(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) **EP 4 287 228 A2**

(12) **EUROPEAN PATENT APPLICATION**

(43) Date of publication:
06.12.2023 Bulletin 2023/49

(21) Application number: **23200647.8**

(22) Date of filing: **19.10.2021**

(51) International Patent Classification (IPC):
H01F 41/082 *(2016.01)*

(52) Cooperative Patent Classification (CPC):
H01F 41/08; H01F 41/082

(84) Designated Contracting States:
AL AT BE BG CH CY CZ DE DK EE ES FI FR GB GR HR HU IE IS IT LI LT LU LV MC MK MT NL NO PL PT RO RS SE SI SK SM TR

(62) Document number(s) of the earlier application(s) in accordance with Art. 76 EPC:
21203515.8 / 4 170 691

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Remarks:
This application was filed on 28-09-2023 as a divisional application to the application mentioned under INID code 62.

(54) **TOROIDAL COIL WINDING MACHINE**

(57) A machine (100, 101) for winding toroidal coils with a fully automatic procedure, comprising a hook (11) shaped to grab the conductor wire (F) and vertically translating, and a forming arm (8) which is controllable in position on three axes, wherein the machine is configured to control the hook and the forming arm (8) so as to form the winding around a toroidal core (T).

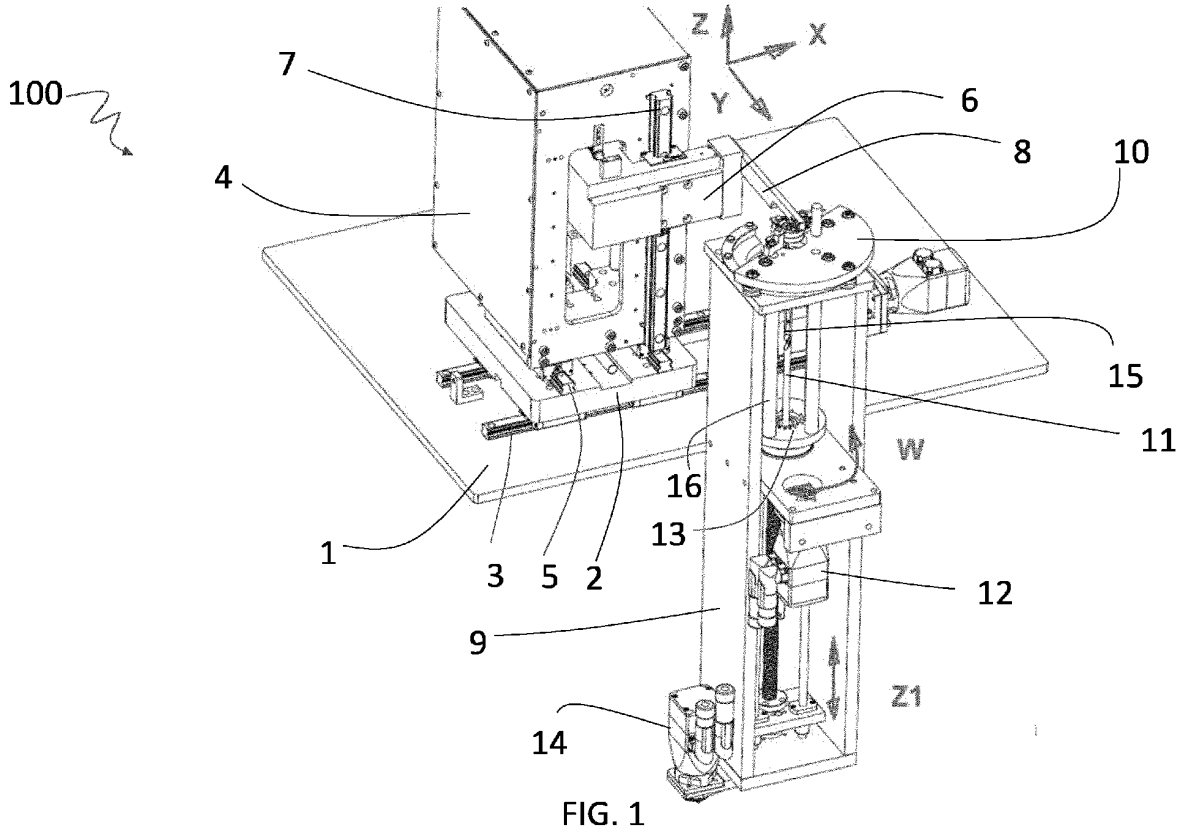

FIG. 1

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Description

Field of application

[0001] The invention relates to the field of winding machines to make a winding of a conductive wire (coil) on a core. In particular, the invention addresses the technical field of toroidal coils.

Prior art

[0002] Toroidal coils are used in several applications and are generally considered to perform better than coils with differently shaped cores. One of the advantages of toroidal coils is the low leakage of flux due to the closed-loop shape of the core.

[0003] However, winding a conductive wire on a toroidal core is a laborious operation. The winding process is complicated by the closed shape of the core which does not allow the wire to turn rapidly around the core, as occurs with known "flyer" winding machines. Furthermore, the realization of the winding is more demanding when the wire has a relatively large section and is difficult to bend and/or when the core has a small size.

[0004] The winding is carried out with the aid of a machine that facilitates the work but the process remains manual. More specifically, the following winding techniques are known, using semi-automatic machines. For a wire with a small diameter, a piece of wire is prepared, pre-cut to size i.e. to a length suitable for the extension expected from the toroid core, and said piece of wire is loaded onto a rotating magazine. For a wire with large diameter, a length of pre-cut wire is prepared to size, as above, which is loaded onto a fixed winding station. Said fixed station essentially comprises a hook with a rapid vertical up-and-down movement. The core or ring intended to receive the winding is positioned so that the vertical trajectory of the hook passes through the central opening of the ring.

[0005] The winding procedure with said semi-automatic fixed station is as follows. The operator positions the ring in place, then fixes one end of the metal wire (usually copper) to a suitable anchoring point, manually places the wire over the center of the ring, and operates the hook. The hook grabs the wire and drags it under the ring; at this point, the operator manually releases the wire from the hook to reposition the wire over the ring thus completing a coil around the ring. After that, the operator can activate the hook again to start making a second coil and so on. In essence, the winding is performed by hand with the only aid of the hook to pass the wire through the central opening of the ring.

[0006] Such procedure speeds up the work but is not satisfactory in terms of speed and accuracy as it still largely depends on manual work and therefore on the precision of the operator. It would be desirable to implement a fully automatic procedure but this need has not yet found an adequate response.

[0007] CN 213 935 949 U and CN 107 424 839 A disclose machines for winding a conductor wire around a toroidal core.

Summary of the invention

[0008] The invention aims to overcome the limitations and drawbacks of the known art, which have been described above. In particular, an object of the invention is to automate the winding operation of toroidal coils.

[0009] The objects are achieved with a toroidal coil winding machine according to the claims.

[0010] A further aspect of the invention is a method for making a toroidal winding according to the claims.

[0011] A machine according to the invention comprises a hook arranged to translate along a vertical axis Z and configured to grab the conductor wire, and further comprises a forming arm which is controllable in position on three axes in the space around the toroidal core (or ring) being processed. The forming arm has a controllable and programmable position in the space around a housing area of the core being processed.

[0012] The invention provides for the making of a toroidal winding in a completely automated manner by means of the cooperation between said hook, said forming arm, and the core support. The latter is arranged to rotate by an appropriate angular pitch following the formation of the coils.

[0013] The main advantage of the invention is the provision of a machine which allows automating a process carried out until now in an essentially manual way, with consequent advantages in terms of productivity, cost reduction and winding precision. In particular, the forming arm movable in space, controlled on three axes, substantially replaces the manual work so far carried out by the operator.

[0014] The term toroidal core as known identifies a closed-loop core, also simply referred to as "donut-shaped".

Description of the invention

[0015] A machine according to the invention can comprise a control system configured to control the hook, the arm, and the rotating support with the following coil winding procedure:

winding a running end of the conductor wire around the core by means of a spatial movement of the forming arm, said movement being performed from a point under the core where the arm engages the wire, to a point where said running end of the wire is located above the central opening of the core in a position which is reachable by the hook;

bringing the running end of the wire back under the core by means of the hook, by passing said running end of the wire through the central opening of the

core;

angularly displacing the core to form a subsequent coil.

[0016] The term "running end" indicates the wire portion which is actively guided to form the coils in analogy with the terminology used in the field of knots.

[0017] The forming arm is provided with bearings or wire guide rollers to obtain the desired dragging effect on the conductor wire. Preferably said bearings are rotatable with respect to the arm and have a central groove adapted to receive the conductor wire so that, when the wire is accommodated in the groove, the arm can move the wire in space and bend it around the core.

[0018] The forming arm comprises two wire guide bearings located on opposite sides of the arm itself. Preferably, the bearings are at the end of the arm.

[0019] The hook has a head which is shaped to grab the conductor wire, preferably with a down facing slot.

[0020] The forming arm is controllable and programmable in position on three axes, i.e., along the vertical axis Z and along a further pair of axes X, Y which define a horizontal plane. More precisely, the axes X, Y, and Z identify a system of orthogonal axes in the space. The position of the forming arm is controllable independently on each of said three axes. The control is preferably obtained by combining the translation on suitable guides arranged along the axes.

[0021] In a preferred embodiment, the machine comprises a first column-shaped structure which contains the hook and which comprises, at the top, the rotating support for the core; a second structure which carries the forming arm, said structure comprising three linear guides oriented according to orthogonal axes X, Y and Z which allow the control of the forming arm in the space.

[0022] More specifically, the machine can comprise, in a first embodiment:

a frame;

a base which is movable with respect to said frame on at least a first rectilinear guide oriented along a first horizontal axis X;

a head which is movable with respect to said base on at least a second rectilinear guide oriented along a second horizontal axis Y perpendicular to said first horizontal axis X;

a carriage carrying the forming arm, said carriage being movable with respect to said head on at least a third linear guide oriented along a vertical axis Z.

[0023] In a second embodiment, which is more preferred, the machine comprises, for controlling the forming arm on three axes:

a head which is movable along a first horizontal axis;

a carriage which is movable with respect to said head along a vertical axis;

where the forming arm is associated with said carriage and is motorized to extend or retract, with respect to the carriage, along a second horizontal axis,

said first horizontal axis, second horizontal axis, and vertical axis being orthogonal axes.

[0024] The machine comprises a housing for the core, preferably provided with a suitable clamping system for the core itself. Said housing is associated with a rotating member, such as a flange, to allow rotation of the core by a controlled angle during the coil forming process.

[0025] In a preferred embodiment, the machine comprises at least one gripper located close to the housing of the core. Said gripper is adapted to clamp one end of a piece of conductor wire, to define an anchoring and a starting winding point. More advantageously, a pair of such grippers is provided, which are arranged above and on opposite sides, i.e. respectively right and left, with respect to the housing for the core. Said grippers preferably have controlled opening and closing, for example by means of a pneumatic control.

[0026] The presence of two grippers on opposite sides of the core housing allows to create a fixed winding starting point to the right or to the left of the working area of the forming arm and hook. This allows making of both clockwise and counterclockwise windings. The terms clockwise winding or counterclockwise winding refers to the direction of rotation of the core as the winding proceeds, conventionally seen from above.

[0027] The two grippers are advantageously movable according to at least one horizontal axis perpendicular to the forming arm, to allow the grippers to be moved away from the winding area, if required, and to adjust the position of the anchoring point. For example, such a degree of freedom can be achieved by mounting each gripper on a pneumatic slide.

[0028] A variant including a single gripper can also be suitable for making both clockwise and counterclockwise windings by providing the single gripper with mobility on two axes or preferably on three axes so that the gripper can be positioned on both sides of the core housing and forming arm.

[0029] By using the gripper or grippers for initially anchoring the wire, the winding procedure can comprise the following initial steps:

a) fixing one end of a piece of conductor wire to a gripper positioned close to a core housing, so as to define a fixed anchoring point for starting the winding, said anchoring point being above the core;

b) starting the winding by feeding the wire through

the core, from top to bottom, by means of the hook thus forming a first half-coil inside the core.

[0030] A notable feature is the starting of the winding from within the toroidal core.

[0031] A winding method according to the invention can generally comprise the following steps:

winding a running end of the conductor wire around the core by means of a spatial movement of the forming arm, said movement being performed from a point under the core where the forming arm engages the wire, up to a point where said running end of the wire is located above the central opening of the core in a position which is reachable by the hook;

bringing the running end of the wire back under the core by means of the hook, by passing said running end of the wire through the central opening of the core;

angularly placing the core to form a subsequent coil;

repeating the sequence listed above until a preset number of coils is formed.

[0032] The steps listed above are automatically carried out in sequence by the machine until the completion of a preset number of winding coils. Moreover, the steps listed above can be carried out after the winding starting step described at a) and b) above.

[0033] A machine according to the invention can be further configured to automatically load and cut to programmable size the piece of wire required for the winding, and/or to automatically load the toroidal core. The machine of the invention can be configured to integrally produce and eject a toroidal coil formed in a fully automatic manner.

[0034] Therefore, the machine can be configured to eject a coil which is ready for assembly and for the subsequent steps of the production process. The further process steps may comprise electrical testing and mounting in an electromechanical device, e.g. hosting a toroidal transformer with winding created according to the invention.

Description of the drawings

[0035]

Fig. 1 shows a machine according to a preferred embodiment of the invention.

Figs. 2-11 show the machine in Fig. 1 at various times during the production of a toroidal coil.

Fig. 12 shows a machine in accordance with a variant of the invention, and Figs. 13 to 23 show a sequence of winding a coil by means of the machine in Fig. 12.

Figs. 12A to 23A show with reference to Figs. 12-23 respectively, the detail of the toroidal core where the conductor wire is wound to form the toroidal coil, to facilitate the understanding of the invention.

