

Summary of the Invention

[0007] Aspects of the invention is set out in the independent claims. Dependent claims describe optional features.

[0008] According to a first aspect of the present inven-

tion, there is provided an automatic tool for tensioning and severing a strap, comprising:

a pistol-shaped housing, having a barrel portion extending between a distal housing end portion and a proximal housing end portion along a longitudinal axis, and a handle portion extending away from said barrel portion in a direction different to said longitudinal axis;

a reel magazine assembly, configured to retainingly receive at least one strap reel and provide for a rotation of the at least one strap reel about a strap reel centre axis, wherein said rotation is directed so as to wind up a strap coiled up onto the at least one strap reel;

a feeder mechanism, provided within said barrel portion and configured to receive an end portion of the strap from the at least one strap reel and move the strap in a direction along said longitudinal axis;

a locking heads magazine assembly, provided within said barrel portion and configured to store a plurality of locking heads and supply one locking head at the time for use with the strap;

a cut-off mechanism, provided within said barrel portion, configured to cut the strap and receive and move said one locking head from said locking heads magazine assembly into a loading position ready for engagement with the strap, and

a drive unit, configured to drive said feeder mechanism so as to selectively move the strap towards said distal housing end portion or towards said reel magazine assembly, and actuate said cut-off mechanism at a predetermined condition.

[0009] The automatic tool may be an automatic fastening or binding tool, for example an automatic cable tie tool.

[0010] Advantageously, said drive unit comprises at least one first electric motor, a switch unit, a tension selector unit adapted to provide a reference parameter indicative of a desired maximum tension of the cable tie strap, and a controller operatively coupled to any one of said at least one first electric motor, said switch unit and said tension selector unit.

[0011] Preferably, said controller is adapted to receive signals from said switch unit and said tension selector unit and control said feeder mechanism and said cut-off mechanism.

[0012] The motor driven two-way feeder mechanism of the tool provides for a more accurate and improved dispensing mechanism of the strap, thus, allowing for significantly reduced wastage of the strap material. Furthermore, the controller-actuated cut-off mechanism provides for improved reproducibility and accuracy of a desired strap tension when installed.

[0013] Advantageously, said controller is adapted to monitor a predetermined performance parameter of said at least one first motor that is indicative of an existing tension in the strap, and compare said predetermined performance parameter to said reference parameter defined by said tension selector unit.

[0014] Advantageously, in some examples, said predetermined performance parameter of said at least one first electric motor is an electric current corresponding to the load of the electric motor.

[0015] In other examples the automatic tool comprises a connecting member disposed between the feeder mechanism and the cut-off mechanism, and an extensometer arranged to detect a deformation of the connecting member, the deformation being indicative of the existing tension in the strap. In such examples the controller may be configured to monitor a signal received from the extensometer and compare said signal to said reference parameter provided by said tension selector unit.

[0016] Preferably, said predetermined condition is met when the existing tension in the strap is greater than or equal to a desired maximum tension provided via said reference parameter of said tension selector unit.

[0017] Advantageously, said switch unit comprises a trigger, configured to affect activation and deactivation of said at least one first electric motor, and a switch mechanism, configured to set the drive direction of said at least one first electric motor.

[0018] Advantageously, the tension selector unit comprises a user interface having a display screen and one or more buttons for a user inputs, in particular a desired strap tension.

[0019] The user interface may be formed by a membrane keyboard. The button(s) of the user interface may be physical or virtual. The display screen may be display a selected or recommended strap tension and/or other information about the automatic tool, such as a battery charge state (e.g., remaining battery power), or a remaining number of locking heads.

[0020] In other examples, the tension selector unit comprises a variable potentiometer adapted to provide a predetermined adjustable resistor range. Advantageously, said reference parameter of said tension selector unit is an electric resistance. Advantageously, the automatic tool further comprises at least one RFID reader operatively coupled with said controller and adapted to receive information from a corresponding RFID tag. In examples, said information comprises at least a maximum value and a minimum value of said reference parameter. Advantageously, in some examples the feeder mechanism comprises a feed roller and a transfer roller, arranged so as to form a friction feed mechanism for the strap.

[0021] Advantageously, said feed roller is operably coupled to a first drive shaft of said at least one first electric motor via a gear mechanism configured to trans-

late rotation of said first drive shaft into rotation of said feed roller.

[0022] Preferably, said transfer roller is rotatably mounted to a pivot link adapted to bias said transfer roller towards said feed roller.

[0023] Advantageously, in other examples the feeder mechanism comprises a first roller and a second roller that are rotatable by the first electric motor. The position of the second roller may be biased against the first roller. The strap may be driven by rotation of the first roller and the second roller when fed between the first roller and the second roller.

[0024] In examples, a first roller gear is coupled to the first roller and a second roller gear is coupled to the second roller. The first and second roller gears may be driven by the first electric motor to rotate the first and second rollers. In some examples the first and second roller gears are directly meshed with each other, but in other examples one or more transfer gears (preferably an even number of transfer gears, such as two transfer gears) are provided between the first and second roller gears.

[0025] In some examples, the feeder mechanism comprises a third roller with a third roller gear. The second roller may be biased against the third roller (as well as the first roller) to form a second drive point for the strap. The strap may be fed between the first and second rollers, and between the second and third rollers. In examples, the third roller gear may be directly meshed with the first roller gear, or one or more transfer gears (preferably an odd number of transfer gears, such as one transfer gear) are provided between the first and third roller gears.

[0026] In this way, rotation of the first roller gear will drive rotation of the first, second, and optional third roller.

[0027] The first electric motor may comprise a drive shaft for driving rotation of the first roller gear. The drive shaft may comprise a worm gear that engages either: the first roller gear, or an input gear fixed to the first roller and first roller gear.

[0028] In examples, the second roller is mounted within the feeder mechanism on a rocker that is moveable to space apart the second roller from the first and optional third rollers. The rocker may spring-biased to urge the second roller against the first and optional third rollers. The feeder mechanism may include a cam mechanism for moving the second roller away from the first and optional third roller so that a strap can be positioned therebetween. The cam mechanism may include a cam shaft that can be rotated by user, for example the cam shaft may extend out of the housing of the automatic tool. In this way, a new strap can be fed through the feeder mechanism by rotating the cam shaft and advancing the strap through the feeder mechanism.

[0029] Advantageously, said feeder mechanism further comprises a strap guide member, arranged to guide the strap though said barrel portion in a direction along said longitudinal axis. The strap guide member may be located between the feed roller or second (or optional third) roller, and the cut-off mechanism. The strap guide member may comprise a funnel opening to receive the strap.

[0030] Advantageously, the cut-off mechanism may comprise an inlet funnel 2404 facing the strap guide member. The inlet funnel 2404 may help to guide the strap into the cut-off mechanism.

[0031] Advantageously, the feeder mechanism may comprise a funnel disposed at an inlet to the feeder mechanism, between the first roller and the reel magazine. The funnel may open towards the reel magazine. The funnel may advantageously guide the end of the strap into the feeder mechanism, in particular between the first and second rollers.

[0032] Advantageously, said cut-off mechanism comprises a blade member slidingly moveable between a first position, disengaged from the loaded strap, and a second position, cuttingly engaged with the loaded strap.

[0033] Preferably, said blade member is releasably lockable in said first position and biased towards said second position.

[0034] Additionally, said drive unit further comprises a second electric motor operatively coupled with said controller and adapted to acuate said cut-off mechanism at said predetermined condition.

[0035] Advantageously, said blade member is operably coupled to said second electric motor via a rotating cam member adapted to move said blade member between said first position and said second position.

[0036] Advantageously, the cut-off mechanism comprises a blade guard disposed distally of the blade member. Preferably, the blade guard forms a distal-most part of the automatic tool, at the end of the barrel portion. The blade guard may include a central opening through which the strap is advanced, and through which the free end of the strap is re-inserted during use. During use, a locking head may be positioned behind the blade guard, in line with the central opening. Advantageously, the blade guard comprises at least one tapered surface located about the central opening, for example above and/or below (on opposite sides of) the central opening, to guide the re-insertion of the free end of the strap into the locking head during use.

[0037] Advantageously, said automatic tool comprises at least one power supply adapted to provide power to said drive unit. Preferably, said power supply is provided by a battery removably mountable within said pistol shaped housing.

[0038] In examples, the reel magazine assembly comprises an openable (e.g., pivotable) and/or removable cover for removing and adding a strap reel. The strap reel and/or cover may be configured so that the strap reel can only be inserted into the reel magazine assembly in a single orientation. For example, a hub of the strap reel may be closed at one end, and/or flanges of the strap reel may have different sizes, only the smaller of which can be inserted into the reel magazine assembly (e.g., cover).

[0039] In examples, the locking heads magazine as-

sembly comprises a magazine rack configured to receive a plurality of locking heads. The magazine rack may be configured to receive a plurality of locking heads connected together in a locking heads magazine. The locking heads magazine assembly may comprise an openable door for inserting the locking heads (or locking heads magazine) into the magazine rack. The magazine rack may comprise a channel shaped to receive the locking heads (or locking heads magazine). The channel and/or the locking heads may be shaped (e.g., with a corresponding slot and protrusion) to only permit the locking heads to be loaded in a single orientation.

[0040] In examples, the locking heads magazine assembly comprises a spring-biased slider arranged to urge the locking heads along the magazine rack, towards the cut-off mechanism.

[0041] In examples, the magazine rack comprises a straight portion extending through the barrel portion in the longitudinal direction, preferably in a lower part of the barrel portion (on the side of the tool from which the handle protrudes). The magazine rack may also include a curved portion that curves up from the straight portion into the cut-off mechanism. The locking heads are preferably held in the straight portion with their openings directed perpendicular to the longitudinal direction, and are rotated by the curved portion such that their openings are aligned with the longitudinal direction.

[0042] In examples, the slider is flexible so as to be able to extend around the curved portion. A spring, for example one or more flat coil springs, may be provided to urge the slider towards the curved portion (and cut-off mechanism). The slider may comprise a lever that protrudes through a slot in the housing to be operable by a user.

[0043] In examples, the openable door may be disposed at the curved portion, at a distal end of the automatic tool, aligned with the straight portion, such that locking heads (or a locking head magazine) can be inserted into the straight portion from the distal end of the automatic tool.

[0044] According to a further aspect of the present invention there is also provided a strap reel, which may each have the features of the strap reel described above. For example, the strap reel may have a hub that is closed at one end so that it can only be loaded into the automatic tool in one orientation. Additionally or alternatively, the strap reel may comprise first and second flanges having different outer dimensions such that the strap reel can only be loaded into the automatic tool in one orientation. In examples, the strap reel may comprise an RFID tag holding information identifying the strap type, or holding information regarding a tension range for the strap.

[0045] According to a further aspect of the present invention there is also provided a locking head, and a locking heads magazine, which may have the features described above. In examples, the locking head(s) may comprise a slot configured to cooperate with a protrusion on the automatic tool (in particular on a magazine rack of the locking heads magazine assembly) to only allow the locking heads to be inserted in one orientation.

[0046] In examples, the or each locking head comprises a moulded body and a central opening. One or more teeth may extend at an angle into the central opening. The teeth may permit movement of the strap (in one or two layers) in one direction, and bite into the strap when the strap is arranged in a double layer in the central opening and pulled in a second direction.

[0047] In the locking heads magazine the locking heads may be connected to each other by joining portions. The joining portions preferably each comprise a plurality, for example two, joining strips. The joining portions (e.g., joining strips) may comprise a pre-cut at which the joining portions are broken to separate the locking heads during use. The pre-cuts are preferably located at a join between each joining portion and a locking head (i.e., at a side wall of each locking head). In this way, the side wall of the joining head does not have any protrusion after separation of a previous locking head and can be accurately seated in the cut-off mechanism.

Brief Description of the Drawings

[0048] An exemplary embodiment of the invention is explained in more detail hereinbelow with reference to the figures:

Figure 1 illustrates a perspective side rear view of a preferred embodiment of the binding tool of the present invention;

Figure 2 illustrates (a) a side view, (b) a front view and (c) a top view of the preferred embodiment of the binding tool of the present invention;

Figure 3 illustrates a side rear view the binding tool of Figure 1, with a front cover of the housing removed so as to expose the interior mechanism;

Figure 4 illustrates an exploded perspective right-side rear view of the binding tool housing and reel magazine assembly, exposing the tool mechanism;

Figure 5 shows an exploded view of the binding tool mechanism without the housing and reel magazine assembly housing;

Figure 6 illustrates the binding tool mechanism with the housing removed and the reel magazine assembly exploded (a) in a perspective left rear side view and (b) in a perspective right rear side view;

Figure 7 illustrates the binding tool mechanism with the housing and the locking heads magazine covers removed (a) in a perspective left rear side view and (b) in a perspective right rear side view;

Figure 8 illustrates a detailed portion of the feeder

mechanism and exposed locking heads magazine assembly (emptied), (a) in a perspective left rear side view and (b) in a perspective right rear side view;

Figure 9 shows a detailed schematic illustration of the feeder mechanism function, (a) with the feeder mechanism in a stopped or locked state, (b) with the feeder mechanism driving forward, (c) with the feeder mechanism driving rearward, and (d) a cross sectional partial side view of the front (distal) portion of the barrel portion of the tool with a strap moved by the feeder mechanism through and out of the barrel portion of the tool;

Figure 10 illustrates a perspective front side view of the binding tool mechanism with the housing removed and the locking heads magazine assembly and cut-off mechanism exploded;

Figure 11 illustrates an exploded perspective view of the cut-off mechanism without the engaging cam member and second electric motor (a) from the front and (b) from the rear, and the assembles cut-off mechanism with operably coupled snail drop cam, drive shaft and second electric motor (c) from the front and (d) from the rear;

Figure 12 (a) to (f) shows a sequence of a front view of the cut-off mechanism during a cutting and loading cycle,

Figure 13 illustrates an example embodiment of the binding system of the present invention (a) in a side-view, (b) during use, when setting a desired maximum strap tension, and (c) during use, when loading locking heads into the locking heads magazine assembly (with the locking heads magazine cover in an open position, and

Figure 14 illustrates the tool of the present invention during use, i.e. while looping a strap around a structure before pushing the end back into the tool,

Figure 15 illustrates a perspective side rear view of a second embodiment of the binding tool of the present invention;

Figure 16 illustrates (a) a side view of the binding tool, and (b) an end view of the binding tool of Figure 15;

Figure 17 illustrates a perspective side rear view of the binding tool of Figure 15 with one part of the housing removed;

Figures 18 and **19** illustrate a cut-off mechanism of the binding tool of Figure 15;

Figure 20 illustrates a locking heads magazine and the cut-off mechanism of the binding tool of Figure 15;

Figure 21 illustrates (a) a perspective side rear view of a third embodiment of the binding tool of the present invention, and (b) a perspective side rear view of the binding tool with one part of the housing removed;

Figure 22 illustrates the drive unit of the binding tool of Figure 21 ;

Figures 23 to 25 illustrate the feeder mechanism of the binding tool of Figure 21 ;

Figure 26 illustrates the cut-off mechanism of the binding tool of Figure 21 ;

Figure 27 illustrates the locking head magazine assembly of the binding tool of Figure 21 ;

Figure 28 illustrates (a) a locking heads magazine, (b) a single locking head, and (c) a side view of the locking head magazine for use with the binding tool of Figure 21;

Figure 29 illustrates a cross-section through the locking heads magazine assembly and locking head of the binding tool of Figure 21; and

Figure 30 illustrates (a) a first perspective side view of a strap reel for the binding tool of Figure 21, and (b) a second perspective side view of the strap reel.

Detailed Description

[0049] The described example embodiments relate to a hand-held binding tool, configured for distributing, tensioning and cutting a reeled strap (in a magazine) utilising separately stored locking heads (magazine). In particular, the described example embodiments of the invention relate to an automatic hand-held binding tool utilising at least one battery powered electric motor that is controlled by a controller. However, the invention is not limited to electric motors and may equally utilise any other powered actuator mechanism, such as, pneumatic or hydraulic motors. Further, the invention is not limited to battery power and may use any other suitable power supply, such as, for example, a mains cable, or any other form of supplying electrical energy (e.g. solar energy).

[0050] Certain terminology is used in the following description for convenience only and is not limiting. The words 'right', 'left', 'lower', 'upper', 'front', 'rear', 'upward', 'down', 'downward', 'above' and 'below' designate directions in the drawings to which reference is made and are with respect to the described component when assembled and mounted (e.g. *in situ*). In particular,

the designated directions used in the description are with respect to the hand-held tool or systems held by the user in a normal, upright position, i.e. the handle portion pointing downwards and the barrel portion pointing forward and away from the user. It is understood that the tool may be used in any other orientation suitable for the job at hand, though, for simplicity, the designated directions are used when the tool is in a "normal" orientation. The words 'inner', 'inwardly' and 'outer', 'outwardly' refer to directions toward and away from, respectively, a designated centreline or a geometric centre of an element being described (e.g. central axis), the particular meaning being readily apparent from the context of the description.

[0051] Further, as used herein, the terms 'connected', 'attached', 'coupled', 'mounted' are intended to include direct connections between two members without any other members interposed therebetween, as well as, indirect connections between members in which one or more other members are interposed therebetween. The terminology includes the words specifically mentioned above, derivatives thereof, and words of similar import.

[0052] Further, unless otherwise specified, the use of ordinal adjectives, such as, 'first', 'second', 'third' etc. merely indicate that different instances of like objects are being referred to and are not intended to imply that the objects so described must be in a given sequence, either temporally, spatially, in ranking or in any other manner.

[0053] Through the description and claims of this specification, the terms 'comprise' and 'contain', and variations thereof, are interpreted to mean 'including but not limited to', and they are not intended to (and do not) exclude other moieties, additives, components, integers or steps. Throughout the description and claims of this specification, the singular encompasses the plural unless the context otherwise requires. In particular, where the indefinite article is used, the specification is to be understood as contemplating plurality, as well as, singularity, unless the context requires otherwise.

[0054] Features, integers, characteristics, compounds, chemical moieties or groups described in conjunction with a particular aspect, embodiment or example of the invention are to be understood to be applicable to any other aspect, embodiment or example described herein unless incompatible therewith. All of the features disclosed in this specification (including any accompanying claims, abstract and drawings), and/or all of the steps of any method or process so disclosed, may be combined in any combination, except combinations where at least some of such features and/or steps are mutually exclusive. The invention is not restricted to the details of any foregoing embodiments. The invention extends to any novel one, or any novel combination, of the features disclosed in this specification (including any accompanying claims, abstract or drawings), or to any novel one, or any novel combination, of the steps of any method or process so disclosed.

First Example Embodiment Automatic Binding Tool 100

[0055] Referring now to Figures 1 to 4, an example embodiment of the automatic binding tool 100 incorporating the principles of the present invention(s) is preferably pistol shaped and intended to be hand-held by the user. The binding tool 100 comprises a housing 102 having a barrel portion 104 extending along a longitudinal axis 110 between a distal housing end portion 106 and a proximal housing end portion 108. A handle portion 112 extends away from the proximal housing end portion 108 in a direction intersecting with the longitudinal axis 110, for example, at an angle between 60° and 90° with respect to the longitudinal axis 110. An adjustment knob 216 for setting a desired cable tie tension through a tension selector unit 214 is provided at the proximal housing end portion 108.

[0056] A magazine 600 for a strap reel (inside) is provided on top of the barrel portion 104 and operably coupled with the tool mechanisms, so as to feed a coiled or reeled strap 1001 into the barrel portion 104 of the tool 100.

[0057] Figures 2 (a) to (c) shows the binding tool 100 in respective (a) side-view (distal end), (b) front-view (distal end) and (c) top-view.

[0058] Figure 3 shows a perspective side view (in the direction marked by arrow 'A', see Figure 2(c)) of the binding tool 100 with a portion of the housing 102 removed, so as to illustrate the mechanism(s) operably embedded within the housing 102. For a better understanding, the tool mechanism has been divided up into separate functional groups with respective ones operably coupled to one another, so as to provide the desired functions of the tool 100. These functional groups include a drive unit 200, mostly embedded within the proximal end of the barrel portion 104, the handle portion 112 and partly in the reel magazine housing and adapted to control, actuate and drive the tool mechanisms. Another functional group is the feeder mechanism 300, embedded within the barrel portion 104 adjacent to the reel magazine assembly 600 and which is adapted to engage with and guidingly move the cable tie strap 1001 through the barrel portion 104 of the tool 100 and apply a predetermined tension to an engaged cable tie strap 1001. The feeder mechanism 300 is actuated by the drive unit 200. The cut-off mechanism 400 is another functional group embedded within the distal end of the barrel portion 104 and which is adapted to cut through the engaged cable tie strap 1001 when a predetermined tension applied to the strap tail is reached, as well as, cooperate with the locking heads magazine assembly 500 which is configured to hold a plurality of separate locking heads 506 and automatically position a locking head 506 for use with the engaged strap 1001. Another functional group of the tool 100 is the reel magazine assembly 600 that is configured to operably store one or more strap reels 1000.

[0059] It is understood that any one of the respective

functional groups 200, 300, 400, 500, 600 may be partially interconnected with another functional group, and a part of one functional group may also be a component of, or at least operably coupled with, another functional group.

[0060] For simplicity and a better understanding, each one of the functional groups 200, 300, 400, 500 and 600 of the present invention is first described separately, before the binding tool function is described as a whole.

(i) Drive unit 200

[0061] Referring now to Figures 3 to 7, the drive unit 200 provides for actuation (driving) and control (tool settings and function) of any one of the feeder mechanism 300 and the cut-off mechanism 400. The drive unit 200 of this particular example embodiment comprises, *inter alia*, a first electric motor 202, a switch unit 204 (with a trigger member 206 and a selector member 208), a removeable battery pack 210, a second electric motor 212, a tension selector unit 214 (with an adjustment knob 216) and a controller 218.

[0062] The controller 218 may be provided on a printed circuit board (PCB) stored in the housing 602 of the reel assembly 600 and operatively coupled with any one of the other components, i.e. the first and second electric motor 202, 212, the tension selector unit 214, the switch unit 204, as well as, the battery pack 210. The controller 218 may include any suitable programmable processor or integrated circuit (IC) configured to receive, process and transmit signals to and from any one of the drive unit components, as well as, execute predetermined sequences, functions and instructions provided by a user. In particular, the controller 218 is configured to detect ("read") the current ('I' in [A]) drawn by the first electric motor 202 when under load, as well as, detect or "read" a voltage provided by the tension selector unit 214 corresponding to a particular target tension of the strap 1001 during use.

[0063] The first electric motor 202 is located in a proximal end portion of the barrel portion 104 with a motor drive shaft 220 extending towards the distal end of the barrel portion 104. The drive shaft 220 is provided with a gear or pinion 222 in order to transfer the torque from the first electric motor 202 to the feeder mechanism 300 during use.

[0064] The switch unit 204 is mounted or integrated with the handle portion 112 and positioned so that a user can operate the switch unit 204 with a finger while holding the tool 100 in one hand, i.e. at the upper front region of the handle portion 112.

[0065] The switch unit 204 of this particular example embodiment comprises a trigger member 206 that is configured to activate and deactivate the first electric motor 202 (with controller 218). The trigger member 206 may be a biased push button operable by the user's index finger while holding the tool 100. In particular, when pressing the push button or trigger member 206 down or towards the handle portion 112 a signal is sent to the controller 218 activating the first electric motor 202. Releasing the push button or trigger member 206 will stop the activation signal and the controller 218 stops the first electric motor 202. It is understood by the user, that any suitable switch or trigger mechanism may be used to activate and deactivate the first electric motor 202 of the tool 100 with or without controller input.

[0066] A selector member 208 or selector switch is provided with the switch unit 204 and is configured to switch the drive direction of the first electric motor 202 between clockwise and counterclockwise, i.e. the drive shaft and attached pinion 222 will run clockwise at a first position of the selector member 208 and counterclockwise at a second position of the selector member 208. That is, the drive unit 204 may provide a characterising signal to the controller 218 corresponding to the position of the selector member 208, thus, switching the motor direction in accordance with the position of the selector member 208. Again, it is understood by the person skilled in the art, that any suitable switch mechanism may be used to switch the motor direction with or without controller input.

[0067] A tension selector unit 214 is provided at the proximal end of the barrel portion 104 and operably coupled with the controller 218 and/or first electric motor 202. The tension selector unit 214 is adapted to provide a signal to the controller 218 or first electric motor 202 that defines a desired maximum strap tension set by the user. In this example, the tension selector unit 214 comprises an adjustment knob 216. The user will turn the adjustment knob 216 so as to select a desired maximum strap tension when attached or fixed to a structure (e.g. a bundle of cables), the strap tension at which the cable strap 1001 is cut by the tool 100 during use. Setting a maximum strap tension will ensure that the force applied by the strap is within a predetermined range suitable to provide a secure fit without damaging the structure.

[0068] In this particular example embodiment, the tension selector unit 214 is provided by a variable potentiometer adapted to provide a range of user-selectable resistances that can be converted to a desired maximum strap tension (e.g. by the controller 218). For example, the controller 218 may be configured to detect a voltage drop caused by the adjusted resistor and convert the particular voltage value into a maximum strap tension during use.

[0069] A particular example is now provided to show how the adjustable resistor value of the potentiometer may be converted into a setting for the desired strap tension. It is understood by the person skilled in the art that any other suitable conversion may be used to provide a desired tension setting to the controller 218.

Example - target strap tension regulation logic:

[0070] The controller 218 reads the resistance factor offered by the potentiometer (i.e. tension selector unit

214). The minimum value available is equal to Ω_{min} and corresponds to a mechanical tension setting of 1. The maximum value available is equal to Ω_{max} and corresponds to a mechanical tension setting of 100. For intermediate values the mechanical tension setting is equal to:

$$\mathrm{SET} = 1 + \left(99 * \frac{\Omega set - \Omega min}{\Omega max - \Omega min}\right)$$

[0071] A range of allowable tensions may be provided for different types of straps 1001, e.g. put in manually or read into the controller 218 via RFID (Radio Frequency IDentification). The range information provided may include a N_{min} and N_{max} of allowable strap tension (in Newton) for the continuous strap 1001 contained in the reel magazine 600. When SET value (set by the user via the adjustment knob 216) is equal to 1, the target strap tension is equal to N_{min}, and when SET value is equal to 100, the target strap tension (or desired strap tension) is equal to N_{max}. For any of the intermediate values within that range, the target strap tension is equal to:

$$\mathrm{N}set = \mathrm{N}min + \left[\frac{\mathrm{N}max - \mathrm{N}min}{99} * (\mathrm{SET} - 1)\right].$$

[0072] The drive unit of this particular example embodiment comprises a second electric motor 212 that is positioned in a distal end portion of the barrel portion 104 having a motor drive shaft 224 extending towards and coupled with the cut-off mechanism 400 of the tool 100. The drive shaft 224 is provided with a rotatable cam member 226 configured to translate the rotational movement of the drive shaft 224 into linear movement of the blade member 402. The second electric motor 212 may be the same or a smaller, less powerful version of the first electric motor 202.

