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(54) **SEWING MACHINE**

(57) A sewing machine is provided. The sewing machine includes a structure including a spine and first and second elongate members extending from the spine and upper and lower head assemblies. The upper head assembly is in the first elongate member and includes first and second motors to drive sewing actions of the upper head assembly. The lower head assembly is in the second elongate member and includes first and second motors to drive sewing actions of the lower head assembly. The first motors of the upper and lower head assemblies and the second motors of the upper and lower head assemblies are synchronized without a mechanical drive connection between the upper and lower head assemblies.

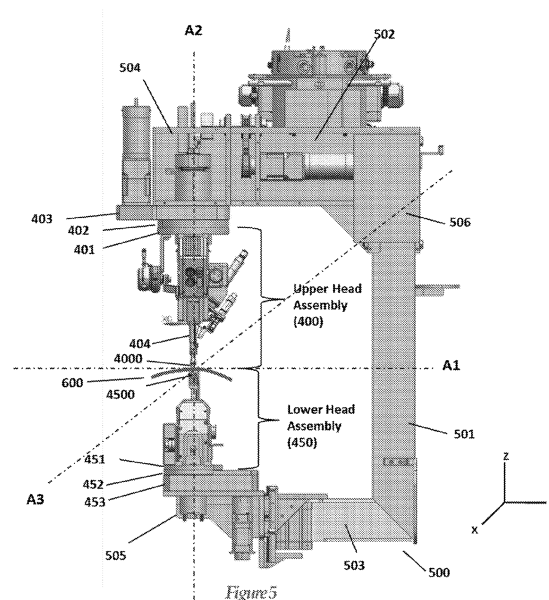


Figure 5

Description

BACKGROUND

[0001] The following description relates to sewing machines and, more specifically, to a sewing machine with fully rotatable sewing heads.

[0002] Currently, application of a decorative live stitch to pre-shaped automotive components can be accomplished via manual or automated stitching methods. Manual stitching is normally utilized on smaller components with relatively linear stitch paths. As part size, weight and stitch path complexity increase, it becomes more difficult for an operator to manually articulate the pre-shaped part under a stationary sewing machine and thus automation becomes more practical. An automated cell using a six-axis robot is commonly utilized with a sewing machine as the end effector. The sewing machine is designed to access required areas of the part within the range of motion of the robot.

[0003] As the trend to apply live stitching to pre-shaped automotive components continues to gain in popularity, the placement and type of stitching required is evolving as well. As the desired stitch path increases in length and/or covers a larger portion of the shaped part surface, additional movement of the sewing head around the outside of the part is required. Movement the sewing head around the outside of the part can present a problem when fixturing the part, however, and the movement can often exceed a range of motion of the robot as well. In addition, automotive manufacturers often prefer unique stitch types, patterns and thread sizes that are not easily provided by conventional sewing systems.

BRIEF DESCRIPTION

[0004] According to an aspect of the invention, a sewing machine for sewing a stitch into an article is provided. The sewing machine includes a support structure, a first head and a second head. The first head is coupled to the support structure and includes a coupler contained within a second actuator assembly and 360° rotatable relative to the support structure and a first stitching element rotatable with the coupler and translatable via a first actuator assembly relative to the coupler. The second head is coupled to the support structure and includes a coupler contained within the second actuator assembly and 360° degree rotatable relative to the support structure and a second stitching element rotatable with the coupler via the first actuator assembly.

[0005] In accordance with additional or alternative embodiments, the support structure includes a spine and first and second elongate members extending from the spine, the first and second elongate members having distal ends to which the first and second stitching elements are coupled, respectively.

[0006] In accordance with additional or alternative embodiments, the first stitching element includes a needle

and the second stitching element includes a looper.

[0007] In accordance with additional or alternative embodiments, the first head includes a first actuator assembly to drive translation of the first stitching element relative to the coupler and rotation of the second stitching element and a second actuator assembly to drive rotations of the first and second heads.

[0008] In accordance with additional or alternative embodiments, the actuation assembly includes a motor, a mechanical linkage extending through the support structure and first and second coupling units by which the mechanical linkage is coupled to the first and second stitching heads.

[0009] In accordance with additional or alternative embodiments, an additional drive assembly drives rotations of the support structure.

[0010] In accordance with additional or alternative embodiments, a robot controller is configured to control respective translations of the first and second stitching heads and operations of the drive assemblies.

[0011] In accordance with additional or alternative embodiments, the robot controller adjusts the predefined stitch path coordinates upon receipt of feedback prior to sewing from a scanner which scan positions of a feature on the article located along the length of the path to be sewn.

[0012] According to another aspect of the invention, a sewing machine for sewing a stitch into an article is provided. The sewing machine includes first and second heads, which are each movable relative to the article, a first head and a second head. The first head includes a coupler rotatable about an axis extending through the first and second heads, a first actuator element to rotate with the coupler and to translate relative to the coupler in first and second directions transverse to the axis, a second actuator element to rotate with the coupler, to translate in the first and second directions with the first actuator element and to rotate relative to the first actuator element in a third direction and a third actuator element to rotate with the coupler, to translate in the first and second directions with the first actuator element, to rotate with the second actuator element in the third direction and to translate relative to second actuator element along the axis in the third direction. The second head includes a coupler rotatable about the axis in the third direction, a first actuator element to rotate with the coupler and to translate relative to the coupler in the first and second directions and a second actuator element to rotate with the coupler, to translate in the first and second directions with the first actuator element, to rotate with the first actuator element in the third direction and to translate relative to first actuator element along the axis in the third direction.

[0013] In accordance with additional or alternative embodiments, the first head includes first and second stitching elements.

[0014] In accordance with additional or alternative embodiments, the first stitching element includes a looper

or a spreader and the second stitching element includes a punch or awl.

[0015] In accordance with additional or alternative embodiments, the first head includes a first actuation element to drive translations of the first stitching element relative to the coupler of the first head in the first and second directions, a second actuation element to drive rotations of the first stitching element relative to the first actuation element and a third actuation element to drive translations of the second stitching element relative to the first stitching element in the third direction.

[0016] In accordance with additional or alternative embodiments, a controller is configured to control and coordinate rotations of the coupler and translations and rotations of stitching elements of each of the first and second heads.

[0017] In accordance with additional or alternative embodiments, the controller includes a scanner to scan positions of a feature on the article and is configured correct for deviations between actual and allowable needle positions in accordance with predefined stitching instructions and the positions of the feature.

[0018] In accordance with additional or alternative embodiments, a first stitching element of the first head includes a looper or a spreader and a second stitching element of the first head includes a punch or awl.

[0019] In accordance with additional or alternative embodiments, a first stitching element of the second head includes a needle.

[0020] In accordance with additional or alternative embodiments, the first and second heads are coupled to first and second independently articulable robotic arms.

[0021] In accordance with additional or alternative embodiments, the first and second heads are coupled to a support structure.

[0022] In accordance with additional or alternative embodiments, the support structure includes a spine and first and second elongate members extending from the spine, the first and second elongate members having distal ends to which the first and second heads are coupled, respectively.

[0023] These and other advantages and features will become more apparent from the following description taken in conjunction with the drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

[0024] The subject matter, which is regarded as the disclosure, is particularly pointed out and distinctly claimed in the claims at the conclusion of the specification. The foregoing and other features and advantages of the disclosure are apparent from the following detailed description taken in conjunction with the accompanying drawings in which:

FIG. 1 is a side view of a mechanically driven sewing machine in accordance with embodiments;

FIG. 2 is a side view of an electrically and mechanically driven sewing machine in accordance with embodiments;

FIG. 3 is a side view of an electrically driven sewing machine in accordance with embodiments;

FIG. 4 is a side view of the sewing machine of FIG. 3 with a support structure in accordance with embodiments; and

FIG. 5 is a side view of a sewing head configuration in accordance with embodiments;

FIG. 6 is a perspective view of a needle bar operation in accordance with embodiments;

FIG. 7 is a perspective view of a coupling of the needle bar in accordance with embodiments;

FIG. 8 is a perspective view of an upper-pneumatic slip ring assembly in accordance with embodiments;

FIG. 9 is a perspective view of a configuration of a lower head assembly in accordance with embodiments;

FIG. 10 is a perspective view of a modification of the upper head assembly in accordance with embodiments;

FIG. 11 is a perspective view of a modification of a lower head assembly in accordance with embodiments;

FIG. 12 is a perspective view of a modification of a lower head assembly in accordance with embodiments; and

FIG. 13 is a perspective view of a modification of a lower head assembly in accordance with embodiments.

[0025] These and other advantages and features will become more apparent from the following description taken in conjunction with the drawings.

DETAILED DESCRIPTION

[0026] As will be described below, a sewing machine is provided with capabilities that meet current sewing demands. The sewing machine is intended for use in automated stitching applications and incorporates independent but synchronized upper and lower head rotations to eliminate a need to locate a machine body at a position perpendicular to the sewing path at all times. As a result, an ability to sew closed loop stitch paths is enhanced as is the capability to stitch curves having smaller radii into

remote areas of a part. The sewing machine includes sewing heads that are each capable of $\pm 360^\circ$ rotation and movement which can be driven mechanically, electromechanically or completely electrically. The sewing machine is designed such that the sewing heads are compact in size to allow for maximum maneuverability around a part. Functional capabilities of the machine are enhanced such that the following stitching technologies can be executed with only minor machine reconfiguration: single or double needle double thread chain stitch through soft materials; single or double needle single thread chain stitch through soft materials; single or double needle single thread chain stitch through rigid substrates; and single needle multi-thread embroidery stitching through soft materials. The sewing machine can also be designed such that the sewing heads can be decoupled with upper and lower heads attached to separate robots for further application flexibility.

[0027] With reference to FIG. 1, a sewing machine 101 is provided and is capable of sewing various types of stitches into an article 102. The sewing machine 101 includes a support structure 110, which is movable relative to the article 102 and which is rotatable about an axis A1 that extends through the article 102. The support structure 110 is movable in forward and back directions (i.e., first directions defined axially relative to the axis A3), side to side directions (i.e., second directions defined axially relative to the axis A1) and up and down directions (i.e., third directions defined axially relative to the axis A2).

[0028] In accordance with embodiments, the support structure 110 may include a spine 111, a first elongate member 112 extending from a first end of the spine 111 and a second elongate member 113 extending from a second end of the spine 111 to be substantially parallel with the first elongate member 112. The first elongate member 112 has a distal end 114 at its far end from the spine 111 and the second elongate member 113 has a distal end 115 at its far end from the spine 111.

[0029] The sewing machine 101 further includes a first stitching head 120, which is coupled to the support structure 110 at the distal end 114 of the first elongate member 112 and a second stitching head 130, which is coupled to the support structure 110 at the distal end 115 of the second elongate member 113. The first stitching head 120 can include or be provided with a first stitching element 1200. The first stitching element 1200 can include a needle. The second stitching head 130 can include or be provided with a second stitching element 1300. The second stitching element 1300 can include a looper.

