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# (54) AUTOMATIC HOOK NEEDLE WINDING MACHINE

(57) The present invention relates to a hook winding machine (1) for winding a coil (2) of wire (3) onto a toroidal core (4) having a through hole (5), an axis (6) defined by said through hole (5), an outer periphery (7), a first side (8) defined by a first axial end face of the core and a second side (9) which is opposite said first side (8) and defined by a second axial end face of the core (4), the hook winding machine (1) comprising

- a core holding device (10) for holding the core (4) during the winding process,
- a hook mechanism (11) with a longitudinally driven hook (12) for capturing the wire (3) and pulling the wire (3) from the first side (8) of the core (4) through the through hole of the core (4) to the second side (9) of the core (4),
- a wire bending device (13) for bending the wire (3) back from the second side (9) of the core (4) over the outer periphery of the core (4) to the first side (8) of the core (4), wherein the wire bending device (13) comprises a rotatable arm (14) that is rotatable about a first rotation axis (15) which is substantially perpendicular to the axis (7) of the toroidal core (4) or to an axis which is parallel to the axis (7) of the toroidal core (4), the rotatable arm (14) comprising a wire grabbing portion for grabbing the wire (3) and holding the wire (3) during bending the wire (3),
- and a control via which the hook winding machine (1) is adapted to alternately perform a pulling step during which the wire (3) is pulled by the hook mechanism (11) from the first side (8) of the core (4) through the through hole (5) of the core (4) to the second side (9) of the core (4) and a bending step during which the wire (3) is bent back by the wire bending mechanism (13) from the second side (9) of the core (4) over the outer periphery (7) of the core (4) to the first side (8) of the core (4), and wherein one winding cycle of the hook winding machine (1) is defined by a pulling step and a consecutive bending step.

According to the invention, the wire bending device (13) comprises a retracting mechanism for retracting the wire grabbing portion in a retracting direction (21) which is parallel to the first rotation axis (15) from an extended position in which the wire grabbing portion automatically grabs the wire (3) when the rotatable arm (14) rotates around the first rotation axis (15) after a pulling step to a retracted position in which the rotatable arm (14) with its wire grabbing portion is adapted to bypass the wire (3) when the rotatable arm (14) rotates around the first rotation axis (15) after a pulling step.

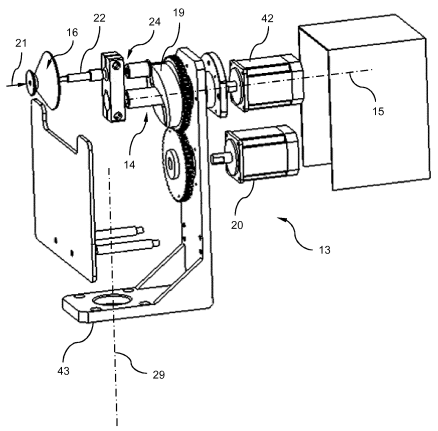


Fig. 3

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## Description

**[0001]** The present invention relates to a hook winding machine according to the preamble of independent claim 1 for winding a coil of wire onto a toroidal core having a trough hole, an axis defined by said through hole, an outer periphery, a first side defined by a first axial end face of the core and a second side which is opposite said first side and defined by a second axial end face of the core.

**[0002]** A hook winding machine according to the preamble of independent claim 1 comprises

- a core holding device for holding the core during the winding process,
- a hook mechanism with a longitudinally driven hook for capturing the wire and pulling the wire from the first side of the core through the through hole of the core to the second side of the core,
- a wire bending device for bending the wire back from the second side of the core over the outer periphery of the core to the first side of the core, wherein the wire bending device comprises a rotatable arm that is rotatable about a first rotation axis which is substantially perpendicular to the axis of the toroidal core or to an axis which is parallel to the axis of the toroidal core, the rotatable arm comprising a wire grabbing portion for grabbing the wire and holding the wire during bending the wire,
- and a control via which the hook winding machine is adapted to alternately perform a pulling step during which the wire is pulled by the hook mechanism from the first side of the core through the through hole of the core to the second side of the core and a bending step during which the wire is bent back by the wire bending mechanism from the second side of the core over the outer periphery of the core to the first side of the core, and wherein one winding cycle of the hook winding machine is defined by a pulling step and a consecutive bending step.

**[0003]** Hook winding machines according to the preamble of independent claim 1 are known from the prior art. A very common hook winding machine of the generic type is a so-called pull winder machine. This type of machine is used to wind coils onto toroidal cores having a through hole of very small diameter. The wire bending device of such a machine comprises a rotatable arm that is usually quite long and rotates about an axis which is stationary while the toroidal core is rotated during the winding process by means of several transport rollers distributed around the periphery of the toroidal core. A pull winder machine has the advantage that relatively thick wire can be used and that, as already mentioned above, the through hole of the toroidal core can have a relatively small diameter. Furthermore, the winding process is mostly automatized. However, a pull winder machine still requires the presence of an operator because the toroidal core has to be inserted between the transport rollers of the rotation mechanism by hand. Furthermore, the wire usually has to be cut and fastened by the operator before the winding process can start. The presence of an operator makes the production process expensive. Moreover, the transport rollers at first roll directly along the outer periphery of the core. After a while, however, the transport rollers roll along windings of the already wound portion of the coil which can have a negative effect on the winding precision. A further disadvantage is that the rotatable arm is quite long which makes the whole machine bulky and also represents a safety hazard.

**[0004]** The object of the present invention is therefore to provide a hook winding machine according to the preamble of independent claim 1 that is compact, provides an enhanced precision, and allows the winding process to be fully automatized.

**[0005]** The object is achieved by the features of independent claim 1. Accordingly, in a generic hook winding machine, the object is achieved according to the invention if the wire bending device comprises a retracting mechanism for retracting the wire grabbing portion in a retracting direction which is parallel to the first rotation axis from an extended position in which the wire grabbing portion automatically grabs the wire when the rotatable arm rotates around the first rotation axis after a pulling step to a retracted position in which the rotatable arm with its wire grabbing portion is adapted to bypass the wire when the rotatable arm rotates around the first rotation axis after a pulling step.

**[0006]** The solution according to the invention allows the toroidal core to be held stationary by the core holding device while the wire bending device rotates around the toroidal core during the winding process. This allows the use of a core holding device that can automatically be equipped with a core such that the winding process can be fully automatized. Furthermore, the winding precision is enhanced and the hook winding machine can be very compact. The possibility of bypassing the wire with the rotatable arm also allows that the wire bending device can be rotated back around the periphery of the toroidal core by an angle of approximately 180° after a portion of the coil has been wound onto a first sector of the toroidal core such that the winding process can be continued along a subsequent sector of the toroidal core with the wire bending device operating from an opposite side. Preferably, the first rotation axis is substantially perpendicular to the axis of the toroidal core. In the present application, "substantially perpendicular" is defined as an angle in the range of from 85° to 95°, wherein an angle of 90° is preferred.

**[0007]** Advantages embodiments of the present invention are the subject matter of the subclaims.

**[0008]** In a particularly preferred embodiment of the present invention, the control is configured such that, dur-

ing each winding cycle, the wire grabbing portion is brought into the retracted position before or during the rotatable arm, in a first rotation step, rotates around the toroidal core in a first rotation direction from a first reversal point at the first side of the toroidal core to a second reversal point at the second side of the toroidal core, the wire grabbing portion thereby bypassing the wire, wherein the wire grabbing portion is brought into the extended position before or during the rotatable arm, in a second rotation step, rotates around the toroidal core in a second rotation direction which is opposite to said first rotation direction from the second reversal point to the first reversal point, the wire grabbing portion thereby grabbing the wire such that the bending step is performed during the second rotation step.

**[0009]** This embodiment has the advantage that the coil can be wound onto a larger sector of the toroidal core without the need to change the position of the core holding device along the circumference of the toroidal core. A rotation angle between the first reversal point and the second reversal point is preferably less than 320°. This ensures that the rotatable arm does not collide with the core holding device.

**[0010]** According to another preferred embodiment of the invention, the control is configured such that the wire grabbing portion is brought from the extended position to the retracted position after the hook has been fully extended by the hook mechanism and before the next pulling step is performed. In this embodiment, the wire is pulled against the shaft of the hook before the pulling step in which the hook is pulled in a direction away from the toroidal core which guarantees that the wire is caught by the hook.

**[0011]** In another preferred embodiment of the present invention, the retracting mechanism comprises a rotatable cam disc and a drive for rotating the cam disc, wherein the retracting mechanism is configured such that rotation of the cam disc causes a displacement of the grabbing portion in the retracting direction. This embodiment provides a simple, precise, fast and inexpensive design of the retracting mechanism. The cam disc is preferably rotatable relative to the rotatable arm around the first rotation axis. This adds to a simple and compact design.

**[0012]** According to another preferred embodiment of the present invention, the rotatable arm comprises an eccentric shaft arranged eccentrically with respect to the first rotation axis and extending in the retracting direction, wherein the eccentric shaft is slidable in the retracting direction, wherein a first axial end of the eccentric shaft carries the wire grabbing portion, and wherein the cam disc acts on a second axial end of the eccentric shaft. This embodiment also adds to a simple and cost-effective design.

**[0013]** In yet another particularly preferred embodiment of the present invention, the wire grabbing portion is formed by a pulley comprising two pulley halves that are pre-tensioned against each other and adapted to receive and hold the wire in a gap formed between the pulley halves when the wire is grabbed. This embodiment has the advantage that the wire is reliably grabbed and held tight during the bending step. Furthermore, this embodiment also adds to a simple and compact design. The pulley halves preferably taper towards each other such that the wire is reliably caught and grabbed by the pulley.

**[0014]** In another preferred embodiment of the present invention, a first pulley half of the two pulley halves which is arranged further away from the second end of the eccentric shaft than a second pulley half of the two pulley halves, is smaller in axial length and maximum diameter then the second pulley half. This makes the whole design even more compact while it is still guaranteed that the wire is reliably caught and grabbed by the pulley.

