(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
10 August 2017 (10.08.2017)

WIPO | PCT

(10) International Publication Number
WO 2017/133766 A1

(51) International Patent Classification:
B21F 3/06 (2006.01) *B21F 3/02* (2006.01)
B21F 35/00 (2006.01)

(21) International Application Number:
PCT/EP2016/052259

(22) International Filing Date:
3 February 2016 (03.02.2016)

(25) Filing Language: English

(26) Publication Language: English

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(81) Designated States *(unless otherwise indicated, for every kind of national protection available)*: AE, AG, AL, AM, AO, AT, AU, AZ, BA, BB, BG, BH, BN, BR, BW, BY, BZ, CA, CH, CL, CN, CO, CR, CU, CZ, DE, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IR, IS, JP, KE, KG, KN, KP, KR, KZ, LA, LC, LK, LR, LS, LU, LY, MA, MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PA, PE, PG, PH, PL, PT, QA, RO, RS, RU, RW, SA, SC, SD, SE, SG, SK, SL, SM, ST, SV, SY, TH, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW.

(84) Designated States *(unless otherwise indicated, for every kind of regional protection available)*: ARIPO (BW, GH, GM, KE, LR, LS, MW, MZ, NA, RW, SD, SL, ST, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, RU, TJ, TM), European (AL, AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, MK, MT, NL, NO, PL, PT, RO, RS, SE, SI, SK, SM, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, KM, ML, MR, NE, SN, TD, TG).

Published:
— *with international search report (Art. 21(3))*

(54) **Title**: COIL SPRING WINDING APPARATUS AND METHOD OF WINDING A COIL SPRING

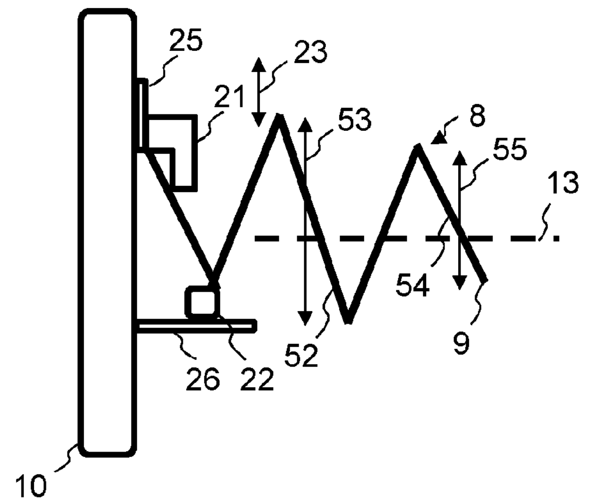

FIG. 8

(57) Abstract: A coil spring winding apparatus (1) comprises a stator and a rotor (10) which is supported on the stator so as to be rotatable about a rotation axis (13). The rotation axis (13) extends along a spring axis of a coil spring wound by the coil spring winding apparatus. At least one winding tool (21, 22) is supported on the rotor (10) so as to rotate about the rotation axis (13) of the rotor (10) upon rotation of the rotor (10). The at least one winding tool (21, 22) is configured to bend a wire (8) to form the coil spring upon rotation of the rotor (10). The at least one winding tool (21, 22) is adjustable relative to the rotor (10).

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Coil spring winding apparatus and method of winding a coil spring

TECHNICAL FIELD

Embodiments of the invention relate to an apparatus and a method of winding a coil spring. Embodiments of the invention relate in particular to an apparatus and a method of winding a coil spring in which a rotor on which one or several winding tools are supported is mounted to be rotatable about a rotation axis of the spring.

BACKGROUND

Mattresses, sofas or other bedding or seating furniture may be provided with innerspring units. Innerspring units may be formed from springs. Machines for forming innerspring units may be provided with a coil spring winding apparatus which is operative to wind a coil spring. Frequently, a plurality of springs having a height that is matched to a height of the innerspring unit are joined to each other to form an innerspring unit. In other cases, an endless coil spring may be processed further, such as by bending, to produce an innerspring unit from the endless coil spring.

Coil spring winding apparatuses may have various configurations. For illustration, some coil spring winding apparatuses may have a rotating mandrel, with the coil spring being wound around an outer surface of the mandrel. Coil spring winding apparatuses of this and many other kinds output a coil spring which rotates about its spring axis while it is being wound. This may prevent such coil spring winding apparatuses from being used in association with some types of machines for forming innerspring units, e.g. machines which are constructed to receive a coil spring which is advanced in a translatory manner for forming the innerspring unit.

Coil spring winding apparatuses which provide a rotor rotating about rotation axis and having a winding tool mounted can be operated in such a manner that they output a coil spring which is advanced in a translatory manner along its spring axis. However, the types of springs which may be produced by such coil spring winding apparatuses may be more limited.

SUMMARY

There is a continued need in the art for a coil spring winding apparatus and a method of winding a coil spring which address at least some of the above needs. There is a continued need in the art for a coil spring winding apparatus and a method of winding a coil spring which can be operated in such a manner that rotation of the wound coil spring, when it is output by the apparatus, about its spring axis may be reduced or eliminated, while allowing springs of different shapes to be produced.

According to embodiments, one or several winding tools are supported on a rotor which is rotatable about a rotation axis, the one or several winding tools being supported on the rotor so as to rotate about the rotation axis about rotation of the rotor, while accommodating an adjustment of the one or several winding tools relative to the rotor. Such a configuration allows the rotor to rotate about the spring axis of the spring that is being formed, so that the spring is advanced from the rotor in a translatory manner. Adjustment of the one or several winding tools relative to the rotor allows variations in spring shape to be implemented, e.g. by producing springs having conical shapes, barrel shapes or hourglass shapes.

A coil spring winding apparatus according to an embodiment comprises a stator and a rotor. The rotor is supported on the stator so as to be rotatable about a rotation axis. The rotation axis may extend along a spring axis of a coil spring wound by the coil spring winding apparatus. At least one winding tool is supported on the rotor to rotate about the rotation axis of the rotor upon rotation of the rotor. The at least one winding tool is configured to bend a wire to form the coil spring upon rotation of the rotor. The at least one winding tool being adjustable relative to the rotor.

A coil spring winding apparatus having such a configuration allows the rotor to rotate about the spring axis of the spring that is being formed, so that the spring is advanced from the rotor in a translatory manner. Adjustment of the one or several winding tools relative to the rotor allows variations in spring shape to be implemented.

The coil spring winding apparatus may be configured to output an endless coil spring.

The coil spring winding apparatus may be configured to output the wound coil spring in such a manner that the wound coil spring, while still being coupled to the rotor, does not rotate about the spring axis.

The coil spring winding apparatus may be configured to output the wound coil spring in such a manner that the wound coil spring, while still being coupled to the rotor, is advanced along the rotation axis of the rotor in a translatory manner.

A pitch and/or a diameter of a turn of the coil spring is adjustable by adjusting the at least one winding tool relative to the rotor. Coil springs having different variations in pitch and/or diameter along the spring axis may be produced by adjustment of the at least one winding tool relative to the rotor.

A wire guide configured to guide the wire may be mounted on the rotor so as to rotate about the rotation axis upon rotation of the rotor. The guide may define a recess configured to guide the wire, so that abutment of the wire on the at least one winding tool causes the wire to bend.

The at least one winding tool may comprise a first winding tool configured to bend the wire so as to set a diameter of a turn of the coil spring. The first winding tool may be a bending tool which bends the wire in a radial direction of the coil spring. The first winding tool may be configured to bend the wire in a plane which extends transverse to the rotation axis of the rotor.

The first winding tool may be supported on the rotor so as to be displaceable relative to the rotor in a direction transverse to the rotation axis. The first winding tool may be supported on the rotor so as to be pivotable relative to the rotor about a pivot axis which extends parallel to the rotation axis.

The at least one winding tool may additionally or alternatively comprise a second winding tool configured to bend the wire so as to set a diameter of a turn of the coil spring. The position of the second winding tool relative to a wire guide may influence both the diameter and the pitch of the turns of the coil spring. The second winding tool may be a deflecting tool which bends the wire in an axial direction of the coil spring. The second winding tool may be configured to bend the wire in a direction along the rotation axis of the rotor.

The second winding tool may be supported on the rotor so as to be displaceable in a direction parallel to the rotation axis of the rotor.

The wire may extend from the wire guide to the first winding tool and then on to the second winding tool. The arrangement of the first winding tool and the second winding tool relative to the wire guide may define the diameter and pitch of turns of the coil spring which are formed by the coil spring winding apparatus.

The coil spring winding apparatus may comprise a first adjustment mechanism configured to adjust a position or an orientation of a first winding tool of the at least one winding tool relative to the rotor. This allows the first winding tool to be automatically adjusted relative to the rotor, in accordance with a desired shape of the coil spring.

The first adjustment mechanism may comprise a first motor mounted on the stator. Balancing of the rotor may thereby be simplified.

The first adjustment mechanism may comprise a first slider. The first motor being configured to effect a displacement of the first slider in a direction parallel to the rotation axis of the rotor to adjust the first winding tool relative to the rotor.

The first adjustment mechanism may comprise a motion conversion mechanism configured to convert the displacement of the first slider parallel to the rotation axis into a motion of the first winding tool transverse to the rotation axis.

The motion conversion mechanism may comprise a wedge member supported on the rotor so as to be displaceable relative to the rotor in a translatory manner in a direction parallel to the rotation axis.

The first slider may comprise an annular abutment surface abutting on an end of the wedge member to displace the wedge member, which rotates about the rotation axis jointly with the rotor, in a direction parallel to the rotation axis.

The motion conversion mechanism may comprise a bevel surface in abutting engagement with the wedge member. The bevel surface may be provided on a member which is pivotably mounted on the rotor and which comprises or otherwise supports the first winding tool.

The coil spring winding apparatus may comprise a second adjustment mechanism configured to adjust at least one of a position or an orientation of a second winding tool of the at least one winding tool relative to the rotor. This allows the second winding tool to be automatically adjusted relative to the rotor, in accordance with a desired shape of the coil spring.

The second adjustment mechanism may comprise a hollow member which is attached to the rotor so as to rotate about the rotation axis upon rotation of the rotor. The hollow member may be a hollow tube. The second winding tool may be mounted to the hollow member.

The hollow member may be positioned such that the wound coil spring extends through the hollow member. The hollow member may be positioned such that the wound coil spring projects from the hollow member.

The second adjustment mechanism may comprise a second motor and a second slider. The second motor may be configured to displace the second slider in a direction parallel to the rotation axis.

The second motor may be mounted on the stator.

The second slider may abuttingly support the hollow member so as to allow the hollow member to rotate jointly with the rotor, while displacing the hollow member parallel to the rotation axis by displacement of the second slider. The second slider may comprise rollers engaged with a face of the hollow member.

The first motor and/or the second motor may respectively be a stepper motor.

The first adjustment mechanism may be configured to adjust the first winding tool relative to the rotor in a direction transverse to the rotation axis.

The second adjustment mechanism may be configured to adjust the second winding tool relative to the rotor in a direction parallel to the rotation axis.

The coil spring winding apparatus may comprise a control device configured to control an adjustment of the at least one winding tool relative to the rotor.

The control device may be coupled to the first adjustment mechanism and the second adjustment mechanism. The control device may be configured to actuate the first adjustment mechanism and/or the second adjustment mechanism only when at least one of a diameter or a pitch of turns of the coil spring is to be changed.

The control device may be configured to control the adjustment of the at least one winding tool relative to the rotor to effect a variation in pitch and/or diameter along the spring axis. This allows complex spring shapes, e.g. of different sections of an endless coil spring, to be implemented in an automated procedure.

The control device may be configured to control a feed of the wire as a function of the variation in pitch and/or diameter in a time-dependent manner. The control device may be configured to set a distance by which the wire is fed to the first and second winding tools per rotation of the rotor as a function of the variation in pitch and/or diameter in a time-dependent manner.

The control device may be configured to compute the distance by which the wire is fed to the first and second winding tools per rotation of the rotor such that it is equal to a length of the wire in the turn which is being wound in the rotation of the rotor, the length being dependent on the pitch and diameter of the turn.

The control device may be configured to compute the feed of the wire as a function of the variation in pitch and/or diameter such that the spring wound by the coil spring winding apparatus is displaced in a translatory manner.

The coil spring winding apparatus may comprise a wire feed device supported on the rotor so as to rotate about the rotation axis upon rotation of the rotor. The wire may be fed by the rotating wire feed device to the rotating first and second winding tools.

The wire feed device may comprises a feed pulley and a plurality of compression rollers configured to urge the wire in abutment with the feed pulley. Reliable control over wire feed may be attained thereby.

The coil spring winding apparatus may comprise a wire feed device drive mechanism comprising a wire feed motor mounted to the stator and a transmission coupled in between the wire feed motor and the feed pulley.

The wire feed device drive mechanism may comprise a first gear driven by the wire feed motor and rotatably mounted on the stator. A sun gear may be coupled to the first gear in a torque-proof manner. The sun gear may be coupled to a revolving gear which revolves around the sun gear. The revolving gear may be coupled to the feed pulley in a torque-proof manner.

According to an embodiment, a machine for producing an innerspring unit is provided. The machine comprises a coil spring winding apparatus according to an embodiment and an innerspring unit assembling device, which is configured to receive an endless coil spring from the coil spring winding apparatus and to produce an innerspring unit from a section of the endless coil spring.

According to an embodiment, a method of winding a coil spring from a wire using a coil spring winding apparatus is provided. The coil spring winding apparatus comprises a rotor. At least one winding tool is supported on the rotor so as to be rotatable about a rotation axis upon rotation of the rotor. The method comprises feeding a wire to the at least one winding tool while the rotor rotates, wherein the at least one winding tool bends the wire to form the coil spring. The method comprises adjusting the at least one winding tool relative to the rotor to control a pitch and/or a diameter of the coil spring.

The method may be performed using the coil spring winding apparatus according to an embodiment.

A coil spring winding apparatus according to an embodiment comprises a stator and a rotor. The rotor is supported on the stator so as to be rotatable about a rotation axis. The rotation axis may extend along a spring axis of a coil spring wound by the coil spring winding apparatus. The coil spring winding apparatus may comprise a wire feed device supported on the rotor so as to rotate about the rotation axis upon rotation of the rotor.

The wire feed device may comprises a feed pulley and a compression mechanism configured to urge the wire in abutment with the feed pulley. Reliable control over wire feed may be attained thereby.