[0030] The sewing machine 101 also includes a first actuation assembly 140, a second actuation assembly 150 and, in some cases, a third actuation assembly 160.

[0031] The first actuation assembly 140 is at least partially disposed within the support structure 110 and is configured to actuate sewing element 1200 of the first stitching head 120 and the sewing element 1300 of the second stitching head 130. Actuation of the sewing element 1200 occurs axially along axis A2 while actuation

of the sewing element 1300 occurs rotationally about an axis in parallel to axis A1. The first actuation assembly 140 includes a motor 141, a mechanical linkage 142 that extends through the support structure 110, a first coupling unit 143 by which the mechanical linkage 142 is coupled to the first stitching head 120 and a second coupling unit 144 by which the mechanical linkage 142 is coupled to the second stitching head 130. The second actuation assembly 150 is at least partially disposed within the support structure 110 and is configured to drive respective rotations of each of the first stitching head 120 and the second stitching head 130 about axis A2. The second actuation assembly 150 includes a motor 151, a mechanical linkage 152 that extends through the support structure 110, a first coupling unit 153 by which the mechanical linkage 152 is coupled to the first stitching head 120 and a second coupling unit 154 by which the mechanical linkage 152 is coupled to the second stitching head 130.

[0032] Where it is available, the third actuation assembly 160 is configured to drive rotations of the support structure 110 about a second axis A1, such that the first stitching head 120 can operate above or below the article 102 and the second stitching head 130 can operate below or above the article 102.

[0033] In accordance with further embodiments, the sewing machine 101 may further include a scanner 170 that, prior to sewing, is configured to detect the relative position of a feature on the article 102 located along the stitch path, and provide feedback to the robot controller which in turn will adjust the coordinates of the predefined stitch path prior to sewing, resulting in part sewn in compliance with predefined stitching constraints.

[0034] With reference to FIG. 2, a sewing machine 201 is provided for sewing a stitch into an article 202. The sewing machine 201 includes a support structure 210, which is movable relative to the article 202. The support structure 210 is movable in forward and back directions (i.e., first directions defined linearly relative to axis A3), side to side directions (i.e., second directions defined linearly relative to the axis A1) and up and down directions (i.e., third directions defined linearly along the axis A2). The support structure 210 is also rotatable about the axis A1 and the article 202.

[0035] In accordance with embodiments, the support structure 210 may include a spine 211, a first elongate member 212 extending from a first end of the spine 211 and a second elongate member 213 extending from a second end of the spine 211 to be substantially parallel with the first elongate member 212. The first elongate member 212 has a distal end 214 at its far end from the spine 211 and the second elongate member 213 has a distal end 215 at its far end from the spine 211.

[0036] The sewing machine 201 further includes a first stitching head 220, a second stitching head 230 and a drive assembly 240. The first stitching head 220 is coupled to the support structure 210 at the distal end 214 of the first elongate member 212. The second stitching head

230 is coupled to the support structure 210 at the distal end 215 of the second elongate member 213. The first stitching head 220 can include or be provided with a first stitching element 2200 with an optional second stitching element 2201. The first stitching element 2200 can include a looper or a spreader. The second stitching element 2201 can consist of a punch or awl. The second stitching head 230 can include or be provided with a third stitching element 2300. The third stitching element 2300 can include a needle.

[0037] The first stitching head 220 includes a coupler 221, a first actuator element 222, which is rotatable with coupler 221 about axis A2 and which is translatable relative to the coupler 221 in the first and second directions, a second actuator element 223 and an optional third actuator element 224. The second actuator element 223 is translatable with the first actuator element 222 in the second and first directions along axes A1 and A3, is rotatable relative to the first actuator element 222 about axis A2 and is also rotatable with coupler 221 about the axis A2. The optional third actuator element 224 translates the second stitching element 2201 relative to second actuator element 223 in the third direction along the axis A2, is translatable with the first actuator element 222, is rotatable with the second actuator element 223 about the axis A2 and is also rotatable with the coupler 221 about the axis A2.

[0038] The second stitching body 230 includes a coupler 231, a first actuator element 232, which is rotatable with coupler 231 about the axis A2 and which is translatable relative to the coupler 231 in the first and second directions along axes A3 and A1, and a second actuator element 233. The second actuator element 233 is translatable with the first actuator element 232 in the second and first directions along axes A1 and A3, is translatable relative to the first actuator element 232 in the third direction along the axis A2 and is rotatable with the coupler 231 about axis A2.

[0039] The drive assembly 240 is at least partially disposed within the support structure 210 to drive rotations of the first and second stitching heads 220 and 230 about the axis A2. The actuation assembly 240 includes a motor 241, a mechanical linkage 242 that extends through the support structure 210, a first coupling unit 243 by which the mechanical linkage 242 is coupled to the first stitching head 220 and a second coupling unit 244 by which the mechanical linkage 242 is coupled to the second stitching head 230.

[0040] An additional drive assembly 270 is provided to drive rotations of the support structure 210 about the axis A1 during sewing. The additional actuation assembly 270 is also utilized to drive the rotations of the support structure 210 about the second axis A2 such that the first stitching head 220 can operate above or below the article 202 and the second stitching head 230 can operate below or above the article 202.

[0041] In accordance with further embodiments, the sewing machine 201 may further include a scanner 280

that, prior to sewing, is configured to detect the relative position of a feature on the article 202 located along the stitch path, and provide feedback to the robot controller which in turn will adjust the coordinates of the predefined stitch path prior to sewing, resulting in part sewn in compliance with predefined stitching constraints.

[0042] With reference to FIG. 3, a sewing machine 301 is provided for sewing a stitch into an article 302. The sewing machine 301 includes a first head 310, which is movable relative to the article 302, and a second head 320, which is movable relative to the article 302.

[0043] The first head 310 includes a first actuator element 311, which is rotatable about an axis A2 extending through the article 302 and the first and second heads 310 and 320, a second actuator element 312, a third actuator element 314, a fourth actuator element 315, and a first stitching element 313 that includes a looper or a spreader. The second actuator element 312 rotates with the first actuator element 311 and is translatable relative to the first actuator element 311 in first and second directions along axes A3 and A1 directions. The third actuator element 314, which is directly coupled to the first stitching element 313, rotates with the first actuator element 311, is translatable with the second actuator element 312 and rotates relative to the second actuator element 312. The fourth actuator element 315 translates optional second stitching element 3130 in the third direction along the axis A2, rotates with the first actuator element 311, translates with second actuator element 312 and rotates with the third actuator element 314.

[0044] The second head 320 includes a first actuator element 321, which is rotatable about the axis A2, a second actuator element 322 and a third actuator element 323. The second actuator element 322 rotates with the first actuator element 321 and is translatable relative to the first actuator element 321 in the first and second directions along the axes A3 and A1. The third actuator element 323 includes a third stitching element 3230 and rotates with the first actuator element 321, translates in the first and second directions along axes A3 and A1 with the second actuator element 322 and is translatable relative to the second actuator element 322 in the third direction along the axis A2.

[0045] In accordance with further embodiments, the sewing machine 301 may further include a scanner 330 that, prior to sewing, is configured to detect the relative position of a feature on the article 302 located along the stitch path, and provide feedback to the robot controller which in turn will adjust the coordinates of the predefined stitch path prior to sewing, resulting in part sewn in compliance with predefined stitching constraints.

[0046] As shown in FIG. 3, the sewing machine 301 may be connected, via tool changers 340 and 350, to first and second independently articulable robotic arms 360 and 370 to which the first and second heads 310 and 320 are coupled, respectively. The robotic arms 360 and 370 can allow the first and second heads 310 and 320 to operate at various positions and attitudes relative to

the article 302 and to be disposed above or below the article 302.

[0047] With reference to FIG. 4, the first and second heads 310 and 320 can be coupled to a support structure 360. The support structure 360 may include a spine 361, a first elongate member 362 extending from a first end of the spine 361 and a second elongate member 363 extending from a second end of the spine 361 to be substantially parallel with the first elongate member 362. The first elongate member 362 has a distal end 364 to which is the first head 310 is coupled at its far end from the spine 361 and the second elongate member 363 has a distal end 365 to which the second head 320 is coupled at its far end from the spine 361.

[0048] Additional drive assembly 370 is provided to drive rotations of the support structure 360 about axis A1, as required in order to position the sewing machine 301 in it optimal position for stitching. The robot controller can be configured to drive the rotations of the support structure 360 about the axis A1 such that the first head 310 can operate above or below the article 302 and the second head 320 can operate below or above the article 302.

Electro-Drive Turning Head Summary

[0049] No mechanical drive connection exists between the upper and lower head assemblies. Two servo driven motors are utilized to drive the upper head assembly. A first motor (located in the first elongate member 502) is used to drive a needle bar up and down along axis A2. The needle (first stitching element 4000) mounts to an end of the needle bar. A second motor (located on the upper head 400) is used to drive an indexer unit that controls the rotational speed and position of the upper head assembly. Two servo driven motors are utilized to drive lower head assembly. A first motor (located in the lower head 450) is used to drive the looper arm in an elliptical path beneath the part 600 surface. The looper (second stitching element 4500) mounts to the looper arm. A second motor (located in the lower distal end 505) is used to drive the indexer unit that controls the rotational speed and position of the lower head assembly. The motors that drive the rotational speed and position of the upper and lower heads are synchronized. The motors that drive the speed of the needle bar on the upper head and the looper on the lower head are synchronized

[0050] Separation and mounting of upper and lower head assemblies to independent but collaborative robots is possible as shown in FIG. 3.

[0051] Electronic machine timing and tuning can be achieved with the following further modifications to the machine construction, which simplifies machine operation and maintenance when used in a production environment. The first motor in the lower head assembly can be replaced with a rotary electrical actuator to control rotary looper motion and an electric linear actuator to control lateral looper motion which eliminates all mechan-

ical cams on the lower head assembly. The first motor currently located in the first elongate member 502 can be replaced with a linear actuator located in the upper head assembly 400. This linear actuator will eliminate the need for the mechanical cam located in the upper distal end 504.

[0052] Utilization of electric actuators that are entirely contained within the upper and lower head assemblies enhances the ability to minimize packaging requirements when decoupling the upper and lower heads completely for use on independent but collaborative robots.

[0053] Needle bar (and needle) speed variation (acceleration) and looper arm (and looper) speed variation (acceleration) are utilized to eliminate the need for needle bar transport in the direction of stitch (axis A3 direction) during sewing, which simplifies head construction and improves overall packaging. Acceleration of the needle bar and looper arm is accomplished through mechanical cams. The needle bar uses one cam at the top of the head (upper distal end 504) to manage acceleration. The looper arm uses two cams located in the lower head) to manage acceleration. The first cam controls the rotary movement (about axis B2 in FIG. 9) of the looper arm and the second cam controls the lateral or voiding movement (along axis B2) of the looper arm.

