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(71) Applicant: **TMT Machinery, Inc.**
Osaka-shi, Osaka 541-0041 (JP)

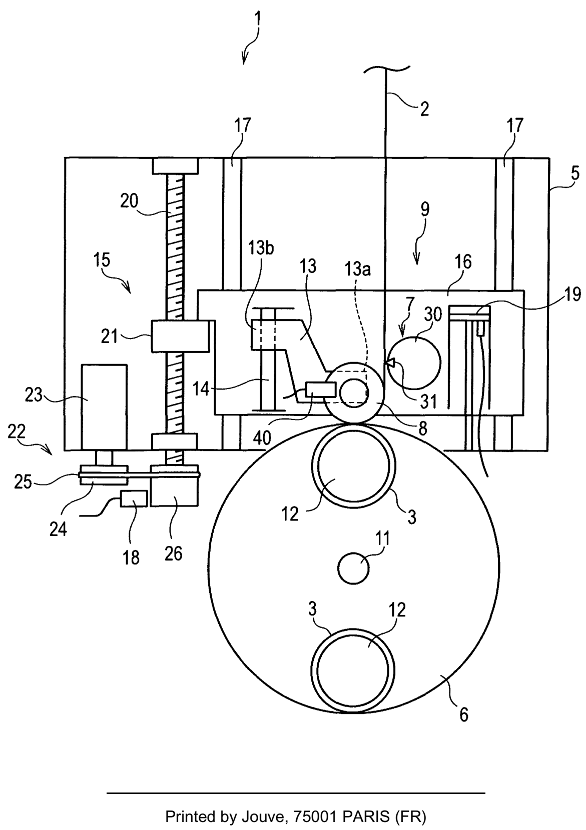
(72) Inventors:
- **Hori, Tetsuya**
  Kyoto-shi, Kyoto (JP)
- **Hashimoto, Kinzo**
  Kyoto-shi, Kyoto (JP)

(74) Representative: **HOFFMANN EITLE**
Patent- und Rechtsanwälte
Arabellastrasse 4
81925 München (DE)

(54) Yarn winding machine and yarn winding method

(57) The present invention provides a technique to prevent possible ribbon winding regardless of yarn type while inhibiting possible bulging. The winder 1 includes a contact roller 8 configured to come into contact with a package 4 during formation of the package 4, a traverse device 7 located upstream side of the contact roller 8 in the traveling direction of an elastic yarn 2, a free length varying means 9 for enabling the free length FL of the elastic yarn 2 located between the contact roller 8 and the traverse device 7 to be varied during formation of the package 4, and a control section 80 configured to control the free length varying means 9 in such a manner that the free length FL is increased during winding start of the package 4 and then reduced toward winding end.

FIGURE6



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Description

Field of the Invention

[0001] The present invention relates to a yarn winding machine and a yarn winding method.

Background of the Invention

[0002] The Unexamined Japanese Patent Application Publication (Tokkai-Hei) No. 9-71367 discloses a technique to prevent what is called bulging when a yarn traversed by a traverse device is wound around a winding bobbin via a contact roller to form a package. In this technique, at the initial stage of winding start, a winding angle is increased to reduce the tightening of a yarn layer formed at the initial stage. The Unexamined Japanese Patent Application Publication (Tokkai-Hei) No. 9-71367 further describes a technique to avoid ribbon winding by gradually reducing the winding angle toward winding end so as to prevent a wind number from becoming smaller than 1.

[0003] However, according to the technique described in the Unexamined Japanese Patent Application Publication (Tokkai-Hei) No. 9-71367, bulging of a relatively low level can be inhibited without problems. However, if bulging of a relatively high level occurs, an attempt to inhibit the bulging inevitably results in ribbon winding. The meanings of the above-mentioned terms will be described below, and the above-described problem will then be described in further detail.

[0004] The bulging is a phenomenon in which windings of the yarn are stacked to bulge the middle of the end surface of a package.

[0005] The ribbon winding is a phenomenon in which the yarn travels along the same route on a peripheral surface of the package so as to be over lappingly wound thereon. The ribbon winding may cause various problems; the yarn may slip down along the end surface of the package during traversing, the contact roller may vibrate, or the yarn may be improperly unwound from the package during the subsequent step. The improper yarn unwinding is particularly likely to occur with elastic yarns because the elastic yarn is pulled in a tangential direction with respect to the circular package. Furthermore, the improper unwinding may cause yarn breakage.

[0006] The wind number N is a numerical value used to predict the occurrence of the ribbon phenomenon. Figure 3 illustrates the definition of the wind number. A rectangle 90 shown in Figure 3 corresponds to a developed surface of a peripheral surface of a package. Positions on the developed surface at which the yarn is wound are denoted by reference characters (a) to (d). Here, reference character D denotes the winding diameter of the package. Reference character S denotes a stroke. Reference character WA denotes the winding angle. Reference character π DtanWA denotes the distance that the yarn advances on the peripheral surface of the package in the axial direction of the package while the yarn travels one round around the peripheral surface of the package in the circumferential direction. In the example shown in Figure 3, when the first winding position of the yarn is shown at reference character (a), then the winding position for the second lap is shown at reference character (b). The yarn then reaches and turns around the upper right corner of the developed surface. The subsequent winding positions are shown at reference characters (c) and (d) by dashed lines. When the yarn is wound at such winding positions as shown in Figure 3, the yarn travels along the same route on the peripheral surface of the package so as to be overlappingly wound thereon. That is, the ribbon winding occurs. To allow the occurrence of the ribbon winding to be analyzed, the wind number N in Expression (1) shown below is used; Expression (1) indicates how many times the yarn turns around during a double stroke 2 x S.

[0007] According to Expression (1), in the case of Figure 3, the wind number N is 4. If the wind number N thus has an integral value and particularly if N = 1, the windings of the yarn locally overlap significantly. The wind number N of 1 is generally called a critical wind number Nd. Thus, to prevent a possible ribbon phenomenon, it is generally appropriate to avoid setting the wind number N to the critical wind number.

[0008]

[Expression 1]

$$N = \frac{2S}{\pi D \tan WA} \quad \cdots (1)$$

[0009] The terms have been described. Now, the problems to be solved by the present invention will be described again with reference to Figures 1 and 2. Figure 1 is a diagram illustrating a technique to inhibit possible bulging by increasing and reducing the winding angle. Figure 2 is a diagram illustrating problems newly occurring if an attempt is made to inhibit possible bulging by increasing and reducing the winding angle. In Figures 1 and 2, the axis of abscissa indicates the winding diameter of a package. The axis of ordinate indicates the winding angle.

[0010] Figure 1A shows winding with no bulging measures taken. Figure 1B shows winding with bulging measures taken as disclosed in the Unexamined Japanese Patent Application Publication (Tokkai-Hei) No. 9-71367. In Figures 1A and 1B, alternate long and two short dashes lines shown with "N = Nd" indicate the condition under which the wind number N is equal to the critical wind number Nd. As shown in (al) in Figure 1A, regardless of the winding diameter D of the package (hereinafter also simply referred to as the winding diameter D), winding at a constant winding angle WA causes windings of the yarn to be stacked to bulge the middle of the end surface of the package. That is, bulging occurs. Thus, in the Unexamined Japanese Patent Application Publication (Tokkai-Hei) No. 9-71367, as shown in (b1) in Figure 1B, the winding angle WA is increased at the initial stage of winding start (when the winding diameter D is small). Then, the density of a yarn layer formed at the initial stage is reduced step by step. Furthermore, at the later stage of winding end (when the winding diameter D is large), the winding angle WA is reduced so that the line of the winding angle WA does not stride over the alternate long and two short dashes line. As shown in (b2) in Figure 1B, this winding allows the offsetting between an increase in the density of the yarn layer formed by the stacked windings of the yarn and a decrease in the density of the yarn layer resulting from the increased winding angle WA. Consequently, a package with possible bulging inhibited is formed.

[0011] However, winding of a yarn type such as elastic yarns involves a strong winding tightening force. Thus, bulging that is more significant than that shown in (a2) in Figure 1A occurs. To allow even the significant bulging to be inhibited using the technique described in the Unexamined Japanese Patent Application Publication (Tokkai-Hei) No. 9-71367, the winding angle WA inevitably needs to be further increased as shown in (c1) in Figure 2C. As a result, the line of the winding angle WA strides over the alternate long and two short dashes line indicating the occurrence condition for ribbon winding, thus causing ribbon winding as described above. At the winding diameter D corresponding to an intersecting point shown by reference character X in the figure, the yarn may slip down along the end surface of the package as shown in (c2) in Figure 2C, or the yarn may be improperly unwound as described above.
Thus, the technique described in the Unexamined Japanese Patent Application Publication (Tokkai-Hei) No. 9-71367 can inhibit possible bulging but may inevitably involve ribbon winding depending on the yarn type.

[0012] The present invention has been developed in view of these problems. A main object of the present invention is to provide a technique to prevent possible ribbon winding regardless of the yarn type while inhibiting possible bulging.

[0013] The problems to be solved by the present invention have been described. The present inventors have been committed to studies in order to drastically review techniques for inhibiting possible bulge. Thus, the present inventors have focused on an increase and reduction in what is called free length during formation of a package, for example, as shown in (d1) in Figure 2D with reference character FL.

[0014] Now, the relationship between the free length and the bulge inhibition effect will be described. Figure 4 is a diagram showing the relationship between the free length and a traverse delay. A free length FL (FL1, FL2) shown in Figure 4 refers to the free length of a yarn over which the yarn engaged with a traverse guide in a traverse device travels after being released from the traverse guide and before coming into contact with the peripheral surface of a contact roller. The free length FL can be increased and reduced by moving the traverse guide away from and closer to the contact roller as shown in Figure 4. When the free length FL is increased from FL1 to FL2, provided that the angle between a straight line extending at the right angle to the axial direction of a bobbin and the traveling direction of the yarn being wound, that is, the winding angle WA, is constant (WA = WA1), the difference between the axial position of the traverse guide and the axial position of the yarn actually received on the peripheral surface of the package, that is, a traverse delay E, increases from E1 to E2. On the other hand, when the free length FL is reduced from FL2 to FL1, provided that the winding angle WA is similarly constant, the traverse delay E decreases from E2 to E1.