First embodiment

[0036] Fig. 1 shows an embodiment of the invention in which the essential details are as follows:

1	frame
2	base movable with respect to frame 1 along axis X
3	pair of guides, axis X
4	head being movable with respect to base 2 along axis Y
5	pair of guides, axis Y
6	carriage translating along axis Z with respect to head 4
7	guide, axis Z
8	forming arm for the wire fixed to carriage 6
9	column support
10	flange or support for fixing the toroidal core being processed
11	hook
12	hook drive motor
13	support of flange 10 or drive flange
14	motor for rotating flange 10
15	tip of the hook 11 shaped to grab the conductor wire
16	attachment tubes between flange 13 and flange 10
17	jaws
18	catch
19	bearing or roller
20	bearing
21	circular guide
22	central hole
F	conductor wire
F1	conductor wire portion
100	machine for winding the conductor wire F

[0037] As can be understood by looking at Fig. 1, the forming arm 8 is controllable on the three axes X, Y, and Z by combining suitable translations of base 2, head 4, and carriage 6, respectively along the guides 3, 5, and 7.

[0038] Fig. 1 indicates, in addition to the orthogonal axes, the ascent and descent direction Z1 of hook 11. The double arrow W indicates the possibility of rotation around axis Z of the core-holder flange 10. Motor 14 imparts a rotation to the drive flange 13; the upper flange 10 is made integral with said drive flange 13 by means of tubes 16.

[0039] Further details can be seen in Fig. 2. The conductor wire F and a core represented by a toroidal ring T anchored to flange 10 by means of two jaws 17 are shown.

[0040] One end E of the conductor wire F is anchored to a catch 18 which is integral with flange 10. The wire portion F1 located under the core T can be defined as a "running end" of the wire, in the sense that it is the part of wire actively participating in the formation of the coils, being spatially guided by the forming arm 8 and the hook 11 as explained below.

[0041] The forming arm 8 is provided with two rollers 19 at one end thereof, arranged on opposite sides of the arm itself. Said rollers 19 are rotatable and provided with a central groove 51 (Fig. 4) adapted to accommodate the wire F.

[0042] Flange 10 is rotatable around axis Z being guided by bearings 20 on a circular guide profile 21. Said profile 21 has a front discontinuity to allow the passage of the forming arm 8.

[0043] The drive flange 13 has a central hole 22 which allows the passage of hook 11.

[0044] The figures indicate the oriented axes X, Y, and Z. Hereafter, a displacement will be referred to as positive or negative in accordance with the direction shown in the figures.

[0045] In the condition of Fig. 2, the wire is introduced through the core T. The forming arm 8 is positioned with one of the rollers 19 in contact with wire F. Starting from this condition, the following figures illustrate a sequence of operation of the machine to create a coil.

[0046] Starting from the condition of Fig. 2, the forming arm 8 retracts in the direction Y (Y-negative displacement), raises itself above the ring T, and moves forward in the direction Y (Y-positive displacement) substantially turning around the core T.

[0047] The running end F1 of the conductor wire follows the forming arm 8 resting on roller 19. By carrying out this sequence of movements, the forming arm 8 essentially bends the wire against the outer surface of ring T (Figs. 3-5).

[0048] Note that the roller 19 in Fig. 2 is in front of the wire F (with respect to the oriented direction Y), which allows the forming arm 8 to "pull" the wire in the Y-negative direction. In Fig. 4, on the other hand, due to the displacement and support of the wire, the roller 19 is located behind the wire, so that the forming arm 8 can "push" the wire in the Y-positive direction to reach the condition shown in Fig. 5.

[0049] The figures concern an example in which wire F is very thick and has a certain rigidity, therefore it does not fall due to its own weight (Fig. 4).

[0050] From the condition in Fig. 4, the arm proceeds in the Y-positive direction bringing the running wire end above the center of ring T and reaching the configuration in Fig. 5. From this position, the running wire end can be grabbed by hook 11 as in Fig. 6 and dragged downwards passing through the core T as shown in Figs. 7 and 8.

[0051] As a result of the dragging of the hook 11, the wire leaves the forming arm 8. Thereby, a coil S1 is essentially completed around the toroidal core T. Note that the free end of the running end F1 is preferably brought under the core (Fig. 7).

[0052] From the position in Fig. 8, the forming arm 8 returns under the ring T, moves with roller 19 in front of the wire, and picks up the wire F, all due to a three-axis control (Figs. 8-9).

[0053] From the position in Fig. 9, the system can start the formation of a new turn (Figs. 10, 11). Flange 10 rotates and angularly positions the core T for the formation of the new coil.

[0054] The forming arm 8 substantially performs a "forth-and-back" winding cycle synchronized with the hook 11 and with the rotation of the flange 10, thus obtaining the desired winding of the coils.

Second embodiment

[0055] Figs. 12 to 23 and the respective details in Figures 12A to 23A represent another embodiment of the invention.

[0056] Details equivalent to those of the first embodiment are indicated by the same reference numerals for simplicity. In the description of this second version, the set of three axes shown in Figures 12 and following is adopted as a reference.

[0057] Machine 100 comprises, similarly to the version described above, a forming arm 8 which is movable and programmable on 3 axes X, Y, Z and carries at its end a roller 19 or other device adapted to accommodate the conductor wire F. The control on the 3 axes X, Y, and Z is obtained by different means but is conceptually equivalent to that in Figs. 1-11.

[0058] More specifically, the machine 100 comprises a head 30 translating along guides 34 according to the axis Y. The forming arm 8 is mounted inside a carriage 31 which is associated with head 30 and is controlled according to the axis Z with a fixed screw - movable nut screw mechanism. Finally, the control along the axis X is given by a system which extracts or retracts the forming arm 8 with respect to carriage 31, for example with a rack.

[0059] The mechanism which moves carriage 31 comprises, in more detail, a screw 32 which is moved by a motor mounted to the rear of the head 30, and which drives the screw 32 by means of a transmission, for example a belt transmission housed in the upper casing 33. Screw 32 engages a nut screw which is integral with the carriage 31 so that the rotation of screw 32 precisely controls the elevation with respect to the axis Z of carriage 31, and therewith, of the forming arm 8.

[0060] However, it should be understood that the drives according to the X, Y, Z axes can be achieved according to other variants.

[0061] The forming arm 8, in this second example, comprises a single end roller 19 instead of a pair of rollers as in the previous version.

[0062] The peculiarity of the version in Figs. 12-23 is given by the presence of two grippers 28, 29 which are placed on the sides of the housing of the toroidal core T and therefore on the sides of the working area of the

forming arm 8. Said grippers 28, 29 are adapted to clamp one end of a piece of conductive wire F to define a fixed wire anchoring and a winding starting point.

[0063] The presence of the two grippers 28 and 29 respectively to the right and to the left of the core T allows to realize clockwise and counterclockwise windings, as defined above. Observing the example of the figures, it is noted that core T turns counterclockwise (see the comparison between Figs. 19 and 20) and therefore the grippers 28 on the right of the core are used to lock the wire. On the other hand, for a clockwise winding, the gripper 29 will be used to define the initial wire anchoring point.

[0064] Each of the two grippers 28, 29 is associated respective with a pneumatic slide 40, 41 capable of moving the gripper according to the axis Y (Fig. 12). In addition, each gripper is mounted on an actuator 42, 43 which controls the opening and closing thereof (Fig. 12A). The movement along the axis Y, given by the pneumatic slides 40 and 41, allows the grippers 28, 29 to be moved away from the winding area when required.

[0065] The grippers 28 and 29 can be defined to be right and left by looking at them from the top and in the positive direction X (extension direction of the forming arm 8).

[0066] By looking at the figures, it is understood that a variant with a single gripper could equally make clockwise and counterclockwise windings, providing a single gripper capable of selective positioning in the place of the gripper 28 or in the place of the gripper 29. For this purpose, the single gripper can be provided with a programmable position on at least the axes Y and Z and preferably on all three axes X, Y, Z. It is noted that the vertical degree of freedom (axis Z) allows the gripper to overcome forming arm 8, i.e. to move on the right or left thereof without interfering with the winding cycle.

[0067] In Fig. 12 and in the detail in Fig. 12A, the following details can be further noted: rotating flange 10 for supporting the toroidal core T; hook 11 with a shaped head 15 for grabbing the conductor wire F; jaws 17 for clamping the core T. Said jaws 17 define the housing which accommodates the toroidal core T.

[0068] Fig. 12A shows the end E of the conductor wire F which is engaged in the right gripper 28. In the same Fig. 12A, it is noted that the conductor wire F is engaged in the recess 50 of the shaped head 15 of hook 11. In this example, the right clamp 28 is used to anchor the end of the conductor wire since the winding is counterclockwise as indicated by arrow W in the figure. For a clockwise winding, the left gripper 29 would be used in an analogous manner.

[0069] As above, the portion of conductor wire F which is spatially dragged or guided from time to time by the forming arm 8 and hook 11 can be referred to as the running end F1 of the wire.

[0070] Starting from the condition of Fig. 12, the winding procedure can be described as follows. The position of the conductor wire F with respect to the core T can be better seen in the details in Figs. 12A - 23A.

[0071] Fig. 13: the hook 11 is lowered by dragging the wire F therewith and starting the formation of a first coil around the core T. Note the coil forming process starts from within the core T.

[0072] Fig. 14: the forming arm 8 moves into position to engage the wire F under the core T. Note the lowering of the carriage 31 along the axis Z (controlled by the screw 32) and the extension of the forming arm 8 outside said carriage 31. By means of a combination of movements along the axes X and Y, the forming arm 8 moves with the head roller 19 in front of the wire F. The conductor wire F is engaged in the circumferential groove 51 of roller 19.

[0073] Fig. 15: the forming arm 8 retracts into carriage 31 in the negative direction X; the roller 19 drags and bends the wire F backwards, bringing it towards the exterior of the core T.

[0074] Fig. 16: the forming arm 8 rises along Z and forms the outer part of the coil around the core T.

[0075] Fig. 17: the forming arm 8 extends out of carriage 31 in the X-positive direction and pushes the wire F over the central hole of the core T into a position which is reachable by the hook 11. The symbol S indicates the coil being formed around the toroidal core T.

[0076] Fig. 18: the wire F is hooked and dragged downwards by hook 11 thus completing the formation of a coil around the core T. The forming arm 8 remains extended to define a sliding point of the wire F in front of the core T.

[0077] Fig. 19: the forming arm 8 moves back and the hook 11 descends thus substantially completing the coil S1. The wire F, passing through the opening of the core T, remains bent in a U-shape around the head of the hook due to its rigidity (being quite thick).

[0078] Fig. 20: flange 10 performs a rotation to prepare the core T for the formation of another coil. The rotation of the flange 10 is counterclockwise when viewed from the top. The gripper 28 opens (controlled by the actuator 42) releasing the end E of the conductor wire. This is possible because the conductor wire is now hooked to the core T by the coil S1 wound around the core.

[0079] Figs. 21-23: the forming arm 8 generates a second coil S2 on the core T after the rotation thereof. In the position in Fig. 21, the forming arm 8 is arranged to engage the wire F under the core T. Starting from the position of Fig. 23, the forming arm then pushes the wire F forward to allow the engagement by the hook 11 (similar condition to Fig. 18) and to continue the sequence.

[0080] Fig. 22 shows that the gripper 28 leaves the winding area due to the slide 40. This is possible because the wire is held by the coils already wound around the core T.

[0081] The process is repeated until the formation of a desired number of coils, i.e. until the winding is completed. The core T can be repositioned to carry out another winding on a different portion of the core itself, again with the forming arm 8, or the core T can be moved to another point of the machine for finishing operations of the terminals, if needed.

Claims

1. A machine (100, 101) for winding a conductor wire (F) around a toroidal core (T), to obtain a toroidal coil, comprising:

   a support (10) adapted to stably accommodate a toroidal core (T), said support (10) being rotatable around a central vertical axis Z;
   a hook (11) shaped to grab the conductor wire (F) and arranged to translate vertically, having a trajectory passing through the central opening of the toroidal core (T) positioned on the support (10);
   a forming arm (8) which is controllable in position on three axes, namely according to a set of three orthogonal axes comprising said vertical axis Z and a further pair of horizontal axes X, Y, said forming arm (8) thus being freely positionable in space around the toroidal core (T) fixed to the support (10);
   wherein said forming arm (8) carries a wire guide member which is adapted to engage the conductor wire (F) so as to drag the conductor wire (F) therewith and fold it in space;
   wherein said machine has a control system configured to control in a coordinated manner the vertical position of the hook (11), the position in space of the forming arm (8), provided with said wire guide member, and the rotation angle of the rotating support (10) to automatically wind coils of the conductor wire (F) around the core (T),
   characterized in that the wire guide member comprises two bearings or rollers (19) mounted on opposite sides of the forming arm (8).

2. The machine according to claim 1, wherein the control system is configured to control the actuation of the hook (11), of the forming arm (8) and of the rotating support (10) by carrying out a coil winding procedure which comprises in sequence at least the following operations:

   a) winding a running end of the conductor wire (F) around the core (T) by means of a movement in the space of the forming arm (8), said movement being performed starting from a point under the core (T) where the forming device engages the wire, up to a point where said running end of the wire is located above the central opening of the core (T) in a position which is reachable by the hook (11);
   b) bringing said running end of the wire back under the core by means of the hook (11), by passing said running end of the wire through the central opening of the core (T);
   c) rotating the core (T) by a predetermined angle so as to position the core for the formation of a subsequent coil.

3. The machine according to claim 1 or 2, wherein said wire guide member comprises at least one bearing or roller (19) mounted on the forming arm (8) and which is rotatable with respect thereto, said bearing or roller (19) having a central groove adapted to accommodate the conductor wire, allowing the forming arm (8) to move the wire in space when the wire is accommodated in the groove.

4. The machine according to one of the preceding claims, wherein the hook (11) has a head having a downfacing slot to hook the conductor wire (F).

5. The machine according to one of the preceding claims, wherein the forming arm (8) is movable in space due to a combination of movements along linear guides oriented according to a set of three orthogonal axes X, Y, and Z.

6. The machine (100) according to one of the preceding claims comprising, for the three-axis control of the forming arm (8):

   a base (2) which is movable with respect to a frame (1) of the machine on at least a first rectilinear guide (3) oriented along a first horizontal axis (X);
   a head (4) which is movable with respect to said base (2) on at least a second rectilinear guide (5) oriented along a second horizontal axis (Y);
   a carriage (6) carrying the forming arm (8), said carriage being movable with respect to the head on at least a third linear guide (7) oriented along a vertical axis Z;
   said first horizontal axis, second horizontal axis, and vertical axis being orthogonal axes.

