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(54) PORTABLE CABLE TIE TOOL

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Description

CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] This application claims priority to U.S. Provisional Application No. 62/629,334, filed February 12, 2018.

BACKGROUND

[0002] A cable tie is a type of fastener, for holding items together, primarily electrical cables or wires. These cable ties are well known. Typically, they are thin, flexible polymeric strips that can be wrapped about the cables. Because of their low cost and ease of use, cable ties find use in a wide range of other applications.

[0003] One common cable tie is made of nylon and has a flexible tape section with teeth that engage with a pawl in a head to form a ratchet so that as the free end of the tape section is pulled the cable tie tightens and does not come undone. Some ties include a tab that can be depressed to release the ratchet so that the tie can be loosened or removed, and possibly reused.

[0004] Tools for applying cable ties about a bundle of wires or similar articles are also well known. These tools may be manual, semi-automatic, or automatic. Many of these tools are complicated multiple operation tools that provide individual cable ties from a dispenser having a cartridge or reel containing a large number of cable ties to a conveyance mechanism for provision to the application tool.

[0005] Portable hand tools of this type are possible when the mechanism for separating each cable tie from the cable tie ribbon is within the tool itself. Thus, individual cable tie ribbons of a manageable length are positioned in the portable tool which sequentially separates, advances and applies each cable tie. Prior automatic cable tie installation tools have utilized various reciprocating mechanisms such as a pushing rod or carriage as the cable tie advancing mechanism to transport the tie into application position around the bundle. Tools of this type still have drawbacks due to the requirement that the reciprocating member needs to be retracted to be in position to transport the next cable tie. Therefore, the simplification of the cable tie advancing mechanism will greatly reduce the complexity of the overall tool. Additionally, the elimination of a reciprocating transport mechanism allows for a shorter length tool and one which uses fewer moving parts.

[0006] The present invention is provided to solve the problems discussed above and other problems, and to provide advantages and aspects not provided by prior cable tie tools devices of this type. A full discussion of the features and advantages of the present invention is deferred to the following detailed description, which proceeds with reference to the accompanying drawings.

[0007] US5595220A discloses a portable automatic cable tie installation tool for applying individual cable ties around bundles of wires.

SUMMARY

[0008] A first aspect of the invention is directed to an automatic cable tie apparatus for tightening and fastening a cable tie about around a bundle of cables or the like, as in the appended claim 1. A first motor imparts rotational movement to a first shaft separately in a first direction and a second direction wherein the first and second directions are one of a clockwise and a counter-clockwise direction, respectively. A cable tie delivery mechanism is operably joined to the first motor such that the cable tie delivery mechanism transfers a cable tie to a cable tie load starting position as the first shaft rotates in the first direction. A transporter is operably joined to the first motor such that the transporter transfers the cable tie from the cable tie load starting position to a cable tie tensioning position as the first shaft rotates in the second direction.

[0009] The first aspect of the invention may further comprise one or more of the following features. A first clutch may be located between the first motor and the cable tie delivery mechanism. The first clutch has an engaged condition wherein rotational movement by the first shaft in the first direction drives a movement by the cable tie delivery mechanism and a disengaged condition wherein rotational movement by the first shaft in the second direction causes the first shaft to freewheel in relation to the cable tie delivery mechanism wherein such rotational movement by the first shaft in the second direction does not impart movement to the cable tie delivery mechanism. A second clutch may be located between the first motor and the transporter. The second clutch has an engaged condition wherein rotational movement by the first shaft in the second direction drives a movement by the transporter and a disengaged condition wherein rotational movement by the first shaft in the first direction causes the first shaft to freewheel in relation to the transporter wherein such rotational movement by the first shaft in the first direction does not impart movement to the transporter.

[0010] The cable tie delivery mechanism may comprise a gearing assembly operably joined to the first motor wherein a first gear in the gearing assembly includes a plurality of chamfered teeth configured to frictionally engage a cable tie carrier to impart movement to the cable tie carrier upon rotation of the first shaft in the first direction to deliver the cable tie in the plurality of cable ties to the cable tie load starting position.

[0011] The transporter may also comprise a gearing assembly operably joined to the first motor wherein a first gear imparts movement to the transporter to convey the cable tie from the cable tie load starting position to the cable tie tensioning position.

[0012] The first aspect of the invention may further comprise a support wall operably joined to the second motor such that the support wall moves upwardly in re-

sponse to the second shaft rotating in the direction corresponding to one of the first direction or the second direction. The support wall may move upwardly to a position adjacent the transporter to support the cable tie as the cable tie moves from the cable tie load starting position to the cable tie tensioning position.

[0013] The first aspect further comprises a second motor imparting rotational movement to a second shaft separately in the first direction or the second direction. A cable tie supporter is operably joined to the second motor such that the cable tie supporter directs a moving cable tie from the cable tie load start position to the cable tie tensioning position as the second shaft rotates in a direction corresponding to one of the first direction or the second direction. A cable tie tensioner is operably joined to the second motor such that the cable tie tensioner decreases a circumferential length of the annular shape as the second shaft rotates in the other of the first direction or the second direction.

[0014] The present disclosure is also directed to an automatic cable tie apparatus for tightening and fastening a cable tie around a bundle of cables or the like. A motor imparts rotational movement to a shaft separately in a first direction or a second direction, wherein the first or second directions are one of a clockwise and a counter-clockwise direction, respectively. A support wall may be operably joined to the motor such that the support wall moves upwardly in response to the shaft rotating in the first direction. The support wall may move upwardly to a position adjacent the transporter to support the cable tie as the cable tie moves from a cable tie load starting position to a cable tie tensioning position.

[0015] A cable tie supporter is operably joined to the motor such that the cable tie supporter directs a moving cable tie from the cable tie load start position to the cable tie tension position as the shaft rotates in the first direction. A cable tie tensioner is operably joined to the motor such that the cable tie tensioner decreases a circumferential length of the annular shape as the shaft rotates in the second direction,

[0016] The present disclosure is also directed to an automatic cable tie apparatus for tightening and fastening a cable tie around a bundle of cables or the like. A plurality of mechanical functions performed in sequence delivers a cable tie from a plurality of cable ties to a cable load starting position, forms the cable tie into an annular form, tensions the cable tie, and shortens a circumferential length of the annular form. A first motor imparts rotational movement to a first shaft separately in a first direction and a second direction wherein the first and second directions are one of a clockwise and a counter-clockwise direction. The first motor separately provides a mechanical power to a first apparatus function in the plurality of mechanical functions as the first shaft rotates in the first direction and a second apparatus function in the plurality of mechanical functions as the first shaft rotates in the second direction. The second motor imparts rotational movement to a second shaft separately in a third direction and a fourth direction wherein the third and fourth directions are one of a clockwise and a counter-clockwise direction. The second motor separately provides a mechanical power to a third apparatus function in the plurality of mechanical functions as the second shaft rotates in the third direction and a fourth apparatus function in the plurality of mechanical functions as the second shaft rotates in the fourth direction. A cable tie delivery mechanism is operably joined to one of the first and second motors and performs one of the plurality of mechanical functions wherein the cable tie delivery mechanism delivers the cable tie to the cable load starting position. A cable tie supporter is operably joined to one of the first and second motors and performs one of the plurality of mechanical functions wherein the cable tie supporter can guide the cable tie into the transport channel, raise the lower jaw, and cut the tie from the carrier strip. A cable tie transporter is operably joined to one of the first and second motors and performs one of the plurality of mechanical functions wherein the cable tie transporter moves the cable tie from the cable tie load starting position to the cable tie tensioning position and bends the cable tie into an annular position. A cable tie tensioner is operably joined to one of the first and second motors and performs one of the plurality of mechanical functions wherein the cable tie tensioner shortens the circumferential length of the annular form and removes the excess cable tie.

[0017] Other features and advantages of the invention will be apparent from the following specification taken in conjunction with the following drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

[0018] To understand the present invention, it will now be described by way of example, with reference to the accompanying drawings in which:

FIG. 1 is a perspective view of a handheld cable tie tool of the present invention;

FIG. 2 is a perspective view of the handheld cable tie tool of the present invention with a housing removed showing a plurality of cable ties loaded therein;

FIG. 3 is a partial perspective view of the handheld cable tie tool loaded with a plurality of cable ties;

FIG. 4 is a partial perspective view of the handheld cable tie tool loaded with a plurality of cable ties showing a cable tie being delivered via an auger towards a cable tie tensioning position;

FIG. 5 is a partial perspective view of the handheld cable tie tool loaded with a plurality of cable ties;

FIG. 6 is a partial perspective view of the handheld cable tie tool loaded with a plurality of cable ties with a support wall in an upper position showing a cable tie in a cable load starting position;

FIG. 7 is a left front perspective view of an upper portion of the cable tie tool of the present invention

with a housing removed;

FIG. 8 is a right front perspective view of an upper portion of the cable tie tool of the present invention with a housing removed;

FIG. 9 is a right rear perspective view of an upper portion of the cable tie tool of the present invention with a housing removed;

FIG. 10 is a left side view of an upper portion of the cable tie tool of the present invention with a housing removed;

FIG. 11 is a right side view of an upper portion of the cable tie tool of the present invention with a housing removed;

FIG. 12 is a right side view of an upper portion of the cable tie tool of the present invention with a housing removed showing a drive belt;

FIG. 13 is a front view an upper portion of the cable tie tool of the present invention with a housing removed;

FIG. 14 is a back view of an upper portion of the cable tie tool of the present invention with a housing removed;

FIG. 15 is a partial cross-sectional view of the apparatus showing a cable tie bent into an annular form and the rear jaw in an upper position; and

FIG. 16 is a partial cross-sectional view of the apparatus showing a cable tie bent into an annular form in a cable tie tensioning position and a circumferential length of the annular form decreased by a cable tie tensioner.

DETAILED DESCRIPTION

[0019] While this invention is susceptible of embodiments in many different forms, there is shown in the drawings and will herein be described in detail preferred embodiments of the invention with the understanding that the present disclosure is to be considered as an exemplification of the principles of the invention and is not intended to limit the broad aspect of the invention to the embodiments illustrated.

[0020] Referring generally to the figures, a portable, handheld cable tie apparatus 10 is illustrated. This cable tie apparatus dispenses a cable tie 14 from a supply of cable ties 18, wraps the cable tie 14 about a plurality of cables (not shown), and tightens the cable tie 14 about the cables. The cable tie apparatus is advantageous for many reasons.

[0021] For example, it is fully self-contained, A supply of cable ties 18, while external to a housing 22 of the cable tie apparatus 10, is easily transported when loaded into or onto the cable tie apparatus 10.

[0022] Additionally, the cable tie apparatus 10 may be operated with one hand. Thus, a user has a hand free to support cables, lift or move cables, and/or feed cables to the cable tie apparatus 10.

[0023] Further, the cable tie apparatus 10 of the present invention is powered by a power source or supply 26, preferably a DC power supply such as a rechargeable battery electronically connected to apparatus drivers. Thus, actuation of the cable tie apparatus 10 by manipulating an actuator 30, such as a trigger, causes a cable tie 14 to be dispensed and wrapped about the cables without further manual intervention,

[0024] As shown in FIGS, 2-6, cable ties 18 used with the cable tie apparatus 10 may be ratchet-type cable ties. One end, typically a head 34, of each cable tie 14 is attached to a carrier strip 38. An opposite end, a tapered tip end 42, is a free end, not attached to the carrier strip 38. The cable ties 18 and carrier strip 38 are fed into a left side of the cable tie apparatus 10. A pair of transfer gears 46 have teeth configured to bite into the carrier strip 38 and index each cable tie 14 into a proper position for separating, e.g. by cutting or severing, the cable tie 14 from the carrier strip 38. A pressure bar 50 creates an upward force to ensure the carrier strip 38 is always loaded up against the transfer gears 46. This is critical for proper operation and cable tie transfer.

[0025] A first motor 55, e.g. a stepper motor, has a shaft joined to a drive gear 56 which transfers rotational movement to the transfer gears 46. Accordingly, the shaft imparts rotational movement separately in a first direction and a second direction wherein the first and second directions are one of a clockwise and a counter-clockwise direction, respectively. The transfer gears 46 transfer movement to the plurality of cable ties 18 attached to the carrier strip 38.

[0026] A cable delivery mechanism 52 is operably joined to the motor 55. This mechanism delivers a cable tie 14 to a load starting position (see, e.g., FIG. 6), The cable ties 14 are loaded on the left side of the apparatus 10 with the carrier strip 38 being urged or pushed upwardly into a carrier strip guide 54. Once the carrier strip 38 reaches the transfer gears 46, the transfer gears 46 engage and bite into the carrier strip 38 and rotate to move the cable ties 14 to a load starting position.

[0027] A tie sensor 58 is located at the end of the carrier strip guide 54 (see, e.g., FIG. 7). The tie sensor 58 (FIG. 8) senses the presence of a cable tie 14. The tie sensor 58 transmits a signal which causes the first motor 55 to stop rotating the drive gear 56 and the carrier strip 38 with the cable ties 14 which stops advancing when a cable tie 14 is located just under a transfer auger 62. When a cable tie 14 is in this position, the apparatus 10 is ready for an operator to begin applying cable ties 14 to a bundle of cables (not shown).