[0015] This will be specifically described with reference to Figure 4. First, if the winding angle WA is set to WA1 and the free length FL is set to FL1, the yarn is received on the contact controller at an axial position N1. At this time, the traverse delay E is E1. That is, the yarn is wound around the package at a position closer to the axial center of the package than the axial position of the traverse guide by a distance corresponding to the traverse delay E1. Similarly, when the winding angle WA remains at WA1 and the free length FL is set to FL2, the traverse delay E is E2. Thus, increasing the free length FL from FL1 to FL2 causes the end surface of the package to be formed closer to the axial center of the package by a distance denoted by ΔE (= E2 - E1) in Figure 4. On the other hand, reducing the free length FL from FL2 to FL1 causes the end surface of the package to be formed closer to the axial end of the package by ΔE. That is, in short, increasing the free length FL reduces the winding width of the package. In contrast, reducing the free length FL increases the winding width of the package.

[0016] The present invention uses the technical interlocking relationship between the free length FL and the winding length of the package to inhibit possible bulging as shown in Figure 5. Figure 5 is a diagram illustrating a mechanism to inhibit possible bulging utilizing the free length FL. Figure 5A shows winding with the free length FL maintained constant. Figure 5B shows winding with the free length FL varied from FL1 through FL2 to FL1 (FL1 < FL2). That is, if winding is carried out with the free length FL maintained constant without using the technique disclosed in the Unexamined Japanese

Patent Application Publication (Tokkai-Hei) No. 9-71367 (the technique for increasing and reducing the winding angle WA), given that no winding tightening force is exerted by stacked windings of the yarn, the winding width remains constant from winding start to winding end as shown in the left part of Figure 5A. In actuality, the stacked windings of the yarn causes a winding tightening force to be exerted, resulting in bulging of the middle of the end surface of the package as shown in the right part of Figure 5A. That is, bulging occurs. In contrast, if the free length FL is varied from FL1 through FL2 to FL1, given that no winding tightening force results from the stacked windings of the yarn, the winding width starts to decrease gradually during winding start as shown in the left part of Figure 5B. Then, when the free length FL reaches FL2, the winding width is smaller than a value measured during the winding start, by Δ E x 2. Thereafter, the winding width gradually increases toward the winding end. When the free length FL eventually varies back to FL1, the winding width becomes equal to the value measured during the winding start. In short, the cross section of the package is shaped like a saddle-backed shape. Thus, in actuality, a winding tightening force resulting from the stacked windings of the yarn causes a recess in the middle of the end surface of the package to be lost as shown in Figure 5B. That is, the package end surface is flattened.

[0017] In short, the above-described technique allows bulging caused by a winding tightening force resulting from the stacked windings of the yarn to be offset by increasing and reducing the winding width so that the cross section of the package is shaped like a saddle-backed shape. In other words, the technique allows possible bulging to be inhibited by increasing and reducing the free length FL.

[0018] A feature of the above-described technique is that an increase and reduction in free length FL does not cause an undesirable change in wind number N. In this regard, the technique is advantageous over the Unexamined Japanese Patent Application Publication (Tokkai-Hei) No. 9-71367.

[0019] The technical object of the present invention has been described. Now, means for solving the above-described problems and the effects of the means will be described.

Summary of the Invention

[0020] According to a first aspect of the present invention, a yarn winding machine that forms a package is configured as follows. The yarn winding machine includes a contact roller configured to come into contact with the package during formation of the package, a traverse device located upstream side of the contact roller in a traveling direction of a yarn, a free length varying means for enabling the free length of the yarn located between the contact roller and the traverse device to be varied during formation of the package, and a control means for controlling the free length varying means in such a manner that the free length is increased during winding start of the package and then reduced toward winding end. This configuration allows possible bulging to be inhibited. Furthermore, an increase and reduction in free length avoids varying the wind number. Thus, winding can be easily carried out with possible bulging inhibited and with the critical wind number avoided. Successful avoidance of the critical wind number in turn allows avoidance of various problems: slip-down of the yarn along the end surface of the package during traversing, vibration of the contact roller, and improper unwinding of the yarn from the package during the subsequent step.

[0021] As shown by a dashed line in (d1) in Figure 2(d), the winding angle may be maintained constant or increased and reduced similarly to the free length.

[0022] The above-described yarn winding machine is further configured as follows. The yarn winding machine further includes a winding angle varying means for enabling the winding angle to be varied. The control means controls the winding angle varying means in such a manner that the winding angle is increased during the winding start of the package and then reduced toward the winding end. In this manner, to allow possible bulging to be inhibited, both the free length and the winding angle are increased and reduced. This enables a reduction in the range of an increase and reduction in free length required to inhibit possible bulging. As a result, the free length varying means can be made compact.

[0023] A second aspect of the present invention provides a yarn winding method of forming a package using a contact roller configured to come into contact with the package during formation of the package and a traverse device located upstream side of the contact roller in a traveling direction of the yarn. The free length of the yarn located between the contact roller and the traverse device is increased during winding start of the package and then reduced toward winding end. This configuration allows possible bulging to be inhibited. Furthermore, an increase and reduction in free length is prevented from changing the wind number. Thus, winding can be easily carried out with possible bulging inhibited and with the critical wind number avoided. Successful avoidance of the critical wind number in turn allows avoidance of various problems: slip-down of the yarn along the end surface of the package during traversing, vibration of the contact roller, and improper unwinding of the yarn from the package during the subsequent step.

[0024] The above-described yarn winding is further carried out by following method. The winding angle is increased during the winding start of the package and then reduced toward the winding end. In this manner, to allow possible bulging to be inhibited, both the free length and the winding angle are increased and reduced. This enables a reduction in the range of an increase and reduction in free length required to inhibit possible bulging.

[0025] Furthermore, if the yarn is elastic, a strong winding tightening force is exerted, resulting in significant bulging

as described above. An attempt to deal with the significant bulging simply by increasing and reducing the winding angle results in the inevitable occurrence of ribbon winding. However, possible ribbon winding can be avoided by increasing and reducing the free length.
Thus, the technique to inhibit possible bulging by increasing and reducing the free length is beneficial particularly when the yarn is elastic.
Other features, elements, processes, steps, characteristics and advantages of the present invention will become more apparent from the following detailed description of preferred embodiments of the present invention with reference to the attached drawings.

Brief Description of the Drawings

[0026]

Figure 1 is a diagram illustrating a technique for inhibiting possible bulging by increasing and reducing a winding angle.
Figure 2 is a diagram illustrating problems newly occurring if an attempt is made to inhibit possible bulging by increasing and reducing the winding angle.
Figure 3 is a diagram illustrating the definition of a wind number.
Figure 4 is a diagram showing the relationship between a free length and a traverse delay.
Figure 5 is a diagram illustrating a mechanism for inhibiting possible bulging utilizing the free length.
Figure 6 is a front view of a winder according to a first embodiment of the present invention.
Figure 7 is a diagram showing the system of the winder.
Figure 8 is a graph showing how free length is controlled based on the winding diameter of the package.
Figure 9 is a flowchart of a control program.
Figure 10 is a diagram showing how the winder operates.
Figure 11 is a graph showing the relationship between time required to wind a package and the height position of a slide box.
Figure 12 is a graph showing the results of tests for confirming the technical effects of the present invention.
Figure 13 is a graph which is similar to Figure 8 and which shows how the free length and the winding angle are controlled based on the winding diameter of the package according to a second embodiment of the present invention.
Figure 14 is a flowchart which is similar to Figure 9 and which illustrates the second embodiment of the present invention.

Detailed Description of the Preferred Embodiments

[0027] A winder 1 as a yarn winding machine according to a first embodiment of the present invention will be described with reference to the drawings. Figure 6 is a front view of the winder according to the first embodiment of the present invention. Figure 7 is a diagram showing the system of the winder.
[0028] The winder 1 is a yarn winding machine configured to wind an elastic yarn 2 around a bobbin 3 to form a package 4 (see Figure 10). The yarn winding machine configured to wind the elastic yarn 2 will be described below. However, the present invention is not limited this aspect. The yarn winding machine may wind any other type of yarn.
As shown in Figure 6, the winder 1 includes a body frame 5, a turret plate 6, a slide box 16, a traverse device 7, a contact roller 8, and a free length varying means 9. As shown in Figure 7, the components of the winder 1 are electrically connected to a control section 80 (control means). The control means 80 includes a CPU (Central Processing Unit) serving as an arithmetic processing device, a ROM (Read Only Memory) configured to store control programs executed by the CPU and data used for the control programs, and a RAM (Random Access Memory) configured to temporarily store data during execution of any of the programs. The control programs allow hardware such as the CPU to function as means for controlling the free length varying means 9 and a means for controlling winding angle varying means described below.
[0029] The turret plate 6 is provided on the body frame 5 as shown in Figure 6. The turret plate 6 can be pivotally moved around a rotating shaft 11 by a rotational driving device (not shown in the drawings). Two bobbin holders 12 around which respective bobbins 3 are installed are arranged symmetrically with respect to the rotating shaft 11 so as to project from the turret plate 6. The turret plate 6 is rotated by the above-described rotational driving device to allow the bobbin 3 located at an upper winding position to be replaced. As shown in Figure 7, the two bobbin holders 12 provided on the turret plate 6 are connected to and rotated by respective driving motor 27. The driving motors 27 are electrically connected to the control section 80. Thus, the control section 80 can freely control the rotation speeds of the bobbin holders 12 by drivingly controlling the respective driving motors 27. Furthermore, a bobbin holder rotation sensor 35 is provided on each of the bobbin holders 12 and electrically connected to the control section 80. The bobbin holder rotation sensor 35 senses the rotation speed of the bobbin holder 12 to transmit a sensing signal to the control section

80. Thus, upon receiving the sensing signal from the bobbin holder rotation sensor 35, the control section 80 can acquire the rotation speed of the bobbin holder 12 based on the sensing signal.

[0030] As shown in Figure 6, the slide box 16 is guided up and down with respect to the body frame 5 along paired rails 17, 17 provided at the respective ends of the slide box 16 so that the slide box 16 is movable in this direction. Elevating the slide box 16 allows the traverse device 7 fixed to the slide box 16 to separate from the contact roller 8. Lowering the slide box 16 allows the traverse device 7 to approach the contact roller 8. The slide box 16 is elevated and lowered by the free length varying means 9.