7. The machine (101) according to any of the preceding claims 1 to 5 comprising, for controlling the forming arm (8) on the three-axis:

   a head (30) movable along a first horizontal axis (Y);
   a carriage (31) movable with respect to said head (30) along a vertical axis (Z);
   wherein the forming arm (8) is associated with said carriage (31) and is motorized to extend or retract, with respect to the carriage (31), along a second horizontal axis (X),
   said first horizontal axis, second horizontal axis, and vertical axis being orthogonal axes.

8. The machine according to one of the preceding claims, wherein the support (10) for fixing the core (T) is configured as a flange.

9. The machine (101) according to one of the preceding claims, comprising at least one gripper located close to a housing of the core, said housing being defined by jaws (17) for clamping the core, said at least one gripper being adapted to clamp one end (E) of a piece of conductor wire (F), to define an anchoring and a starting point of winding of the conductor wire.

10. The machine according to claim 9 comprising a pair of said grippers (28, 29) which are arranged above and on opposite sides with respect to said housing for the core (T).

11. A method for making a winding of conductor wire (F) on a toroidal core (T) by using a machine (100, 101) according to one or more of the preceding claims, wherein the method comprises the steps of:

winding a running end (F1) of the conductor wire (F) around the core (T) by means of a movement in space of the forming arm (8), said movement being performed from a point under the core (T) where the forming arm (8) engages the conductor wire (F), up to a point where said running end of the conductor wire is located above the central opening of the core in a position which is reachable by the hook (11);
bringing the running end of the wire back under the core by means of the hook (11), by passing the wire through the central opening of the core (T);
angularly placing the core (T) for the formation of a subsequent coil;
repeating the sequence listed above until a preset number of coils is formed,
wherein the steps listed above are automatically carried out in sequence by the machine until a preset number of winding coils is completed.

12. The method according to claim 11 comprising the initial steps of:

a) fixing one end (E) of a piece of conductor wire (F) to the at least one gripper (28) positioned close to a housing (17) of the core, so as to define a fixed anchoring point for starting the winding, said anchoring point being above the core;
b) starting the winding by dragging the wire through the core, from top to bottom, by means of the hook (11) thus forming a first half-coil inside the core.