[0028] The first motor 55 shaft is further joined to cable tie transporter 60. The cable tie transporter 60 moves the cable tie 14 linearly from the cable tie load starting position to a cable tie tensioning position. The cable tie transporter 60 includes a second set of gears 63, 64 which drive the auger 62. The drive gear 63 transfers movement to an auger gear 64 directly attached to an end of the auger 62.

[0029] The cable tie delivery mechanism 52 and the cable tie transporter 60 each have a one-way clutch 65.

The drive gears 56, 63 are outfitted with the clutches 65. These clutches 65 are set to engage in one direction and disengage in the other direction. This enables the first motor 55 to separately enable two different functions with one prime mover. In this case, when the shaft of the first motor 55 rotates in a first direction, it drives revolution of a first drive gear 56 which transfers motion to the transfer gears 46 to index the plurality of cable ties 18. When the shaft of the first motor 55 rotates in a second direction, it drives revolution of a drive gear 63 which transfers motion to the auger gear 64 which causes the auger 62 to transfer a cable tie 14 from the plurality of cable ties 18 outwardly along a length of the auger 62 towards front and rear jaws 68, 70. The cable tie 14 is pushed around the cable tie supporter 66 of the front and rear jaws 68, 70 into an annular shape around a bundle of cables (not shown).

[0030] Thus, one clutch 65 is located between the first motor 55 and the cable tie delivery mechanism 52. This clutch 65 has an engaged condition wherein rotational movement by the first motor 55 shaft in the first direction drives a movement by the cable tie delivery mechanism 52 and a disengaged condition wherein rotational movement by the first motor 55 shaft in the second direction causes the cable tie delivery mechanism 52 to freewheel in relation to the first motor 55 shaft. Such rotational movement by the first motor 55 shaft in the second direction does not impart movement to the cable tie delivery mechanism 52.

[0031] A second clutch 65 is located between the first motor 55 and the cable tie transporter 60. This clutch 65 also has an engaged condition wherein rotational movement by the first motor 55 shaft in the second direction drives a movement by the cable tie transporter 60 and a disengaged condition wherein rotational movement by the first motor 55 shaft in the first direction causes drive gear 63 to freewheel in relation to the fist motor 55 shaft. Such rotational movement by the first motor 55 shaft in the first direction does not impart movement to the cable tie transporter 60.

[0032] Further to the transfer gears 46, each gear exhibits a modified end of tooth profile (see, e.g., FIG. 5). Tips of the transfer gears 46 have two small chamfers on each side of every tooth. This chamfer profile makes the end of each tooth pointed and allows the teeth to frictionally engage by biting into the carrier strip 38 and reliably impart movement to the carrier strip 38 and index the cable ties 18. This profile also reduces the surface area of each tooth to allow surface penetration of the carrier strip 38 regardless of whether the cable ties 18 are dry or wet.

[0033] The operator positions front and rear jaws 68, 70 around the bundle of cables and actuates the apparatus 10 by engaging the actuator 30, e.g. pressing a trigger on the apparatus.

[0034] A second motor 74 imparts rotational movement to a shaft separately in the clockwise and counter-clockwise directions. A cable lie supporter 66, is operably joined to the second motor 74 such that the cable tie supporter 66 directs a cable tie tapered tip end 42 through the cable tie head 34 as the shaft rotates in one of a clockwise or counter-clockwise direction (see, e.g., FIG. 15). A cable tie tensioner is also operably joined to the second motor 74 such that the cable tie tensioner decreases a circumferential length of the annular shape when the tapered tip end 42 engages the gripper gear 122 as the shaft rotates in the opposite direction to the direction which drives the cable tie supporter 66.

[0035] Upon actuation, the second motor 74, such as a brushless motor, causes a drive belt 78 to move. The drive belt 78 is wound about a motor pulley 82 attached to the second motor 74, an idler 86, cam pulley 90, and a tensioning and cut-off pulley 94. The second motor 74 drives the motor pulley 82 which drives the drive belt 78 causing rotation of the cam pulley 90 and the tensioning and cut-off pulley 94.

[0036] A support wall 98 is operably joined to the second motor 74 to support the cable tie 14 as the cable tie 14 moves from the cable tie load starting position to the cable tie tensioning position. A support wall 98 moves upwardly to a position adjacent the cable tie transporter 60 in response to the second motor 74 shaft rotating in the direction corresponding to one of a clockwise or counter-clockwise direction.

[0037] Rotation, generally 180 degrees, of cam pulley 90 causes a movement in the support wall 98. The support wall 98 moves upwardly into an upper position (see, e.g. FIG. 4 and 6). The support wall 98 is operably joined to the rear jaw 70 and includes features that actuate closing of the rear jaw 70 (compare, e.g., FIG. 11 with FIG. 15), cutting the cable tie 14 from the carrier strip 38, and supporting the cable tie 14 being transferred by the auger 62 from the load starting position to a tensioning position. During the supporting wall's 98 upward movement three events occur to locate the cable tie 14 in a proper or desired position.

[0038] First, the support wall 98 is operably joined to the second motor 74 such that the support, wall moves upwardly in response to the second shaft rotating in the direction corresponding to one of the first direction or the second direction. The support wall 98 moves upward with the rear of the support wall 98 moving up first due to a resistance on a front portion of the support wall 98 created by a rear jaw linkage 99. The support wall 98 moves upwardly on an angle until a cutter blade 102 attached to a rear portion of the support wall 98 contacts the cable tie 14. This adds resistance to the rear of the support wall 98 moving upwardly and causes the front of the support wall 98 to move up angularly until the front of the support wall 98 is totally up and stopped by one or more pins 103.

[0039] A rear portion of the support wall 98 includes the cutter blade 102 that separates, frees, or cuts the cable tie 14 from the carrier strip 38. When the cutter blade 102 contacts a carrier strip connecting gate, the support wall 98 experiences resistance which causes the front portion of the support wall 98 to start rising. This

angular motion creates a sweeping action that pulls a cable tie 14 in the plurality of cable ties 18 into a loading channel. This aligns the cable tie 14 for proper tie transfer by the auger 62.

[0040] Secondly, while the support wall 98 is moving upwardly, it actuates the rear jaw linkage 99 that causes the rear jaw 70 to close around a cable bundle, or the like (see, e.g. FIGS. 6 and 15).

[0041] Thirdly, the support wall 98 continues in its upward travel until the cable tie 14 is separated from the carrier strip 38. Once the cable tie 14 is separated, the cam pulley 90 stops, and the support wall 98 is in its final, fully upward position. The cam pulley 90 holds the support wall 98 in this position during cable tie transfer. The support wall 98 acts as a lower guide against which a bottom surface of the cable tie 14 is supported as it travels outwardly along the length of the auger 62 to the tensioning position.

[0042] At this point the first motor 55 reverses direction, and the auger 62 begins turning. This causes the cable tie 14 to transfer forwardly toward the front and rear jaws 68, 70 until it reaches a head stop 110,

[0043] Cable tie 14 movement is achieved by the tie head 34 trapped within a helical channel 114 in the auger 62. Rotation of the auger 62 causes the tie head 34 to move linearly forwardly within the helical channel 114.

[0044] A one-way clutch 65 is located between the second motor 74 and the cam pulley 90. This clutch 65 has an engaged condition wherein rotational movement by the second motor 74 shaft in one direction drives a movement by the cam pulley 90, A disengaged condition occurs when the shaft rotates in the opposite direction. Here, rotational movement by the shaft in the opposite direction causes the cam pulley 90 to freewheel in relation to the second motor 74 shaft. Such rotational movement by the shaft in the opposite direction does not impart movement to the cam pulley 90.

[0045] Similarly, another one-way clutch 65 is located between the second motor 74 and the cable tie tensioner. This clutch 65 has an engaged condition where rotational movement by the second motor shaft in one of the clockwise or counter-clockwise directions drives a movement by the cable tie tensioner. In a disengaged condition, rotational movement by the shaft in the opposite direction causes the cable tie tensioner to freewheel in relation to the second motor 74 shaft. Such rotational movement by the shaft in the opposite direction does not impart movement to the cable tie tensioner.

[0046] The tensioning and cut-off pulley 94 and the cam pulley 90 include one-way clutches 65 pressed into the tensioning and cut-off pulley and the cam pulley 94, 90, respectively. The purpose of the one-way clutch 65 is to allow the pulley 94 and cam pulley 90 to perform a function in one direction and free spin in the other direction. The tensioning and cut-off pulley 94 and the cam pulley 90 have one-way clutches 65 installed in opposite directions so the same second motor 74 can perform two different operations by just reversing direction (see FIGS. 11 and 12).

[0047] The last function is tensioning the cable tie 14 about a bundle of cables, or the like, and severing the free end 42 at the tie head 34. This is the same function as performed in the PAT1M 4.0 system marketed and sold by Panduit Corp. and also described in U.S. Patent No. 5,595,220, the full disclosure of which is hereby incorporated by reference and for the specific description of the tensioning on the cable tie 14 about a bundle of cables and the severing of the cable tie 14 at the tie head 34. In the present apparatus 10, the second motor 74 reverses direction and the tensioning and cut-off pulley 94 is engaged such that an intermediate gear 115 is driven by the tensioning and cut-off pulley 94.

[0048] The auger 62 transfers the cable tie 14 from a load position to the head stop 110. As the cable tie 14 is pushed forward, the free end 42 moves around the front and rear jaws 68, 70 into an annular shape. The second motor 74 rotates in a clockwise or counter-clockwise direction and moves the front jaw 68 inwardly to push the free end 42 into the tie head 34.

[0049] Here, the free end 42 of the cable tie 14 traverses within a groove 118 within the front and rear jaws 68, 70 which forms a guide within which the cable tie 14 travels to form a circumferential condition wherein the free end 42 of the cable tie 14 feeds through the tie head 34.

[0050] The front jaw 68 movement threads the free end 42 through the tie head 34 and delivers the free end 42 to a gripper gear 122. Once the free end 42 feeds through the tie head 34, the front jaw 68 pushes an intermediate portion of the cable tie 14 farther through the tie head 34 where the free end 42 is gripped by a gripper gear 122. The gripper gear 122 rotates which causes the free end 42 to move and the cable tie 14 to tension or tighten about the cable bundle, This process continues until a predetermined set tension is reached. The predetermined tension is adjustable by a knob 124. At this, a second cutter blade 126 is actuated and cuts the intermediate portion of the cable tie 14 flush to the tie head 34.

[0051] The tensioning and cut-off pulley 94 has a gear 127 (see, e.g., FIGS. 9 and 13) which drives the intermediate gear 115. The intermediate gear 115 is joined by a shaft to a gripper drive gear 128. The gripper drive gear 128 drives the gripper gear 122.

[0052] A front jaw cam roller 130 (see, e.g., FIG. 13), which is revolving along with gear 127 pushes the front jaw cam link 134 forward resulting in the front jaw 68 pivoting about a pivot point 138 to rotate in thereby threading the free end 42 of the cable tie 14 through the tie head 34 and forcing the intermediate portion of the cable tie 14 into engagement with the gripper gear 122. The front jaw 68 is returned to its normal position after front jaw cam roller 130 has revolved sufficiently by front jaw return extension spring 142.

[0053] A tension adjusting assembly is mechanically linked to the gripper gear 122 and applies a preset force through a tension limiting spring 146 to a tension retainer link 150 which is translated to a detent cam follower 154

such that as the gripper gear 122 pulls on the cable tie 14, increasing the downward force applied to a gripper detent link 158, a point is reached where the downward force overcomes the force applied by the tension assembly and gripper gear 122 begins walking down the cable tie. When the gripper detent link 158 rotates, it pulls on a severance link which causes a second cutter blade 126 to cut the excess intermediate portion of the cable tie 14 from the tensioned tie. When the excess portion has been cut, a tension limiting spring 146 forces the gripper detent link 158 back into position and engagement of detent cam follower 154 with a detent or recess in the tensioning retaining link. The return of the gripper detent link 158 causes activation of a sensor 170 indicating that the cable tie 14 has been cut, and the cycle was successfully completed. Continued rotation of gripper gear 122 drives the severed portion of the cable tie 14 out of the apparatus 10.

[0054] The tensioning and cut-off pulley 94 also includes a timing control cutout 178 (see, e.g., FIG. 9) and is timed so that it completes one revolution per tool cycle, The revolution of the tensioning and cut-off pulley 94 is timed so that when a sensor 170 first senses the timing control cutout 178, the motor 74 slows down. When sensor 170 senses an end of timing control cutout 178, indicating that the front jaw 68 has returned to the original position, the motor 74 stops.

[0055] Thus, when the cable tie 14 reaches the predetermined tension of the tensioning limiting spring 146, the tension retainer 150 releases. This causes the gripper detent link 158 to move around a main pivot shaft which causes the second cutter blade 126 to cut the tensioned cable tie 14.