[0031] The traverse device traverses the elastic yarn 2 and is fixed to the slide box 16. The traverse device 7 is configured to set traverse width to a fixed value, and includes a traverse cam 30, a traverse guide 31, and a traverse motor 28 (see Figure 7). The traverse cam 30 is rotatably supported in the slide box 16, and includes a spiral traverse cam groove in the peripheral surface thereof. The traverse guide 31 is moved along the traverse cam groove and reciprocated in the axial direction of the traverse cam 30 by rotationally driving the traverse cam 30. The traverse guide 31 guides the elastic yarn 2 to the contact roller 8 while traversing the elastic yarn 2 in the lateral direction. The traverse motor 28 rotationally drives the traverse cam 30 and is electrically connected to the control section 80. Thus, the control section 80 can freely control the rotation speed of the traverse cam 30 by drivingly controlling the traverse motor 28. The above-described winding angle WA is determined by the rotation speed of the traverse cam 30. Thus, in this sense, the control section 80 can freely control the winding angle WA through control of the rotation speed of the traverse cam 30. The above-described winding angle varying means includes the traverse cam 30 and the traverse motor 28, serving as a driving source for the traverse cam 30.

[0032] The contact roller 8 is located downstream side of the traverse device 7 in the traveling direction of the elastic yarn 2. The contact roller 8 rotates in conjunction with the package 4 being formed, to receive and then pass the elastic yarn 2 traversed by the traverse device 7 to the peripheral surface of the package 4. The contact roller 8 is rotatably supported on a first end 13a side of an arm 13. A second end 13b of the arm 13 is inserted into a slide bar 14 supported in the slide boxl 16. That is, the contact roller 8 is configured to slidable up and down with respect to the slide box 16 via the arm 13. The contact roller 8 includes a rotation sensor 40 configured to sense the rotation speed of the contact roller 8. The rotation sensor 40 is electrically connected to the control section 80. The rotation sensor 40 senses the rotation speed of the contact roller 8 rotating in conjunction with the package 4, to transmit a sensing signal to the control section 80. Thus, by receiving the sensing signal from the rotation sensor 40, the control section 80 can acquire the rotation speed of the contact roller 8 based on the sensing signal. To maintain the traveling speed of the elastic yarn 2 constant, the control section 80 appropriately controls the driving motor 27 so as to maintain the rotation speed or peripheral speed of the contact roller 8 constant.

[0033] The free length varying means 9 elevates and lowers the slide box 16 during formation of the package 4 so as to enable a change in the free length FL (see Figure 10) of the elastic yarn 2 located between the contact roller 8 and the traverse device 7. The free length varying means 9 includes a ball screw mechanism 15, a position sensor 18, and a cylinder 19. Here, the free length FL refers to the free length of the elastic yarn 2 over which the elastic yarn 2 engaged with the traverse guide 31 in the traverse device 7 is released from the traverse guide 31 and then come into contact with the peripheral surface of the contact roller 8.

[0034] The ball spring mechanism 15 is a driving source configured to elevate and lower the slide box 16. The ball spring mechanism 15 includes a screw rod 20, a ball nut 21, and an elevating and lowering driving section 22. The screw rod 20 is located along the up-down direction of the body frame 5 and supported so as to be rotatable with respect to the body frame 5. The ball nut 21 is threadably fitted around the screw rod 20 and engaged with the slide box 16 from below. The elevating and lowering driving section 22 rotationally drives the screw rod 20. When the screw rod 20 is rotated forward or backward by the elevating and lowering driving section 22, the slide box 16 elevates or lowers via the ball nut 21. The elevating and lowering driving section 22 includes a motor 23, a first gear 24, a belt 25, and a second gear 26. The motor 23 is connected to the first gear 24. The belt 25 is wound between the first gear 24 and the second gear 26. The screw rod 20 is connected to the second gear 26. In this configuration, when the motor 23 is driven, the rotational driving force of the motor 23 is transmitted to the screw rod 20 via the first gear 24, the belt 25, and the second gear 26. Thus, the screw rod 20 is rotated. As shown in Figure 7, the motor 23 is electrically connected to the control section 80. Thus, the control section 80 can control the motor 23. Consequently, the control section 80 can freely elevate and lower the slide box 16 through control of the motor 23.

[0035] The position sensor 18 is provided opposite the second gear 26 to sense the rotation of the second gear 26 at every predetermined angle. The position sensor 18 is electrically connected to the control section 80. Every time the position sensor 18 senses the rotation of the second gear 26 at the predetermined angle, the position sensor 18 transmits a sensing signal to the control section 80. Thus, the control section 80 can acquire the height position of the slide box 16 and thus the height position of the traverse device 7 supported in the slide box 16, based on the number of times that the control section 80 has received a sensing from the position sensor 18.

[0036] The cylinder 19 carries most of the weight of the slide box 16 by means of cylinder pressure so that the above-described elevating and lowering driving section 22 requires only a weak driving force to elevate and lower the slide box

16. The cylinder pressure of the cylinder 19 is adjusted by an air supply section 36.

[0037] As described above, the free length varying means 9 includes the position sensor 18 configured to sense the height position of the traverse device 7. Thus, the winder 1 can accurately control the height position of the traverse device 7 and thus the above-described free length FL while appropriately feeding back the result of the sensing by the position sensor 18.

[0038] Figure 8 is a graph showing how the free length FL is controlled based on the winding diameter D of the package 4. The axis of abscissa indicates the winding diameter D of the package 4. The axis of ordinate indicates the free length FL. The ROM in the above-described control section 80 stores the correspondence relationship FL = f(D) between the winding diameter D and the free length FL, for example, in a table form. Specifically, as shown in Figure 8, the correspondence relationship FL = f(D) is such that the free length FL increases rapidly from FL1 to FL2 consistently with the winding diameter D, during the winding start of the package 4, that is, while the winding diameter D is varying from D1 to D2, and then decreases gradually from FL2 to FL1 with increasing winding diameter D toward the winding end, that is, while the winding diameter D is varying from D2 to D3. As described above, the free length FL is rapidly increased during the winding start of the package 4 and gradually reduced toward the winding end. In other words, the reason for (D2 - D1) < (D3- D2) is as follows. The yarn layer is compressed hard during the winding start but not substantially compressed during the winding end.

[0039] Now, the operation of the winder 1 will be described with reference to Figures 8 to 10. Figure 9 is a flowchart of a control program. Figure 10 is a diagram showing how the winder operates. Unlike the Unexamined Japanese Patent Application Publication (Tokkai-Hei) No. 9-71367, the present embodiment does not adopt the technique to increase and reduce the winding angle WA in order to inhibit possible bulging.

[0040] As shown in Figure 10A, with the free length FL set to FL1, winding of the elastic yarn 2 is started. Then, the control section 80 first calculates the winding diameter D of the current package 4 (S300). Specifically, the control section 80 acquires the rotation speed of the contact controller 8 based on a sensing signal from the rotation sensor 40. The control section 80 acquires the rotation speed of the bobbin holder 12 based on a sensing signal from the bobbin holder rotation sensor 35. Based on the rotation speed of the contact controller 8, the rotation speed of the bobbin holder 12, and the diameter of the contact controller 8 pre-stored in the ROM, the control section 80 calculates the winding diameter D of the current package 4.

[0041] Then, the control section 80 calculates an increment ΔD in the winding diameter D of the package 4 (S310). Specifically, the control section 80 determines the difference between the past winding diameter D calculated as described in S300 and the current winding diameter D of the package 4 calculated as described in S300 to calculate the increment ΔD in the winding diameter D of the package 4.

[0042] Then, as shown in Figure 8, the control section 80 calculates the free length FL corresponding to the winding diameter D (S320). Specifically, based on the winding diameters D calculated as described in S300 and the correspondence relationship FL = f(D) (see Figure 8) stored in the ROM in a table form, the control section 80 calculates the free length FL corresponding to the winding diameter D as shown in Figure 8.

[0043] Then, the control section 80 calculates the variation amount ΔFL of the free length FL (S330). Specifically, the control section 80 determines the difference between the past free length FL calculated as described in S320 and the current free length FL calculated as described in S320 to calculate the variation amount ΔFL of the free length FL. Figure 8 indicates that the variation amount ΔFL has positive values while the winding diameter D is varying from D1 to D2. The variation amount ΔFL has negative values while the winding diameter D is varying from D2 to D3.

[0044] Then, the control section 80 calculates the movement amount ΔG of the slide box 16 (S340). Specifically, based on the increment ΔD in the winding diameter D of the package 4 calculated as described in S310, the variation amount ΔFL of the free length FL calculated as described in S330, and Expression 2 shown below, the control section 80 calculates the movement amount ΔG (the upward direction of the body frame 5 corresponds to the positive side) of the slide box 16. The ΔFL in Expression (2) may take a negative value as described above. Thus, if the absolute value of the variation amount ΔFL is larger than ΔD, the movement amount ΔG has a negative value.

[0045]

[Expression 2]

$$\Delta G = \Delta D + \Delta FL \cdots (2)$$

[0046] Then, the control section 80 moves the slide box 16 up and down based on the movement amount ΔG calculated as described in S340 (S350). Specifically, the control section 80 drivingly controls the motor 23 so as to elevate and lower the slide box 16 until the height position of the slide box 16 determined based on a sensing signal received from the position sensor 18 varies by the movement amount ΔG.

[0047] Then, the control section 80 determines whether or not the winding diameter D of the package 4 calculated as described in S300 has reached a predetermined value Dmax (S360). If the control section 80 determines that the winding diameter D has not reached the predetermined value Dmax yet (S360: N0), the control section 80 shifts back to the processing in S300. On the other hand, if the control section 80 determines that the winding diameter D has reached the predetermined value Dmax (S360: YES), the control section 80 rotates the turret plate 6, changes the bobbin, and then starts a new winding operation.