**[0015]** According to another particularly preferred embodiment of the present invention, the core holding device is configured to hold the toroidal core stationary while the wire bending device rotates, after each winding cycle, around the core by a certain advancing angle about a second rotation axis. The second rotation axis preferably corresponds to the axis of the core. The advancing angle between consecutive winding cycles preferably remains constant. It is particularly preferred if the hook mechanism is configured to rotate together with the wire bending device about the second rotation axis. This ensures that the hook is always ideally positioned in relation to the wire.

**[0016]** In another preferred embodiment of the present invention, the core holding device is a first core holding device holding the core at a first sector of the core, wherein the hook winding machine further comprises a second core holding device configured to take over after a portion of the coil has already been wound onto a second sector of the core, wherein the second holding device holds the core at the second sector of the core, wherein the first core holding device and the second core holding device both are retractable, and wherein the first core holding device is retracted after the second core holding device has taken over such that another portion of the coil can be wound onto the first sector of the core. This embodiment allows that a single coil can be wound onto the full circumference of the core.

**[0017]** The object is alternatively achieved by the features of independent claim 12. Accordingly, in a generic hook winding machine according to the preamble of claims 1 and 12, the object is achieved according to the invention if the hook winding machine further comprises a wire feeding device for feeding at least a first portion of a used length of wire required for the coil from the first side of the core through the through hole of the core before the winding process starts. This solution allows that the winding process is further automatized. The solution according to claim 12 can be combined with the solution according to claim 1 and with all the aforementioned embodiments.

**[0018]** In another preferred embodiment, the wire feeding device is movable in a direction perpendicular to the axis of the core in order to hold a second portion of the

used length of wire, which remains at the first side of the core, eccentrically with respect to the axis of the core during the winding process without the used length of wire required for the coil being cut off before the winding process has been finished. This embodiment makes an additional component for fixing the wire unnecessary. It is further preferred if the wire feeding device can be positioned along three axes.

**[0019]** In another particularly preferred embodiment of the present invention, the hook winding machine further comprises an automatic core feeding device, a cutting unit for cutting the wire and an automatic discharge unit for discharging completed products such that the hook winding machine is fully-automatically operable without any operator's assistance. The cutting unit can be integrated into the wire feeding device. The automatic core feeding device may comprise a magazine and/or a separating unit with a vibration plate as is state of the art.

**[0020]** One embodiment of the present invention will be illustrated more in detail below with reference to drawings.

**[0021]** In the drawings:

Figure 1: shows a perspective view of a hook winding machine according to the invention,

Figure 2: shows a perspective view of the wire bending device of the hook winding machine of Figure 1,

Figure 3: shows an exploded perspective view of the wire bending device shown in Figure 2,

Figure 4: shows a perspective view of the hook mechanism of the hook winding machine of Figure 1,

Figure 5: shows a schematic perspective view of a toroidal core illustrating a wire feeding step,

Figure 6: shows a schematic sectional view of the toroidal core illustrating a first bending step of the winding process,

Figure 7: shows a detailed view of the pulley of the wire bending device shown in Figures 2 and 3,

Figure 8: shows the pulley of Figure 7 with the wire being grabbed between two pulley halves of the pulley,

Figure 9: shows a schematic sectional view of the toroidal core as shown in Figure 6 after the first bending step and prior to the first pulling step,

Figure 10: shows a schematic sectional view of the toroidal core shown in Figure 9 with the section plane shifted by 90°,

Figure 11: shows a top view of the toroidal core corresponding to the sectional view shown in Figure 9,

Figure 12: shows the same view as Figure 11 with the pulley of the wire bending device retracted from its extended position to its retracted position,

Figure 13: shows a sectional view of the toroidal core during the first pulling step,

Figure 14: shows a top view of the toroidal core after the first pulling step with the wire bending device being rotated around the core by an advancing angle $\beta$, and

Figure 15: shows a top view of the toroidal core with a partly wound coil during a change of the core holding device.

**[0022]** In the following illustrations, equal parts are designated by equal reference numerals. If a figure contains reference numerals which are not explicitly discussed in the pertaining description of the figures, reference is made to previous or subsequent descriptions of the figures.

**[0023]** Figure 1 shows a perspective view of a hook winding machine 1 according to an embodiment of the present invention. The hook winding machine 1 comprises inter alia an automatic core feeding device 37, a core holding device 10, a wire feeding device 33, a display and input unit 40 as well as a hook mechanism 11 and a wire bending device 13 to be discussed below in further detail. All components and subsystems of the hook winding machine 1 are arranged on a common worktable and/or attached to a common frame of the hook winding machine 1.

**[0024]** The wire bending device 13 is shown in further detail in figures 2 and 3. It comprises a rotatable arm 14 that is rotatable about a first rotation axis 15 and that is driven by a rotating drive 42 shown in the exploded view in figure 3. The rotatable arm 14 comprises an eccentric shaft 22 arranged eccentrically with respect to and parallel to the first rotation axis 15. The eccentric shaft 22 is slidably supported in another component of the rotatable arm such that the eccentric shaft 22 can be shifted along its longitudinal direction. At its first axial end 23, the eccentric shaft 22 carries a pulley 16 forming a wire grabbing portion of the rotatable arm 14. A cam disk 19 is rotatably supported concentrically to the first rotation axis 15 of the rotatable arm. The cam disc 19 is driven via a spur gear by a drive 20. A cam surface of the cam disc 19 is in contact with the second end 24 of the eccentric

shaft 22 such that rotation of the cam disc 19 causes an axial displacement of the eccentric shaft 22 and the pulley 16 at the eccentric shaft's first end along the longitudinal direction of the eccentric shaft which corresponds to a retracting direction 21 parallel to the first rotation axis 15.

**[0025]** As can be seen in figures 7 and 8, the pulley 16 comprises two pulley halves 25 and 26 that are pre-tensioned against each other by a pre-tensioning spring 27 acting between the second pulley half 26 and an axial stop surface of the eccentric shaft 22. As shown in the figures, the pulley halves taper towards each other. Moreover, the second pulley half 26 is bigger in diameter and axial length than the first pulley half 25.

**[0026]** Figure 4 shows a detailed view of the hook mechanism 11 of the hook winding machine 1 shown in figure 1. The hook winding mechanism comprises a longitudinally driven hook 12 connected to the slider 38 of a belt drive driven by hook mechanism drive 39. It should be mentioned that other types of drive for actuating the hook mechanism are generally possible. The hook mechanism may, for example, comprise a pneumatic cylinder instead of the belt drive shown in figure 4. The hook mechanism 11 can be rotated with respect to the stationary frame of the hook winding machine around a second rotation axis 29 by the rotating unit 41. A connecting flange 43 of the wire bending device 13 shown in figures 2 and 3 is firmly connected to a connecting flange 44 of the hook mechanism 11 such that the wire bending device 13 rotates together with the hook mechanism 11 around the second rotation axis 29.

**[0027]** When the hook winding machine 1 is operated, the automatic core feeding device 37 transfers a toroidal core to the core holding device 10 which then moves the core to the wire bending device 13 and the hook mechanism 11 such that an axis of the core coincides with the second rotation axis 29. Figure 5 shows the core holding device 10 holding the toroidal core 4 in a position ready for the winding process. As shown in figure 5, the toroidal core 4 has a through hole 5, and axis 6 defined by said through hole, an outer periphery 7, a first side 8 defined by a first axial end face of the core and a second side 9 opposite said first side 8 and defined by a second axial end face of the core.

**[0028]** Before the actual winding process can start, the wire feeding device 33, which is only schematically shown in figure 5, automatically moves over the toroidal core 4 and feeds a first portion 35 of a used length 34 of wire 3 required for the coil from the first side 8 of the core 4 through the through hole 5 of the core 4. The wire feeding device then moves in a direction perpendicular to the axis 6 of the core 4 in order to hold a second portion 36 of the used length 34 of wire 3, which remains at the first side 8 of the core 4, eccentrically with respect to the axis 6 of the core 4.

**[0029]** In a first bending step shown in figure 6, the wire 3 is then bent back by the wire bending mechanism 13 from the second side 9 of the core 4 over the outer periphery 7 of the core 4 to the first side 8 of the core 4. To this end, the rotatable arm 14 of the wire bending device 13 rotates around the first rotation axis 15 by a rotation angle $\alpha$ in a first rotation direction 17 such that the pulley 16 moves from position A in which no contact between pulley 16 and wire 3 exists over position B in which the wire 3 is grabbed by the pulley 16 to position C. At position B, the wire 3 is caught by the pulley 16 and guided, by the tapered surfaces of the two pulley halves 25 and 26, into a gap 28 between the two pulley halves which forms when the wire 3 is trapped between the two pulley halves 25 and 26 as shown in figure 8.

**[0030]** Next, the hook mechanism 11 moves the hook 12 upwards to a fully extended position as shown in figures 9, 10 and 11. A special shape of the hook 12 as well as a certain flexibility of the hook 12 thereby allow the head of the hook 12 to slide past the wire 3.

**[0031]** In a next step as shown in figure 12, the pulley is brought from its extended position indicated with dotted lines to its retracted position indicated with solid lines. Thereby, the wire 3 is pulled against the shaft of the hook 12 before the pulling step in which the hook 12 is pulled down which guarantees that the wire 3 is caught by the hook 12.

**[0032]** The following pulling step during which the wire 3 is pulled by the hook mechanism 11 from the first side 8 of the core 4 through the through hole 5 of the core 4 to the second side 9 of the core 4 is shown in figure 13. As the wire 3 is pulled down, the wire 3 slides out of the gap 28 between the two pulley halves 25 and 26. The rotatable arm 14 of the wire bending device 13 rotates back in a second rotation direction 18 indicated in figure 6 which is opposite to the first rotation direction 17 such that the pulley moves from position C to position A, thereby bypassing the wire 3 as the pulley 16 remains in its retracted position until position A is reached.

**[0033]** Before the following bending step, the pulley 16 is brought into its retracted position again and the wire bending device 13 is rotated together with the hook mechanism 11, as shown in figure 14, around the core 4 by an advancing angle $\beta$ about the second rotation axis 29 which coincides with the axis 6 of the toroidal core 4.