[0056] The support wall 98 then lowers to a down position (see, e.g., FIG. 10) aided by a spring force provide by a spring 174. The next cable tie 14 in the plurality of cable ties 18 indexes to the load position. This completes one cycle of the cable tie apparatus 10.

[0057] The support wall 98 is lowered by rotating the cam pulley 90 another 180 degrees. A sensor 170 senses a position of the support wall 98 to ensure it is in a fully down position.

[0058] When the support wall 98 is down, and the sensor 170 confirms its position, the next cable tie 14 in the plurality of cable ties 18 is indexed into the load position.

[0059] As described above, according to an embodiment of the invention, the cable tie apparatus 10 performs a plurality of mechanical functions in sequence. These functions are driven or powered by the first and second motors 55, 74, which are actuated or controlled by a plurality of sensors 170, generally proximity sensors or optical sensors. The functions deliver a cable tie 14 from a plurality of cable ties 18 to a cable load starting position, transport the cable tie 14 from that position to a cable tie tensioning position, forms the cable tie 14 into an annular ring, and shortens a circumferential length of the annular form about a bundle of cables.

[0060] The first motor 55 imparts rotational movement to a shaft separately in a first direction and a second direction. The first and second directions are one of a clockwise and a counter-clockwise direction. The first motor 55 separately provides a mechanical power to a first apparatus function in the plurality of mechanical functions as the shaft rotates in the first direction. The first motor 55 separately provides a mechanical power to a second apparatus function in the plurality of mechanical functions as the shaft rotates in the second direction,

[0061] The second motor 74 imparts rotational movement to a shaft separately in a third direction and a fourth direction wherein the third and fourth directions are one of a clockwise and a counter-clockwise direction, The second motor 74 separately provides a mechanical power to a third apparatus function in the plurality of mechanical functions as its shaft rotates in the third direction. The second motor 74 separately provides a mechanical power to a fourth apparatus function in the plurality of mechanical functions as its shaft rotates in the fourth direction.

[0062] The cable tie delivery mechanism is operably joined to one of the first and second motors 55, 74 and performs one of the plurality of mechanical functions wherein the cable tie delivery mechanism delivers the cable tie 14 to a cable load starting position.

[0063] The cable tie transporter is operably joined to one of the first and second motors 55, 74 and performs one of the plurality of mechanical functions wherein the cable tie transporter moves the cable tie 14 from the cable tie load starting position to the cable tie tensioning position.

[0064] The cable tie tensioner is operably joined to one of the first and second motors 55, 74 and performs one of the plurality of mechanical functions wherein the cable tie tensioner shortens the circumferential length of the annular form.

Claims

1. An automatic cable tie apparatus (10) for tightening and fastening a cable tie (14) around a bundle of cables, comprising:

a first motor (55) imparting rotational movement to a first shaft separately in a first direction and a second direction wherein the first and second directions are one of a clockwise and counter-clockwise direction, respectively;

a cable tie delivery mechanism (52) operably joined to the first motor such that the cable tie delivery mechanism transfers a cable tie to a cable tie load starting position as the first shaft rotates in the first direction; and

a transporter (60) operably joined to the first motor such that the transporter transfers the cable tie from the cable tie load starting position to a cable tie tensioning position as the first shaft rotates in the second direction; **characterized by**

a second motor (74) imparting rotational movement to a second shaft separately in the first direction and the second direction;
a cable tie guide (66) operably joined to the second motor such that the cable tie guide directs the moving cable tie as the second shaft rotates in a direction corresponding to one of the first direction or the second direction; and
a cable tie tensioner operably joined to the second motor such that the cable tie tensioner decreases a circumferential length of the cable tie as the second shaft rotates in an opposite direction to said
direction corresponding to one of the first direction or the second direction.

2. The automatic cable tie apparatus (10) of Claim 1 further comprising:

a first clutch (65) located between the first motor (55) and the cable tie delivery mechanism (52), the first clutch having an engaged condition wherein rotational movement by the first shaft in the first direction drives a movement by the cable tie delivery mechanism (52) and a disengaged condition wherein rotational movement by the first shaft in the second direction causes the first shaft to freewheel in relation to the cable tie delivery mechanism (52) wherein such rotational movement by the first shaft in the second direction does not impart movement to the cable tie delivery mechanism.

3. The automatic cable tie apparatus (10) of Claim 2 further comprising:
a second clutch (65) located between the first motor (55) and the transporter (60), the second clutch having an engaged condition wherein rotational movement by the first shaft in the second direction drives a movement by the transporter (60) and a disengaged condition wherein rotational movement by the first shaft in the first direction causes the first shaft to freewheel in relation to the transporter (60) wherein such rotational movement by the first shaft in the first direction does not impart movement to the transporter.

4. The automatic cable tie apparatus (10) of Claim 3 wherein the cable tie delivery mechanism (52) comprises a gearing assembly operably joined to the first motor wherein a first gear in the gearing assembly includes a plurality of chamfered teeth configured to frictionally engage a cable tie carrier to impart movement to the cable tie carrier upon rotation of the first shaft in the first direction to deliver the cable tie to the cable tie load starting position.

5. The automatic cable tie apparatus (10) of Claim 4 wherein the transporter (60) comprises a gearing assembly operably joined to the first motor wherein a first gear imparts movement to the transporter (60) to convey the cable tie from the cable tie load starting position to the cable tie tensioning position.

6. The automatic cable tie apparatus (10) of Claim 1 wherein the transporter (60) comprises an auger (62) having a helical channel in which a cable tie head (34) is held to impart a linear movement of the cable tie (14) from the cable tie load starting position to the cable tie tensioning position.

7. The automatic cable tie apparatus (10) of Claim 6, wherein the auger (62) pushes the cable tie forward around a cable tie supporter (66) of front and rear jaws (68, 70) into an annular shape around the bundle of cables.

8. The automatic cable tie apparatus (10) of Claim 1 further comprising:
a third clutch located between the second motor (74) and the cable tie guide (66), the third clutch having an engaged condition wherein rotational movement by the second shaft in the direction corresponding to one of the first direction or the second direction drives a movement by the cable tie guide (66) and a disengaged condition wherein rotational movement by the second shaft in the opposite direction to the direction corresponding to one of the first direction or the second direction causes the second shaft to freewheel in relation to the cable tie guide (66) wherein such rotational movement by the second shaft in the opposite direction to the direction corresponding to one of the first direction or the second direction does not impart movement to the cable tie guide (66).

9. The automatic cable tie apparatus (10) of Claim 8 further comprising:
a fourth clutch located between the second motor (74) and the cable tie tensioner, the fourth clutch having an engaged condition wherein rotational movement by the second shaft in the opposite direction to the direction corresponding to one of the first direction or the second direction drives a movement by the cable tie tensioner and a disengaged condition wherein rotational movement by the second shaft in the direction corresponding to one of the first direction or the second direction causes the second shaft to freewheel in relation to the cable tie tensioner wherein such rotational movement by the second shaft in the direction corresponding to one of the first direction or the second direction does not impart movement to the cable tie tensioner.

10. The automatic cable tie apparatus (10) of Claim 9 wherein the cable tie guide (66) comprising a support

wall (98) operably joined to the second motor (74) such that the support wall moves upwardly in response to the second shaft rotating in the direction corresponding to one of the first direction or the second direction.

11. The automatic cable tie apparatus (10) of Claim 10 wherein the support wall (98) moves upwardly to a position adjacent the transporter (60) to support the cable tie (14) as the cable tie (14) moves from the cable tie load starting position to the cable tie tensioning position.

12. The automatic cable tie apparatus (10) of Claim 10 wherein upward movement of the support wall (98) actuates rear jaw (70) closing the rear jaw (70) around the cable bundle.

13. The automatic cable tie apparatus (10) of Claim 10 wherein upward movement of the support wall (98) cuts the cable tie (14) from a carrier strip and pulls the cable tie (14) into the cable tie load starting position.

Patentansprüche

1. Automatische Kabelbindervorrichtung (10) zum Spannen und Befestigen eines Kabelbinders (14) um ein Kabelbündel, umfassend:

einen ersten Motor (55), der eine Drehbewegung auf eine erste Welle separat in einer ersten Richtung und einer zweiten Richtung aufbringt, wobei die erste und die zweite Richtung eine einer Richtung im Uhrzeigersinn bzw. gegen den Uhrzeigersinn ist;
einen Kabelbinderzuführmechanismus (52), der mit dem ersten Motor derart wirkverbunden ist, dass der Kabelbinderzuführmechanismus einen Kabelbinder zu einer Kabelbinderladestartposition überführt, während sich die erste Welle in der ersten Richtung dreht; und
eine Transportvorrichtung (60), die mit dem ersten Motor derart wirkverbunden ist, dass die Transportvorrichtung den Kabelbinder von der Kabelbinderladestartposition zu einer Kabelbinderspannposition überführt, während sich die erste Welle in der zweiten Richtung dreht;
gekennzeichnet durch
einen zweiten Motor (74), der eine Drehbewegung auf eine zweite Welle separat in der ersten Richtung und der zweiten Richtung aufbringt;
eine Kabelbinderführung (66), die mit dem zweiten Motor derart wirkverbunden ist, dass die Kabelbinderführung den sich bewegenden Kabelbinder lenkt, während sich die zweite Welle in einer Richtung dreht, die einer der ersten Richtung oder der zweiten Richtung entspricht; und
eine Kabelbinderspannvorrichtung, die mit dem zweiten Motor derart wirkverbunden ist, dass die Kabelbinderspannvorrichtung eine Umfangslänge des Kabelbinders verringert, während sich die zweite Welle in einer entgegengesetzten Richtung zu der Richtung dreht, die einer der ersten Richtung oder der zweiten Richtung entspricht.

2. Automatische Kabelbindervorrichtung (10) nach Anspruch 1, ferner umfassend:
eine erste Kupplung (65), die sich zwischen dem ersten Motor (55) und dem Kabelbinderzuführmechanismus (52) befindet, wobei die erste Kupplung einen eingerückten Zustand, in dem eine Drehbewegung durch die erste Welle in der ersten Richtung eine Bewegung durch den Kabelbinderzuführmechanismus (52) antreibt, und einen ausgerückten Zustand, in dem eine Drehbewegung durch die erste Welle in der zweiten Richtung bewirkt, dass die erste Welle in Relation zu dem Kabelbinderzuführmechanismus (52) freiläuft, wobei eine solche Drehbewegung durch die erste Welle in der zweiten Richtung keine Bewegung auf den Kabelbinderzuführmechanismus aufbringt, aufweist.

3. Automatische Kabelbindervorrichtung (10) nach Anspruch 2, ferner umfassend:
eine zweite Kupplung (65), die sich zwischen dem ersten Motor (55) und der Transportvorrichtung (60) befindet, wobei die zweite Kupplung einen eingerückten Zustand, in dem eine Drehbewegung durch die erste Welle in der zweiten Richtung eine Bewegung durch die Transportvorrichtung (60) antreibt, und einen ausgerückten Zustand, in dem eine Drehbewegung durch die erste Welle in der ersten Richtung bewirkt, dass die erste Welle in Relation zu der Transportvorrichtung (60) freiläuft, wobei eine solche Drehbewegung durch die erste Welle in der ersten Richtung keine Bewegung auf die Transportvorrichtung aufbringt, aufweist.

4. Automatische Kabelbindervorrichtung (10) nach Anspruch 3, wobei der Kabelbinderzuführmechanismus (52) eine Zahnradanordnung umfasst, die mit dem ersten Motor wirkverbunden ist, wobei ein erstes Zahnrad in der Zahnradanordnung eine Mehrzahl von abgeschrägten Zähnen aufweist, die dazu ausgelegt sind, einen Kabelbinderträger reibschlüssig in Eingriff zu nehmen, um eine Bewegung auf den Kabelbinderträger bei Drehung der ersten Welle in der ersten Richtung aufzubringen, um den Kabelbinder zu der Kabelbinderladestartposition zu liefern.

5. Automatische Kabelbindervorrichtung (10) nach Anspruch 4, wobei die Transportvorrichtung (60) eine

Zahnradanordnung umfasst, die mit dem ersten Motor wirkverbunden ist, wobei ein erstes Zahnrad eine Bewegung auf die Transportvorrichtung (60) aufbringt, um den Kabelbinder von der Kabelbinderladestartposition zu der Kabelbinderspannposition zu befördern.

6. Automatische Kabelbindervorrichtung (10) nach Anspruch 1, wobei die Transportvorrichtung (60) eine Schnecke (62) umfasst, die einen spiralförmigen Kanal aufweist, in dem ein Kabelbinderkopf (34) gehalten ist, um eine lineare Bewegung des Kabelbinders (14) von der Kabelbinderladestartposition zu der Kabelbinderspannposition aufzubringen.