[0048] The above-described series of control allows the operation of the winder 1 shown in Figure 10 to be implemented. That is, according to the correspondence relationship FL = f(D) shown in Figure 8, the free length FL increases gradually from FL1 to FL2 while the winding diameter D is varying from D1 to D2 and decreases gradually from FL2 to FL1 while the winding diameter D is varying from D2 to D3 as shown in Figure 10.

[0049] Furthermore, the above-describe series of control allows the slide box 16 to be elevated and lowered as shown in Figure 11 by a solid line. Figure 11 is a graph showing the relationship between the time for which winding of a package 4 is carried out and the height of the slight box 16. The axis of abscissa indicates the winding time. The axis of ordinate indicates the height position of the slide box 16. In Figure 11, the solid line shows how the height position of the slide box 16 according to the present embodiment varies. An alternate long and two short dashes line shows how the height position of the slide box 16 varies with the free length FL maintained constant. The alternate long and two short dashes line is high on the right side because in order to allow the free length FL to be maintained constant even though the contact roller 8 is pushed up by the thickened package 4, the slide box 16 is elevated to offset the increment ΔD in winding diameter D. In Figure 11, as shown by the solid line, according to the present embodiment, while the winding diameter D of the package 4 is varying from D2 to D3, since the absolute value of the variation amount ΔFL is larger than the increment ΔD, the movement amount Δ G of the slide box 16 has a negative value, thus allowing the slide box 16 to lower.

[0050] The operation of the winder 1 has been described. Now, the results of tests for confirming the bulging inhibiting effect exerted by the winder I according to the present embodiment will be described.

(Test Conditions)

Raw yarn used: Spandex yarn 44dtex

[0051] Winding angle WA: 12 degrees at the winding start and 10 degrees at the winding end. A constant winding angle WA makes the wind number N equal to the critical wind number Nd toward the winding end. Thus, the winding angle WA is reduced toward the winding end. The reduction in winding angle WA has no relation with the inhibition of possible bulging.

Free length FL: as shown by an alternate long and two short dashes line in Figure 12.

[0052] Figure 12 is a graph showing the results of tests for confirming the technical effects of the present invention. The axis of abscissa indicates the winding diameter D of the package 4. The axis of ordinate indicates the end surface of the package 4 and the free length FL. An alternate long and two short dashes line in Figure 12 indicates the correspondence relationship FL = f(D) adopted in the tests. In Figure 12, a thick solid line indicates an example in which the free length FL is increased and reduced based on the correspondence relationship FL = f(D). A thin solid line indicates a comparative example in which the free length FL is constant (minimum). The reference (origin) of the left axis of ordinate is the end surface of the bobbin 3. In Figure 12, the axial direction of the bobbin 3 coincides with the vertical direction in the sheet of the drawing. The radial direction of the bobbin 3 coincides with the horizontal direction in the sheet of the drawing.

[0053] Figure 12 described above indicates that possible bulging can be sufficiently inhibited by increasing the free length FL during the winding start of the package 4 and reducing the free length FL toward the winding end. In neither of the example and the comparative example, a trace of slip-down of the yarn 2 along the end surface of the package 4 was found.

(Summary)

(Claims 1 and 3)

[0054] In the above-described embodiment, the winder 1 that forms the package 4 is configured as follows. The winder 1 includes the contact roller 8 configured to come into contact with the package 4 during formation of the package 4, the traverse device 7 located upstream side of the contact roller 8 in the traveling direction of the elastic yarn 2, the free length varying means 9 for enabling the free length FL of the elastic yarn 2 located between the contact roller 8 and the traverse device 7 (specifically, the traverse guide 31) to be varied during formation of the package 4, and the control section 80 configured to control the free length varying means 9 in such a manner that the free length FL is increased during winding start of the package 4 and then reduced toward winding end. This configuration allows possible bulging to be inhibited. Furthermore, an increase and reduction in free length FL avoids varying the wind number N. Thus, winding can be easily carried out with possible bulging inhibited and with the critical wind number Nd avoided. Successful avoidance of the critical wind number Nd in turn allows avoidance of various problems: slip-down of the elastic yarn 2 along the end surface of the package 4 during traversing, vibration of the contact roller 8, and improper unwinding of the yarn from the package 4 during the subsequent step.

[0055] The above-described embodiment does not adopt the technique to increase and reduce the winding angle WA in order to inhibit possible bulging. However, the technique to increase and reduce the winding angle WA may also be used. Furthermore, if a constant winding angle WA inevitably makes the wind number N equal to the critical wind number Nd toward the winding end, the winding angle WA may be slightly reduced toward the winding end.

[0056] Additionally, as shown in Figure 8, the free length FL is increased from FL1 to FL2 and reduced back to FL1. However, the free length FL need not necessarily be reduced back to FL1. However, to allow the winding width of the package 4 to be maintained constant regardless of the winding diameter D of the package 4 as shown in the right part of Figure 5B, the free length FL is preferably increased from FL1 to FL2 and then reduced back to FL1.

[0057] Furthermore, in the above-described embodiment, the increase and reduction in free length FL is set based on the winding diameter D, that is, the correspondence relationship FL = f(D). Alternatively, the increase and reduction in free length FL is set based on the winding time (t), that is, so that FL = f(t).

[0058] Additionally, the winding diameter D2, shown in Figure 8, of the package 4 corresponding to the turning point where the free length FL that has been increased so far starts to be reduced is preferably appropriately increased and reduced depending on yarn winding conditions.

(Claim 5)

[0059] Furthermore, in the above-described embodiment, the elastic yarn 2 is wound around the bobbin 3. If the elastic yarn 2 is used, a strong winding tightening force is exerted, resulting in significant bulging as described above. An attempt to deal with the significant bulging simply by increasing and reducing the winding angle WA results in the inevitable occurrence of ribbon winding. However, possible ribbon winding can be avoided by increasing and reducing the free length FL. Thus, the technique to inhibit possible bulging by increasing and reducing the free length FL is beneficial particularly when the elastic yarn 2 is used.

[0060] Now, a second embodiment of the present invention will be described below with reference to Figures 13 and 14. The differences between the present embodiment and the first embodiment will mainly be described, and duplicate descriptions are appropriately omitted.

[0061] Figure 13 is a graph which is similar to Figure 8 and which shows how the free length FL and the winding angle WA are controlled based on the winding diameter D of the package 4 according to the second embodiment of the present invention. The axis of abscissa indicates the winding diameter D of the package 4. The axis of ordinate indicates the free length FL and the winding angle WA. In the above-described first embodiment, the ROM in the control section 80 stores the correspondence relationship FL = f(D) between the winding diameter D and the free length FL of the package 4 as shown in Figure 8. However, in the present embodiment, the ROM in the control section 80 stores another correspondence relationship FL = g(D) between the winding diameter D and the free length FL of the package 4 in a table form as shown in Figure 13. The difference between the correspondence relationship FL = f(D) according to the above-described first embodiment and the correspondence relationship FL = g(D) according to the present embodiment is that in the former relationship, the free length FL reciprocates between FL1 and FL2, whereas in the latter relationship, the free length FL reciprocates between FL1 and FL3 (however, FL1 < FL3 < FL2).

[0062] In short, the range of an increase and reduction in free length FL in the correspondence relationship FL = g(D) according to the present embodiment is smaller than that in the correspondence relationship FL = f(D) according to the above-described first embodiment.

[0063] Furthermore, in the present embodiment, the ROM in the control section 80 stores not only the correspondence relationship FL = g(D) between the winding diameter D and the free length FL of the package 4 in a table form as shown in Figure 13 but also the correspondence relationship between WA = h(D) between the winding diameter D and the winding angle WA of the package 4 in a table form also as shown in Figure 13. Specifically, as shown in Figure 13, during the winding start, that is, while the winding diameter D is varying from D1 to D2, the winding angle WA increases from WA1 to WA2 consistently with the winding diameter D. On the other hand, during the winding end, that is, while the winding diameter D is varying from D2 to D3, the winding angle WA reduces from WA2 to WA1 consistently with the winding diameter D so as to prevent the wind number N from equaling the critical wind number Nd.

[0064] Now, the operation of the winder 1 according to the present invention will be described with reference to Figures

10, 13, and 14. Figure 14 is a flowchart which is similar to Figure 9 and which illustrates the second embodiment of the present invention. As shown in Figure 13, like the Unexamined Japanese Patent Application Publication (Tokkai-Hei) No. 9-71367, the present embodiment adopts the technique to increase and reduce the winding angle WA in order to inhibit possible bulging.

[0065] As shown in Figure 10A, winding of the elastic yarn 2 is started with the free length FL set to FL1. Then, the control section 80 first calculates the winding diameter D of the current package 4.

[0066] Then, the control section 80 calculates the increment ΔD in the winding diameter D of the package 4 (S310).

[0067] Then, the control section 80 calculates the free length FL corresponding to the winding diameter D as shown in Figure 13 (S320). Specifically, based on the winding diameter D calculated as described in S300 and the correspondence relationship FL = g(D) stored in the ROM in a table form (see Figure 13), the control section 80 calculates the free length FL corresponding to the winding diameter D as shown in Figure 13.

[0068] The control section 80 then calculates the variation amount ΔFL of the free length (S330).

[0069] The control section 80 then calculates the movement amount ΔG of the slide box 16 (S340) .

[0070] The control section 80 then moves the slide box 16 up and down based on the movement amount ΔG calculated in S340 (S350).

[0071] The control section 80 then calculates the winding angle WA corresponding to the winding diameter D as shown in Figure 13 (S360). Specifically, based on the winding diameter D calculated as described in S300 and the correspondence relationship WA = h(D) stored in the ROM in a table form (see Figure 13), the control section 80 calculates the winding angle WA corresponding to the winding diameter D as shown in Figure 13.

[0072] The control section 80 then changes the current winding angle WA to the winding angle WA calculated as described in S360 (S370). Specifically, the control section 80 acquires the rotation speed of the contact roller 8 based on a sensing signal received from the rotation sensor 40. Then, taking into account the rotation speed of the contact roller 8, that is, the peripheral speed of the package 4, the control section 80 drivingly controls the traverse motor 28 so as to increase or reduce the rotation speed of the traverse cam 30 so that the current winding angle WA is set to the winding angle WA calculated as described in S360.