The coil spring winding apparatus may comprise a wire feed device drive mechanism comprising a wire feed motor mounted to the stator and a transmission coupled in between the wire feed motor and the feed pulley.

A coil spring winding apparatus and a method according to embodiments may be used to produce an endless coil spring, without being limited thereto. A coil spring winding apparatus and a method according to embodiments are operable so as to output a spring which, even when it is still connected to the rotor, does not rotate about its spring axis, which may be beneficial for the further processing of the coil spring into an innerspring unit. A coil spring winding apparatus and a method according to embodiments allow springs having different spring shapes to be wound, without requiring a replacement of parts of the coil spring winding apparatus.

BRIEF DESCRIPTION OF THE DRAWINGS

Embodiments of the invention will be described in detail with reference to the drawings in which like reference numerals designate like elements.

FIG. 1 shows a schematic front view of a coil spring winding apparatus according to an embodiment.

FIG. 2 shows an enlarged partial front view of the coil spring winding apparatus of FIG. 1.

FIG. 3 shows a side view of a coil spring winding apparatus according to an embodiment.

FIG. 4 shows a side view of a coil spring winding apparatus according to an embodiment.

FIG. 5 shows a side view of the coil spring winding apparatus of FIG. 1 during operation.

FIG. 6 shows a side view of the coil spring winding apparatus of FIG. 1 during operation.

FIG. 7 shows a side view of the coil spring winding apparatus of FIG. 1 during operation.

FIG. 8 shows a side view of the coil spring winding apparatus of FIG. 1 during operation.

FIG. 9 shows a side view of the coil spring winding apparatus of FIG. 1 during operation.

FIG. 10 shows a schematic front view of a coil spring winding apparatus according to an embodiment.

FIG. 11 shows a partial perspective view of a coil spring winding apparatus according to an embodiment.

FIG. 12 shows a schematic side view of a coil spring winding apparatus according to an embodiment.

FIG. 13 shows a perspective view of a coil spring winding apparatus according to an embodiment.

FIG. 14 shows a perspective detail view of the coil spring winding apparatus of FIG. 13.

FIG. 15 shows a perspective detail view of the coil spring winding apparatus of FIG. 13.

FIG. 16 shows a side view of the coil spring winding apparatus of FIG. 13.

FIG. 17 shows a perspective detail view of a rotor of a coil spring winding apparatus according to an embodiment.

FIG. 18 shows a perspective view of a rotor drive mechanism of a coil spring winding apparatus according to an embodiment.

FIG. 19 shows a perspective view of an adjustment mechanism configured to adjust a winding tool supported on a rotor of a coil spring winding apparatus according to an embodiment.

FIG. 20 shows a perspective view of an adjustment mechanism configured to adjust a winding tool supported on a rotor of a coil spring winding apparatus according to an embodiment.

FIG. 21 shows a front view of components of an adjustment mechanism configured to adjust a winding tool supported on a rotor of a coil spring winding apparatus according to an embodiment.

FIG. 22 shows a cross-sectional view along lines XXII-XXII of FIG. 21.

FIG. 23 shows a perspective view of a feed device drive mechanism of a coil spring winding apparatus according to an embodiment.

FIG. 24 is a flow chart of a method according to an embodiment.

FIG. 25 is a flow chart of a method according to an embodiment.

DESCRIPTION OF EMBODIMENTS

Embodiments of the invention will be described with reference to the drawings in which like reference numerals designate like elements.

While embodiments of the invention will be described in the context of specific applications of a coil spring winding apparatus, it will be appreciated that the embodiments are not limited thereto. For illustration, while some embodiments will be described in the context of a coil spring winding apparatus which is operative to output an endless coil spring, the configuration of the coil spring winding apparatus according to embodiments is not limited thereto, and the coil spring winding apparatus may alternatively or additionally be used for producing coil springs having a finite height. For further illustration, while some embodiments will be described in the context of a coil spring winding apparatus which is operative to output a coil spring which, even when it is still coupled to a rotor of the a coil spring winding apparatus, does not rotate about its spring axis, the configuration of the coil spring winding apparatus according to embodiments is not limited thereto.

FIG. 1 illustrates a coil spring winding apparatus 1 according to an embodiment. FIG. 2 shows an enlarged front view of the coil spring winding apparatus 1 of FIG. 1, with a viewing direction along a rotation axis of a rotor. FIG. 3 shows an enlarged side view of the coil spring winding apparatus 1 of FIG. 1, with a viewing direction transverse to the rotation axis of the rotor.

The coil spring winding apparatus 1 comprises a stator 2 and a rotor 10 rotatably supported by the stator 2. As will be explained in more detail, the rotor 10 is rotatable about a rotation axis 13. The rotation axis 13 coincides with or extends parallel to a spring axis of a coil spring which is wound by the coil spring winding apparatus 1.

In operation, the rotor 10 may rotate about the coil spring which it produces, advancing the coil spring in a translatory manner from the rotor 10 along the rotation axis of the rotor. The rotor 10 may comprise an outer circumference 11 which may be circular and which is supported on a support 5 of the stator 2. The support 5 may comprise a suitable bearing for rotatably supporting the rotor 10. The rotor may comprise a central opening 12 positioned along its rotation axis 13. The central opening may allow a wire 8 to be supplied to one or several winding tools 21, 22 which are supported on the rotor 10.

The wire 8 may be supplied to the rotor 10 along a direction along the rotation axis 13 of the rotor 10. The wire 8 may be drawn towards the rotor 10 by a feed device which may be supported on the rotor 10, as will be explained in more detail.

At least one winding tool 21, 22 may be supported on the rotor 10. The at least one winding tool 21, 22 may be supported on the rotor 10 so as to rotate with the rotor 10 around the rotation axis 13 upon rotation of the rotor 10. One or several of the winding tools 21, 22 may be supported on the rotor 10 so as to be adjustable relative to the rotor 10 in a translatory and/or pivoting manner, for example.

The one or several winding tools 21, 22 may have different configurations. For illustration, the winding tools 21, 22 may comprise a first winding tool 21 which may act as a bending tool that bends a wire 8 exiting a wire guide 14 mounted on the rotor 10. The wire guide 14 may define a passage 15 for the wire 8.

The winding tools 21, 22 may comprise a second winding tool 22 which may act as a deflecting tool that deflects the wire 8 from the plane defined by the wire guide 14 and the first winding tool 21. The second winding tool 22 may be configured to bend the wire 8 in a direction which corresponds to the axial direction of the coil spring by deflecting the wire 8 away from the rotor 10, thereby setting the pitch of turns of the coil spring. The position of the second winding tool 22 relative to the wire guide 14 may also influence the diameter of the turns of the coil spring. The second winding tool 22 may be configured to perform a bending operation which deflects the wire 8 in a direction along the rotation axis 13, to thereby form an pitch the coil spring. The second winding tool 22 may be offset from the first winding tool 21 in a direction parallel to the rotation axis 13 of the rotor 10.

The relative positions of the wire guide 14, the first winding tool 21 and the second winding tool 22 define the geometry, in particular the diameter and pitch, of turns of the coil spring which are wound by the coil spring winding apparatus 1. In operation of the coil spring winding apparatus 1, the wire guide 14, the first winding tool 21 and the second winding tool 22 abuttingly engage the wire 8 to bend it parallel to the plane of the rotor 10 and along the rotation axis 13 of the rotor 10, thereby defining the diameter and pitch of a turn of the coil spring.

As will be explained in more detail below, the coil spring winding apparatus 1 is configured such that the coil spring which is wound by the coil spring winding apparatus 1 is pushed out in a translatory manner along the rotation axis 13 of the rotor. The coil spring winding apparatus 1 is operable to provide a coil spring which, even when it is still being wound and is still being coupled to the rotor 10, does not rotate about its spring axis.

The coil spring winding apparatus 1 is configured such that a diameter and/or pitch of the wound coil spring may be varied, e.g. between turns of a coil spring or from one coil spring to another. The coil spring winding apparatus 1 may be configured to control a position of the first winding tool 21 relative to the rotor 10 so that a first diameter of a first turn of a coil spring is different from a second diameter of a second turn of the same coil spring. The coil spring winding apparatus 1 may be configured to control a position of the second winding tool 22 relative to the rotor 10 so that a first pitch of a first turn of a coil spring is different from a second pitch of a second turn of the same coil spring. The position of the second winding tool 22 relative to the rotor 10 and, in particular, relative to the wire guide 14 may also influence the diameter of the turns. Springs having a wide variety of different shapes, defined by a variation of diameter and/or pitch of turns of the coil spring, may thereby be formed without requiring operation of the coil spring winding apparatus 1 to be paused for exchanging components on the rotor 10.

The coil spring winding apparatus 1 may comprise a first adjustment mechanism configured to adjust a position of the first winding tool 21 relative to the rotor 10. The first adjustment mechanism may be configured to pivot the first winding tool 21 relative to the rotor 10 and/or to displace the first winding tool 21 relative to the rotor 10 while the rotor 10 rotates about its rotation axis. Variations in diameter between turns may thereby be effected without requiring the rotor 10 to be stopped.

The first winding tool 21 may be displaceable in a direction transverse to the rotation axis 13 of the rotor 10. The first winding tool 21 may be displaceable in a plane which is orthogonal to the rotation axis 13 of the rotor 10. A displacement 23 of the first winding tool in a direction transverse to the rotation axis 13 causes a change in diameter of turns of the wound coil spring.

The first winding tool 21 may be mounted to the rotor 10 via a first mount structure 25 which allows the first winding tool 21 to be displaced transverse to the rotation axis 13 relative to the rotor 10, while forcing the first winding tool 21 to rotate about the rotation axis 13 upon rotation of the rotor 10.

The first adjustment mechanism may be configured to maintain the first winding tool 21 in its position relative to the rotor 10 when the first adjustment mechanism is not actuated. For illustration, the first adjustment mechanism may comprise a first slider which is displaceable along the rotation axis 13 of the rotor 10 and which is configured to displace a wedge member in a direction parallel to the rotation axis 13. The wedge member may be supported on the rotor 10 such that it is forced to rotate about the rotation axis 13 jointly with the rotor. Engagement of the wedge member with a mating bevel surface may convert the displacement of the wedge member along the rotation axis into a displacement of the first winding tool 21 in a direction 23 which is transverse to the rotation axis 13 of the rotor 10.

The first adjustment mechanism may comprise a first motor 39. The first motor 39 may be mounted on the stator 2. The first motor 39 may be mounted on a base 3 or a superstructure 4 of the stator 2. This position of the first motor 39 facilitates establishing the required power connections and connections to a control device 20, while mitigating difficulties which would be associated with a motor positioned on the rotor 10.

The control device 20 may control the adjustment of the first winding tool 21 in accordance with data which defines the shape of the coil spring, so as to reposition the first winding tool 21 relative to the rotor 10 while the rotor 10 rotates.

The control device 20 may further be configured to control a rotor drive motor 19 which is operative to rotationally drive the rotor 10. The control device 20 may be configured to control the first motor 39 and the rotor drive motor 19 in a coordinated manner, so as to adjust the position of the first winding tool 21 relative to the rotor 10 in a time-dependent manner, which is a function of the rotation speed of the rotor 10.

The control device 20 may further be configured to control a second adjustment mechanism which is configured to adjust the second winding tool 22 relative to the rotor 10.

The second adjustment mechanism may be configured to displace the second winding tool 22 relative to the rotor 10 while the rotor 10 rotates about its rotation axis. Variations in pitch, and optionally also in diameter, between turns may thereby be effected without requiring the rotor 10 to be stopped.

The second winding tool 22 may be displaceable in a direction parallel to the rotation axis 13 of the rotor 10. A displacement 24 of the second winding tool in a direction along the rotation axis 13 causes a change in pitch and optionally also a change in diameter of turns of the wound coil spring.

The second winding tool 22 may be mounted to the rotor 10 via a second mount structure 26 which allows the second winding tool 22 to be displaced parallel to the rotation axis 13 relative to the rotor 10, while forcing the second winding tool 22 to rotate about the rotation axis 13 upon rotation of the rotor 10.

The second adjustment mechanism may be configured to maintain the second winding tool 22 in its position relative to the rotor 10 when the second adjustment mechanism is not actuated. For illustration, the second adjustment mechanism may comprise a second slider which is displaceable along the rotation axis 13 of the rotor 10 and which is configured to displace the second winding tool 22 in a direction 24 parallel to the rotation axis 13. The second winding tool 22 may be supported on the rotor 10 such that it is forced to rotate about the rotation axis 13 jointly with the rotor, while permitting the second winding tool 22 to be displaceable along the rotation axis 13.

The second adjustment mechanism may comprise the second motor. The second motor may be mounted on the stator 2. The second motor may be mounted on a base 3 or a superstructure 4 of the stator 2. This position of the second motor facilitates establishing the required power connections and connections to a control device 20, while mitigating difficulties which would be associated with a motor positioned on the rotor 10.

The control device 20 may control the adjustment of the second winding tool 22 in accordance with data which defines the shape of the coil spring, so as to reposition the second winding tool 22 relative to the rotor 10 while the rotor 10 rotates. The control device 20 may be configured to control the second motor and the rotor drive motor 19 in a coordinated manner, so as to adjust the position of the second winding tool 22 relative to the rotor 10 in a time-dependent manner, which is a function of the rotation speed of the rotor 10.

In order to vary both a diameter and a pitch of turns of the coil spring along the spring axis, the control device 20 may be configured to control the first adjustment mechanism and the second adjustment mechanism in a coordinated manner, so as to set the positions of the first winding tool 21 and of the second winding tool 22 relative to the wire guide 14 in dependence on data which define the shape of the coil spring to be wound.

Other configurations may be used in other embodiments. For illustration, it is not required for both the first winding tool 21 and the second winding tool 22 to be displaceably supported on the rotor 10. A coil spring winding apparatus according to an embodiment may comprise only one winding tool which is supported on the rotor 10 so as to be displaceable relative to the rotor 10. For illustration, in order to effect variations in diameter of turns of the coil spring, the coil spring winding apparatus according to an embodiment may comprise a first winding tool 21 which is displaceably supported on the rotor 10 and which defines the diameter of the turns of the coil spring by bending the wire 8 in a plane extending transverse to the rotation axis 13 of the rotor 10.

FIG. 4 shows a side view of a coil spring winding apparatus according to another embodiment. The first winding tool 21 may be supported on the rotor 10 so as to be not displaceable relative to the rotor 10. The second winding tool 22 may be displaceable supported on the rotor 10. A displacement 24 of the second winding tool 22 during rotation of the rotor 10 effects a variation in pitch and optionally also affects the diameter of turns of the coil spring.

