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(54) **YARN WINDER**

GARNWICKLER

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Description

BACKGROUND OF THE INVENTION

[0001] The present invention relates to a yarn winder.

[0002] WO2020075383A1 discloses a yarn winder configured to wind a running yarn onto a bobbin, so as to form a package. Specifically, the yarn winder includes a traverse unit having a traverse guide for traversing the yarn along the axial direction of the bobbin, a winding unit for rotating the bobbin, and a roller (feed roller) for feeding the yarn to the winding unit. Tension is applied to the yarn by the difference between the winding speed at which the yarn is wound onto the bobbin and the yarn feeding speed at which the yarn is sent by the feed roller. (In other words, the yarn winder includes a tension applying unit configured to apply tension to the yarn which is wound onto the bobbin) . Because tension is controlled to be at a predetermined value in this way, a package with a predetermined winding density is formed in accordance with the use.

[0003] The tension which is actually applied to the yarn may vary due to a reciprocal movement of the traverse guide. For example, when the traverse guide is moved from the center toward one end side in an area where the traverse guide reciprocates in a predetermined traverse direction, the tension may be unintentionally increased because the length of a yarn path is increased and the yarn is pulled outward by the traverse guide in the area where the traverse guide reciprocates in the traverse direction. Meanwhile, when the direction of the traverse guide is switched from the outward to the inward in the area where the traverse guide reciprocates in the traverse direction, the tension may be unintentionally decreased because the length of the yarn path is decreased and the yarn is temporarily pulled by the traverse guide more gently than usual. This variation of tension is suppressed in such a way that, for example, a controller (tension adjustment unit) such as a computer controls the yarn feeding speed. For example, EP1318097B1 has proposed a means for controlling the yarn feeding speed by using information regarding a position of the traverse guide. EP 1 520 827 A1 discloses a yarn winder according to the preamble of claim 1.

SUMMARY OF THE INVENTION

[0004] There is some time lag (delay) between acquisition of information for the tension adjustment in consideration of the position (and/or speed) of a traverse guide by a tension adjustment unit and actual adjustment of tension. The time lag is caused by, for example, the time required for calculation performed by the tension adjustment unit and the time required for the response of a tension applying unit. Due to such a delay, for example, when the traverse cycle is short (i.e., the movement of the traverse guide is quick), actual tension adjustment may not sufficiently follow a variation of tension which is caused by the movement of the traverse guide. This may cause a problem in which a variation of tension is not sufficiently suppressed. WO2020075383A1 and EP1318097B1 are silent on the above-described time lag.

[0005] An object of the present invention is to effectively suppress a variation of tension due to the reciprocal movement of a traverse guide.

[0006] According to a first aspect of the invention, a yarn winder configured to wind a running yarn onto a bobbin includes: a traverse unit which includes a traverse guide for traversing the yarn along an axial direction of the bobbin; a tension applying unit configured to apply tension to the yarn which is to be wound onto the bobbin; and a control unit, the control unit includes: a prediction information acquisition unit configured to obtain prediction information regarding at least one of a predicted future position and predicted future speed of the traverse guide; and a tension adjustment unit configured to control the tension applying unit based on adjustment information regarding the adjustment of the tension, and the tension adjustment unit obtains the adjustment information corresponding to a predetermined first time point in association with the prediction information corresponding to a second time point which is a time point after the elapse of a predetermined time from the first time point.

[0007] In the present invention, the adjustment information corresponding to the first time point is obtained in association with the prediction information corresponding to the second time point which is a time point after the elapse of a predetermined time (i.e., which is a predetermined time later) from the first time point. In this regard, "obtained in association with" indicates that there is some relation (such as calculation and link) between the adjustment information corresponding to the first time point and the prediction information corresponding to the second time point. The predetermined time can be set or determined in consideration of the above-described time lag (delay).

[0008] This enables the tension adjustment unit to output a signal at a time point earlier than the second time point by a predetermined time. The signal is related to the adjustment, which is supposed to be actually executed at the second time point, of the tension. Because of this, the above-described delay is compensated, and thus the tension is adjusted at an appropriate timing. Therefore, the variation of the tension due to the reciprocal movement of the traverse guide is effectively suppressed.

[0009] According to a second aspect of the invention, the yarn winder of the first aspect is arranged such that the predetermined time is shorter than a reciprocal cycle of the traverse guide.

[0010] In the present invention, the predetermined time is shorter than the reciprocal cycle of the traverse guide. Because of this, it is possible to suppress the increase in difference between a predicted position and/or predicted speed of the traverse guide at the second time point and an actual position and/or actual speed of the traverse guide at the second time point. In this regard, the predicted position and the predicted speed are predicted at the first time point. The tension is therefore finely controllable.

[0011] According to a third aspect of the invention, the yarn winder of the first or second aspect further includes a tension detection unit configured to detect the tension applied to the yarn, and the tension adjustment unit obtains the adjustment information based on a detection result of the tension detection unit.

[0012] The tension of the yarn may be varied not only due to the reciprocal movement of the traverse guide but also due to other disturbance factors. By obtaining the adjustment information based on a detection result of the tension detection unit, it is possible to perform a feedback control so that the magnitude of the tension is close to a predetermined target value in the present invention. Therefore, because the variation of the tension due to disturbance factors except the reciprocal movement of the traverse guide is also suppressed, the tension is further stabilized.

[0013] According to a fourth aspect of the invention, the yarn winder of any one of the first to third aspects is arranged such that the tension applying unit includes: a winding unit configured to wind the yarn onto the bobbin; and a yarn feeding unit configured to send the yarn to the bobbin, the tension applying unit applies the tension to the yarn by utilizing a difference between a winding speed at which the yarn is wound onto the bobbin by the winding unit and a yarn feeding speed at which the yarn is sent to the bobbin by the yarn feeding unit, and the tension adjustment unit controls the tension by controlling the yarn feeding unit.

[0014] When the tension is applied to the yarn Y by difference between the winding speed and the yarn feeding speed, the tension can be controlled by controlling the winding speed. However, when the tension is controlled by controlling the winding speed, a winding angle (this angle is a helix angle) of the yarn may be unintentionally varied. In this case, it is further necessary to control the traverse unit in order to suppress the variation of a helix angle. This may complicate the control. In the present invention, because the tension is controlled by controlling the yarn feeding speed, the control of the tension is simplified as compared to cases where the winding unit is controlled in order to control the tension.

[0015] According to a fifth aspect of the invention, the yarn winder of any one of the first to fourth aspects is arranged such that the control unit changes a target value of the tension during the reciprocal cycle of the traverse guide.

[0016] The control in which the variation of the tension is suppressed in consideration of the above-described time lag in the present invention is especially effective in the structure configured so that a target value of the tension is changed during the reciprocal cycle of the traverse guide.

[0017] According to a sixth aspect of the invention, in a traverse direction in which the traverse guide moves, the yarn winder of the fifth aspect is arranged such that the control unit arranges a target value of the tension when the traverse guide is positioned at one end in a traverse area where the traverse guide reciprocates in regard to the traverse direction to be lower than a target value of the tension when the traverse guide is positioned at a center in the traverse area.

[0018] When the tension of the yarn is high while the traverse guide is positioned at one end side in the traverse area, the yarn may be unintentionally pulled inward in the axial direction of the bobbin at the time of changing the direction of the traverse guide. As a result, an amount of the yarn wound onto the inside of a target position in the axial direction of the bobbin may be increased so as to deteriorate the shape of a package. In the present invention, the tension when the traverse guide is positioned at one end side in the traverse area is arranged to be low. It is therefore possible to suppress the yarn from being unintentionally pulled inward in the axial direction of the bobbin at the time of changing the direction of the traverse guide.

BRIEF DESCRIPTION OF THE DRAWINGS

[0019]

FIG. 1 is a schematic front view of a re-winder of an embodiment.

FIG. 2 shows an electric structure of the re-winder.

FIG. 3 shows a graph of the relationship between a position of a traverse guide and time points and a graph of the relationship between the speed of the traverse guide and time points.

FIG. 4 shows a graph of the relationship between the position of the traverse guide and time points of a first reference example, a graph of the relationship between the number of rotations of a feed roller and time points of the first reference example, and a graph of the relationship between the tension of a yarn and time points of the first reference example.

FIG. 5 shows a graph of the relationship between the position of the traverse guide and time points of a second reference example, a graph of the relationship between the number of rotations of the feed roller and time points of the second reference example, and a graph of the relationship between the tension of the yarn and time points of the second reference example.

FIG. 6 is a table showing the correspondence between a predicted position of the traverse guide, a predicted speed of the traverse guide, and time points.

FIG. 7 is a table showing the relationship between the predicted position of the traverse guide at one time point and the desired number of rotations of the feed roller at that time point.

FIG. 8 is a table showing the relationship between a command value regarding the number of rotations of the feed roller and time points in consideration of a predetermined time lag.

FIG. 9 shows a graph of the relationship between the position of the traverse guide of the present embodiment and time points, a graph of the relationship between the number of rotations of the feed roller of the present embodiment and time points, and a graph of the relationship between the tension of the yarn of the present embodiment and time points.

FIG. 10 shows a graph of the relationship between a position of a traverse guide of a modification and time points, a graph of the relationship between the number of rotations of a feed roller of the modification and time points, and a graph of the relationship between the tension of a yarn of the modification and time points.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0020] The following will describe an embodiment of the present invention with reference to FIG. 1 to FIG. 9. An up-down direction and a left-right direction shown in FIG. 1 will be referred to as an up-down direction and a left-right direction of a re-winder 1. A direction orthogonal to both the up-down direction and the left-right direction (i.e., a direction perpendicular to the plane of FIG. 1) will be referred to as a front-rear direction. A direction in which a yarn Y runs will be referred to as a yarn running direction.