[0054] An unlimited degree of synchronized upper and lower head rotation in both directions about the needle bar axis A2 during stitching is possible.

[0055] The following additional functional components/systems are located on and rotate with the upper head: a vision system/scanner for real-time sewing path correction (electrically controlled), a presser foot (mechanically actuated from a needle bar cam follower), thread trimming scissors (electro-pneumatically actuated), thread swiping arm (electro-pneumatically actuated) and a thread brake (mechanically actuated from a needle holder cam follower).

[0056] Transmission of electrical and pneumatic energy from the static upper arm to the rotary upper head is accomplished through an electro-pneumatic slip ring. A clock spring assembly can also be used in conjunction with a pneumatic-only slip ring to accomplish both electric and pneumatic signal transmission. Transmission of electrical energy from the static lower arm to the rotary lower head is accomplished through an electric slip ring. A combination electro-pneumatic slip ring as used in the upper head assembly can also be implemented on the lower as needed. The lower head assembly can be moved along axis A2 to allow sewing machine access to the part as well as pull down loose thread tails (eliminates the need for a secondary thread pull operation) at the start and end points of the stitch path. The upper and lower head assemblies are modular and be interchanged with other functional units for sewing flexibility as well as ease of repair. The upper head assembly can be configured to utilize the following alternative stitching elements 4000: chain stitch: needle, awl and spreader; lock stitch: needle. The lower head assembly can be configured to

utilize the following alternative stitching elements 4500: chain stitch: butterfly looper, oscillatory looper, hook looper, spreader or needle and castoff; lock stitch: hook. The upper head can also be reconfigured to manage needle bar zig-zag motion during stitching. This zig-zag motion is required to create embroidered logos and patterns on the part/article 600. The sewing head configuration shown in FIG. 5 provides further detail to the concept shown in FIG 4.

[0057] The upper head 400 and lower head 450 can be coupled to sewing head support structure 500. The sewing head support structure 500 may include a spine 501, a first elongate member 502 extending from the first end of the spine 501 and a second elongate member 503 extended from the second end of the spine 501 to be substantially parallel with the first elongate member 502. The first elongate member 502 has a distal end 504 to which the first head 400 is coupled at its far end from the spine 501 and the second elongate member 503 has a distal end 505 to which the second head 450 is coupled at its far end from the spine 501.

[0058] The spine 501 serves to connect the first elongate member 502 to the second elongate member 503. No mechanical drive mechanism is contained within the spine 501. Electrical wiring from the control box 506 to the distal end 505 may be routed internal or external to the spine 501.

[0059] The upper head assembly 400 contains a first stitching element 4000 consisting of a needle or awl with spreader. The upper head assembly 400 includes a coupler 401 driven by a rotary actuator plate 402 that is integral to a motor driven indexer unit 403 which provides the ability to rotate the upper head assembly 400 an unlimited number of degrees of rotation in either direction about axis A2.

[0060] The lower head assembly 450 contains a second stitching element 4500 consisting of a looper, hook, spreader or needle with castoff. The lower head assembly 450 includes a coupler 451 driven by a rotary actuator plate 452 that is rotated by a motor driven indexer unit 453 to provide the ability to rotate the lower head assembly 450 an unlimited number of degrees of rotation in either direction about axis A2.

[0061] During the stitching process, the upper head assembly 400 and lower head assembly 450 rotate synchronously with one another about axis A2 in order to maintain the proper alignment necessary between the first stitching element 4000 and the second stitching element 4500 for stitch formation. During upper and lower head rotation about the axis A2, the sewing head support structure 500 containing the upper head 400 and lower head 450 can be moved linearly and rotationally about the x, y and z axes as required by the design of the part being sewn.

[0062] As shown in FIG. 6, a needle bar 404 rotates with the upper head assembly 400 and moves bidirectionally along the axis A2. The need for needle bar 404 transport in a stitching direction A3 is eliminated with the

integration of a needle bar cam 405, which provides the necessary needle bar 404 acceleration to minimize the first stitching element 4000 engagement time with the article 600 during stitching. The needle bar cam 405 houses a cam collar 405a that clamps to the needle bar 404 allowing rotation but not translation of the needle bar 404 relative to the needle bar cam 405. The needle bar cam 405 controls movement of the needle bar 404 along axis A2 while allowing rotation of the needle bar 404 around axis A2. The needle bar cam 405 is driven by a motor and gearbox assembly 406 through a series of pulleys 407 and 408, a belt 409, an upper drive shaft 410 and a crank arm/counterweight assembly 411.

[0063] Referring to FIG. 7, a needle bar coupler 412 is utilized to connect the needle bar 404 to the rotating upper head assembly 400. The coupler 412 engages a series of splines 413 on the needle bar 404. The splines 413 allows needle bar movement along axis A2 while a coupler key 414 engages the upper head structure 414a to prevent rotation of the needle bar 404 relative to the upper head assembly 400.

[0064] A presser foot 415 is utilized to stabilize the part 600 during stitch formation. The presser foot 415 moves in parallel to axis A2 with each downstroke of needle bar 404. A cam follower 416 attached to the needle bar 404 engages a lift arm 417 which connects to a presser bar 418 through lift bracket 419. Pneumatic cylinder 420 provides downward force as required to ensure presser foot 415 contact with the part during the duration of cam follower 416 disengagement with lift arm 417.

[0065] Referring to FIG. 8, an upper electro-pneumatic slip ring assembly 421 is utilized to transport both electrical and pneumatic energy from the static distal end 504 of the first elongate member 502 to the rotary upper head assembly 400. Electro-pneumatic energy is required for actuators such as a thread trimmer 422, a thread swiper 423 and the pressure foot cylinder 420 located on the upper head assembly 400. Electrical energy is required to power and control the vision system scanner 424 which is used to correct the position of the sewing head support structure 500 as well as the rotation of the upper head assembly 400 and lower head assembly 450 to the part 600 locating feature 601.

[0066] FIG. 9 shows one configuration of the lower head assembly 450 where the second stitching element 4500 is comprised of a hook looper. Alternatively, a butterfly or oscillatory hook looper can also be used. The looper mounts to a looper arm 4500a. Looper arm movement is comprised of both rotary and lateral motion about a looper arm shaft 454. Rotary motion is controlled through a rotary cam 455 that rotates about axis B1. Looper arm lateral motion is controlled through a voiding cam 456 that also rotates about axis B1. A motor and gearbox assembly 457 drives the rotation of the looper cam driveshaft 454a through a series of pulleys 458 and 459 connected via a drive belt 460. Electrical power for the motor and gearbox assembly 457 is provided through a lower electrical slip ring 461 which transfers the re-

quired electrical energy from the distal end 505 of the second elongate member 503 to the rotating lower head assembly 450.

[0067] Referring still to FIG. 9, the distal end 505 and lower head assembly 450 is movable along axis A2 to enable the sewing head support structure 500 to enter and exit the part 600 to be stitched without obstruction. The distal end 505 is mounted to the second elongate member 503 via a set of bearing blocks 462 mounted on lift rails 463. Upon actuation, a pneumatic lift cylinder 464 can raise or lower the entire distal end 505 including the lower head assembly 450 as desired. During stitching, the pneumatic lift cylinder 464 is in its fully retracted position. During entry-to and exit-from the part 600, the pneumatic lift cylinder 464 is in its fully extended position.

[0068] As an alternative and shown in FIG. 10, the upper head assembly 400 is modified to laterally move a needle bar extension 404a in an alternating or zig-zag manner along axis A1. A motor and gearbox assembly 465 rotates an eccentric 466 which is coupled to a connecting rod 467. The connecting rod 467 is attached to the rock frame 468 which houses a secondary needle bar 404a and a presser bar 469. The secondary needle bar 404a is connected to the needle bar 404 via a flexible union 470. For every rotation of the motor and gearbox assembly 465, the rock frame rotates a fixed distance about pivot shaft 472, displacing the secondary needle bar 404a and presser bar 469 a fixed distance 471 along the axis A1. Timing is such that the position of the secondary needle bar relative to the article 600 will alternate from max to min positions along axis A1 with each successive needle stroke. This type of configuration can be used to produce a zig-zag type stitch on the article 600 but also be used for producing embroidered logos and designs on preformed or shaped parts.

[0069] To accommodate needle bar 404a lateral motion, the lower head assembly 450 can be modified to use a secondary stitching element 4500 consisting of a continually rotating hook assembly as shown in FIG. 11. In this instance, a lock type stitch is formed as a result of the interface between the primary 4000 and secondary 4500 stitching elements. A motor and gearbox assembly 473 is mounted to the rotating lower head assembly 450 and utilizes a pair of pulleys 474, 475 connected by a belt and helical gears 476, 477 which engage to drive the rotation of hook.

[0070] As shown in FIG. 12, another alternative for the lower head assembly 450 has a second stitching element 4500 consisting of a spreader that rotates about axis A2 and wraps the sewing thread 478 around a first stitching element 4000 consisting of a hook needle to create a type 101 chain stitch on the finished part 600. A motor and gearbox assembly 479 is mounted to the rotating lower head assembly 450 and is directly coupled to a lift eccentric 480 which converts rotary motion to the linear fore-aft motion of a rack 481 which in turn drives oscillatory rotation of a pinion 482. A pinion shaft 483 subsequently drives rotation of a first bevel gear 484 which

drives a second bevel gear 485 that connects directly to the spreader drive shaft 486. Subsequent rotation of the spreader about the axis A2 is adjustable via adjustment of the lift eccentric 480.

[0071] As shown in FIG. 13, yet another alternative for the lower head assembly 450 has a second stitching element 4500 consisting of an oscillatory looper that rotates about axis A2 and engages the first stitching element 4000 consisting of a needle to create a type 401 chain stitch on the article 600. A motor and gearbox assembly 487 is mounted to the rotating lower head assembly 450 and is directly coupled to a lift eccentric 488 which converts rotary motion to the linear fore-aft motion of a rack 489 which in turn drives oscillatory rotation of a pinion 490. A pinion shaft 491 subsequently drives rotation a first bevel gear 492 which drives a second bevel gear 493 that connects directly to the looper drive shaft 494. Subsequent rotation of the oscillatory looper about the axis A2 is adjustable via adjustment of the lift eccentric 488.

[0072] Upper head lower head assemblies are modular and can be interchanged with alternative upper and lower head configurations as desired.