7. Automatische Kabelbindervorrichtung (10) nach Anspruch 6, wobei die Schnecke (62) den Kabelbinder nach vorn um eine Kabelbinderstützvorrichtung (66) aus vorderen und hinteren Backen (68, 70) in eine ringförmige Form um das Kabelbündel drückt.

8. Automatische Kabelbindervorrichtung (10) nach Anspruch 1, ferner umfassend:
eine dritte Kupplung, die sich zwischen dem zweiten Motor (74) und der Kabelbinderführung (66) befindet, wobei die dritte Kupplung einen eingerückten Zustand, in dem eine Drehbewegung durch die zweite Welle in der Richtung, die einer der ersten Richtung oder der zweiten Richtung entspricht, eine Bewegung durch die Kabelbinderführung (66) antreibt, und einen ausgerückten Zustand, in dem eine Drehbewegung durch die zweite Welle in der entgegengesetzten Richtung zu der Richtung, die einer der ersten Richtung oder der zweiten Richtung entspricht, bewirkt, dass die zweite Welle in Relation zu der Kabelbinderführung (66) freiläuft, wobei eine solche Drehbewegung durch die zweite Welle in der entgegengesetzten Richtung zu der Richtung, die einer der ersten Richtung oder der zweiten Richtung entspricht, keine Bewegung auf die Kabelbinderführung (66) aufbringt, aufweist.

9. Automatische Kabelbindervorrichtung (10) nach Anspruch 8, ferner umfassend:
eine vierte Kupplung, die sich zwischen dem zweiten Motor (74) und der Kabelbinderspannvorrichtung befindet, wobei die vierte Kupplung einen eingerückten Zustand, in dem eine Drehbewegung durch die zweite Welle in der entgegengesetzten Richtung zu der Richtung, die einer der ersten Richtung oder der zweiten Richtung entspricht, eine Bewegung durch die Kabelbinderspannvorrichtung antreibt, und einen ausgerückten Zustand, in dem eine Drehbewegung durch die zweite Welle in der Richtung, die einer der ersten Richtung oder der zweiten Richtung entspricht, bewirkt, dass die zweite Welle in Relation zu der Kabelbinderspannvorrichtung freiläuft, wobei eine solche Drehbewegung durch die zweite Welle in der Richtung, die einer der ersten Richtung oder der zweiten Richtung entspricht, keine Bewegung auf die Kabelbinderspannvorrichtung aufbringt, aufweist.

10. Automatische Kabelbindervorrichtung (10) nach Anspruch 9, wobei die Kabelbinderführung (66) eine Stützwand (98) umfasst, die mit dem zweiten Motor (74) derart wirkverbunden ist, dass die Stützwand sich in Reaktion darauf nach oben bewegt, dass sich die zweite Welle in der Richtung dreht, die einer der ersten Richtung oder der zweiten Richtung entspricht.

11. Automatische Kabelbindervorrichtung (10) nach Anspruch 10, wobei sich die Stützwand (98) aufwärts zu einer Position bewegt, die an die Transportvorrichtung (60) angrenzt, um den Kabelbinder (14) zu stützen, während sich der Kabelbinder (14) von der Kabelbinderladestartposition zu der Kabelbinderspannposition bewegt.

12. Automatische Kabelbindervorrichtung (10) nach Anspruch 10, wobei die Aufwärtsbewegung der Stützwand (98) die hintere Backe (70) betätigt, sodass sich die hintere Backe (70) um das Kabelbündel schließt.

13. Automatische Kabelbindervorrichtung (10) nach Anspruch 10, wobei die Aufwärtsbewegung der Stützwand (98) den Kabelbinder (14) von einem Trägerstreifen abschneidet und den Kabelbinder (14) in die Kabelbinderladestartposition zieht.

Revendications

1. Appareil d'attache de câble automatique (10) pour serrer et attacher une attache de câble (14) autour d'un faisceau de câbles, comprenant :

un premier moteur (55) transmettant un mouvement de rotation à un premier arbre séparément dans une première direction et une seconde direction dans lequel les première et seconde directions sont l'une d'une direction horaire et antihoraire, respectivement ;
un mécanisme de libération d'attache de câble (52) joint de manière opérationnelle au premier moteur de telle sorte que le mécanisme de libération d'attache de câble transfère une attache de câble à une position de démarrage de chargement d'attache de câble lorsque le premier arbre tourne dans la première direction ; et
un dispositif de transport (60) joint de manière opérationnelle au premier moteur de telle sorte que le dispositif de transport transfère l'attache de câble de la position de démarrage de char-

gement d'attache de câble vers une position de mise sous tension d'attache de câble lorsque le premier arbre tourne dans la seconde direction ; **caractérisé par**

un second moteur (74) transmettant un mouvement de rotation à un second arbre séparément dans la première direction et la seconde direction ;

un guide d'attache de câble (66) joint de manière opérationnelle au second moteur de telle sorte que le guide d'attache de câble dirige l'attache de câble en mouvement lorsque le second arbre tourne dans une direction correspondant à l'une de la première direction ou de la seconde direction ; et

un tendeur d'attache de câble joint de manière opérationnelle au second moteur de telle sorte que le tendeur d'attache de câble diminue une longueur circonférentielle de l'attache de câble lorsque le second arbre tourne dans une direction opposée à ladite direction correspondant à l'une de la première direction ou de la seconde direction.

2. Appareil d'attache de câble automatique (10) selon la revendication 1 comprenant en outre :

un premier embrayage (65) situé entre le premier moteur (55) et le mécanisme de libération d'attache de câble (52), le premier embrayage ayant un état de mise en prise dans lequel un mouvement de rotation par le premier arbre dans la première direction entraîne un mouvement par le mécanisme de libération d'attache de câble (52) et un état de désaccouplement dans lequel un mouvement de rotation par le premier arbre dans la seconde direction amène le premier arbre à être en roue libre par rapport au mécanisme de libération d'attache de câble (52) dans lequel un tel mouvement de rotation par le premier arbre dans la seconde direction ne transmet pas de mouvement au mécanisme de libération d'attache de câble.

3. Appareil d'attache de câble automatique (10) selon la revendication 2 comprenant en outre :

un second embrayage (65) situé entre le premier moteur (55) et le dispositif de transport (60), le second embrayage ayant un état de mise en prise dans lequel un mouvement de rotation par le premier arbre dans la seconde direction entraîne un mouvement par le dispositif de transport (60) et un état de désaccouplement dans lequel un mouvement de rotation par le premier arbre dans la première direction amène le premier arbre à être en roue libre par rapport au dispositif de transport (60) dans lequel un tel mouvement de rotation par le premier arbre dans la première direction ne transmet pas de mouvement au dispositif de transport.

4. Appareil d'attache de câble automatique (10) selon la revendication 3 dans lequel le mécanisme de libération d'attache de câble (52) comprend un ensemble d'engrenages joint de manière opérationnelle au premier moteur dans lequel un premier engrenage dans l'ensemble d'engrenages inclut une pluralité de dents chanfreinées configurées pour mettre en prise par friction un support d'attache de câble pour transmettre un mouvement au support d'attache de câble lors de la rotation du premier arbre dans la première direction pour libérer l'attache de câble dans la position de démarrage de chargement d'attache de câble.

5. Appareil d'attache de câble automatique (10) selon la revendication 4 dans lequel le dispositif de transport (60) comprend un ensemble d'engrenages joint de manière opérationnelle au premier moteur dans lequel un premier engrenage transmet un mouvement au dispositif de transport (60) pour transporter l'attache de câble de la position de démarrage de chargement d'attache de câble à la position de mise sous tension d'attache de câble.

6. Appareil d'attache de câble automatique (10) selon la revendication 1 dans lequel le dispositif de transport (60) comprend une vis sans fin (62) ayant un canal hélicoïdal dans lequel une tête d'attache de câble (34) est maintenue pour transmettre un mouvement linéaire de l'attache de câble (14) de la position de démarrage de chargement d'attache de câble à la position de mise sous tension d'attache de câble.

7. Appareil d'attache de câble automatique (10) selon la revendication 6, dans lequel la vis sans fin (62) pousse l'attache de câble vers l'avant autour d'un dispositif de support d'attache de câble (66) de mâchoires avant et arrière (68, 70) dans une forme annulaire autour du faisceau de câbles.

8. Appareil d'attache de câble automatique (10) selon la revendication 1 comprenant en outre :

un troisième embrayage situé entre le second moteur (74) et le guide d'attache de câble (66), le troisième embrayage ayant un état de mise en prise dans lequel un mouvement de rotation par le second arbre dans la direction correspondant à l'une de la première direction ou de la seconde direction entraîne un mouvement par le guide d'attache de câble (66) et un état de désaccouplement dans lequel un mouvement de rotation par le second arbre dans la direction opposée à la direction correspondant à l'une de la première direction ou de la seconde direction amène le second arbre à être en roue libre par rapport au guide d'attache de câble (66) dans lequel un tel mouvement de rotation par le second arbre dans la direction opposée à la direction cor-

respondant à l'une de la première direction ou de la seconde direction ne transmet pas de mouvement au guide d'attache de câble (66).

9. Appareil d'attache de câble automatique (10) selon la revendication 8 comprenant en outre :
un quatrième embrayage situé entre le second moteur (74) et le tendeur d'attache de câble, le quatrième embrayage ayant un état de mise en prise dans lequel un mouvement de rotation par le second arbre dans la direction opposée à la direction correspondant à l'une de la première direction ou de la seconde direction entraîne un mouvement par le tendeur d'attache de câble et un état de désaccouplement dans lequel un mouvement de rotation par le second arbre dans la direction correspondant à l'une de la première direction ou de la seconde direction amène le second arbre à être en roue libre par rapport au tendeur d'attache de câble dans lequel un tel mouvement de rotation par le second arbre dans la direction correspondant à l'une de la première direction ou de la seconde direction ne transmet pas de mouvement au tendeur d'attache de câble.

10. Appareil d'attache de câble automatique (10) selon la revendication 9 dans lequel le guide d'attache de câble (66) comprend une paroi de support (98) jointe de manière opérationnelle au second moteur (74) de telle sorte que la paroi de support se déplace vers le haut en réponse à la rotation du second arbre dans la direction correspondant à l'une de la première direction ou de la seconde direction.

11. Appareil d'attache de câble automatique (10) selon la revendication 10 dans lequel la paroi de support (98) se déplace vers le haut vers une position adjacente au dispositif de transport (60) pour supporter l'attache de câble (14) lorsque l'attache de câble (14) se déplace de la position de démarrage de chargement d'attache de câble vers la position de mise sous tension d'attache de câble.

12. Appareil d'attache de câble automatique (10) selon la revendication 10 dans lequel un mouvement vers le haut de la paroi de support (98) actionne la mâchoire arrière (70) en fermant la mâchoire arrière (70) autour du faisceau de câbles.

13. Appareil d'attache de câble automatique (10) selon la revendication 10 dans lequel un mouvement vers le haut de la paroi de support (98) découpe l'attache de câble (14) d'une bande de support et tire l'attache de câble (14) dans la position de démarrage de chargement d'attache de câble.