[0073] Alternatively, the first electric motor 202 may be utilised to drive both, the feeder mechanism 300 and the cut-off mechanism 400, wherein the activation of the first electric motor 202 and respective feeder 300 and cut-off mechanism 400 are controlled via the controller 218 and a suitable switch mechanism (not shown) between the feeder mechanism 300 and the cut-off mechanism 400.

[0074] In this particular example embodiment, the tool 100 further comprises a RFID (Radio Frequency Identification) receiver or reader configured to wirelessly receive information from a remote RFID transmitter or tag (not shown). The RFID reader (including an antenna) may be located and operatively coupled with the controller 218, so as to read RFID tags that are placed within a working distance (e.g. on the strap reel 1000) and then provide the read information to the controller 218. The RFID antenna may be shielded on one side so as to reduce risk of interference.

[0075] For example, the RFID label or tag may have, among other data, the information regarding N_{min} and N_{max} of the desired strap tension to define the admittable range of tension to be applied at the strap 1001. This will allow the user to benefit from a full scale of tension regulation via the adjustment knob 216, i.e. the range of available discrete maximum desired strap tensions is defined by the N_{min} and N_{max} range provided via RFID from the cable strap reel 1000, thus, improving the resolution of available desired strap tensions and allowing the user to fine tune the tool for specific applications. Additionally and/or optionally, the information provided from the RFID tag may include specific motor (feeder) speeds, the length of available strap per reel and may trigger a signal (visual, audible, tactile) indicating the approaching end of the available strap 1001.

[0076] Further, it is understood by the person skilled in the art, that any other suitable actuator (controllable and actuatable by the controller 218) may be used for "driving" the cut-off mechanism 400.

[0077] A power supply or battery pack 210 is mounted within the handle portion 112 of the tool 100 and operatively coupled with any of the components of the drive unit 200, i.e. the battery pack 210 may be connected with the first and second electric motor 202, 212, the controller 218, the tension selector unit 214 and the switch unit 204, depending on the functional setup between the controller 218 and the other components. The battery pack 210 may be a rechargeable battery removably mounted within the handle portion 112.

[0078] In examples, the battery pack 210 may comprise a 12V, 2.5 Ah battery, for example a lithium ion battery. In examples, the battery pack 120 may provide 18V or higher. The battery pack 210 is preferably rechargeable.

[0079] However, it is understood by the person skilled in the art that any other suitable power source may be used to drive the drive unit 200. For example, power may be provided via an extension cable to the mains or through solar charging (into a battery). Other suitable power sources (non-electric) may include pressurised fluid (external connection or cartridge), or combustion (fuel).

(ii) Feeder mechanism 300

[0080] Referring now to Figures 8 and 9, the feeder mechanism 300 is operably coupled with the first electric motor 202 via the drive shaft 220 and the pinion 222. In particular, the feeder mechanism 300 comprises a transmission gear mechanism having an input stage 302 and an output stage 304 arranged in a parallel gear configuration. The input stage 302 comprises a bevel gear 306, intersectingly coupled with the bevel geared pinion 222 of the drive shaft 220, and a parallelly spaced apart coaxial first spur gear 308. The output stage 304 comprises a second spur gear 310 operably engaged with the first spur gear 308. A feed roller 312 or pulling gear is coupled coaxially spaced apart with the second spur gear 310 such that rotation of the second spur gear 310 is trans-

ferred directly onto the feed roller 312. A transfer roller 314 is arranged parallel to and operably engageable with the feed roller 312 so as to form a friction feed mechanism for a strap provided from the reel magazine assembly 600. In particular, the transfer roller 314 is mounted within the housing 102 via a rotatable pivot link 316 configured to bias (e.g. via a suitable spring member - not shown) the transfer roller 314 towards the feed roller 312, thus, pressing an engaged strap 1001 against the feed roller 312. The feed roller 312 has an outer surface that is adapted to provide sufficient friction between the feed roller 312 and the strap 1001 during use, e.g. teeth or tines may be provided to "hook" into the strap 1001 in order to transmit sufficient force onto the strap 1001 and avoid or minimise slippage during use. The gear mechanism and roller arrangement is configured to allow movement of the strap 1001 in both directions, i.e. forward (e.g. first motor drive shaft 220 rotates clockwise) and backward (e.g. first motor drive shaft 220 rotates counter clockwise). Further, it is understood by the person skilled in the art, that any suitable gear mechanism may be used to transfer the rotational movement of the first motor drive shaft 220 to the feed roller 312, with or without torque and/or rotational speed changes.

[0081] As shown particularly in Figure 9(d), a strap guide member 318 or guide channel extends from the feeder mechanism 300 to the distal end of the barrel portion 104 and is configured to receive a cable trap tie 1001 pulled by the feeder mechanism 300 from the exit of the reel magazine assembly 600 to be pushed through the barrel portion 104 and out of the distal end of the tool 100. The strap guide member 318 may be provided by a U-shaped channel dimensioned so as to accommodate a strap 1001. A proximal portion of the strap guide member 318 may be provided at the reel magazine assembly 600 to extend to the feed roller 312 of the feeder mechanism 300 (see Fig. 9(a)).

(iii) Cut-off mechanism 400

[0082] Referring now particularly to Figures 10, 11 and 12, the cut-off mechanism 400 of this example comprises a blade member 402, a locking head release assembly 404, a biasing member 406 and a blade guard 408. The locking head release assembly 404 comprises two opposing guide members 410 or jaws adapted to slidingly receive and guide the blade member 402, such that the blade member 402 can slidingly move between an upper position and a lower position. In the upper position, the blade member 402 is cuttingly disengaged from a loaded strap 1001, i.e. the blade 402 does not make contact with the strap 1001 which is free to move through the blade member's centre aperture 412 so as to exit the tool 100 at its distal end and loop around a structure. When moving from the upper position into the lower position, the blade member 402 cuttingly engages with a loaded strap 1001 so as to cleanly cut through the portion of the strap positioned within the blade member aperture 412. A biasing member 406 is provided at the top of the blade member 402 between a spring retainer portion of the rack member 502 of the locking heads assembly 500 and a top surface of the blade member 402, configured to bias the blade member 402 towards its lower position. The lower surface of the blade member 402 is provided with a step portion 414 so as to form a stepped cam follower 416. The step portion 414 is configured to operably engage with a rotating cam member 226 of a second electric motor 212 controlled by the controller 218. The rotating cam member 226 of this example is a snail drop cam configured to cause a sudden drop of the cam follower 416 and the blade member 402.

[0083] Alternatively, the rotatable cam member 226 may be driven by the first electric motor 202 via a suitable gear mechanism adapted to selectively engage with the drive shaft 224 of the cam member 226, i.e. the controller can selectively switch the output of the first electric motor 202 between the feeder mechanism 300 and the rotatable cam member 226 operably coupled with the blade member 402.

[0084] Each one of two opposing stop members 418a,b is slidably coupled with a respective blade guide member 410a,b and biased towards each other with a connecting spring member 420. Each one of the opposing stop members 418a,b is configured to slide between an open position, laterally outwards with respect to the opposing blade guide members 410a,b and away from a vertical longitudinal central plane (VLCP) of the tool 100, and a closed position, inwards with respect to the opposing blade guide members 410a,b and towards the VLCP of the tool 100. When in the open position, the gap formed between the opposing blade guide members 410a,b that is suitable for a loaded locking head 506 to pass through and eject from the tool 100. When in the closed position, the gap formed between the opposing blade guide members 410a,b is not suitable or sufficient for a locking head 506 to pass through thus locking the locking head 506 into place for use with the next strap 1001. Each one of the stop member 418a,b comprises a recessed cam follower 422a,b arranged on the interior edge of the stop member 418a,b. The recessed cam follower 422a,b is formed by a stepped upper end and an inclined lower end, and which is configured to cooperate with corresponding lateral blade cams 424a,b provided at the blade member 402.

[0085] In use, and with particular reference to Figures 12 (a) to (f), the cam follower 416 of the step portion 414 slidingly sits on the cam surface of the cam member 226 and rides up towards the gradually increasing swell of the snail drop cam 226 when rotating the cam 226 in its operable direction (i.e. towards the gradually increasing swell). When reaching the peak of the cam 226, the cam follower 416 suddenly drops down onto the start of the gradually increasing swell into its second position. The sudden drop is forced by the biasing member 406. When the blade member 402 drops into its second position, the lateral blade cams 424a,b force respective recessed cam

followers 422a,b to move laterally outward and away from the vertical longitudinal central plane (VLCP) of the tool 100 against the bias provided by the spring member 420, thus, opening the gap between the stop members 418a,b and allowing a loaded and cut locking head to eject. Continuing rotation of the snail drop cam 226 moves the blade member 402 back up towards its first position (against the biasing force of the biasing member 406) wherein the recessed cam followers 422a,b of the stop members 418a,b move back into engagement with the lateral blade cams 424a,b and allow the stop member 418a,b to move back laterally inwards towards the VLCP of the tool 100, thus, reducing the gap between the stop members 418a,b so as to prevent any locking heads 506 from ejecting, as well as, allowing the next locking head 506 to move into a loaded position. Once a new locking head 506 is loaded into position, the next strap 1001 can be moved through the blade member aperture 412 and applied to the next structure to be looped back into the tool 100 and into engagement with the loaded locking head 506 before the strap 1001 is tightened via the reversed feeder mechanism 300 and cut via the cut-off mechanism 400.

[0086] The second electric motor 212 is controlled via the controller 218. In particular, the controller 218 is configured to measure the current drawn (i.e. the load of the motor) by the first electric motor 202 when tensioning the applied strap 1001 and convert the drawn current into a tension applied by the tool 100 to the strap 1001. For example, as the load on the motor (the torque) increases, the amount of current that the motor draws increases linearly. The linear tension in the strap can be determined with the diameter of the feed roller 312 and torque needed to maintain the opposing forces (strap tension and motor torque) in balance. As the torque value acting on the strap 1001 (via the feed roller 312) may be modified through the transmission gear mechanism, the actual torque value present at the motor drive shaft 220 is determined using the dimensions of the roller and gear ratios. The actual torque acting on the motor drive shaft 220 is directly proportional to the current drawn by the first electric motor 202, allowing the controller 218 to determine the actual tension of the strap 1001 by monitoring the drawn current of the first electric motor 202 and compare it to a preset (via the selector member 208) desired maximum strap tension. When the desired maximum strap tension is reached or exceeded, the controller 218 will simultaneously deactivate the first electric motor 202 (and stop the feeder mechanism 300) and activate the second electric motor 212 and actuate the cut-off mechanism 400, so as to, cut through the strap section extending out of the engaged locking head 506 and release the engaged locking head 506 and looped strap 1001 from the tool 100.

(iv) Locking heads magazine assembly 500

[0087] This example tool 100 is provided with a magazine assembly 500 for storing the separate locking heads 506 and cooperating with the cut-off mechanism 400 so as to move a new locking head 506 into position for use with the next strap 1001.

[0088] Referring now particularly to Figures 3, 5, 7, 8 and 10, the locking head magazine assembly 500 comprises a rack member 502 having a spring retainer portion at its distal end, a spring-biased locking head cover 508, a locking heads cartridge 510 including a plurality of locking heads 506 and a spring-biased plunger 512. The locking head cover 508 is pivotably mounted, so as to rotatably move between an open position, allowing access to the inserted cartridge 510, and a closed position, securing the cartridge 510 to the rack member 502 via a spring-biased hook mechanism 514, actuatable by a push button 516. The cover 508 is spring-biased towards its open position. The cartridge 510 is used to store and correctly align (parallel) the locking heads 506. The spring biased plunger 512 is provided on top of the rack member 502, so as to operably engage with the locking heads 506 stored within the cartridge 510 and when placed into the locking heads magazine 500. In particular, the plunger 512 is adapted to provide a biasing force onto the parallelly aligned locking heads 506, so as to push the locking heads 506 towards the distal housing end portion 106. The plunger 512 includes an offset head engagement member 518, so that, when the locking heads 506 are stored within the cartridge 510 and operably coupled with the plunger 512, the parallelly arranged rows of locking heads 506 are axially offset, i.e. only one locking head 506 is positioned at the forefront to be loaded next. Thus, when the cut-off mechanism 400 is actuated, only that one locking head 506 is loaded and operably positioned for the next loop of strap 1001, during use.

[0089] Preferably, the axial offset between the two rows of locking heads 506 is about half a thickness of a locking head 506. A plunger screw 5200 may be provided to indicate the amount of locking heads 506 left in the cartridge 510 when the cover 508 is closed. Here, the plunger screw 520 is mounted through the cover 508 and cartridge 510, both of which have a central slot so that the plunger screw 520 can move with the head engagement member 518.

[0090] In use, the locking heads cover 508 is opened by depressing the push button 516 and disengaging the hook 514 from the spring biased cover 508 (which will open automatically, when the plunger screw 520 is removed). The locking heads 506 are then placed into the cartridge 510 and the filled cartridge 510 is placed onto the rack member 502 with the engagement member 518 pushing against the two locking heads 506 at the proximal end, thus, axially offsetting the two rows by about half a locking head thickness (see Figs. 7 to 9). The locking heads cover 508 is then rotated back into its closed position and secured by the hook 514. The locking heads magazine 500 is now ready for use with the tool 100.

(v) Reel magazine assembly 600

[0091] Referring now in particular to Figures 3, 4, 5 and 6, the reel magazine assembly 600 is operably coupled to a mid-section of the barrel portion 104 of the tool housing 102. Preferably, the reel housing 602 (made up of two halves, as is the tool housing 102) is integrally formed with the tool housing 102.

[0092] The reel magazine assembly 600 may include a reel biasing mechanism (not shown) configured to automatically rewind the strap 1001 onto the cable strap reel 1000, as well as, provide a constant tension/bias of the strap 1001 fed into the tool 100.

[0093] The biasing mechanism may further (optionally additionally) be adapted to provide a friction coupling adapted to selectively engage and disengage the cable strap reel 1000 from the rotational bias provided by the biasing mechanism. The reel housing 602 further comprises a removable reel cover 604 to allow installation and removal of the cable strap reel 1000. In addition, the reel housing 602 is provided with a separate controller compartment 606 and a removable compartment cover 608 configured to house the controller 218. The removable reel cover 604 may further be provided with a central aperture 610 configured to allow the user to visually inspect the strap amount left on the reel 1000.

[0094] During operation, a fully stored cable strap reel 1000 is operably mounted within the reel housing 602 through the opening provided by the removable reel cover 604 and an end portion of a strap 1001 is fed into the feeder mechanism 300. After use, the cable strap reel 1000 is typically under a rotational bias tension urging to wind up any reeled off strap 1001. Optionally, the rotational bias may be removed by disengaging the mounted cable strap reel 1000 from a biasing mechanism. Once the rotational bias of the wound-up biasing mechanism 704 has been removed, the cable strap reel 1000 can be accessed or replaced via the removable cover 604 to then feed a new strap 1001 into the feeder guide mechanism 300. In addition, the cable strap reel 1000 may be made of a recycled cardboard material suitable to hold the one or more coiled straps.

Example - description of a typical working sequence of the first example binding tool 100

[0095] The working mode of the tool 100 can be divided into two subsequent phases (a) tool preparation and (b) tool cycle. The first phase (a) has the purpose to prepare the tool 100 to be working ready or primed for a particular job. This can be done so the tool 100 is fully primed or only partially primed, depending on the needs of the job. The second phase (b) is the same for every bundling action or job.

(a) Tool Preparation:

[0096] The initial tool preparation is the sequence of operations needed to prepare or prime the tool 100 to perform in a predetermined (desired) way. This includes checking the charging status of the battery 210 and recharge the battery 210 if required, check and load a suitable number of locking heads 506 into the magazine assembly (see Fig. 13(c)), pulling an end portion of the strap 1001 from the cable strap reel 1000 into the feeder mechanism 300 until it is engaged with the feed roller 312 and transfer roller 314, and setting a desired maximum cable strap tension for the job via the adjustment knob 216 of the tension selector unit 214 (see Fig. 13(b)), for example, tuning the adjustment knob 216 to select a cable tension between 1 and 10, which is converted by the controller 218 into a desired maximum cable strap tension using the received tag information (N_{min} and N_{max}) for the currently loaded cable strap reel 1000.

(b) Tool Working Cycle:

[0097] The tool working cycle is the same for every operation once the tool 100 is primed and provides the user with a length of strap 1001 that can be looped around a structure and reengaged with the tool 100 to be tightened and locked using a locking head 506. The following steps are provided in the required order:

(1) The user slides the selector member 208 to the tool's "forward" position, thus, providing the controller 218 with a forward driving signal for the first electric motor 202;

(2) The user presses the trigger member 206 to activate the first electric motor 202 (via controller 218);

(3) The rotating drive shaft 220 of the first electric motor 202 drives the feeder mechanism 300 to pull the strap 1001 forward towards the distal housing end portion 106, through the disengaged blade member aperture 412 and the loaded locking head 506 and out of the tool 100;

(4) The user releases the trigger member 206 when sufficient length of the strap is pushed out of the tool 100 to stop the first electric motor 202;

(5) The user looped the free end section of the delivered strap 1001 around the structure (e.g. bundle of cables) and insert the end back into the tool 100 through the loaded locking head 506 and the blade member aperture 412 until the end portion of the strap abuttingly engages with an end stop (e.g. provided at the locking head release assembly 404 or the rack member 502);

(6) The user slides the selector member 208 to the tool's "rearward" or "reverse" position, thus, providing the controller 218 with a rearward driving signal

for the first electric motor 202;

(7) The user presses the trigger member 206 to activate the first electric motor 202 (via controller 218) now pulling the loaded strap 1001 back in;

(8) The controller 218 monitors the current drawn by the first electric motor 202 and determines the tension applied to the loaded strap 1001 (while comparing it with the preset desired maximum or target cable strap tension);

(9) When the target cable strap tension is reached or exceeded, the controller 218 initiates deactivation (stopping) of the first electric motor 202 and activation of the second electric motor 212 so as to actuate the cut-off mechanism 400;

(10) At this instance, the second electric motor 212 rotatingly drives the cam member 226 a full turn (even if the trigger member is released by the user). A sensor may be provided to verify the final rest position of the cam member 226, i.e. a signal is sent to the controller 218 when the final rest position of the cam member 226 is reached, deactivating the second electric motor 212;

(11) During activation, the cam member 226 (snail drop cam) rotates so as to drop the blade member 402 cutting through the loaded strap 1001 and opening the stop members 418a,b to release the locking head 506, and reloading the next locking head 506 from the locking heads magazine assembly 500 - in one example, the starting position of the cam member 226 may be about 10° forward of the step portion for the drop;

(12) The cam member 226 (i.e. rotated the starting position), blade member 402 (i.e. moved back up compressing the biasing member 406) and stop members 418a,b (i.e. moved back inwards) are reset ready for the next working cycle and the next locking head 506 is moved into the loaded position, before the second electric motor 212 is deactivated (stopped).

Second Example Embodiment Automatic Binding Tool 1500

[0098] Referring now to Figures 15 to 20, a second example embodiment of the automatic binding tool 1500 incorporating the principles of the present invention(s) is preferably pistol shaped and intended to be hand-held by the user. The binding tool 1500 is similar to the first example binding tool 100 described above and only differences are described hereinafter.

[0099] In particular, in the same manner as the first example binding tool 100, the binding tool 1500 comprises a housing 102 having a barrel portion 104 extending along a longitudinal axis 110 between a distal housing end portion 106 and a proximal housing end portion 108. A handle portion 112 extends away from the proximal housing end portion 108 in a direction intersecting with the longitudinal axis 110, for example, at an angle between 60° and 90° with respect to the longitudinal axis 110. An adjustment knob 216 for setting a desired cable tie tension through a tension selector unit is provided at the proximal housing end portion 108.

[0100] A magazine 600 for a strap reel (inside) is provided on top of the barrel portion 104 and operably coupled with the tool mechanisms, so as to feed a coiled or reeled strap 1001 into the barrel portion 104 of the tool 100.

[0101] Figures 16 (a) and (b) show the binding tool 1500 in respective (a) side-view (distal end), (b) front-view (distal end).

[0102] Figure 17 shows a perspective side view of the binding tool 1500 with a portion of the housing 102 removed, so as to illustrate the mechanism(s) operably embedded within the housing 102.

[0103] In this second example binding tool 1500 the drive unit 200, feeder mechanism 300 and reel magazine assembly 600 are the same as in the first example binding tool 100 described in detail above and further description is therefore omitted. The cut-off mechanism 1400 and locking heads magazine assembly 1500 of the second example binding tool 1500 are different to those of the first example binding tool 100 and are described below.

Cut-off mechanism 1400

[0104] Referring now particularly to Figures 18 and 19, the cut-off mechanism 1400 of this example binding tool 1500 comprises a blade member 1402, a locking head release assembly 1404, and a blade guard 1408. The blade member 1402 is behind the blade guard 1408 in the assembled tool 1500 shown in Figure 18, and is visible in Figures 19(b) and (c), in which the blade guard 1408 is not shown.

[0105] As shown in most detail in Figure 19, the blade member 1402 is mounted to a cam follower member 1412 that can move up and down relative to a blade guide member 1406. The cam follower member 1412 is slidably mounted to the blade guide member 1406. The cam follower member 1412 has a slotted cam opening 1420 in which a cam 1416 is received. The cam 1416 is mounted to the second motor 212 via an offset shaft 1418 that is offset relative to the rotational axis of the second motor 212 such that rotation of the second motor 212 moves the cam follower member 1412 and blade member 1402 in an up and down motion, during which the cam 1416 also moves sideways in the slotted cam opening 1420. The cam 1416 may be a bearing mounted to an end of the offset shaft 1418, and in some examples the bearing can be omitted such that an end of the offset shaft

1418 forms the cam 1416.

[0106] In a starting position, as illustrated, the blade member 1402 is in a lower position, away from the locking head 506. To cut the strap the second motor 212 rotates the offset shaft 1418 to move the blade member 1402 up to cut the strap. Further rotation of the second motor 212 moves the blade member 1402 back down again to the illustrated starting position. A sensor 1428, e.g., a proximity sensor, (see Figure 18(c)) may be provided to detect the position of the cam follower member 1412 to verify that a full rotation of the offset shaft 1418 has been completed.

[0107] As described above, during the cutting action the cam follower member 1412 moves up and then down again. The locking head release assembly 1404 comprises two opposing gates 1410 or jaws that are pivotally mounted to the cam follower member 1412 and to the blade guide member 1406. In particular, the two gates 1410 are pivotally mounted to the cam follower member 1412 at pivots 1422 via slots 1424 in the gates 1410. The gates 1410 are also pivotally mounted to the blade guide member 1406 at pivots 1426 that are located inwardly of pivots 1422. The two gates 1410 protrude downwards from pivots 1426 to block exit of the locking head 506 in the position shown in Figure 19. During a cutting action, as the cam follower member 1412 moves upwards, the protruding parts of the gates 1410 pivot away from each other to permit exit of the locking head 506 from the binding tool 1500. In this way, rotation of the second motor 212 through one rotation of the offset shaft 1418 causes the blade member 1402 to cut the strap behind the locking head 506 and also opens the gates 1410 to free the locking head 506 for release.

[0108] The second electric motor 212 is controlled via the controller 218. In particular, the controller 218 is configured to measure the current drawn (i.e. the load of the motor) by the first electric motor 202 when tensioning the applied strap 1001 and convert the drawn current into a tension applied by the tool 100 to the strap 1001. For example, as the load on the motor (the torque) increases, the amount of current that the motor draws increases linearly. The linear tension in the strap can be determined with the diameter of the feed roller 312 and torque needed to maintain the opposing forces (strap tension and motor torque) in balance. As the torque value acting on the strap 1001 (via the feed roller 312) may be modified through the transmission gear mechanism, the actual torque value present at the motor drive shaft 220 is determined using the dimensions of the roller an gear ratios. The actual torque acting on the motor drive shaft 220 is directly proportional to the current drawn by the first electric motor 202, allowing the controller 218 to determine the actual tension of the strap 1001 by monitoring the drawn current of the first electric motor 202 and compare it to a preset (via the selector member 208) desired maximum strap tension. When the desired maximum strap tension is reached or exceeded, the controller 218 will simultaneously deactivate the first electric motor 202 (and stop the feeder mechanism 300) and activate the second electric motor 212 and actuate the cut-off mechanism 1400, so as to cut through the strap section extending out of the engaged locking head 506 and release the engaged locking head 506 and looped strap 1001 from the tool 1500.

[0109] In an alternative example the offset shaft 1418 may be driven by the first electric motor 202 via a suitable gear mechanism adapted to selectively engage with the offset shaft 1418, i.e. the controller can selectively switch the output of the first electric motor 202 between the feeder mechanism 300 and the offset shaft 1418 operably coupled with the blade member 1402.

[0110] In some examples, a separate cutting system may be provided to cut the locking head 506 from a chain of locking heads 506 held within the tool.

Locking heads magazine assembly 1500

[0111] As shown in Figures 15 and 20, in the second example binding tool 1500 the locking heads magazine assembly 1500 is positioned in a lower part of the barrel portion 104. The locking heads magazine assembly 1500 includes a cartridge 1504 with an internal channel to receive the locking heads 506. The cartridge 1504 has an opening 1510 located below the adjustment knob 216 at the proximal housing end portion 108. Locking heads 506, preferably in the form of a chain of locking heads 1502, are positioned in the channel within the cartridge 1504 through the opening 1510. The channel within the cartridge 1504 also includes a ramp portion 1508 located at the distal housing end portion 106 which diverts locking heads 506 upwards into the cut-off mechanism 1400 and into position for receiving the strap 1001 during use. A spring plunger 1506 is slidable along the channel in the cartridge 1504 and urges the locking heads 506 towards the ramp portion 1508.

[0112] In the chain of locking heads 1502 the locking heads 506 are oriented with their openings perpendicular to the axial direction of the binding tool 1500, and as they move through the ramp portion 1504 they are oriented such that the openings are parallel to the axial direction of the binding tool 1500 and are positioned to receive the strap 1001 as described above.

[0113] The cartridge 1504 may be loaded with locking heads 506 (e.g., a chain of locking heads 1502) directly through the opening 1510. Additionally or alternatively, the cartridge 1504 may be detachable from the binding tool 1500. The cartridge may be attached to the binding tool by spring-biased retention hooks 1512 shown in Figure 20(a). The spring biased retention hooks 1512 can be disengaged using lever 1514, which protrudes from the housing as shown in Figure 15, to remove the cartridge 1504 from the binding tool 1500 for cleaning and/or re-loading.

[0114] A sliding tab 1520 may be provided to indicate the amount of locking heads 506 left in the feed channel 1504. Here, the sliding tab 1520 is mounted through the

housing as shown in Figure 15. When the sliding tab 1520 approaches or reaches the ramp portion 1508 the user knows to detach and replenish the cartridge 1504.

[0115] In some examples, a foremost locking head 506 with the strap 1001 attached thereto is severed from the chain of locking heads 1502 by the blade member 1402 during cutting of the strap 1001 as described above. Therefore, the cutting heads 506 are separated from the chain 1502 as they are ejected from the tool 1500. In other examples, the cutting heads 506 may be separately added to the channel 504 so they are already separate components, or the locking heads 506 be connected by a frangible connection that is broken by the tension of the strap 1001 pulling the locked locking head 506 from the binding tool 1500 after the strap 1001 has been cut. In some examples, the tool 1500 includes a second cutting system to cut the foremost locking head 506 from the chain 1502.