[0073] Upper and lower head assemblies can be separated from the common support structure and mounted to independent but collaborative robots for stitching of an article

[0074] Electronic machine timing and tuning can be achieved with further modifications to the machine construction, which simplifies machine operation and maintenance when used in a production environment. The motor and gearbox assembly 457 in the lower head assembly 450 can be replaced with a rotary electrical actuator to control rotary looper motion and an electric linear actuator to control lateral looper motion which eliminates all mechanical cams on the lower head assembly. The motor and gearbox assembly 406 located in the first elongate member 502 can be replaced with a linear actuator located in the upper head assembly 400. This linear actuator will eliminate the need for the mechanical cam 411 located in the upper distal end 504. Utilization of electric actuators that are entirely contained within the upper and lower head assemblies enhances the ability to minimize packaging requirements when decoupling the upper and lower heads completely for use on independent but collaborative robots.

[0075] Technical effects and benefits of the present disclosure are the provision of a sewing machine incorporating upper and lower sewing heads for use in automated stitching applications to eliminate a need to locate a machine body at a position perpendicular to the sewing path at all times and to enhance an ability to sew closed loop stitch paths and curves having small radii, such as the case when embroidering. In addition, the sewing machine provides for closed loop chain stitch patterns on large contoured parts that have no internal feature openings (which are normally required for sewing head access) as well as start and stop positions that are perfectly

aligned to create the effect of multiple components sewn together. The sewing machine also provides for intricate and complex chain stitch patterns that are placed on large countered parts, stitching capabilities around entire perimeter and interior portions of such products (where the products contains minimal or no openings internal to the part for sewing head access) and patterns that can be programmed to create an image, logo or text on products (embroidery) requiring very tight directional changes and turning radii (e.g., in-plane turning radii or the stitch turning radius on the surface of the flat or contoured part of less than 5 mm and in some cases less than 2 mm) where the turning radii is dictated by stitch length and an ability to rotate/turn the needle and hook within short periods of time and over short distances.

[0076] While the disclosure is provided in detail in connection with only a limited number of embodiments, it should be readily understood that the disclosure is not limited to such disclosed embodiments. Rather, the disclosure can be modified to incorporate any number of variations, alterations, substitutions or equivalent arrangements not heretofore described, but which are commensurate with the spirit and scope of the disclosure. Additionally, while various embodiments of the disclosure have been described, it is to be understood that the exemplary embodiment(s) may include only some of the described exemplary aspects. Accordingly, the disclosure is not to be seen as limited by the foregoing description, but is only limited by the scope of the appended claims.

Claims

1. A sewing machine, comprising:

a structure comprising a spine and first and second elongate members extending from the spine;
an upper head assembly coupled to the first elongate member:

two servo motors comprising a first motor and a second motors to drive the upper head assembly; and
a lower head assembly coupled to the second elongate member;
two servo motors comprising a first motor and a second motor to drive the lower head assembly,
wherein the first motor that drives the upper assembly and the first motor that drives the lower head assembly are synchronized;
wherein the second motor that drives the upper assembly and the second motor that drives the lower head assemblies are synchronized,
and wherein no mechanical drive connec-

tion exists between the upper and lower head assemblies.

2. The sewing machine according to claim 1, wherein the upper head assembly comprises:

a needle bar, which is upwardly and downwardly drivable by the first motor that drives the upper head assembly; and
an indexer unit, which is drivable by the second motor that drives the upper head assembly, to control a rotational speed and position of the upper head assembly.

3. The sewing machine according to claim 2, wherein the sewing machine further comprises a cam to accelerate the needle bar upwardly and downwardly.

4. The sewing machine according to claim 1, wherein the lower head assembly comprises:

a looper arm, which is drivable in an elliptical path by the first motor that drives the lower head assembly; and
an indexer unit, which is drivable by the second motor that drives the lower head assembly to control a rotational speed and position of the lower head assembly.

5. The sewing machine according to claim 4, wherein the lower head assembly further comprises a first cam to control rotary movement of the looper arm and a second cam to control lateral movement of the looper arm.

6. The sewing machine according to any one of the preceding claims, wherein the first motor that drives the upper assembly is located in the elongate member (502).

7. The sewing machine according to any one of the preceding claims, wherein the second motor that drives the upper assembly is located in the upper head assembly (400).

8. The sewing machine according to any one of the preceding claims, wherein the first motor that drives the lower assembly is located in the lower head assembly (450).

9. The sewing machine according to any one of the preceding claims, wherein the second motor that drives the lower assembly is located in a distal end (505) of the second elongate member.

10. The sewing machine according to claim 1, wherein the first motor of the lower head assembly comprises:

a rotary electric actuator to control rotary looper motion; and
an electric linear actuator to control lateral looper motion.

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11. The sewing machine according to claim 2, wherein the first motor that drives the upper head assembly comprises an electric linear actuator located in the upper head assembly (400).

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12. The sewing machine according to any one of the preceding claims, wherein the sewing machine further comprises an electro-pneumatic slip ring by which electrical and pneumatic energy is transmitted to the upper head assembly.

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13. The sewing machine according to any one of claims 1 to 11, wherein the sewing machine further comprises a clock spring coupled with a pneumatic-only slip ring by which electrical and pneumatic energy is transmitted to the upper head assembly.

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14. The sewing machine according to any one of the preceding claims, wherein the sewing machine further comprises an electric slip ring by which electrical energy is transmitted to the lower head assembly.

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15. The sewing machine according to any one of the preceding claims, wherein the upper and lower head assemblies are modular and interchangeable with other functional units.

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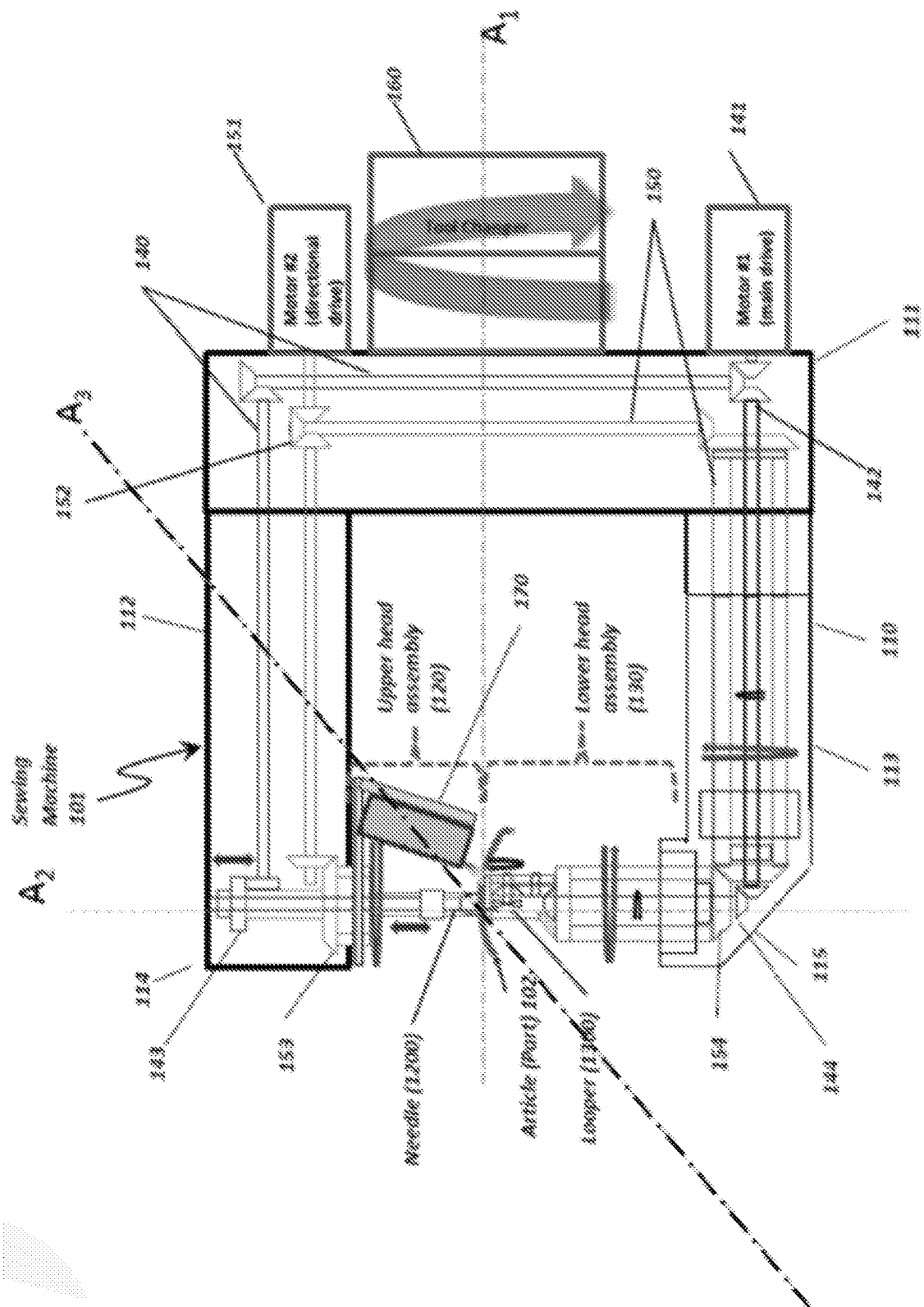