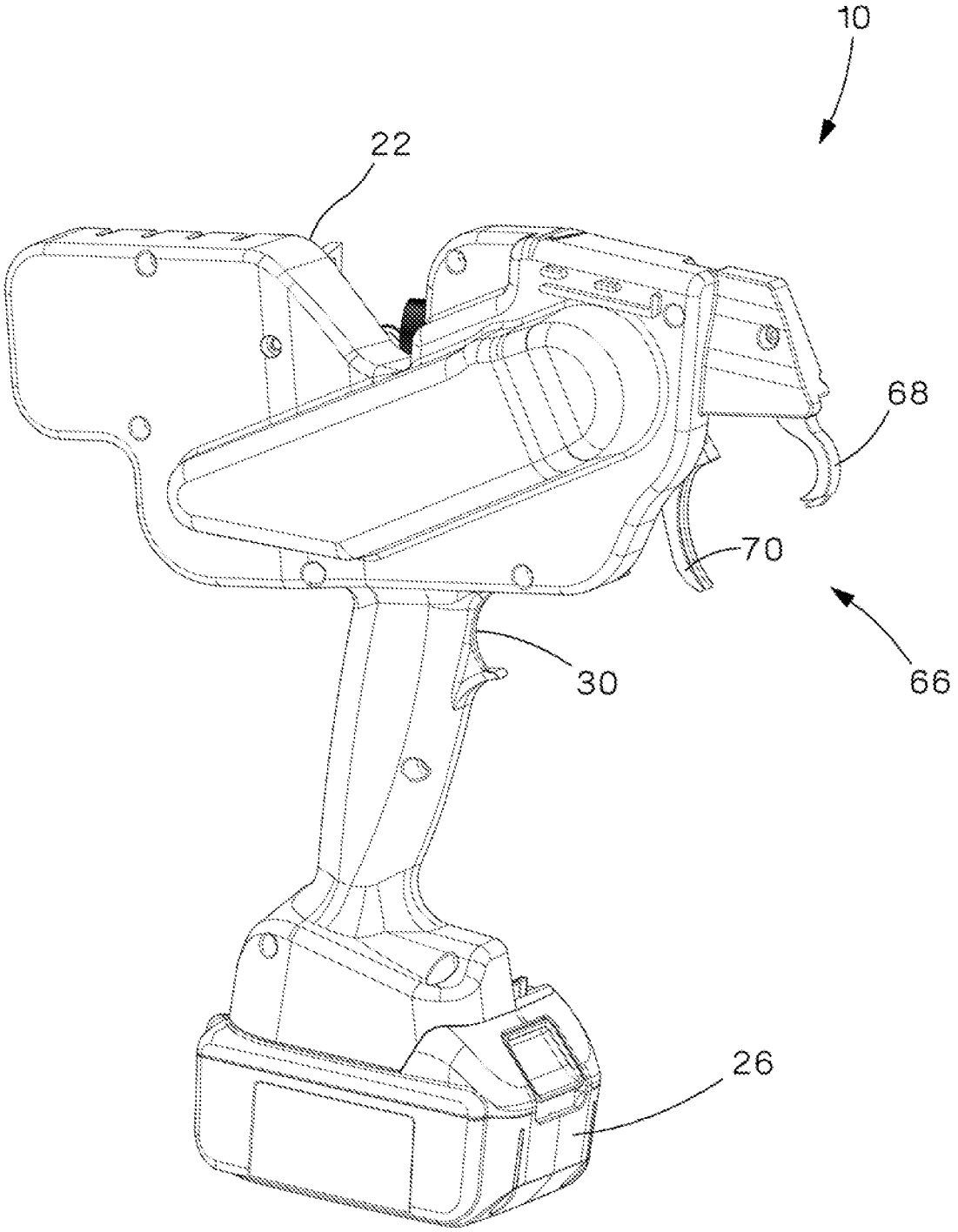

FIG.1

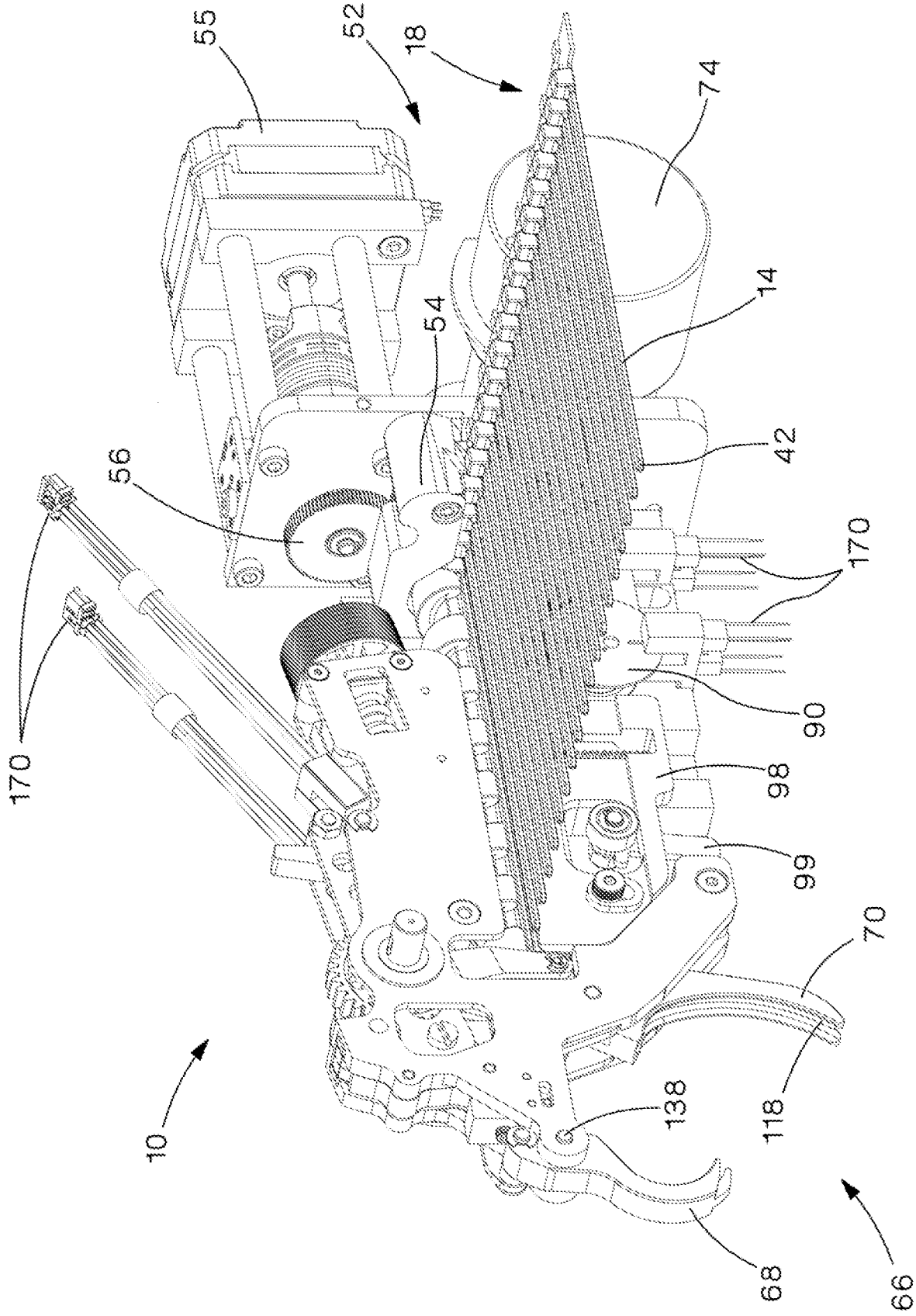

FIG.2

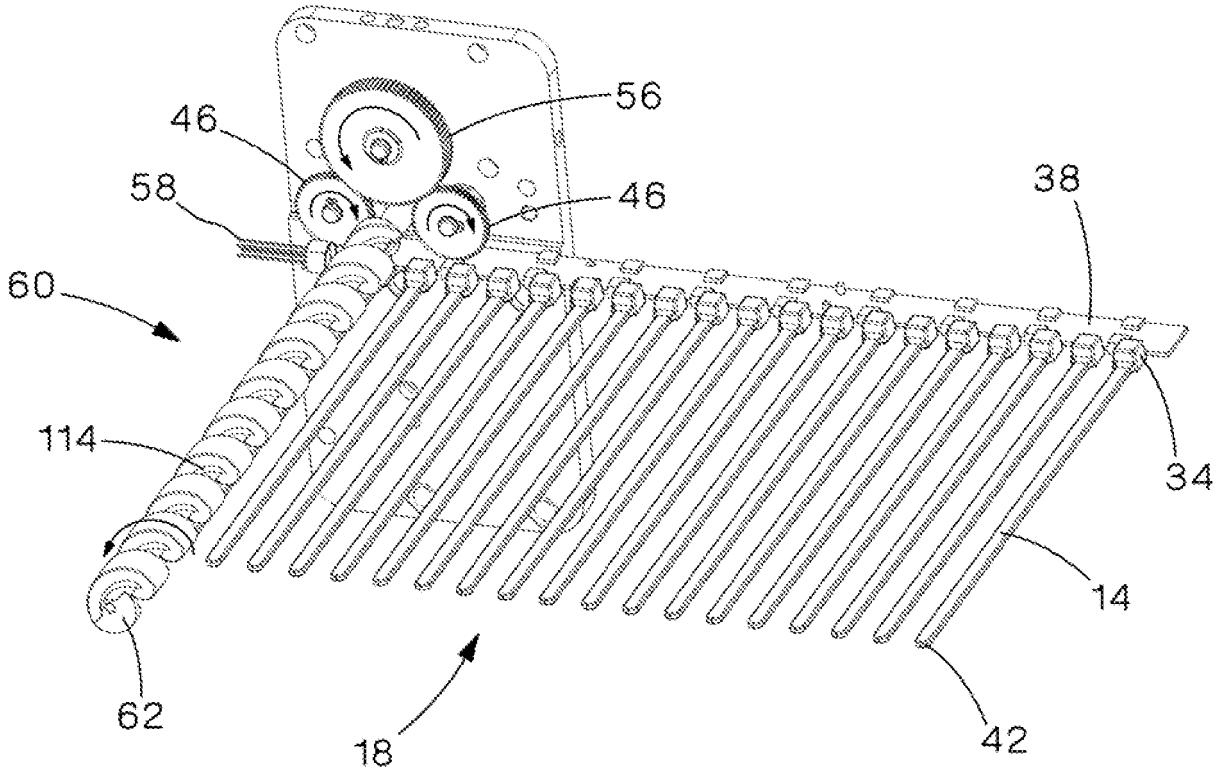

FIG.3

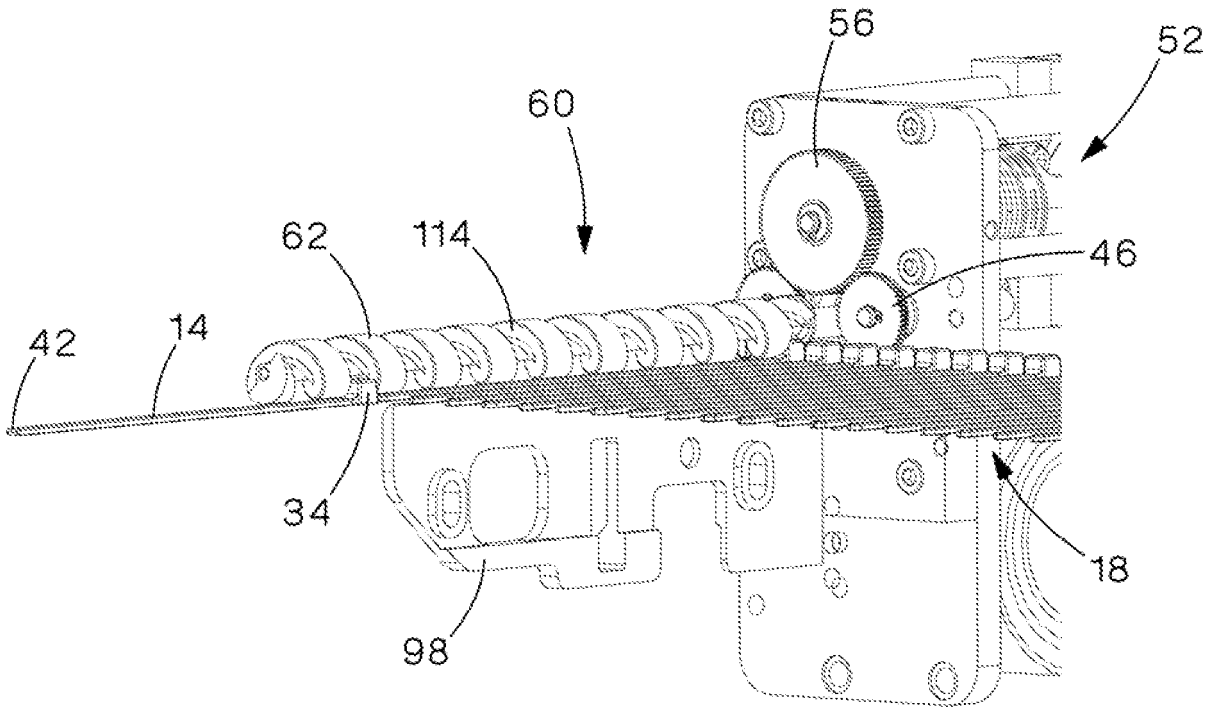

FIG.4

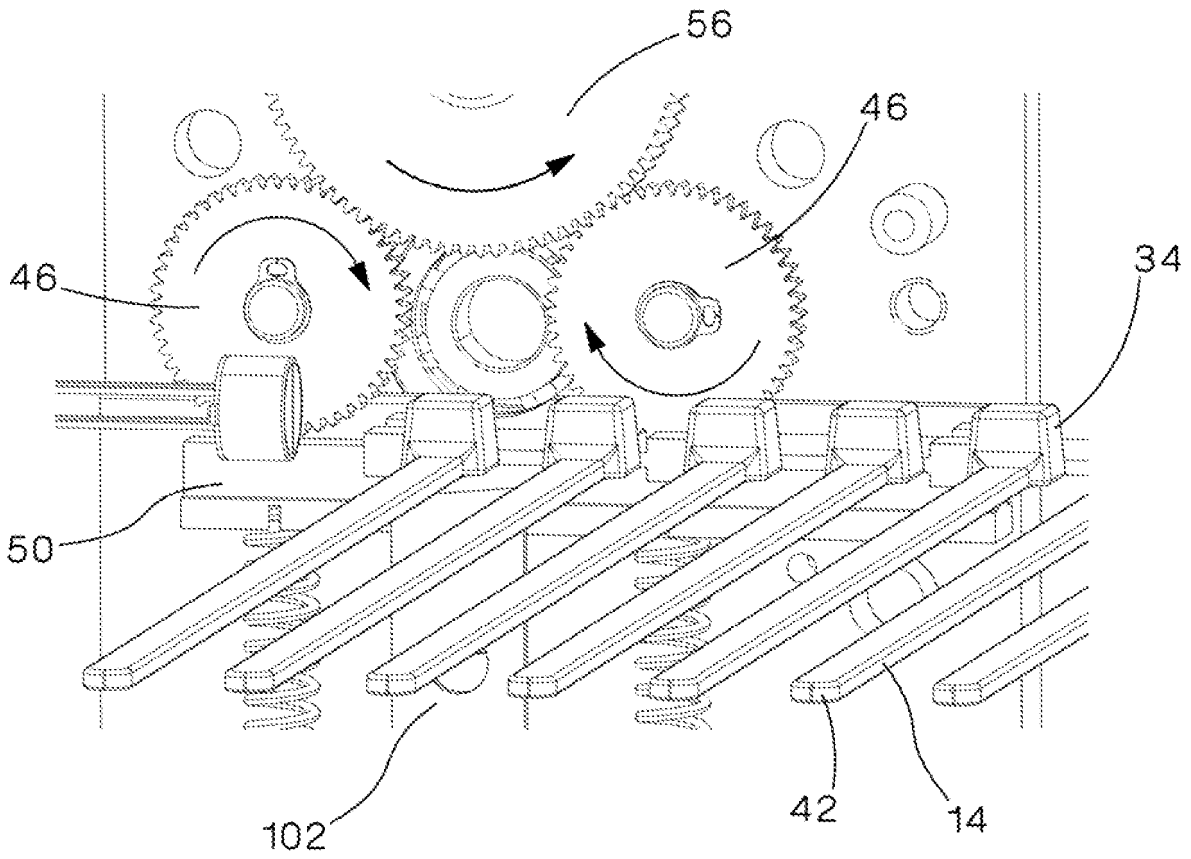

FIG.5