(Structure of Re-Winder)

[0021] To begin with, the structure of a re-winder 1 (a yarn winder of the present invention) of the present embodiment will be described with reference to FIG. 1. FIG. 1 is a schematic front view of the re-winder 1. As shown in FIG. 1, the re-winder 1 includes a frame 11, a yarn supplying unit 12, a winding unit 13, a yarn feeding unit 14, and a controller 15 (a control unit of the present invention). The re-winder 1 is configured to unwind a yarn Y from a yarn supply package Ps supported by the yarn supplying unit 12 and to re-wind the yarn Y back to a winding bobbin Bw (a bobbin of the present invention) by the winding unit 13, so as to form a wound package Pw. To be more specific, the re-winder 1 is used for, for example, re-winding the yarn Y wound on a yarn supply package Ps in a more beautiful manner and for forming a wound package Pw with a desired density.

[0022] The frame 11 is provided to extend in the up-down direction. The frame 11 vertically extends on, e.g., an unillustrated floor. At a lower part of the frame 11, the yarn supplying unit 12 is provided. At an upper part of the frame 11, the winding unit 13 is provided. At an intermediate portion of the frame 11 in the up-down direction, the yarn feeding unit 14 is provided.

[0023] The yarn supplying unit 12 is provided at the lower part of the frame 11. The yarn supplying unit 12 is arranged to support the yarn supply package Ps which is formed by winding the yarn Y onto a yarn supplying bobbin Bs. The yarn supplying unit 12 is therefore able to supply the yarn Y.

[0024] The winding unit 13 is configured to form the wound package Pw by winding the yarn Y onto the winding bobbin Bw. The winding unit 13 is provided at the upper part of the frame 11. The winding unit 13 includes a cradle arm 21, a winding motor 22, a traverse unit 23, and a contact roller 24.

[0025] The cradle arm 21 is, for example, attached to the frame 11 to be swingable. The cradle arm 21 is arranged to support the winding bobbin Bw to be rotatable in such a way that, for example, the left-right direction is the axial direction of the winding bobbin Bw. For example, at a leading end portion of the cradle arm 21, a bobbin holder (not illustrated) is rotatably attached to hold the winding bobbin Bw. The winding motor 22 is a motor configured to rotationally drive the bobbin holder. The winding motor 22 is, e.g., a typical stepping motor. The winding motor 22 may include a rotary encoder (not illustrated) configured to detect a rotation angle of a rotational shaft (not illustrated) of the winding motor 22. The winding motor 22 is configured so that the number of rotations of its rotational shaft (i.e., the number of rotations per a predetermined time) is variable. The winding motor 22 is therefore able to change the winding speed at which the yarn Y is wound onto the winding bobbin Bw (i.e., the circumferential speed of a surface of the wound package Pw). The winding motor 22 is electrically connected to the controller 15 (see FIG. 2).

[0026] The traverse unit 23 is configured to traverse the yarn Y along the axial direction of the winding bobbin Bw (the left-right direction in the present embodiment). The traverse unit 23 is provided immediately upstream of the wound package Pw in the yarn running direction. The traverse unit 23 includes a traverse motor 31, an endless belt 32, and a traverse guide 33.

[0027] The traverse motor 31 is, e.g., a typical stepping motor. The traverse motor 31 is configured to enable its rotational shaft (not illustrated) to be rotated forward and backward. The traverse motor 31 may include a rotary encoder (not illustrated) configured to detect a rotation angle of the rotational shaft (not illustrated) of the traverse motor 31. The traverse motor 31 is configured so that the number of rotations of its rotational shaft is variable. The traverse motor 31 is electrically connected to the controller 15 (see FIG. 2). The endless belt 32 is a belt member to which the traverse guide 33 is attached. The endless belt 32 is wound onto pulleys 34 and 35 which are separated from each other in the left-right direction and a driving pulley 36 connected to the rotational shaft of the traverse motor 31, and is substantially triangular in shape when wound onto the pulleys. The endless belt 32 is reciprocally driven by the traverse motor 31. The traverse guide 33 is attached to the endless belt 32 and is provided between the pulley 34 and the pulley 35 in the left-right direction. The traverse guide 33 linearly and reciprocally runs in the left-right direction as the endless belt 32 is reciprocally driven by the traverse motor 31 (see arrows in FIG. 1). As a result, the traverse guide 33 traverses the yarn Y in the left-right direction (hereinafter, this direction may be referred to as a traverse direction).

[0028] The contact roller 24 makes contact with the surface of the wound package Pw and applies a contact pressure to the surface, so as to adjust the shape of the wound package Pw. The contact roller 24 makes contact with the wound package Pw and is rotated by the rotation of the wound package Pw.

[0029] The yarn feeding unit 14 is configured to send the yarn Y unwound from the yarn supply package Ps, to the winding bobbin Bw. The yarn feeding unit 14 is provided between the yarn supplying unit 12 and the winding unit 13 in the yarn running direction. The yarn feeding unit 14 includes a feed roller 41 and a roller drive motor 42.

[0030] The feed roller 41 is a roller onto which the yarn Y is wound. The feed roller 41 is, e.g., a known nip roller. The feed roller 41 is provided on a front surface of the frame 11. The feed roller 41 is configured to rotate so that the yarn Y is sent to the downstream side in the yarn running direction. The feed roller 41 is rotationally driven by the roller drive motor 42. The roller drive motor 42 is, e.g., a typical stepping motor. The roller drive motor 42 may include a rotary encoder (not illustrated) configured to detect a rotation angle of a rotational shaft (not illustrated) of the roller drive motor 42. The roller drive motor 42 is configured so that the number of rotations of its rotational shaft is variable. The roller drive motor 42 is therefore able to change the number of rotations of the feed roller 41 (i.e., able to change the yarn feeding speed of the feed roller 41). The roller drive motor 42 is electrically connected to the controller 15 (see FIG. 2). In the present embodiment, tension is applied to the yarn Y by the difference between the winding speed of the winding unit 13 and the yarn feeding speed of the yarn feeding unit 14. That is, the combination of the structure of the winding unit 13 and the structure of the yarn feeding unit 14 corresponds to a tension applying unit of the present invention. Tension generally increases as the above-described difference between the speeds increases, and tension generally decreases as the above-described difference between the speeds decreases.

[0031] At a lower part (on the upstream side in the yarn running direction) of the yarn feeding unit 14, a yarn guide 16 is provided. The yarn guide 16 is provided, for example, on an extension of the central axis of the yarn supplying bobbin Bs. The yarn guide 16 guides the yarn Y unwound from the yarn supply package Ps, to the downstream side in the yarn running direction. At an upper part (on the downstream side in the yarn running direction) of the yarn feeding unit 14, a tension sensor 17 (a tension detection unit of the present invention) is provided. The tension sensor 17 is configured to detect the tension applied to the yarn Y running from the yarn feeding unit 14 toward the winding unit 13. While the tension sensor 17 is, e.g., an unillustrated contact-type sensor having a piezoelectric element, the disclosure is not limited to this. The tension sensor 17 is electrically connected to the controller 15 (see FIG. 2). The tension sensor 17 outputs a detection signal to the controller 15. The tension sensor 17 functions as a fulcrum guide about which the yarn Y is traversed by the traverse guide 33. A yarn guide (not illustrated) which functions as a fulcrum guide may be provided downstream of the tension sensor 17 in the yarn running direction.

[0032] The controller 15 includes members such as CPU, a ROM, and a RAM (a storage unit 51; see FIG. 2). The storage unit 51 stores, for example, parameters such as an amount of the wound yarn Y, the winding speed, and the target tension which is supposed to be applied to the yarn Y. The controller 15 controls components by using the CPU and a program stored in the ROM, based on the parameters stored in the storage unit 51. The controller 15 is electrically connected to the winding motor 22, the traverse motor 31, the roller drive motor 42, and the tension sensor 17 (see FIG. 2).

[0033] As described later, the controller 15 functions as a winding control unit 52, a traverse control unit 53 (a prediction information acquisition unit of the present invention), and a roller control unit 54 (a tension adjustment unit of the present invention; see FIG. 2). To begin with, the controller 15 obtains winding information regarding a target value of the number of rotations of the winding bobbin Bw (or the winding speed of the yarn Y wound by the winding unit 13) from the storage unit 51. The controller 15 outputs a signal for controlling the torque of the winding motor 22 to the winding motor 22, based on the winding information. That is, the controller 15 functions as the winding control unit 52 configured to control the winding motor 22.

[0034] The controller 15 further obtains target traverse information regarding a target position and target speed of the traverse guide 33, from the storage unit 51. The controller 15 outputs a signal for controlling the torque of the traverse motor 31 to the traverse motor 31, based on the target traverse information. That is, the controller 15 functions as the traverse control unit 53 configured to control the traverse motor 31.

[0035] The controller 15 further obtains yarn feeding information regarding the number of rotations of the feed roller 41 (i.e., the yarn feeding speed of the yarn feeding unit 14). The controller 15 outputs a signal for controlling the number of rotations of the feed roller 41 (specifically, the torque of the roller drive motor 42) to the roller drive motor 42, based on the yarn feeding information. That is, the controller 15 functions as the roller control unit 54 configured to control the roller drive motor 42.

[0036] In the re-winder 1 arranged as described above, the yarn Y unwound from the yarn supply package Ps runs toward the downstream side in the yarn running direction. The running yarn Y is wound onto the rotating winding bobbin Bw while being traversed in the left-right direction (traverse direction) by the traverse guide 33. The tension applied to the yarn Y is controlled to be close to a predetermined target tension mainly by adjusting the number of rotations of the feed roller 41 (i.e., by adjusting the yarn feeding speed of the yarn feeding unit 14). That is, the tension of the yarn Y is controlled in such a way that the controller 15 (roller control unit 54) adjusts the number of rotations of the feed roller 41 based on rotation number adjustment information (adjustment information of the present invention) regarding the number of rotations of the feed roller 41. The details of tension control will be given later.

(Reciprocal Movement of Traverse Guide)

[0037] The reciprocal movement of the traverse guide 33 will be described with reference to FIG. 3. The topmost graph in FIG. 3 shows the relationship between the position, in regard to the traverse direction, of the traverse guide 33 and time points. The lowermost graph in FIG. 3 shows the relationship between the speed, in regard to the traverse direction, of the traverse guide 33 and time points.