FIG. 1

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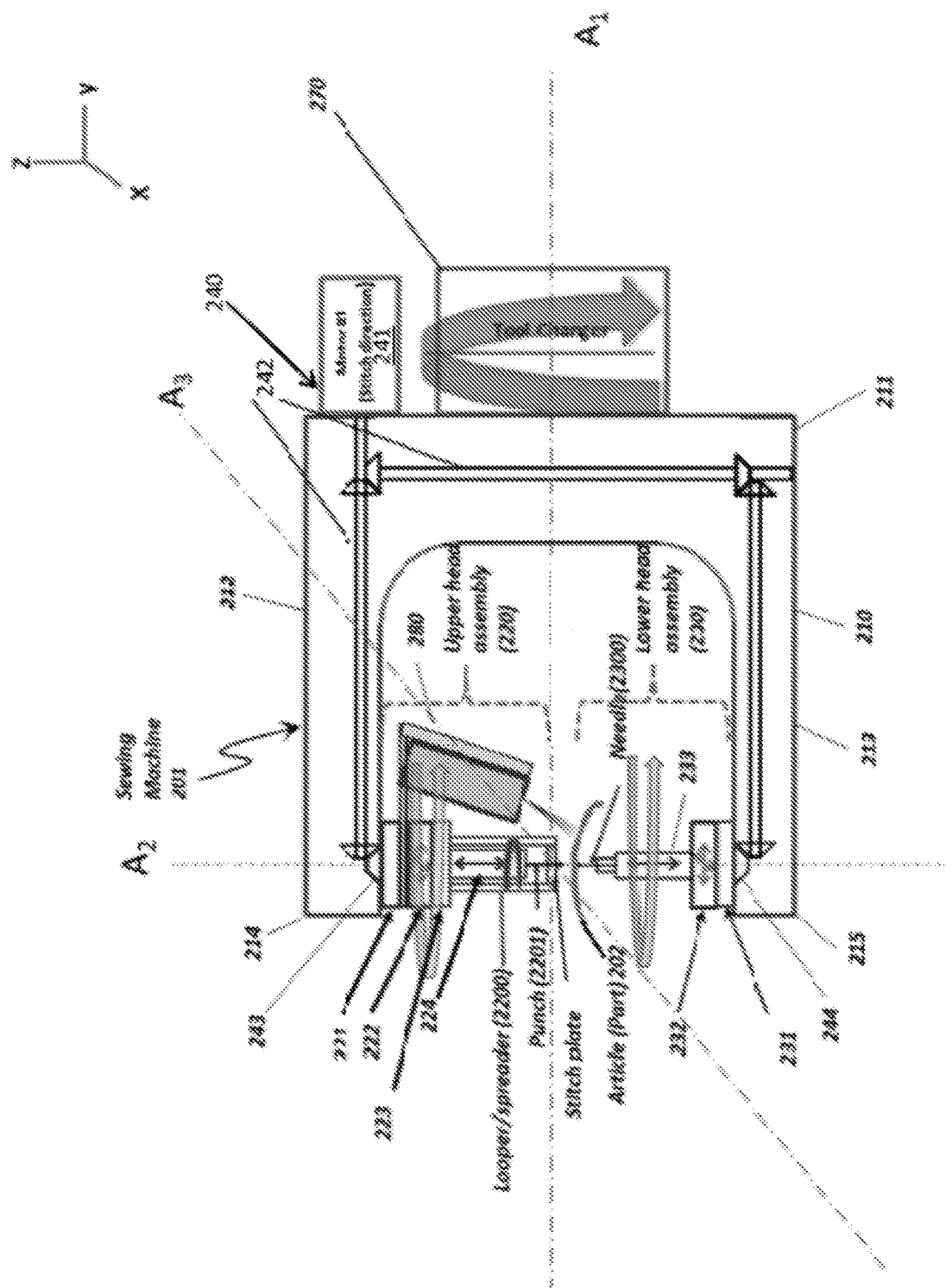


FIG. 3

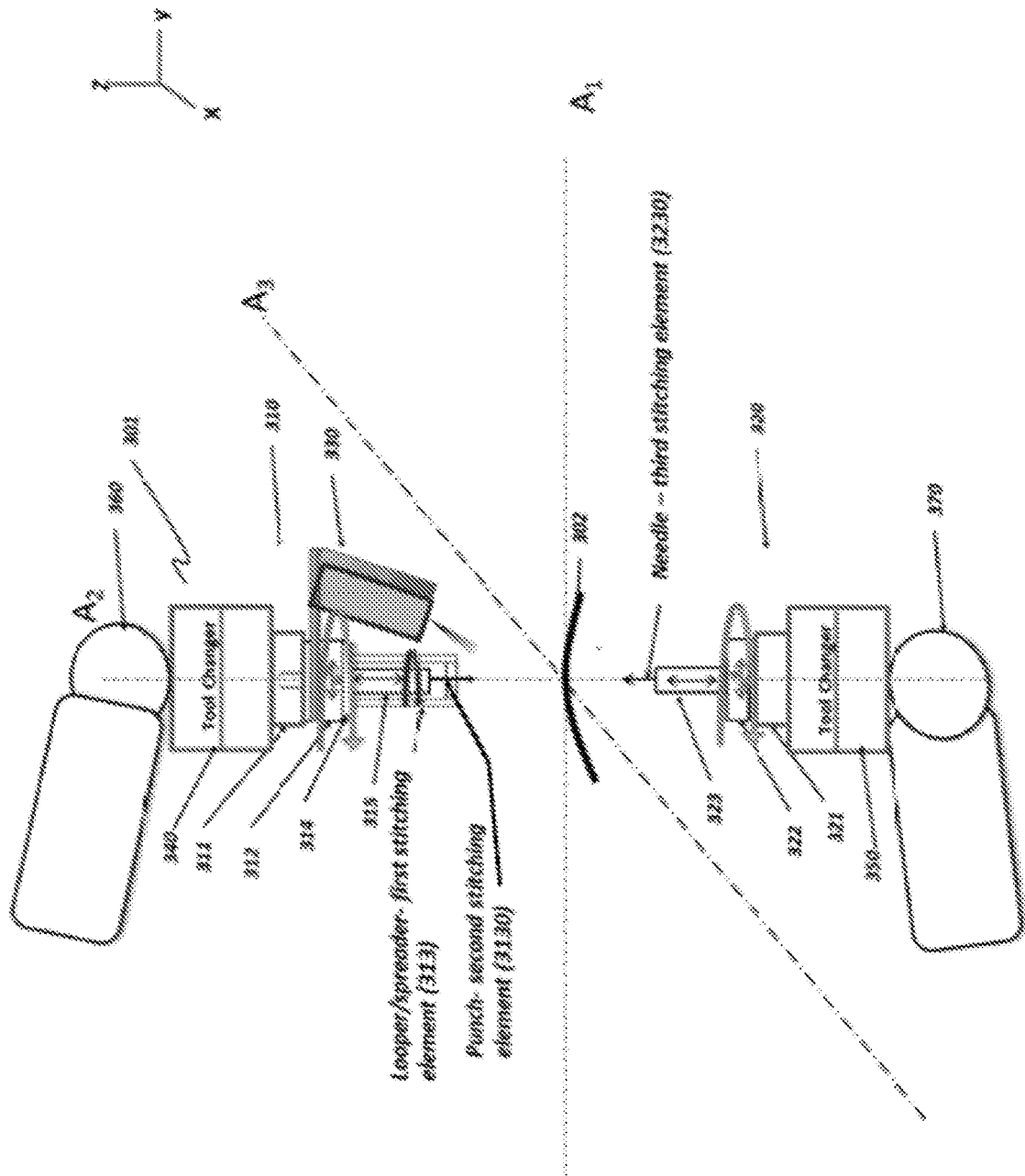
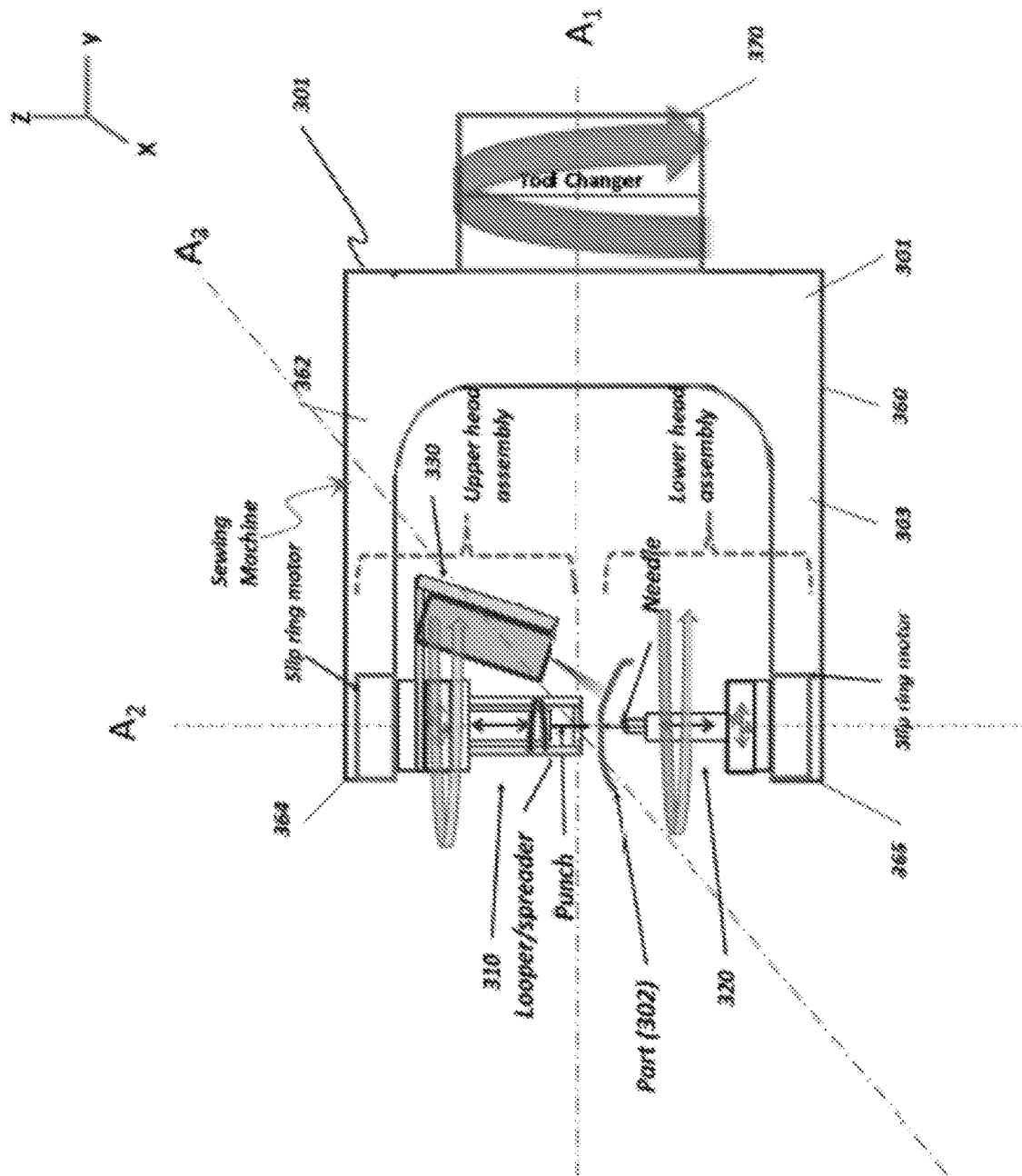