**[0034]** The pulling and bending steps are repeated such that a coil 2 is finally wound onto a sector 32 of the toroidal core 4 as shown in figure 15. The hook winding machine 1 may comprise a second core holding device 30 that takes over after a portion of the coil has been wound onto sector 32. The second core holding device 30 is adapted to hold the already wound sector 32 such that the first core holding device 10 can be retracted and another portion of the coil can be wound onto the sector 31 of the core 4. In this manner, it is possible to wind a coil that covers 360° of the toroidal core 4.

**[0035]** The hook winding machine 1 according to the described embodiment further comprises a cutting unit for cutting the wire 3 after the winding process has been finished and an automatic discharge unit for discharging completed products such that the hook winding machine 1 is fully-automatically operable without any operator's

assistance.

**[0036]** It should be mentioned that the hook winding machine may, for example, comprise several core holding devices that are arranged on a holding device revolver in order to speed up the production process. It is also conceivable that the hook winding machine comprises several wire bending devices and hook mechanisms such that two or more coils can be wound at the same time.

**List of reference numerals**

**[0037]**

| | |
|---|---|
| 1 | Hook winding machine |
| 2 | Coil |
| 3 | Wire |
| 4 | Toroidal core |
| 5 | Through hole of the toroidal core |
| 6 | Axis of the toroidal core |
| 7 | Outer periphery of the toroidal core |
| 8 | First side of the toroidal core |
| 9 | Second side of the toroidal core |
| 10 | Core holding device |
| 11 | Hook mechanism |
| 12 | Hook |
| 13 | Wire bending device |
| 14 | Rotatable arm |
| 15 | First rotation axis |
| 16 | Pulley |
| 17 | First rotation direction |
| 18 | Second rotation direction |
| 19 | Cam disc |
| 20 | Drive |
| 21 | Retracting direction |
| 22 | Eccentric shaft |
| 23 | First axial end of the eccentric shaft |
| 24 | Second axial end of the eccentric shaft |
| 25 | First pulley half |
| 26 | Second pulley half |
| 27 | Pre-tensioning spring |
| 28 | Gap between pulley halves |
| 29 | Second rotation axis |
| 30 | Second core holding device |
| 31 | First sector of the core |
| 32 | Second sector of the core |
| 33 | Wire feeding device |
| 34 | Used length of wire |
| 35 | First portion of used length of wire |
| 36 | Second portion of used length of wire |
| 37 | Automatic core feeding device |
| 38 | Slider |
| 39 | Hook mechanism drive |
| 40 | Display and input unit |
| 41 | Rotating unit |
| 42 | Rotating drive |
| 43 | Connecting flange of wire bending device |
| 44 | Connecting flange of hook mechanism |
| $\alpha$ | Rotation angle |
| $\beta$ | Advancing angle |
| A | Position A in the first reversal point |
| B | Position B in which the wire is grabbed by the pulley |
| C | Position C in the second reversal point |

**Claims**

**1.** Hook winding machine (1) for winding a coil (2) of wire (3) onto a toroidal core (4) having a trough hole (5), an axis (6) defined by said through hole (5), an outer periphery (7), a first side (8) defined by a first axial end face of the core and a second side (9) which is opposite said first side (8) and defined by a second axial end face of the core (4), the hook winding machine (1) comprising:

- a core holding device (10) for holding the core (4) during the winding process,
- a hook mechanism (11) with a longitudinally driven hook (12) for capturing the wire (3) and pulling the wire (3) from the first side (8) of the core (4) through the through hole of the core (4) to the second side (9) of the core (4),
- a wire bending device (13) for bending the wire (3) back from the second side (9) of the core (4) over the outer periphery of the core (4) to the first side (8) of the core (4), wherein the wire bending device (13) comprises a rotatable arm (14) that is rotatable about a first rotation axis (15) which is substantially perpendicular to the axis (7) of the toroidal core (4) or to an axis which is parallel to the axis (7) of the toroidal core (4), the rotatable arm (14) comprising a wire grabbing portion for grabbing the wire (3) and holding the wire (3) during bending the wire (3),
- and a control via which the hook winding machine (1) is adapted to alternately perform a pulling step during which the wire (3) is pulled by the hook mechanism (11) from the first side (8) of the core (4) through the through hole (5) of the core (4) to the second side (9) of the core (4) and a bending step during which the wire (3) is bent back by the wire bending mechanism (13) from the second side (9) of the core (4) over the outer periphery (7) of the core (4) to the first side (8) of the core (4), and wherein one winding cycle of the hook winding machine (1) is defined by a pulling step and a consecutive bending step,

**characterized in that**

the wire bending device (13) comprises a retracting mechanism for retracting the wire grabbing portion in a retracting direction (21) which is parallel to the first rotation axis (15) from an extended position in which the wire grabbing portion automatically grabs the wire (3) when the rotatable arm (14) rotates

around the first rotation axis (15) after a pulling step to a retracted position in which the rotatable arm (14) with its wire grabbing portion is adapted to bypass the wire (3) when the rotatable arm (14) rotates around the first rotation axis (15) after a pulling step.

**2.** Hook winding machine (1) according to claim 1, **characterized in that** the control is configured such that, during each winding cycle, the wire grabbing portion is brought into the retracted position before or during the rotatable arm (14), in a first rotation step, rotates around the toroidal core (4) in a first rotation direction (17) from a first reversal point (position A) at the first side (8) of the toroidal core (4) to a second reversal point (position C) at the second side (9) of the toroidal core (4), the wire grabbing portion thereby bypassing the wire (3), wherein the wire grabbing portion is brought into the extended position before or during the rotatable arm (14), in a second rotation step, rotates around the toroidal core (4) in a second rotation direction (18) which is opposite to said first rotation direction (17) from the second reversal point (position C) to the first reversal point (position A), the wire grabbing portion thereby grabbing the wire (3) such that the bending step is performed during the second rotation step.

**3.** Hook winding machine (1) according to claim 2, **characterized in that** a rotation angle ($\alpha$) between the first reversal point (position A) and the second reversal point (position C) is less than 320°.

**4.** Hook winding machine (1) according to claim 2 or 3, **characterized in that** the control is configured such that the wire grabbing portion is brought from the extended position to the retracted position after the hook (12) has been fully extended by the hook mechanism (11) and before the next pulling step is performed.

**5.** Hook winding machine (1) according to any one of claims 1 to 4, **characterized in that** the retracting mechanism comprises a rotatable cam disc (19) and a drive (20) for rotating the cam disc (19), wherein the retracting mechanism is configured such that rotation of the cam disc (19) causes a displacement of the grabbing portion in the retracting direction (21), wherein the cam disc (19) is preferably rotatable relative to the rotatable arm (14) around the first rotation axis (15).

**6.** Hook winding machine (1) according to claim 5, **characterized in that** the rotatable arm (14) comprises an eccentric shaft (22) arranged eccentrically with respect to the first rotation axis (15) and extending in the retracting direction (21), wherein the eccentric shaft (22) is slidable in the retracting direction (21), wherein a first axial end (23) of the eccentric shaft (22) carries the wire grabbing portion, and wherein the cam disc (19) acts on a second axial end (24) of the eccentric shaft (22).

**7.** Hook winding machine (1) according to any one of claims 1 to 6, **characterized in that** the wire grabbing portion is formed by a pulley (16) comprising two pulley halves (25, 26) that are pre-tensioned against each other and adapted to receive and hold the wire (3) in a gap (28) formed between the pulley halves (25, 26) when the wire (3) is grabbed.

**8.** Hook winding machine (1) according to claim 7, **characterized in that** the pulley halves (25, 26) taper towards each other.

**9.** Hook winding machine (1) according to claim 8, **characterized in that** a first pulley half (25) of the two pulley halves (25, 26) which is arranged further away from the second end (24) of the eccentric shaft (22) than a second pulley half (26) of the two pulley halves (25, 26), is smaller in axial length and maximum diameter then the second pulley half (26).

**10.** Hook winding machine (1) according to any one of claims 1 to 9, **characterized in that** the core holding device (10) is configured to hold the toroidal core (4) stationary while the wire bending device (13) rotates, after each winding cycle, around the core (4) by a certain advancing angle ($\beta$) about a second rotation axis (29), wherein the second rotation axis (29) preferably corresponds to the axis (7) of the core (4).

**11.** Hook winding machine (1) according to claim 10, **characterized in that** the hook mechanism (11) is configured to rotate together with the wire bending device (13) about the second rotation axis (29).

**12.** Hook winding device according to claim 10 or 11, **characterized in that** the core holding device (10) is a first core holding device holding the core (4) at a first sector (31) of the core (4), wherein the hook winding machine (1) further comprises a second core holding device (30) configured to take over after a portion of the coil has already been wound onto a second sector (32) of the core (4), wherein the second holding device holds the core (4) at the second sector (32) of the core (4), wherein the first core holding device (10) and the second core holding device (30) both are retractable, and wherein the first core holding device (10) is retracted after the second core holding device (30) has taken over such that another portion of the coil can be wound onto the first sector of the core (4).