[0038] In the topmost graph in FIG. 3, the horizontal axis indicates time points whereas the vertical axis indicates the position of the traverse guide 33 in regard to the traverse direction. For convenience, a direction leftward of the center of an area where the traverse guide 33 reciprocates (i.e., traverse area) will be regarded as a positive direction of the vertical axis of the graph. A direction rightward of the center of the traverse area will be regarded as a negative direction of the vertical axis of the graph. The traverse guide 33 reciprocates in the left-right direction in such a way that the traverse motor 31 is driven by the controller 15. The symbol "T" shown in FIG. 3 indicates the cycle in which the traverse guide 33 completes a reciprocal movement once. To be more specific, when it is at a time point of 0 in FIG. 3, the traverse guide 33 is positioned at the center of the traverse area. In addition to that, when it is at a time point of T/4, the traverse guide 33 is positioned at the left end of the traverse area. In addition to that, when it is at a time point of T/2, the traverse guide 33 is positioned at the center of the traverse area. In addition to that, when it is at a time point of is 3T/4, the traverse guide 33 is positioned at the right end of the traverse area. When the traverse guide 33 is positioned at the center of the traverse area, a yarn path from the fulcrum guide (tension sensor 17 in the present embodiment) to the traverse guide 33 is the shortest. Meanwhile, when the traverse guide 33 is positioned at an end of the traverse area, the yarn path is the longest.

[0039] The speed of the traverse guide 33 varies as shown in the lowermost graph in FIG. 3. To be more specific, when it is at a time point of T/4 in FIG. 3, the direction of the traverse guide 33 is switched from leftward to rightward in the traverse area in regard to the traverse direction. In addition to that, when it is at a time point of 3T/4, the direction of the traverse guide 33 is switched from rightward to leftward in the traverse area in regard to the traverse direction.

(Variation of Tension of Yarn due to Reciprocal Movement of Traverse Guide)

[0040] The following will describe a variation of tension due to the reciprocal movement of the traverse guide 33 with reference to FIG. 4 and FIG. 5. FIG. 4 shows a graph of the relationship between the position of the traverse guide 33 and time points of a first reference example, a graph of the relationship between the number of rotations of the feed roller 41 and time points of the first reference example, and a graph of the relationship between the tension of the yarn Y and time points of the first reference example. FIG. 5 shows graphs of a second reference example. In FIG. 4 and FIG. 5, the topmost graph shows the relationship between the position of the traverse guide 33 and time points. In addition to that, the graph on the middle part in the up-down direction of the figure shows the relationship between the number of rotations of the feed roller 41 and time points. In addition to that, the lowermost graph shows the relationship between the tension of the yarn Y and time points.

[0041] The magnitude of tension of the yarn Y is roughly determined by the difference between the winding speed and the yarn feeding speed as described above. However, the tension which is actually applied to the yarn Y may vary due to a reciprocal movement of the traverse guide 33. For example, when the traverse guide 33 is moved from the center toward one end side in the traverse area in regard to the traverse direction, the tension may be unintentionally increased because the length of the yarn path is increased and the yarn Y is pulled outward by the traverse guide 33 in the traverse area in regard to the traverse direction. Meanwhile, when the direction of the traverse guide 33 is switched from the outward to the inward at one end side in the traverse area in regard to the traverse direction, the tension may be unintentionally decreased because the length of the yarn path is decreased and the yarn Y is temporarily pulled by the traverse guide 33 more gently than usual.

[0042] In order to suppress this variation of tension, many types of means have been proposed. As a first reference example, there is a control means for suppressing a variation of tension by reflecting a detection result of the tension sensor 17 onto the control of the roller drive motor 42. This control is, e.g., a typical feedback control. This control changes, e.g., the number of rotations of the feed roller 41 as shown in FIG. 4, with the result that the yarn feeding speed is also changed. However, because this control method changes the yarn feeding speed after tension has been actually varied, the following problems may occur. For example, when the traverse cycle is short (i.e., the movement of the traverse guide is quick), the adjustment of the yarn feeding speed may not sufficiently follow a variation of tension which is caused by the movement of the traverse guide 33. In this case, because a variation of tension is not sufficiently suppressed, the actual tension (see a solid line in the lower most graph in FIG. 4) is different from the target tension (see a dotted line in the lowermost graph in FIG. 4) as shown in FIG. 4.

[0043] As a second reference example, there is a control means for adjusting the yarn feeding speed by using information regarding the position and/or speed of the traverse guide 33. In this control method, information regarding a variation of tension in accordance with the position of the traverse guide 33 is taken into consideration for the adjustment of the yarn feeding speed. That is, when it is predicted that the tension increases due to the movement of the traverse guide 33, the number of rotations of the feed roller 41 is controlled (see FIG. 5) so that the yarn feeding speed increases. Meanwhile, when it is predicted that the tension decreases, the number of rotations of the feed roller 41 is controlled (see FIG. 5) so that the yarn feeding speed decreases.

[0044] However, there is some time lag (delay) between when the controller 15 (roller control 54) obtains information regarding the change in the number of rotations of the feed roller 41 and when the number of rotations of the feed roller 41 is actually changed. The time lag is caused by factors such as the time required for calculation performed by the roller control unit 54, the inertial mass of a rotational shaft (not illustrated) of the roller drive motor 42, and the inertial mass of the feed roller 41. Due to such a delay, for example, when the traverse cycle is very short (i.e., when the movement of the traverse guide 33 is very quick), the adjustment of the yarn feeding speed may not be completed in time. The control means of the second reference example (see FIG. 5) may therefore suppress a variation of tension as compared to the means of the first reference example (see FIG. 4), but may not sufficiently suppress a variation of tension (see FIG. 5). In order to effectively suppress a variation of tension due to the reciprocal movement of the traverse guide 33, the controller 15 of the present embodiment performs control as follows.

(Specific Method of Controlling Tension)

[0045] The following will describe a specific method in which the controller 15 controls tension, with reference to FIG. 6 to FIG. 9. The later-described method of controlling tension is a method of controlling tension during one cycle (above-described T) in which the traverse guide 33 completes a reciprocal movement once, i.e., during a reciprocal cycle of the traverse guide 33. In this embodiment, the target tension is constant (see a broken line in the lowermost graph in FIG. 9). In the present embodiment, the winding speed is substantially constant during the reciprocal cycle of the traverse guide 33.

[0046] The storage unit 51 stores, e.g., a table in which a target position and target speed of the traverse guide 33 are associated with time. Alternatively, for example, the controller 15 may be configured to calculate the target position and/or the target speed as a function of time. Alternatively, the storage unit 51 may store a table in which one of the target position and target speed of the traverse guide 33 is associated with time. In this case, based on one of the target position and target speed of the traverse guide 33, the controller 15 may calculate the other of these. As such, the controller 15 (traverse control unit 53) controls the operation of the traverse motor 31 based on information regarding the target position and target speed of the traverse guide 33.

[0047] This information regarding the target position and target speed of the traverse guide 33 is also used as information regarding a future position (predicted position) and future speed (predicted speed) of the traverse guide 33 (hereinafter, this information will be referred to as prediction information). For example, as shown in the table of FIG. 6, x1 is a predicted position where the traverse guide 33 is supposed to be positioned at a predetermined time point t1 (first time point of the present invention). In addition to that, a predicted speed of traverse guide 33 is v1 at the time point t1. Furthermore, x2 and v2 are a predicted position and predicted speed of the traverse guide 33 at a time point t2 (second time point of the present invention) which is a time point after the elapse of a predetermined time dt from the time point t1. In this regard, "dt" indicates the time shorter than the reciprocal cycle of the traverse guide 33. Likewise, x3 and v3 are a predicted position and predicted speed of the traverse guide 33 at a time point t3 which is a time point after the elapse of a predetermined time dt from the time point t2.

[0048] FIG. 7 shows the relationship between a predicted position of the traverse guide 33 at one time point and the desired number of rotations of the feed roller 41 at that time point. For example, the predicted position of the traverse guide 33 at the time point t1 is x1 as described above. The desired number of rotations of the feed roller 41 is, e.g., n1 at the time point t1. The "n1" indicates the number of rotations of the feed roller 41 in consideration of a variation of tension of the yarn Y due to the reciprocal movement of the traverse guide 33, and this number is used for arranging the actual tension at the time point t1 to be substantially identical to the target tension. Likewise, the desired number of rotations of the feed roller 41 is n2 at the time point t2 (predicted position x2). In addition to that, the desired number of rotations of the feed roller 41 is n3 at the time point t3 (predicted position x3).

[0049] As described above, there is some time lag (delay) between when the controller 15 (roller control unit 54) obtains information regarding the adjustment of the number of rotations of the feed roller 41 (i.e., rotation number adjustment information) and when the number of rotations of the feed roller 41 is actually changed. Assume that such a time lag is substantially equal to, e.g., an above-described predetermined time dt. In this case, the roller control unit 54 controls the yarn feeding unit 14 as follows. In other words, the controller 15 is set as follows on the premise that a predetermined time dt is substantially equal to the above time lag.

[0050] The storage unit 51 stores, e.g., a function used when a command value regarding the number of rotations of the feed roller 41 (hereinafter, this value will be referred to as a rotation number command value) is calculated based on information regarding a predicated future position and predicted future speed of the traverse guide 33 (prediction information). This function is, e.g., a function with a fixed coefficient. (That is, as the same prediction information is input, this function outputs a constant rotation number command value). The roller control unit 54 receives prediction information from the traverse control unit 53, and calculates a rotation number command value with use of the function. When the roller control unit 54 calculates a rotation number command value corresponding to the time point t1 (i.e., calculates information regarding a control signal which is supposed to be output at the time point t1 from the roller control unit 54 to the roller drive motor 42), the roller control unit 54 uses prediction information corresponding to the time point t2 which is a time point after the elapse of a predetermined time dt from the time point t1. The prediction information corresponding to the time point t2 is information regarding a predicted position and predicted speed of the traverse guide 33 at the time point t2.

[0051] To be more specific, because the traverse control unit 53 swiftly sends prediction information to the roller control unit 54, the prediction information corresponding to the time point t2 is available for calculating a rotation number command value corresponding to the time point t1. As a result, the rotation number command value corresponding to the time point t1 is calculated as n2 (see the table of FIG. 8 and the graph on the middle part of FIG. 9). That is, the roller control unit 54 obtains a rotation number command value regarding the predicted position x2 and predicted speed v2 of the traverse guide 33 at the time point t2 (i.e., obtains n2), as rotation number adjustment information corresponding to the time point t1. In other words, the rotation number adjustment information corresponding to the time point t1 is obtained in association with prediction information corresponding to the time point t2 which is a time point after the elapse of a predetermined time dt from the time point t1.