FIG. 4



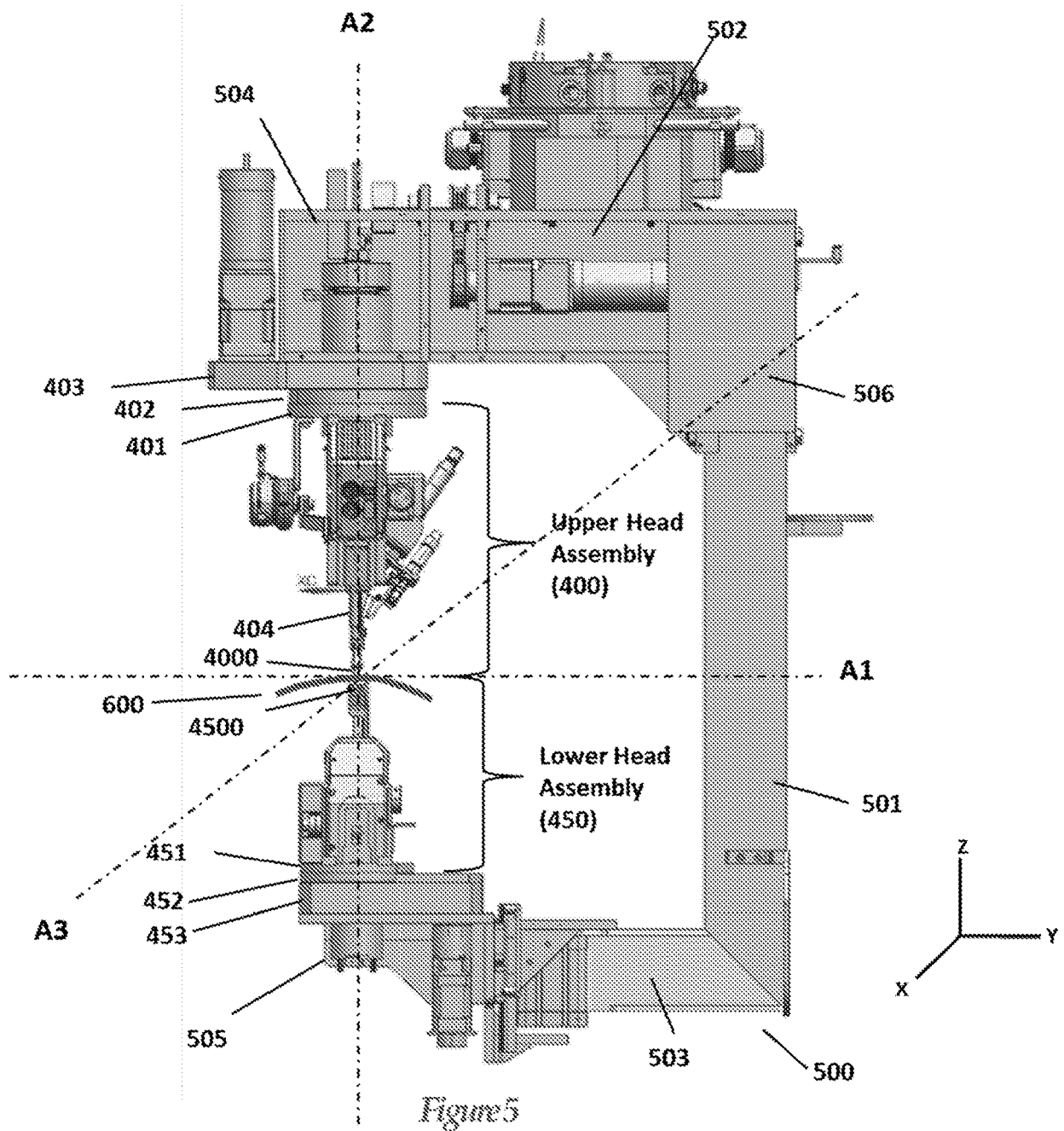


Figure 5

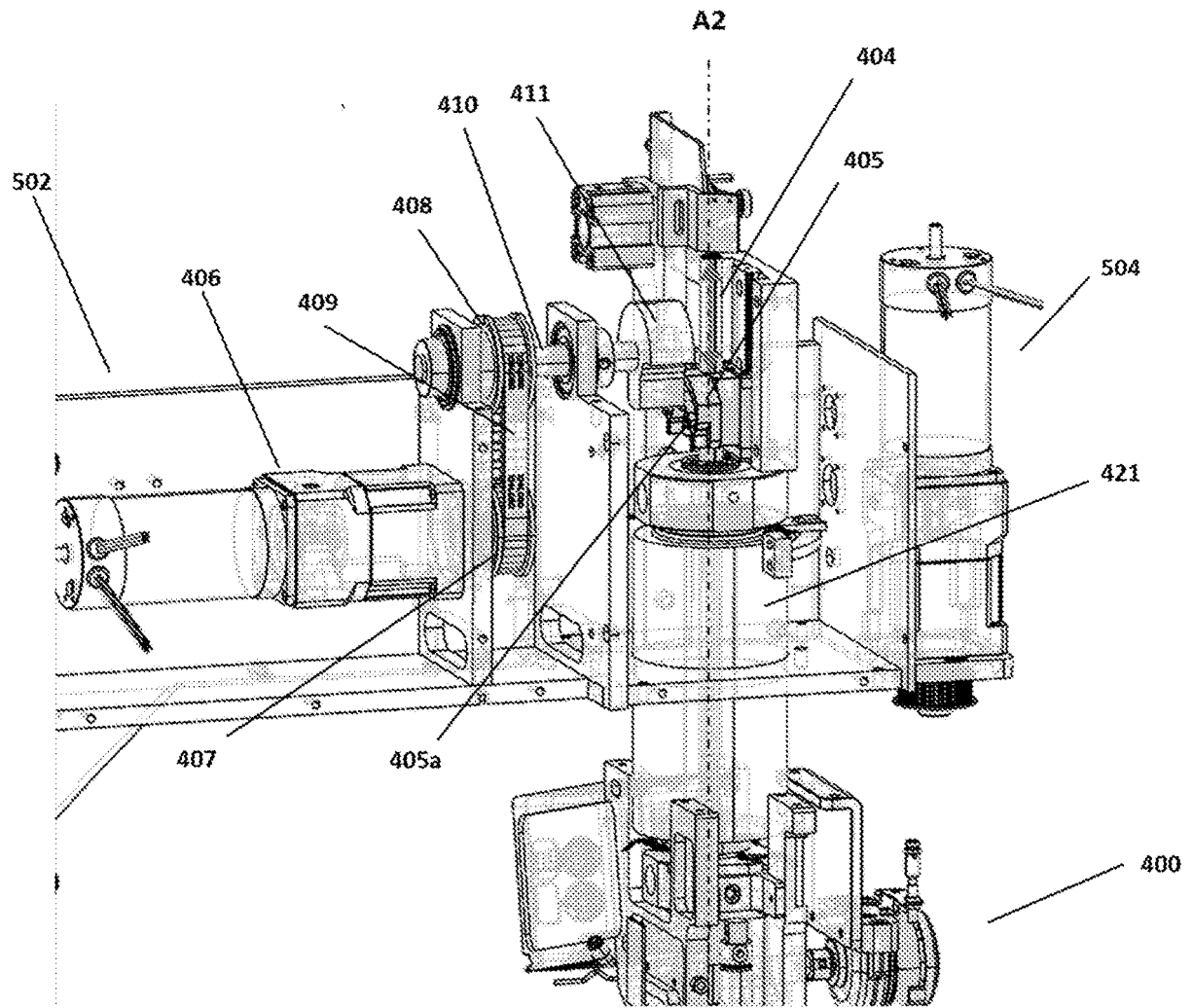
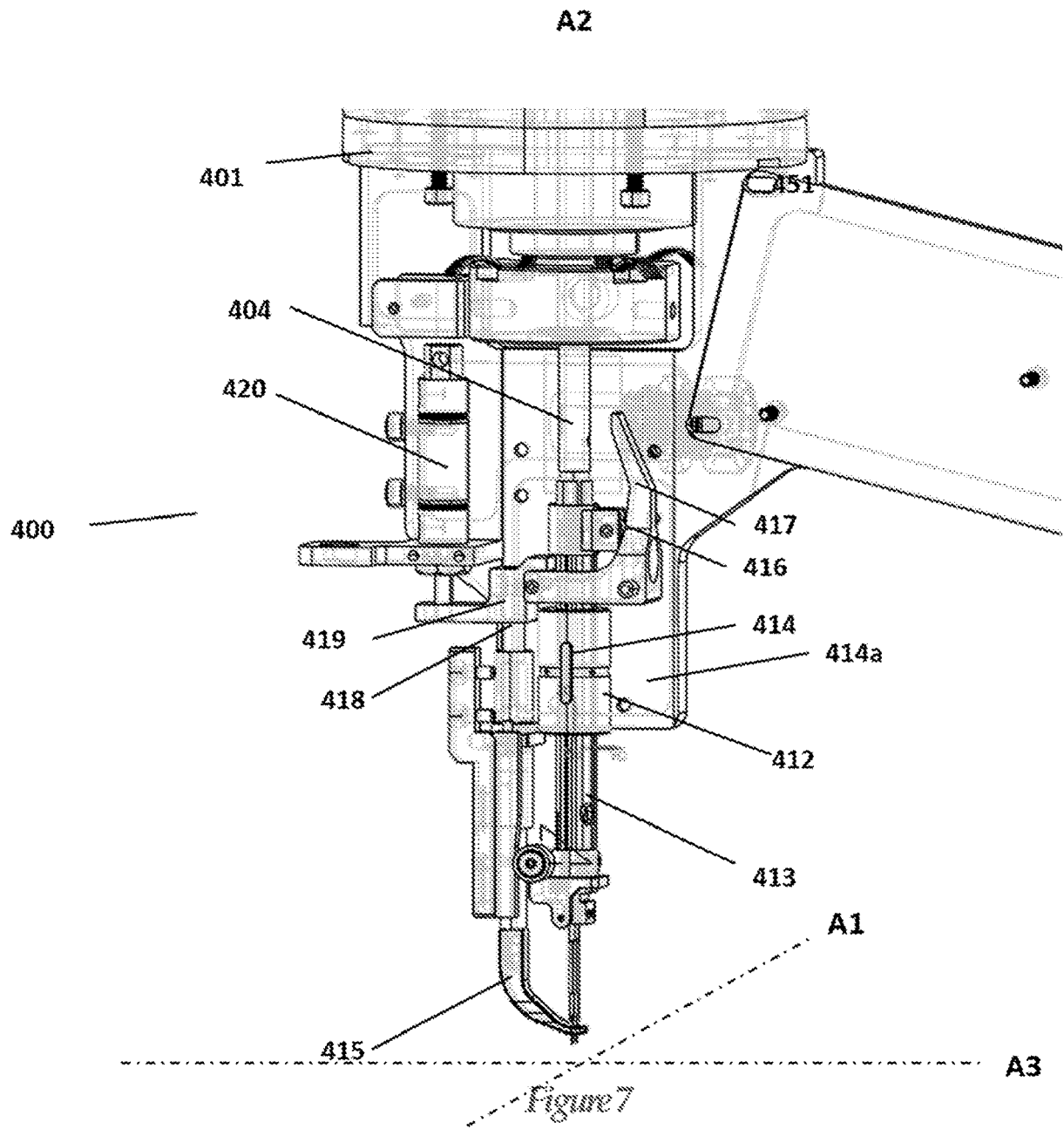