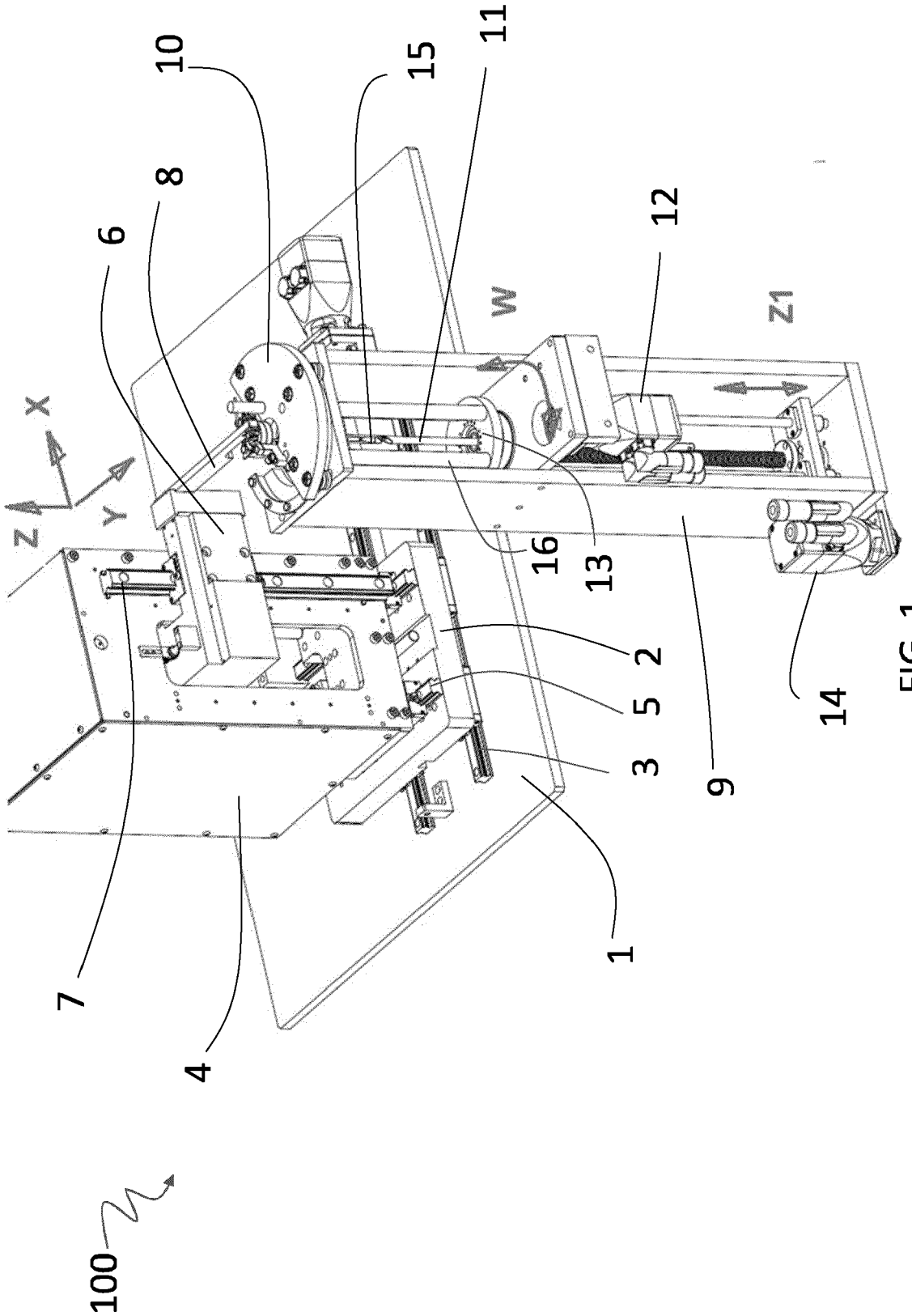

FIG. 1

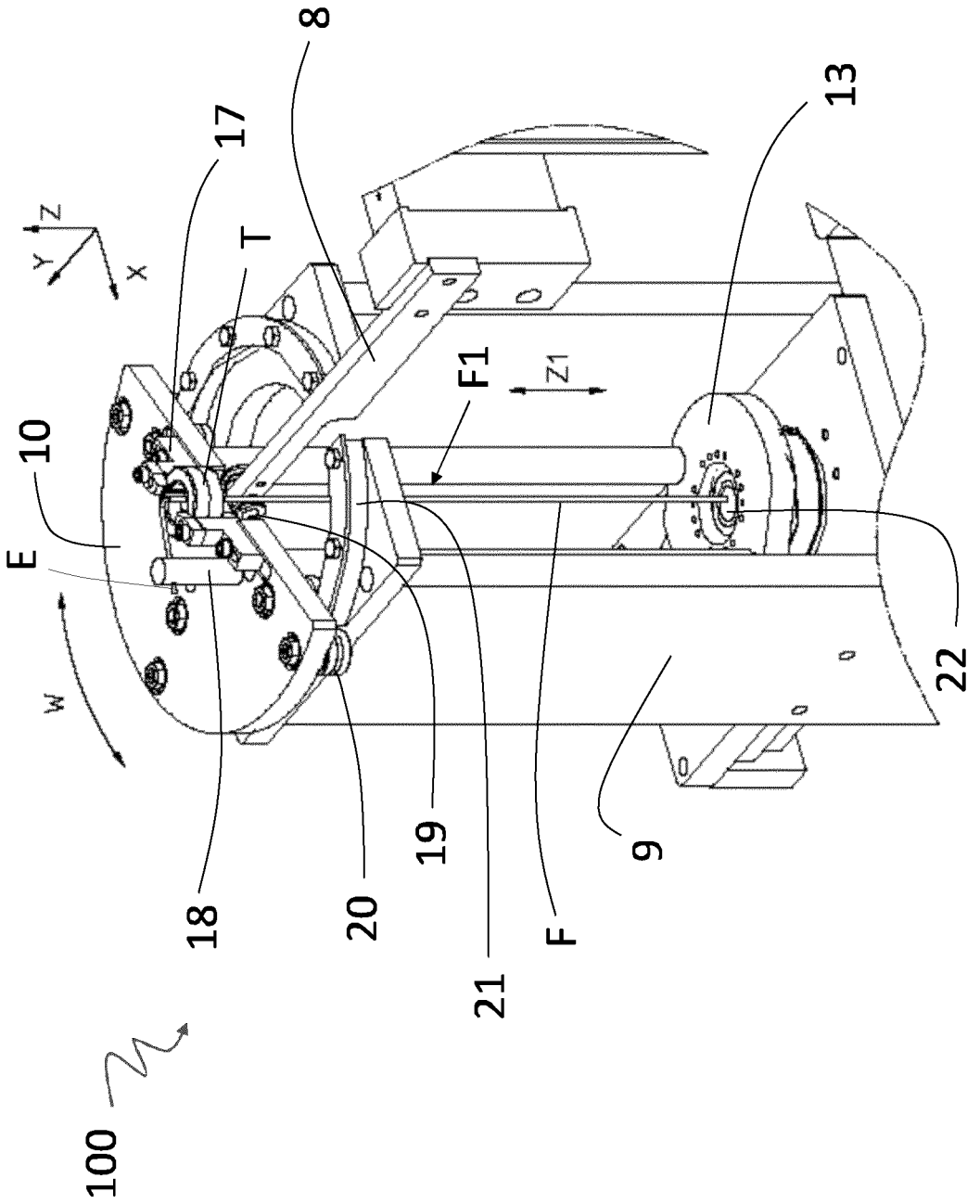

FIG. 2

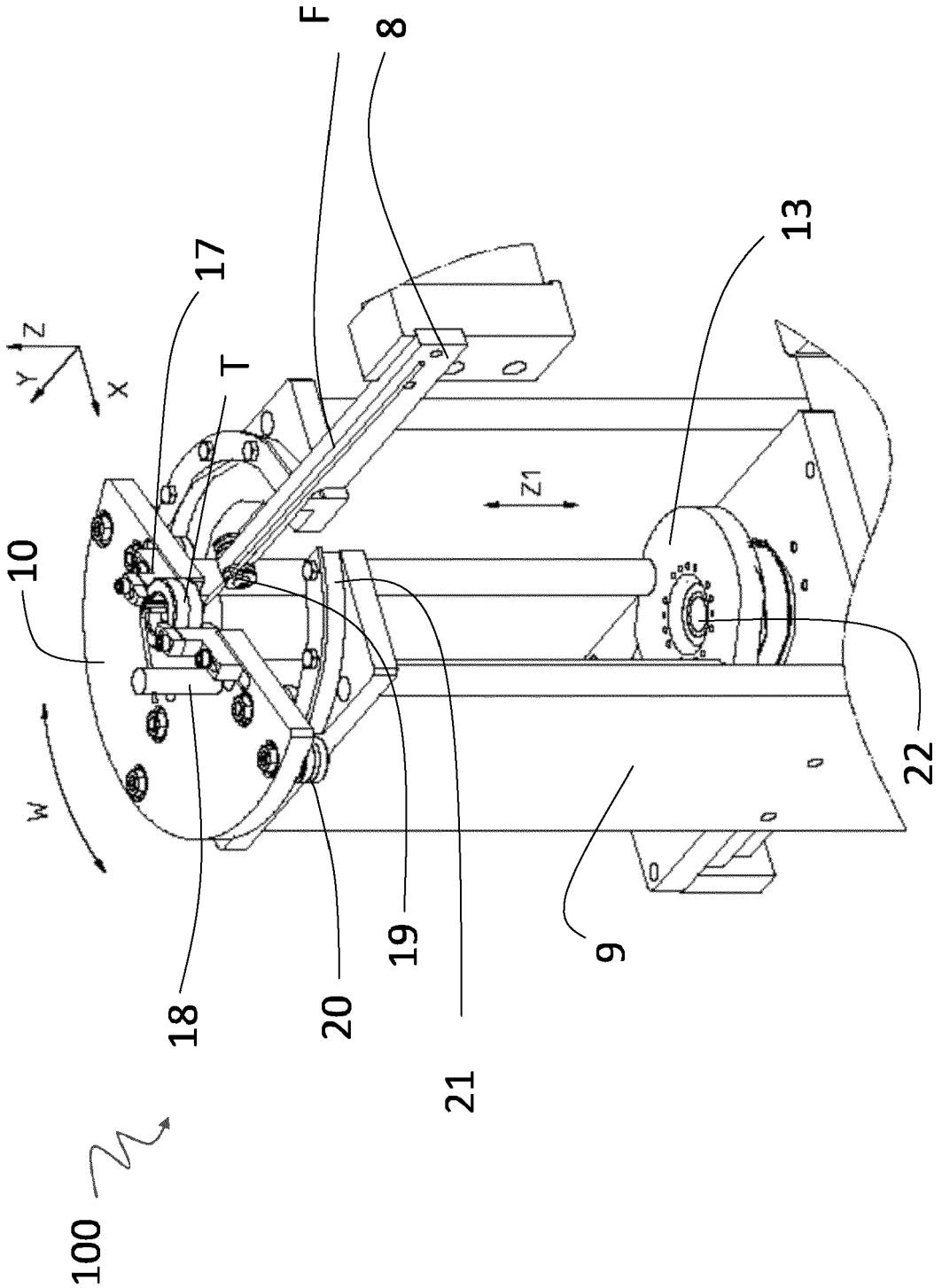

FIG. 3

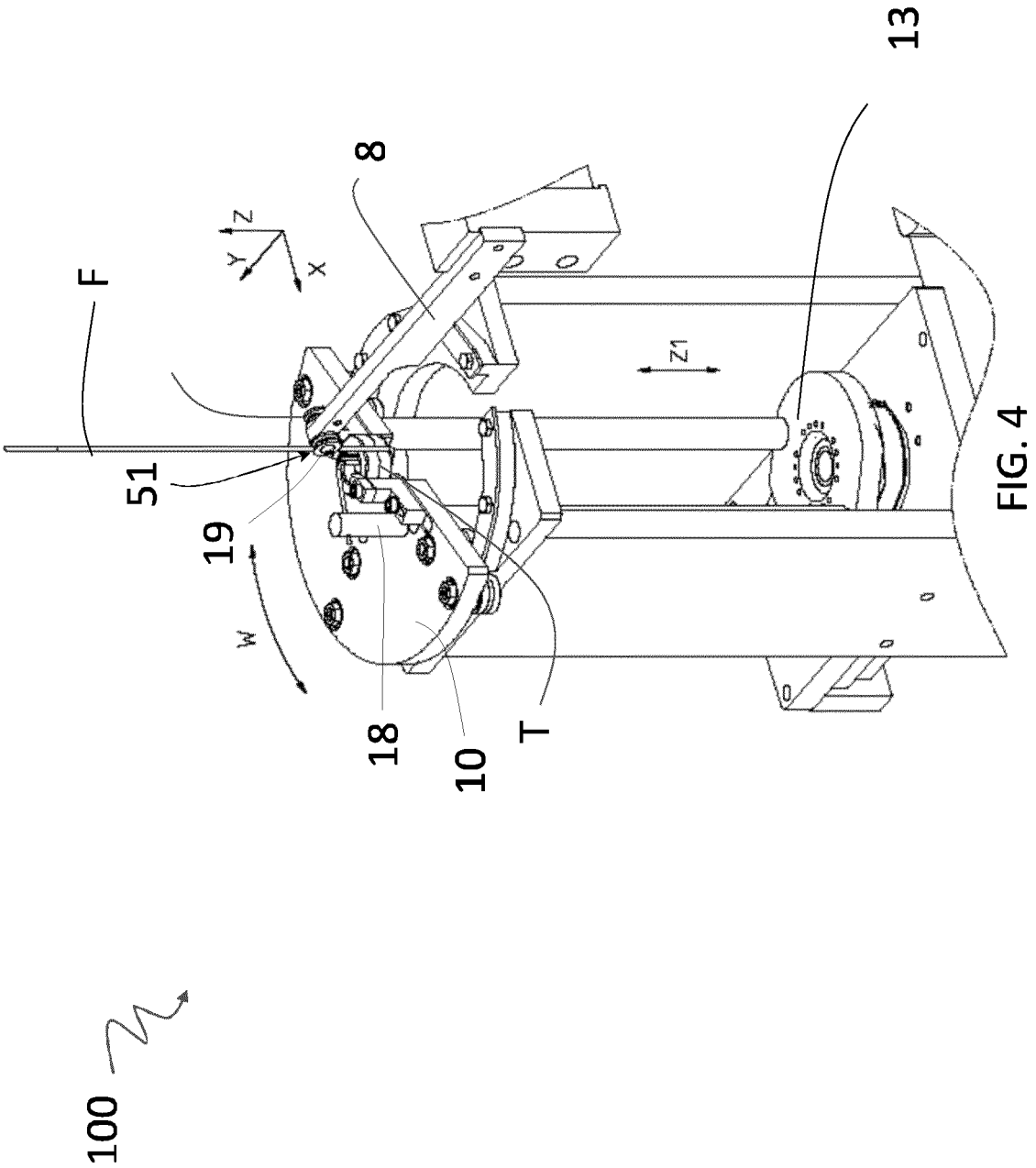

FIG. 4

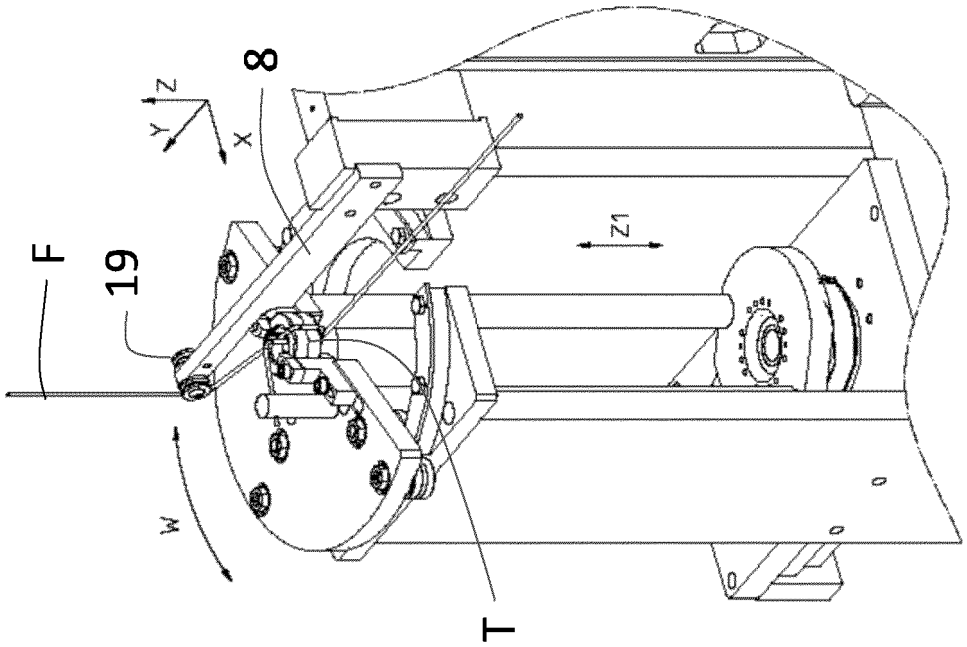

FIG. 5

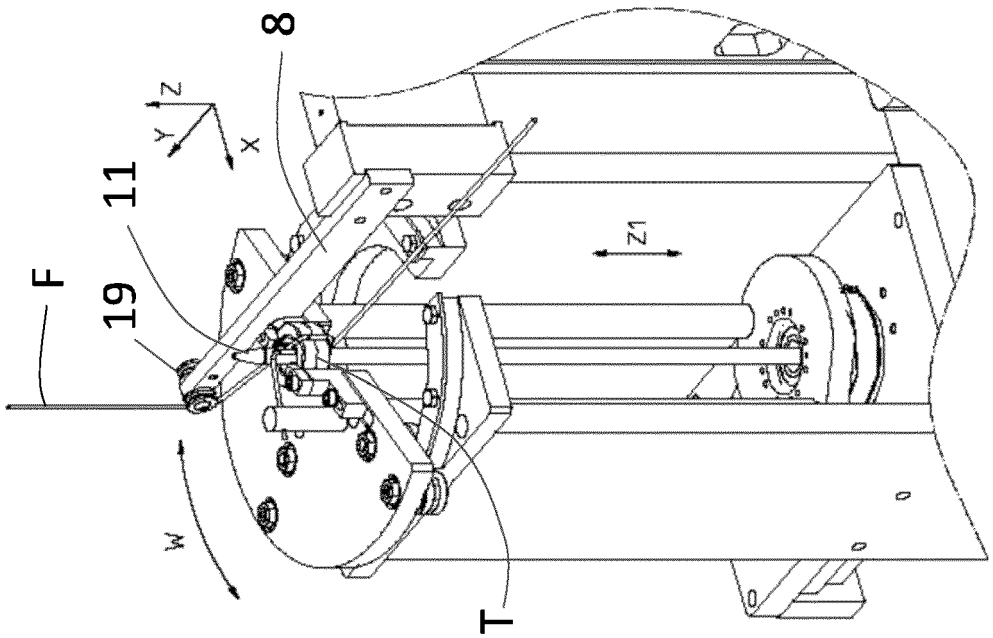