[0052] This enables the roller control unit 54 to output a control signal, used for adjusting the number of rotations of the feed roller 41 to n2, at a time point earlier than the time point t2 by a predetermined time dt (see broken lines which vertically extend at the central portion of FIG. 9). To be more specific, it is necessary to arrange the actual number of rotations of the feed roller 41 (see a solid line in the graph on the middle part of FIG. 9) to be maximized when the traverse guide 33 is about to reach an outer end in the traverse area in regard to the traverse direction (at the time point t2 in FIG. 9). To achieve this, a command value regarding the number of rotations of the feed roller 41 (see a broken line in the graph on the middle part of FIG. 9) is maximized at the time point t1 which precedes the time point t2 by a predetermined time dt. This compensates the above-described time lag (delay), and thus the number of rotations of the feed roller 41 is adjusted at an appropriate timing. That is, tension is adjusted at an appropriate timing so as to effectively suppress a variation of tension.

[0053] In this regard, the roller control unit 54 may obtain a rotation number command value further in consideration of a detection result of the tension sensor 17. That is, the roller control unit 54 may finally calculate (generate) a command value regarding the number of rotations of the feed roller 41 (to be more specific, a command value regarding the torque of the roller drive motor 42) based on the above-described rotation number command value and a detection result of the tension sensor 17. Because of this, a variation of tension due to disturbance factors except the reciprocal movement of the traverse guide 33 is also suppressed.

[0054] As described above, rotation number adjustment information corresponding to the time point t1 is obtained in association with prediction information corresponding to the time point t2 which is a time point after the elapse of a predetermined time dt from the time point t1 (i.e., t2 is later than t1 by the predetermined time dt) . This enables the roller control unit 54 to output a signal at a time point which is earlier than the time point t2 by a predetermined time dt. The signal is related to the adjustment, which is supposed to be executed at the time point t2, of the number of rotations of the feed roller 41 (i.e., the adjustment of tension). Because of this, the above-described delay is compensated, and thus tension is adjusted at an appropriate timing. Therefore, a variation of tension due to the reciprocal movement of the traverse guide 33 is effectively suppressed.

[0055] A predetermined time dt is shorter than the reciprocal cycle of the traverse guide 33. Because of this, it is possible to suppress the increase in difference between a predicted position of the traverse guide 33 at the time point t2 and an actual position of the traverse guide 33 at the time point t2. In this regard, the predicted position is predicted at the time point t1. Tension is therefore finely controllable.

[0056] By obtaining rotation number adjustment information based on a detection result of the tension sensor 17, it is possible to perform a feedback control so that the tension is close to a predetermined target value. Therefore, because a variation of tension due to disturbance factors except the reciprocal movement of the traverse guide 33 is also suppressed, tension is further stabilized.

[0057] In the present embodiment, the yarn feeding speed of the yarn feeding unit 14 is controlled so as to control tension. Therefore, the control of tension is simplified as compared to cases where the winding unit 13 is controlled in order to control tension.

[0058] The following will describe modifications of the above-described embodiment. The members identical with those in the embodiment above will be denoted by the same reference numerals, and the explanations thereof are not repeated.

(1) While in the embodiment above the roller control unit 54 calculates a rotation number command value of the feed roller 41 with use of a function based on prediction information, the disclosure is not limited to this. For example, the storage unit 51 may store a table in which time points are associated with the following items: a rotation number command value corresponding to the time point t1; and information regarding a predicted position and/or predicted speed of the feed roller 41 at the time point t2. To be more specific, rotation number adjustment information corresponding to the time point t1 may be a rotation number command value corresponding to the predicted position x2 and the predicted speed v2 at the time point t2 (i.e., this value is n2; see FIG. 8). The roller control unit 54 may control the yarn feeding unit 14 by obtaining such information from the storage unit 51. This control is also included in "the control in which information regarding a rotation number command value corresponding to the time point t1 is obtained in association with prediction information corresponding to the time point t2".

(2) Alternatively, information regarding a rotation number command value may not be clearly associated with prediction information by, e.g., a function or a table. That is, as described above, it is necessary to arrange the actual number of rotations of the feed roller 41 (see a solid line in the graph on the middle part of FIG. 9) to be maximized when the traverse guide 33 is about to reach one end side in the traverse area in regard to the traverse direction (at the time point t2 in FIG. 9). Meanwhile, a rotation number command value of the feed roller 41 (see a broken line in the graph on the middle part of FIG. 9) is not maximized at the time point t2 but at the time point t1 which precedes the time point t2 by a predetermined time dt. Therefore, information regarding a rotation number command value may not be clearly associated with prediction information as long as the time point t1 precedes the time point t2 by a predetermined time dt. In this regard, the roller control unit 54 outputs a control signal for arranging the number of rotations of the feed roller 41 to be maximum to the roller drive motor 42 at the time point t1. This control is also included in "the control in which information regarding a rotation number command value corresponding to the time point t1 is obtained in association with prediction information corresponding to the time point t2".

(3) While in the embodiment above a rotation number command value of the feed roller 41 is obtained by, e.g., a predetermined function (i.e., a coefficient included in this function is fixed), the disclosure is not limited to this. For example, this function may include a changeable coefficient. The controller 15 may store the following items during the formation of the wound package Pw: information regarding a rotation number command value; and a detection result of the tension sensor. The controller 15 may perform the calculation for updating the above-described coefficient so as to minimize a variation of tension of the yarn Y, based on these stored sets of information. In other words, the controller 15 may be configured to perform learning in order to obtain an optimal rotation number command value, during the formation of the wound package Pw.

(4) While in the embodiment above the target tension of the yarn Y is constant, the disclosure is not limited to this. The controller 15 may change a target value of tension during the reciprocal cycle of the traverse guide 33. To be more specific, as shown in FIG. 10, a target value of tension related to the traverse guide 33 positioned at one end side in the traverse area in regard to the traverse direction may be lower than a target value of tension related to the traverse guide 33 positioned at the center in the traverse area in regard to the traverse direction. This brings about the following effects. That is, when the tension of the yarn Y is high while the traverse guide 33 is positioned at one end side in the traverse area in regard to the traverse direction, the yarn Y may be unintentionally pulled inward in the axial direction of the winding bobbin Bw at the time of changing the direction of the traverse guide 33. As a result, an amount of the yarn Y wound onto the inside of a target position in the axial direction of the winding bobbin Bw may be increased so that the shape of the wound package Pw is collapsed. In this modification, tension is low while the traverse guide 33 is positioned at one end side in the traverse area in regard to the traverse direction. It is therefore possible to suppress the yarn Y from being unintentionally pulled inward in the axial direction of the winding bobbin Bw at the time of changing the direction of the traverse guide 33. As such, the control of suppressing a variation of tension in consideration of the above-described time lag is especially effective in the structure configured so that a target value of tension is changed during the reciprocal cycle of the traverse guide 33.

(5) While in the embodiment above a predetermined time dt is shorter than the reciprocal cycle of the traverse guide 33, the disclosure is not limited to this. When the reciprocal cycle of the traverse guide 33 is very short (i.e., the movement of the traverse guide 33 is very quick), a predetermined time dt may be longer than the reciprocal cycle of the traverse guide 33.

(6) A predetermined time dt may be changed in accordance with a winding condition, etc. A predetermined time dt may be constant from the start of forming the wound package Pw to the end of forming the wound package Pw. Alternatively, a predetermined

time dt may be suitably changed during an interval between the start of forming the wound package Pw and the end of forming the wound package Pw.

(7) While in the embodiment above the re-winder 1 includes the tension sensor 17, the disclosure is not limited to this. Even when the tension sensor 17 is not provided, a variation of tension due to the reciprocal movement of the traverse guide 33 can be suppressed by the above-described control.

(8) While in the embodiment above the controller 15 controls the tension of the yarn Y by controlling the yarn feeding speed, the disclosure is not limited to this. The controller 15 may control the tension of the yarn Y by controlling the winding speed.

(9) While in the embodiment above tension is applied to the yarn Y by the difference between the winding speed and the yarn feeding speed, the structure of the tension applying unit is not limited to this. The re-winder 1 may include, e.g., a tension application device (not illustrated) including a guide member (not illustrated) configured to sandwich the yarn Y, instead of the yarn feeding unit 14. With this arrangement, tension is applied to the yarn Y by the friction force generated by the guide member sandwiching the yarn Y. The tension application device may be configured so that the contact length at which the yarn Y make contact with the guide member and/or the force with which the guide member sandwiches the yarn Y are changeable. Such a tension applying unit applying tension to the yarn Y by the friction force instead of the above-described difference between the speeds may be provided.

(10) While in the embodiment above the traverse guide 33 is attached to the endless belt 32, the disclosure is not limited to this. For example, the traverse guide 33 may be attached to a leading end portion of an arm that is driven in a swinging manner (see Japanese Unexamined Patent Publication No. 2007-153554). Alternatively, the traverse guide 33 may be reciprocated by a linear motor, etc.

(11) While in the embodiment above the traverse guide 33 is driven by a driving source which is able to drive forward and reverse, the disclosure is not limited to this. For example, the re-winder 1 may include a camtype traverse unit which is driven by a driving source that is a motor rotationally driving in one direction.

(12) The present invention can be applied to not only the re-winder 1 but also to various types of yarn winders configured to wind yarns onto bobbins.

Claims

1. A yarn winder (1) configured to wind a running yarn (Y) onto a bobbin (Bw), comprising:

    a traverse unit (23) which includes a traverse guide (33) for traversing the yarn (Y) along an axial direction of the bobbin (Bw);
    a tension applying unit (13, 14) configured to apply tension to the yarn (Y) which is to be wound onto the bobbin (Bw); and
    a control unit (15),
    characterized in that the control unit (15) includes:

        a prediction information acquisition unit (53) configured to obtain prediction information regarding at least one of a predicted future position and predicted future speed of the traverse guide (33); and
        a tension adjustment unit (54) configured to control the tension applying unit (13, 14) based on adjustment information regarding the adjustment of the tension, and
        the tension adjustment unit (54) obtaining the adjustment information corresponding to a predetermined first time point (t1) in association with the prediction information corresponding to a second time point (t2) which is a time point after the elapse of a predetermined time (dt) from the first time point (t1).