In yet another embodiment, one of the first winding tool 21 and the second winding tool 22 may be displaceably supported on the rotor 10, so as to be displaceable both along the rotation axis 13 and transverse to the rotation axis 13. Variations in both diameter and pitch may thereby be effected using one displaceable winding tool in combination with one or several wire guide elements which are stationary relative to the rotor 10.

Operation of the coil spring winding apparatus 1 will be described in more detail with reference to FIG. 5 to FIG. 9.

FIG. 5 to FIG. 7 illustrate operation of the coil spring winding apparatus 1 according to an embodiment while the coil spring winding apparatus 1 winds a coil spring. An end 9 of the wire 8 wound into the coil spring advances along a line 51 which extends parallel to the rotation axis 13, even when the coil spring is still coupled to the rotor 10 and is still being wound.

FIG. 5 shows a side view of the coil spring winding apparatus 1 at a time during operation. The first winding tool 21 and the second winding tool 22 rotate jointly with the rotor 10 about the rotation axis 13. The positions of the first and second winding tools 21, 22 relative to the wire guide 14 sets a diameter and pitch of turns of the coil spring. An end 9 of the of the wire 8 wound into the coil spring is positioned on a line 51.

FIG. 6 shows a side view of the coil spring winding apparatus 1 after rotation of the rotor 10 by 180° relative to the state shown in FIG. 5. The rotor 10 rotates about the rotation axis 13 which extends along the spring axis of the wound coil spring. The 180° rotation causes one half turn of the coil spring to be wound. While the rotor 10 is rotated relative to the state shown in FIG. 5, the coil spring wound by the coil spring winding apparatus 1 does not rotate even while the coil spring is still being wound. The end 9 of the of the wire 8 wound into the coil spring is advanced along the line 51 which extends parallel to the rotation axis 13 in a translatory manner. It will be appreciated that the line 51 is stationary in a world reference frame and does not co-rotate with the rotor 10.

FIG. 7 shows a side view of the coil spring winding apparatus 1 after rotation of the rotor 10 by 360° relative to the state shown in FIG. 5 and by 180° relative to the state shown in FIG. 5. The rotor 10 rotates about the rotation axis 13 which extends along the spring axis of the wound coil spring. The 360° rotation compared to the state shown in FIG. 5 causes one turn of the coil spring to be wound. While the rotor 10 is rotated relative to the state shown in FIG. 6, the coil spring wound by the coil spring winding apparatus 1 does not rotate even while the coil spring is still being wound. The end 9 of the of the wire 8 wound into the coil spring continues to be advanced along the line 51 which extends parallel to the rotation axis 13 in a translatory manner.

FIG. 8 shows a side view of a coil spring winding apparatus 1 when the first winding tool 21 is displaced in a direction 23 transverse to the rotation axis 13 of the rotor 10 while the coil spring is being wound. A variation in diameter of turns of the coil spring is thereby effected. A turn 54 of the coil spring wound upon a rotation of the rotor 10 may have a diameter 55. A further turn 52 of the coil spring wound upon a further rotation of the rotor 10 may have a further diameter 53 which is different from the diameter 55.

A wide variety of spring shapes may be produced, such as barrel-shaped springs, hourglass-shaped springs, conical springs or frustoconical springs.

When the coil spring winding apparatus 1 is operated to produce an endless coil spring which is then further processed into an innerspring unit, the control device 20 may adjust the position of the first winding tool 21 relative to the rotor 10 in a periodical manner while the first winding tool 21 and the rotor 10 rotate about the rotation axis 13. A desired pattern of different diameters may thereby be repeated along the endless coil spring.

FIG. 9 shows a side view of a coil spring winding apparatus 1 when the second winding tool 22 is displaced in a direction 24 along the rotation axis 13 of the rotor 10 while the coil spring is being wound. A variation in pitch of turns of the coil spring is thereby effected. A turn 58 of the coil spring wound upon a rotation of the rotor 10 may have a pitch 59. A further turn 56 of the coil spring wound upon a further rotation of the rotor 10 may have a further pitch 57 which is different from the pitch 59. The diameter of the turns may also be varied by displacement of the second winding tool 22 relative to the wire guide 14.

The control device 20 may control the position of the second winding tool 22 relative to the rotor 10 while the second winding tool 22 and the rotor 10 rotate about the rotation axis 13, to thereby attain a desired variation in pitch of the turns along the spring axis.

When the coil spring winding apparatus 1 is operated to produce an endless coil spring which is then further processed into an innerspring unit, the control device 20 may adjust the position of the second winding tool 22 relative to the rotor 10 in a periodical manner while the second winding tool 22 and the rotor 10 rotate about the rotation axis 13. A desired pattern of different pitches may thereby be repeated along the endless coil spring.

A variation in diameter and a variation in pitch may be implemented by displacing the first winding tool 21 and the second winding tool 22 while the rotor 10 rotates.

In the coil spring winding apparatus 1 according to any embodiment, a feed device which draws the wire to the rotor 10 and/or which feeds it along the first and second winding tools 21, 22 may be provided on the rotor 10. The feed device may be mounted on the rotor so as to rotate about the rotation axis 13 upon rotation of the rotor 10. A feed pulley of the feed device may be mounted rotatably on the rotor 10. A rotation axis of the feed pulley may be parallel to the rotation axis 13 of the rotor 10 and may be offset from the rotation axis 13 of the rotor 10 in a direction transverse to the rotation axis 13 of the rotor 10.

At least a wire feed motor of a feed device drive mechanism which rotationally drives the feed pulley 61 may be mounted on the stator 2. The feed device drive mechanism may comprise a revolving gear drive which has an input coupled to the wire feed motor and a revolving gear which is mounted to revolve about the rotation axis 13 of the rotor 10 at an angular velocity defined by the angular velocity of the rotor 10. A rotation of the revolving gear about its own rotation axis is controlled by an output speed of the wire feed motor.

Configurations of the feed device and feed device drive mechanism of a coil spring apparatus according to embodiments will be described next.

FIG. 10 shows a front view of a coil spring winding apparatus according to an embodiment. A feed device 60 is supported on the rotor 10. The feed device 60 may comprise a feed pulley 61. The feed pulley 61 has an outer surface configured for abutment of the wire 8. The feed pulley 61 may advance the wire 8 which is urged against the feed pulley 61 by a force fit, in particular a frictional fit.

The feed pulley 61 may extend in a plane transverse to the rotation axis 13 of the rotor 10. The feed pulley 61 may be operative to guide the wire 8 along an arc extending in a plane transverse to the rotation axis 13 towards the wire guide 14. The feed pulley 61 may be configured to receive the wire 8 from a central opening 12 through which the wire is guided through the rotor 10.

A deflection roller 16 may be rotatably supported on the rotor 10. The deflection roller 16 may be operative to deflect the wire 8 from a direction generally along the rotation axis 13 to a direction transverse to the rotation axis 13.

FIG. 11 shows a perspective view of the rotor 10 with a feed device 60 supported thereon. The feed device 60 may comprise the feed pulley 61. The feed pulley 61 may be rotatable relative to the rotor 10 about a pulley rotation axis 65. The pulley rotation axis 65 revolves about the rotation axis 13 of the rotor 10 in operation of the coil spring winding apparatus 1. In addition, the feed pulley 61 is rotationally driven about the pulley rotation axis 65 by a feed device drive mechanism. A configuration of the feed device drive mechanism which may be used in embodiments will be described in more detail below.

The feed device 60 may be configured to urge the wire 8 against the feed pulley 61. The feed device 60 may comprise a compression mechanism 62 which is configured to urge the wire against the feed pulley 61. The feed pulley 61 may be rotationally driven by a feed device drive mechanism. An implementation of the feed device drive mechanism will be described in more detail below. The control device 20 may control operation of the feed device drive mechanism. The coil spring winding apparatus 1 may be configured such that the feed pulley 61 is driven to advance the wire 8 by a distance per rotation of the rotor 10 which corresponds to the length of the turn of the coil spring which is being wound during that rotation. The control device 10 may compute the amount of wire by which the wire 8 must be advanced in dependence on the diameter and pitch of the turn of the coil spring which is being wound by the coil spring winding apparatus 1 during the respective rotation of the rotor 10. Alternatively, the coil spring winding apparatus 1 may be configured such that the feed pulley 61 is driven to advance the wire 8 at a constant speed, with the angular velocity of the rotor 10 being adjusted in accordance with the length of wire required per turn of the coil spring.

According to further embodiments, a configuration of the feed device mounted on the rotor 10, as exemplarily explained with reference to FIG. 10 and FIG. 11, may also be used on a coil spring winding apparatus in which the first and/or second winding tools 21, 22 are not adjustable relative to the rotor 10.

FIG. 12 is a schematic side view of the coil spring winding apparatus 1 according to an embodiment. The coil spring winding apparatus 1 may have any one of the configurations explained with reference to FIG. 1 to FIG. 11 above.

The coil spring winding apparatus 1 may comprise a rotor drive motor 19 to drive the rotor 10. The rotor drive motor 19 may be mounted on the stator 2.

The coil spring winding apparatus 1 may comprise a wire feed motor 69 to drive the feed pulley 61. The wire feed motor 69 may be mounted on the stator 2. The wire feed motor 69 may drive an input of a revolving gear drive, with the revolving gear being coupled to the feed pulley 61 in a torque-proof manner.

The coil spring winding apparatus 1 may comprise a first motor 39 which is controllable to adjust a position of the first winding tool 21 relative to the rotor 10. The first motor 39 may be a stepper motor. As will be explained in more detail, the first motor 39 may be coupled to a first slider to displace the first slider in a direction parallel to the rotation axis 13 of the rotor 10. The axial displacement of the first slider may be converted into a motion of the first winding tool 21 which is directed transverse to the rotation axis 13 by a motion conversion mechanism. The motion conversion mechanism may comprise mating bevel surfaces.

The coil spring winding apparatus 1 may comprise a second motor 49 which is controllable to adjust a position of the second winding tool 22 relative to the rotor 10. The second motor 49 may be a stepper motor. As will be explained in more detail, the second motor 49 may be coupled to a second slider to displace the second slider in a direction parallel to the rotation axis 13 of the rotor 10. A hollow member may be coupled to the second slider so as to be displaced in the direction parallel to the rotation axis 13. The hollow member may be coupled to the rotor 10 in a torque-proof manner. The second winding tool 22 may project towards an interior of the hollow member. The coil spring winding apparatus 1 may be configured such that the wound spring extends through the interior of the hollow member.

The coil spring winding apparatus 1 may comprise a wire supply mechanism 80. The wire supply mechanism 80 may be operative to guide the wire 8 to the rotor 10 along a direction which extends along the rotation axis 13 of the rotor 10.

The wire supply mechanism 80 may comprise a guide member 82, which may be roller, around which the wire 8 is guided before it is supplied to the rotor 10.

Rotation of the rotor 10 causes the wire 8 to become twisted along the distance 81 between the guide member 82 and the rotor 10. The internal twist of the wire 8 is beneficial because it allows greater pitch angles to be attained in the wound spring. The internal twist of the wire 8 results in an intrinsic pitch of the coil spring wound by the coil spring winding apparatus 1.

In order to control the twist of the wire 8, which influences the pitch angle of the coil spring, the coil spring winding apparatus may be configured such that the distance 81 along which the wire 8 is twisted is adjustable. The guide member 82 may be displaceably mounted on a support 83.

The various drive mechanisms of the coil spring winding apparatus 1 may have various different configurations. Configurations of a rotor drive mechanism, of a feed device drive mechanism, of a first adjustment mechanism to adjust the first winding tool 21 and of a second adjustment mechanism to adjust the second winding tool 22 will be described with reference to FIG. 13 to FIG. 23. It will be appreciated that alternative configurations may be implemented in other embodiments. For illustration, only some of the drive mechanisms may be configured as explained with reference to FIG. 13 to FIG. 23. One or several of the drive mechanisms may be omitted. For illustration, if only one of the first winding tool 21 and the second winding tool 22 is adjustable relative to the rotor 10, only the first adjustment mechanism or only the second adjustment mechanism needs to be provided.

FIG. 13 shows a perspective view of a coil spring winding apparatus 1 according to an embodiment. FIG. 14 and FIG. 15 show partial perspective views illustrating the rotor and the various drive mechanisms in more detail. FIG. 16 is a partial side view. FIG. 17 is an enlarged perspective view of the rotor 10 and components mounted thereon. FIG. 18 shows a perspective view of a rotor drive mechanism. FIG. 19 shows a perspective view of a second adjustment mechanism configured to adjust the second winding tool 22 in a direction parallel to the rotation axis 13 of the rotor 10. FIG. 20 shows a perspective view of a first adjustment mechanism configured to adjust the first winding tool 21 in a direction transverse to the rotation axis 13 of the rotor 10. FIG. 21 is a partial front view of components of the first adjustment mechanism. FIG. 22 is a cross-sectional view along lines XXII-XXII in FIG. 21. FIG. 23 shows a perspective view of a feed device drive mechanism.

A configuration of a rotor drive mechanism of a coil spring winding apparatus 1 according to an embodiment will be described with reference to FIG. 13 to FIG. 18. The rotor drive mechanism is configured to rotationally drive the rotor 10. The rotor drive mechanism comprises a rotor drive motor 19. The rotor drive motor 19 may be supported on the stator 2. The rotor drive motor 19 may have a gear coupled to an output shaft of the rotor drive motor 19. The gear may engage a driving belt 18. The driving belt 18 may be provided with a toothing engaged with the gear on the output of the rotor drive motor 19 and engaged with an external toothing 17 of the rotor 10.

The control device 20 may control the rotor drive motor 19 such that the rotor 10 rotates at a constant angular speed. Alternatively, the control device 20 may control the rotor drive motor 19 such that the rotor 10 is rotated at an angular speed which depends on the diameter and pitch of turns of the coil spring which is being wound. This may be desirable when the feed device 60 feeds the wire 8 at a constant speed, for example.

A configuration of a second adjustment mechanism 40 of a coil spring winding apparatus 1 according to an embodiment will be described with reference to FIG. 13 to FIG. 17 and FIG. 19. The second adjustment mechanism 40 is operative to displace the second winding tool 22 in a direction 24 parallel to the rotation axis 13 of the rotor 10. The second adjustment mechanism 40 may be configured to adjust the position of the second winding tool 22 relative to the rotor 10 while the rotor 10 rotates, to thereby adjust a pitch of turns of the coil spring which is being wound. The diameter of turns may also be affected by the position of the second winding tool 22 relative to the wire guide 14.