**13.** Hook winding machine (1), in particular according to any one of claims 1 to 12, for winding a coil of wire (3) onto a toroidal core (4) having a trough hole (5),

an axis (6) defined by said through hole (5), an outer periphery (7), a first side (8) defined by a first axial end face of the core (4) and a second side (9) which is opposite said first side (8) and defined by a second axial end face of the core (4), the hook winding machine (1) comprising:

- a core holding device (10) for holding the core (4) during the winding process,
- a hook mechanism (11) with a longitudinally driven hook (12) for capturing the wire (3) and pulling the wire (3) from the first side (8) of the core (4) through the through hole of the core (4) to the second side (9) of the core (4),
- a wire bending device (13) for bending the wire (3) back from the second side (9) of the core (4) over the outer periphery of the core (4) to the first side (8) of the core (4), wherein the wire bending device (13) comprises a rotatable arm (14) that is rotatable about a first rotation axis (15) which is substantially perpendicular to the axis (7) of the toroidal core (4) or to an axis which is parallel to the axis (7) of the toroidal core (4), the rotatable arm (14) comprising a wire grabbing portion for grabbing the wire (3) and holding the wire (3) during bending the wire (3),
- and a control via which the hook winding machine (1) is adapted to alternately perform a pulling step during which the wire (3) is pulled by the hook mechanism (11) from the first side (8) of the core (4) through the through hole (5) of the core (4) to the second side (9) of the core (4) and a bending step during which the wire (3) is bent back by the wire bending mechanism (13) from the second side (9) of the core (4) over the outer periphery (7) of the core (4) to the first side (8) of the core (4), and wherein one winding cycle of the hook winding machine (1) is defined by a pulling step and a consecutive bending step,

**characterized in that**
the hook winding machine (1) further comprises a wire feeding device (33) for feeding at least a first portion (35) of a used length (34) of wire (3) required for the coil (2) from the first side (8) of the core (4) through the through hole (5) of the core (4) before the winding process starts.

**14.** Hook winding machine (1) according to claim 13, **characterized in that** the wire feeding device (33) is movable in a direction perpendicular to the axis (7) of the core (4) in order to hold a second portion (36) of the used length (34) of wire (3), which remains at the first side (8) of the core (4), eccentrically with respect to the axis (7) of the core (4) during the winding process without the used length (34) of wire (3) required for the coil (2) being cut off before the winding process has been finished.

**15.** Hook winding machine (1) according to claim 13, **characterized in that** the hook winding machine (1) further comprises an automatic core feeding device (37), a cutting unit for cutting the wire (3) and an automatic discharge unit for discharging completed products such that the hook winding machine (1) is fully-automatically operable without any operator's assistance.