[0073] The control section 80 then determines whether or not the winding diameter D of the package 4 calculated as described in S300 has reached the predetermined value Dmax (S380). Upon determining that the winding diameter D has not reached the predetermined value (S380: NO), the control section 80 shifts back to the processing in S300. On the other hand, upon determining that the winding diameter D has reached the predetermined value (S380: YES), the control section 80 rotates the turret plate 6, changes the bobbin 3, and starts a new winding operation.

(Summary)

(Claims 2 and 4)

[0074] As described above, in the present embodiment, the winder 1 is further configured as follows. The winder 1 further includes a winding angle varying means for enabling the winding angle WA to be varied. The control means 80 controls the winding angle varying means in such a manner that the winding angle WA is increased during the winding start of the package 4 and then reduced toward the winding end. In this manner, to allow possible bulging to be inhibited, both the free length FL and the winding angle WA are increased and reduced. This enables a reduction in the range of an increase and reduction in free length FL required to inhibit possible bulging. As a result, the free length varying means 9 can be made compact.

[0075] Furthermore, when the technique to vary the winding width by varying the traverse width is compared with the technique to vary the winding width by varying the free length FL and the winding angle WA (that is, the traverse speed) with the traverse width maintained constant as is the case with the present embodiment, the latter technique allows the traverse width to remain constant, allowing even a yarn type such as elastic yarns to be smoothly wound. Moreover, the end surface is properly finished.

[0076] The preferred embodiments of the present invention have been described. However, the above-described embodiments may be varied as follows.

[0077] In the above-described second embodiment, as shown in Figure 13, the turnaround point relating to the increase and reduction in free length FL and the turning point relating to the increase and reduction in the winding angle WA are reached when the winding diameter D of the package 4 reaches D2. However, alternatively, on the time axis, the turning point relating to the increase and reduction in free length FL may be out of alignment with the turning point relating to the increase and reduction in winding angle WA.

[0078] Furthermore, in the above-described second embodiment, as shown in Figure 13, the winding angle WA is set to WA1 both at the start and end points of winding. However, the winding angle WA at the start point may be different from that at the end point instead of being the same as that at the end point.

While the present invention has been described with respect to preferred embodiments thereof, it will be apparent to those skilled in the art that the disclosed invention may be modified in numerous ways and may assume many embodiments other than those specifically set out and described above. Accordingly, it is intended by the appended claims to cover all modifications of the present invention that fall within the scope of the invention.

Claims

1. A yarn winding machine configured to form a package, the yarn winding machine being **characterized by** including:

   a contact roller configured to come into contact with the package during formation of the package;
   a traverse device located upstream side of the contact roller in a traveling direction of a yarn;
   a free length varying means for enabling the free length of the yarn located between the contact roller and the traverse device to be varied during formation of the package; and
   a control means for controlling the free length varying means in such a manner that the free length is increased during winding start of the package and then reduced toward winding end.

2. The yarn winding machine according to Claim 1, **characterized by** further including a winding angle varying means for enabling the winding angle to be varied, and
   in that the control means controls the winding angle varying means in such a manner that the winding angle is increased during the winding start of the package and then reduced toward the winding end.

3. A yarn winding method of forming a package using a contact roller configured to come into contact with the package during formation of the package and a traverse device located upstream side of the contact roller in a traveling direction of the yarn, the method being **characterized in that**:

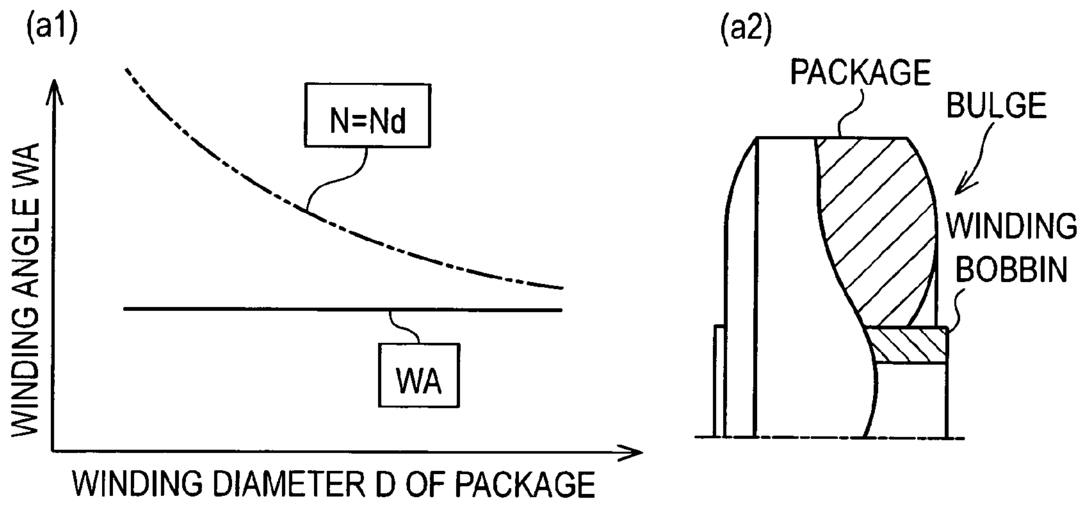
   the free length of the yarn located between the contact roller and the traverse device is increased during winding start of the package and then reduced toward winding end.

4. The yarn winding method according to Claim 3, **characterized in that** a winding angle is increased during the winding start of the package and then reduced toward the winding end.

5. The yarn winding method according to Claim 3 or Claim 4, **characterized in that** the yarn is elastic.

FIGURE1

(A) BULGE OCCURRENCE STATE



(B) INHIBITION OF POSSIBLE BULGING BY INCREASING AND REDUCING WINDING ANGLE (TECHNIQUE IN UNEXAMINED JAPANESE PATENT APPLICATION PUBLICATION (TOKKAI-HEI) NO. 9 - 71367→OK

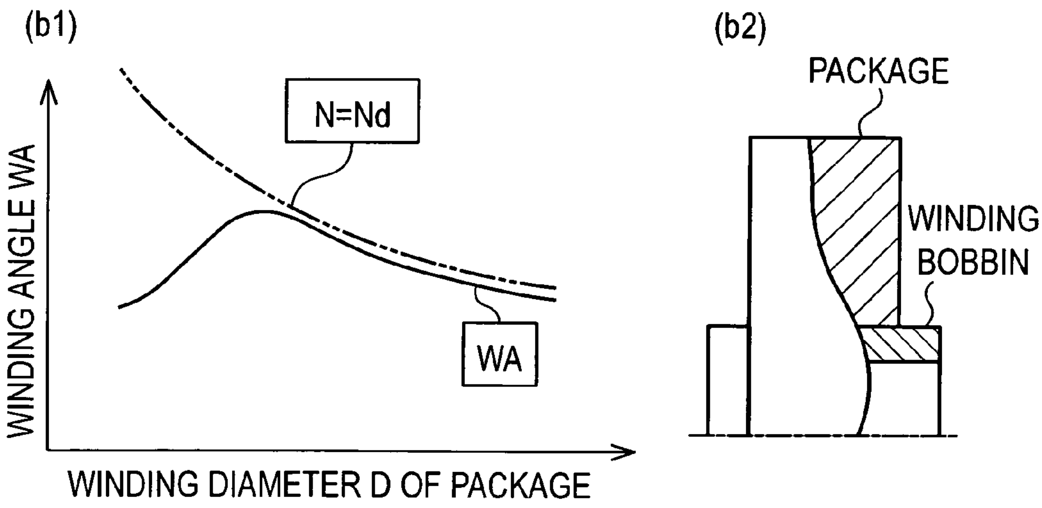
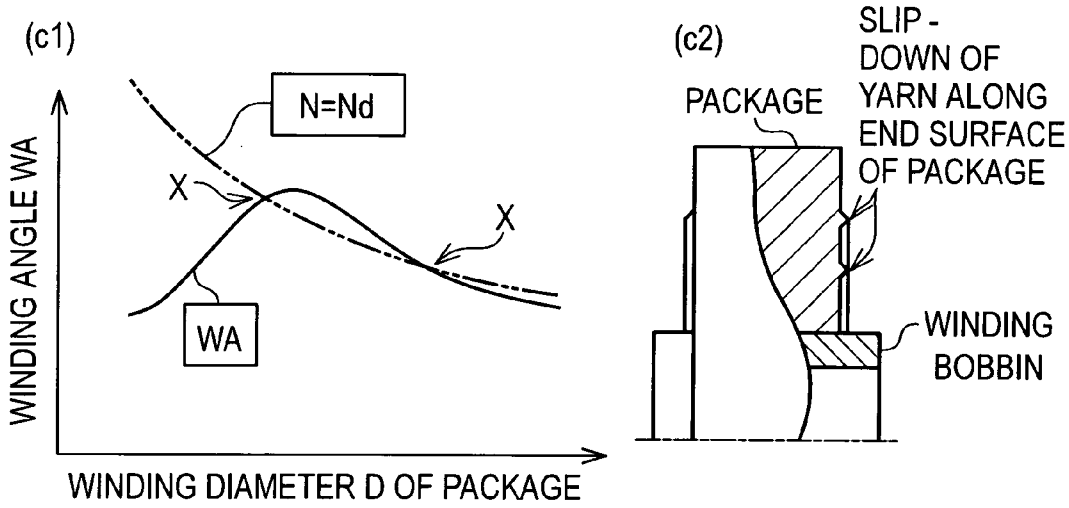