The second adjustment mechanism 40 comprises a second motor 49. The second motor 49 may be mounted to the stator 2. The second motor 49 may have an output coupled to a second slider 41 via a rotational to linear motion conversion mechanism, which may comprise a spindle drive, a rack and pinion drive, or any other rotational to linear motion conversion mechanism.

The second adjustment mechanism 40 comprises the second slider 41. The second slider 41 is mounted so as to be displaceable along the rotation axis 13 of the rotor 10 in a translatory manner. The second slider 41 may be coupled to a hollow member 42 in such a manner that the linear displacement of the second slider 41 displaces the hollow member 42 in the direction parallel to the rotation axis 13. The second slider 41 and the hollow member 42 may be configured such that the hollow member 42 is rotatable relative to the second slider 41. One or several rollers 45 may be provided to rotationally support the hollow member 42.

The hollow member 42 is coupled to the rotor 10 in a torque-proof manner, while being displaceable relative to the rotor 10 in a direction parallel to the rotation axis 13 of the rotor 10. To this end, a rail 43 projecting from the hollow member 42 may be slidingly received in a mating recess of the rotor 10. The rail 43 may lock the hollow member 42 to the rotor 10 in such a manner that the hollow member 42 is forced to rotate jointly with the rotor 10 about the rotation axis 13 upon rotation of the rotor 10, while being displaceably in a translatory manner relative to the rotor 10 in the direction parallel to the rotation axis 13. The wound coil spring may be supported by a support plate 91 after exiting the hollow member 42.

The hollow member 42 may be a hollow tube. The hollow member 42 may be arranged such that a center axis of the hollow member 42 is arranged along the rotation axis 13 of the rotor 10.

The second winding tool 22 may be rigidly attached to the hollow member 42. A mount 44 may be provided which mounts the second winding tool 22 such that it is supported on the rotor 10 via the rail 43, which permits the second winding tool 22 to be displaced relative to the rotor 10 in the direction parallel to the rotation axis 13.

In operation of the coil spring winding apparatus 1, the wound coil spring is output from the rotor 10 through the interior of the hollow member 42. The hollow member 42 rotates about the turns of the coil spring which have just been wound, while the coil spring is advanced in a translatory manner through the rotating hollow member 42.

In order to adjust the pitch of turns of the wound coil spring, the control device 20 may control the second motor 49. Actuation of the second motor 49 may displace the second slider 41. Displacement of the second slider 41 in a direction towards the rotor 10 displaces the rotating hollow member 42 towards the rotor 10, causing the second winding tool 22 to be displaced towards the rotor 10, while the second winding tool 22 moves about the rotation axis 13 with the rotor 10. The pitch of the turns of the coil spring may thereby be reduced. Displacement of the second slider 41 in a direction away from the rotor 10 displaces the rotating hollow member 42 away from the rotor 10, causing the second winding tool 22 to be displaced away from the rotor 10, while the second winding tool 22 moves about the rotation axis 13 with the rotor 10. The pitch of the turns of the coil spring may thereby be increased.

A configuration of a first adjustment mechanism 30 of a coil spring winding apparatus 1 according to an embodiment will be described with reference to FIG. 13 to FIG. 17 and FIG. 20 to FIG. 22. The first adjustment mechanism 30 is operative to displace the first winding tool 21 in a direction 23 transverse to the rotation axis 13 of the rotor 10. The first adjustment mechanism 30 may be configured to adjust the position of the first winding tool 21 relative to the rotor 10 while the rotor 10 rotates, to thereby adjust a diameter of turns of the coil spring which is being wound.

The first adjustment mechanism 30 comprises a first motor 39. The first motor 39 may be mounted to the stator 2. The first motor 39 may have an output coupled to a first slider 31 via a rotational to linear motion conversion mechanism, which may comprise a spindle drive, a rack and pinion drive, or any other rotational to linear motion conversion mechanism.

The first adjustment mechanism 30 comprises the first slider 31. The first slider 31 is mounted so as to be displaceable along the rotation axis 13 of the rotor 10 in a translatory manner.

The first slider 31 may be engaged with a motion conversion mechanism which converts a displacement of the first slider 31 in a direction along the rotation axis 13 of the rotor 10 in a displacement 23 of the first winding tool 21 in a direction transverse to the rotation axis 13 of the rotor 10.

The motion conversion mechanism may comprise a wedge member 33. The wedge member 33 may comprise a wedge surface 36. The wedge member 33 may be coupled to the rotor 10 in a torque-proof manner, while being displaceable relative to the rotor 10 in a direction parallel to the rotation axis 13 of the rotor 10. To this end, a rail 35 projecting from the wedge member 33 may be slidingly received in a mating recess of the rotor 10. The rail 35 may lock the wedge member 33 to the rotor 10 in such a manner that the wedge member 33 is forced to rotate jointly with the rotor 10 about the rotation axis 13 upon rotation of the rotor 10, while being displaceably in a translatory manner relative to the rotor 10 in the direction parallel to the rotation axis 13.

The motion conversion mechanism may comprise a mating bevel surface 37 which is in abutting engagement with the wedge surface 36 of the wedge member 33. The bevel surface 37 may be provided on a member 38 which is mounted on the rotor 10 so as to be displaceable relative to the rotor 10 in a direction transverse to the rotation axis 13 of the rotor 10. The member 38 and the wedge member 33 may be mounted such that the member 38 is displaceable in a direction which is perpendicular to the direction in which the wedge member 33 is displaceable relative to the rotor 10. For illustration, the member 38 may be pivot member mounted on the rotor so as to be pivotable about a pivot axis. The pivot axis may be parallel to the rotation axis 13 of the rotor 10.

A bias mechanism (not shown) may bias the member 38 into abutting engagement against the wedge surface 36 of the wedge member 33.

The first slider 31 may engage the wedge member 33 so as to allow the wedge member 33 to rotate relative to the first slider 31. The first slider 31 may have an annular surface on which a roller provided on the end of the wedge member 33 rolls off. Displacement of the first slider 31 in the direction parallel to the rotation axis 13 of the rotor 10 causes the wedge member 33, which rotates with the rotor 10 about the rotation axis 13, to be displaced parallel to the rotation axis 13. The wedge surface 36 of the wedge member 33 forces the member 38, which also rotates jointly with the rotor 10, to be displaced in a direction 23 transverse to the rotation axis 13 of the rotor 10.

The first winding tool 21 may be mounted to or may be integrally formed with the member 38.

In operation of the coil spring winding apparatus 1, the wound coil spring is output from the rotor 10 through the interior of the hollow member 42. The hollow member 42 rotates about the turns of the coil spring which have just been wound, while the coil spring is advanced in a translatory manner through the rotating hollow member 42.

In order to adjust the diameter of turns of the wound coil spring, the control device 20 may control the first motor 39. Actuation of the first motor 39 may displace the first slider 31. Displacement of the first slider 31 in a direction towards the rotor 10 displaces the wedge member 33 towards the rotor 10, causing the member 38 with the first winding tool 21 to pivot in a first pivot direction relative to the rotor 10. This displaces the first winding tool 21 relative to the rotor 10 in a direction 23 transverse to the rotation axis 10. The diameter of the turns of the coil spring may thereby be reduced. Upon displacement of the first slider 31 in a direction away from the rotor 10, the bias force exerted onto the wedge member 33 by the member 38 displaces the wedge member 33 away from the rotor 10, causing the first winding tool 21 to be displaced away from the rotor 10, causing the member 38 with the first winding tool 21 to pivot in a second pivot direction relative to the rotor 10 which is opposite to the first pivot direction. The diameter of the turns of the coil spring may thereby be increased.

A configuration of a feed device drive mechanism 70 of a coil spring winding apparatus 1 according to an embodiment will be described with reference to FIG. 23. The feed device drive mechanism 70 is configured to rotate the feed pulley 61 about the pulley rotation axis 65 while the pulley rotation axis 65 revolves about the rotation axis 13 of the rotor 10.

The feed device drive mechanism 70 may generally comprise a revolving gear drive. A revolving gear 76 (best seen in FIG. 15) revolves about the rotation axis 13 of the rotor 10 at a speed determined by the angular velocity of the rotor 10. The revolving gear 76 may be attached to the feed pulley 61 by a shaft 77 in a torque-proof manner. Rotation of the revolving gear 76 causes the feed pulley 61 to rotate about its pulley rotation axis 65 at an angular velocity that corresponds to that of the revolving gear 76.

The revolving gear 76 may be rotationally driven through a driving belt 75. The driving belt 75 is engaged with a sun gear 74. The sun gear 74 is mounted on an intermediate gear 73 in a torque-proof manner. The intermediate gear 73 may have larger diameter than the sun gear for torque conversion. The intermediate gear 73 is rotationally driven via a driving belt 72 which is connected to a gear 71 rotationally coupled to an output shaft of the wire feed motor 69.

In operation, the control device 20 control the wire feed motor 69. Rotation of the gear 71 drives the intermediate gear 73 through the driving belt 72. Rotation of the intermediate gear 73 forces the sun gear 74 to rotate about an axis which corresponds to the rotation axis 13. Rotation of the sun gear 74 rotationally drives the revolving gear 76 through the driving belt 75. Rotation of the revolving gear 76 rotates the feed pulley 61 via the shaft 77.

The control device 20 may be configured to control the wire feed motor 69. The control device 20 may be configured to control the wire feed motor 69 such that the feed pulley 61 is rotated at a constant angular velocity. In a preferred implementation, the control device 20 may be configured to control the wire feed motor 69 such that the angular velocity of the feed pulley depends on the pitch and diameter of the turn of the coil spring which is being wound. This allows the rotor 10 to rotate at constant angular velocity, while the wire feed is adjusted under the control of the control device 20 such that the length of wire fed per time to the winding tools 21, 22 corresponds just to the amount of wire required per time to wind the respective turn of the coil spring.

FIG. 24 is a flow chart of a method 110 according to an embodiment. The method 110 may be performed by the coil spring winding apparatus 1 according to any one of the embodiments described with reference to FIG. 1 to FIG. 23. The method 110 may be performed under the control of the control device 20.

At 111, the rotor drive mechanism is started. The rotor drive motor 19 may be operated to rotate the rotor 10 at a constant or time-dependent angular velocity.

At 112, the position(s) of one or several winding tools 21, 22 supported on the rotor 10 are adjusted relative to the rotor 10. A first winding tool 21 may be displaced in a plane transverse to the rotation axis 13 of the rotor 10, while it rotates about the rotation axis 13 upon rotation of the rotor 10, to thereby adjust a diameter of the turns of the coil spring that are being wound. Alternatively or additionally, a second winding tool 22 may be displaced in a direction along the rotation axis 13 of the rotor 10, to thereby adjust a pitch of the turns of the coil spring that are being wound. The diameter of the turns of the coil spring may also be influenced by the displacement of the second winding tool 22.

Adjusting the position(s) of one or several winding tools 21, 22 supported on the rotor 10 may comprise determining whether a diameter and/or pitch is to be varied on the turn of the coil spring that is being wound, and actuating a motor of an adjustment mechanism associated with the winding tool 21, 22 that needs to be repositioned relative to the rotor 10 to vary the diameter and/or pitch.

Adjusting the position(s) of one or several winding tools 21, 22 supported on the rotor 10 may comprise selectively actuating a motor of an adjustment mechanism associated with the winding tool 21, 22 that needs to be repositioned relative to the rotor 10 to vary the diameter and/or pitch only when it is desired to change the diameter and/or pitch.

FIG. 25 is a flow chart of a method 120 according to an embodiment. The method 120 may be performed by the coil spring winding apparatus 1 according to any one of the embodiments described with reference to FIG. 1 to FIG. 23. The method 120 may be performed under the control of the control device 20.

At 121, information on a shape of a coil spring to be wound may be retrieved. The information may be retrieved from a storage medium or memory which has stored therein instructions defining a diameter and pitch of the coil spring along the spring axis. The coil spring winding apparatus 1 may comprise an input interface configured to allow the user to define the shape of the coil spring to be wound. The information on the shape of the coil spring may be retrieved from the user interface or from data generated based on a user input.

At 122, the rotor drive mechanism 19 is started. The rotor drive mechanism 19 may be operated to rotate the rotor 10 at a constant angular velocity.

At 123, the position(s) of one or several winding tools 21, 22 supported on the rotor 10 are adjusted relative to the rotor 10. Step 123 may be implemented as explained for step 112 above.

At 124, while the rotor 10 is rotated, the feed device drive mechanism 70 may be controlled as a function of the pitch and diameter of the turn that is being wound. The wire feed motor 69 may be controlled such that the angular velocity of the feed pulley 61 depends on the pitch and diameter of the turn of the coil spring which is being wound. This allows the rotor 10 to rotate at constant angular velocity, while the wire feed is adjusted under the control of the control device 20 such that the length of wire fed per time to the winding tools 21, 22 corresponds just to the amount of wire required per time to wind the respective turn of the coil spring.

While embodiments of the invention have been described with reference to the drawings, a wide variety of modifications may be implemented in other embodiments. For illustration, it is not required that a plurality of adjustable winding tools are mounted on the rotor. A coil spring winding apparatus according to an embodiment may be configured to output coil springs having constant diameter along their spring axis, but variable pitch, in which case only a winding tool 22 displaceable along the rotation axis 13 may need to be provided. A coil spring winding apparatus according to an embodiment may be configured to output coil springs having constant pitch along their spring axis, but variable diameter, in which case only a winding tool 21 displaceable transverse to the rotation axis 13 may need to be provided.

While embodiments have been described in which the coil spring winding apparatus is configured to produce an endless coil spring from wire, the coil spring winding apparatus may also be configured to cut the series of turns output from the rotor 10 into coil springs having finite height.

The coil spring winding apparatus and method according to embodiments of the invention may be used for manufacturing innerspring units for mattresses, sofas, armchairs, or other bedding or seating furniture, without being limited thereto.

CLAIMS

1. A coil spring winding apparatus (1), comprising:

a stator (2); and

a rotor (10) which is supported on the stator (2) so as to be rotatable about a rotation axis (13) which extends along a spring axis of a coil spring wound by the coil spring winding apparatus (1);

wherein at least one winding tool (21, 22) is supported on the rotor (10) so as to rotate about the rotation axis (13) of the rotor (10) upon rotation of the rotor (10), the at least one winding tool (21, 22) being configured to bend a wire (8) to form the coil spring upon rotation of the rotor (10), the at least one winding tool (21, 22) being adjustable relative to the rotor (10).