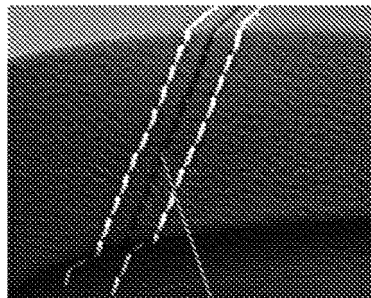
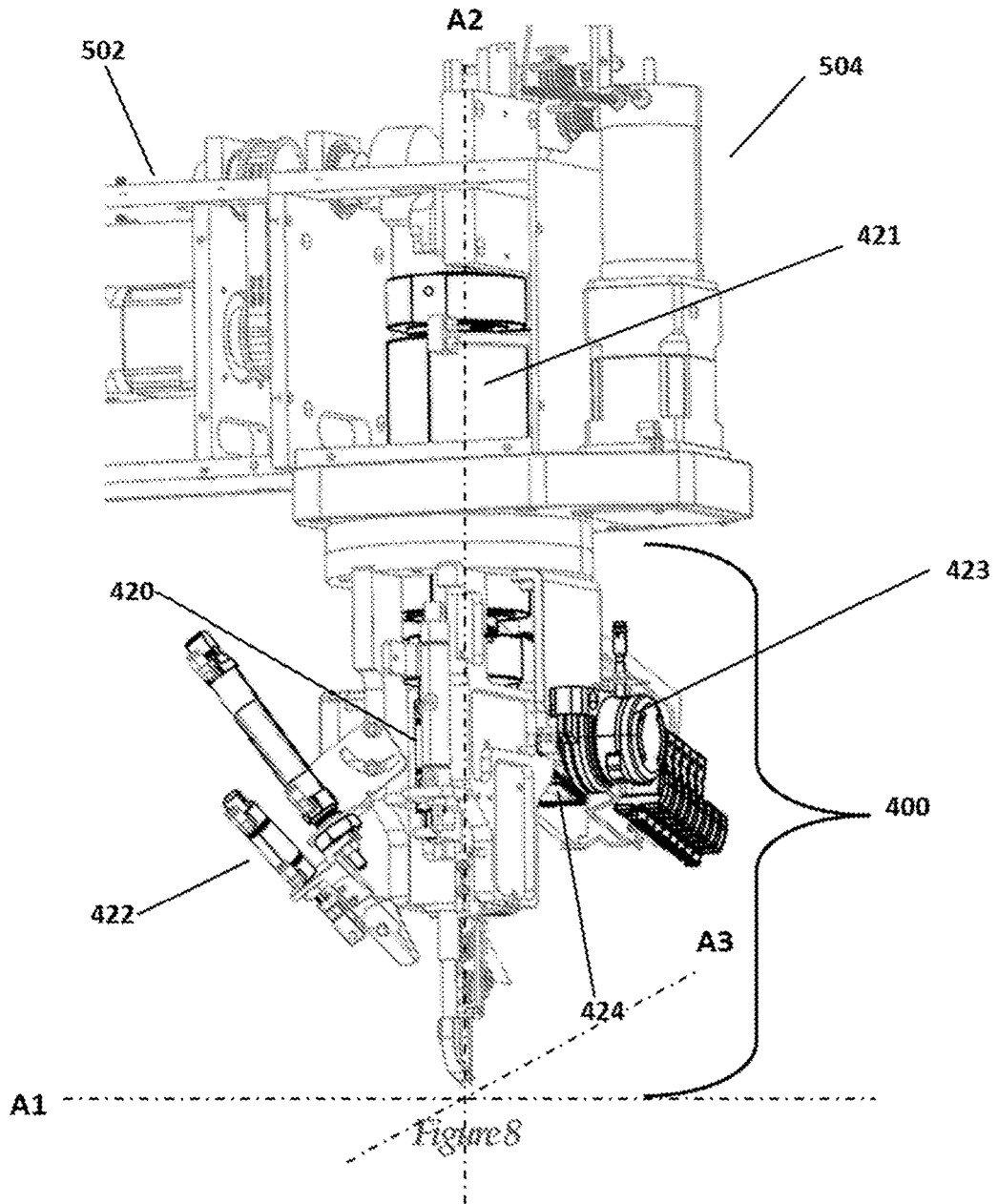
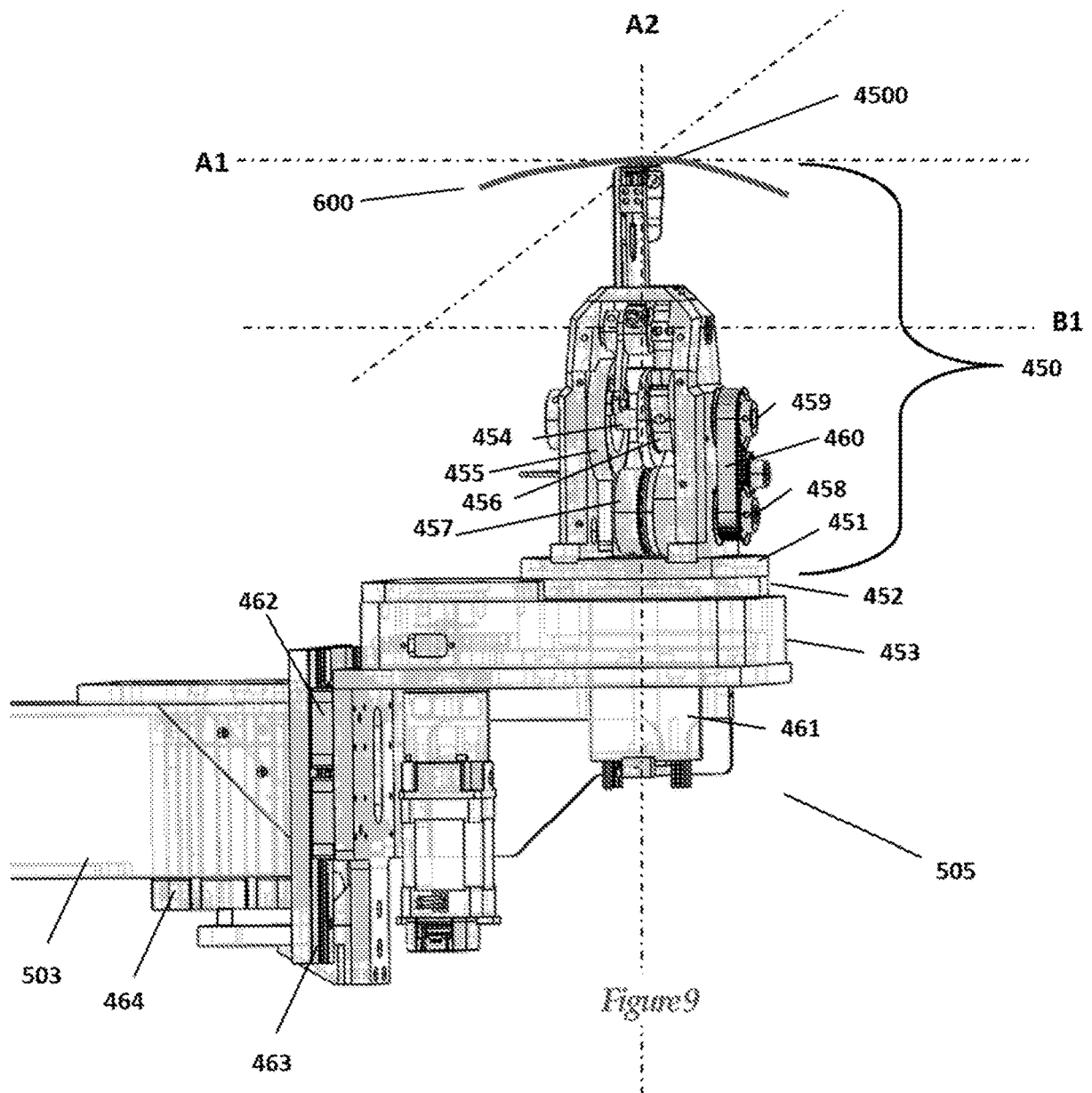