2. The yarn winder (1) according to claim 1, wherein, the predetermined time (dt) is shorter than a reciprocal cycle of the traverse guide (33).

3. The yarn winder (1) according to claim 1 or 2, further comprising a tension detection unit (17) configured to detect the tension applied to the yarn (Y), wherein, the tension adjustment unit (54) obtains the adjustment information based on a detection result of the tension detection unit (17).

4. The yarn winder (1) according to any one of claims 1 to 3, wherein, the tension applying unit (13, 14) includes:

    a winding unit (13) configured to wind the yarn (Y) onto the bobbin (Bw); and a yarn feeding unit (14) configured to send the yarn (Y) to the bobbin (Bw),
    the tension applying unit (13, 14) applies the tension to the yarn (Y) by utilizing a difference between a winding speed at which the yarn (Y) is wound onto the bobbin (Bw) by the winding unit (13) and a yarn feeding speed at which the yarn (Y) is sent to the bobbin (Bw) by the yarn feeding unit (14), and
    the tension adjustment unit (54) controls the tension by controlling the yarn feeding unit (14).

5. The yarn winder (1) according to any one of claims 1 to 4, wherein, the control unit (15) changes a target

value of the tension during the reciprocal cycle of the traverse guide (33).

6. The yarn winder (1) according to claim 5, wherein, in a traverse direction in which the traverse guide (33) moves, the control unit (15) arranges a target value of the tension when the traverse guide (33) is positioned at one end in a traverse area where the traverse guide (33) reciprocates in regard to the traverse direction to be lower than a target value of the tension when the traverse guide (33) is positioned at a center in the traverse area.

Patentansprüche

1. Garnwickler (1), der konfiguriert ist, um ein laufendes Garn (Y) auf eine Spule (Bw) zu wickeln, umfassend:

   eine Verfahreinheit (23), die eine Verfahrführung (33) zum Verfahren des Garns (Y) entlang einer axialen Richtung der Spule (Bw) einschließt;
   eine Spannungsanwendungseinheit (13, 14), die konfiguriert ist, um Spannung auf das Garn (Y) anzuwenden, das auf die Spule (Bw) gewickelt werden soll; und
   eine Steuereinheit (15),
   dadurch gekennzeichnet, dass die Steuereinheit (15) Folgendes einschließt:

      eine Vorhersageinformations-Erfassungseinheit (53), die konfiguriert ist, um Vorhersageinformationen in Bezug auf mindestens eines einer vorhergesagten künftigen Position und einer vorhergesagten künftigen Geschwindigkeit der Verfahrführung (33) zu erhalten; und
      eine Spannungsanpassungseinheit (54), die konfiguriert ist, um die Spannungsanwendungseinheit (13, 14) basierend auf Anpassungsinformationen in Bezug auf die Anpassung der Spannung zu steuern, und wobei die Spannungsanpassungseinheit (54) die Anpassungsinformationen, die einem vorbestimmten ersten Zeitpunkt (t1) entsprechen, in Verbindung mit den Vorhersageinformationen, die einem zweiten Zeitpunkt (t2), der ein Zeitpunkt nach dem Ablauf einer vorbestimmten Zeit (dt) seit dem ersten Zeitpunkt (t1) ist, entsprechen, erhält.

2. Garnwickler (1) nach Anspruch 1, wobei die vorbestimmte Zeit (dt) kürzer ist als ein gegenläufiger Zyklus der Verfahrführung (33).

3. Garnwickler (1) nach Anspruch 1 oder 2, weiter umfassend eine Spannungserkennungseinheit (17), die konfiguriert ist, um die auf das Garn (Y) angewendete Spannung zu erkennen, wobei,
die Spannungsanpassungseinheit (54) die Anpassungsinformationen basierend auf einem Erkennungsergebnis der Spannungserkennungseinheit (17) erhält.

4. Garnwickler (1) nach einem der Ansprüche 1 bis 3, wobei, die Spannungsanwendungseinheit (13, 14) Folgendes einschließt:

   eine Wickeleinheit (13), die konfiguriert ist, um das Garn (Y) auf die Spule (Bw) zu wickeln; und
   eine Garnzuführeinheit (14), die konfiguriert ist, um das Garn (Y) an die Spule (Bw) zu senden,
   wobei die Spannungsanwendungseinheit (13, 14) die Spannung auf das Garn (Y) durch Verwenden einer Differenz zwischen einer Wickelgeschwindigkeit, mit der das Garn (Y) von der Wickeleinheit (13) auf die Spule (Bw) gewickelt wird, und einer Garnzuführgeschwindigkeit, mit der das Garn (Y) von der Garnzuführeinheit (14) an die Spule (Bw) gesendet wird, anwendet, und
   wobei die Spannungsanpassungseinheit (54) die Spannung durch Steuern der Garnzuführeinheit (14) steuert.

5. Garnwickler (1) nach einem der Ansprüche 1 bis 4, wobei die Steuereinheit (15) einen Zielwert der Spannung während des gegenläufigen Zyklus der Verfahrführung (33) verändert.

6. Garnwickler (1) nach Anspruch 5, wobei die Steuereinheit (15) in eine Verfahrrichtung, in die sich die Verfahrführung (33) bewegt, einen Zielwert der Spannung anordnet, wenn die Verfahrführung (33) an einem Ende in einem Verfahrbereich, in dem die Verfahrführung (33) in Bezug auf die Verfahrrichtung umkehrt, positioniert ist, sodass er niedriger ist als ein Zielwert der Spannung, wenn die Verfahrführung (33) in einer Mitte des Verfahrbereichs positioniert ist.

Revendications

1. Renvideur de fil (1) configuré pour enrouler un fil courant (Y) sur une bobine (Bw), comprenant :

   une unité de course (23) qui inclut un guide-course (33) pour diriger le fil (Y) le long d'une direction axiale de la bobine (Bw) ;
   une unité d'application de tension (13, 14) configurée pour appliquer une tension au fil (Y) qui doit être enroulé sur la bobine (Bw) ; et
   une unité de commande (15),
   caractérisé en ce que l'unité de commande

(15) inclut :

une unité d'acquisition d'informations de prédiction (53) configurée pour obtenir des informations de prédiction concernant au moins une d'une future position prédite et d'une future vitesse prédite du guide de traverse (33) ; et
une unité d'ajustement de tension (54) configurée pour commander l'unité d'application de tension (13, 14) sur la base d'informations d'ajustement concernant l'ajustement de la tension, et
l'unité d'ajustement de tension (54) obtenant les informations d'ajustement correspondant à un premier moment prédéterminé (t1) en association avec les informations de prédiction correspondant à un second moment (t2) qui est un moment après le laps d'un temps prédéterminé (dt) depuis le premier moment (t1).

2. Renvideur de fil (1) selon la revendication 1, dans lequel le temps prédéterminé (dt) est plus court qu'un cycle inverse du guide-course (33).

3. Renvideur de fil (1) selon la revendication 1 ou 2, comprenant en outre une unité de détection de tension (17) configurée pour détecter la tension appliquée au fil (Y), dans lequel,
l'unité d'ajustement de tension (54) obtient des informations d'ajustement sur la base d'un résultat de détection de l'unité de détection de tension (17).

4. Renvideur de fil (1) selon l'une quelconque des revendications 1 à 3, dans lequel l'unité d'application de tension (13, 14) inclut :

une unité d'enroulement (13) configurée pour enrouler le fil (Y) sur la bobine (Bw) ; et une unité d'alimentation en fil (14) configurée pour envoyer le fil (Y) à la bobine (Bw),
l'unité d'application de tension (13, 14) applique la tension au fil (Y) en utilisant une différence entre une vitesse d'enroulement à laquelle le fil (Y) est enroulé sur la bobine (Bw) par l'unité d'enroulement (13), et une vitesse d'alimentation en fil à laquelle le fil (Y) est envoyé à la bobine (Bw) par l'unité d'alimentation en fil (14), et
l'unité d'ajustement de tension (54) commande la tension en commandant l'unité d'alimentation en fil (14).

5. Renvideur de fil (1) selon l'une quelconque des revendications 1 à 4, dans lequel l'unité de commande (15) change une valeur cible de la tension pendant le cycle inverse du guide-course (33).

6. Renvideur de fil (1) selon la revendication 5, dans lequel, dans une direction de course dans laquelle le guide-course (33) se déplace, l'unité de commande (15) fixe une valeur cible de la tension lorsque le guide-course (33) est positionné à une extrémité dans une zone de course où le guide-course (33) effectue un mouvement de va-et-vient par rapport à la direction de course, pour qu'elle soit inférieure à une valeur cible de la tension lorsque le guide-course (33) est positionné au centre dans la zone de course.