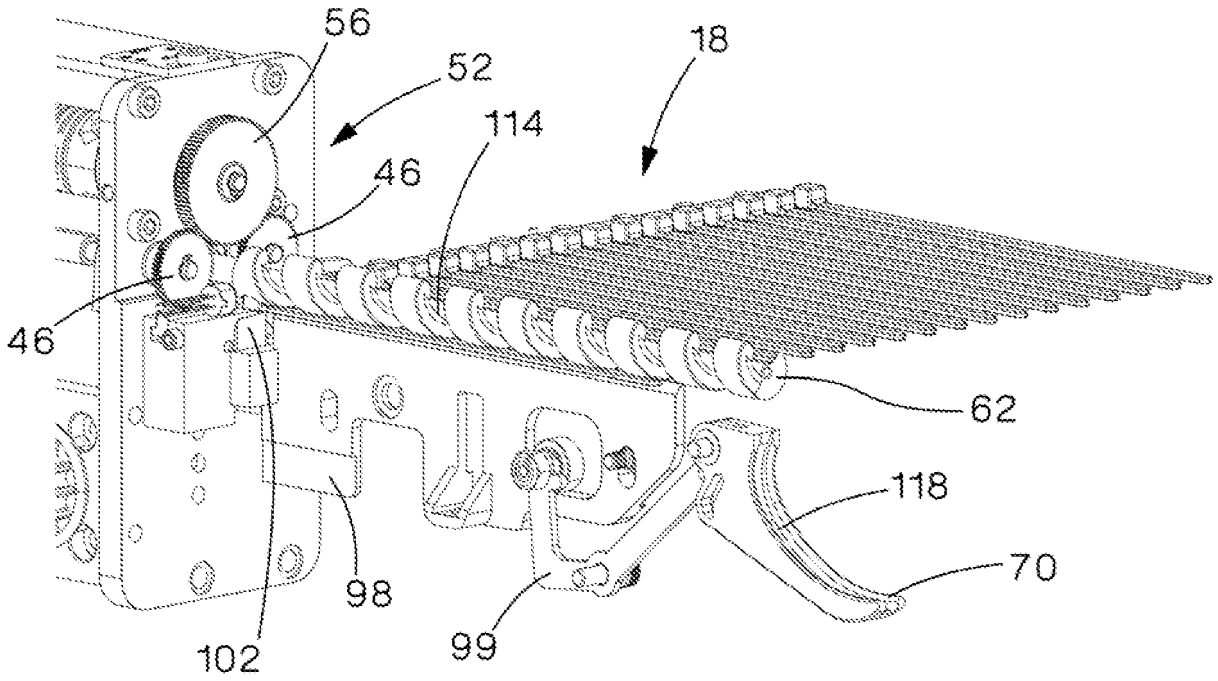

FIG.6

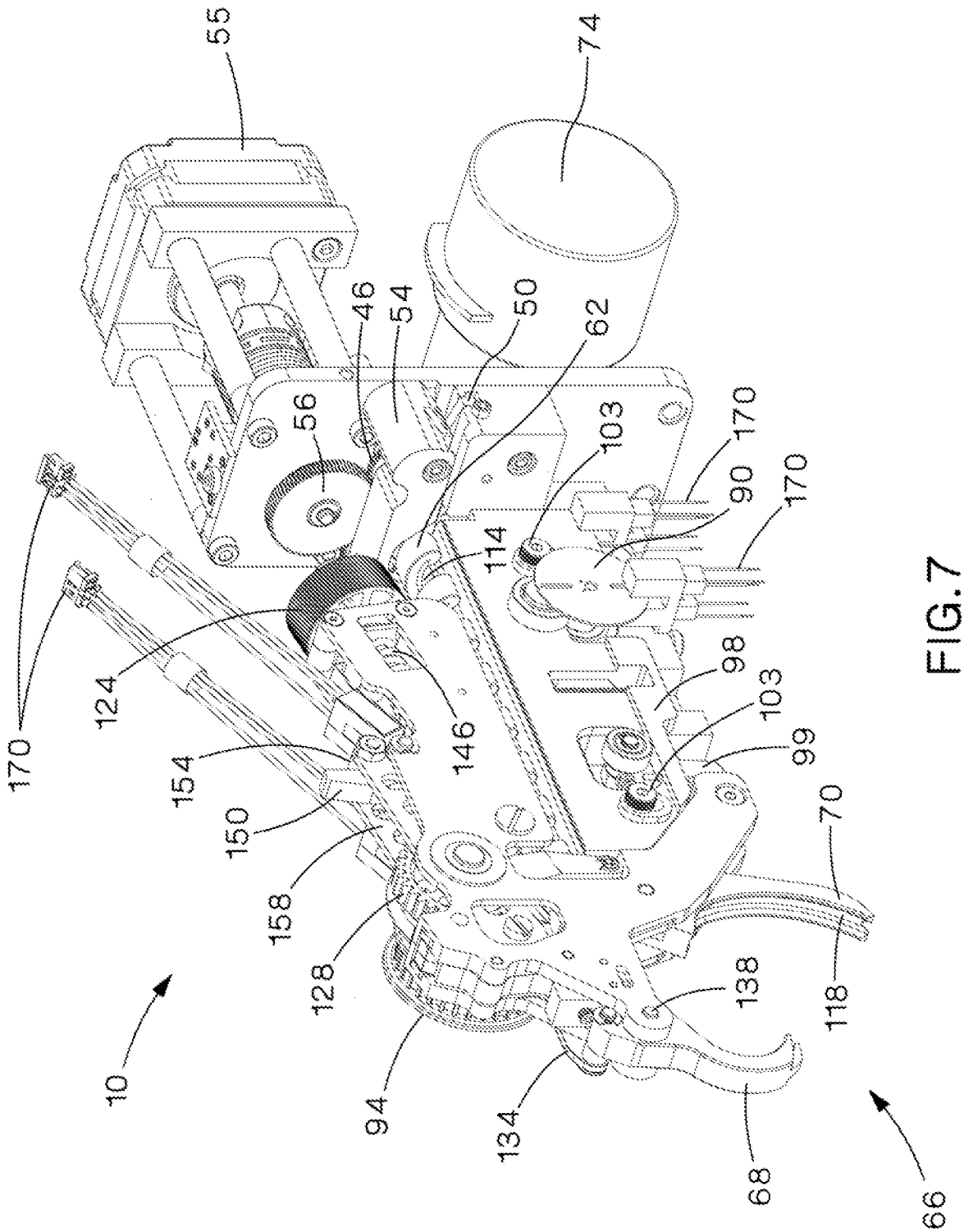
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FIG. 7

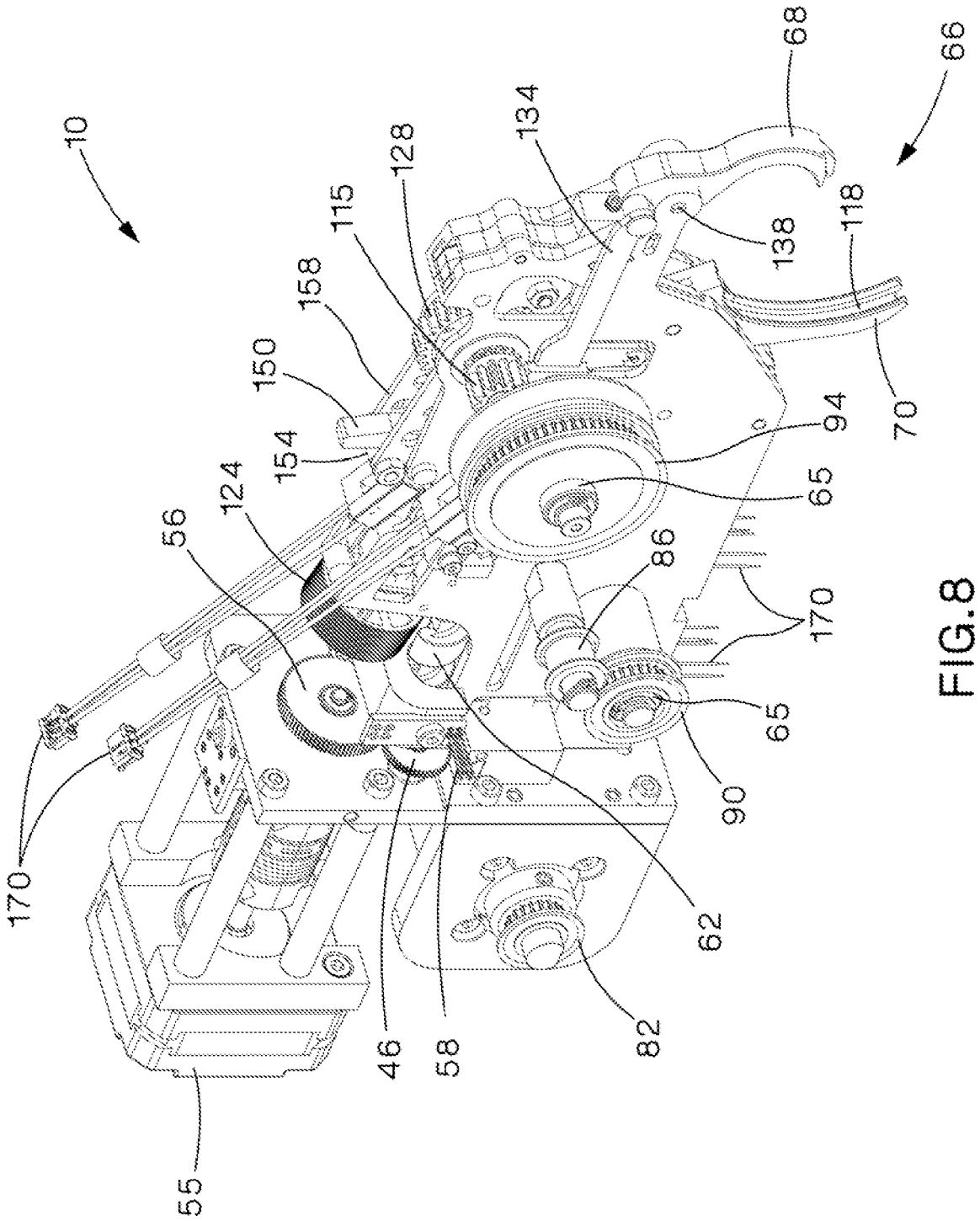
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FIG.8