FIGURE2

(C) INHIBITION OF POSSIBLE BULGING BY INCREASING AND REDUCING WINDING ANGLE (RIBBON INTERFERENCE OCCURS) → NG



(D) INHIBITION OF POSSIBLE BULGING BY INCREASING AND REDUCING FREE LENGTH (NO RIBBON INTERFERENCE OCCURS) → OK

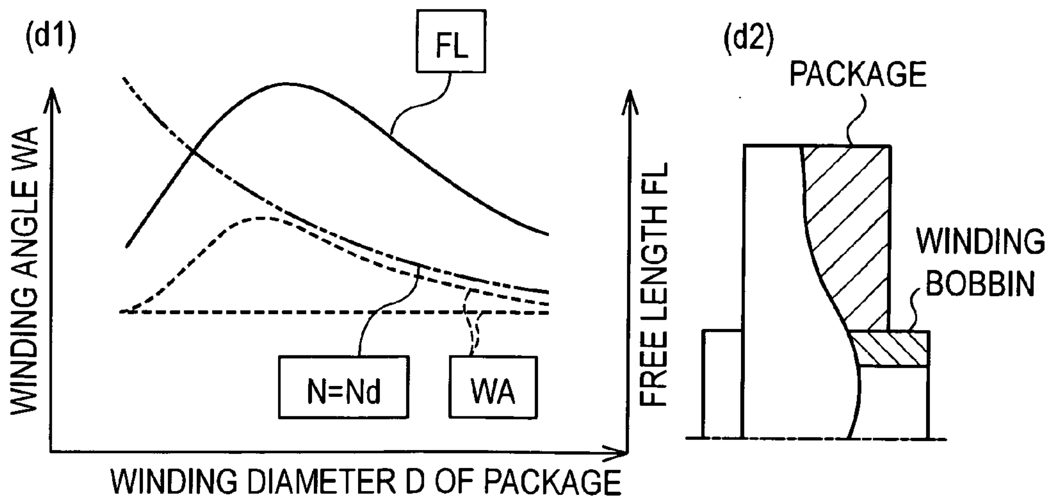


FIGURE3

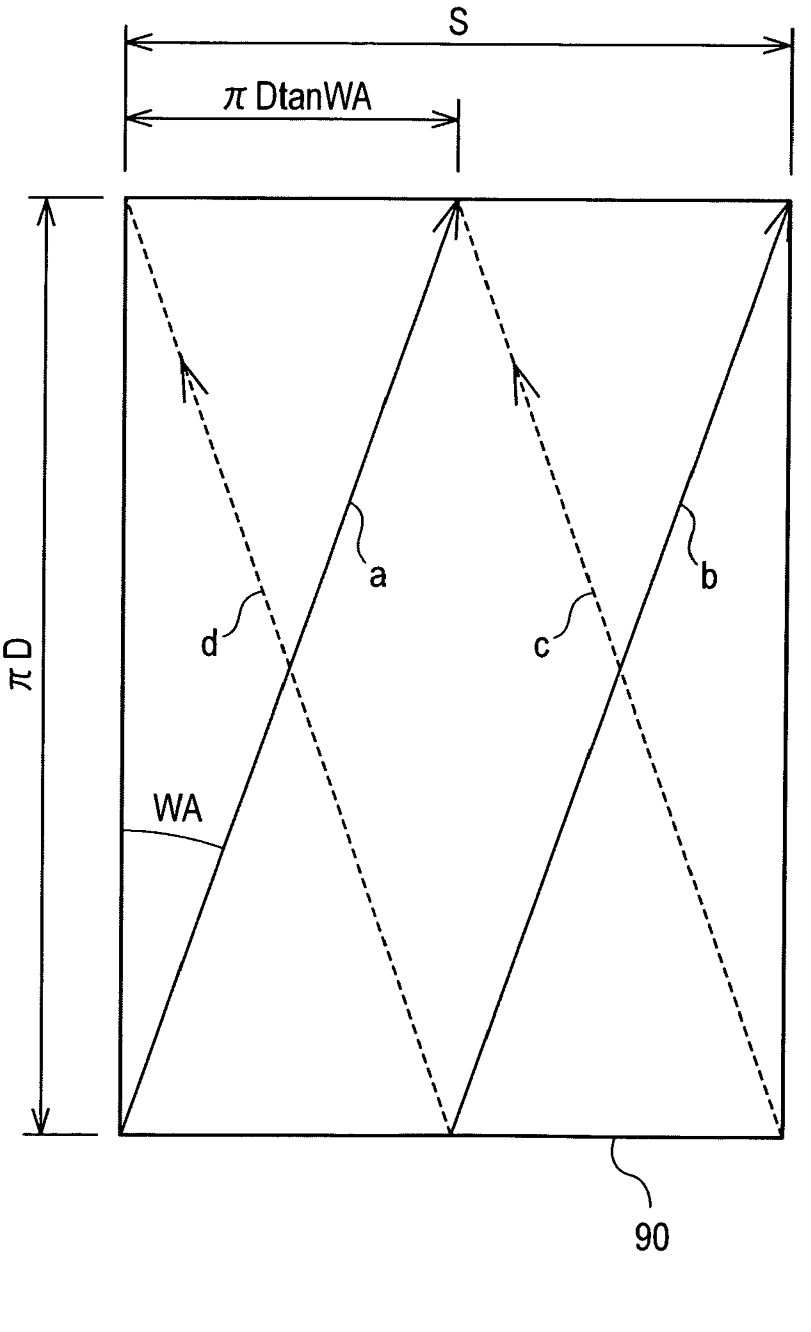


FIGURE4

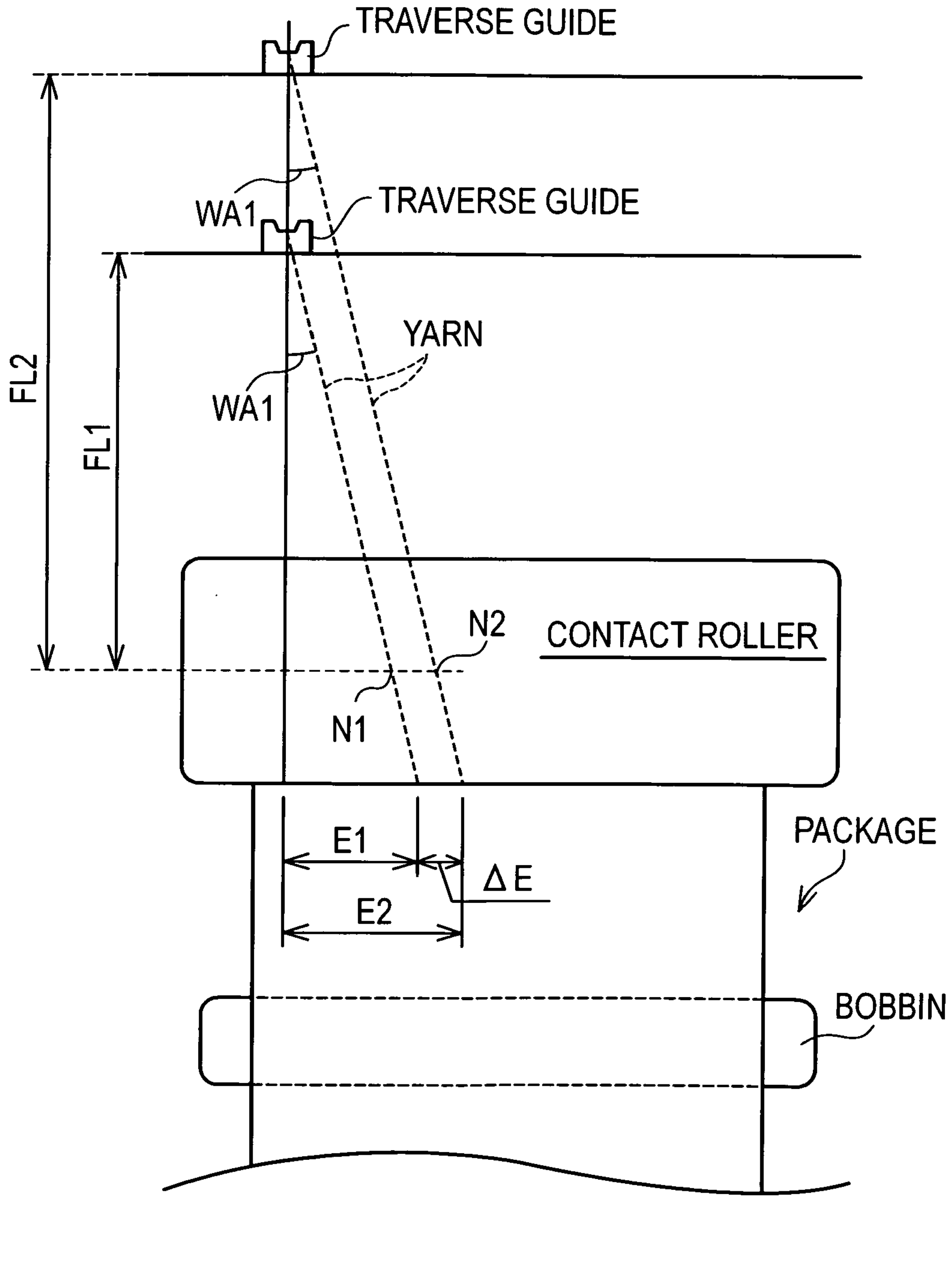
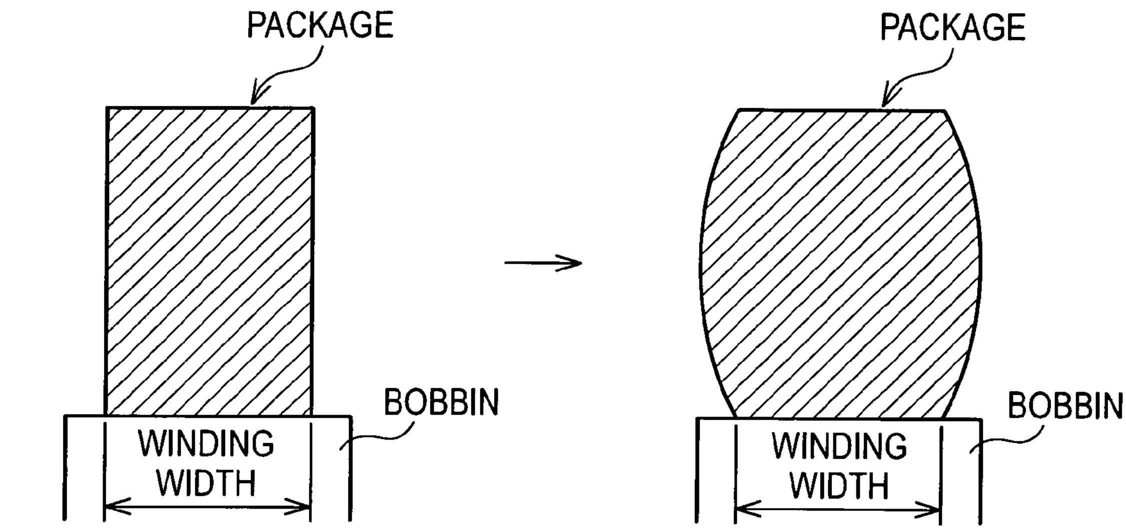