Example - description of a typical working sequence of the second example binding tool 1500

[0116] The working mode of the second example binding tool 1500 is similar to the working mode of the first example binding tool 100 described in detail above and can be divided into two subsequent phases (a) tool preparation phase and (b) tool working cycle. Only differences with the operation of the first example binding tool 100 are described below.

[0117] In the tool preparation phase (a) the locking heads magazine assembly 1500 is loaded and attached to the bottom of the tool 1500 as described with reference to Figures 15 and 20 above.

[0118] The other tool preparation steps are the same as the first example binding tool 100.

[0119] In the tool working cycle of the second example binding tool 1500, steps (1) to (10) as described above with reference to the first example binding tool 100 are the same. Steps (11) and (12) are replaced by alternative step (11) as set out below:

(11) During activation of the second motor 212 the offset shaft 1418 moves the cam 1416 and cam follower member 1412 upwards so as to cut through the loaded strap 1001 and open the gates 1410 release the locking head 506, and permit the next locking head 506 to move into position from the locking heads magazine assembly 1500.

Third Example Embodiment Automatic Binding Tool 2000

[0120] Figures 21 to 30 illustrate a third example embodiment of the automatic binding tool 2000 incorporating the principles of the present invention(s). The binding tool 2000 is preferably pistol shaped and intended to be hand-held by the user. The binding tool 2000 is similar to the first and second example binding tools 100, 1500 described above.

[0121] As with the previous examples the binding tool 2000 comprises a housing 102 having a barrel portion 104 extending along a longitudinal axis between a distal housing end portion 106 and a proximal housing end portion 108. A handle portion 112 extends away from the proximal housing end portion 108 in a direction intersecting with the longitudinal axis, for example, at an angle between 60° and 90° with respect to the longitudinal axis.

[0122] A magazine 2600 for a strap reel (inside) is provided on top of the barrel portion 104 and operably coupled with the tool mechanisms, so as to feed a coiled or reeled strap 2001 into the barrel portion 104 of the tool 100.

[0123] Figure 21(a) shows the complete binding tool 2000, and Figure 21(b) shows the binding tool 2000 with one side of the housing 102 removed. As illustrated, the housing 102 comprises a first housing part 102a and a second housing part 102b (removed in Figure 21(b) that form a clamshell housing within which the functional mechanisms of the binding tool 2000 are housed.

[0124] For a better understanding, the tool mechanism has been divided up into separate functional groups with respective ones operably coupled to one another, so as to provide the desired functions of the tool 2000. These functional groups include a drive unit 2200, mostly embedded within the proximal end 108 of the barrel portion 104, the handle portion 112 and partly in the reel magazine housing and adapted to control, actuate and drive the tool mechanisms. Another functional group is the feeder mechanism 2300, embedded within the barrel portion 104 adjacent to the reel magazine assembly 2600 and which is adapted to engage with and guidingly move the cable tie strap through the barrel portion 104 of the tool 2000 and apply a predetermined tension to an engaged cable tie strap. The feeder mechanism 2300 is actuated by the drive unit 2200. The cut-off mechanism 2400 is another functional group embedded within the distal end 106 of the barrel portion 104 and which is adapted to cut through the engaged cable tie strap when a predetermined tension applied to the strap tail is reached, as well as, cooperate with the locking heads magazine assembly 2500 which is configured to hold a plurality of separate locking heads and automatically position a locking head for use with the engaged strap. Another functional group of the tool 2000 is the reel magazine assembly 2600 that is configured to operably store one or more strap reels.

[0125] It is understood that any one of the respective functional groups 2200, 2300, 2400, 2500, 2600 may be partially interconnected with another functional group, and a part of one functional group may also be a component of, or at least operably coupled with, another functional group.

[0126] For simplicity and a better understanding, each one of the functional groups 2200, 2300, 2400, 2500 and 2600 is first described separately, before the binding tool function is described as a whole.

(i) Drive unit 2200

[0127] Referring now to Figures 21(a) to FIG. 22, the drive unit 2200 provides for actuation (driving) and control (tool settings and function) of any one of the feeder mechanism 2300 and the cut-off mechanism 2400. The drive unit 2200 of this particular example embodiment comprises, *inter alia*, a first electric motor 202, a switch unit 204 (with a trigger member and a selector member as described above), a removeable battery pack 210, and a second electric motor 212. As described above, in this example a user interface 2016 is provided to input a desired tension. The drive unit 2200 also includes a controller, which is housed within the reel assembly 2600 as with previous examples.

[0128] As with the previous examples, the controller may be provided on a printed circuit board (PCB) stored in the housing of the reel assembly 2600 and operatively coupled with any one of the other components, i.e. the first and second electric motor 202, 212, a user interface 2016, the switch unit 204, as well as, the battery pack 210. The controller may include any suitable programmable processor or integrated circuit (IC) configured to receive, process and transmit signals to and from any one of the drive unit components, as well as, execute predetermined sequences, functions and instructions provided by a user.

[0129] The first electric motor 202 is located in a proximal end portion 108 of the barrel portion 104 with a motor drive shaft 220 extending towards the distal end of the barrel portion 104. The drive shaft 220 is connected to the feeder mechanism 300 as described further below.

[0130] The switch unit 204 is mounted or integrated with the handle portion 112 and positioned so that a user can operate the switch unit 204 with a finger while holding the tool 2000 in one hand, i.e. at the upper front region of the handle portion 112.

[0131] The switch unit 204 of this example embodiment is the same as described above with reference to the tool 100 and tool 1500. The trigger member 206 is configured to activate and deactivate the first electric motor 202 (with controller). The trigger member 206 may be a biased push button operable by the user's index finger while holding the tool 2000. In particular, when pressing the push button or trigger member down or towards the handle portion 112 a signal is sent to the controller activating the first electric motor 202. Releasing the push button or trigger member will stop the activation signal and the controller stops the first electric motor 202. It is understood by the user, that any suitable switch or trigger mechanism may be used to activate and deactivate the first electric motor 202 of the tool 2000 with or without controller input.

[0132] In examples, as described above, a selector member or selector switch is provided with the switch unit 204 and is configured to switch the drive direction of the first electric motor 202 between clockwise and counterclockwise, i.e. the drive shaft will run clockwise at a first position of the selector member and counterclockwise at a second position of the selector member. It is understood by the person skilled in the art, that any suitable switch mechanism may be used to switch the motor direction with or without controller input.

[0133] In this example, the tension selector unit comprises a user interface 2016 is provided for setting a desired cable tie tension. The user interface 2016 is provided towards the proximal housing end portion 108. In particular, the user interface 2016 may comprise a display screen and one or more buttons. In some, examples the user interface 2016 may comprise a membrane keyboard. The user may use the button(s) to increase or decrease the desired tension, for example by selecting one or more preset tensions. The user interface 2016 may provide for setting a tension limit, or maximum tension. Setting a maximum strap tension will ensure that the force applied by the strap is with a predetermined range suitable to provide a secure fit without damaging the structure. The display screen may display the selected tension. The tool 2000 may also include the RFID reader as described with reference to the first example tool 100.

[0134] The display screen may also display other tool information, such as a battery charge state, or the status of the strap reel and/or locking head magazine (e.g., to indicate the how much reel is left, or how many locking heads are left).

[0135] The drive unit 2200 of this particular example embodiment also comprises a second electric motor 212 that is positioned in a distal end portion of the barrel portion 104 having a motor drive shaft 224 extending towards and coupled with the cut-off mechanism 2400 of the tool 2000 as described further hereinafter. The second electric motor 212 may be the same or a smaller, less powerful version of the first electric motor 202.

[0136] Alternatively, the first electric motor 202 may be utilised to drive both, the feeder mechanism 2300 and the cut-off mechanism 2400, wherein the activation of the first electric motor 202 and respective feeder 2300 and cut-off mechanisms 2400 are controlled via the controller and a suitable switch mechanism (not shown) between the feeder mechanism 2300 and the cut-off mechanism 2400.

[0137] Further, it is understood by the person skilled in the art, that any other suitable actuator (controllable and actuatable by the controller) may be used for "driving" the cut-off mechanism 2400.

[0138] As described above with reference to the first example tool 100, a power supply or battery pack 210 is mounted within the handle portion 112 of the tool 2000.

[0139] As shown in Figures 21(b) and 22, in contrast to the earlier examples, in the this example binding tool 2000 the cut-off mechanism 2400 is coupled to the feeder mechanism 2300 by a connecting member 2002 The connecting member 2002 is a C-shaped bridging component having a first end 2004 attached to the feeder mechanism 2300, a second end 2006 attached to the cut-

off mechanism 2400, and a bridging part 2008 extending therebetween. The connecting member 2002 directly connects the feeder mechanism 2300 to the cut-off mechanism 2400. Preferably, the connecting member 2002 is metal.

[0140] During use, tension applied to the strap reel by the feeder mechanism 2300 will impart a compressive and/or deflecting force on the connecting member 2002. In this example the connecting member 2002 is subject to this compressive and/or deflecting force and not the housing 102, which may flex. Accordingly, the tension is more reliably applied to the strap and the longevity of the housing 102 may be improved.

[0141] Additionally, the binding tool 2000 may include an extensometer (e.g., a strain gauge) to detect the compressive and/or deflecting force. The control system of the binding tool 2000 may use the detected compressive and/or deflecting force in addition to, or instead of, the motor current (or other parameter) to determine the tension in the strap reel. Operation of the first motor 202 and/or the second motor 212 may be controlled, at least in part, in dependence on the detected compressive and/or deflecting force.

(ii) Feeder mechanism 2300

[0142] As shown in Figures 22 and 23, the feeder mechanism 2300 is operably coupled with the first electric motor 202 via the drive shaft 220. The first electric motor 202 acts to rotate the feeder mechanism 2300. The feeder mechanism 2300 is operable to drive the reel strap from the reel magazine assembly 2600 (see Figure 21(b)) towards the distal housing portion 106 (in particular towards the cut-off mechanism 2400) so as to advance the reel strap during use. The feeder mechanism 2300 is also operable to retract the reel strap in the proximal direction in order to tighten the strap and apply tension before the cut-off mechanism 2400 cuts the strap. As shown in Figures 22 and 23, a strap guide member 2018 or guide channel is provided between the feeder mechanism 2300 and the cut-off assembly 2400 to guide the strap therebetween. A funnel 2020 is provided between the reel magazine assembly and an input to the feeder mechanism 2300 to guide the strap into the feeder mechanism 2300.

[0143] As described below, the feeder mechanism 2300 comprises a gear train and a plurality of rollers that act to grip and drive the strap in each direction according to the direction of rotation of the first electric motor 202. The gears of the gear train are arranged to rotate the rollers, and the strap is contacted (e.g., pinched) by the rollers to affect movement of the strap. The rollers and gear train are supported on various shafts that are housed, on bearings or bushings, in feeder housing 2322 shown in Figure 23. Figures 24(a), 24(b) and 25 illustrate the gear train and rollers of the feeder mechanism 2300.

[0144] As shown most clearly in Figure 24(a), the feeder mechanism 2300 includes three rollers 2312a, 2312b, 2312c. The strap passes into the feeder mechanism 2300 at inlet 2320, which is aligned with, or defined by, the funnel 2020 shown in Figure 23. From the inlet 2320 the strap passes between the first roller 2312a and the second roller 2312b, then between the second roller 2312b and the third roller 2312c. As the strap passes between the rollers 2312a, 2312b, 2312c it is pinched between the rollers 2312a, 2312b, 2312c. A spring 2322 acts to urge the second roller 2312b against the first and third rollers 2312a, 2312c as described in more detail with reference to Figure 25 below.

[0145] The gear train, shown most clearly in Figure 24(b), comprises a worm gear 2310 attached to the drive shaft 220. In Figure 24(b) the input gear 2314 is located behind the roller 2312a. The worm gear 2310 engages input gear 2314, which is rotationally fixed to the first roller 2312a, for example on the same shaft. Therefore, the drive shaft 220 drives rotation of the first roller 2312a via the worm gear 2310 and input gear 2314. A first roller gear 2316a is also provided rotationally fixed to the first roller 2312a. In Figure 24(b) the first roller gear 2316a is located in front of the roller 2312a. The first roller gear 2316a is thereby rotated with the first roller 2312a and the input gear 2314.

[0146] First and second transfer gears 2318a, 2318b rotationally couple the first roller gear 2316a to a second roller gear 2316b, which is rotationally fixed to the second roller 2312b (located in front of the second roller 2312b as illustrated). In this way, the second roller 2312b is also rotated during use. The second roller 2312b is rotated oppositely to the first roller 2312a.

[0147] A third transfer gear 2318c rotationally couples the first roller gear 2316a to a third roller gear 2316c, which is rotationally fixed to the third roller 2312c (located in front of the third roller 2312c as illustrated). In this way, the third roller 2312c is also rotated during use. The third roller 2312c is rotated in the same direction as the first roller 2312a.

[0148] Accordingly, the gear train transfers rotation from the first electric motor (212, see Figure 23), via input shaft 220, to each of the rollers 2312a, 2312b, 2312c. The strap is pinched between the rollers 2312a, 2312b, 2312c can be advanced or retracted according to the rotational direction of the first electric motor 212.

[0149] Figure 25 illustrates the feeder mechanism 2300 with the feeder housing 2022 removed. The input shaft 220, worm gear 2310, input gear 2314, first roller 2312a, first roller gear 2316a, and first and second transfer gears 2318a, 2318b are shown.

[0150] The various gears and rollers are mounted on shafts as follows:

The input gear 2314, first roller 2312a, and first roller gear 2316a are mounted to first roller shaft 2324a.

[0151] The second roller (2312b, see Figure 24(b)) and second roller gear (2316b, see Figure 24(b)) are mounted to second roller shaft 2324b.

[0152] The third roller (2312c, see Figure 24(b)) and

third roller gear (2316c, see Figure 24(b)) are mounted to third roller shaft 2324c.

[0153] The first, second and transfer gears 2318a, 2318b, 2318c are mounted to transfer gear shafts 2326a, 2326b, 2326c, respectively.

[0154] As illustrated, the first and second transfer gear shafts 2326a, 2326b and the second roller shaft 2324b are rotationally mounted to a rocker 2336. The second transfer gear shaft 2326b and the second roller shaft 2324b are mounted solely to the rocker 2336. The first transfer gear shaft 2326a is elongated to also be rotationally coupled to the feeder housing 2322 as shown in Figure 23. The first roller shaft 2324a, third roller shaft 2324c, and third transfer gear shaft 2326c are rotationally fixed, by bearings or bushings, to the feeder housing 2322 as shown in Figure 23. In this way, the rocker 2336, the first and second transfer gear shafts 2326a, 2326b and the second roller shaft 2324b can rotate within the feeder housing 2322 about the first transfer gear shaft 2326a, and move relative to the first roller shaft 2324a, third roller shaft 2324c, and third transfer gear shaft 2326c.

[0155] A spring 2334 is provided to bias the rocker 2336 such that the second roller 2312b is pressed against the first and third rollers 2312a, 2312c. In this way, the spring 2334 provides the pinching or gripping force between the rollers 2312a, 2312b, 2312c to grip the strap during use.

[0156] In order to open up the feeder mechanism 2300 for feeding the end of the a new strap reel through the feeder mechanism 2300, a cam shaft 2328 is provided. The cam shaft 2328 is rotationally fixed to the feeder housing 2322 as shown in Figure 23. As shown in Figure 25, the cam shaft 2328 includes a cam 2330 that acts in a cam slot 2330 formed in the rocker 2336. Rotation of the cam shaft 2328 causes the cam 2330 to urge the rocker 2336 against the force of the spring 2334, opening a gap between the first and second rollers 2312a, 2312b, and between the second and third rollers 2312b, 2312c. The cam shaft 2328 protrudes through the side of the housing 102 of the tool 2000, as shown in Figure 21(a), allowing a user to rotate the cam shaft 2328. The cam shaft 2328 includes flat ends, allowing the user to use a spanner or pliers to grip and rotate the cam shaft 2328. A knob, handle or lever may be provided on the cam shaft 2328.

(iii) Cut-off mechanism 2400

[0157] In this example tool 2000 the cut-off mechanism 2400 functions in substantially the same manner as the cut-off mechanism 1400 described with reference to the second embodiment tool 1500, in particular as described with reference to Figures 18 and 19. Alternatively, the cut-off mechanism 2400 may be the same as the cut-off mechanism 400 described with reference to the first embodiment tool 100. Only differences between the third example cut-off mechanism 2400 and the second example cut-off mechanism 1400 are described below.

[0158] As shown in Figures 26(a) to 26(c), the second electric motor 212 is coupled to the cut-off mechanism 2400 and operable to drive motion of the blade as previously described. The blade is provided within the cut-off assembly 2400 and actuated by the second electric motor 212 to cut the strap once it has been tensioned. The motion of the blade also actuates the locking head release assembly 1404, which works as described previously. The distal end of the cut-off mechanism, 2400 comprises a blade guard 2402.

[0159] In this example, as shown in Figure 26(a), an inlet funnel 2404 is provided on the proximal side of the cut-off mechanism 2400 through which the strap passes from the feeder mechanism 2300 described above. In particular, the inlet funnel 2404 receives the strap from the strap guide member 2018 illustrated in Figure 22. The inlet funnel 2404 has a mouth opening in the proximal direction to help the end of the strap feed from the feeder mechanism 2300 into the cut-off mechanism 2400 when a new reel is fed through the tool 2000.

[0160] As shown in Figure 26(b) and in more detail in Figure 26(c), the blade guard 2402 comprises a tapered opening 2406. The tapered opening 2406 includes a central opening 2408 through which the end of the strap is fed back into the tool 2000 during use to be inserted into a locking head, as described hereinafter.

[0161] To facilitate the re-insertion of the end of the strap, the tapered opening 2406 includes an upper tapered guide portion 2410 located above the central opening 2406. The upper tapered guide portion 2410 may include a sloped main wall 2412 and sloped side walls 2414, as illustrated, to guide the re-insertion end of the strap towards the central opening 2408.

[0162] As also illustrated, the tapered opening 2406 includes a lower tapered guide portion 2416, which is tapered towards the central opening 2408 to guide the re-insertion end of the strap towards the central opening 2408.

[0163] In the illustrated example the blade guard 2402 has two thicknesses - an upper potion 2418, in which the upper tapered guide portion 2410 is formed, has a greater thickness than a lower portion 2420, in which the lower tapered guide portion 2416 is formed. The different thickness portions 2418, 2420 help to define the tapered opening 2406 and improve guiding of the strap through the central opening 2408, into a locking head.

[0164] In addition, the central opening 2408 is formed (substantially or entirely)_at the thickness of the lower portion 2420. This may reduce the distance between the front surface of the blade guard 2402 and the locking head behind the blade guard 2402. This means that the end of the strap does not have to be pushed as far back into the tool 2000 to facilitate connection with the locking head, saving time and improving the results of the tool's operation.

[0165] A further advantage of providing the central opening 2408 in the thinner lower portion 2420 is that the distance between the locking head within the tool

2000 and the cable bundle being tied is reduced, meaning that the completed tie (strap and locking head) will more tightly bundle the cables.

(iv) Locking heads magazine assembly 2500

[0166] The locking heads magazine assembly 2500 of the tool 2000 is located in the underside of the barrel portion 104, as with the second example described above.

[0167] In this example, as shown in Figures 27(a) to 27(c), the locking heads magazine assembly 2500 comprises a magazine rail 2502 in which a plurality of locking heads can be stored. Figure 27(a) shows the complete locking heads magazine assembly 2500, Figure 27(b) shows the locking heads magazine assembly 2500 with one side removed to show the internal workings, and Figure 17(c) shows a magnified perspective end view of the locking heads magazine assembly 2500.

[0168] The magazine rail 2502 comprises a central channel that is substantially enclosed (e.g., with only a slot opening along one side) and shaped to receive the locking heads. The magazine rail 2502 includes a straight portion 2504 that extends along the bottom of the barrel portion (104, see Figure 21(a)), and a curved portion 2506 that curves upwardly to feed the locking heads into the cut-off assembly 2400 at the correct orientation (with their openings directed distally).

[0169] As shown in Figure 27(b), the locking heads magazine assembly 2500 includes a slider 2508 that is received within the central channel of the magazine rail 2502. The slider 2508 includes a lever 2510 that extends out of a slot in the housing 102 of the tool 2000 (see Figure 21(a)) to be accessible to a user for re-loading locking heads.

[0170] A spring 2512, in this case a pair of springs, is provided to bias the slider 2508 towards the curved portion 2506. The slider 2508 is flexible so that it can deform around the curved portion 2506 and push the locking heads up into the cut-off mechanism 2400. The spring 2512 is arranged at the transition between the straight portion 2504 and the curved portion 2506 and attached to a proximal end of the slider 2508, for example at the lever 2510. The spring 2512 acts to pull the slider 2508 towards the curved portion 2506. The length of the slider 2508 is configured so that the end of the slider can push the last locking head into the cut-off mechanism 2400 when the spring 2512 reaches its limit. In this example the two springs forming the spring 2512 are flat coil springs, in particular constant force flat coil springs. However, it will be appreciated that other types of springs may be used, for example extension springs.

[0171] As shown most clearly in Figure 27(c), the locking heads magazine assembly 2500 includes a re-loading door 2514. The re-loading door 2514 is disposed at the curved portion 2506 of the magazine rail 2502 and is pivotally connected to the magazine rail 2502 so it can be opened to gain access to the central channel of the magazine rail 2502 in line with the straight portion 2504. In this way, a locking head magazine 2520, such as that illustrated in Figure 28(a), can be fed into the magazine rail 2502. The user may retract the slider 2508 using lever 2510. Once the re-loading door 2514 is closed it will deflect the locking heads up through the curved portion 2506 into the cut-off assembly 2400 during use.

[0172] As shown in Figure 28(a), the locking head magazine 2520 comprises a plurality of locking heads 2522 joined to each other by joining portions 2524. The joining portions 2524 are broken as the locking heads 2522 are separated from each other in the cut-off assembly 2400.

[0173] As shown in Figure 28(b), each locking head 2522 comprises a body portion 2526, which may for example be polymer. The body portions 2526 of multiple locking heads 2522 may be moulded as a single part. The body portion 2526 has a central opening 2530 through which the strap is fed to be secured to the locking head 2522. The locking head 2522 also includes teeth 2530 protruding at an angle into the central opening 2528. The teeth 2530 are preferably metal, or example steel. The teeth 2530 are preferably deflectable to grip the strap as described below.

[0174] When a single thickness of the strap is fed through the central opening 2528 (when the feeder mechanism 2300 advances the strap during use) the teeth permit free movement of the strap because the strap can pass through the gap between the teeth 2530. When the end of the strap is fed back into the locking head 2522 after wrapping around a bundle, the teeth 2530 are angled to permit the strap to be pushed back through the central opening 2528. Once pushed in, when two thicknesses of the strap are present within the central opening 2528, the angle of the teeth 2530 prevents movement out of the central opening 2528, thereby locking the strap about the bundle and maintaining the applied tension. In this configuration the strap can be cut (by the cut-off mechanism 2400) to separate the locked locking head and strap.

[0175] As illustrated in Figure 28(a) and 28(c), each joining portion 2524 between two locking heads 2522 of the locking head magazine 2520 comprise two joining strips 2536a, 2536b. As shown most clearly in Figure 28(c), each joining strip 2536a, 2536b comprises a pre-cut 2538 at one end, where it joins one of the locking heads 2522. The pre-cuts 2538 create points of weakness in the connections between each locking head 2522 and the joining strips 2536a, 2536b. Therefore, as the locking heads 2522 are separated from each other in the cut-off mechanism 2400 the position of the break in the joining strips 2536a, 2536b will be at the pre-cuts 2538, in particular directly at the side wall of the locking head 2522. The pre-cuts 2538 are formed at the side walls of the locking heads 2522 that will be 'free' (i.e., not connected to another locking head 2522) in the cut-off mechanism 2400. This side wall of each locking head 2522 abuts an internal surface in the cut-off mechanism

2400 when it is the end locking head 2522, and the absence of any joining strip 2536a, 2536b on this end of the locking head 2522 in the cut-off mechanism 2400 helps to ensure good alignment of the locking head 2522 in the cut-off mechanism 2400 (i.e., the locking head 2522 can sit flush on the surface within the cut-off mechanism 2400).

[0176] In some examples, as illustrated in Figure 29, the central channel of the magazine rail 2502 and/or the locking head magazine 2520 may be shaped so as to only permit insertion of the locking head magazine 2520 in the correct orientation. For example, the locking head magazine 2520 (for example each locking head 2520) may include a slot 2532 that aligns with a protrusion 2534 in the magazine rail 2502 (e.g., close to the reloading door 2514). In this way, the user is prevented from inserting the locking head magazine 2520 in the wrong orientation. Preferably the slot 2532 and protrusion 2534 are offset to one side of the magazine rail 2502, restricting the insertion of the locking head magazine 2520 to one single orientation.

[0177] In examples, the locking heads magazine assembly 2500 may include a sensor arranged to detect when the last locking head has been loaded into the cut-off mechanism 2400, or when no further locking heads are remaining, or when a set number of locking heads are remaining. For example, the sensor may detect the position of the front of the slider 2508 when it reaches a location corresponding to a set number of locking heads remaining (e.g., zero, one, two locking heads remaining). The sensor may be located at or near the end of the magazine rail 2502, close to the cut-off mechanism 2400.

[0178] Additionally or alternatively, the position of the lever 2510 (which is visible on the exterior of the tool 200 as shown in Figure 21(a)) can indicate the number of locking heads remaining, or when a new locking heads magazine 2520 needs to be loaded.

(v) Reel magazine assembly 2600

[0179] The reel magazine assembly 2600 is substantially the same as described with reference to the first and second embodiments 600, 1600. In particular, the reel magazine assembly 2600 is substantially the same as the reel magazine assembly 600 described with reference to Figures 3, 4, 5 and 6. Only differences between the third example cut-off mechanism 2400 and the second example cut-off mechanism 1400 are described below.

[0180] As shown in Figure 21(b), in the third example tool 2000 the reel magazine assembly 2600 is disposed lower down, closer to the handle 112, as compared with previous examples. This reduces the height of the tool 2000 and improves operability.

[0181] As with the previous examples, the reel 1000 is placed into the reel magazine assembly 2600 by a user through a reel cover. In this example, as shown in Figure 21(a), the reel cover 2604 is pivotally mounted to the housing 102 at pivot 2604 so it can be pivoted open to change the reel 1000.

[0182] As shown in Figures 30(a) and 30(b), the reel 1000 is preferably shaped so as to only be insertable in the reel magazine assembly 2600 in a single orientation. In particular, the reel 1000 includes a hub 2608 and two flanges 2610a, 2610b. The hub 2608 is tubular, preferably cylindrical, with a central opening. One end of the tubular hub 2608 is closed by end cap 2612. The other end of the tubular hub 2608 is open to receive a shaft of the reel magazine assembly 2600, for example a spring-biased shaft mounted to the reel cover 2604. When the reel cover 2604 is opened the reel 1000 can be placed on the shaft, and can only be placed on the shaft in one orientation due to the end cap 2612.