FIG.1

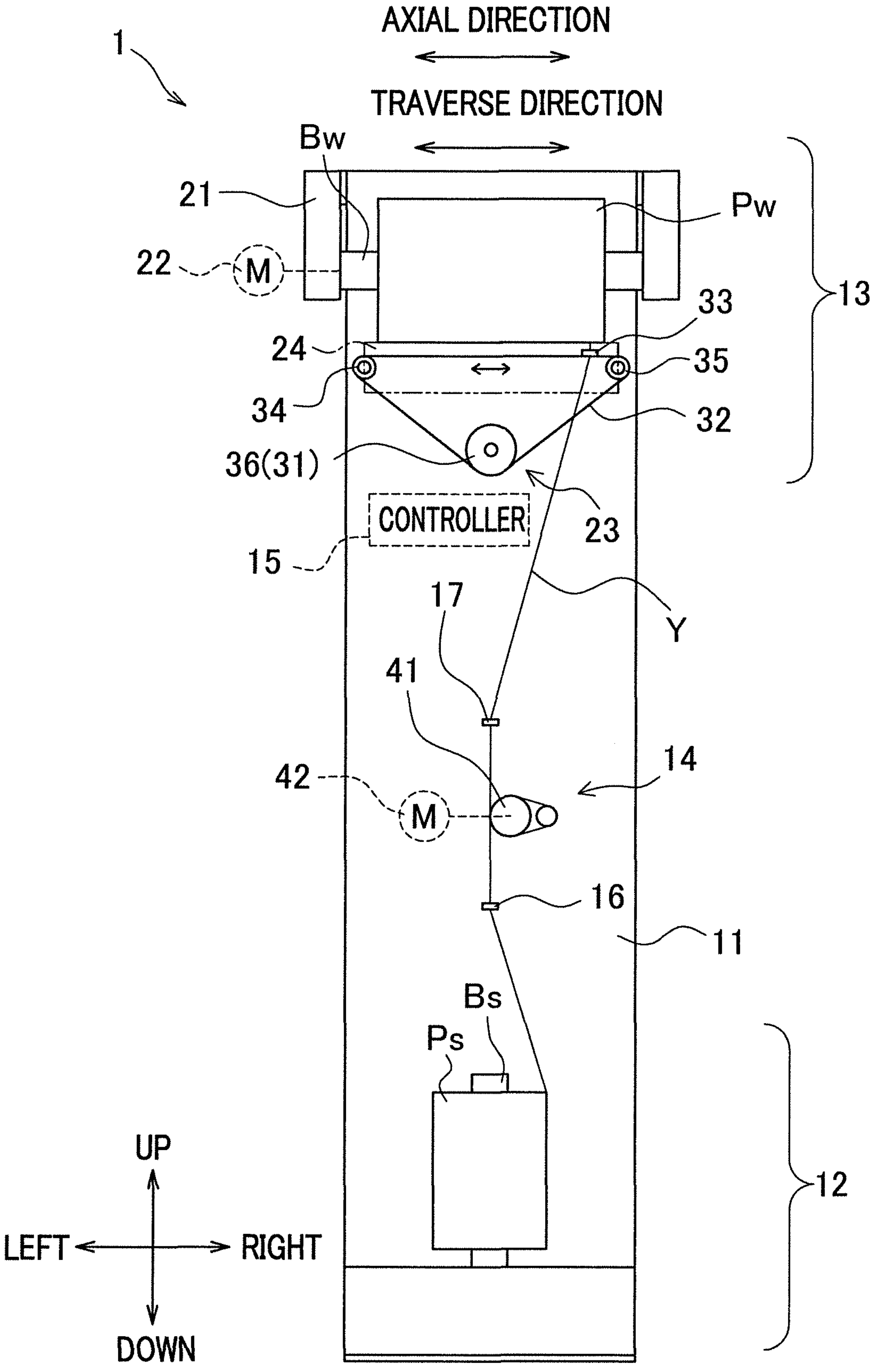

AXIAL DIRECTION
TRAVERSE DIRECTION
1
Bw
21
22
M
Pw
13
33
24
35
34
32
36(31)
23
CONTROLLER
15
17
Y
41
14
42
M
16
11
Bs
Ps
12
UP
LEFT
RIGHT
DOWN

FIG.2

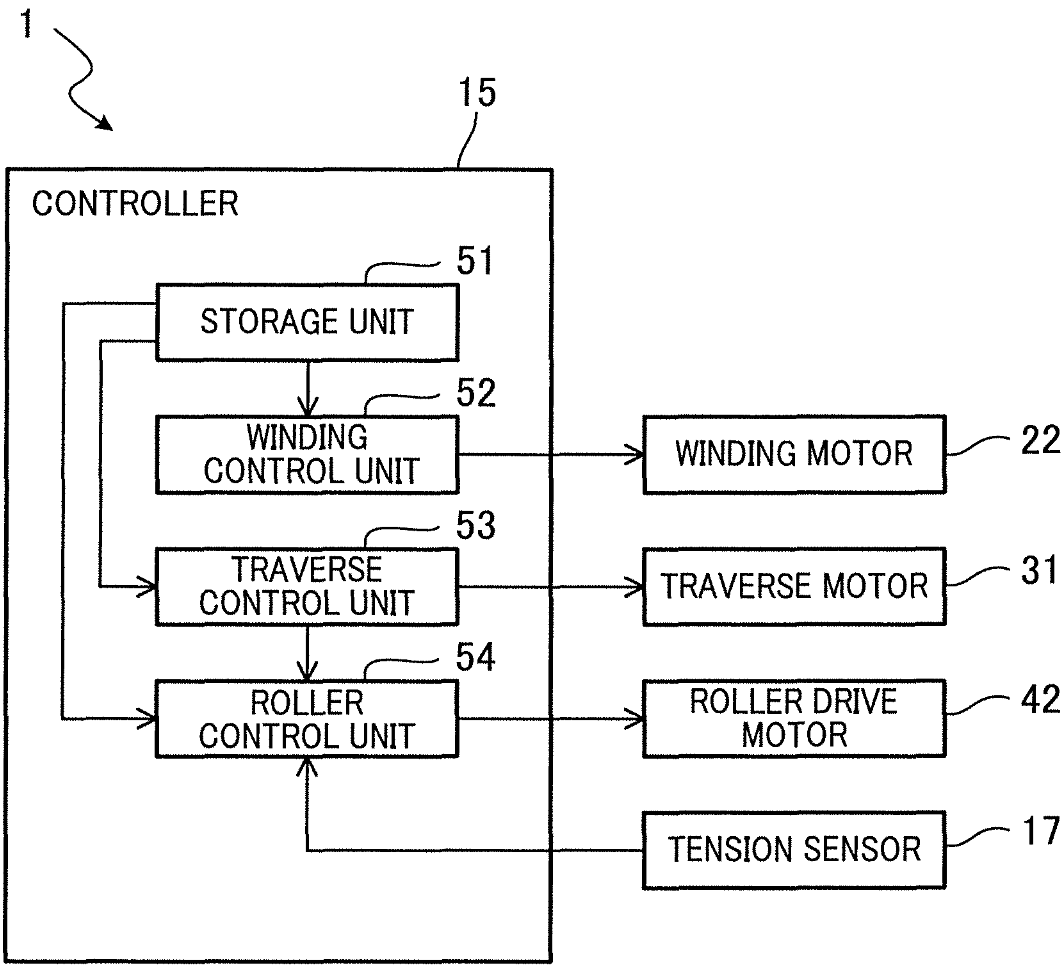
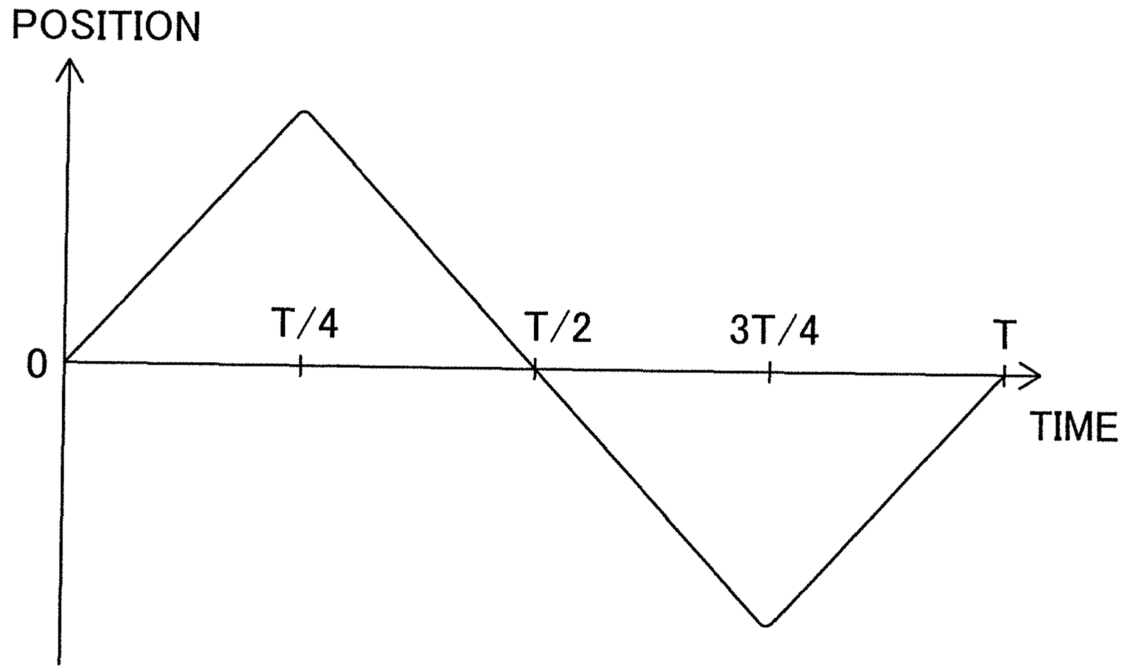

1
15
CONTROLLER
51
STORAGE UNIT
52
WINDING CONTROL UNIT
53
TRAVERSE CONTROL UNIT
54
ROLLER CONTROL UNIT
WINDING MOTOR
22
TRAVERSE MOTOR
31
ROLLER DRIVE MOTOR
42
TENSION SENSOR
17