FIG. 6

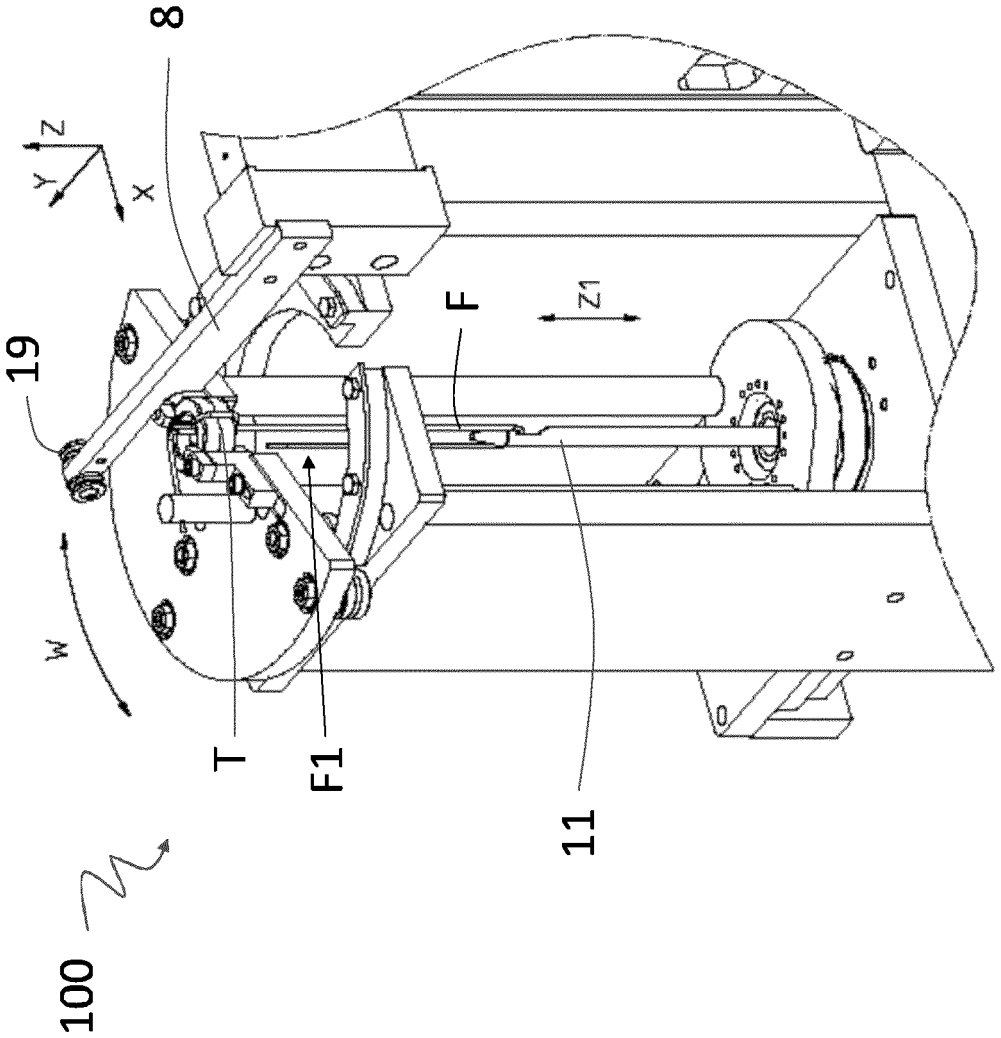

FIG. 7

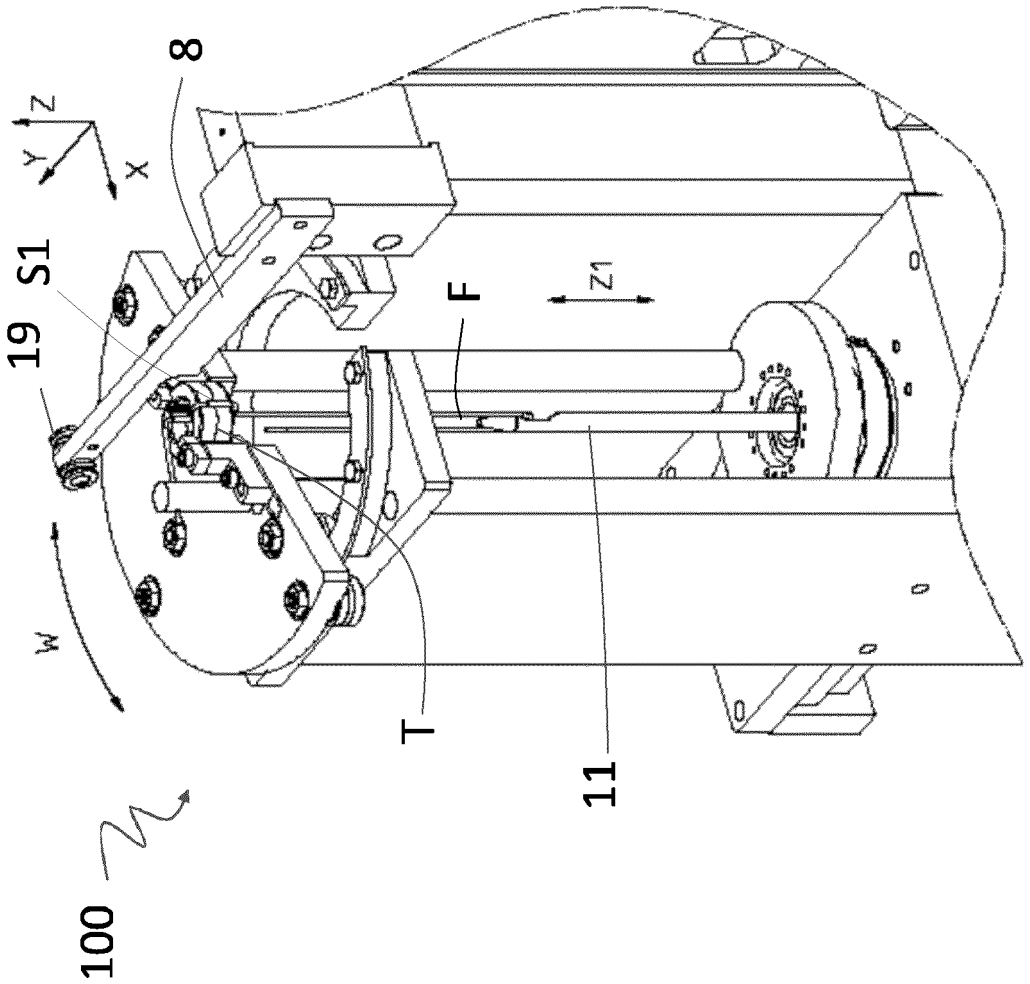

FIG. 8

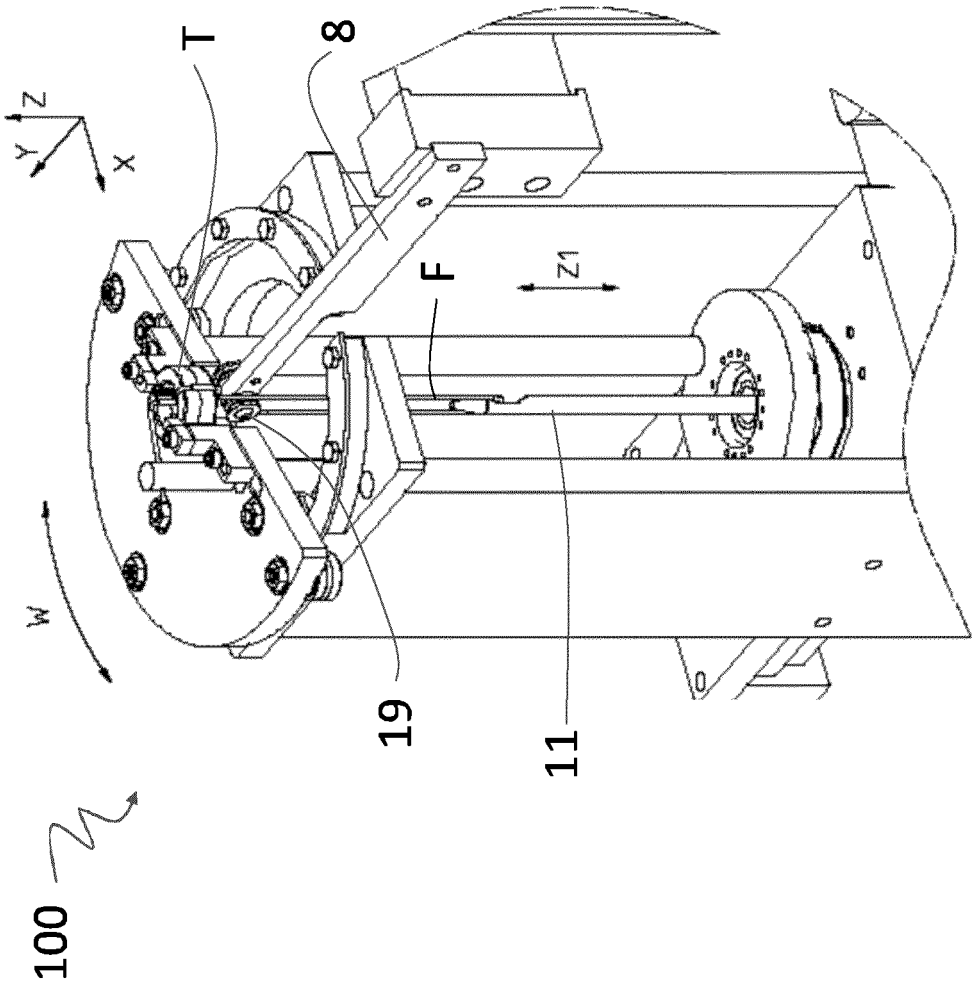

FIG. 9

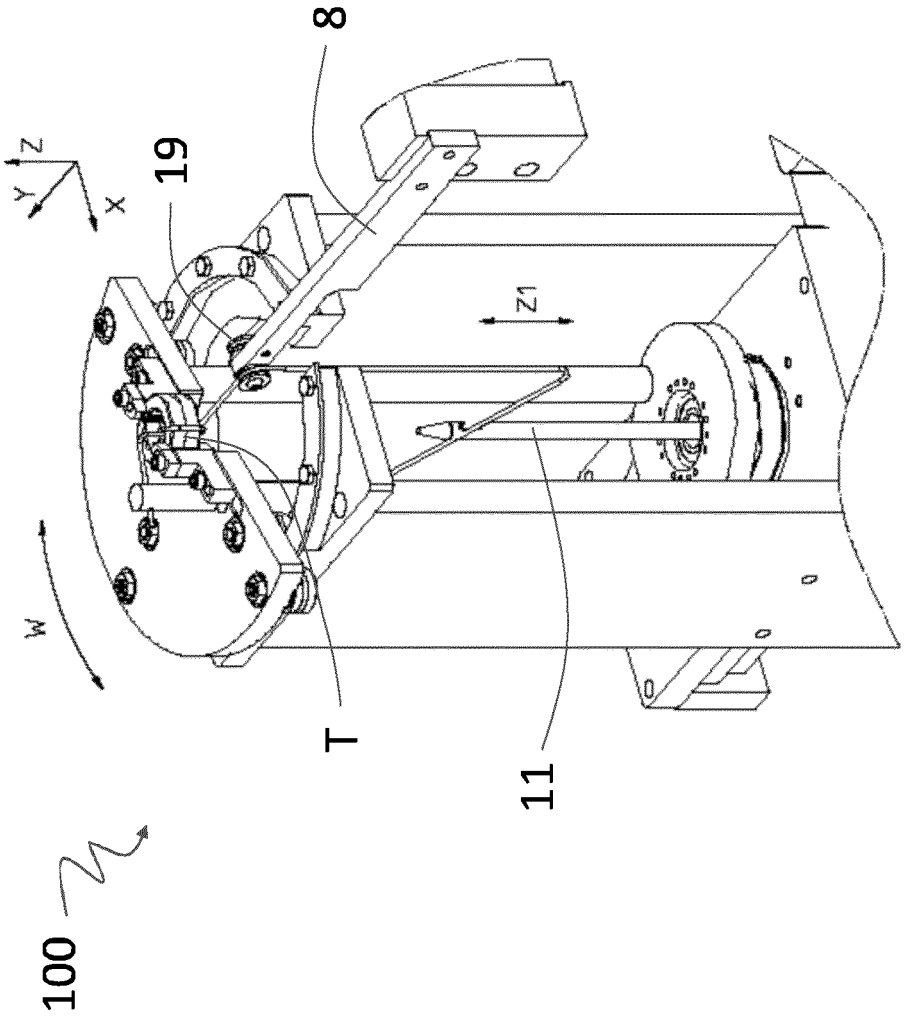

FIG. 10

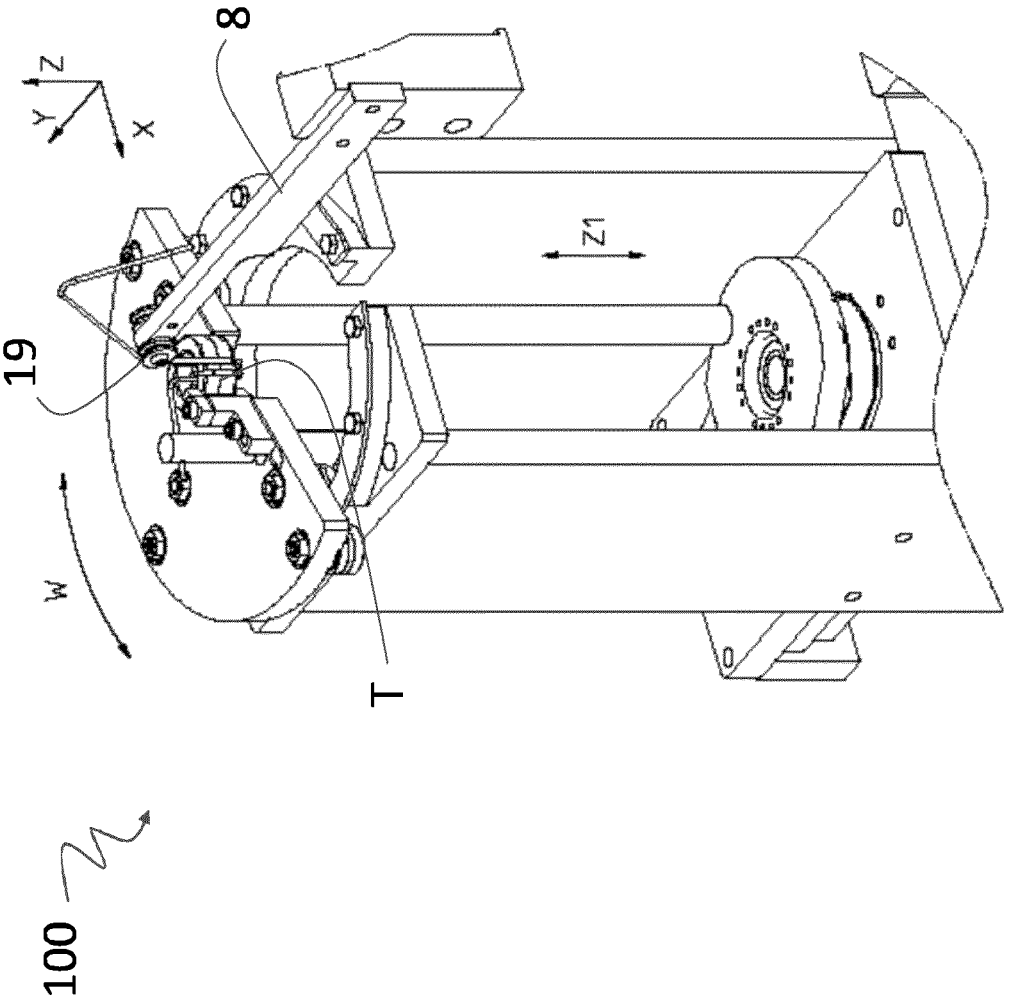

FIG. 11

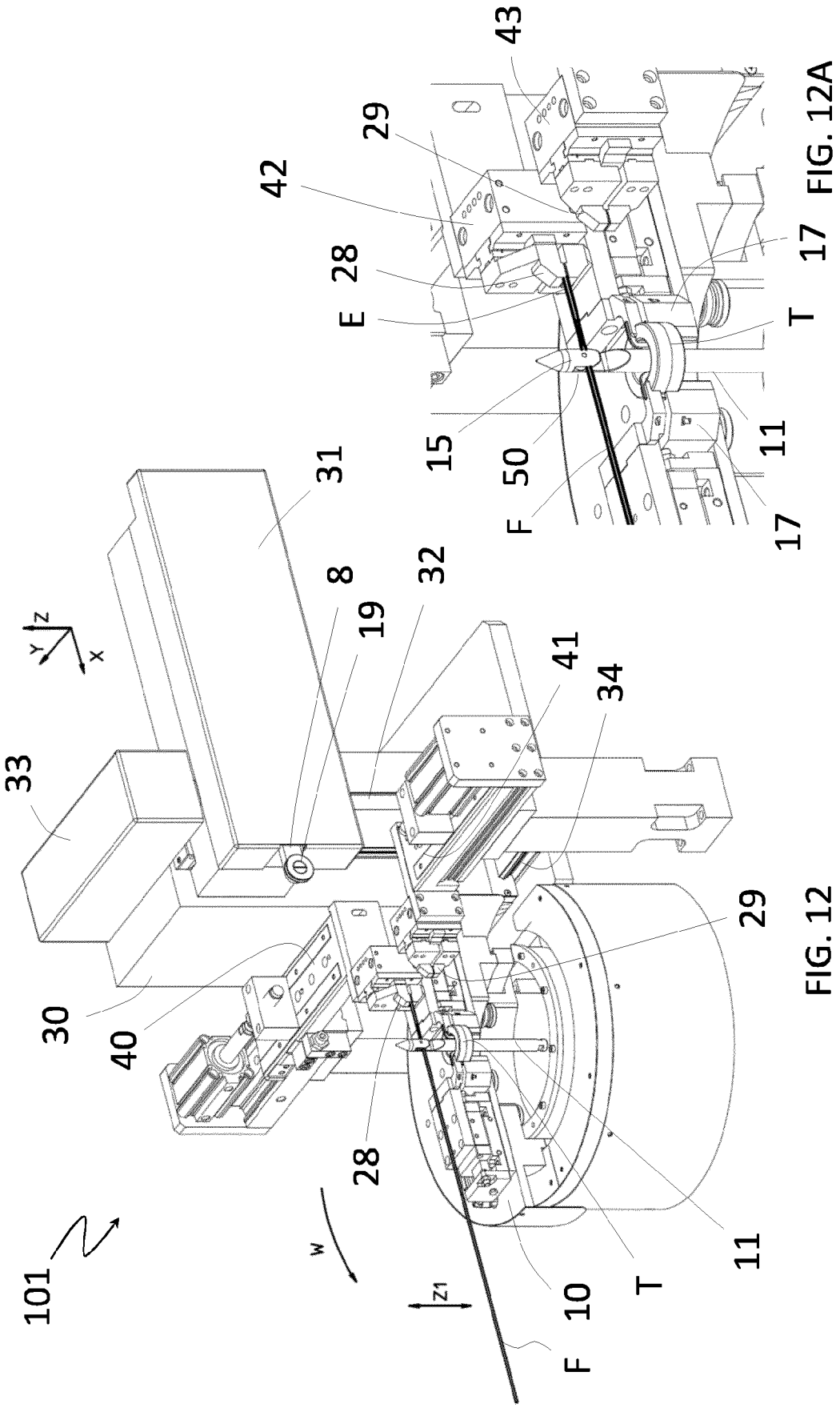