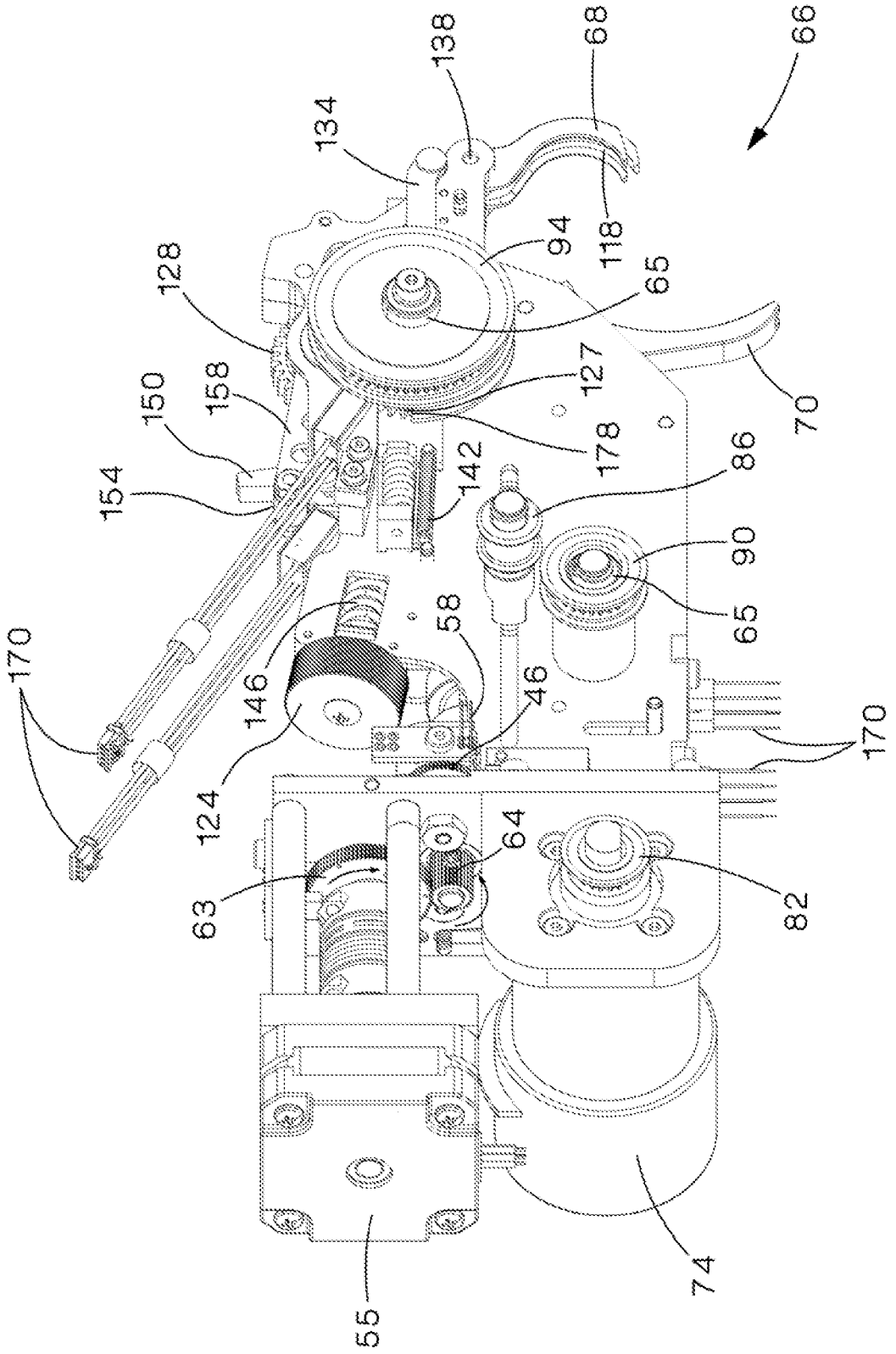
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FIG.9

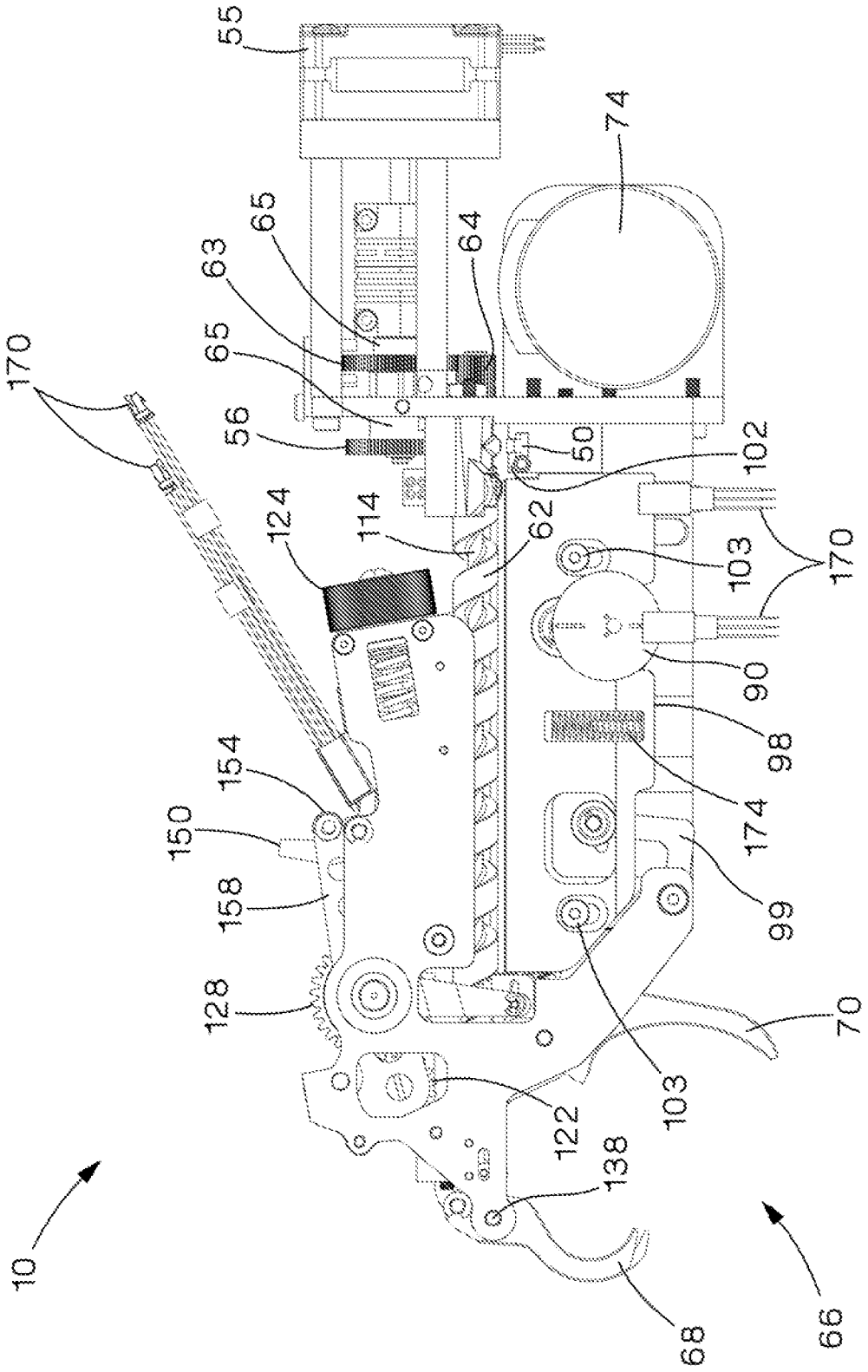
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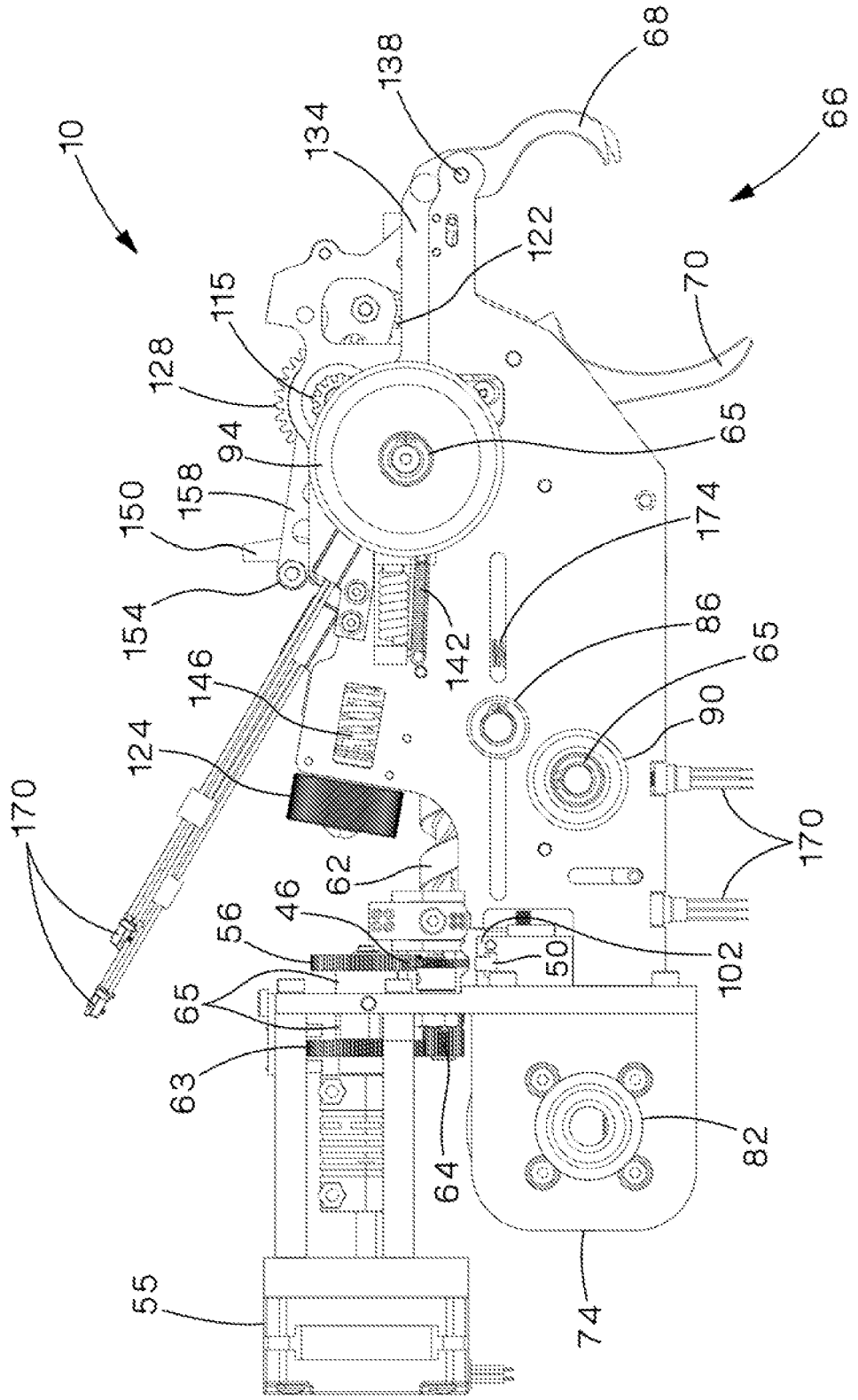
FIG.10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174
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102
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63
64
82
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74

FIG.11

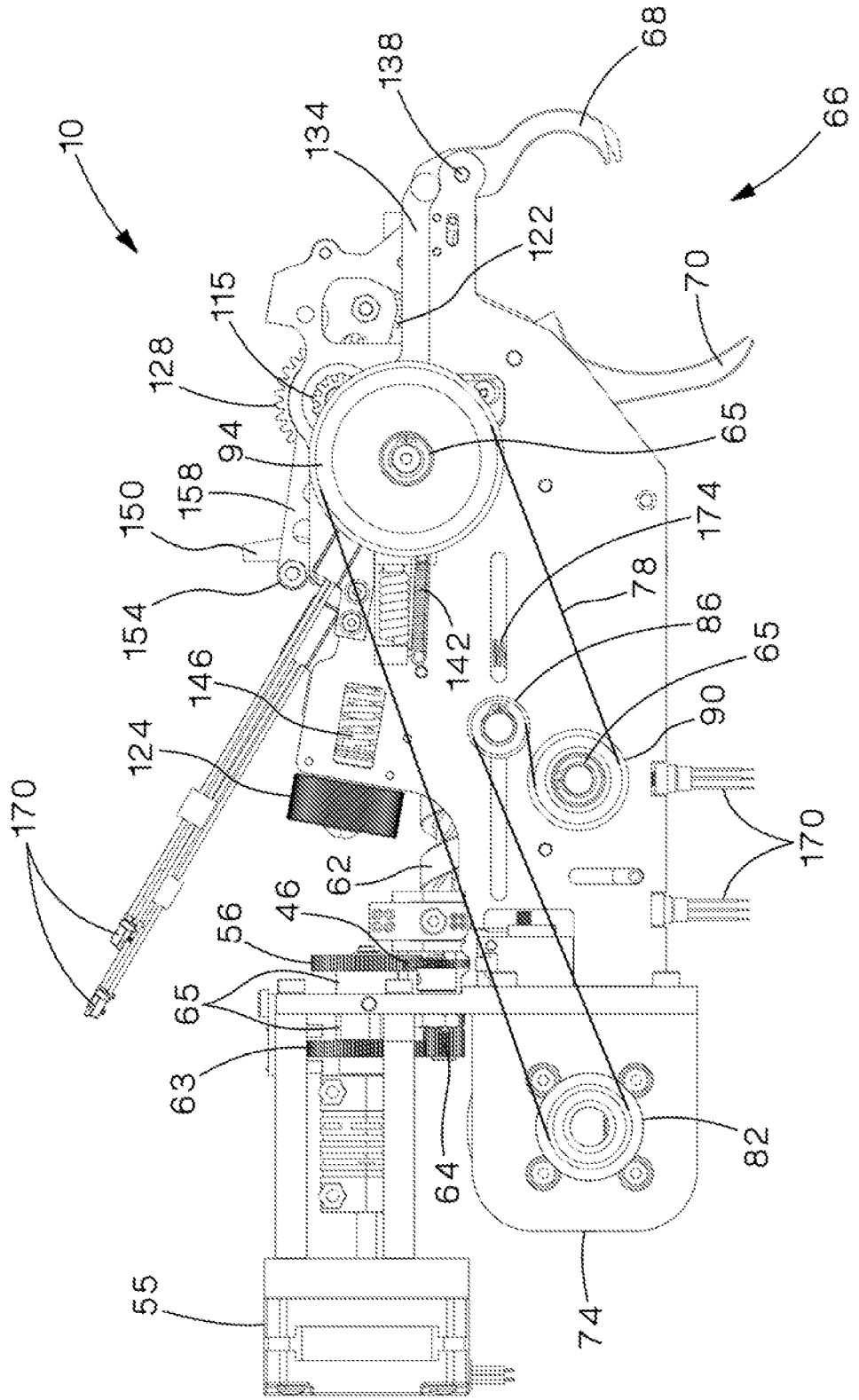
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FIG.12