2. The coil spring winding apparatus according to claim 1,

wherein a pitch (57, 59) and/or a diameter (53, 55) of a turn of the coil spring is adjustable by adjusting the at least one winding tool (21, 22) relative to the rotor (10).

3. The coil spring winding apparatus according to claim 2, further comprising:

a first adjustment mechanism (30) configured to adjust a position or an orientation of a first winding tool (21) of the at least one winding tool (21, 22) relative to the rotor (10).

4. The coil spring winding apparatus according to claim 3,

wherein the first adjustment mechanism (30) comprises a first motor (39) mounted on the stator (2).

5. The coil spring winding apparatus according to claim 4,

wherein the first adjustment mechanism (30) comprises a first slider (31), the first motor (39) being configured to effect a displacement of the first slider (31) in a direction parallel to the rotation axis (13) of the rotor (10) to adjust the first winding tool (21) relative to the rotor (10).

6. The coil spring winding apparatus according to any one of claims 3 to 5, further comprising:

a second adjustment mechanism (40) configured to adjust at least one of a position or an orientation of a second winding tool (22) of the at least one winding tool (21, 22) relative to the rotor (10).

7. The coil spring winding apparatus according to claim 6,

wherein the first adjustment mechanism (30) is configured to adjust the first winding tool (21) relative to the rotor (10) in a direction (23) transverse to the rotation axis (13), and

wherein the second adjustment mechanism (40) is configured to adjust the second winding tool (22) relative to the rotor (10) in a direction (24) parallel to the rotation axis (13).

8. The coil spring winding apparatus according to any one of the preceding claims, further comprising:

a control device (20) configured to control an adjustment of the at least one winding tool (21, 22) relative to the rotor (10).

9. The coil spring winding apparatus according to claim 8,

wherein the control device (20) is configured to control the adjustment of the at least one winding tool (21, 22) relative to the rotor (10) to effect a variation in pitch (57, 59) and/or diameter (53, 55) along the spring axis.

10. The coil spring winding apparatus according to claim 9,

wherein the control device (20) is configured to control a feed of the wire (8) as a function of the variation in pitch (57, 59) and/or diameter (53, 55)in a time-dependent manner.

11. The coil spring winding apparatus according to claim 10,

wherein the control device (20) is configured to compute the feed of the wire (8) as a function of the variation in pitch (57, 59) and/or diameter (53, 55) such that the spring wound by the coil spring winding apparatus (1) is displaced in a translatory manner.

12. The coil spring winding apparatus according to any one of the preceding claims, further comprising:

a wire feed device (60) supported on the rotor (10) so as to rotate about the rotation axis (13) upon rotation of the rotor (10).

13. The coil spring winding apparatus according to claim 12,

wherein the wire feed device (60) comprises a feed pulley (61) and a compression mechanism (62) configured to urge the wire (8) in abutment with the feed pulley (61).

14. The coil spring winding apparatus according to claim 13, further comprising:

a wire feed device drive mechanism (70) comprising a wire feed motor (69) mounted to the stator (2) and a transmission (71-77) coupled in between the wire feed motor (69) and the feed pulley (61).

15. A method of winding a coil spring from a wire (8) using a coil spring winding apparatus (1) which comprises a rotor (10), wherein at least one winding tool (21, 22) is supported on the rotor (10) so as to be rotatable about a rotation axis (13) upon rotation of the rotor (10), the method comprising:

feeding the wire (8) to the at least one winding tool (21, 22) while the rotor (10) rotates, wherein the at least one winding tool (21, 22) bends the wire (8) to form the coil spring; and

adjusting the at least one winding tool (21, 22) relative to the rotor (10) to control a pitch (57, 59) and/or a diameter (53, 55) of the coil spring.