FIG. 12

FIG. 12A

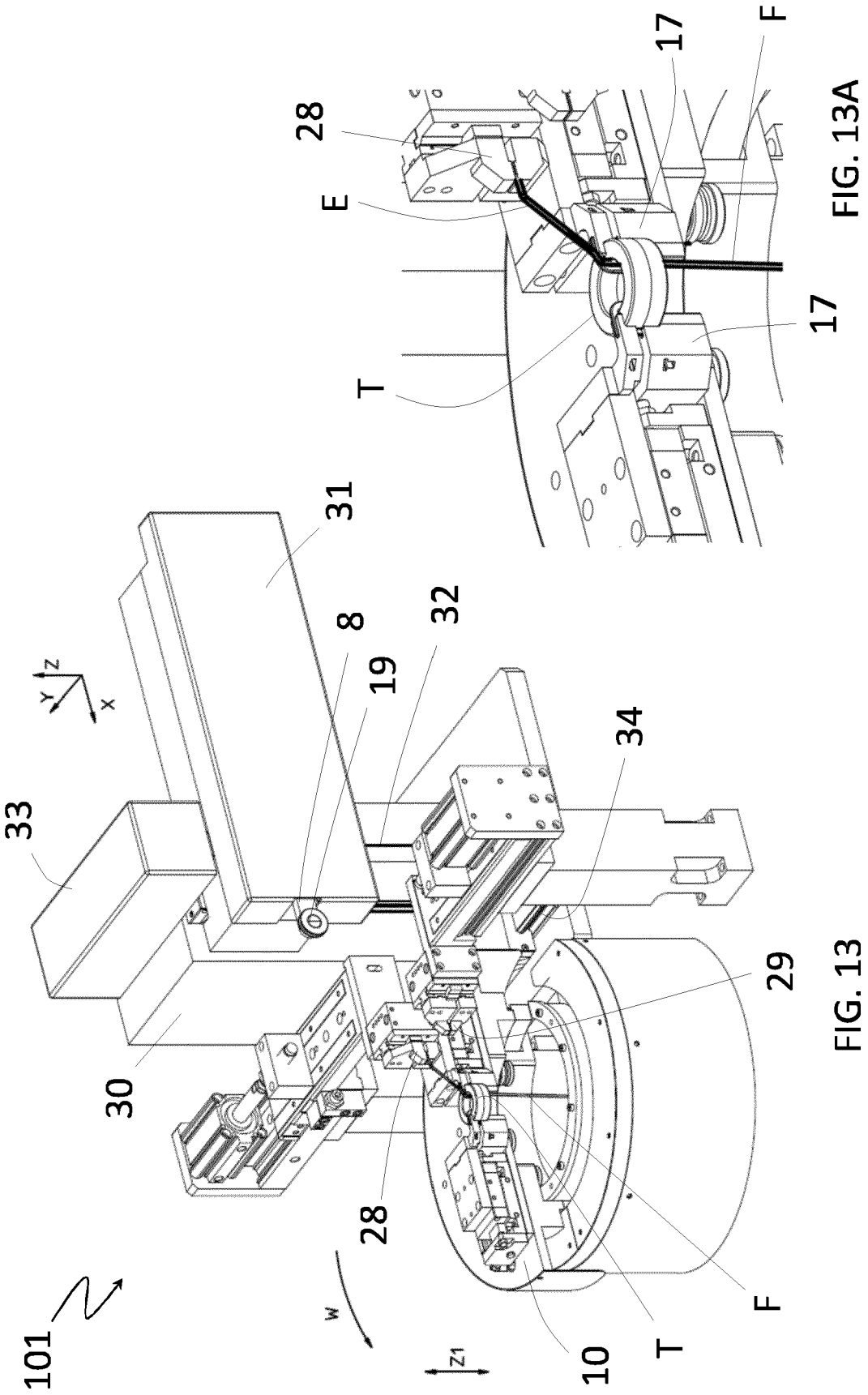

FIG. 13

FIG. 13A

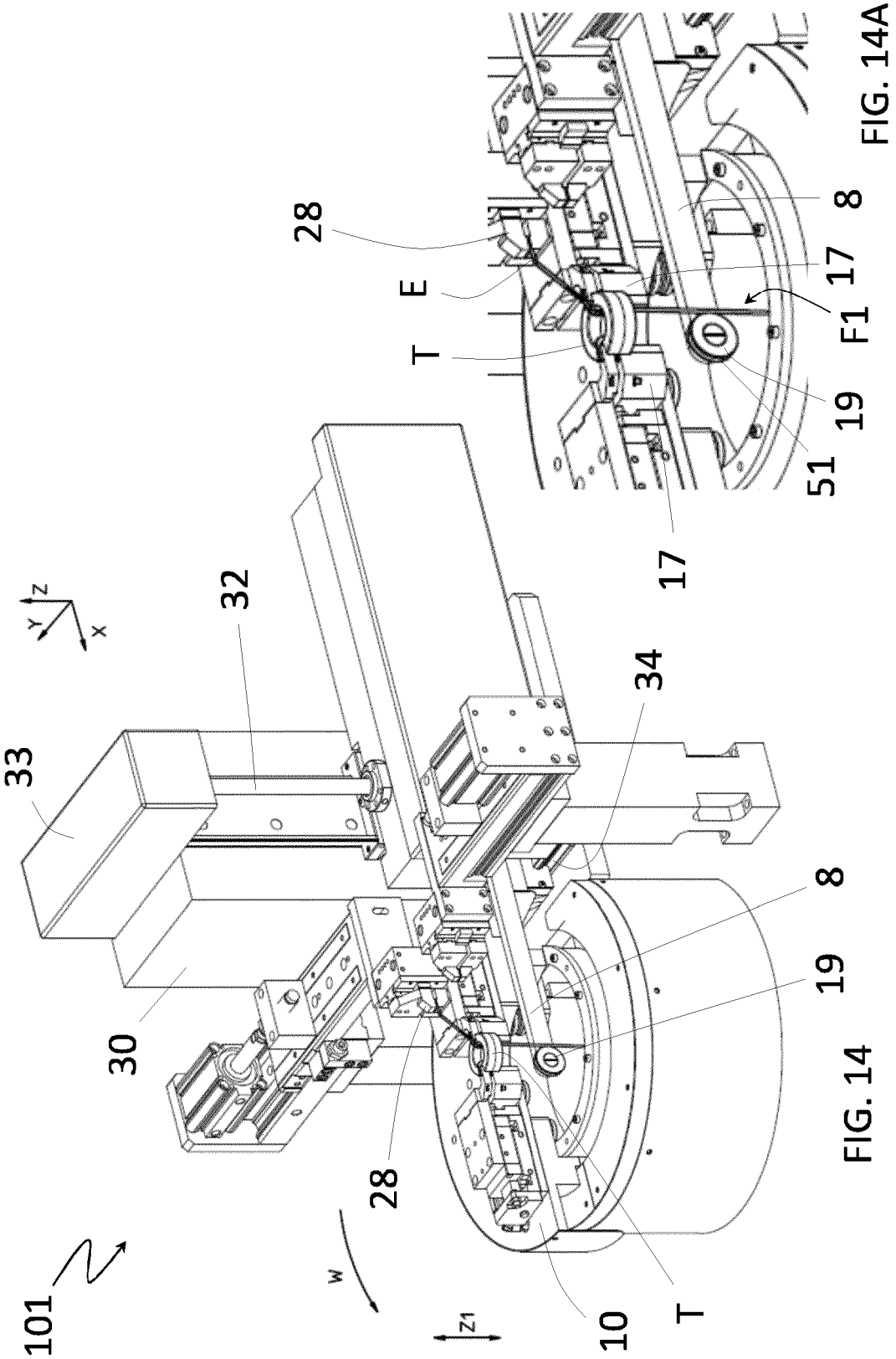

FIG. 14

FIG. 14A

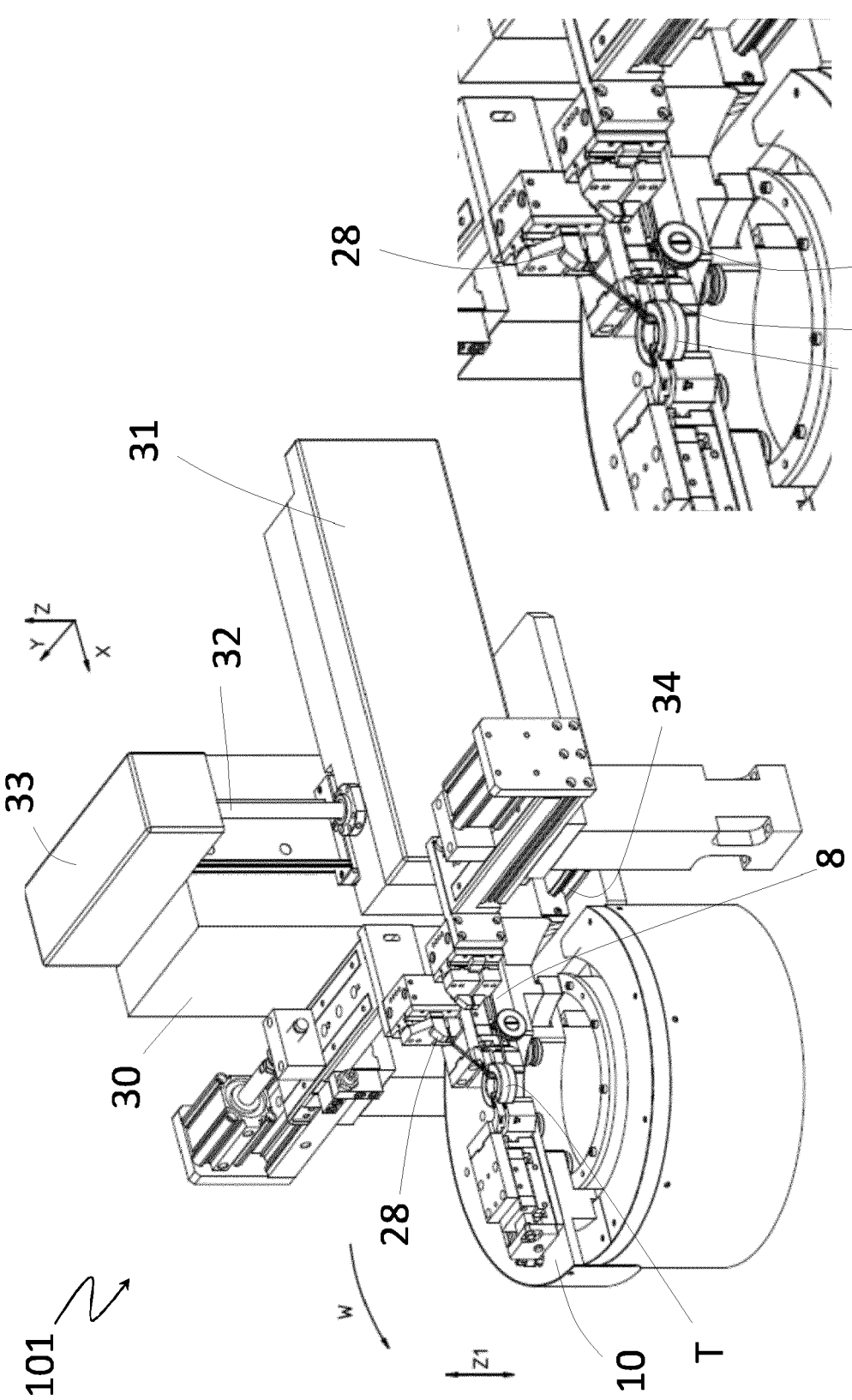

FIG. 15

FIG. 15A

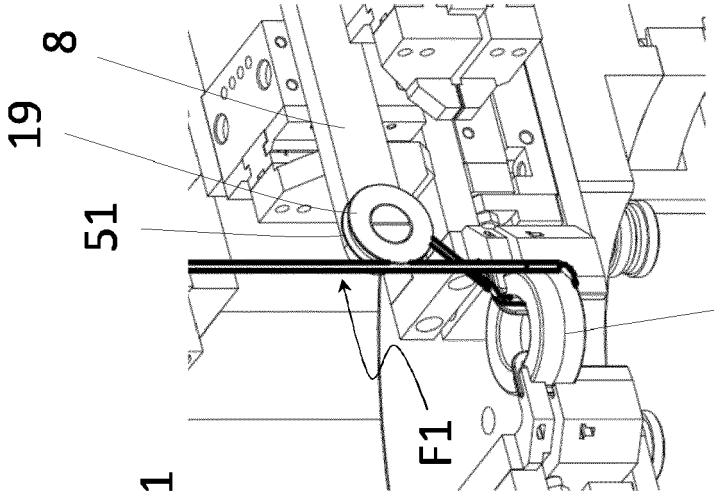

FIG. 16A

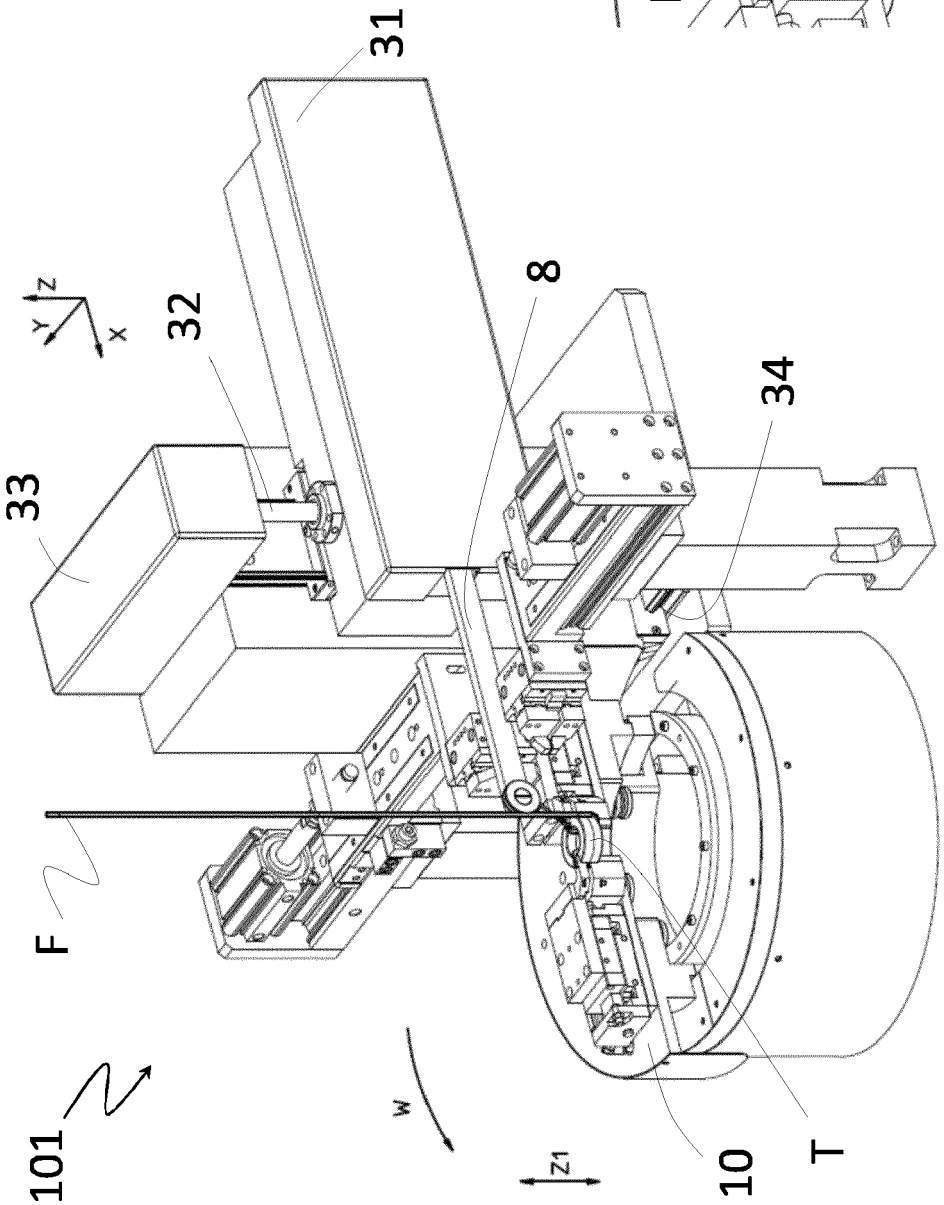