[0183] Additionally, the first flange 2610a may be smaller in outer diameter than the second flange 2610b. The inner opening of the reel cover 2604 in which the reel 1000 is received may be shaped to be larger than the first flange 2610a and smaller than the second flange 2610b. In this way, the reel 1000 can only be inserted into the reel cover 2604 in a single orientation.

[0184] Beneficially, the orientation of insertion of the reel 1000 into the reel magazine assembly 2600 can ensure that the end of the strap is properly directed towards the funnel (2020, see Figure 22) of the feeder mechanism (2300, see Figure 22). Additionally, the orientation of the reel 1000 can ensure that when the end of the strap is advanced through the cut-off mechanism 2400 and out of the distal end of the tool 2000, it is curved slightly upwards (due to the wrapping of the strap about the reel 1000). This curvature may help the user to wrap the strap about the items to be bundled, and also facilitate re-insertion of the end back into the cut-off mechanism 2400.

Example - description of a typical working sequence of the first example binding tool 2000

[0185] The working mode of the tool 2000 can be divided into two subsequent phases (a) tool preparation and (b) tool cycle. The first phase (a) has the purpose to prepare the tool 2000 to be working ready or primed for a particular job. This can be done so the tool 2000 is fully primed or only partially primed, depending on the needs of the job. The second phase (b) is the same for every bundling action or job.

(c) Tool Preparation:

[0186] The initial tool preparation is the sequence of operations needed to prepare or prime the tool 2000 to perform in a predetermined (desired) way. This includes:

(a) checking the charging status of the battery 210 and recharge the battery 210 if required,
(b) check and load a locking head magazine 2520 into the magazine assembly 2400 (see Figures 27 to

29),
(c) opening the feeder mechanism 2300 using the cam shaft 2328 and feeding an end of the strap from the cable strap reel 1000 into the feeder mechanism 2300 until it is engaged with the rollers 2312a, 2312b, 2312c (see Figures 22 to 25), and
(d) setting a desired maximum cable strap tension for the job via the user interface 2016 (see Figure 21(a)).

(d) Tool Working Cycle:

[0187] The tool working cycle is the same for every operation once the tool 2000 is primed and provides the user with a length of strap that can be looped around a structure and reengaged with the tool 2000 to be tightened and locked using a locking head 2522. The following steps are provided in the required order:

(13) The selects "forward" position using the switch unit 204 of the drive unit 2200, thus, providing the controller with a forward driving signal for the first electric motor 202;

(14) The user presses the trigger member of the switch unit 204 to activate the first electric motor 202 (via controller);

(15) The rotating drive shaft 220 of the first electric motor 202 drives the feeder mechanism 2300 to pull the strap forward towards the distal housing end portion 106, through the cut-off mechanism 2400 and the loaded locking head 2522 and out of the distal end of the tool 2000;

(16) The user releases the trigger member when sufficient length of the strap is pushed out of the tool 2000 to stop the first electric motor 202;

(17) The user loops the free end section of the delivered strap around the structure (e.g. bundle of cables) and insert the end back into the tool 2000 through the loaded locking head 2522 in the cut-off mechanism 2400 via the central opening 2408 of the blade guard 2402 until the end portion of the strap is received in the locking head 2522;

(18) The user slides the selector member of the switch unit 204 to the tool's "rearward" or "reverse" position, thus, providing the controller with a rearward driving signal for the first electric motor 202;

(19) The user presses the trigger member of the switch unit 204 to activate the first electric motor 202 (via controller) now pulling the loaded strap back in;

(20) The controller monitors the tension applied to the strap, e.g., based on one or more of a current drawn by the first electric motor 202 and a deformation of the connecting member 2002, and determines the tension applied to the loaded strap (while comparing it with the preset desired maximum or target cable strap tension);

(21) When the target cable strap tension is reached or exceeded, the controller initiates deactivation (stopping) of the first electric motor 202 and activation of the second electric motor 212 so as to actuate the cut-off mechanism 2400;

(22) At this instance, the second electric motor 212 rotatingly drives the cut-off mechanism 2400 to operate the blade to cut the strap and release the locked locking head with strap loop;

(23) The cut-off mechanism and locking heads magazine assembly 2500 cooperate to move the next locking head 2522 into the cut-off mechanism 2400, when the tool 2000 is ready for the next tool cycle.

[0188] It will be appreciated by persons skilled in the art that the above embodiment(s) have been described by way of example only and not in any limitative sense, and that various alterations and modifications are possible without departing from the scope of the invention as defined by the appended claims. Various modifications to the detailed designs as described above are possible, for example, variations may exist in shape, size, arrangement (i.e. a single unitary components or two separate components), assembly or the like.

Claims

1. An automatic tool for tensioning and severing a strap, comprising:

a pistol-shaped housing, having a barrel portion extending between a distal housing end portion and a proximal housing end portion along a longitudinal axis, and a handle portion extending away from said barrel portion in a direction different to said longitudinal axis;
a reel magazine assembly, configured to retainingly receive at least one strap reel and provide for a rotation of the at least one strap reel about a strap reel centre axis, wherein said rotation is directed so as to wind up a strap coiled up onto the at least one strap reel;
a feeder mechanism, provided within said barrel portion and configured to receive an end portion of the strap from the at least one strap reel and move the strap in a direction along said longitudinal axis;
a locking heads magazine assembly, provided within said barrel portion and configured to store

a plurality of locking heads and supply one locking head at the time for use with the strap;
a cut-off mechanism, provided within said barrel portion, configured to cut the strap and receive and move said one locking head from said locking heads magazine assembly into a loading position ready for engagement with the strap;
a drive unit, configured to drive said feeder mechanism so as to selectively move the strap towards said distal housing end portion or towards said reel magazine assembly, and actuate said cut-off mechanism at a predetermined condition.

2. An automatic tool according to claim 1, wherein said drive unit comprises at least one first electric motor, a switch unit, a tension selector unit adapted to provide a reference parameter indicative of a desired maximum tension of the strap, and a controller operatively coupled to any one of said at least one first electric motor, said switch unit and said tension selector unit.

3. An automatic tool according to claim 2, wherein said controller is adapted to receive signals from said switch unit and said tension selector unit and control said feeder mechanism and said cut-off mechanism.

4. An automatic tool according to claim 3, wherein said controller is adapted to monitor a predetermined performance parameter of said at least one first motor that is indicative of an existing tension in the strap, and compare said predetermined performance parameter to said reference parameter provided by said tension selector unit.

5. An automatic tool according to claim 4, wherein said predetermined performance parameter of said at least one first electric motor is an electric current corresponding to the load of the electric motor.

6. An automatic tool according to any one of claims 2 to 5, comprising a connecting member disposed between the feeder mechanism and the cut-off mechanism, and an extensometer arranged to detect a deformation of the connecting member, the deformation being indicative of the existing tension in the strap, and wherein the controller is configured to monitor a signal received from the extensometer and compare said signal to said reference parameter provided by said tension selector unit.

7. An automatic tool according to any one of claims 4 to 6, wherein said predetermined condition is met when the existing tension in the strap is greater than or equal to a desired maximum tension defined via said reference parameter of said tension selector unit.

8. An automatic tool according to any one of claims 2 to 7, wherein said switch unit comprises a trigger member, configured to affect activation and deactivation of said at least one first electric motor, and a switch member, configured to set the drive direction of said at least one first electric motor.

9. An automatic tool according to any one of claims 2 to 8, wherein said tension selector unit comprises a user interface having a display screen and one or more buttons for a user inputs, in particular a desired strap tension.

10. An automatic tool according to any one of claims 2 to 9, further comprising at least one RFID reader operatively coupled with said controller and adapted to receive information from a corresponding RFID tag.

11. An automatic tool according to any one of the preceding claims, wherein the feeder mechanism comprises a first roller and a second roller that are rotatable by the first electric motor, wherein the position of the second roller is biased against the first roller, and wherein the strap is driven by rotation of the first roller and the second roller when fed between the first roller and the second roller.

12. An automatic tool according to claim 11, wherein a first roller gear is coupled to the first roller and a second roller gear is coupled to the second roller, the first and second roller gears being driven by the first electric motor to rotate the first and second rollers.

13. An automatic tool according to any one of the preceding claims, wherein said cut-off mechanism comprises a blade member slidingly moveable between a first position, disengaged from the loaded strap, and a second position, cuttingly engaged with the loaded strap.

14. An automatic tool according to claim 13, wherein said drive unit further comprises a second electric motor operatively coupled with said controller and adapted to acuate said cut-off mechanism at said predetermined condition.

15. An automatic tool according to claim 14, wherein said blade member is operably coupled to said second electric motor via a rotating cam member adapted to move said blade member between said first position and said second position.

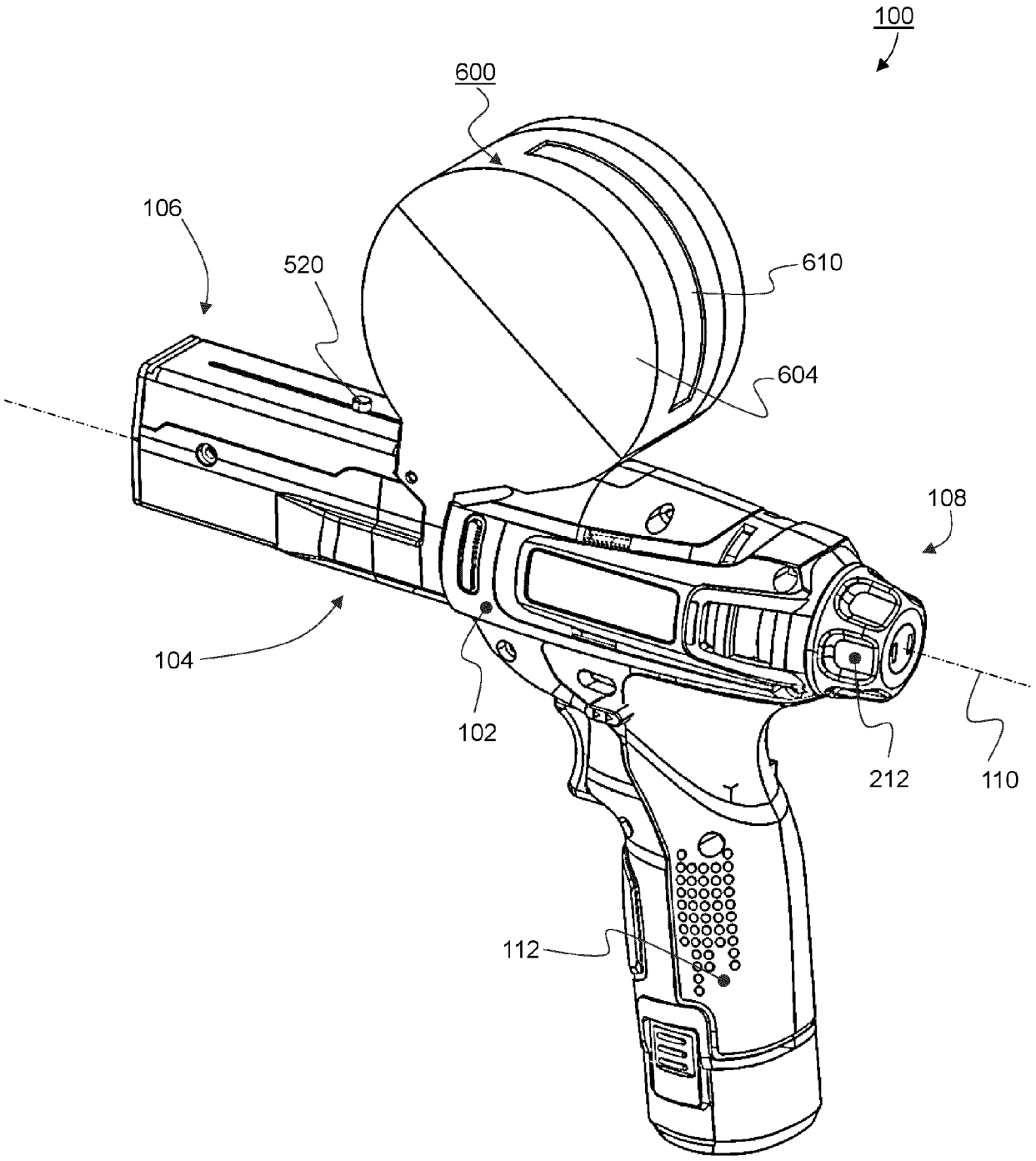
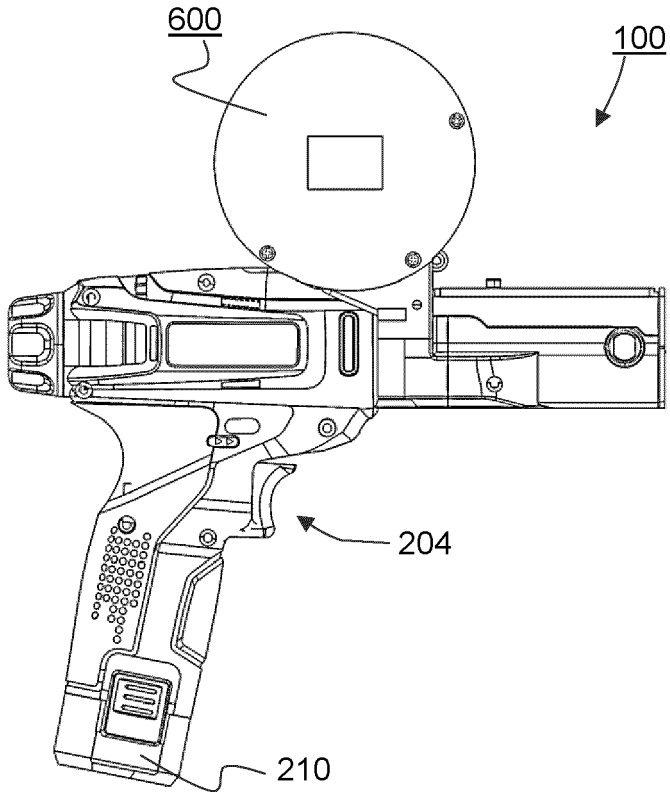
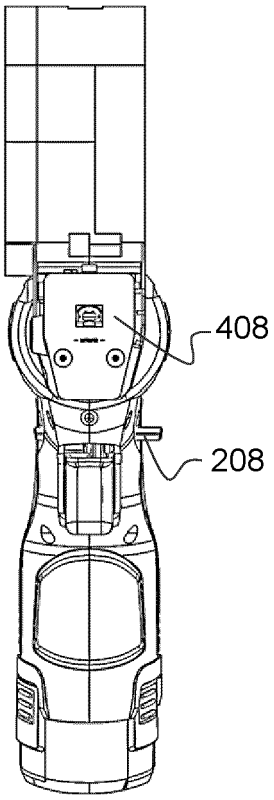


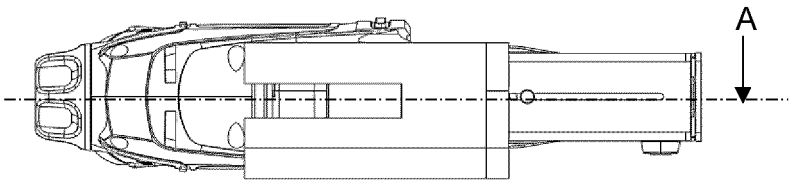
FIG. 1



(a)



(b)



(c)