FIG.3



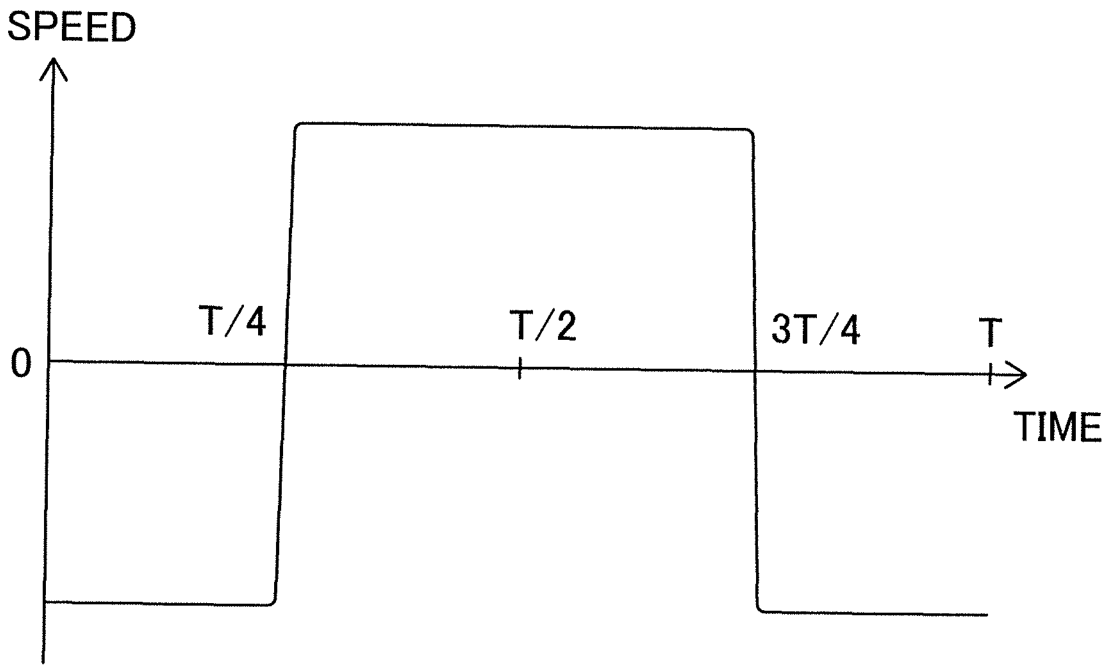


FIG.4

FIRST REFERENCE EXAMPLE

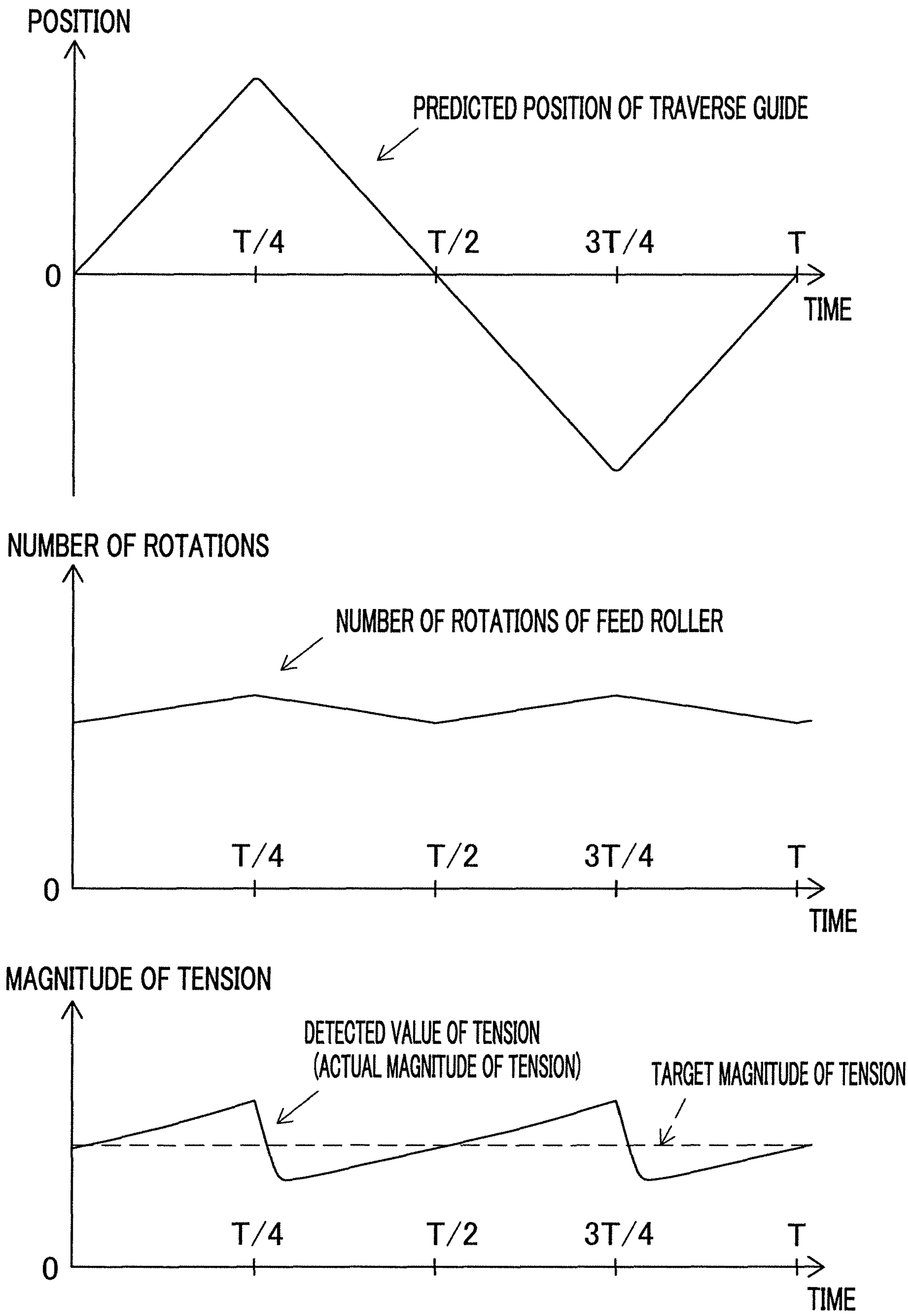


FIG.5

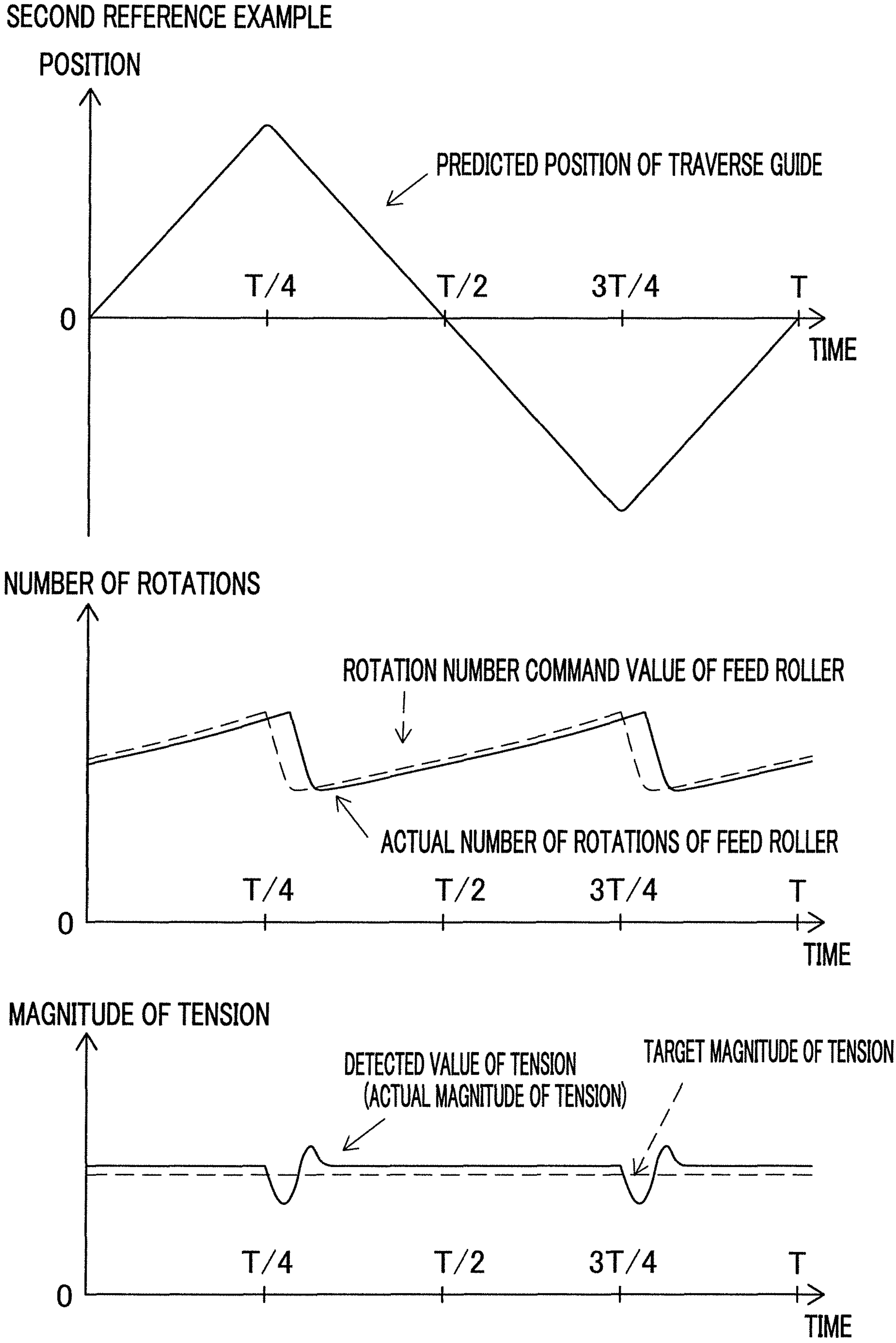

SECOND REFERENCE EXAMPLE
POSITION
PREDICTED POSITION OF TRAVERSE GUIDE
0
T/4
T/2
3T/4
T
TIME
NUMBER OF ROTATIONS
ROTATION NUMBER COMMAND VALUE OF FEED ROLLER
ACTUAL NUMBER OF ROTATIONS OF FEED ROLLER
0
T/4
T/2
3T/4
T
TIME
MAGNITUDE OF TENSION
DETECTED VALUE OF TENSION
(ACTUAL MAGNITUDE OF TENSION)
TARGET MAGNITUDE OF TENSION
0
T/4
T/2
3T/4
T
TIME

FIG.6

CORRESPONDENCE BETWEEN PREDICTED POSITION, PREDICTED SPEED OF TRAVERSE GUIDE, AND TIME (TIME POINTS)

TIME (TIME POINTS)	PREDICTED POSITION	PREDICTED SPEED
⋮	⋮	⋮
t1	x1	v1
⋮	⋮	⋮
t2 (= t1 + dt)	x2	v2
⋮	⋮	⋮
t3 (= t2 + dt)	x3	v3
⋮	⋮	⋮