FIG. 16

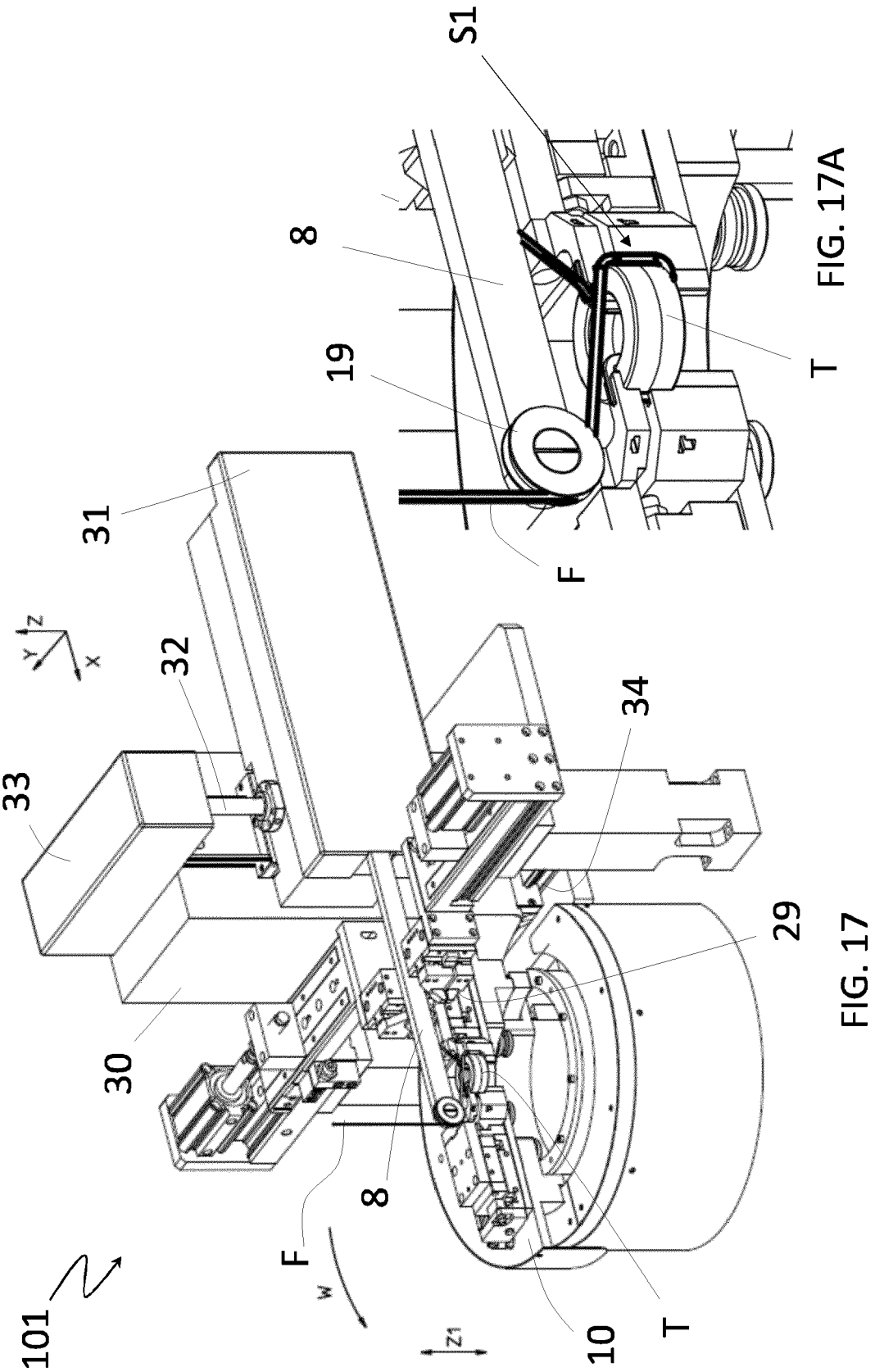

FIG. 17A

FIG. 17

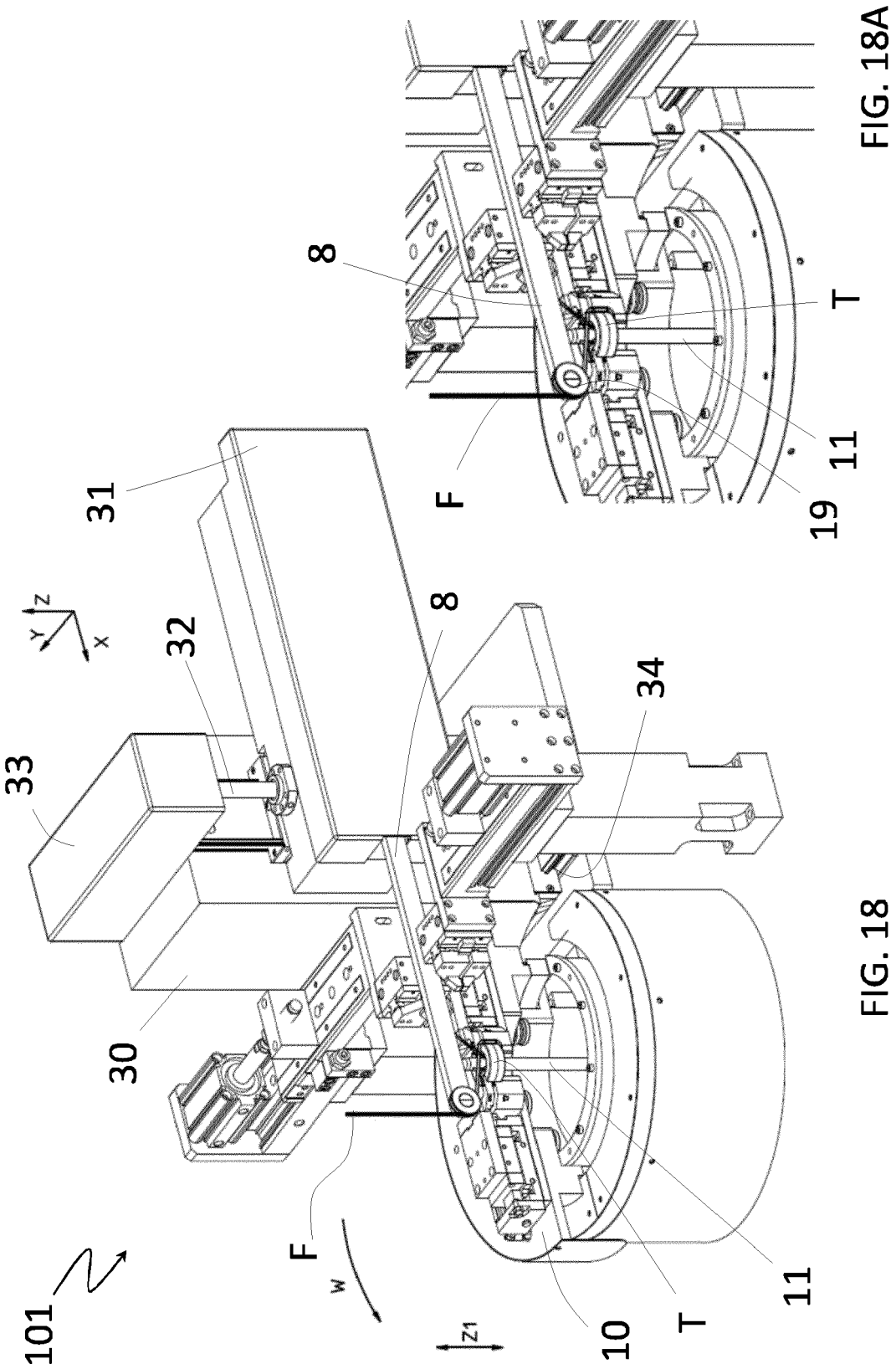

FIG. 18

FIG. 18A

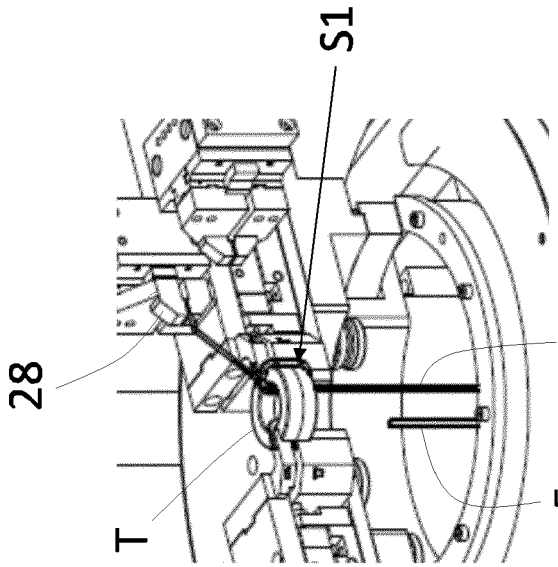

FIG. 19A

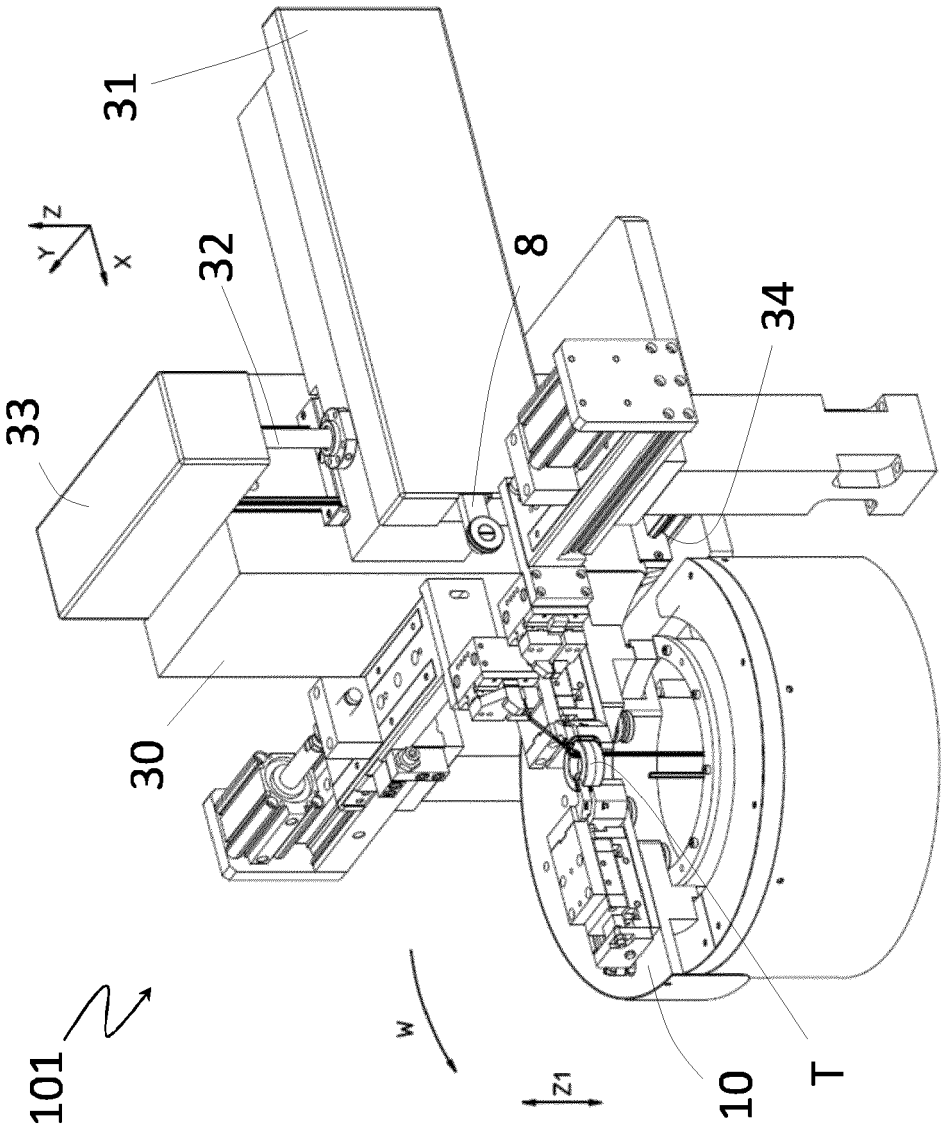

FIG. 19

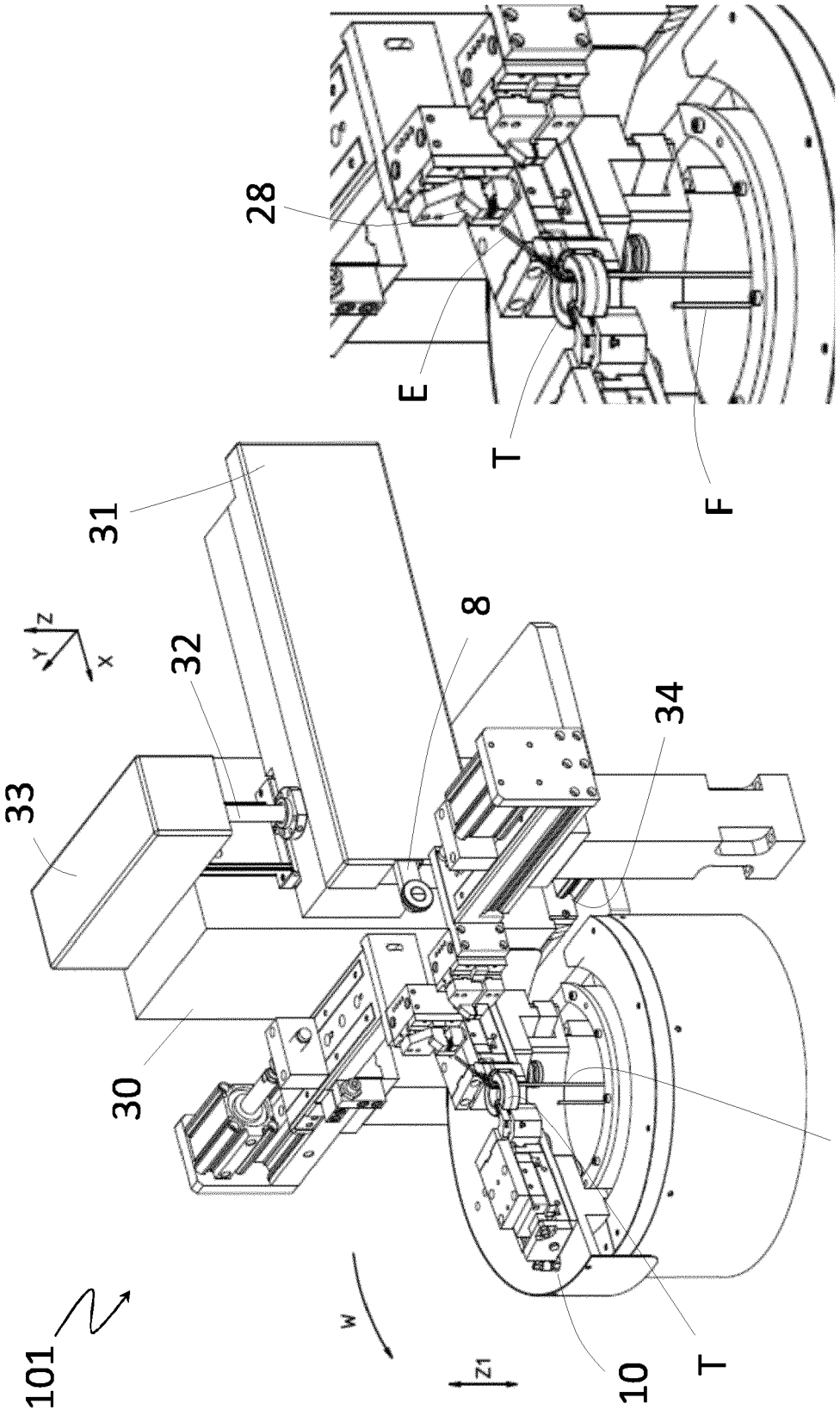

FIG. 20A

FIG. 20