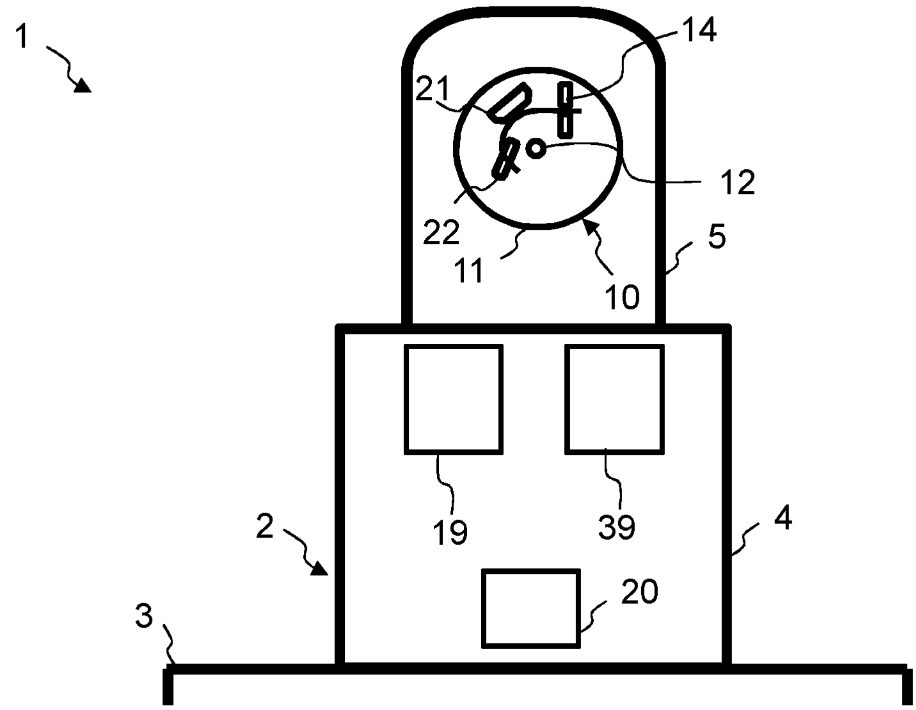

FIG. 1

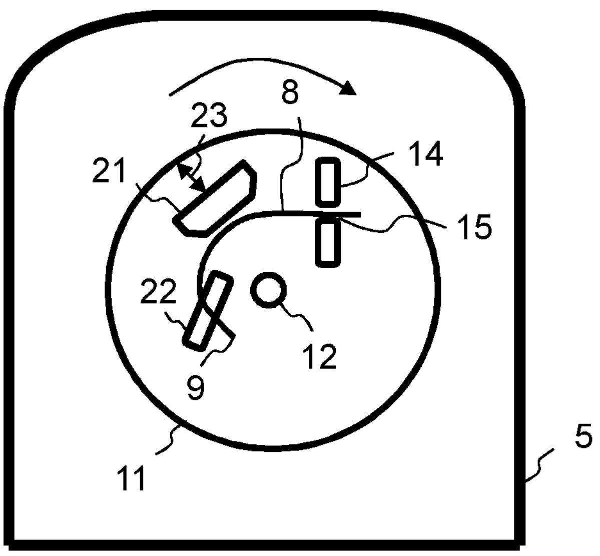

FIG. 2

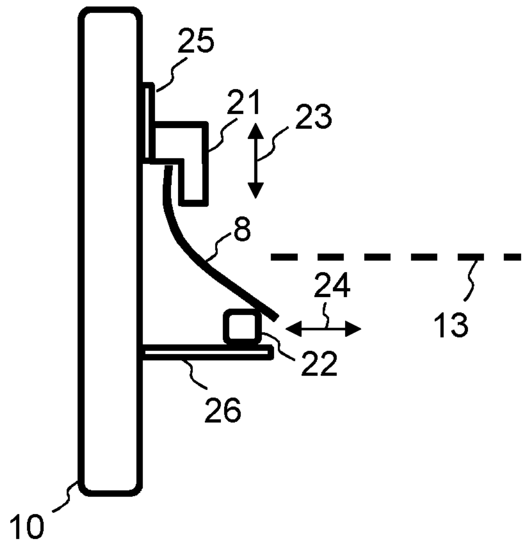

FIG. 3

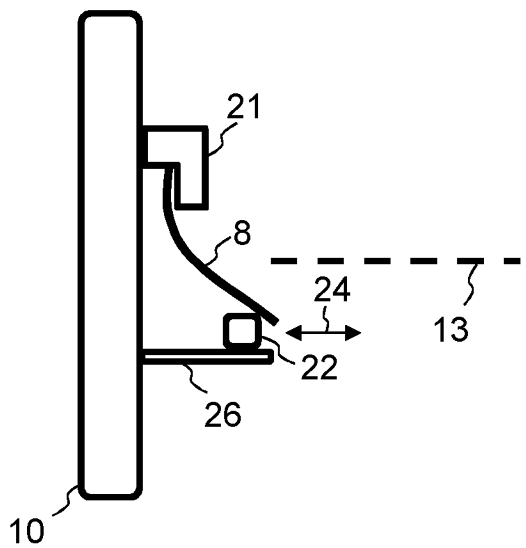

FIG. 4

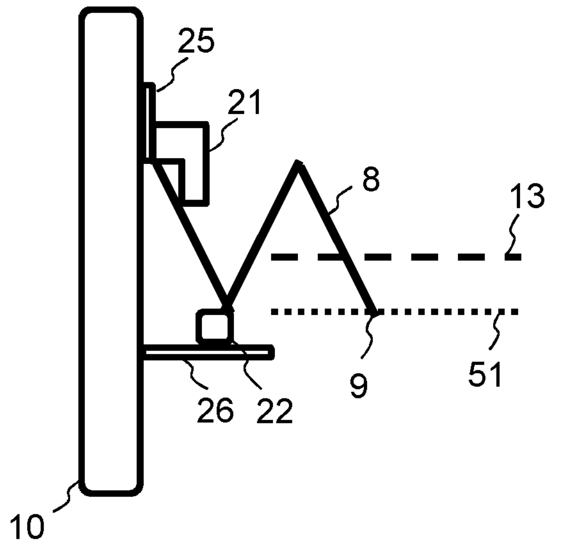

FIG. 5

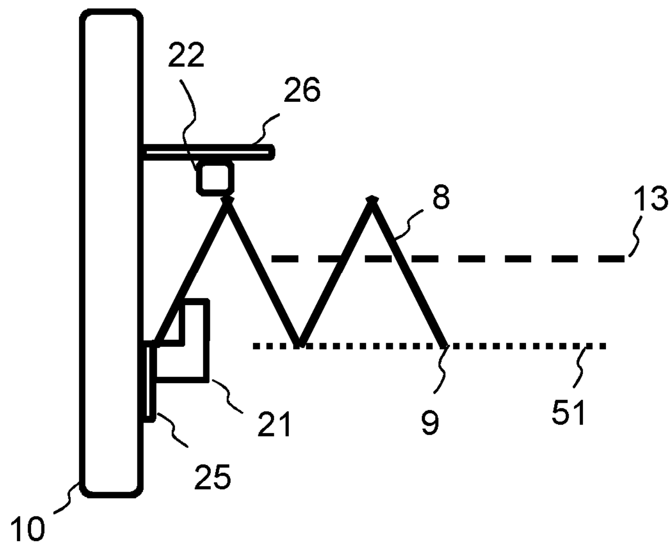

FIG. 6

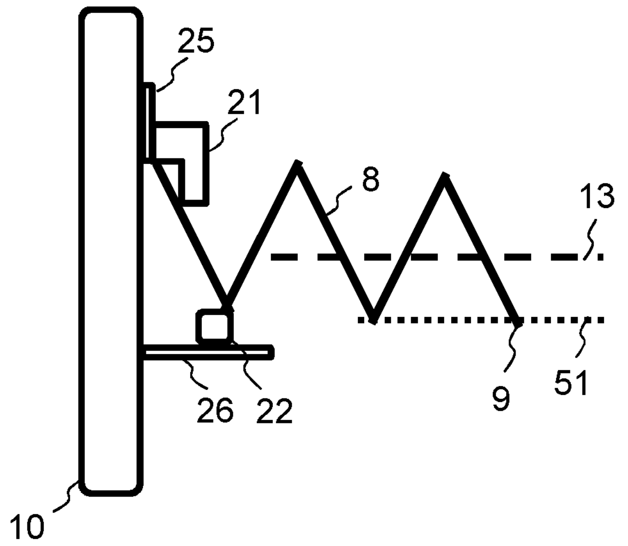

FIG. 7

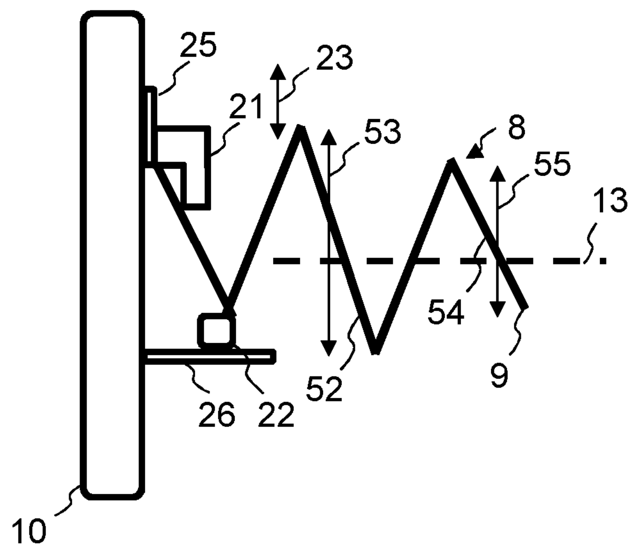

FIG. 8

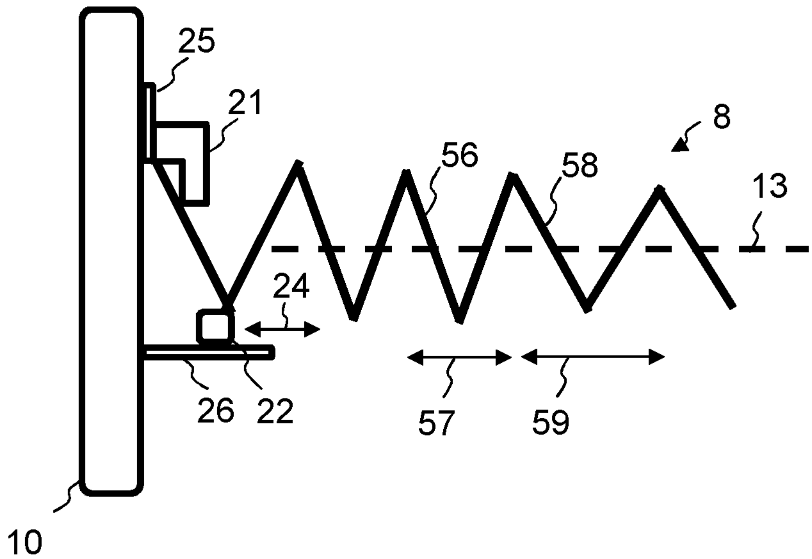

FIG. 9

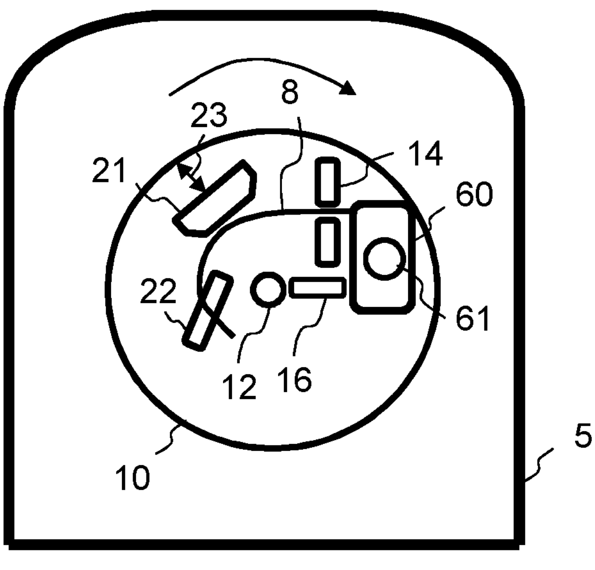

FIG. 10

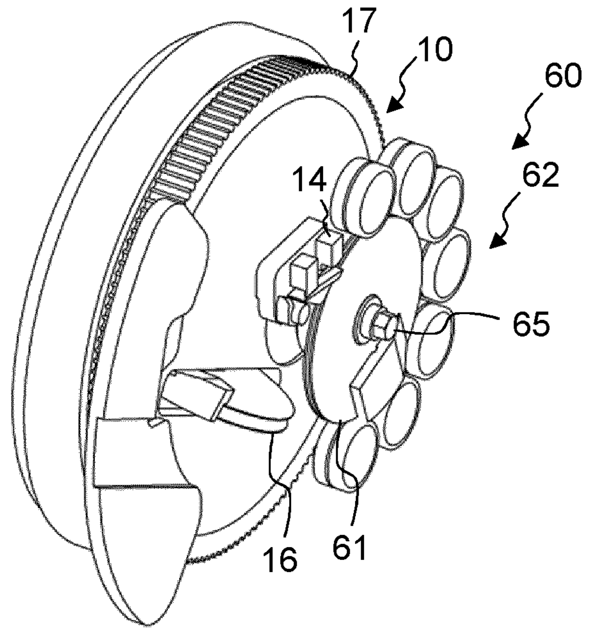

FIG. 11

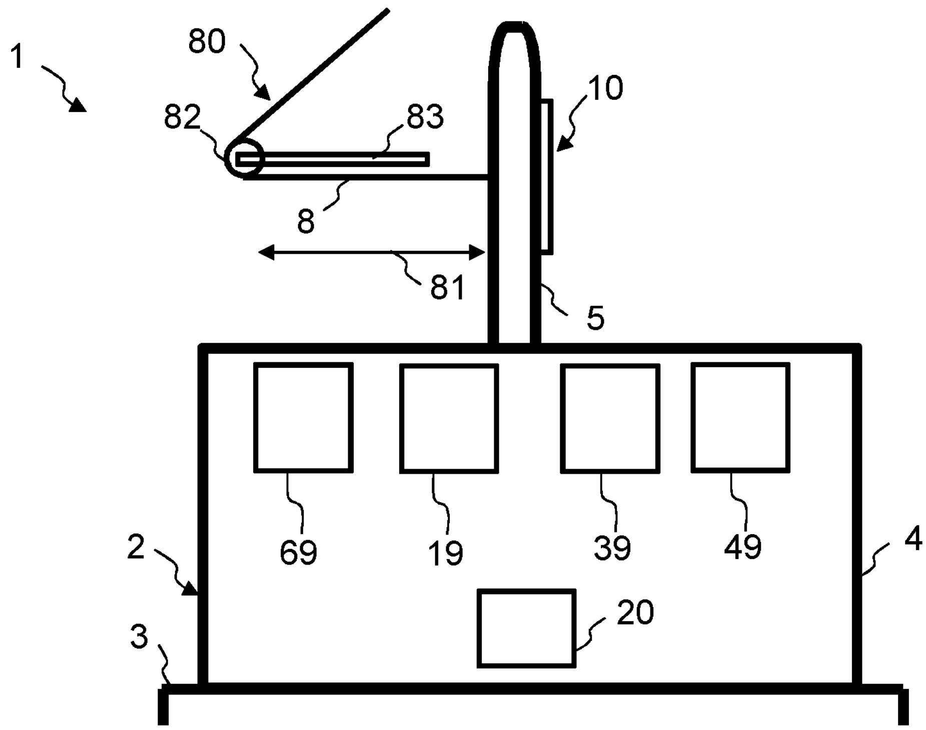

FIG. 12

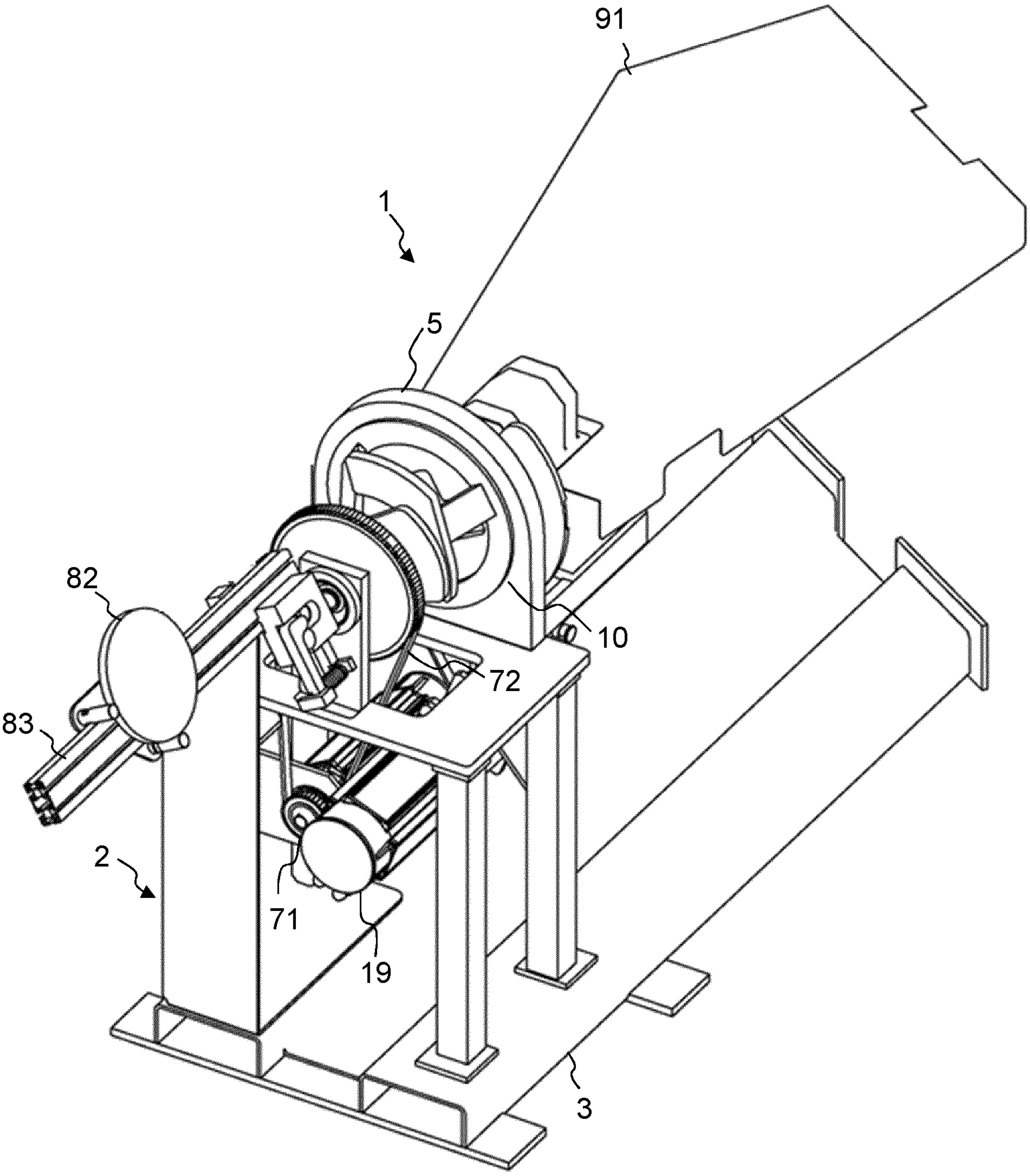

FIG. 13

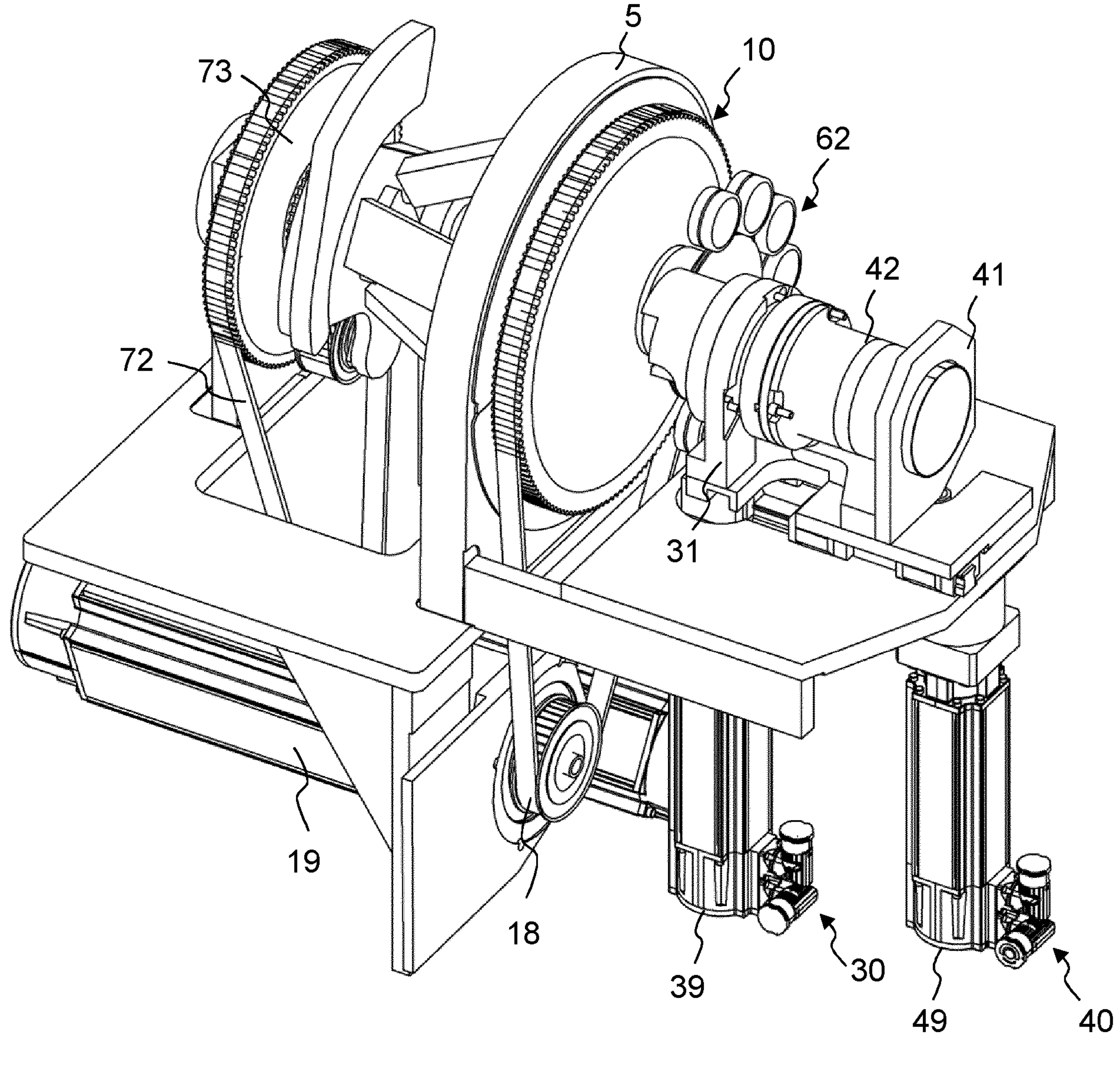

FIG. 14

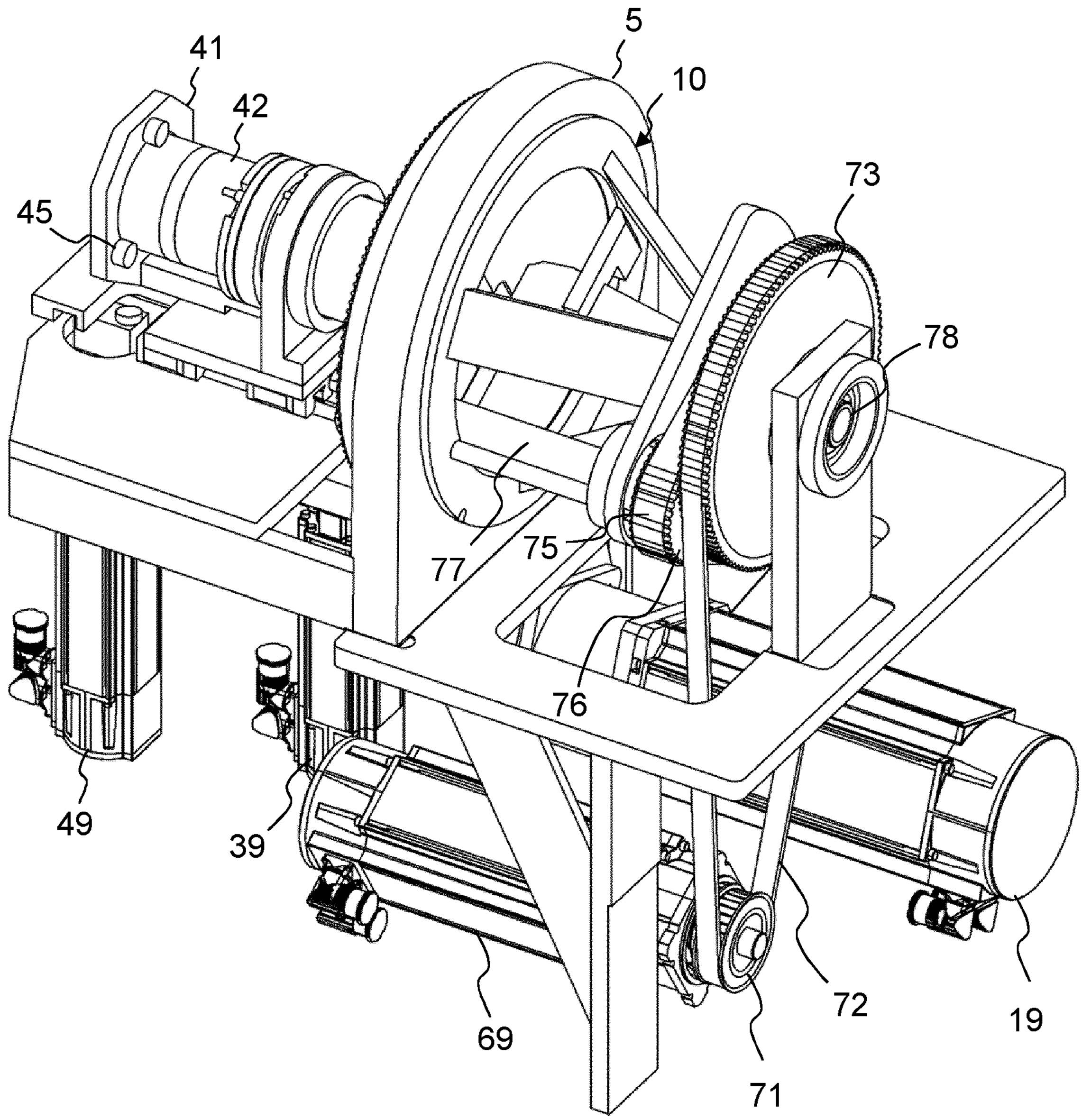

FIG. 15

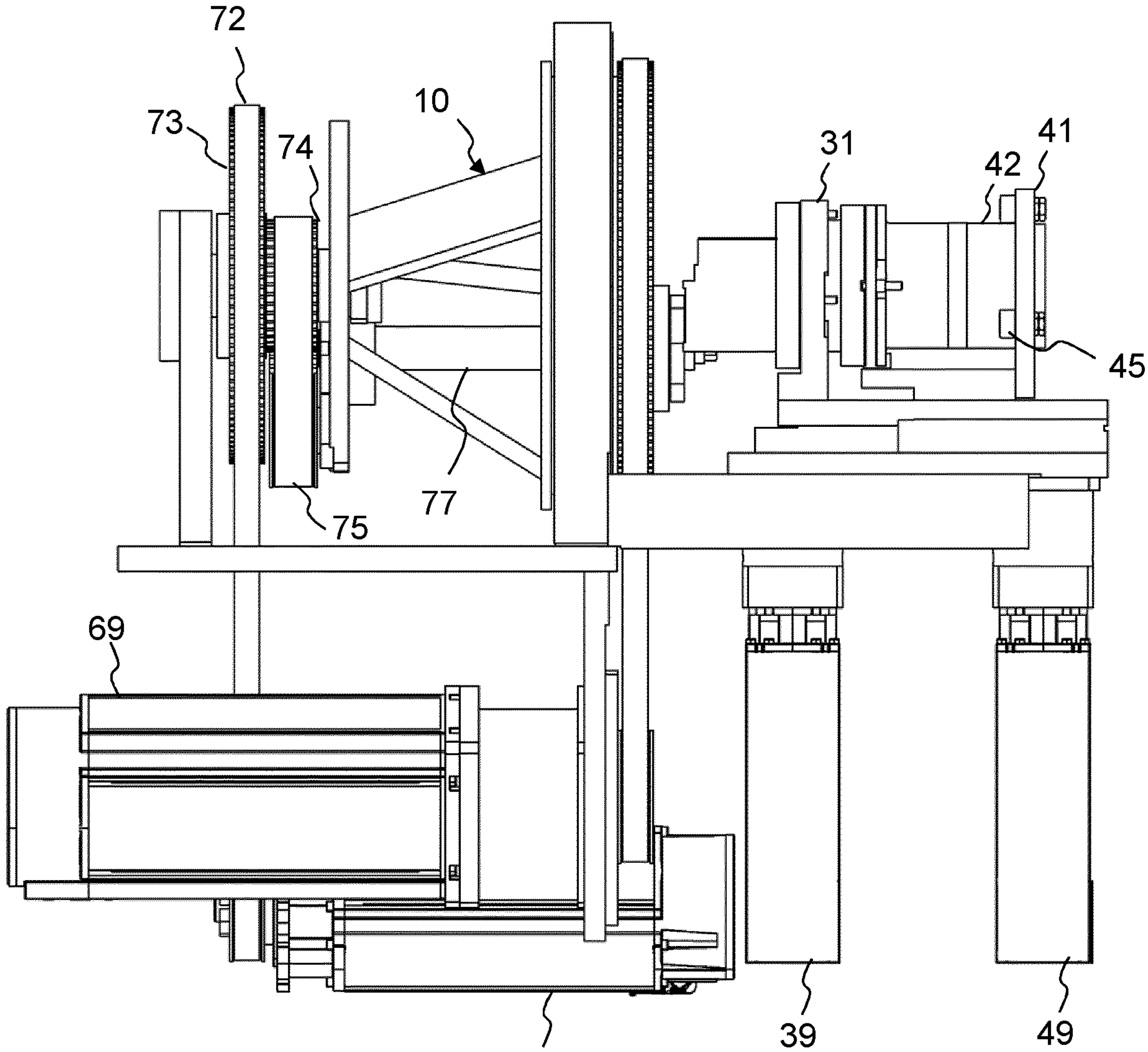

FIG. 16

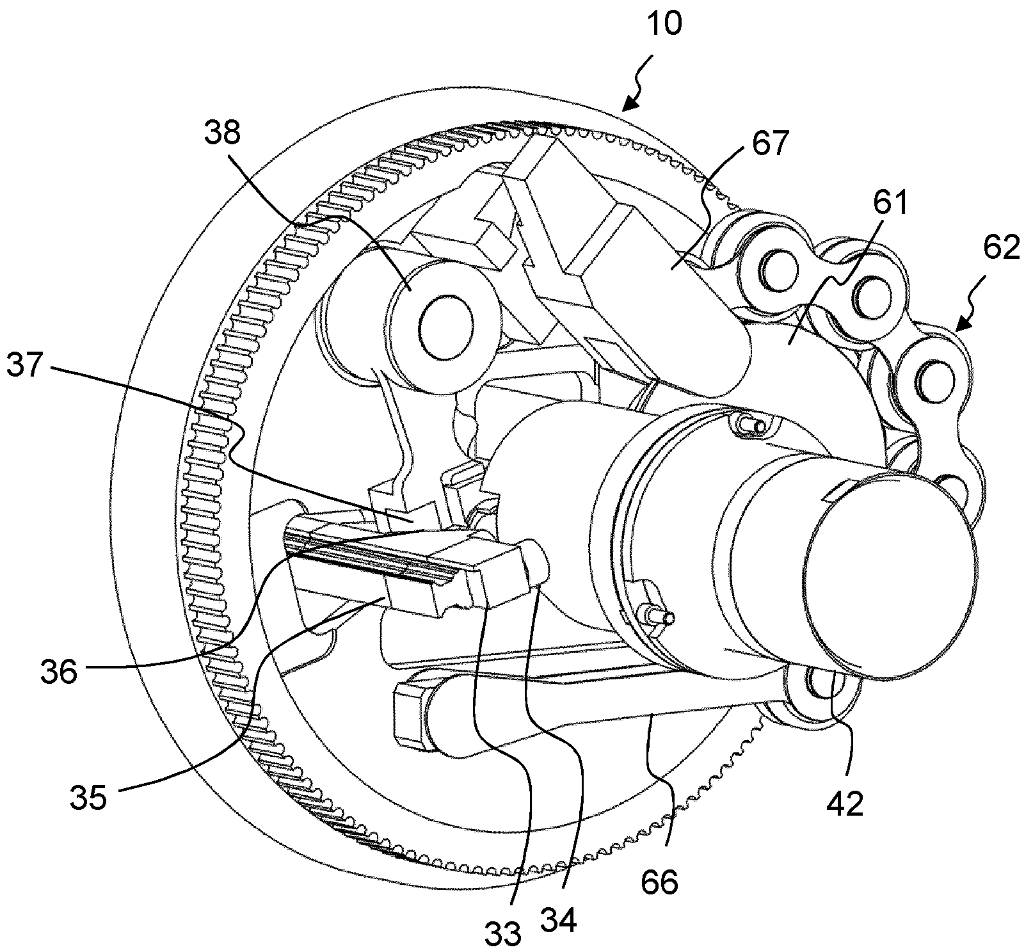

FIG. 17

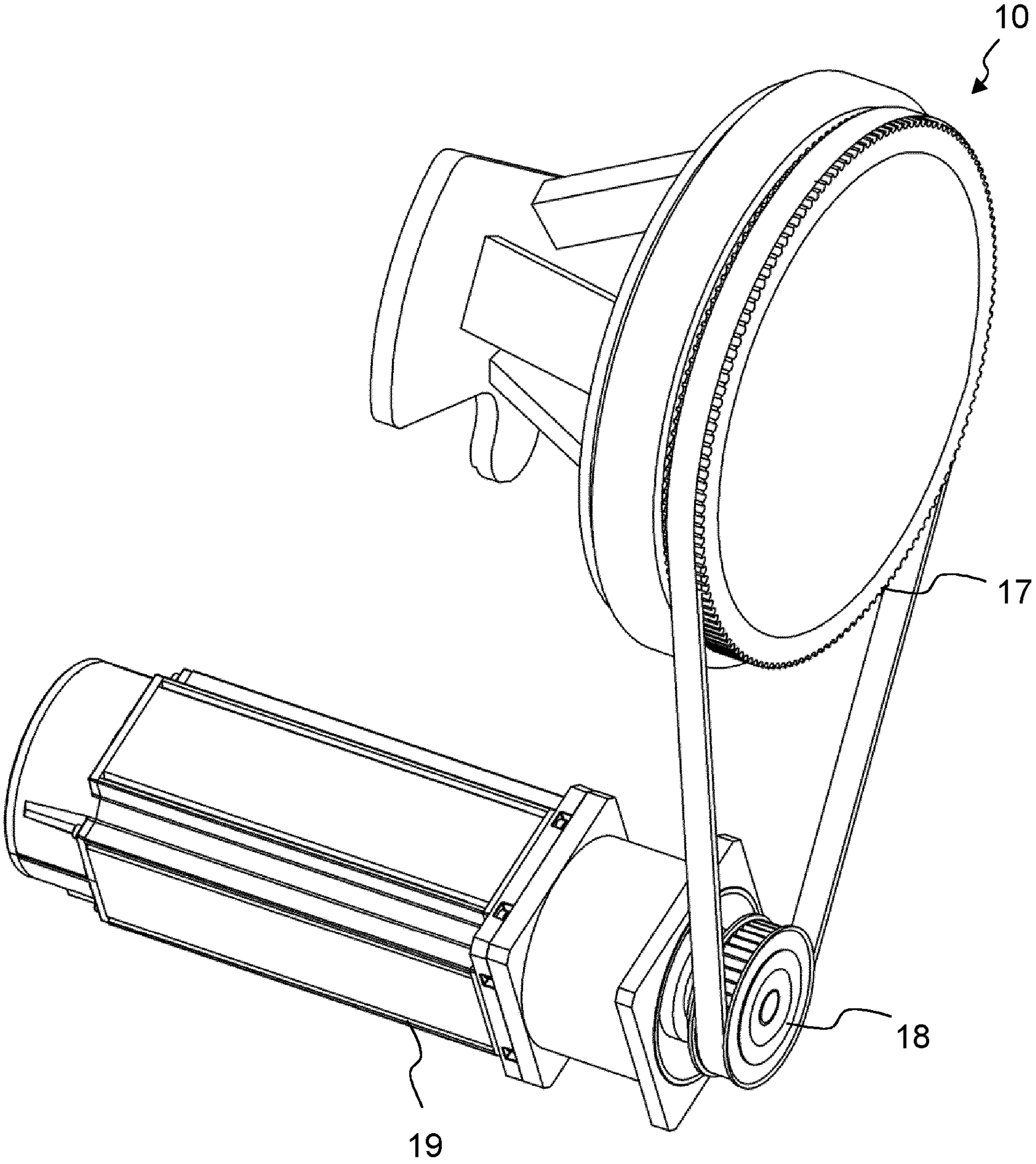

FIG. 18

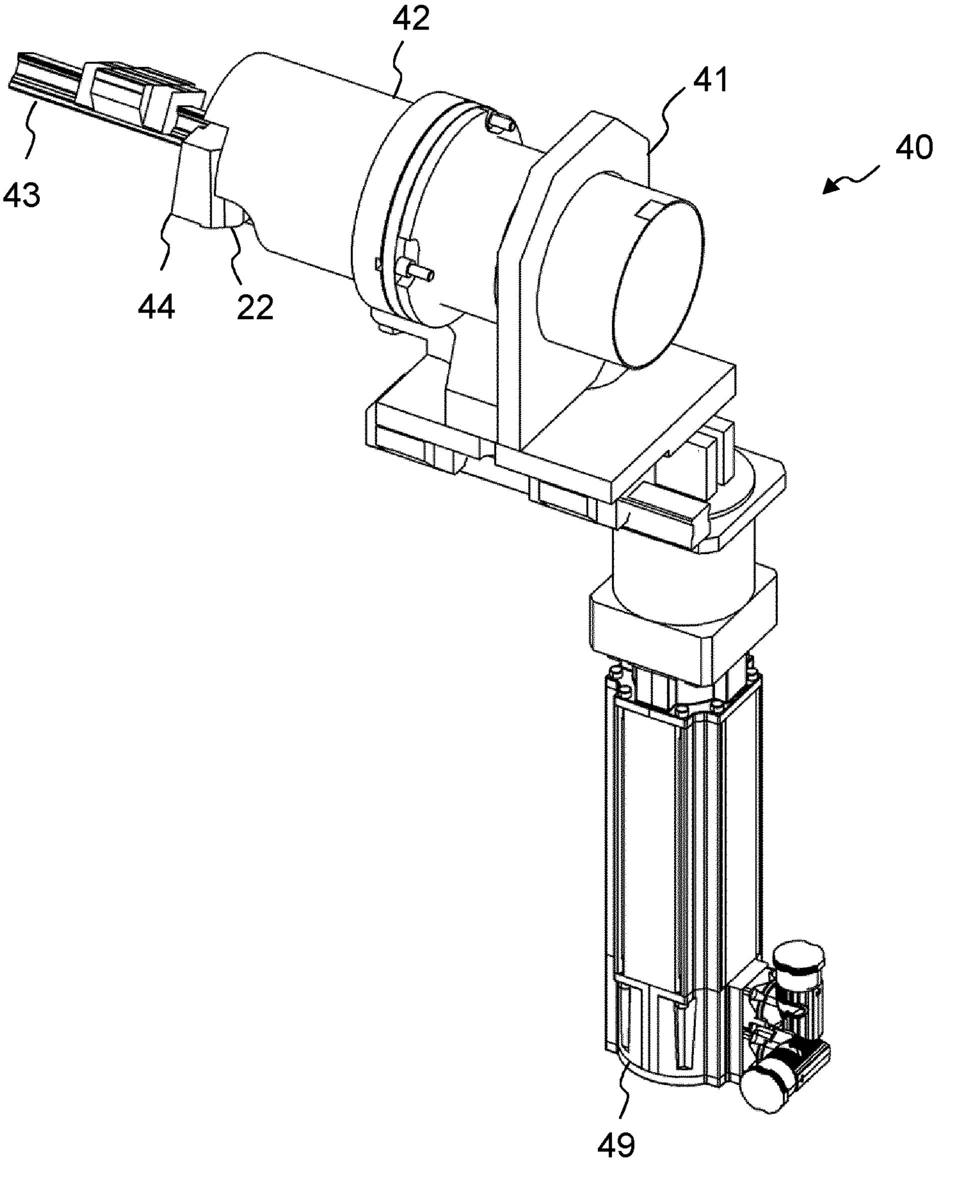

FIG. 19

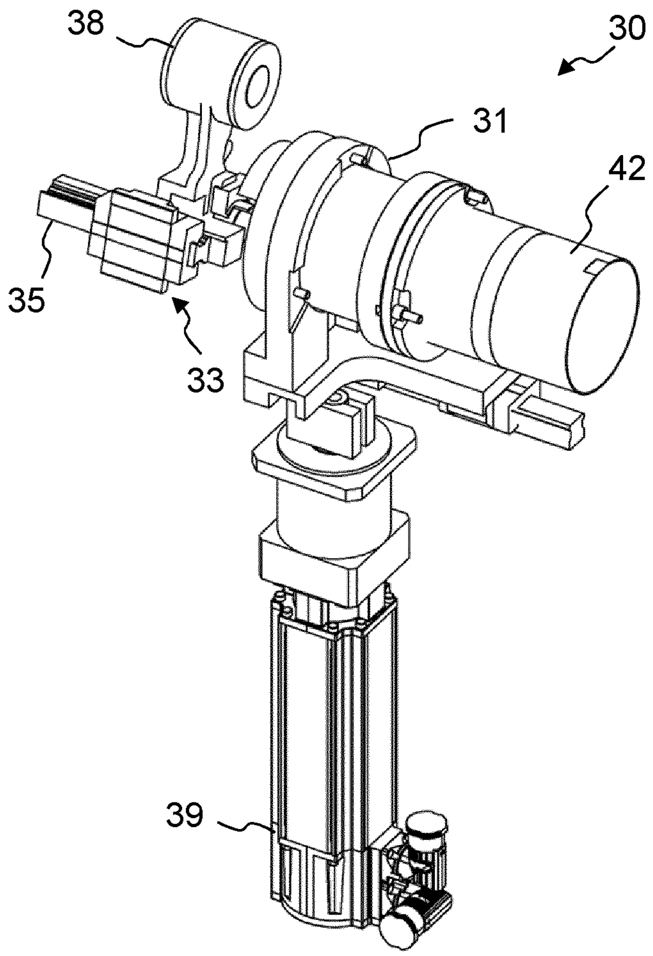

FIG. 20

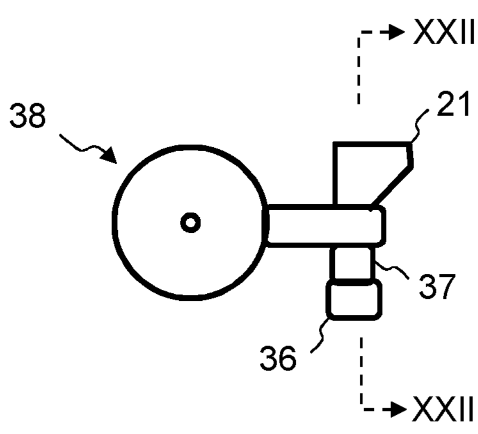

FIG. 21