FIG. 2

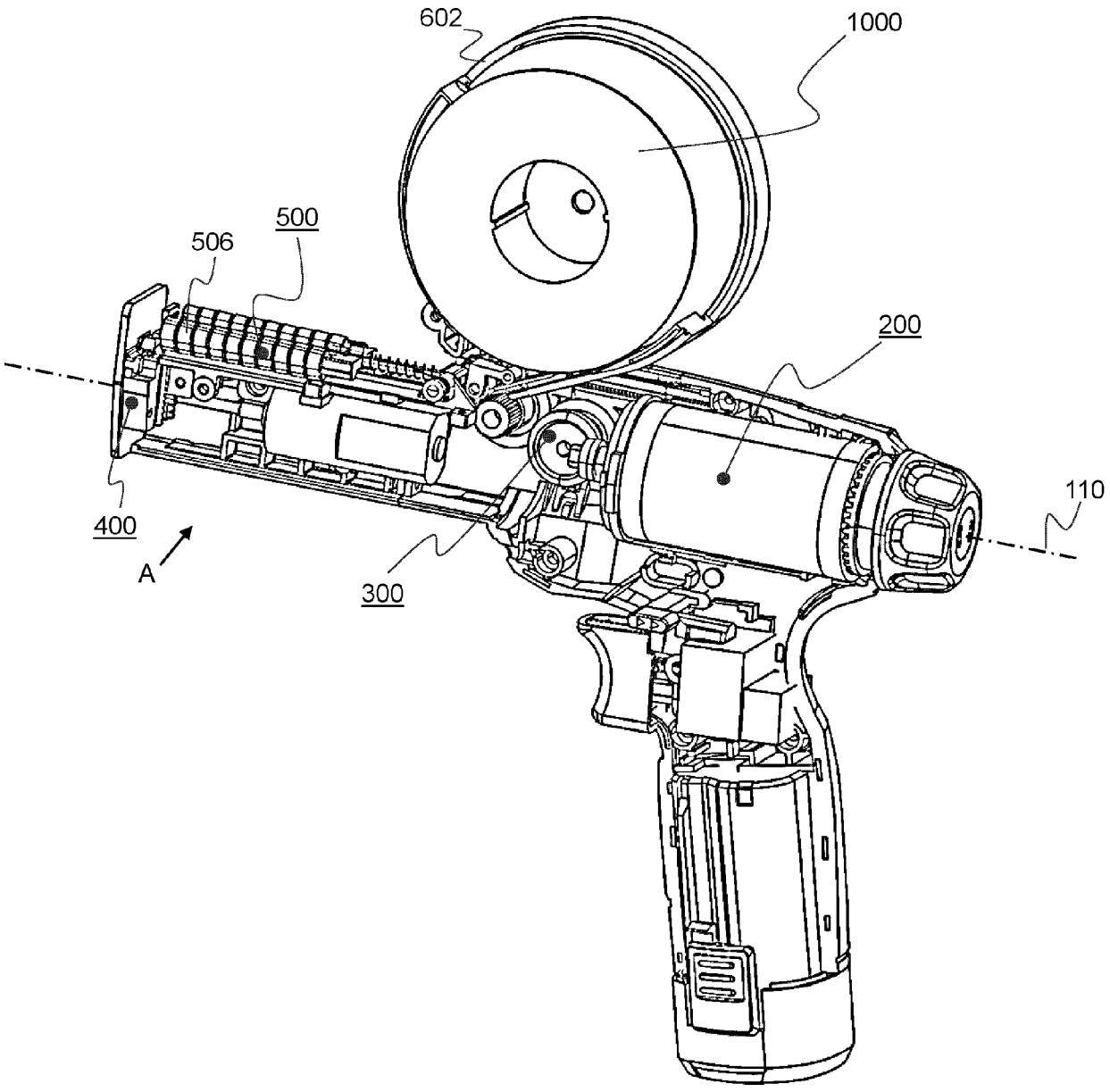


FIG. 3

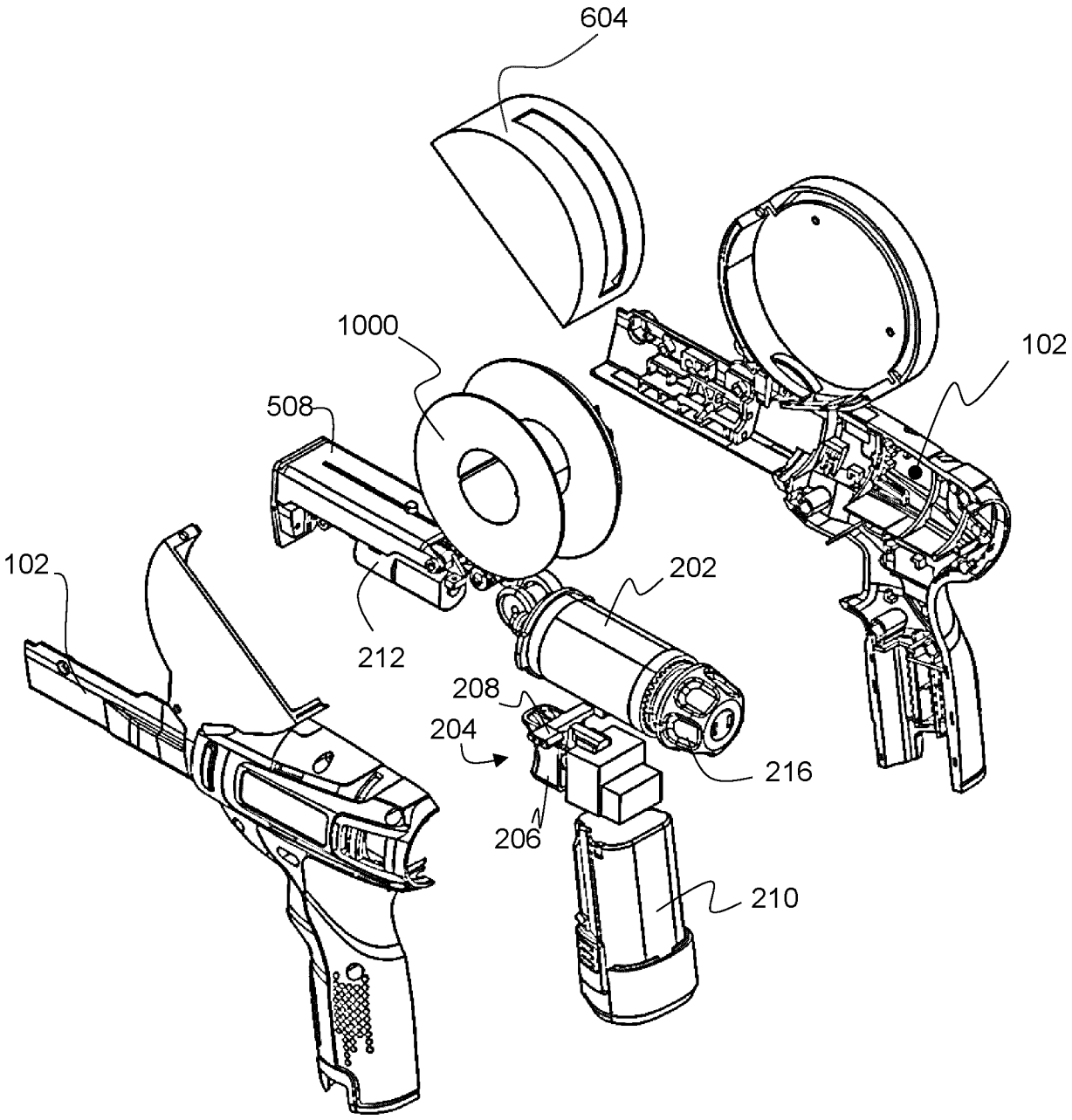


FIG. 4

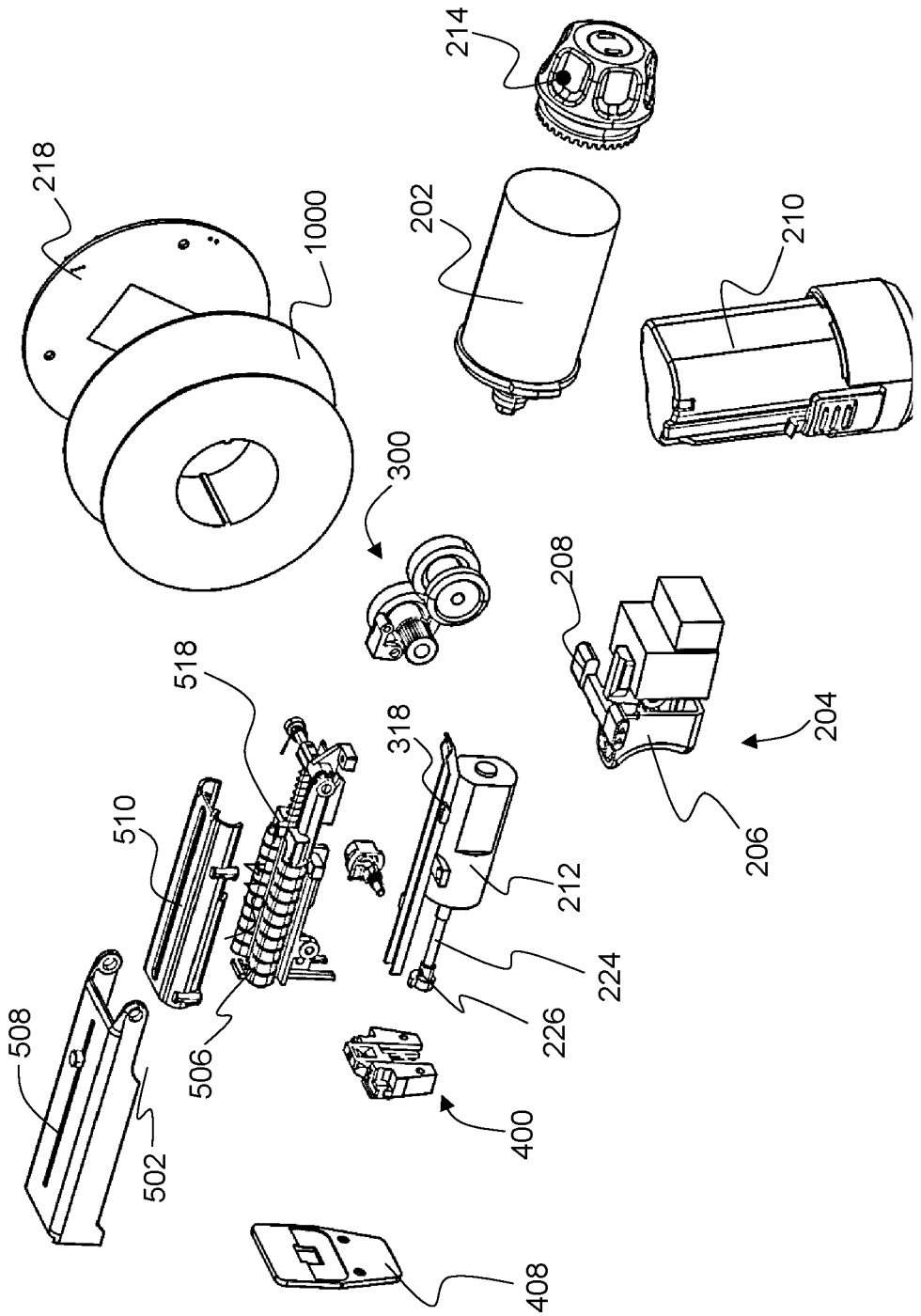
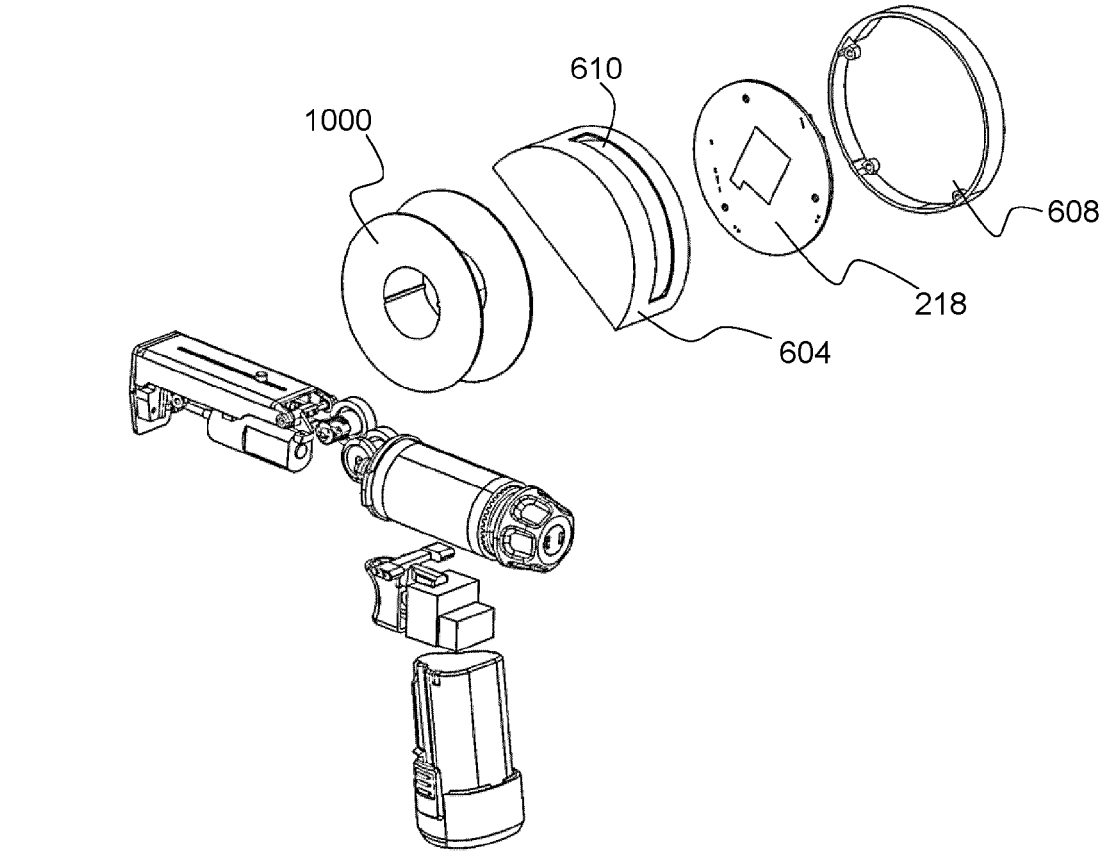
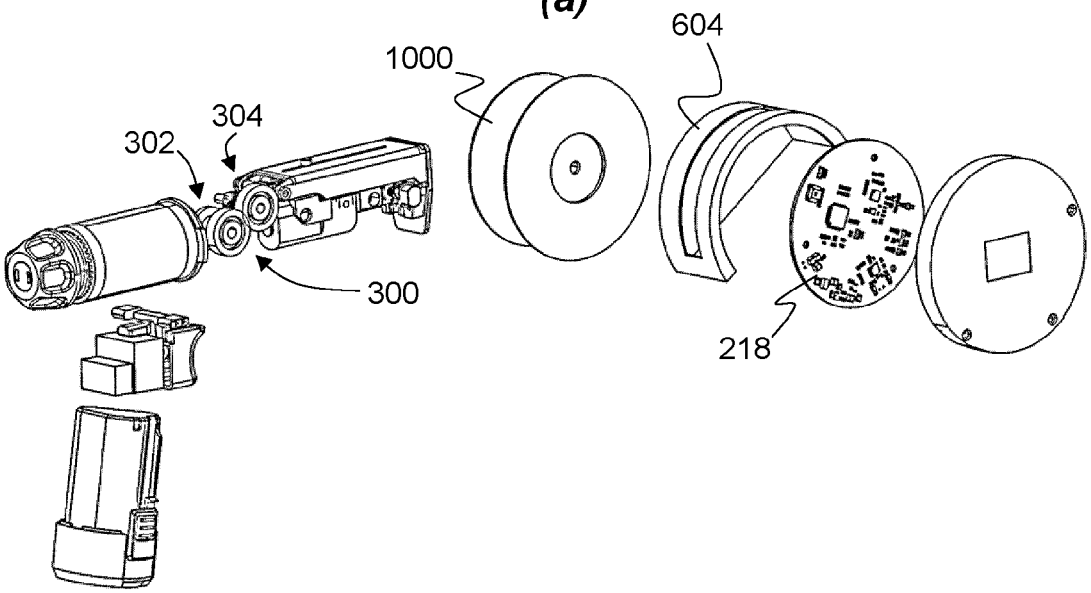

214
218
1000
202
210
300
208
518
318
204
510
212
206
224
508
506
226
400
502
408

FIG.5

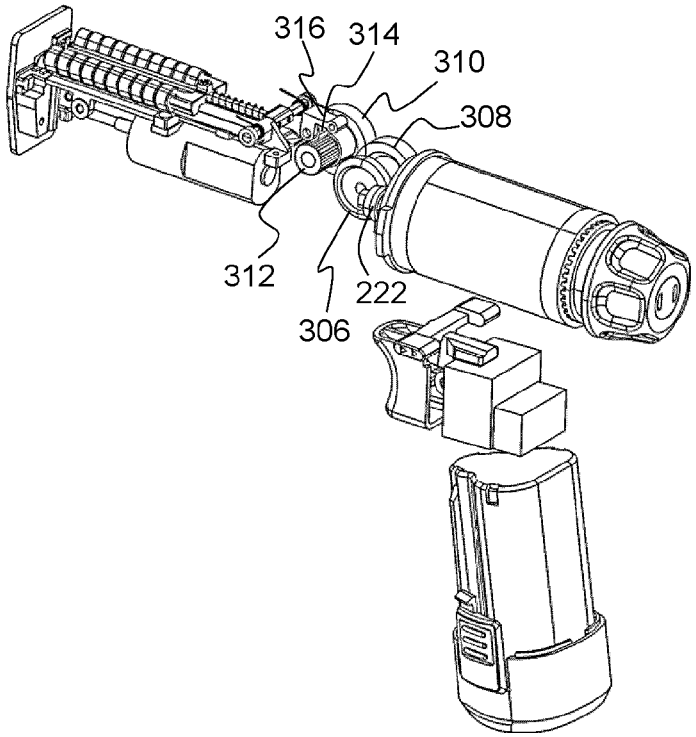


(a)

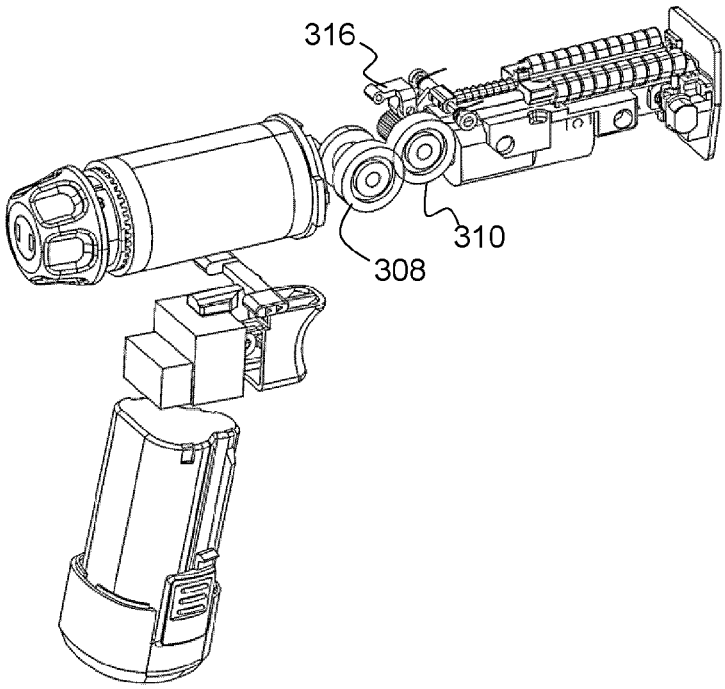


(b)

FIG. 6

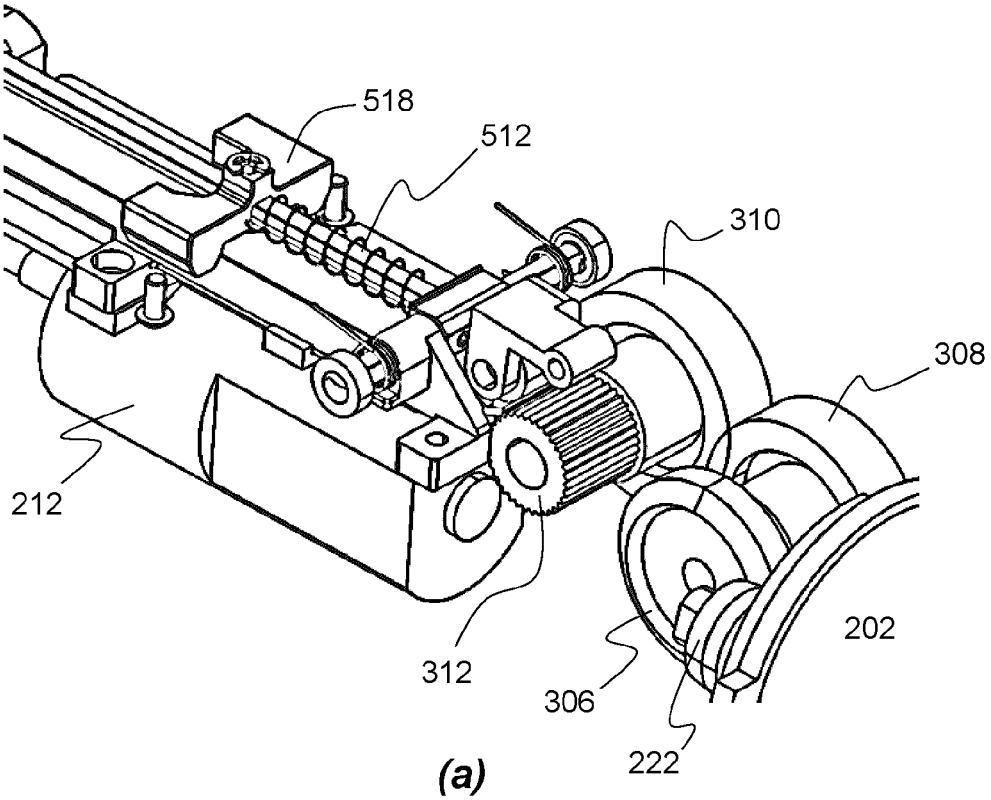


(a)

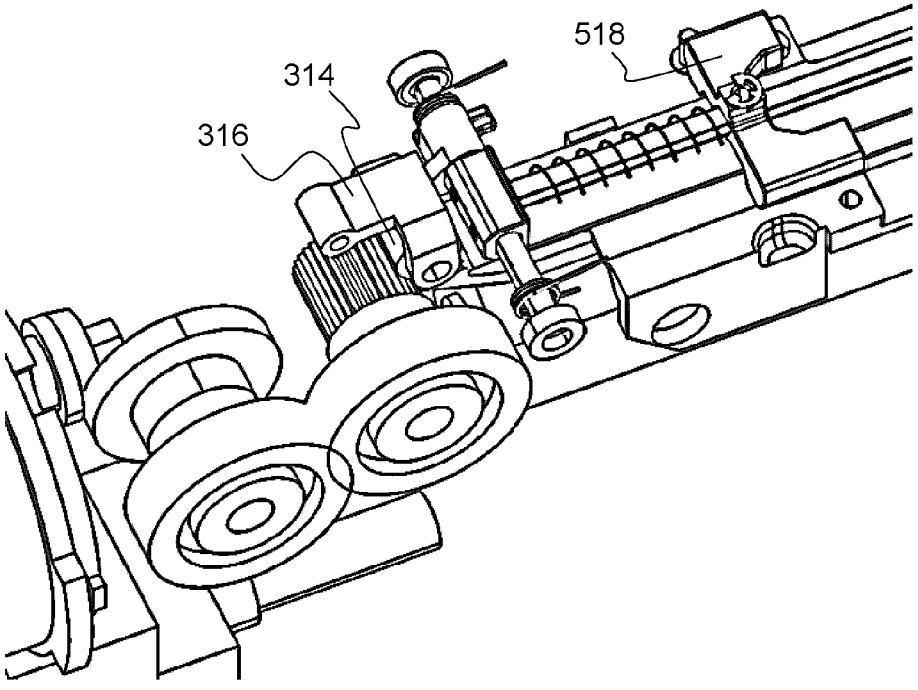


(b)

FIG. 7

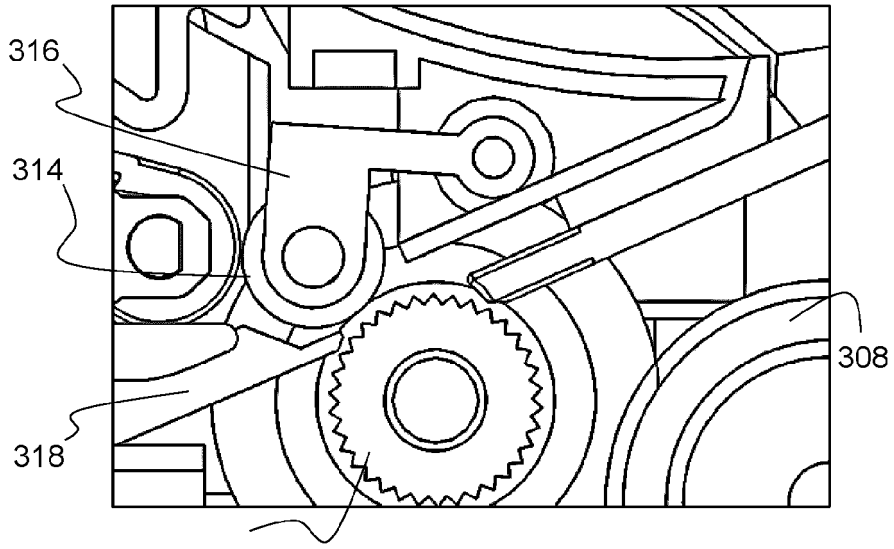


(a)

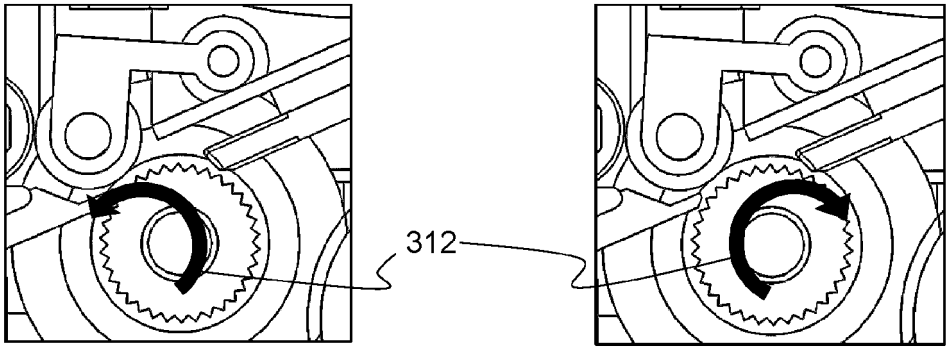


(b)

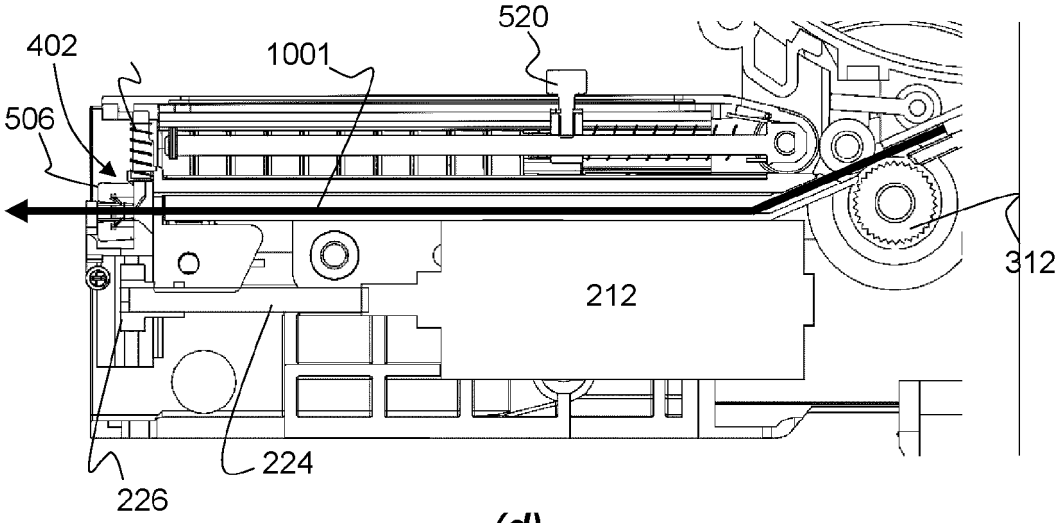
FIG. 8



(a)

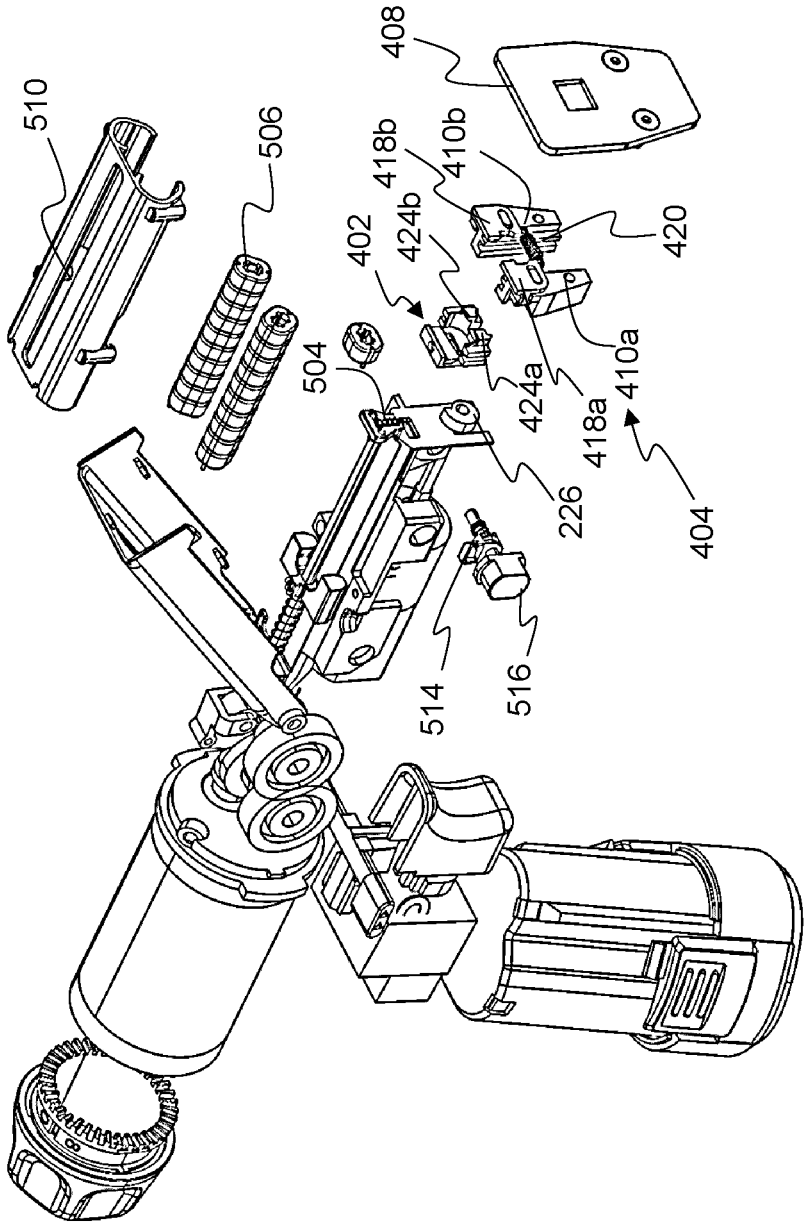


(b) *(c)*



(d)

FIG. 9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506
408
418b
410b
402
424b
420
504
424a
418a
410a
226
404
514
516

FIG. 10

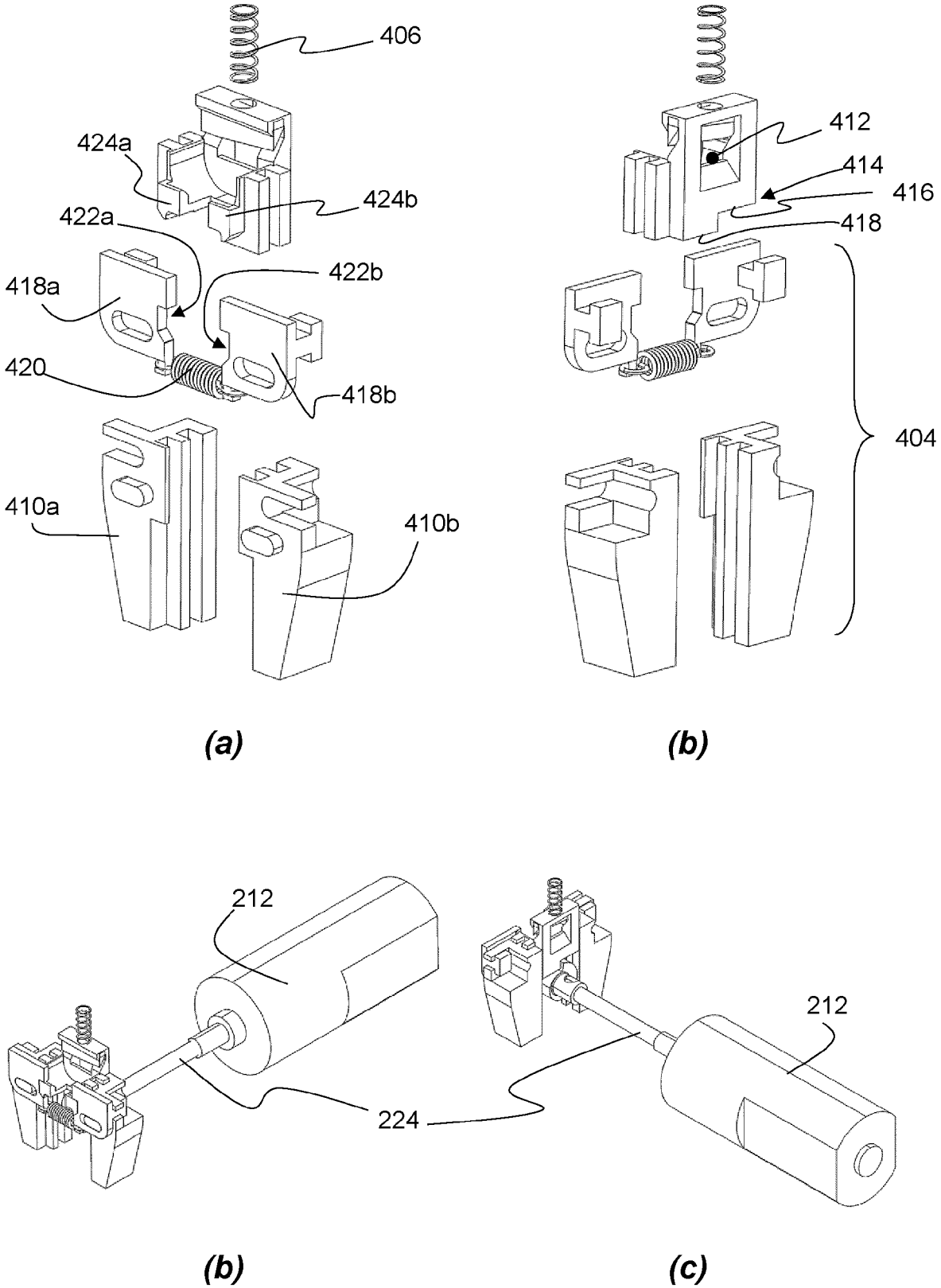

406
424a
424b
422a
422b
418a
420
418b
410a
410b
412
414
416
418
404
(a)
(b)
212
224
212
(b)
(c)