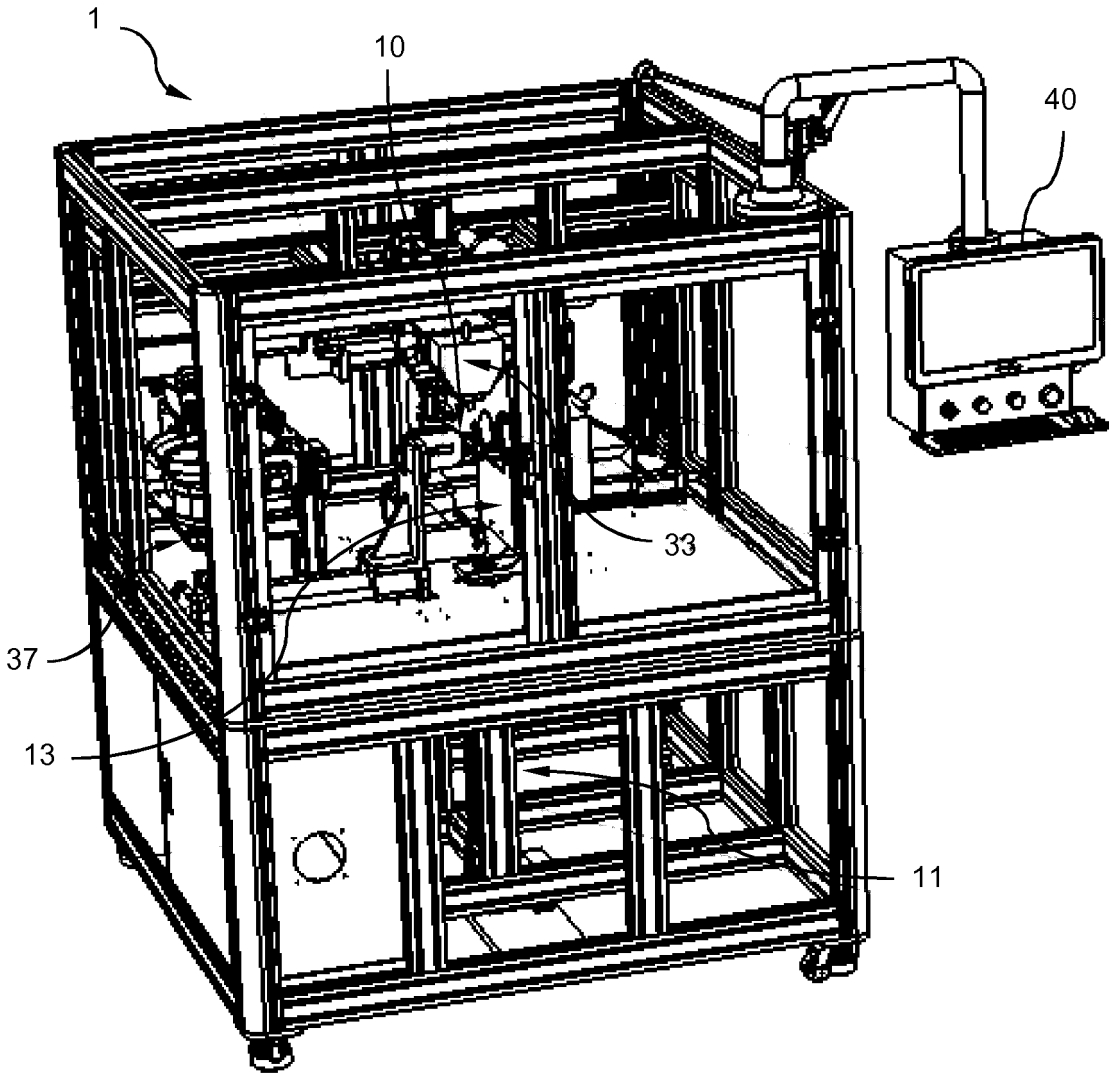


Fig. 1

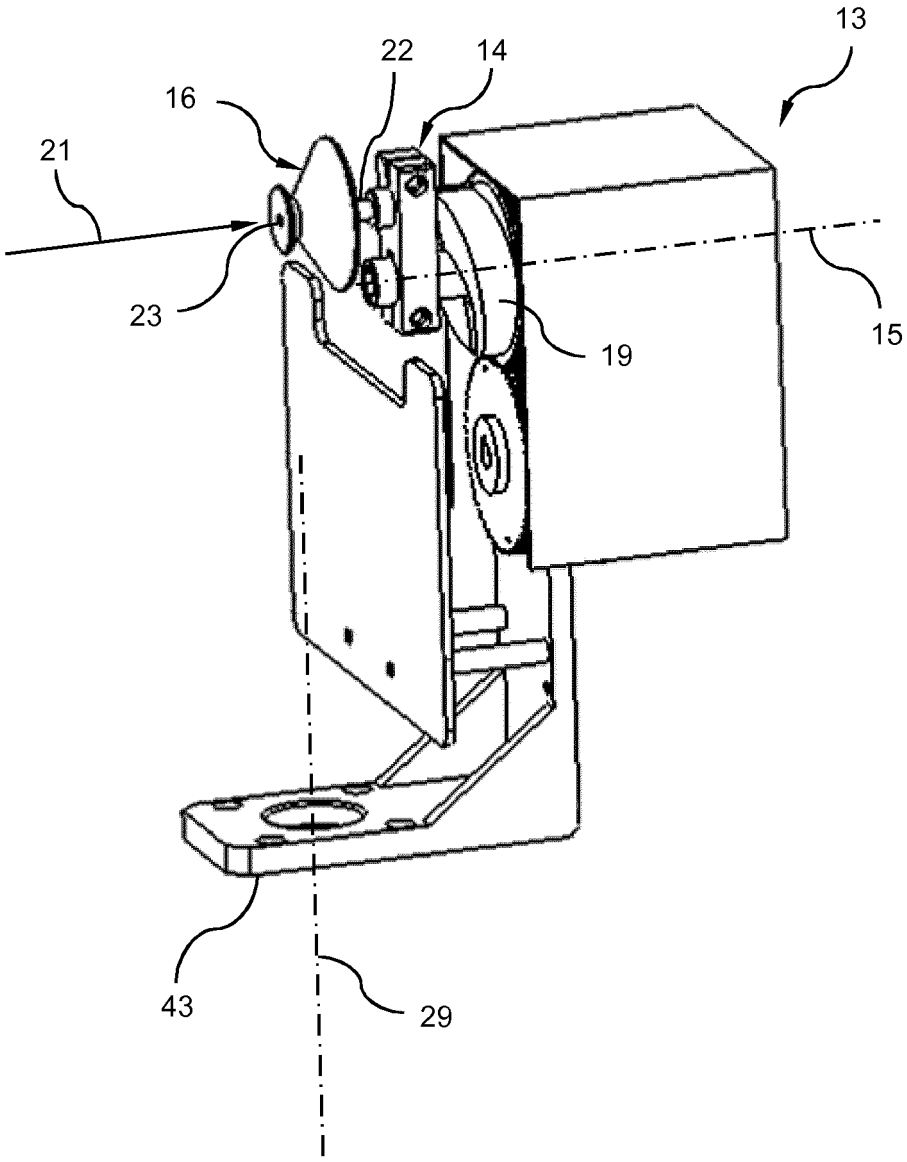


Fig. 2

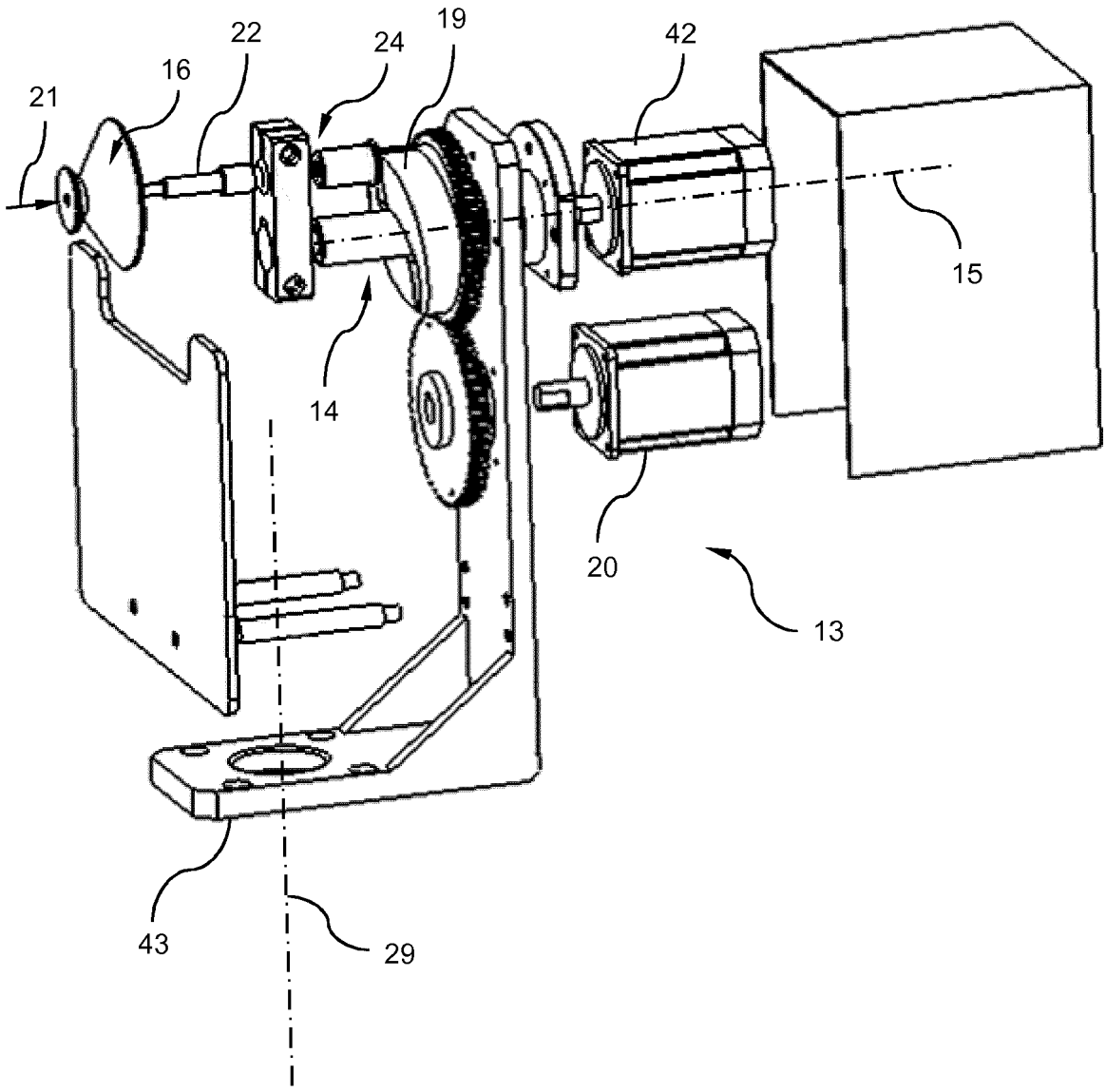


Fig. 3

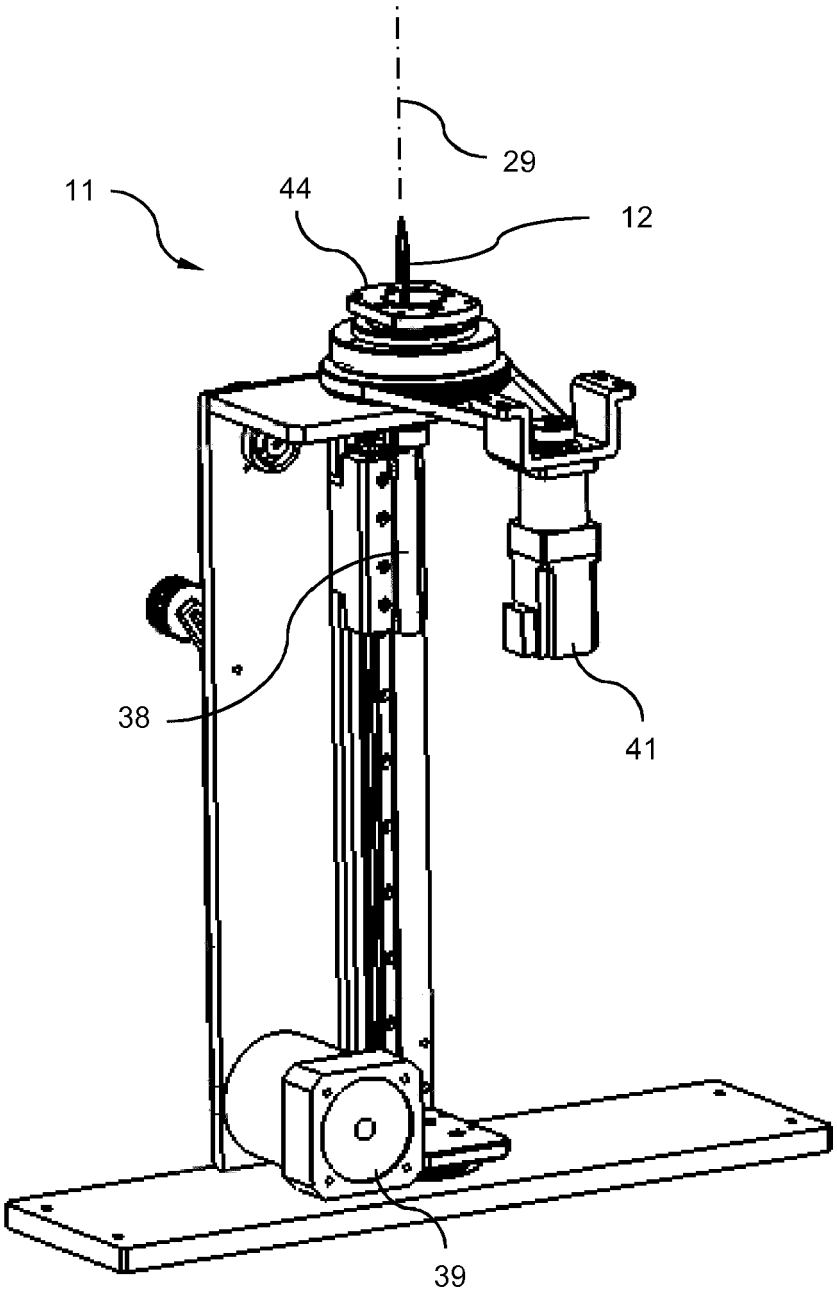


Fig. 4

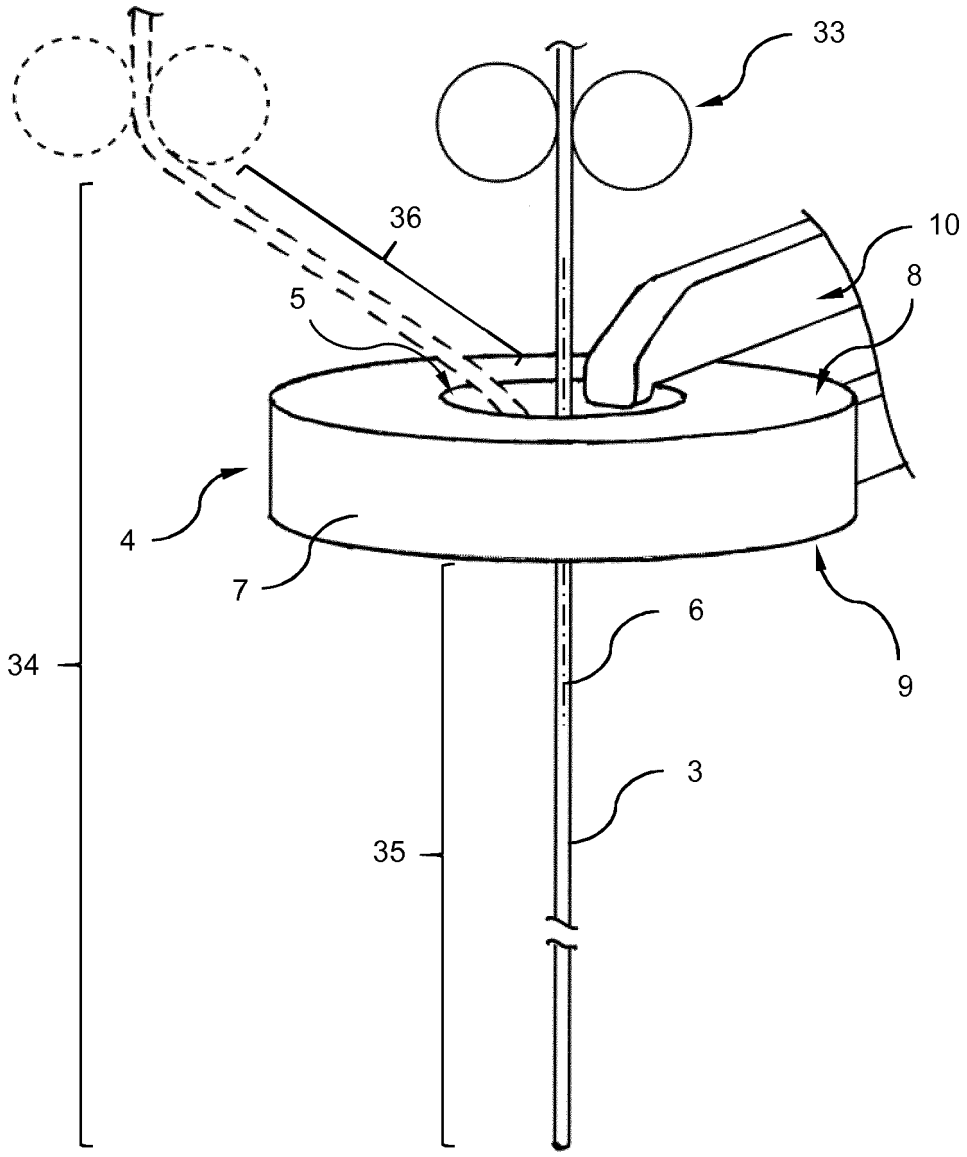


Fig. 5

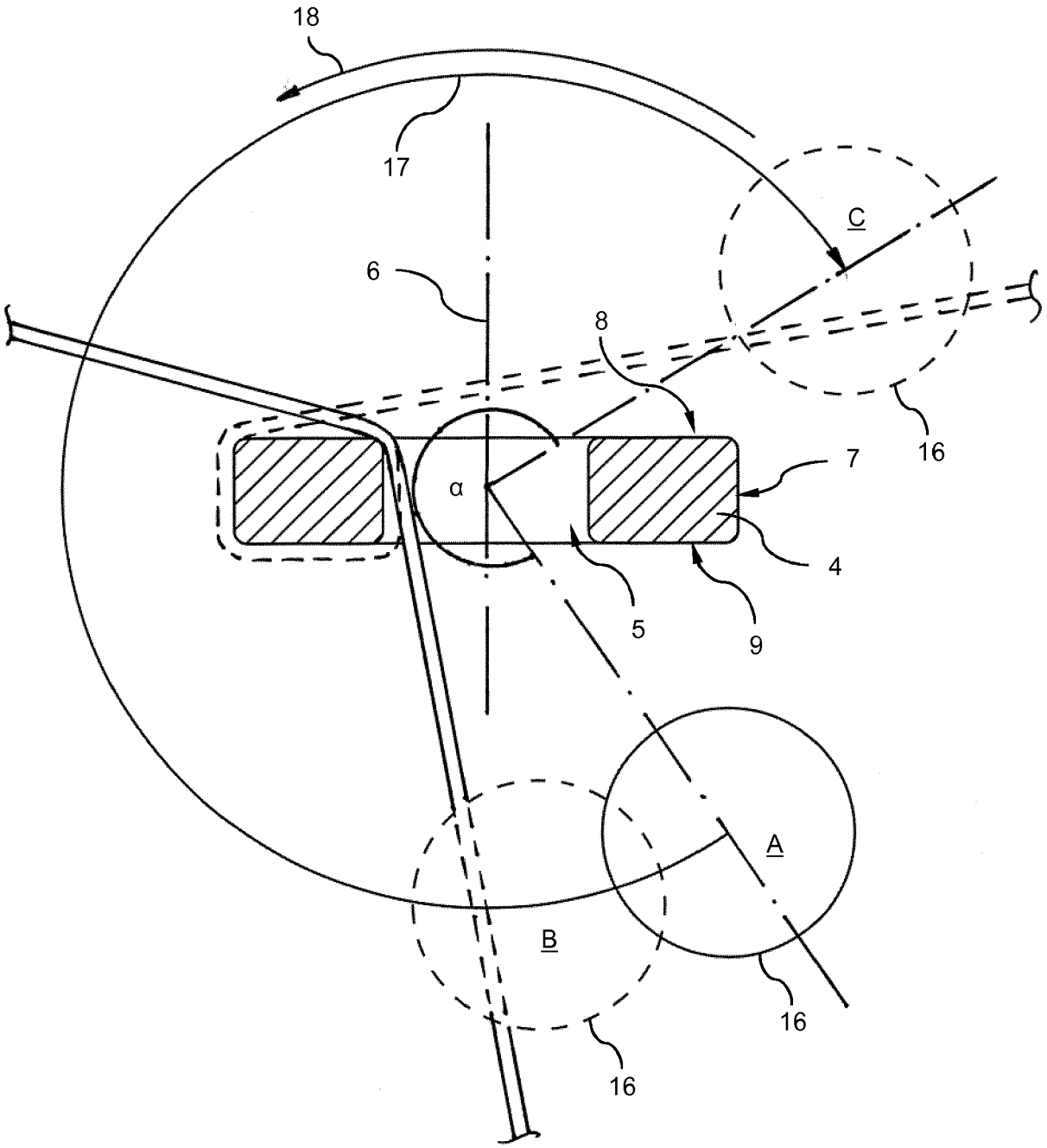


Fig. 6

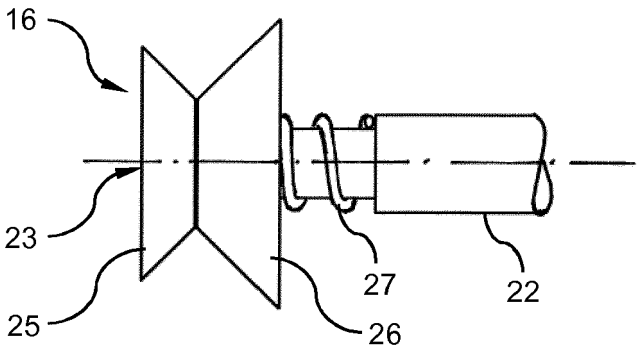


Fig 7

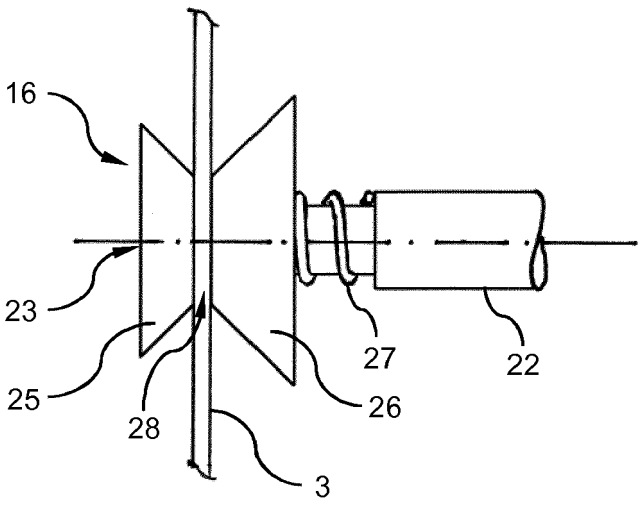


Fig. 8

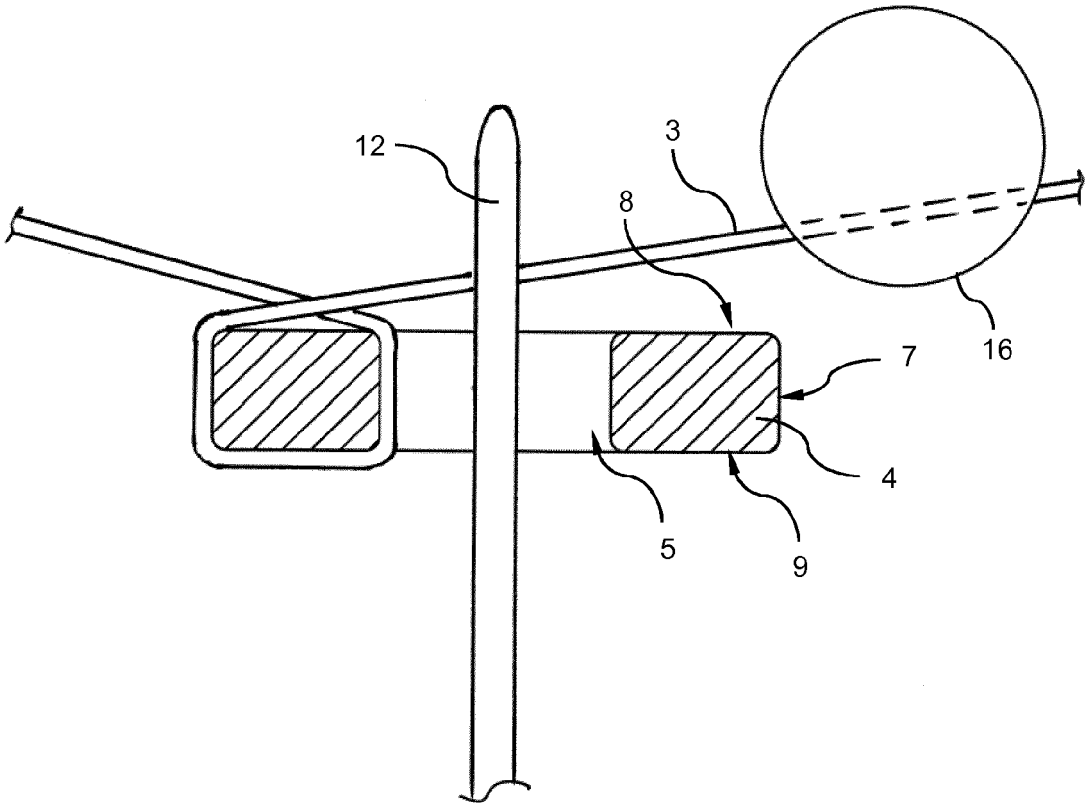


Fig. 9

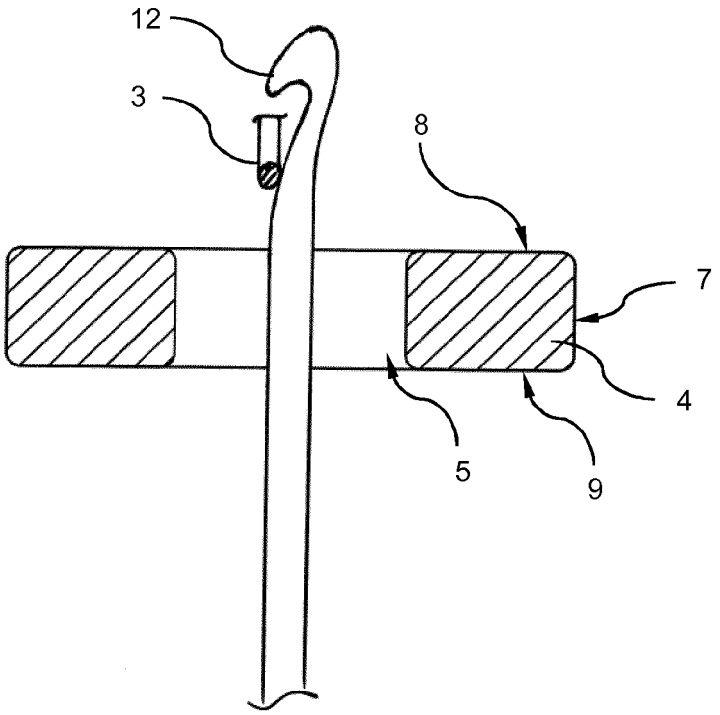


Fig. 10

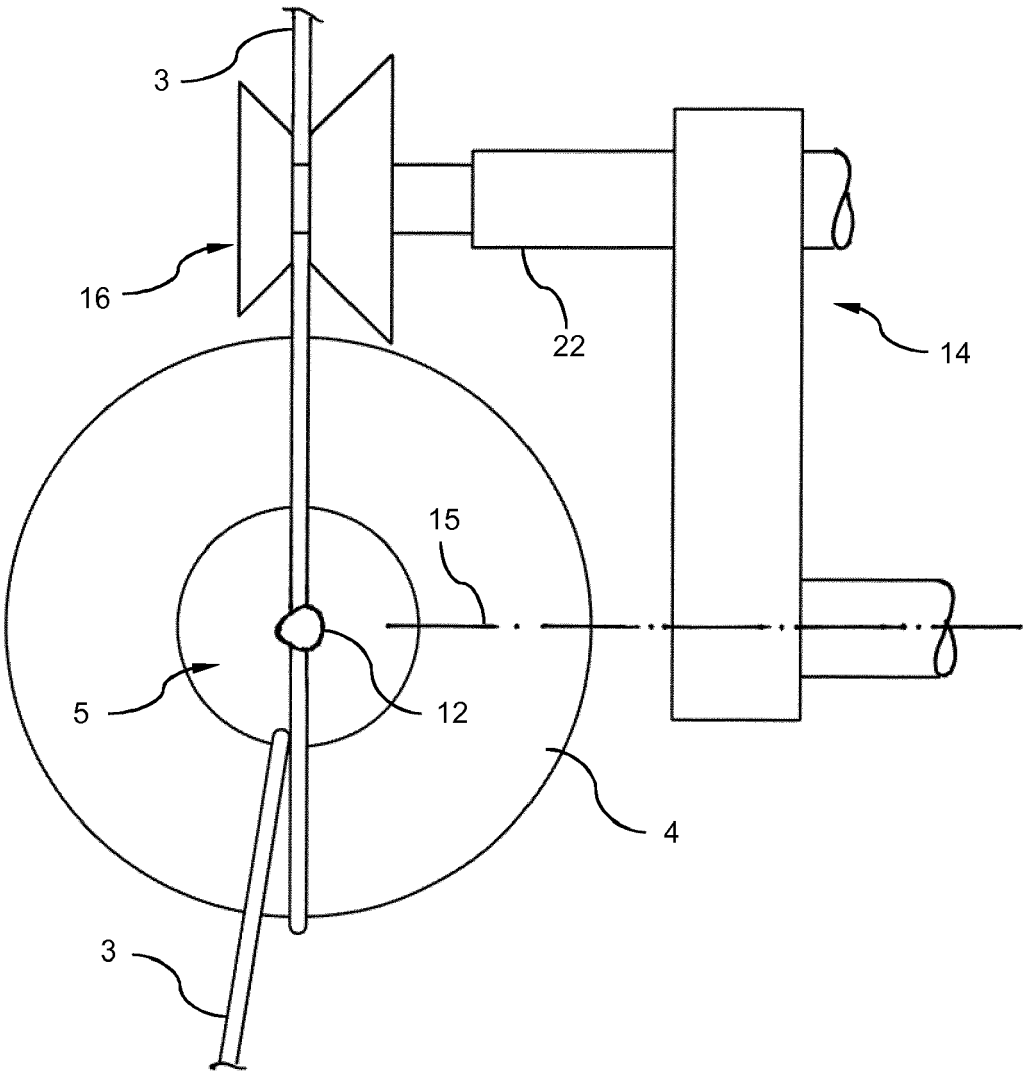


Fig. 11

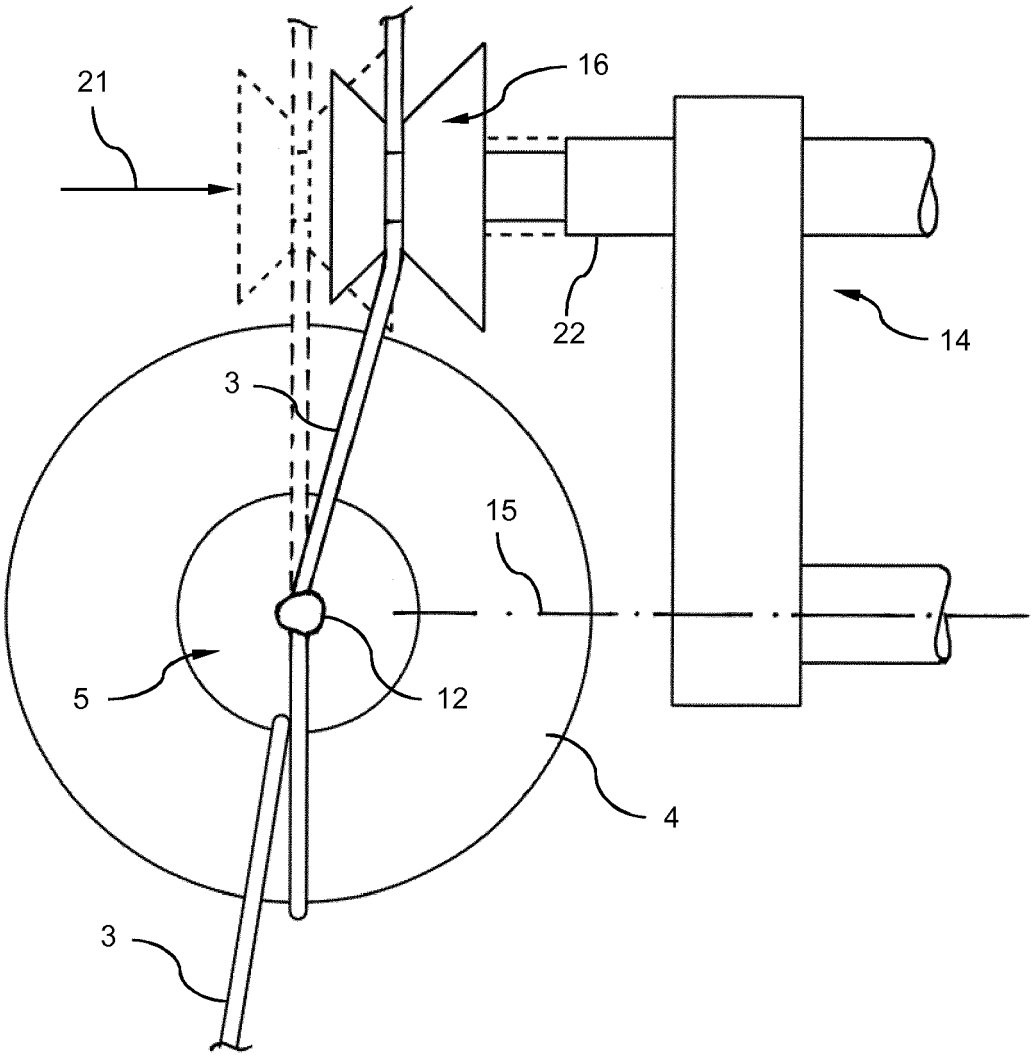


Fig. 12

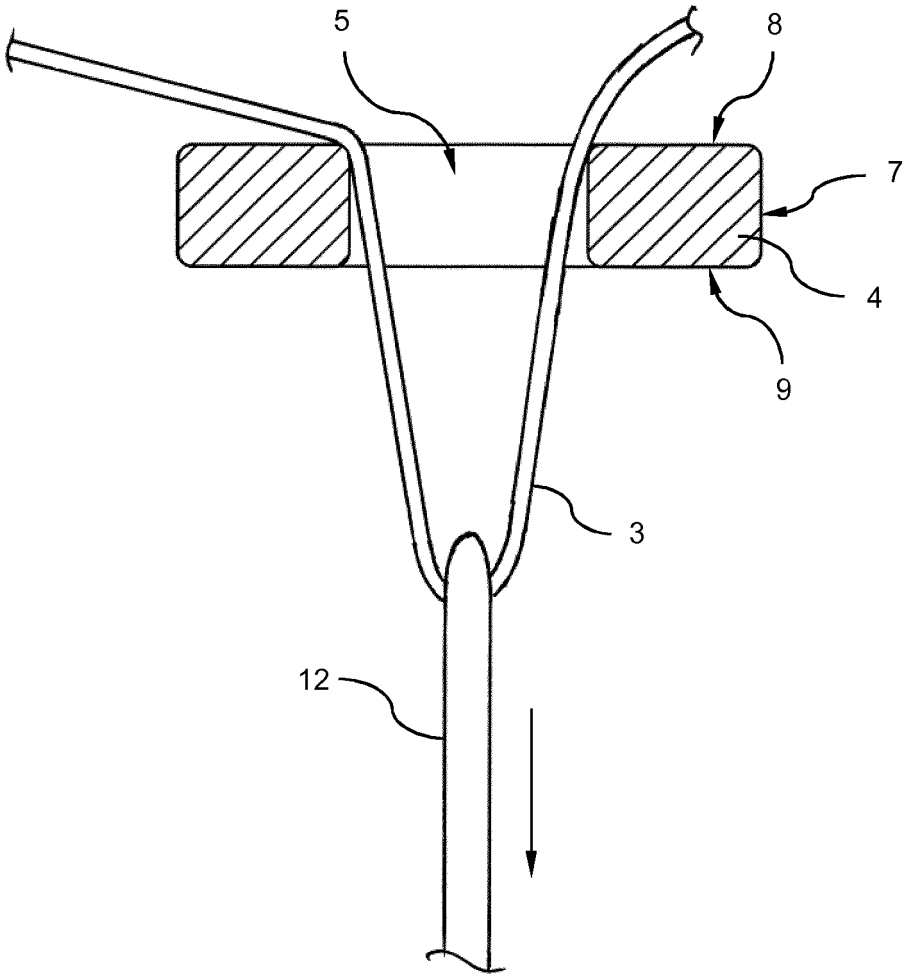


Fig. 13

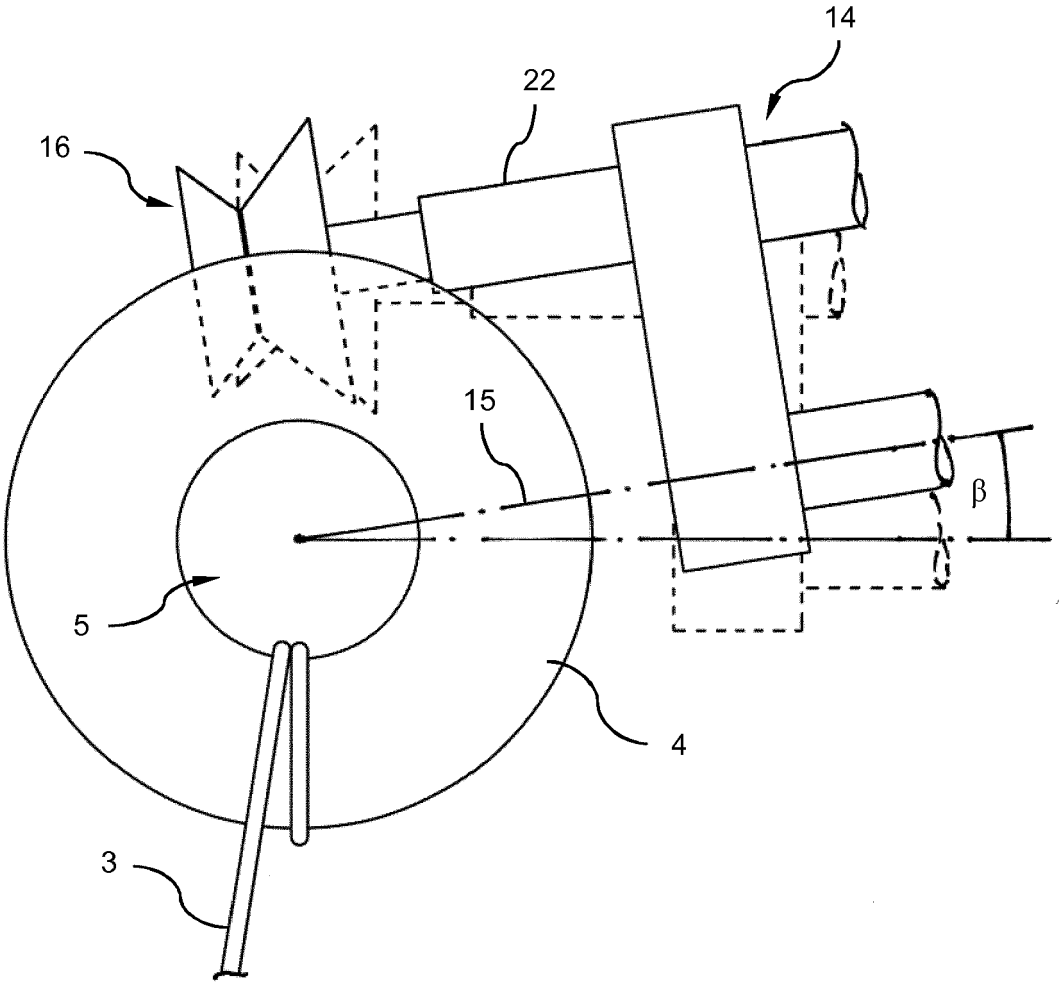


Fig. 14

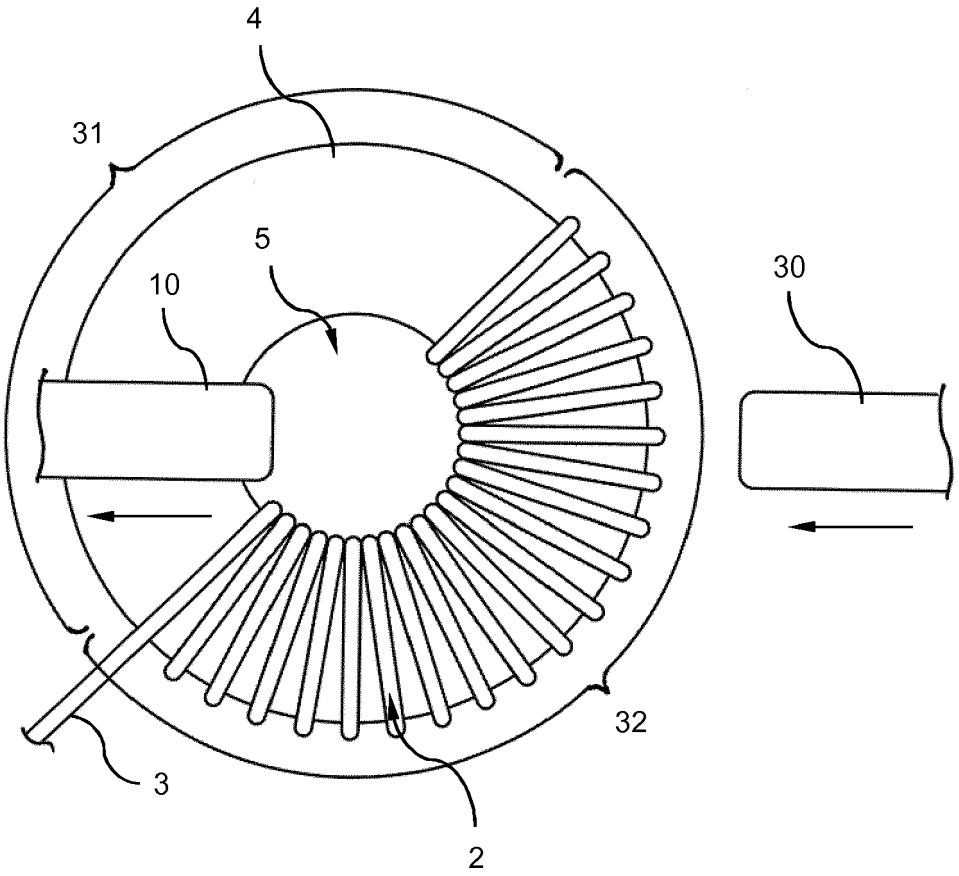


Fig. 15

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# EUROPEAN SEARCH REPORT

Application Number
EP 18 20 0393

## DOCUMENTS CONSIDERED TO BE RELEVANT

| Category | Citation of document with indication, where appropriate, of relevant passages | Relevant to claim | CLASSIFICATION OF THE APPLICATION (IPC) |
|---|---|---|---|
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| Y<br>A | JP 2015 050254 A (TAGA)<br>16 March 2015 (2015-03-16)<br>* figure 1 * | 8,9,12<br>1-7,10,<br>11,13-15 | |
| Y<br>A | JP H11 238643 A (TOKIN)<br>31 August 1999 (1999-08-31)<br>* figure 1 * | 12<br>1-11,<br>13-15 | |