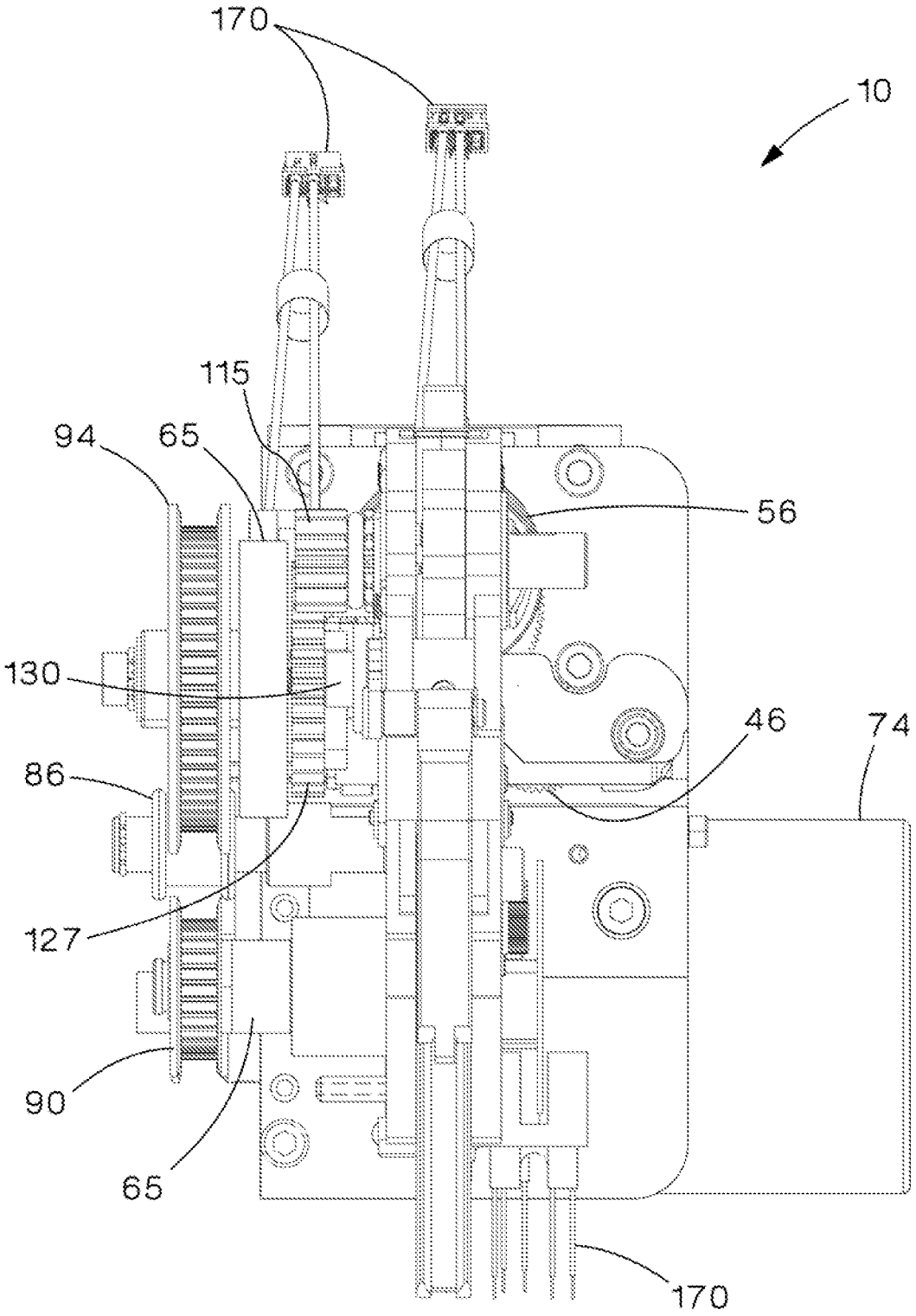

FIG.13

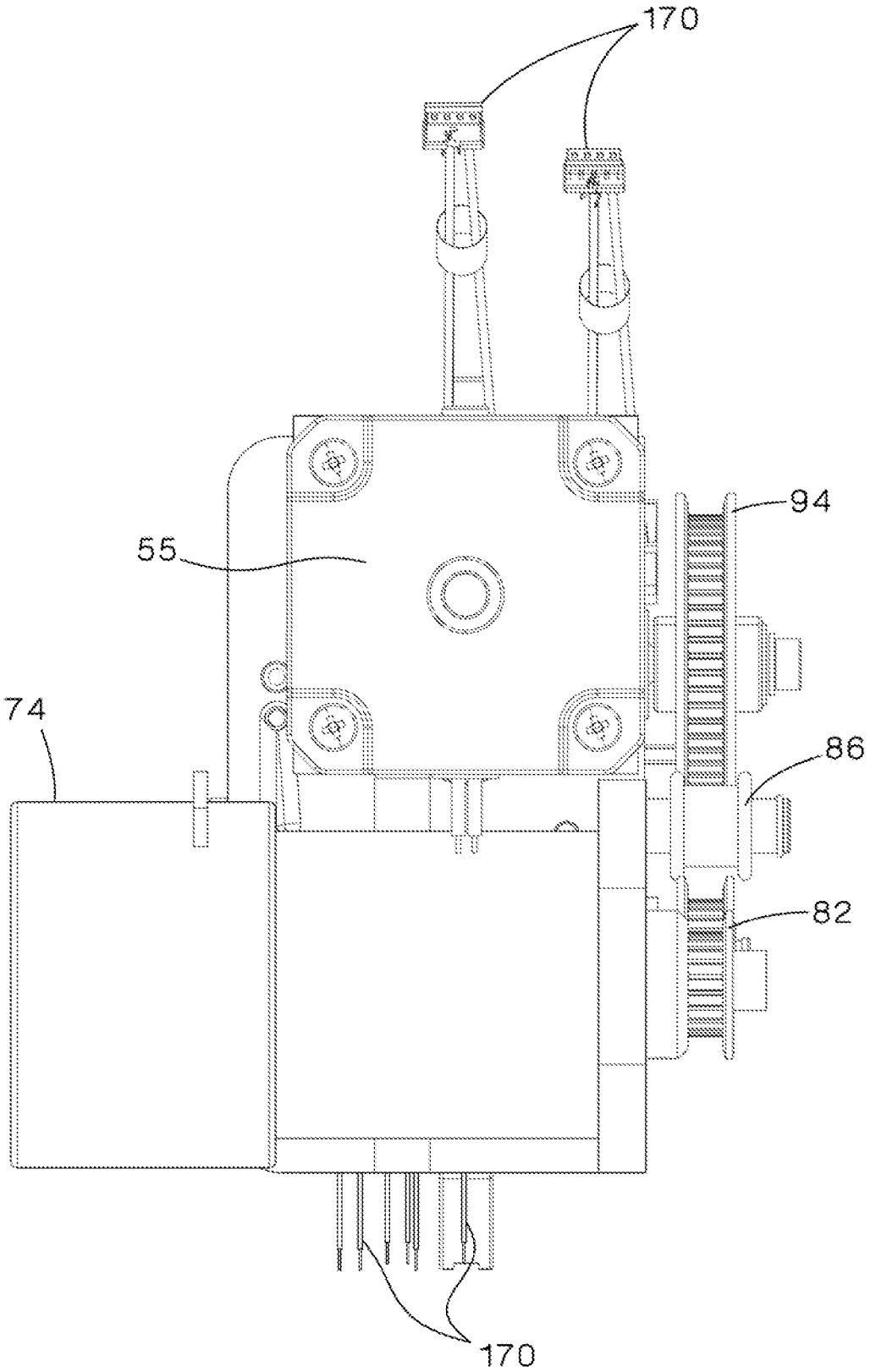

FIG.14

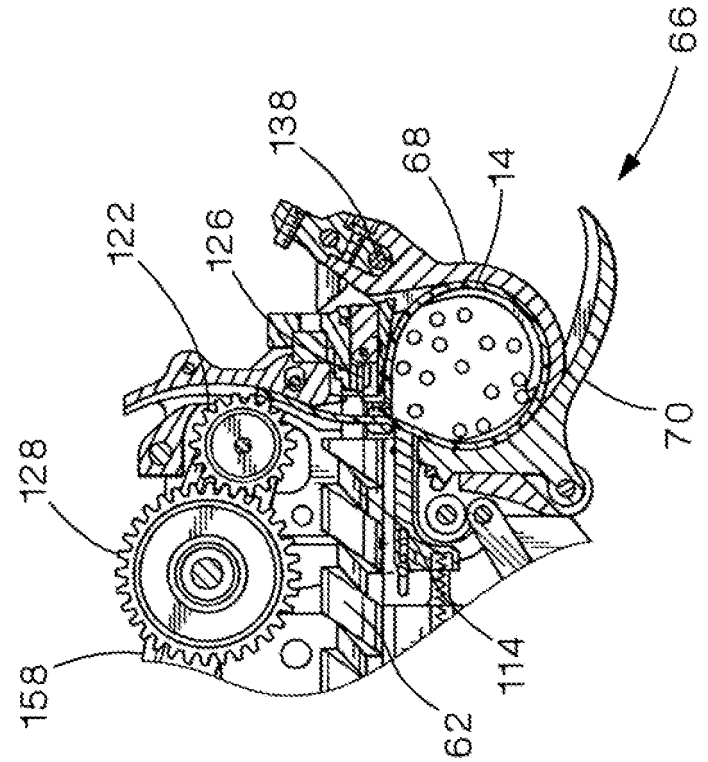
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FIG.16

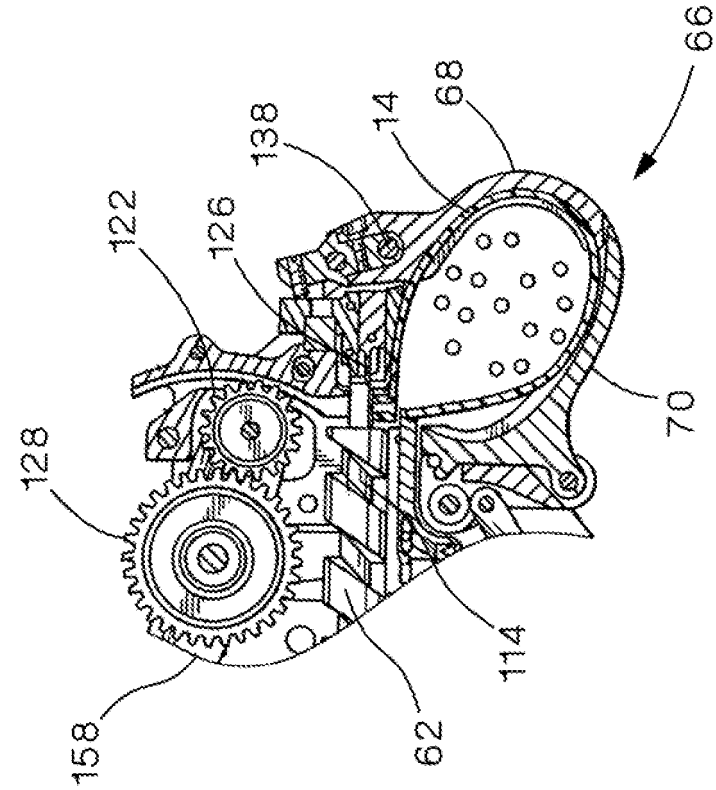
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FIG.15

REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- US 62629334 **[0001]**
- US 5595220 A **[0007] [0047]**