FIG. 11

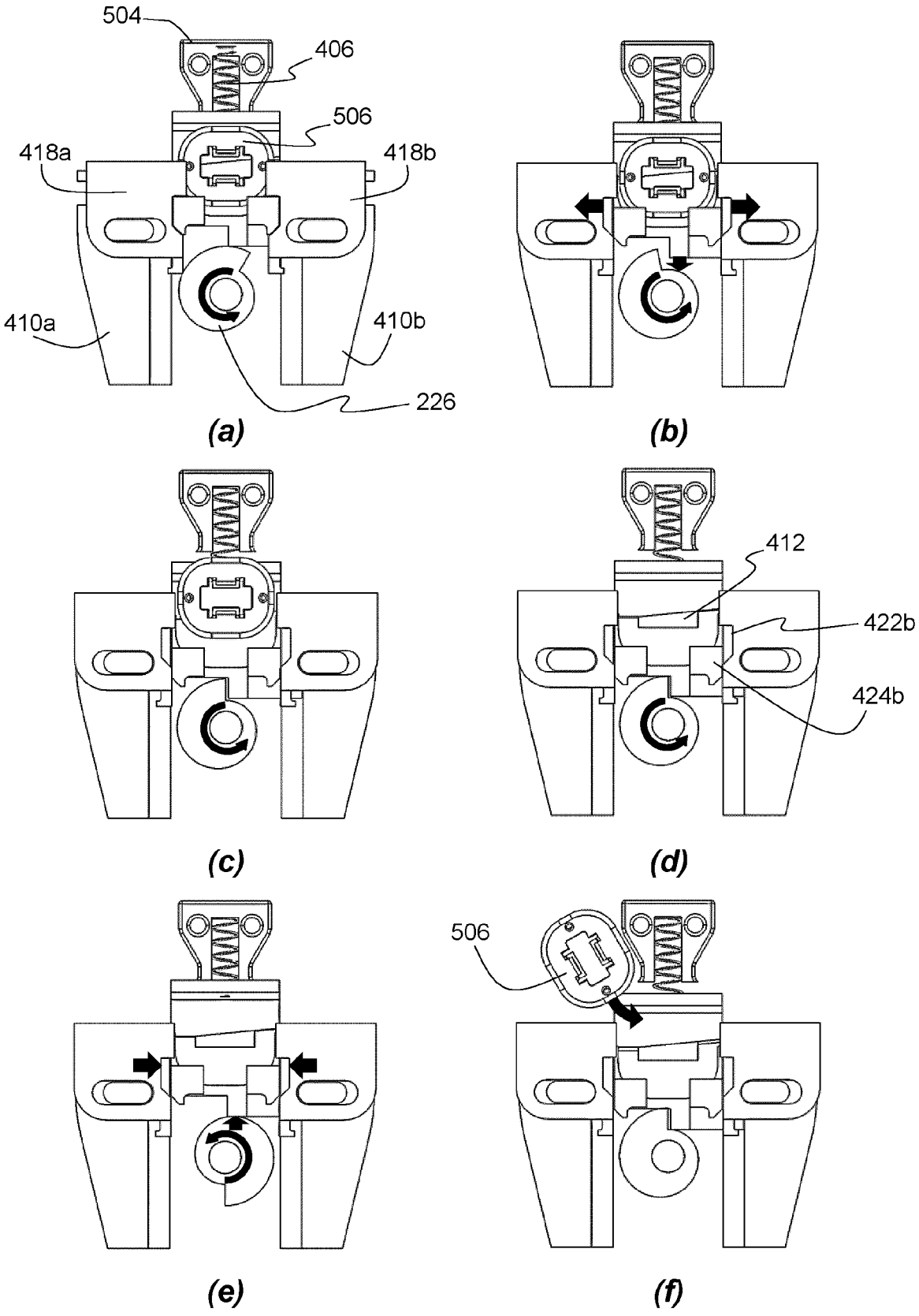
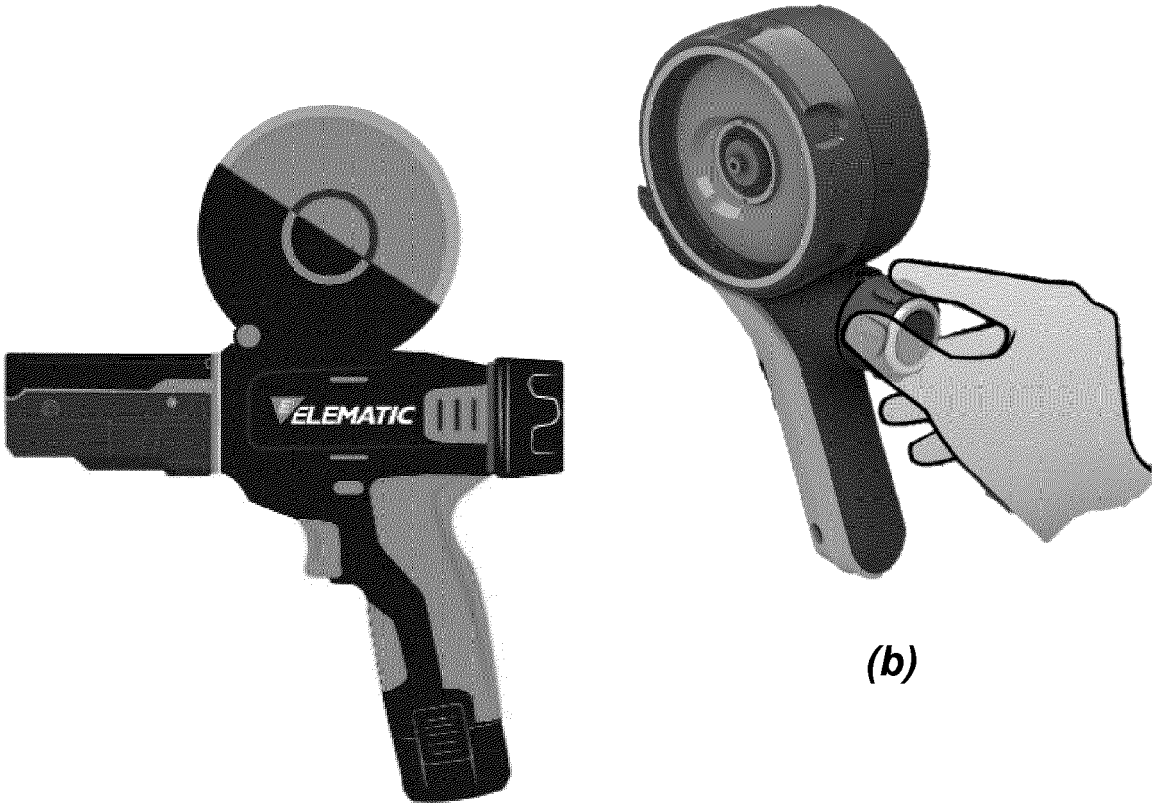
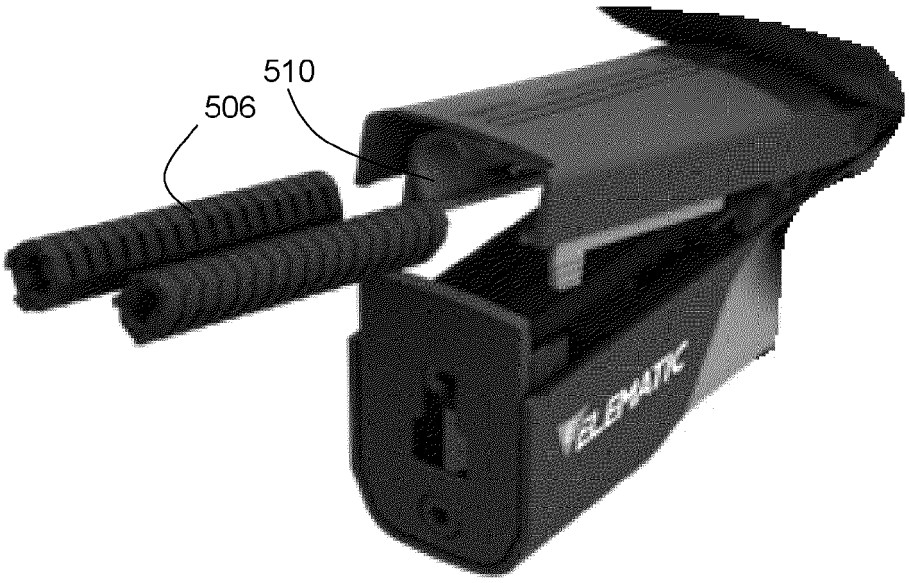


FIG. 12



(a)

(b)



(c)

FIG. 13

FIG. 14

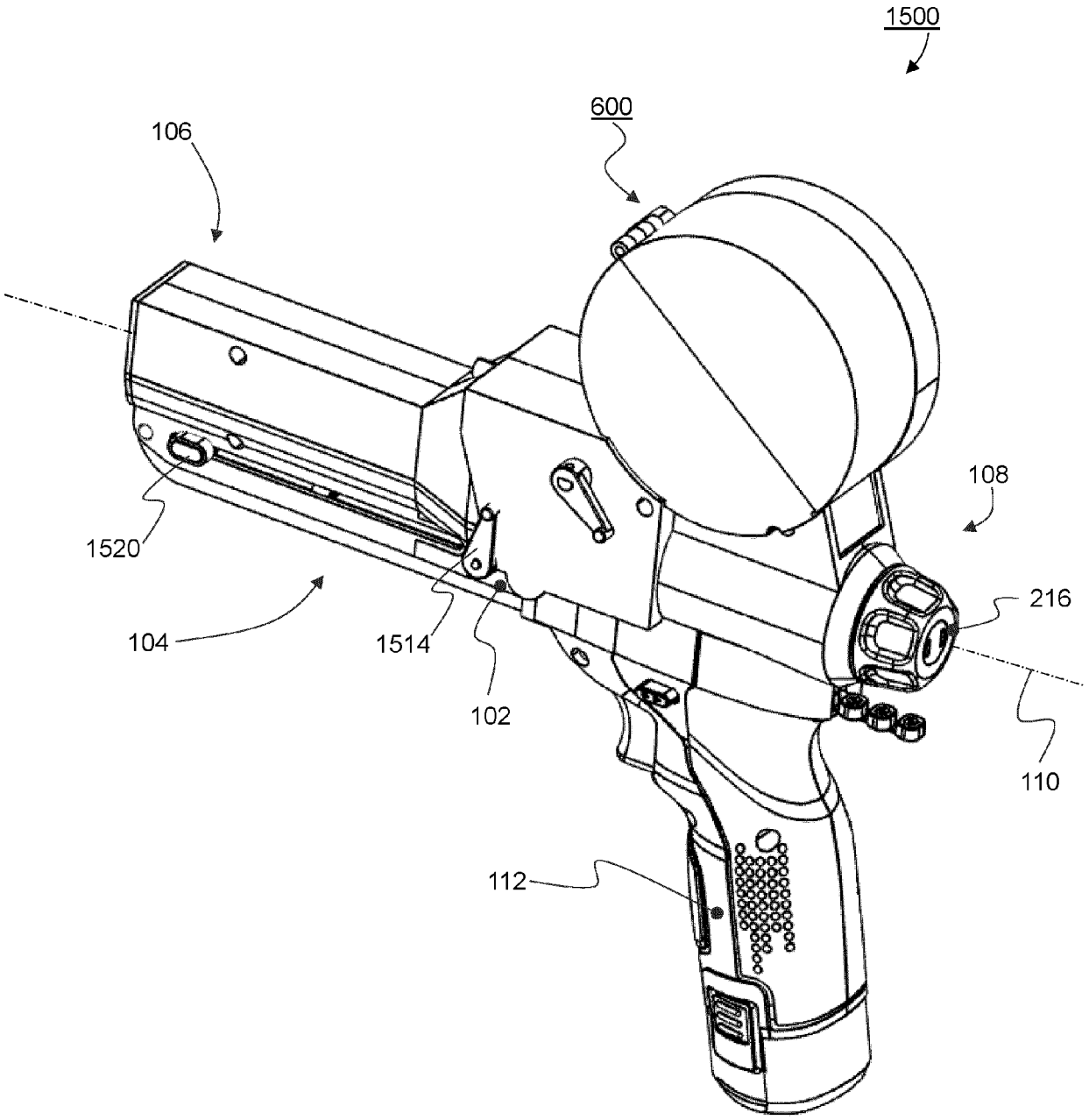


FIG. 15

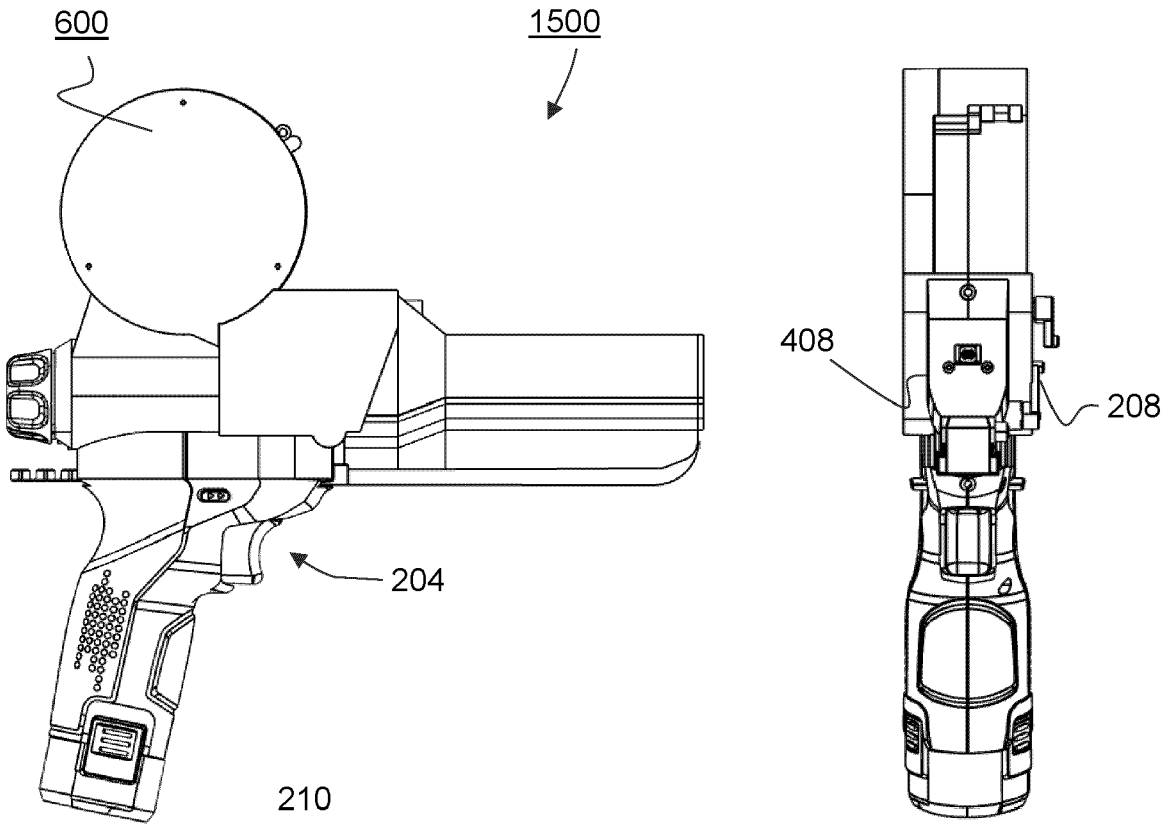


FIG. 16

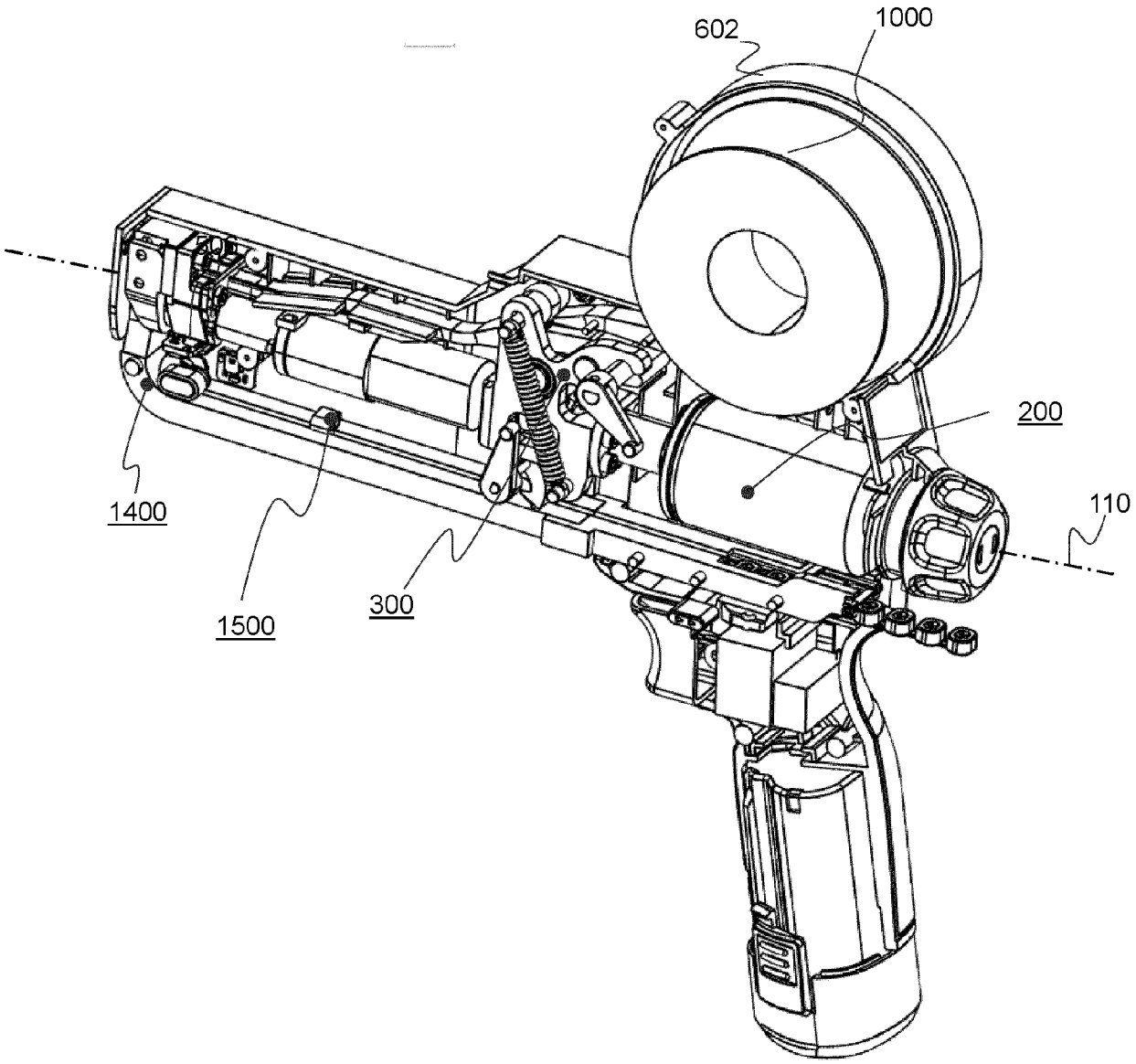
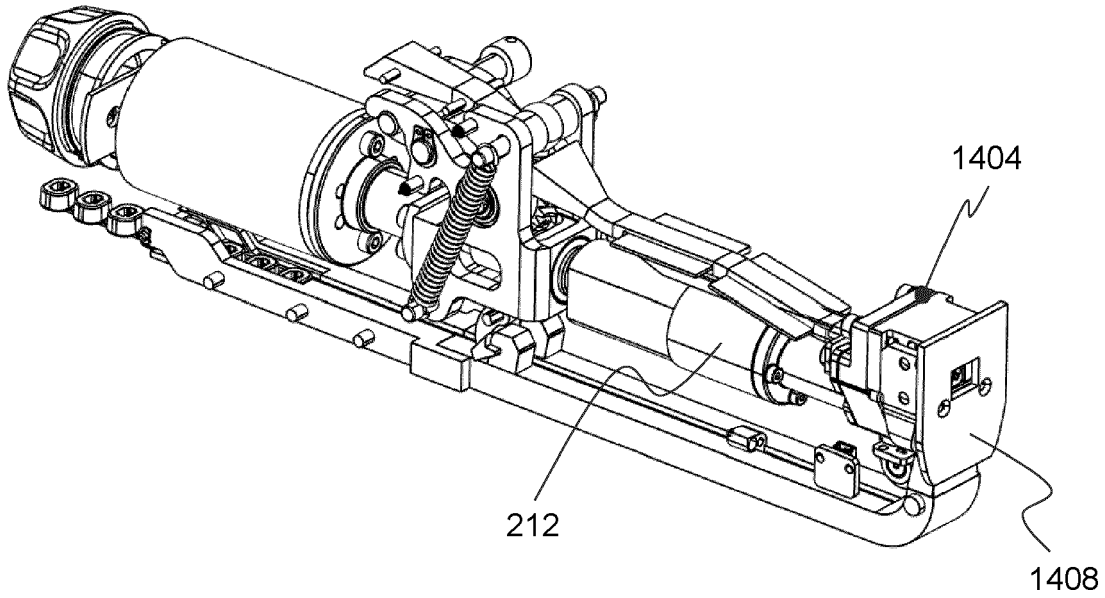
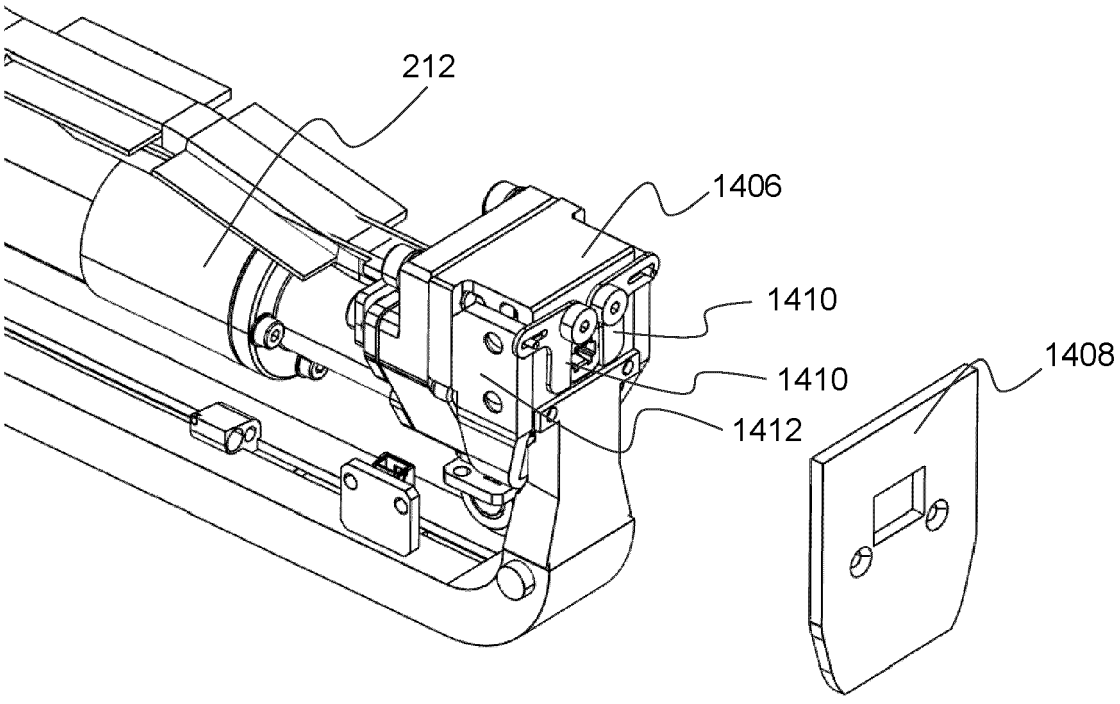


FIG. 17

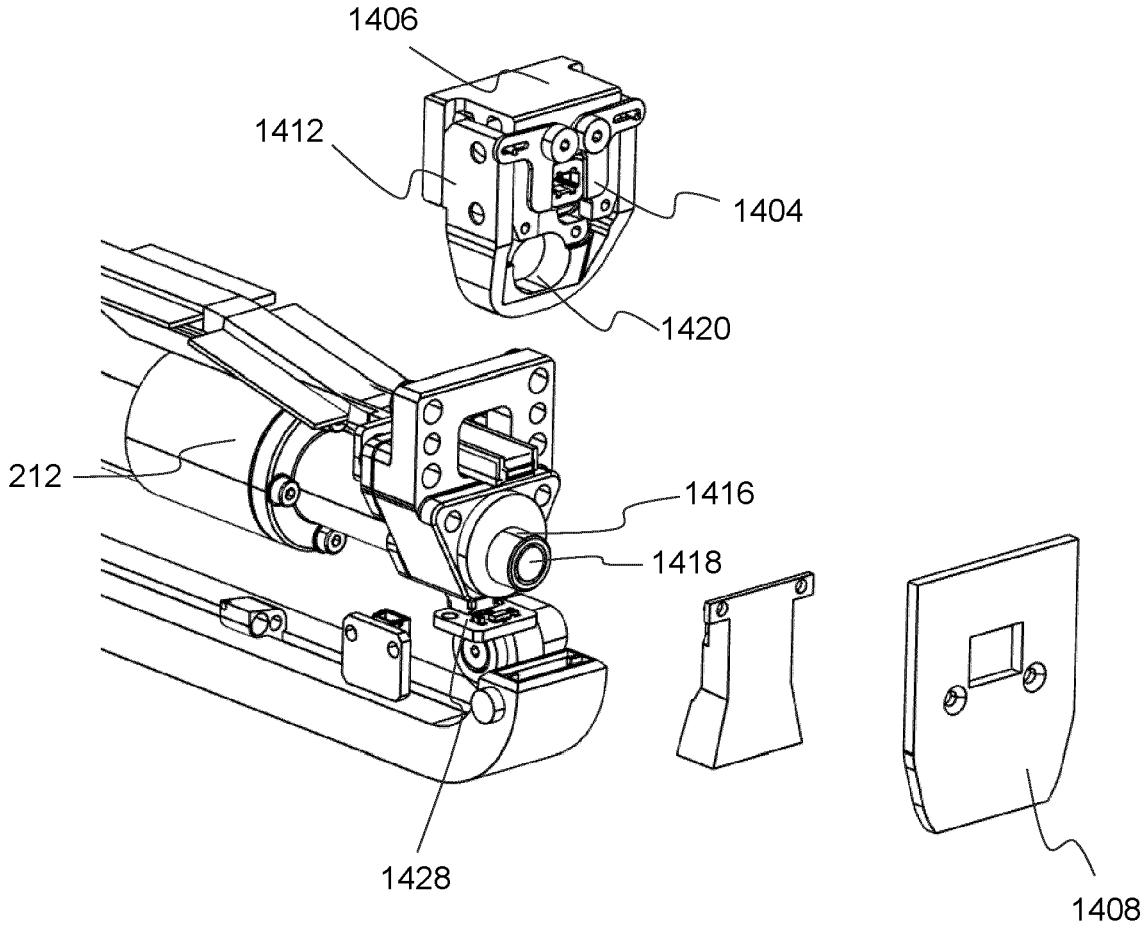


(a)



(b)

FIG. 18



(c)