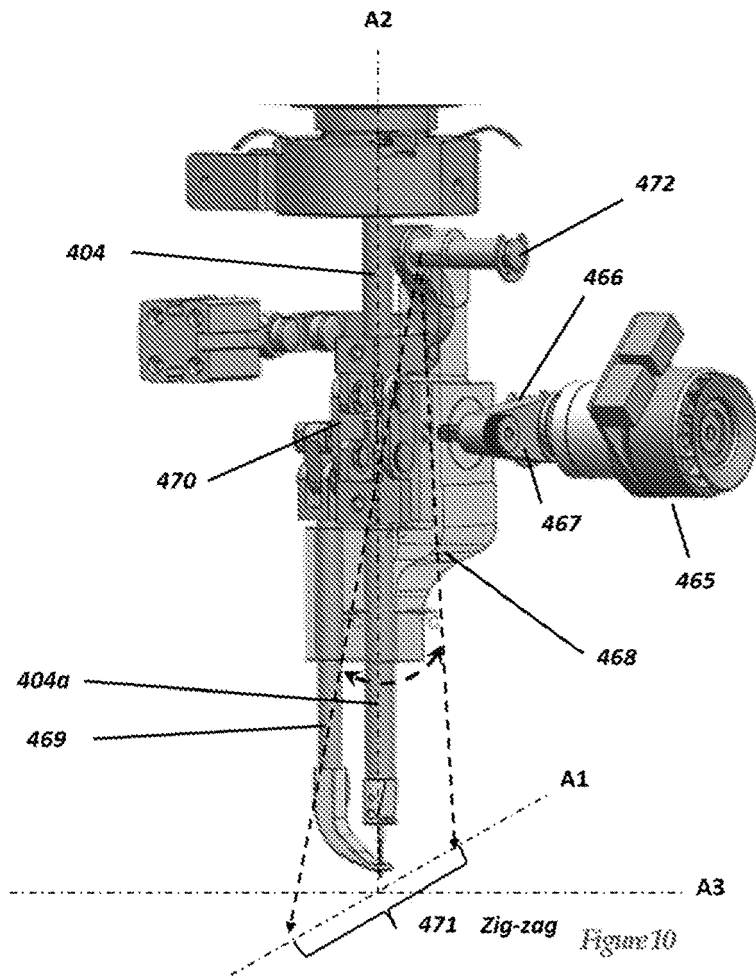
Figure 6



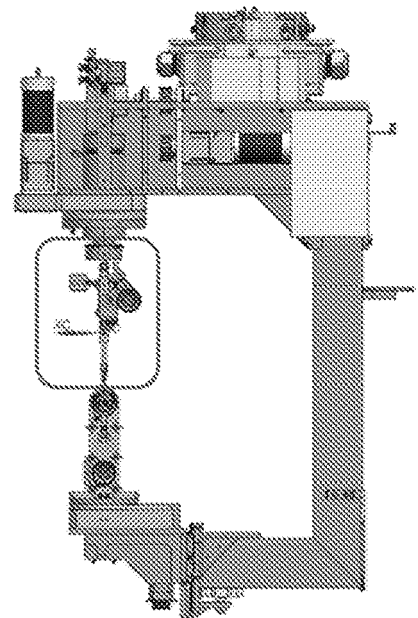


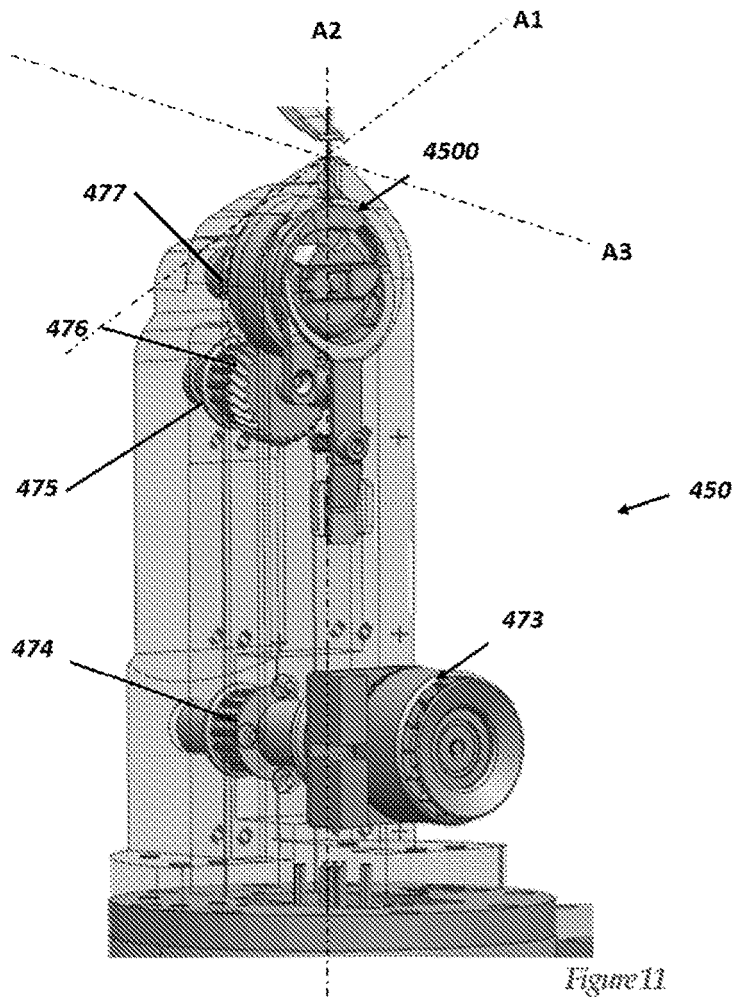
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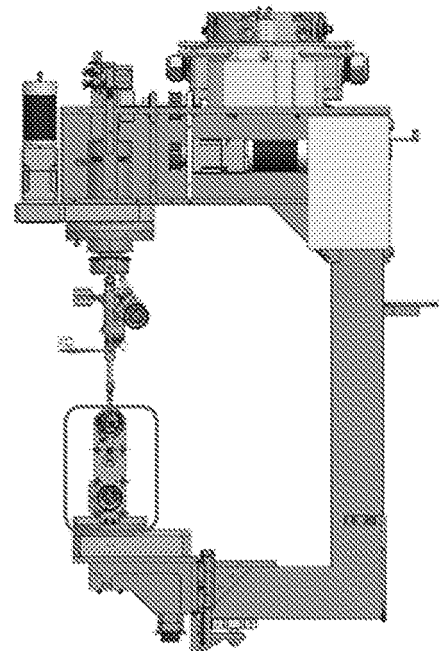


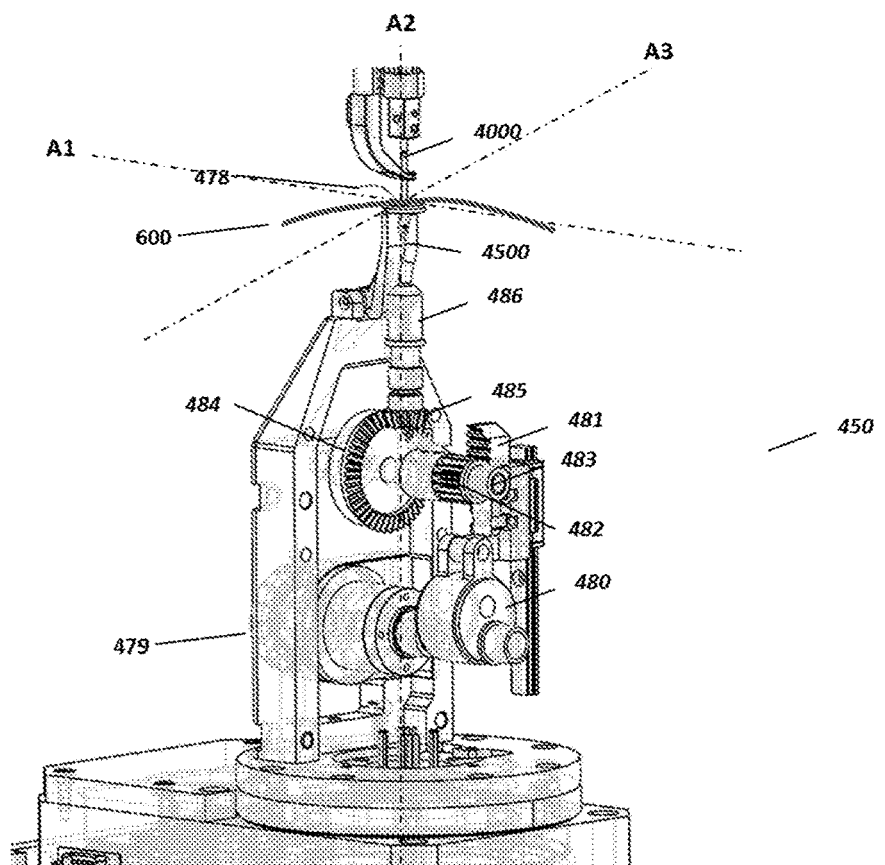
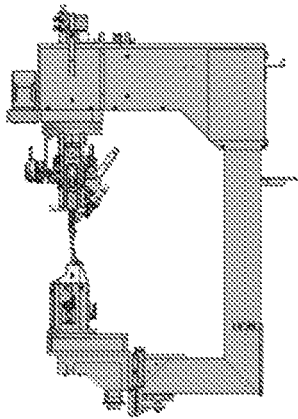
Alternative #1





Alternative #1





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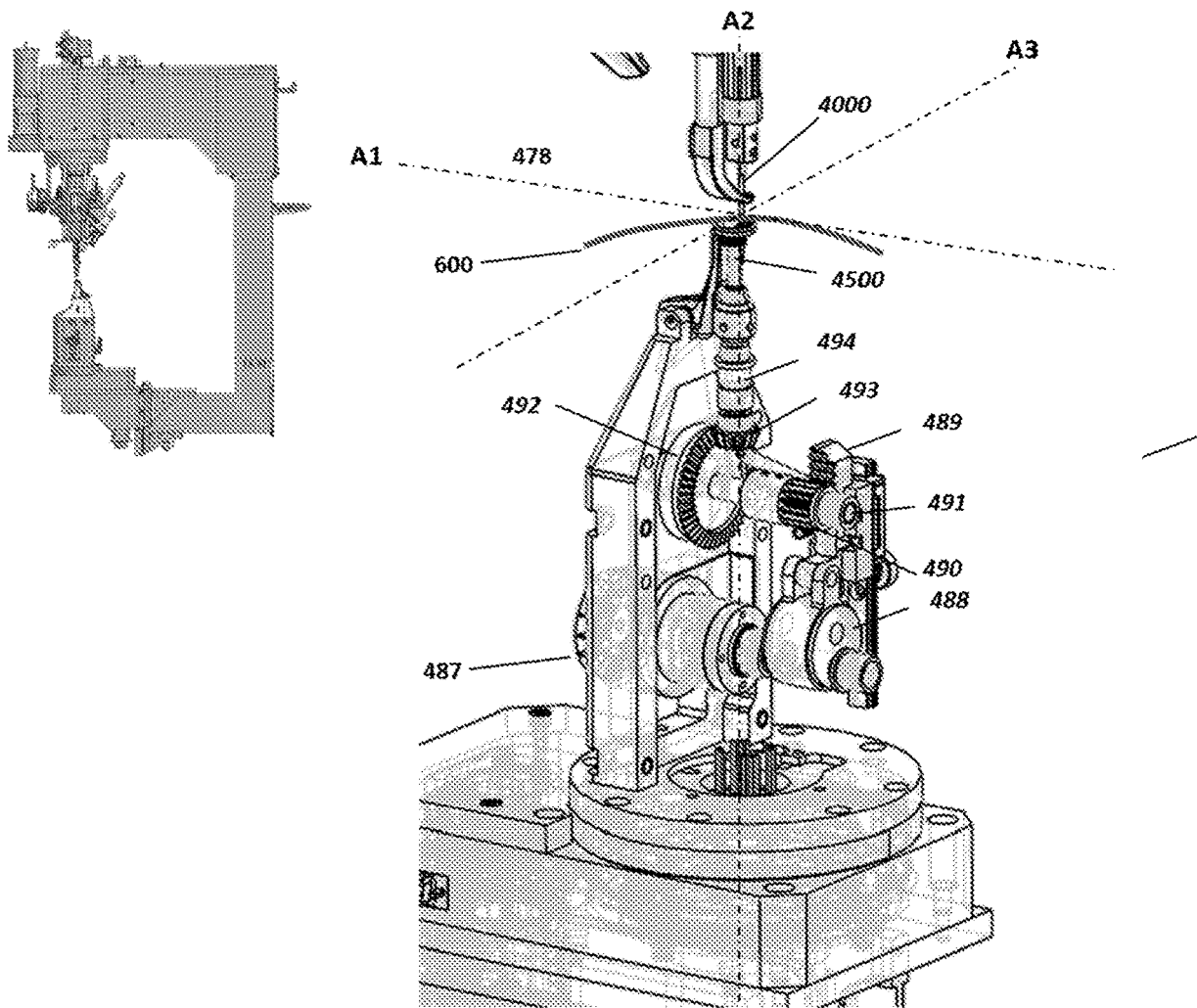


Figure 13



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Application Number

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Y	* the whole document *	11	D05B57/30
A	-----	10,12,13	D05B69/12
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	* paragraphs [0031], [0046] - paragraph [0051]; figures 3, 4 *		
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Place of search		Date of completion of the search	Examiner
Munich		28 May 2024	Braun, Stefanie
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X : particularly relevant if taken alone		T : theory or principle underlying the invention	
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A : technological background		D : document cited in the application	
O : non-written disclosure		L : document cited for other reasons	
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