TRAVERSE GUIDE
WA1
TRAVERSE GUIDE
YARN
FL2
FL1
WA1
N2
CONTACT ROLLER
N1
PACKAGE
E1
ΔE
E2
BOBBIN

FIGURE5

(A) FREE LENGTH FL CONSTANT



(B) FREE LENGTH FL FROM FL1 THROUGH FL2 TO FL1 (FL1 < FL2)

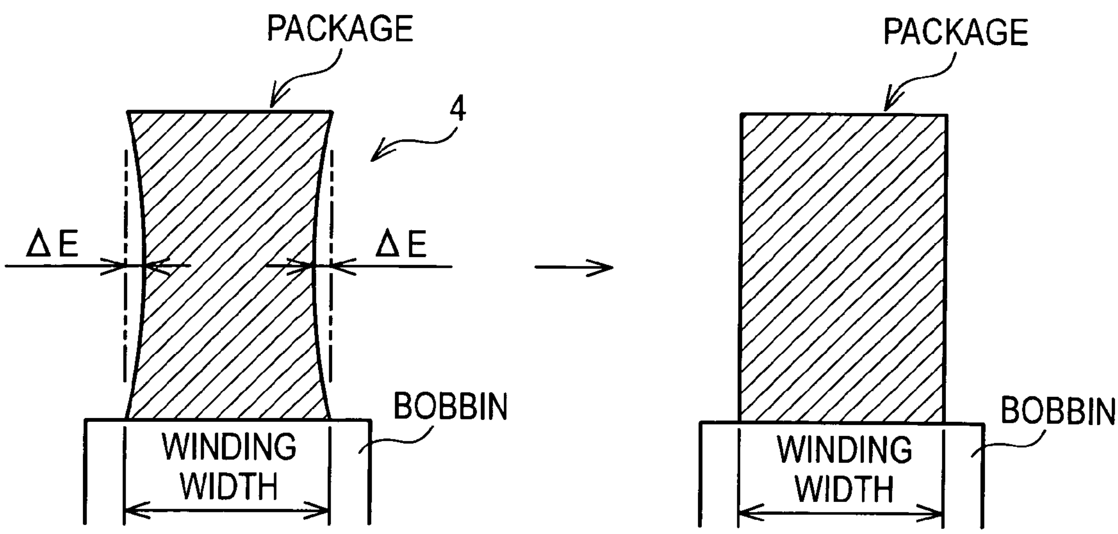


FIGURE6

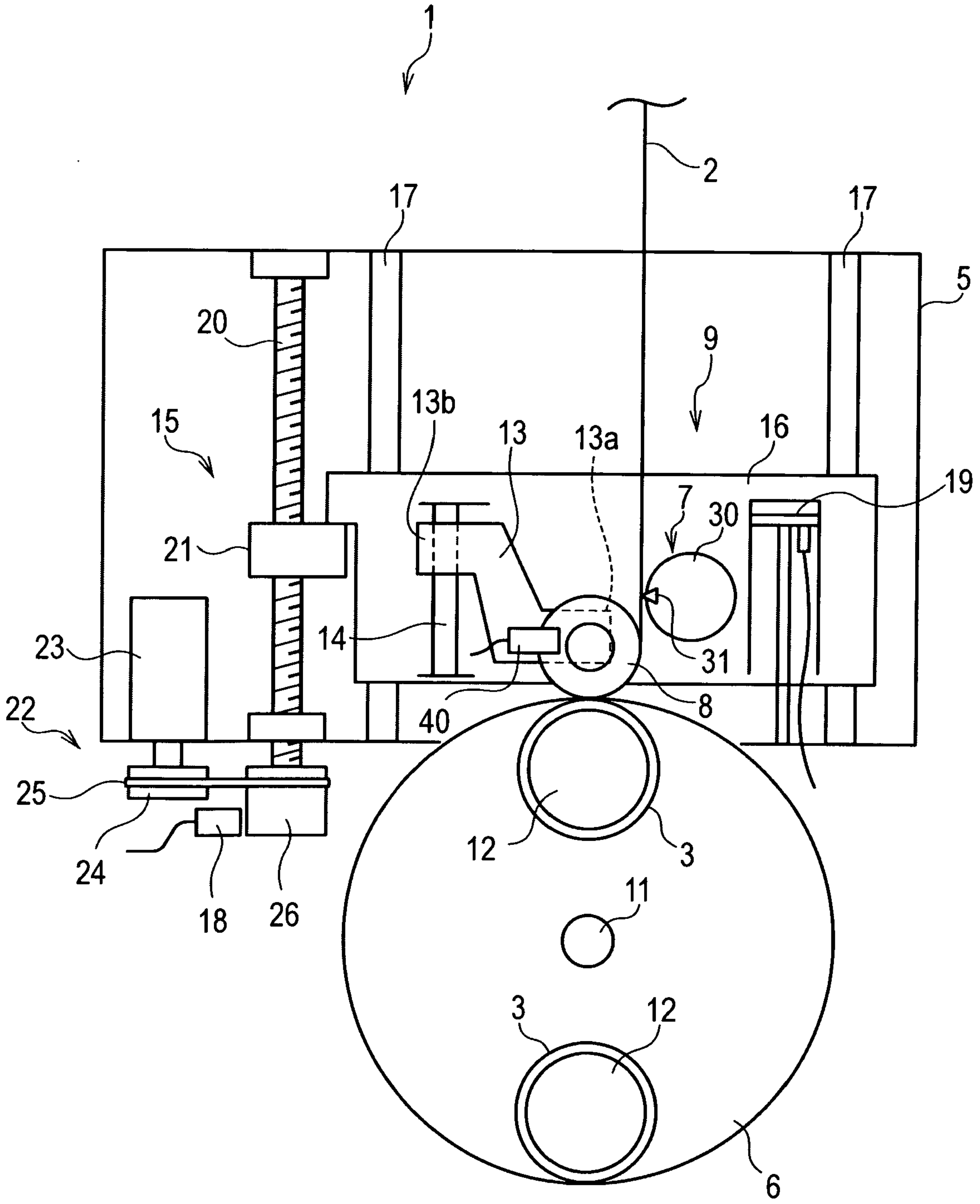

1
2
17
17
5
20
9
13b
13
13a
16
15
19
7
30
21
14
31
23
40
8
22
25
24
12
3
18
26
11
3
12
6

FIGURE7

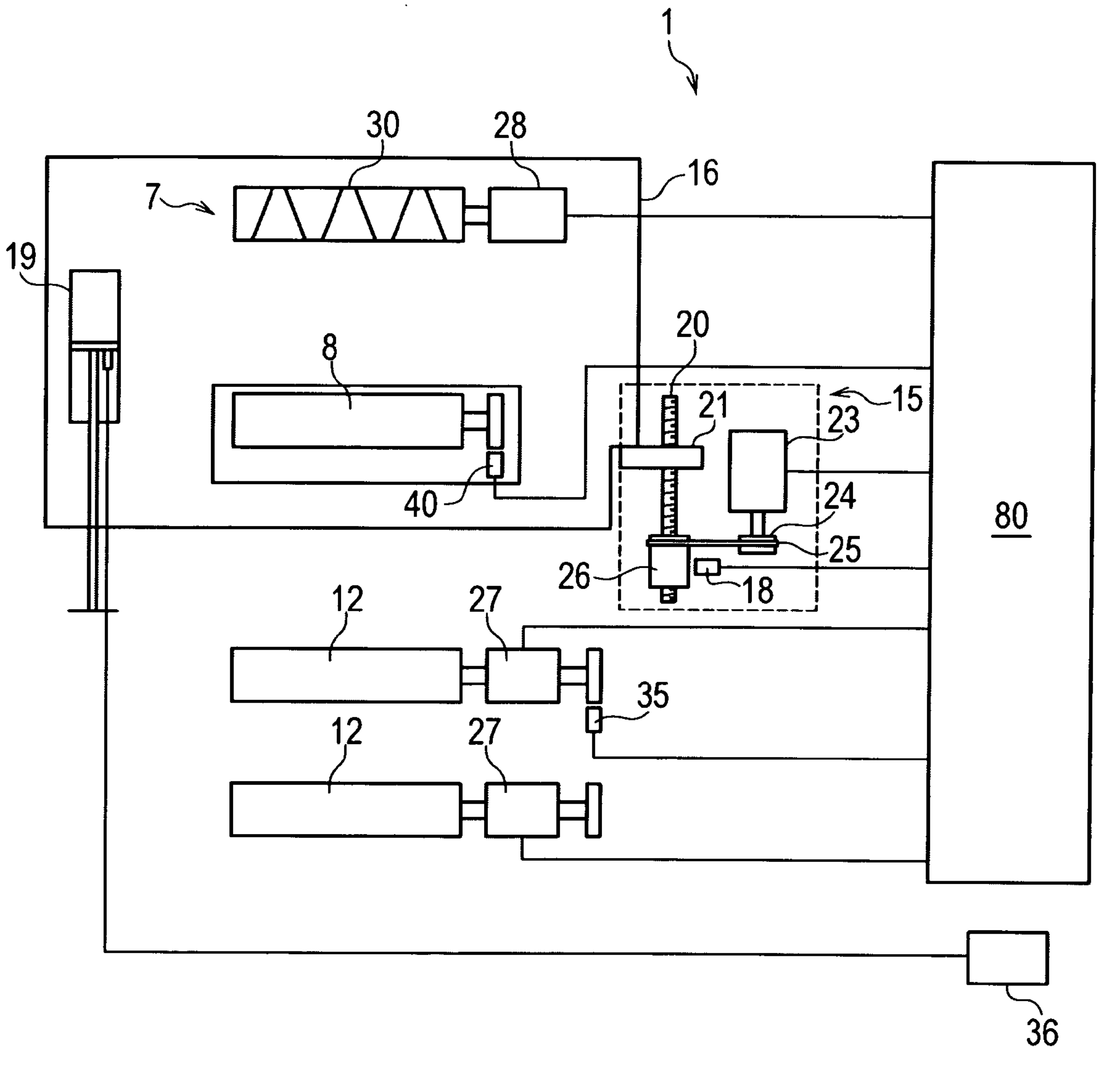
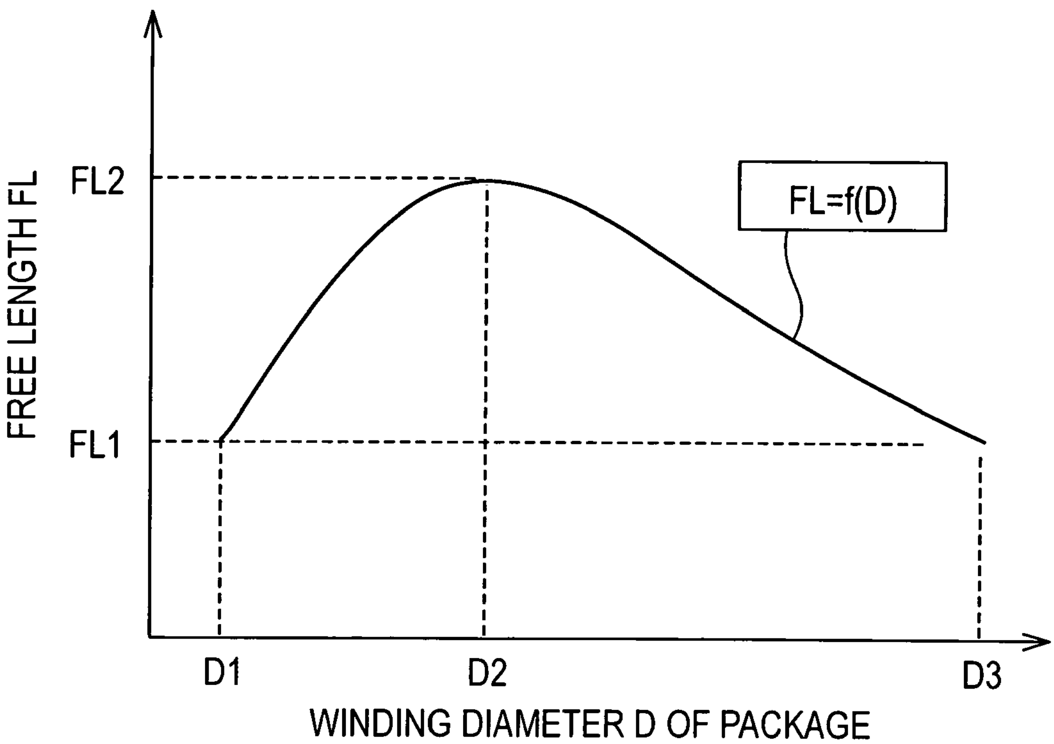