FIG. 18

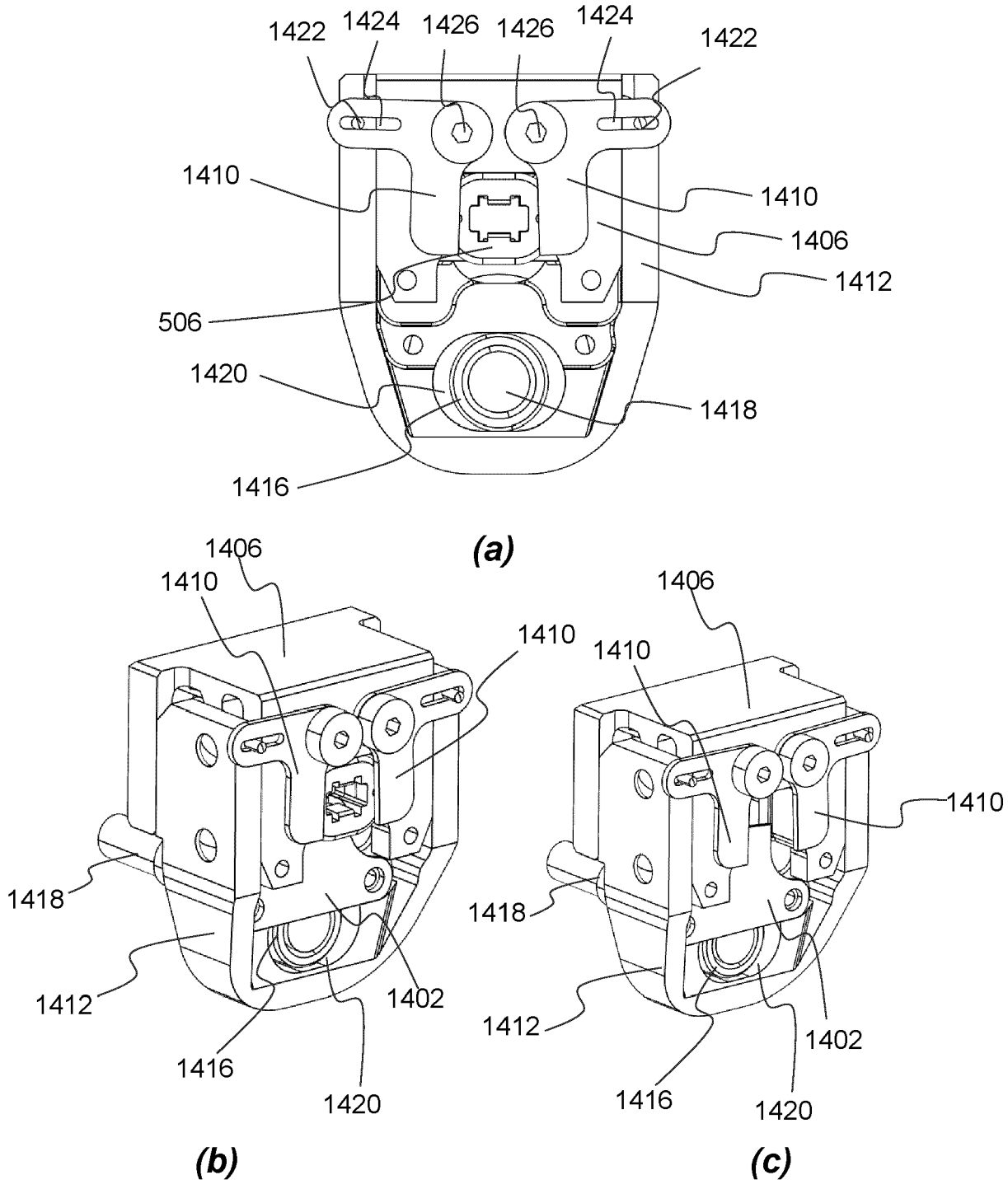
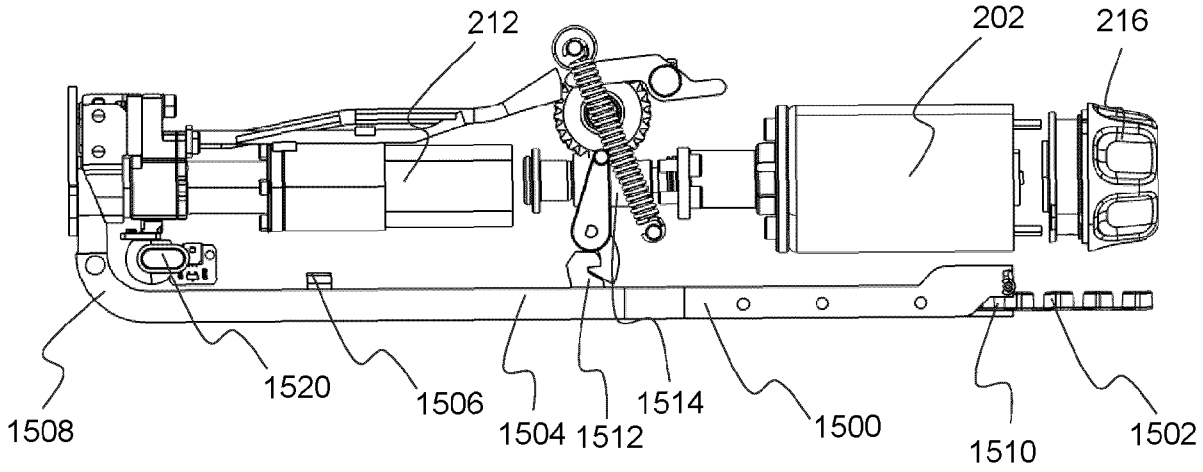
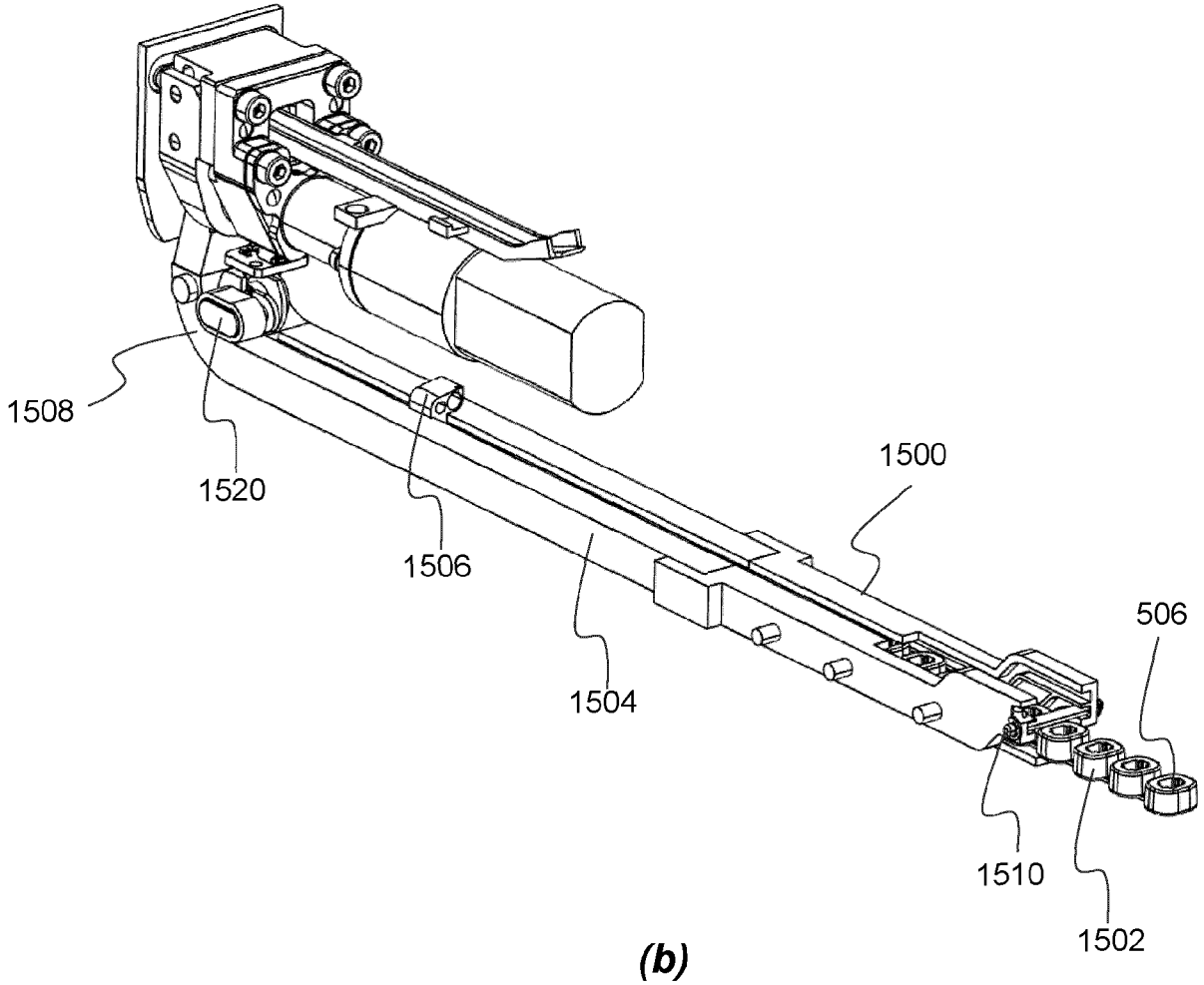

1422
1424
1426
1426
1424
1422
1410
1410
1406
1412
506
1420
1418
1416
(a)
1406
1410
1410
1418
1412
1402
1416
1420
(b)
1406
1410
1410
1418
1412
1402
1416
1420
(c)

FIG. 19


212
202
216
1508
1520
1506
1504
1512
1514
1500
1510
1502

(a)


1508
1520
1506
1500
506
1504
1510
1502

(b)

FIG. 20

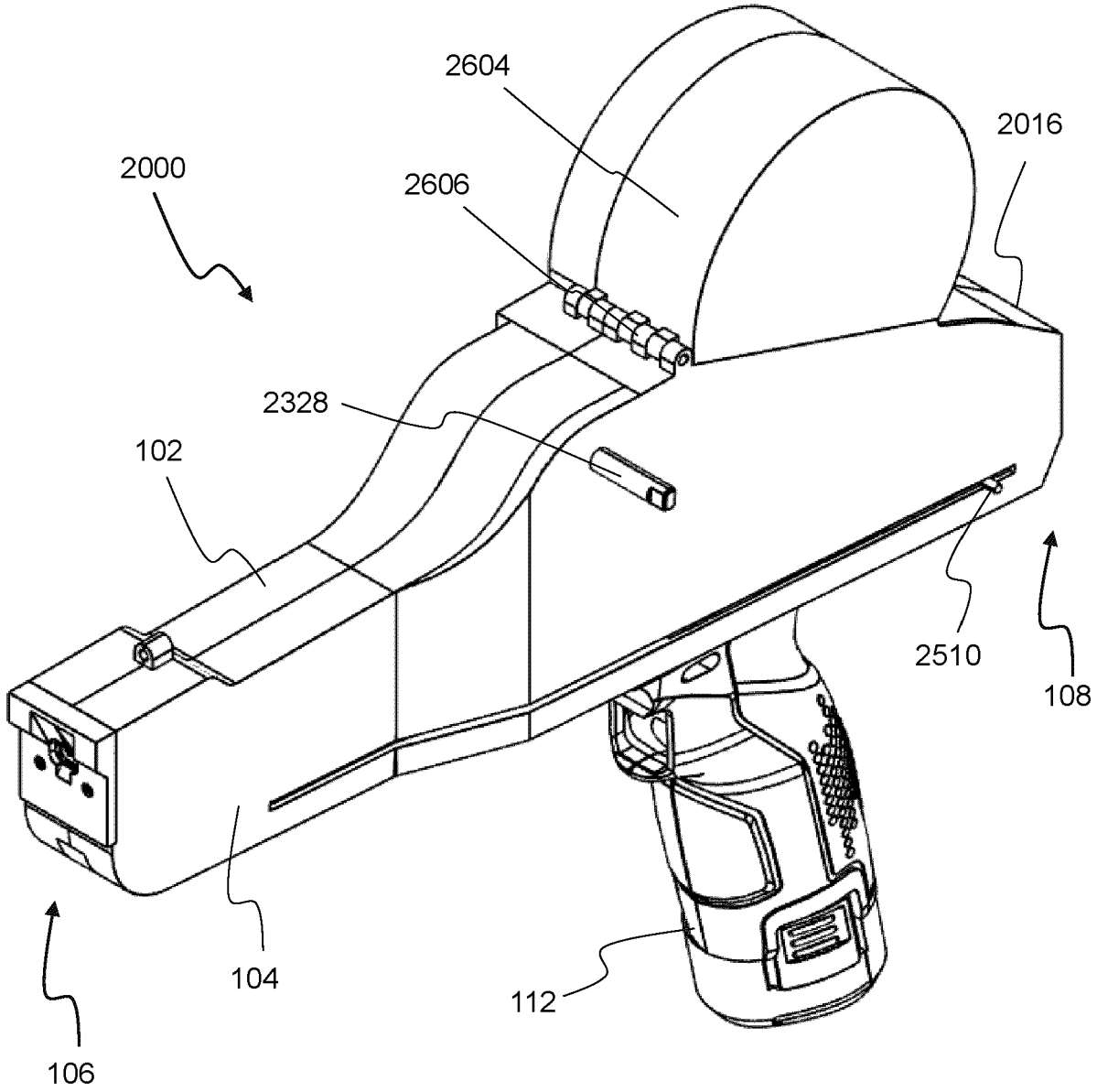


FIG. 21(a)

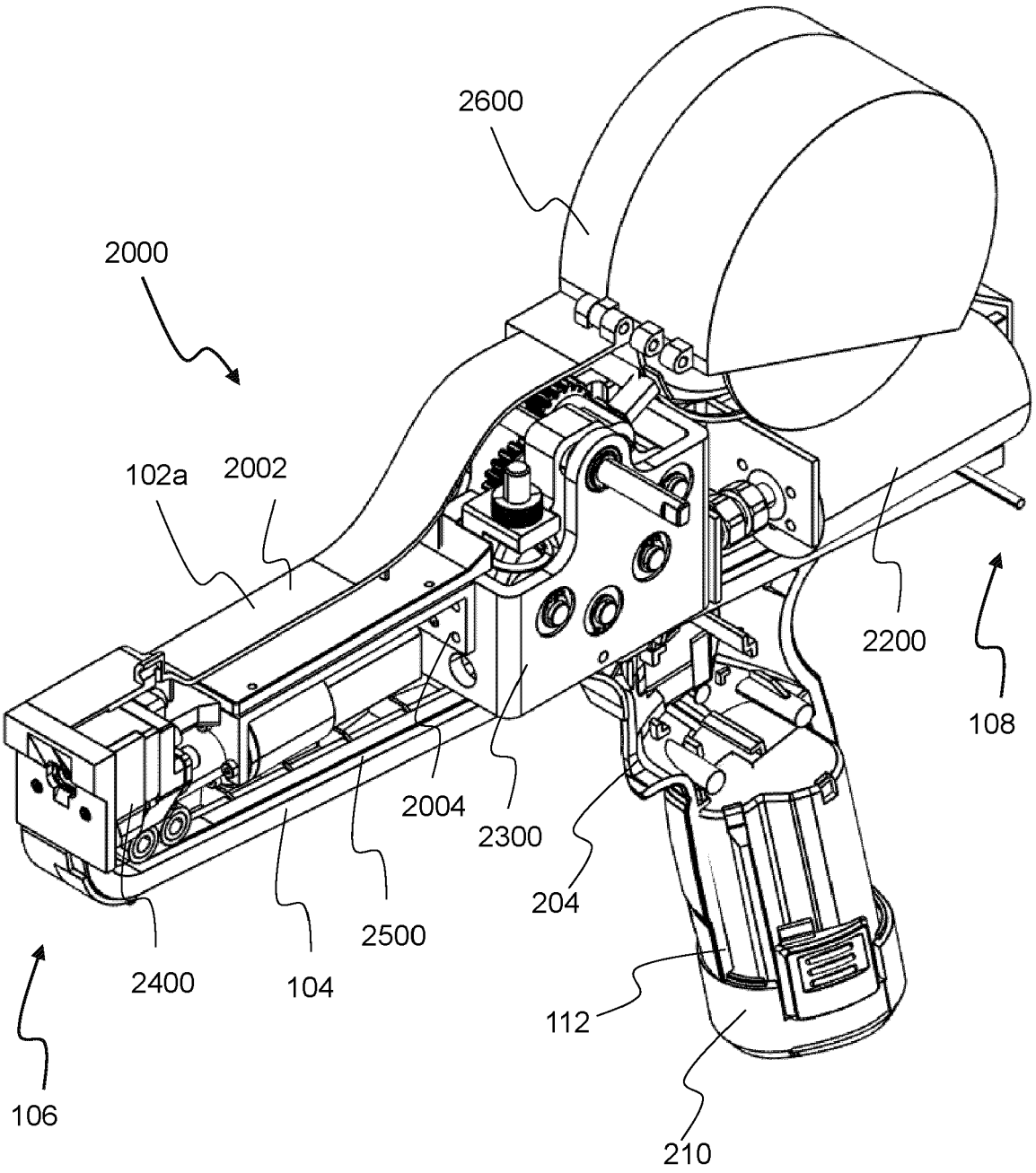

2600
2000
102a
2002
2200
108
2004
2300
204
2500
2400
104
112
106
210

FIG. 21(b)

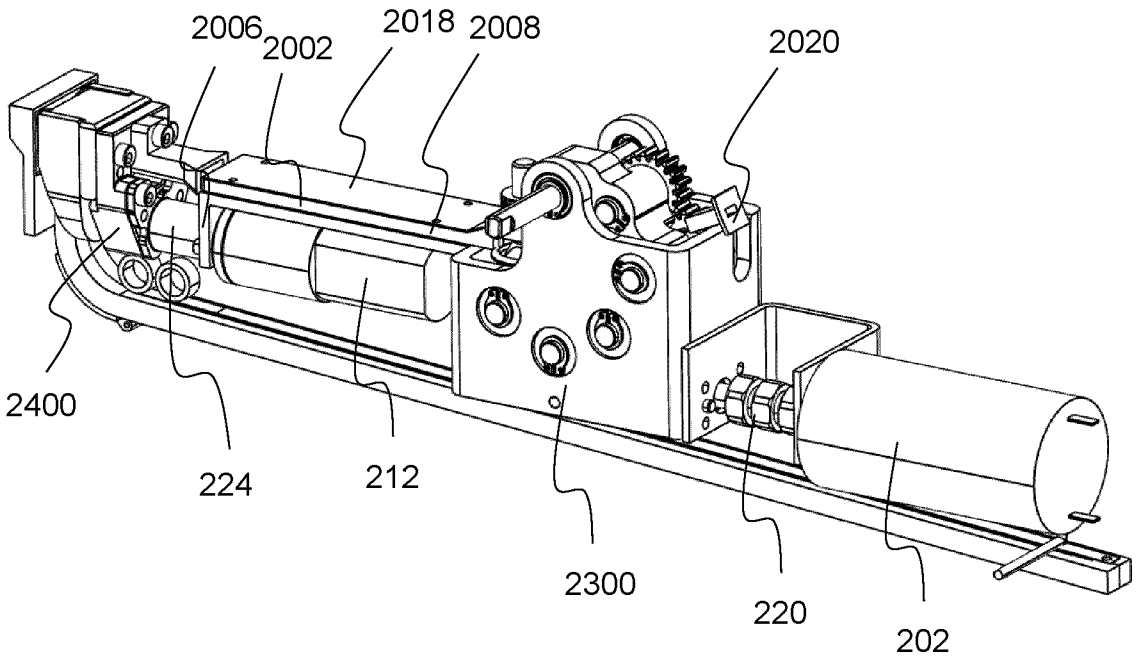

2006
2002
2018
2008
2020
2400
224
212
2300
220
202

FIG. 22

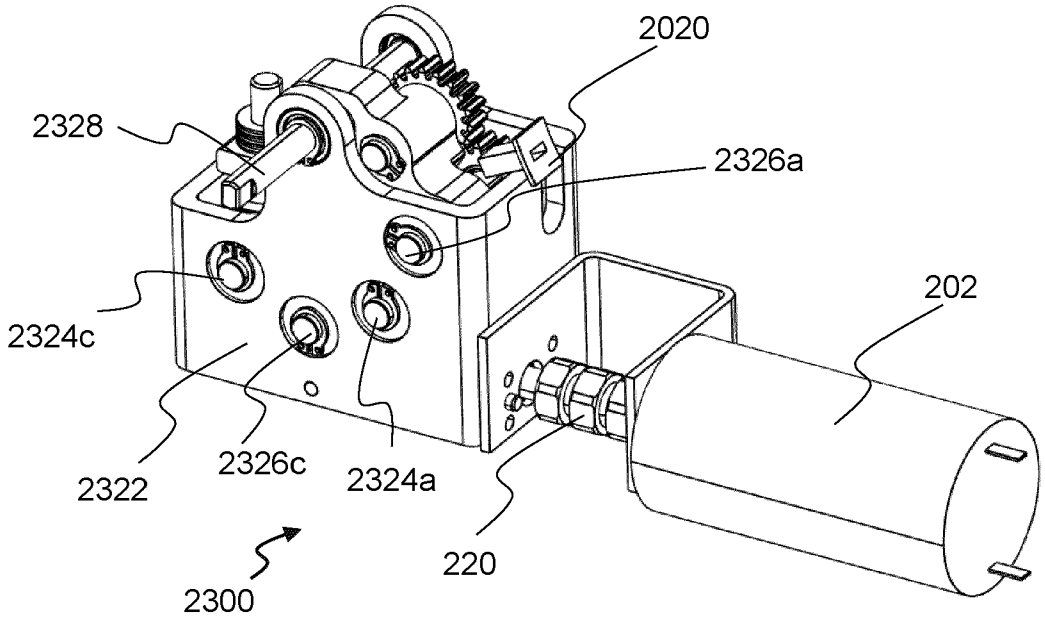

2020
2328
2326a
202
2324c
2322
2326c
2324a
220
2300

FIG. 23

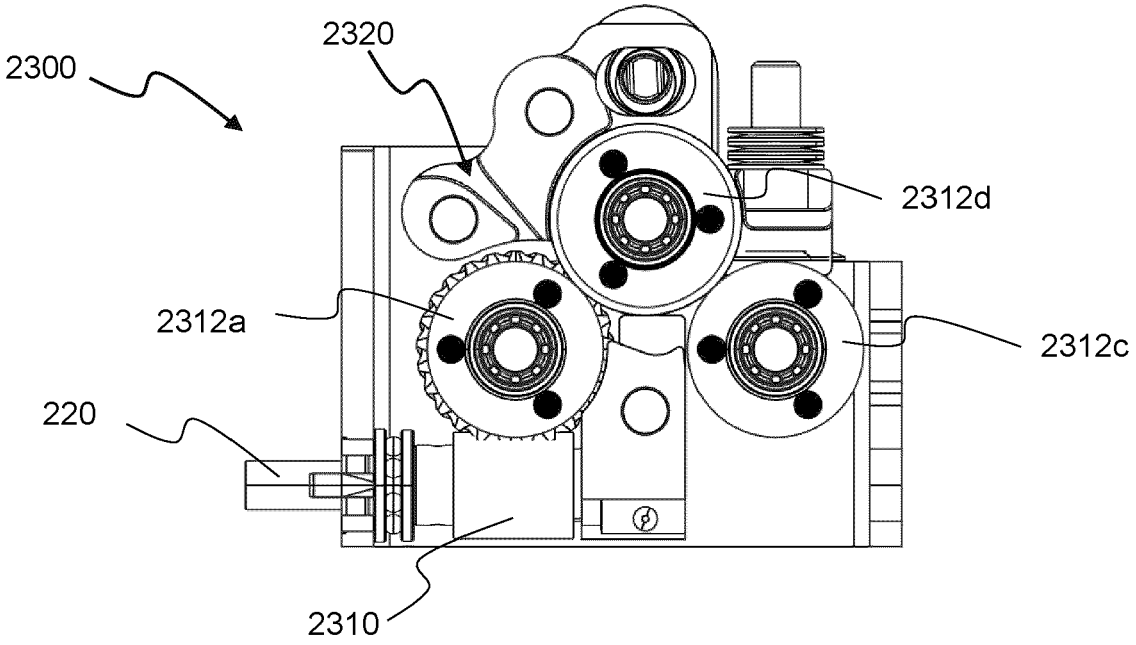


FIG. 24(a)

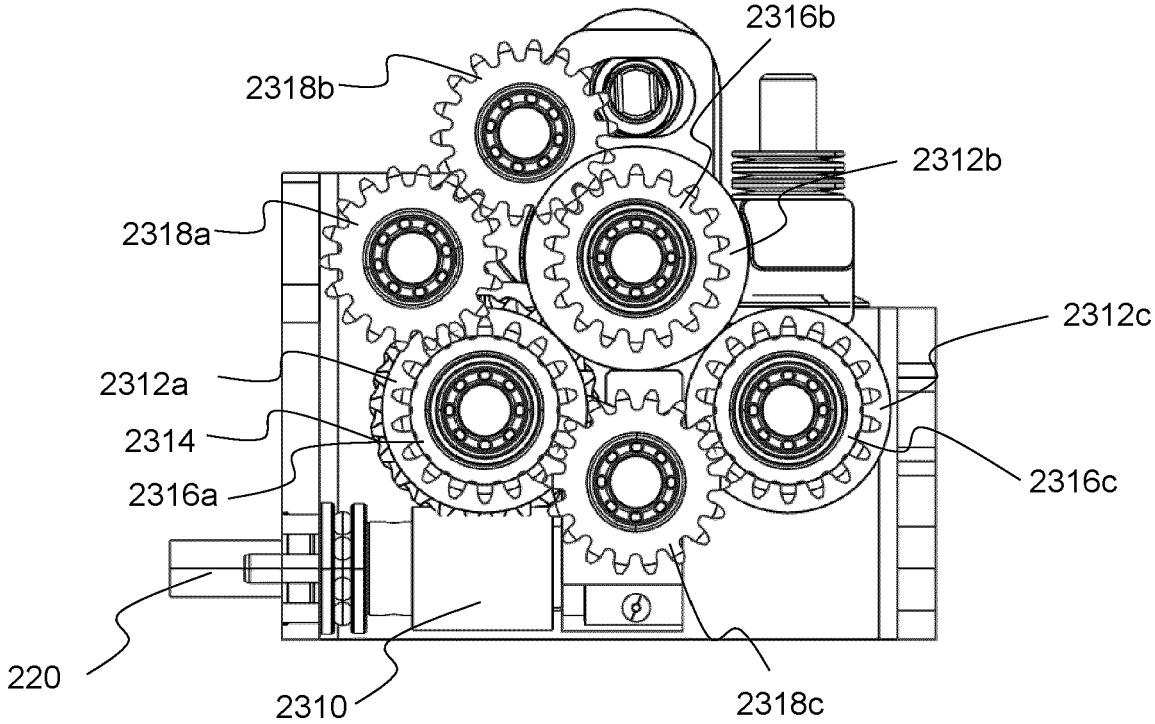


FIG. 24(b)