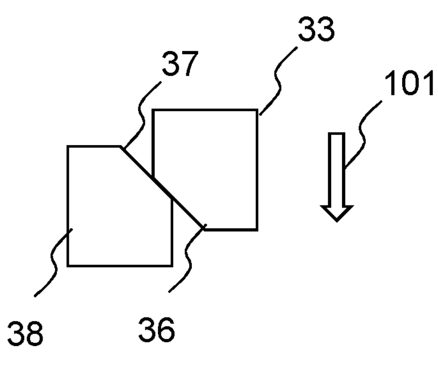

FIG. 22

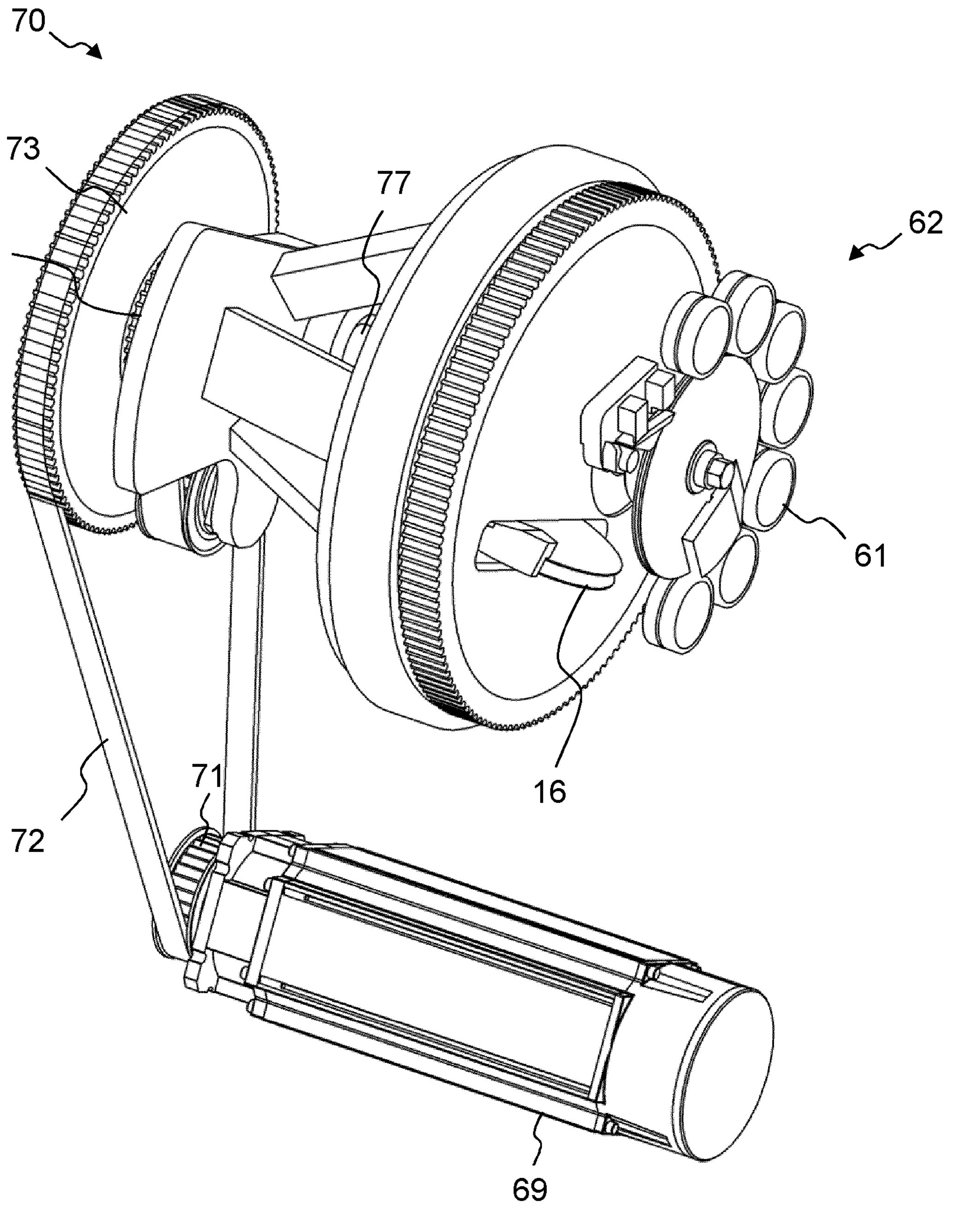

FIG. 23

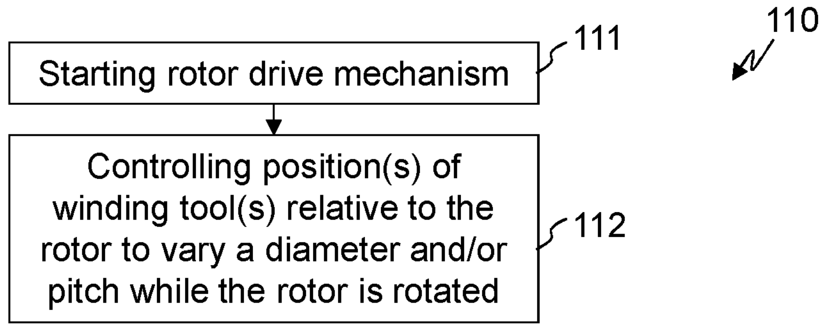
110
111
Starting rotor drive mechanism
112
Controlling position(s) of winding tool(s) relative to the rotor to vary a diameter and/or pitch while the rotor is rotated

FIG. 24

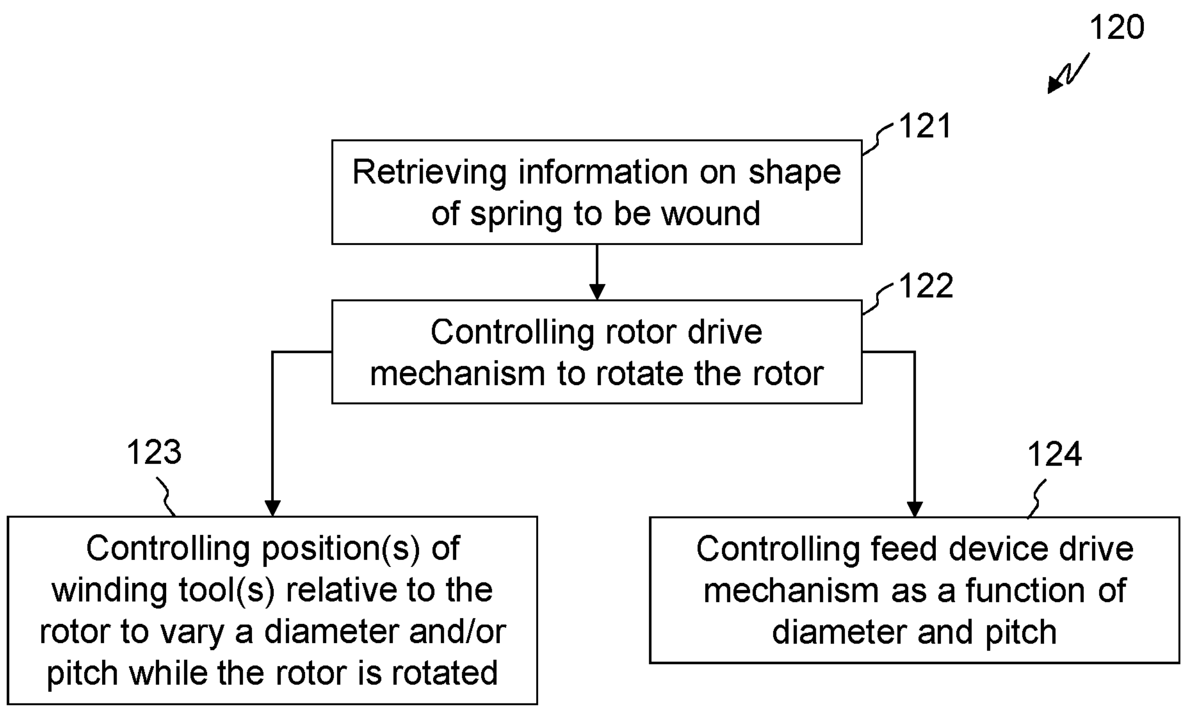
120
121
Retrieving information on shape of spring to be wound
122
Controlling rotor drive mechanism to rotate the rotor
123
Controlling position(s) of winding tool(s) relative to the rotor to vary a diameter and/or pitch while the rotor is rotated
124
Controlling feed device drive mechanism as a function of diameter and pitch

FIG. 25

INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2016/052259

A. CLASSIFICATION OF SUBJECT MATTER
INV. B21F3/06 B21F35/00
ADD. B21F3/02

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
B21F

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 3 779 058 A (NORMAN H) 18 December 1973 (1973-12-18) column 1, line 5 - line 9 column 1, line 56 - column 2, line 9 column 2, line 50 - column 4, line 62; figures 1-7 -----	1-15
X	US 3 541 828 A (NORMAN HARRY H) 24 November 1970 (1970-11-24) column 7, line 21 - column 14, line 65; figures 1-15 -----	1-15
X	US 4 700 558 A (MOHR HENRY G [US]) 20 October 1987 (1987-10-20) column 5, line 24 - column 9, line 59; figures 1-7 -----	1-3,15
	-/--	

[X] Further documents are listed in the continuation of Box C.

[X] See patent family annex.

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

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Date of the actual completion of the international search	Date of mailing of the international search report
22 September 2016	30/09/2016

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Ritter, Florian

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C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	DE 27 00 924 A1 (AEG TELEFUNKEN KABELWERKE) 13 July 1978 (1978-07-13) the whole document -----	1,15

1

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No
PCT/EP2016/052259

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