FIG.7

RELATIONSHIP BETWEEN PREDICTED POSITION OF TRAVERSE GUIDE AND DESIRED NUMBER OF ROTATIONS OF FEED ROLLER

TIME (TIME POINTS)	PREDICTED POSITION	DESIRED NUMBER OF ROTATIONS
⋮	⋮	⋮
t1	x1	n1
⋮	⋮	⋮
t2 (= t1 + dt)	x2	n2
⋮	⋮	⋮
t3 (= t2 + dt)	x3	n3
⋮	⋮	⋮

FIG.8

TABLE SHOWING ROTATION NUMBER COMMAND VALUE OF FEED ROLLER

(TIME LAG IS CONSIDERED)

TIME (TIME POINTS)	PREDICTED POSITION	PREDICTED SPEED	ROTATION NUMBER COMMAND VALUE
⋮	⋮	⋮	⋮
t1	x2	v2	n2
⋮	⋮	⋮	⋮
t2 (= t1 + dt)	x3	v3	n3
⋮	⋮	⋮	⋮

FIG.9

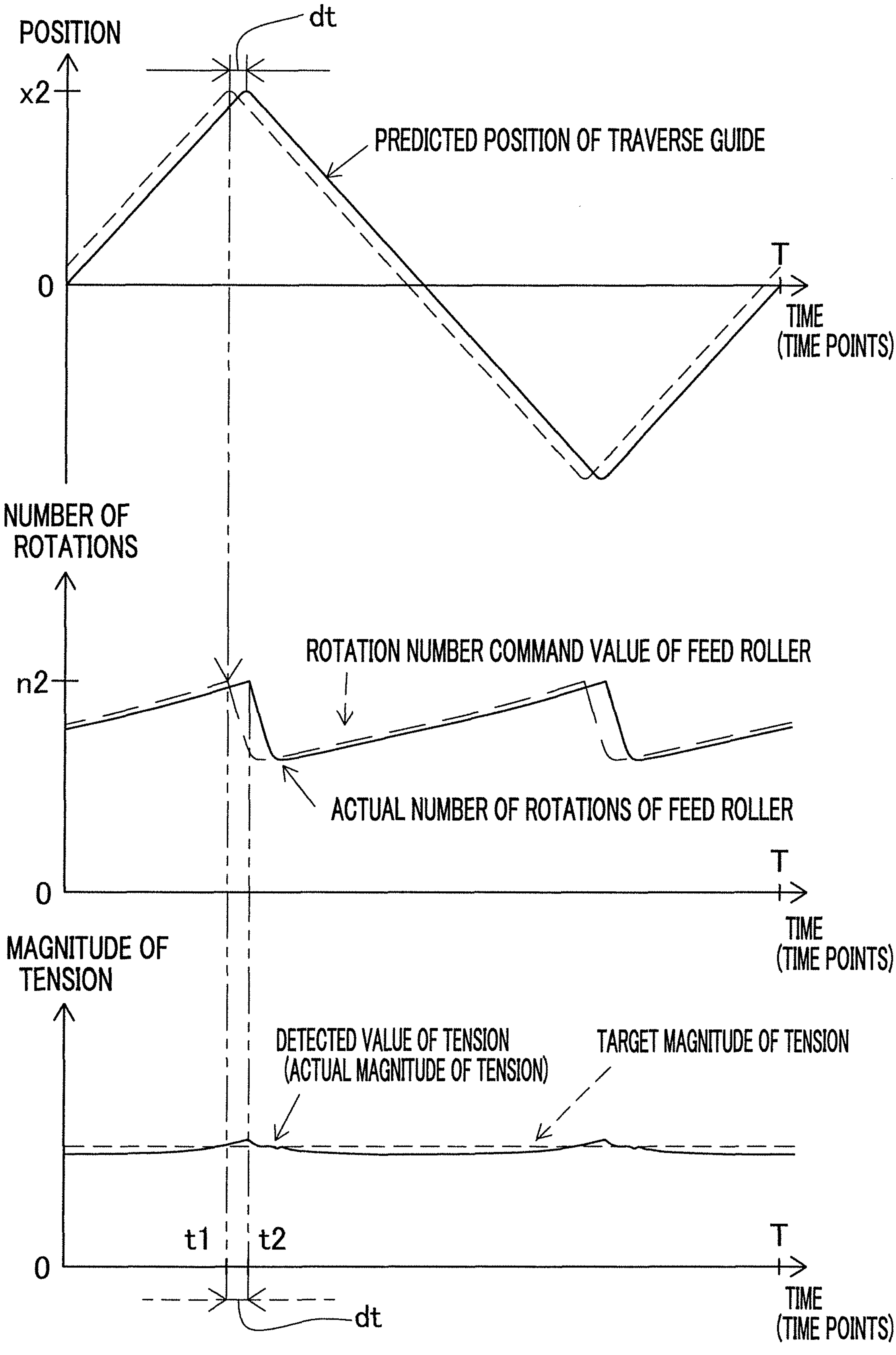
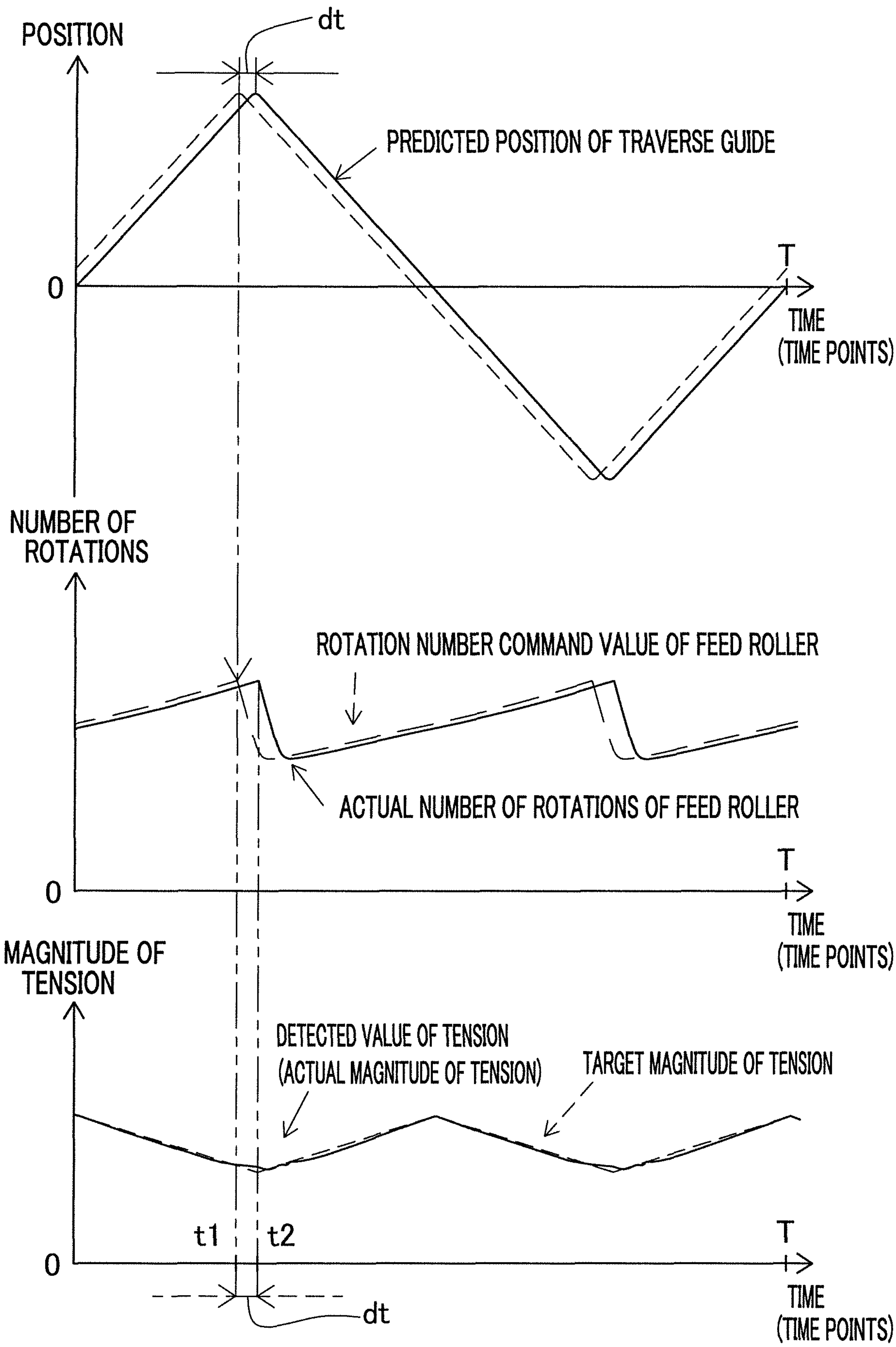

POSITION
dt
x2
PREDICTED POSITION OF TRAVERSE GUIDE
0
T
TIME
(TIME POINTS)
NUMBER OF ROTATIONS
ROTATION NUMBER COMMAND VALUE OF FEED ROLLER
n2
ACTUAL NUMBER OF ROTATIONS OF FEED ROLLER
0
T
TIME
(TIME POINTS)
MAGNITUDE OF TENSION
DETECTED VALUE OF TENSION
(ACTUAL MAGNITUDE OF TENSION)
TARGET MAGNITUDE OF TENSION
t1
t2
T
0
TIME
(TIME POINTS)
dt

FIG.10


dt
POSITION
PREDICTED POSITION OF TRAVERSE GUIDE
0
T
TIME
(TIME POINTS)
NUMBER OF
ROTATIONS
ROTATION NUMBER COMMAND VALUE OF FEED ROLLER
ACTUAL NUMBER OF ROTATIONS OF FEED ROLLER
0
T
TIME
(TIME POINTS)
MAGNITUDE OF
TENSION
DETECTED VALUE OF TENSION
(ACTUAL MAGNITUDE OF TENSION)
TARGET MAGNITUDE OF TENSION
t1
t2
0
T
TIME
(TIME POINTS)
dt

REFERENCES CITED IN THE DESCRIPTION

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