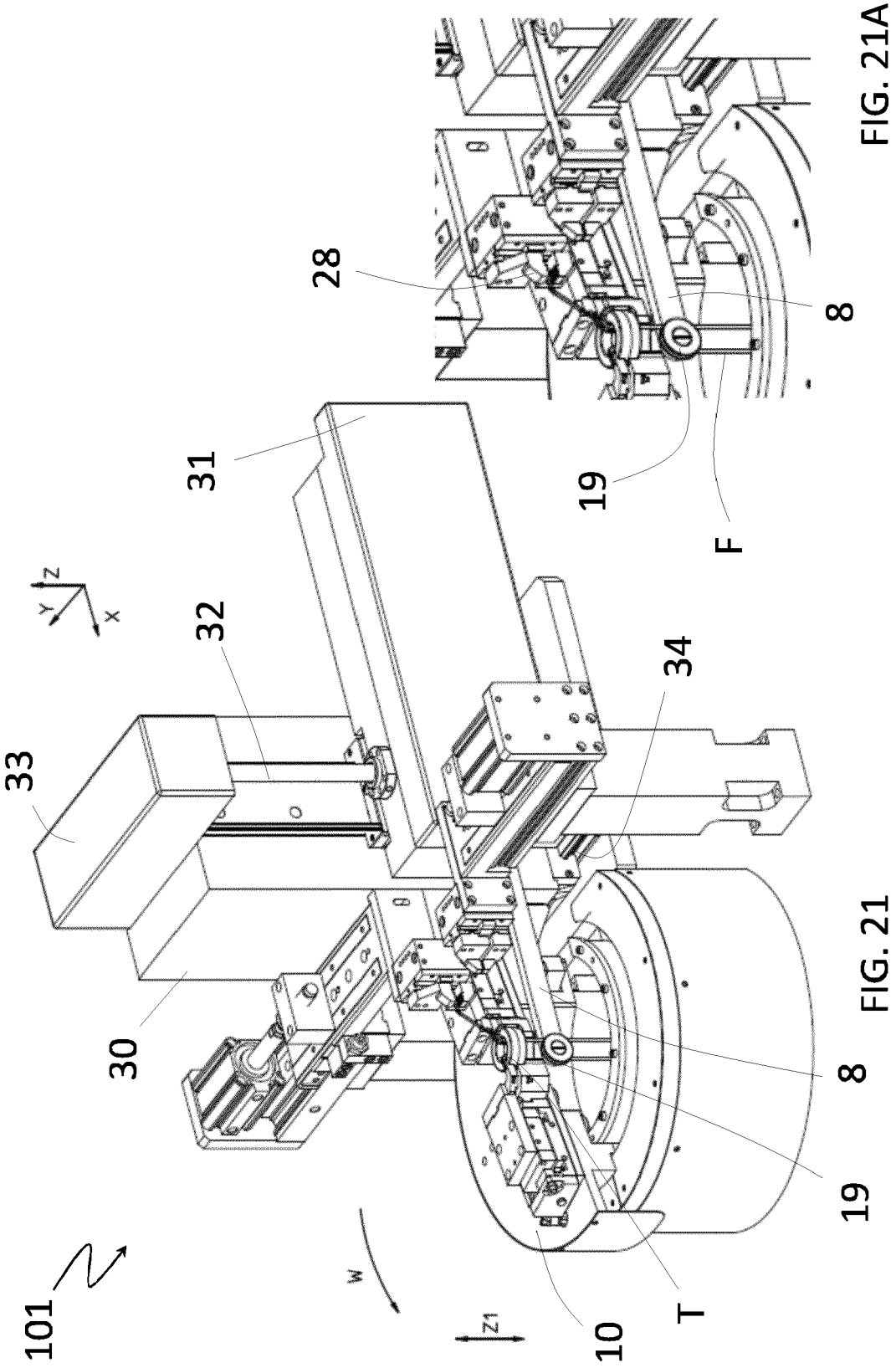

FIG. 21

FIG. 21A

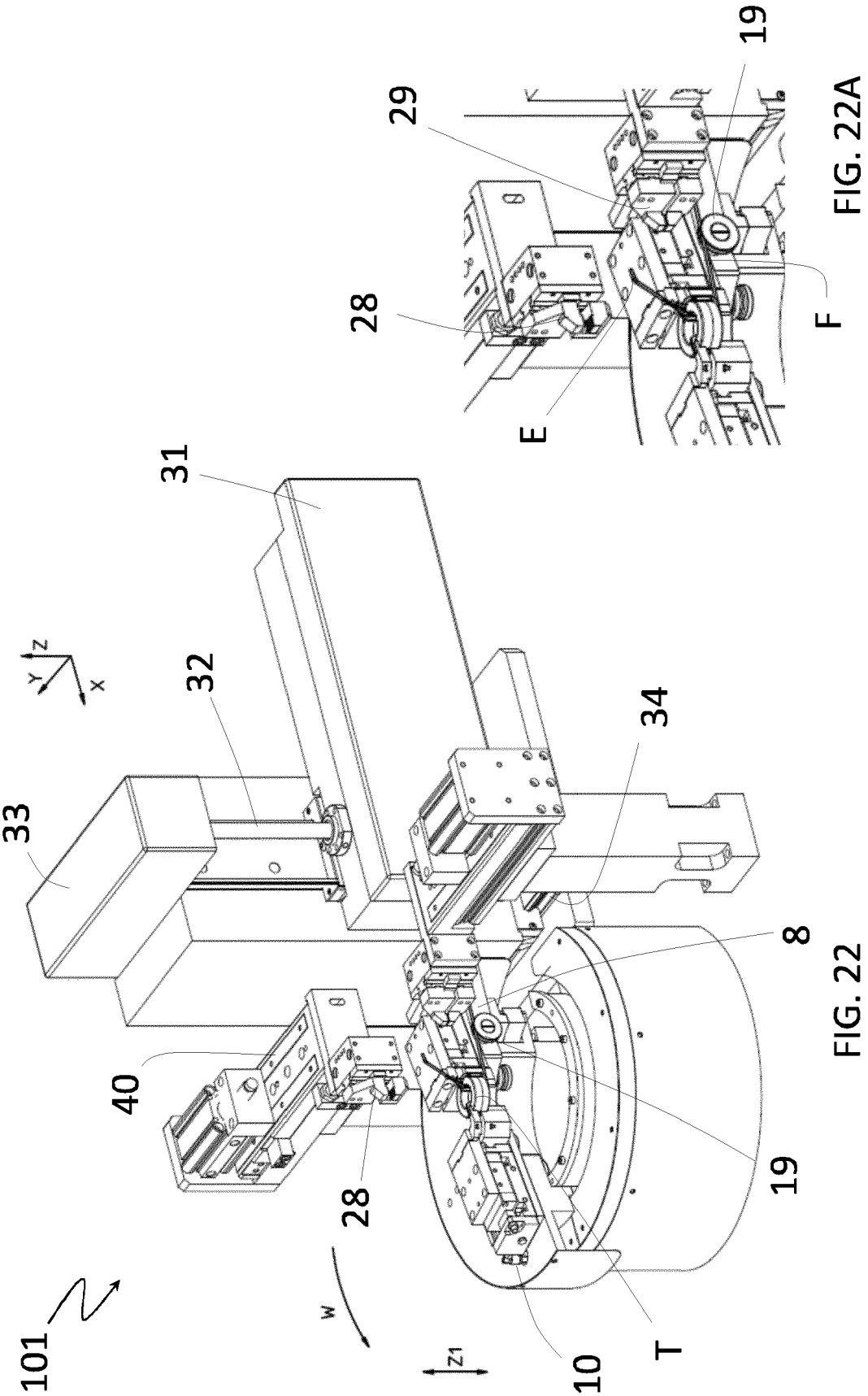

FIG. 22

FIG. 22A

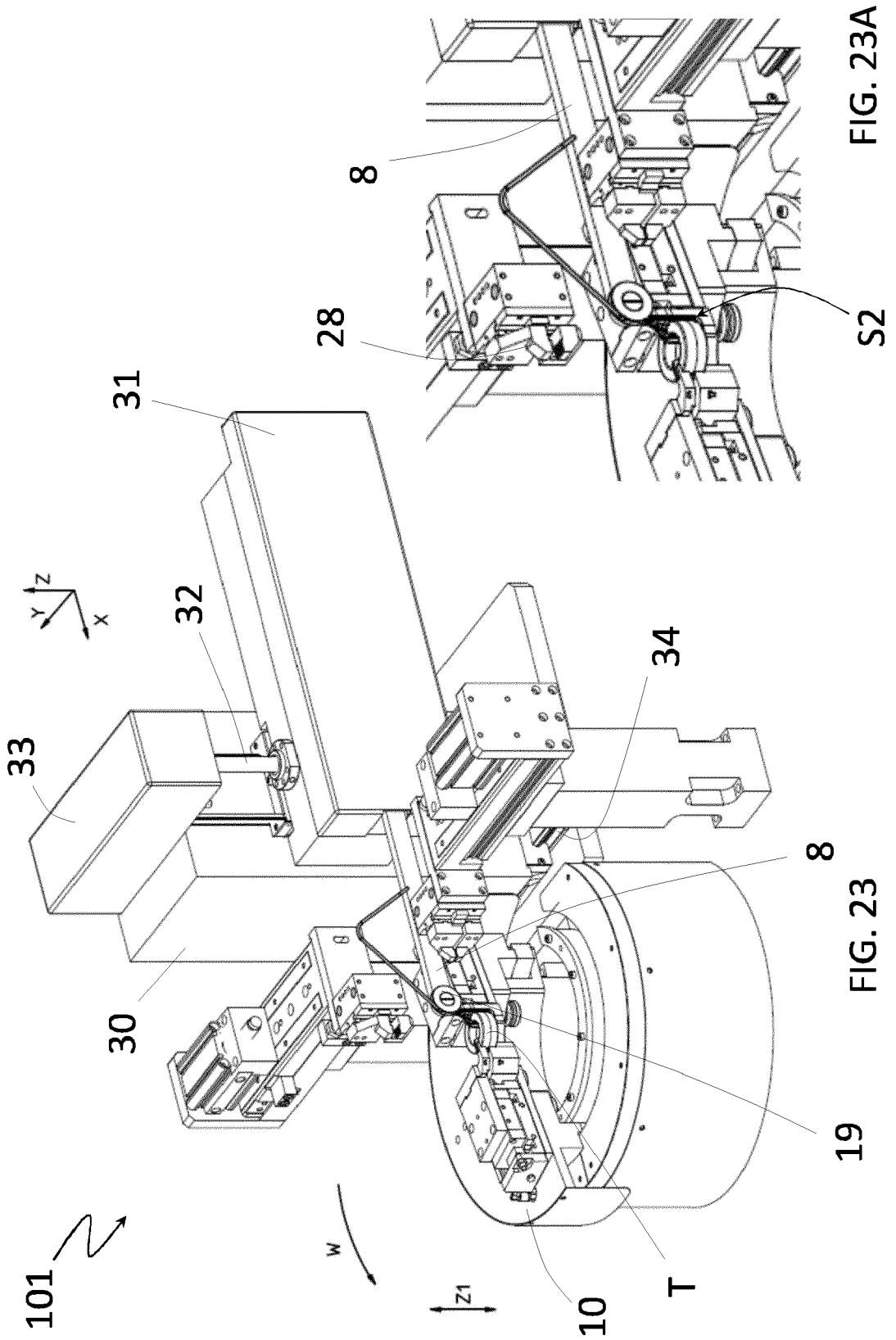

FIG. 23

FIG. 23A

REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- CN 213935949 U **[0007]**
- CN 107424839 A **[0007]**