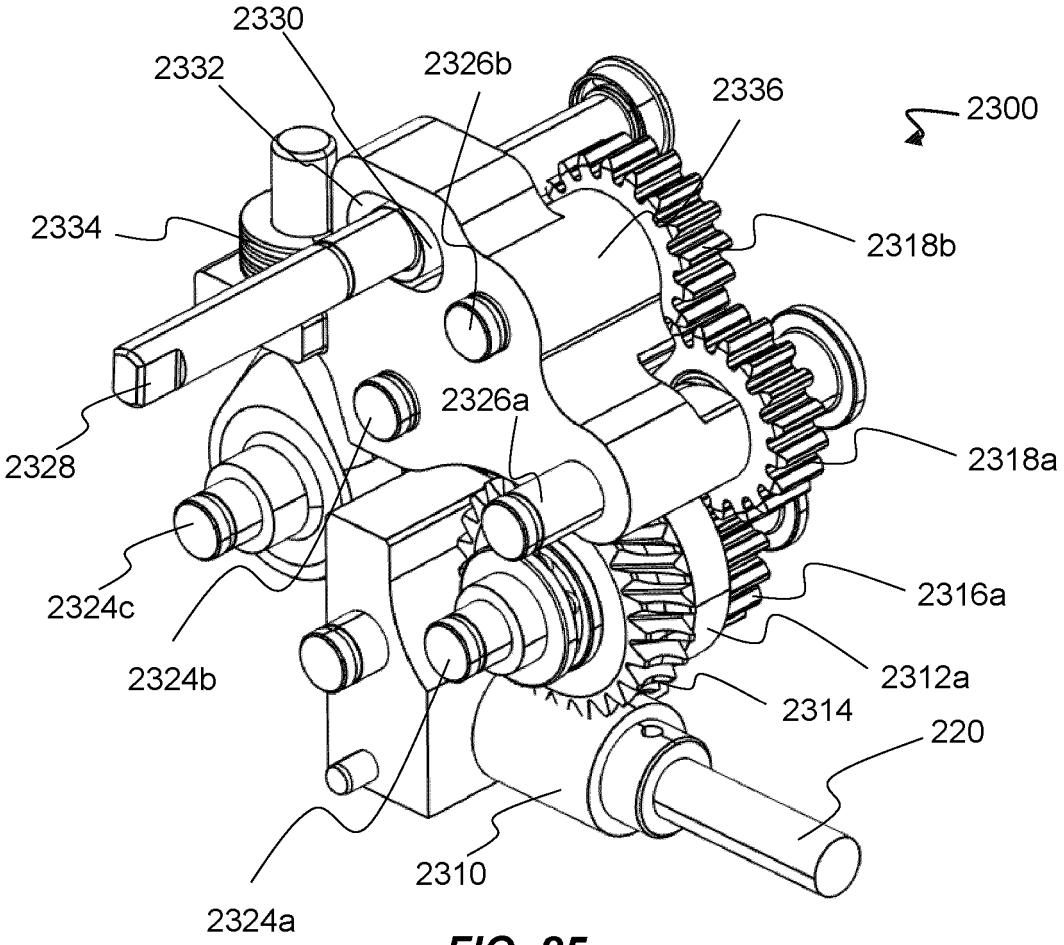


FIG. 25

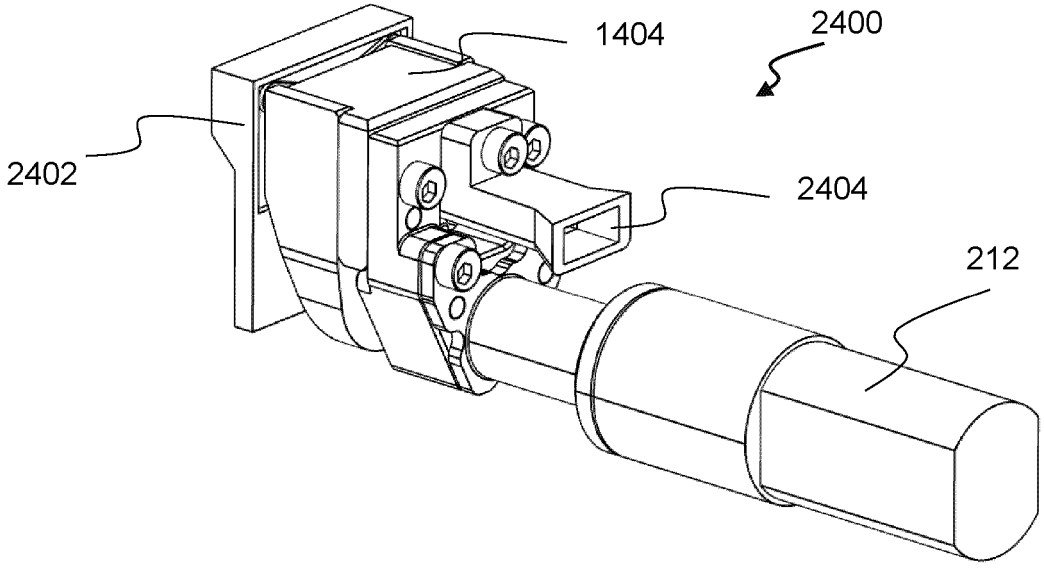


FIG. 26(a)

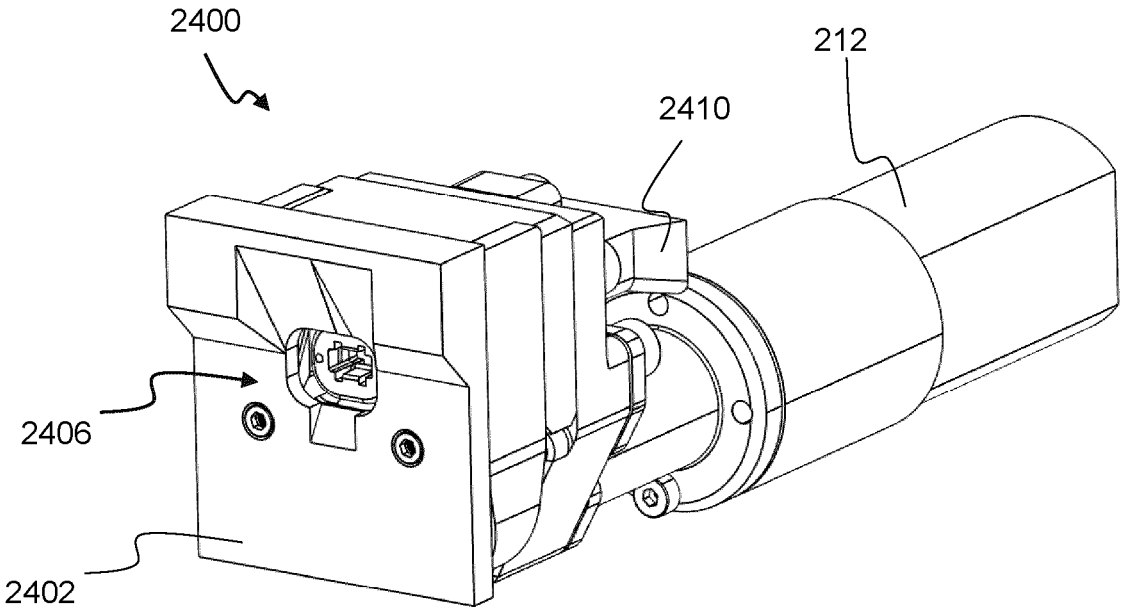


FIG. 26(b)

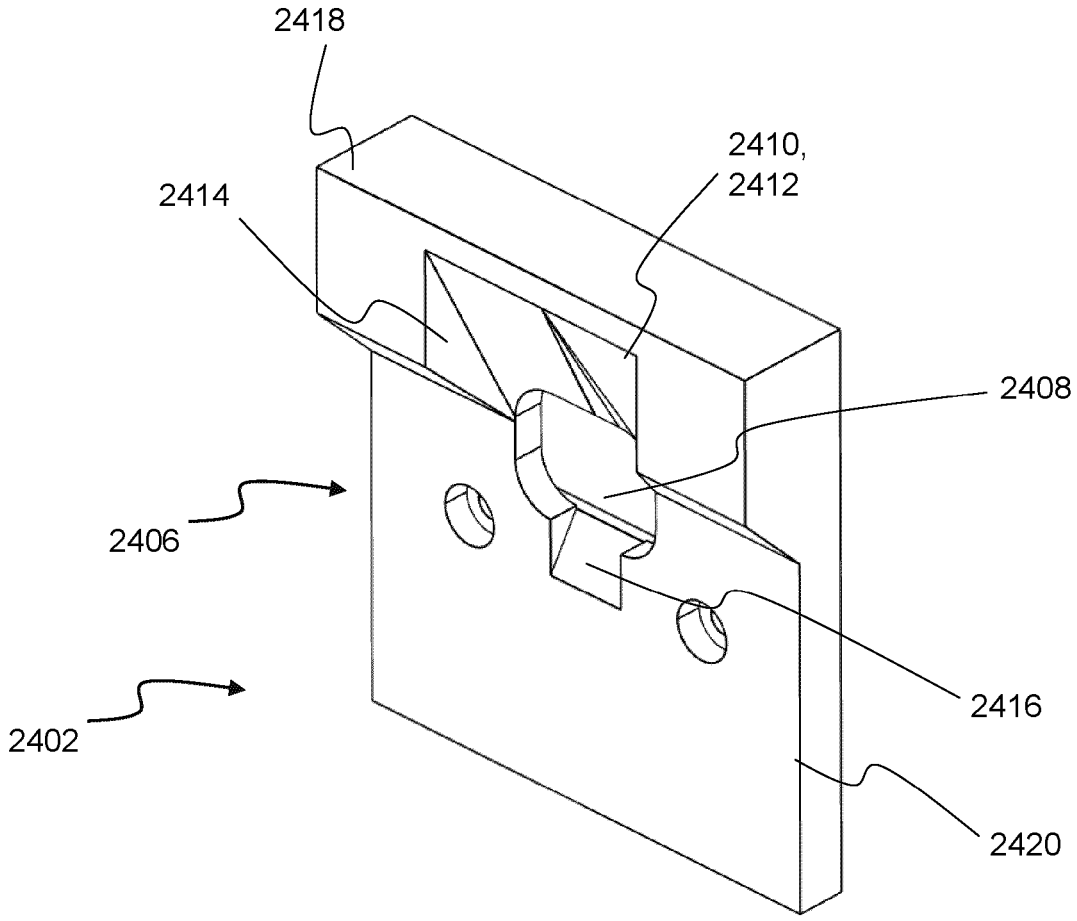


FIG. 26(c)

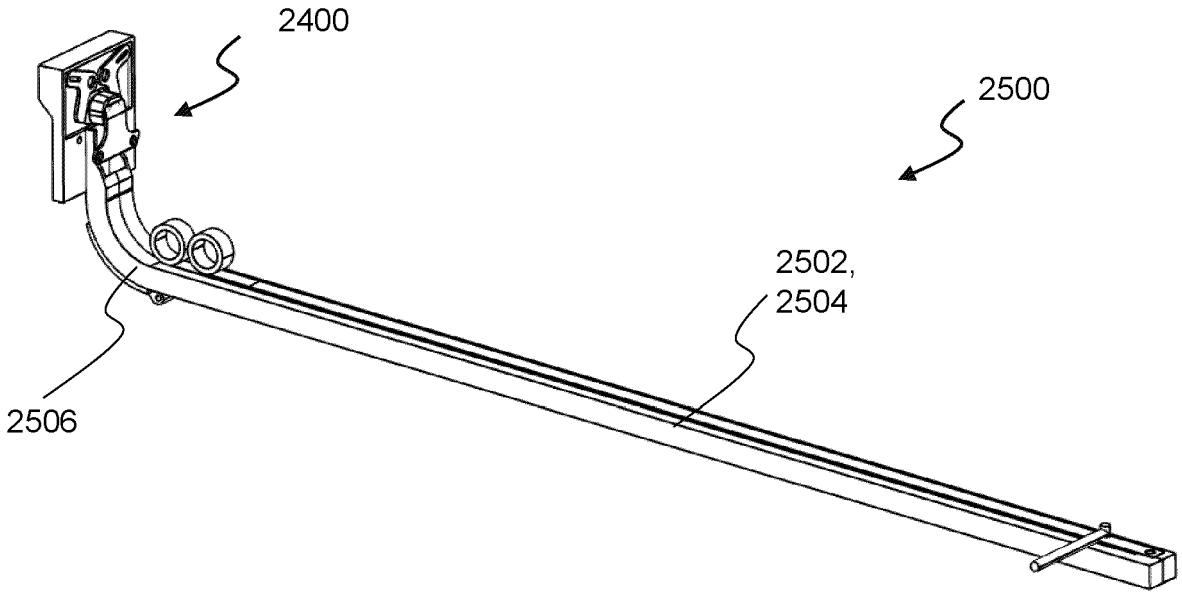


FIG. 27(a)

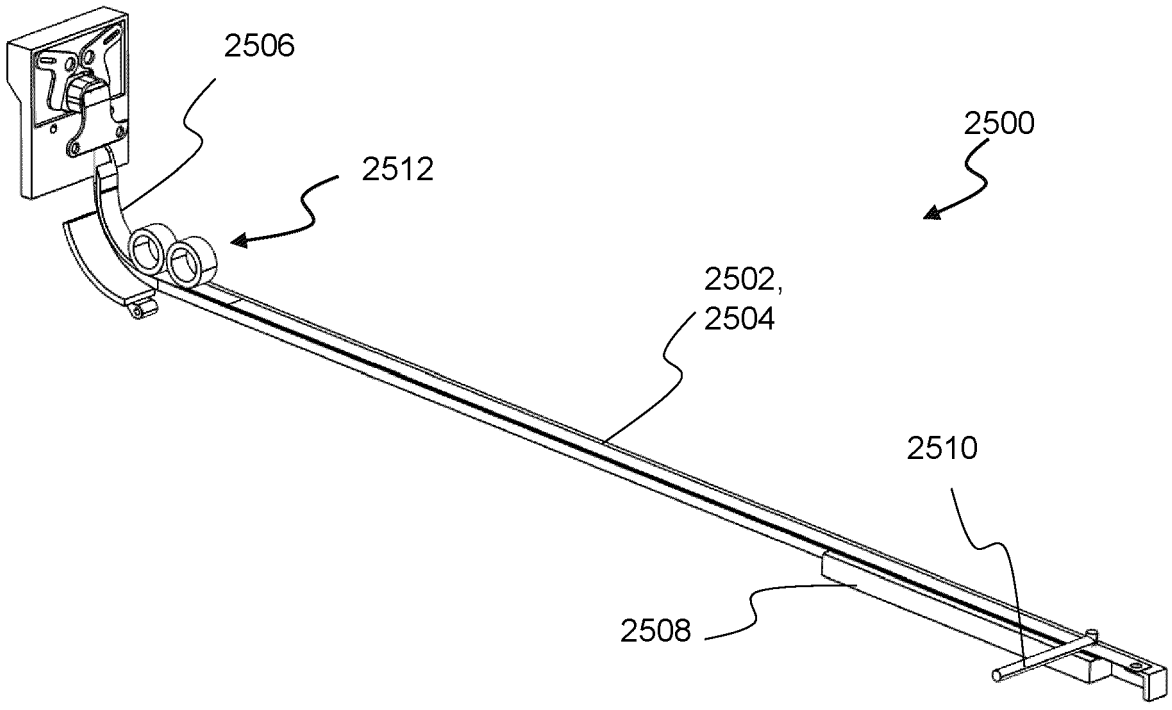


FIG. 27(b)

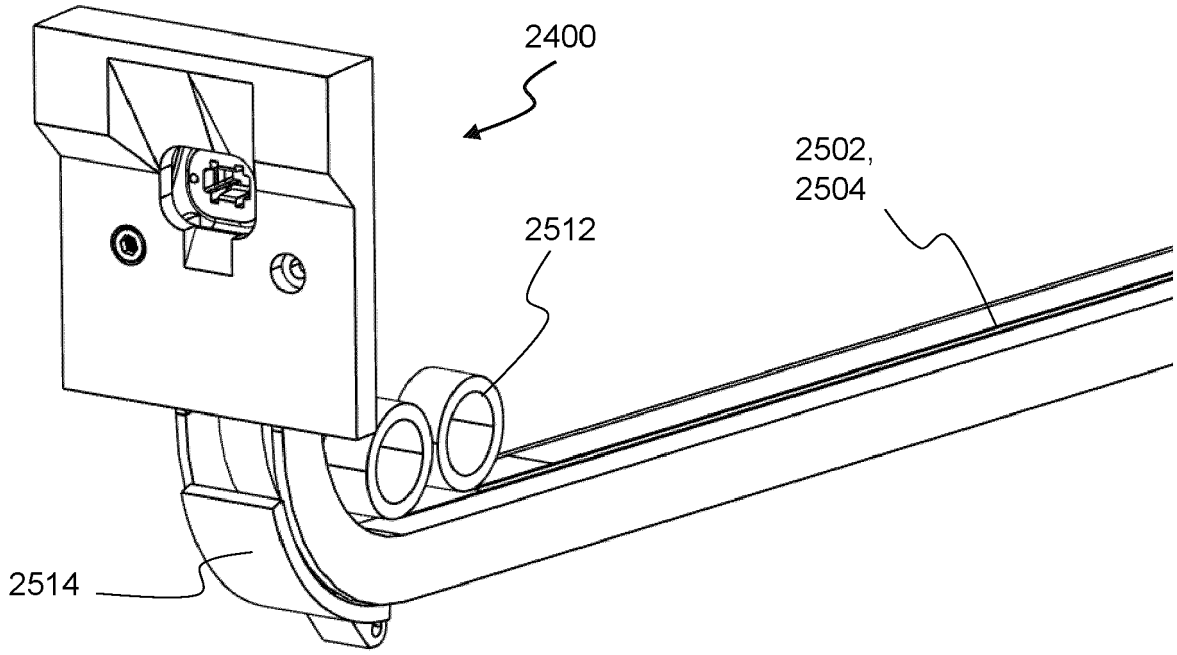


FIG. 27(c)

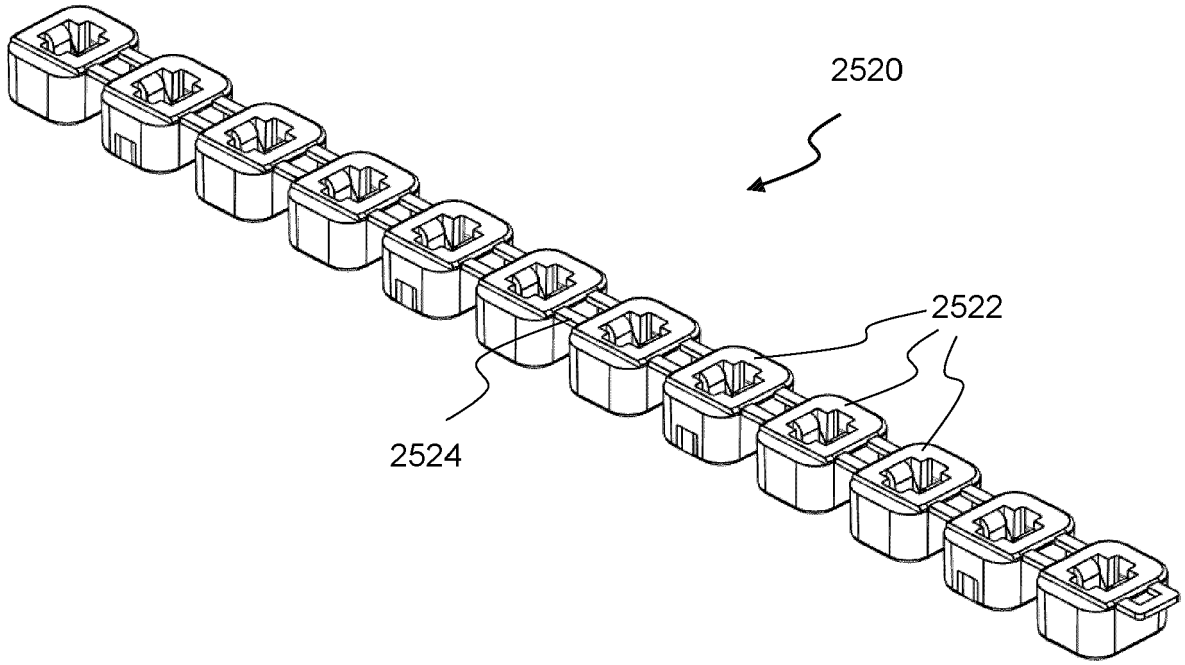


FIG. 28(a)

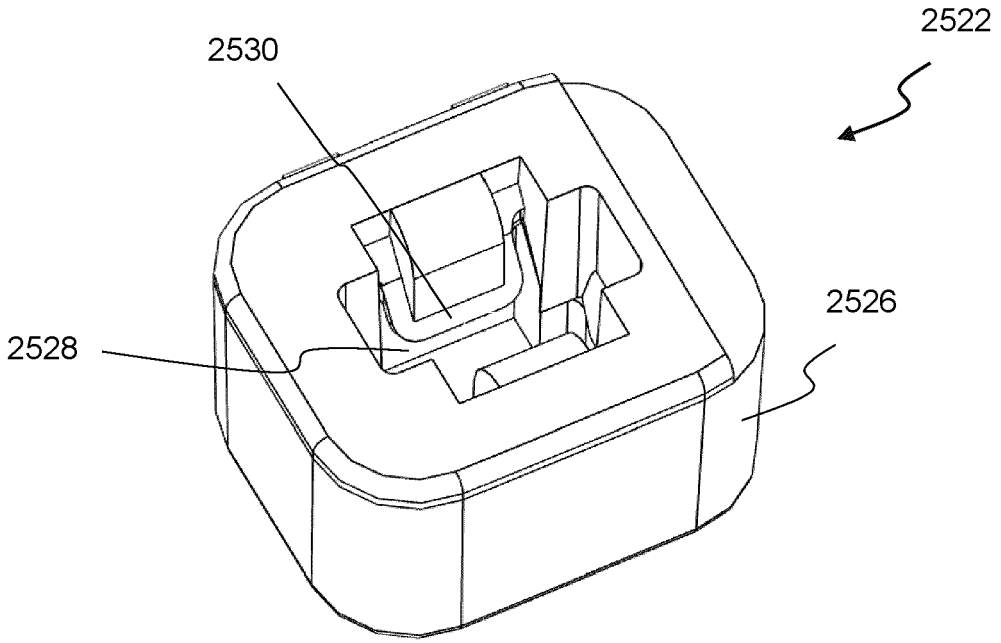


FIG. 28(b)

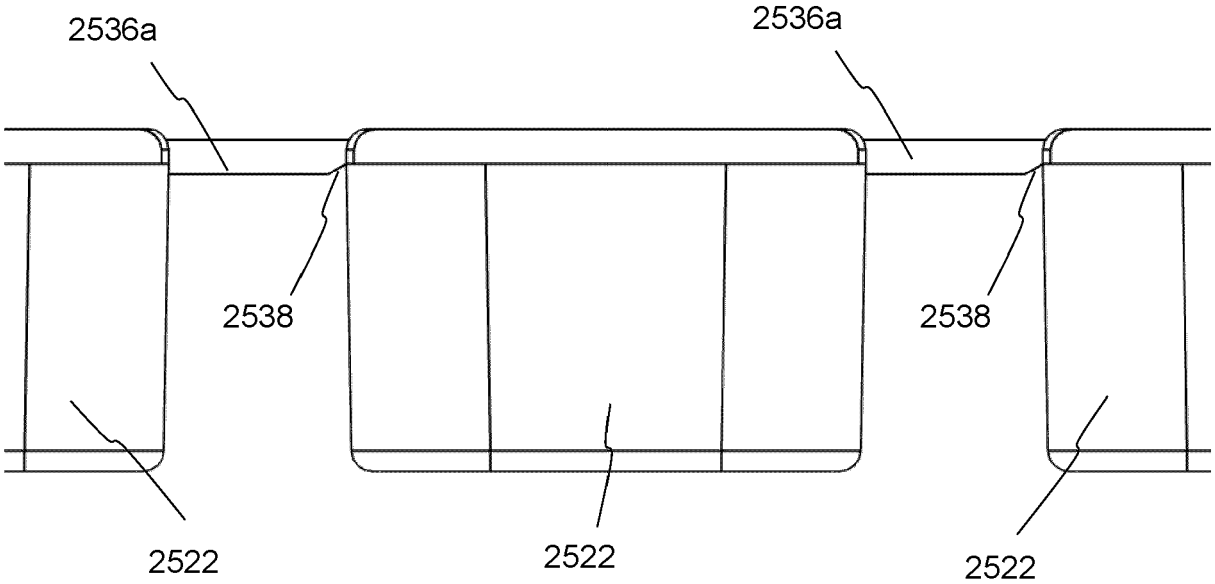


FIG. 28(c)

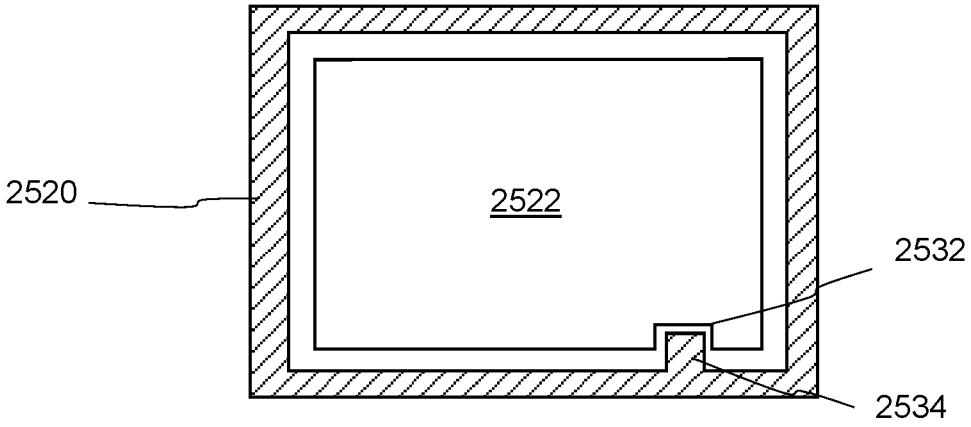


FIG. 29

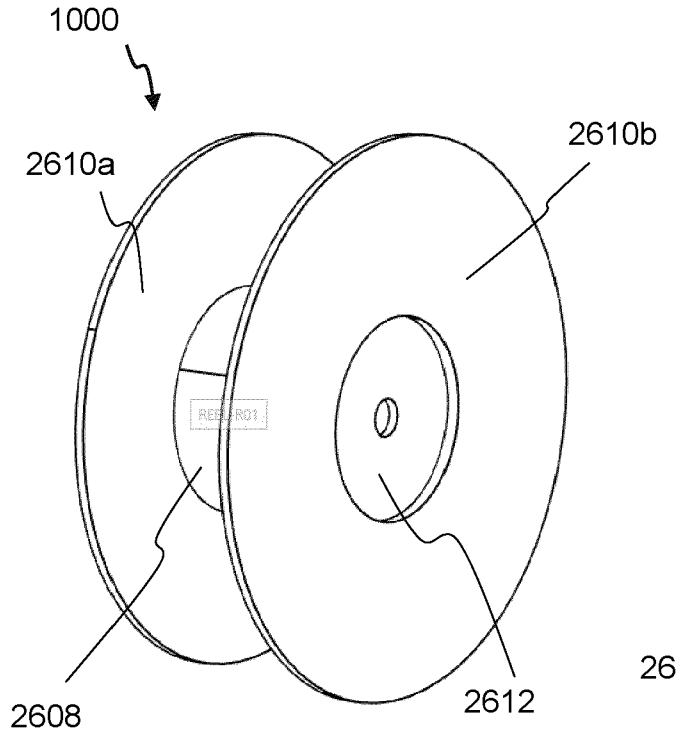


FIG. 30(a)

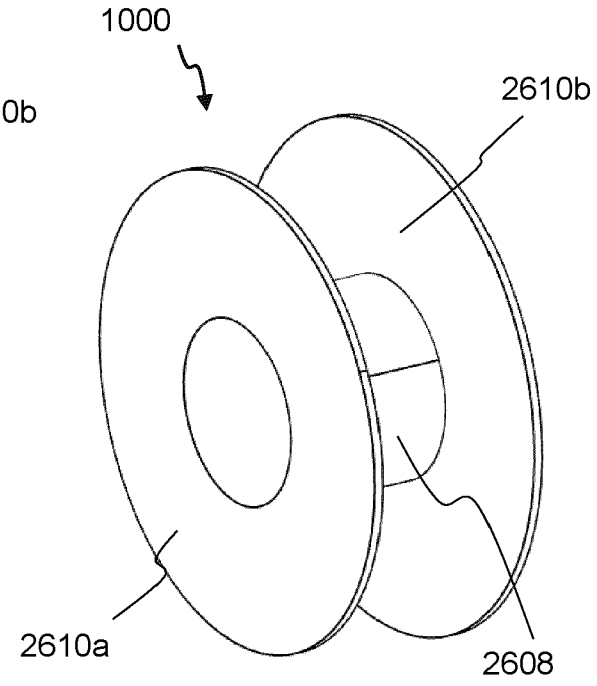


FIG. 30(b)

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EUROPEAN SEARCH REPORT

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The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
Munich	27 November 2024	Lawder, M

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