| A | US 3 601 731 A (CHRISTIANA ET AL)<br>24 August 1971 (1971-08-24)<br>* column 3, lines 3-75 *<br>* figures 4, 5 * | 1-15 | |
| A | CH 353 810 A (STANDARD TELEPHON & RADIO)<br>30 April 1961 (1961-04-30)<br>* page 2, lines 3-27 *<br>* figures 1, 2, 4 * | 1-15 | TECHNICAL FIELDS SEARCHED (IPC)<br>H01F<br>B65H |

The present search report has been drawn up for all claims

| Place of search | Date of completion of the search | Examiner |
|---|---|---|
| Munich | 8 August 2019 | Subke, Kai-Olaf |

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
Y : particularly relevant if combined with another document of the same category
A : technological background
O : non-written disclosure
P : intermediate document

T : theory or principle underlying the invention
E : earlier patent document, but published on, or after the filing date
D : document cited in the application
L : document cited for other reasons

& : member of the same patent family, corresponding document

EPO FORM 1503 03.82 (P04C01)

Europäisches Patentamt
European Patent Office
Office européen des brevets

Application Number
EP 18 20 0393

## CLAIMS INCURRING FEES

The present European patent application comprised at the time of filing claims for which payment was due.

☐ Only part of the claims have been paid within the prescribed time limit. The present European search report has been drawn up for those claims for which no payment was due and for those claims for which claims fees have been paid, namely claim(s):

☐ No claims fees have been paid within the prescribed time limit. The present European search report has been drawn up for those claims for which no payment was due.

## LACK OF UNITY OF INVENTION

The Search Division considers that the present European patent application does not comply with the requirements of unity of invention and relates to several inventions or groups of inventions, namely:

see sheet B

☒ All further search fees have been paid within the fixed time limit. The present European search report has been drawn up for all claims.

☐ As all searchable claims could be searched without effort justifying an additional fee, the Search Division did not invite payment of any additional fee.

☐ Only part of the further search fees have been paid within the fixed time limit. The present European search report has been drawn up for those parts of the European patent application which relate to the inventions in respect of which search fees have been paid, namely claims:

☐ None of the further search fees have been paid within the fixed time limit. The present European search report has been drawn up for those parts of the European patent application which relate to the invention first mentioned in the claims, namely claims:

☐ The present supplementary European search report has been drawn up for those parts of the European patent application which relate to the invention first mentioned in the claims (Rule 164 (1) EPC).

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## LACK OF UNITY OF INVENTION
## SHEET B

Application Number
EP 18 20 0393

The Search Division considers that the present European patent application does not comply with the requirements of unity of invention and relates to several inventions or groups of inventions, namely:

1. claims: 1-12

   hook winding machine with a retractable wire grabber on the winding device

   ---

2. claims: 13-15

   hook winding machine with wire feeding from top

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## ANNEX TO THE EUROPEAN SEARCH REPORT ON EUROPEAN PATENT APPLICATION NO. EP 18 20 0393

This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report. The members are as contained in the European Patent Office EDP file on
The European Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

08-08-2019

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For more details about this annex : see Official Journal of the European Patent Office, No. 12/82