FIGURE8



FREE LENGTH FL
FL2
FL1
FL=f(D)
D1
D2
D3
WINDING DIAMETER D OF PACKAGE

FIGURE9

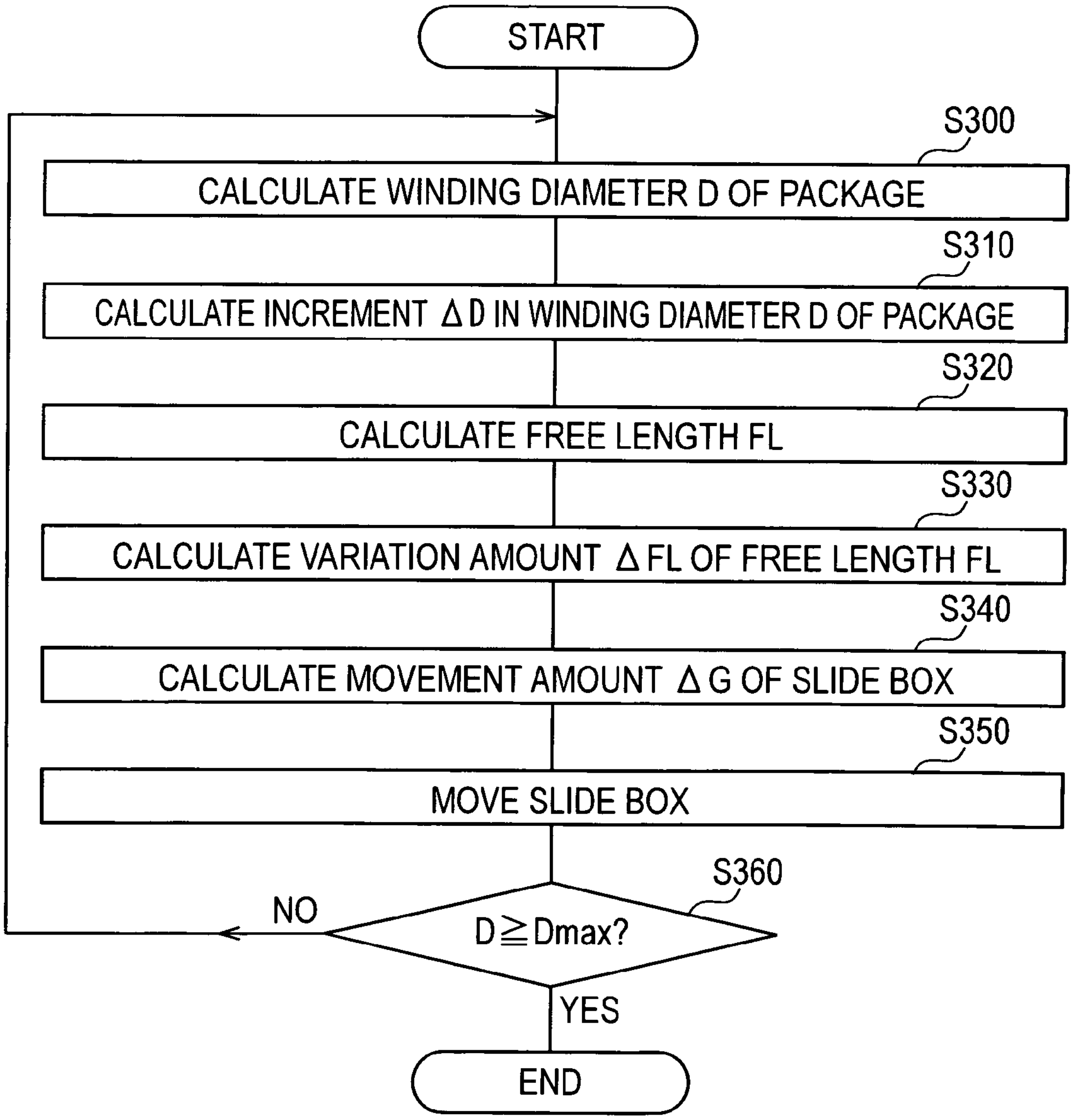

START
S300
CALCULATE WINDING DIAMETER D OF PACKAGE
S310
CALCULATE INCREMENT ΔD IN WINDING DIAMETER D OF PACKAGE
S320
CALCULATE FREE LENGTH FL
S330
CALCULATE VARIATION AMOUNT ΔFL OF FREE LENGTH FL
S340
CALCULATE MOVEMENT AMOUNT ΔG OF SLIDE BOX
S350
MOVE SLIDE BOX
S360
D≧Dmax?
NO
YES
END

FIGURE10A

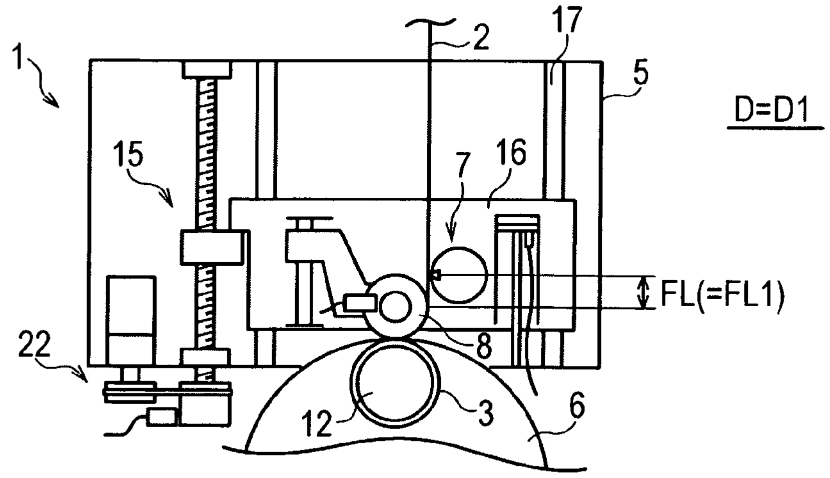


FIGURE10B

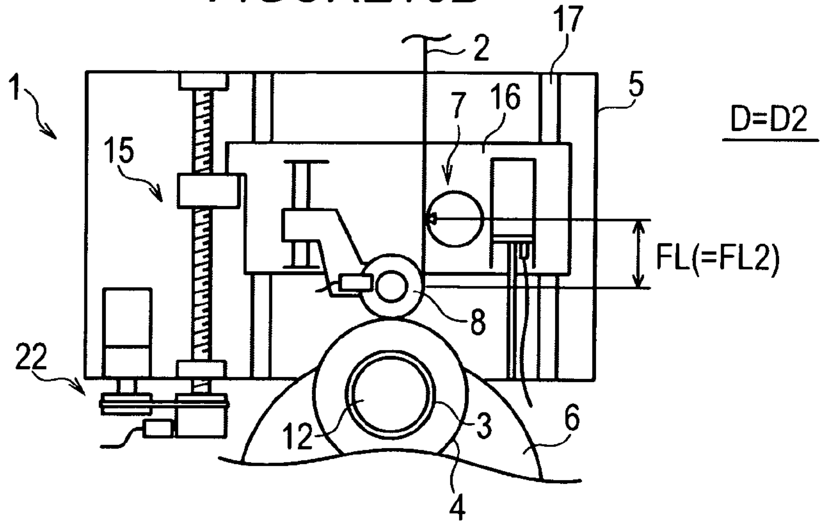


FIGURE10C

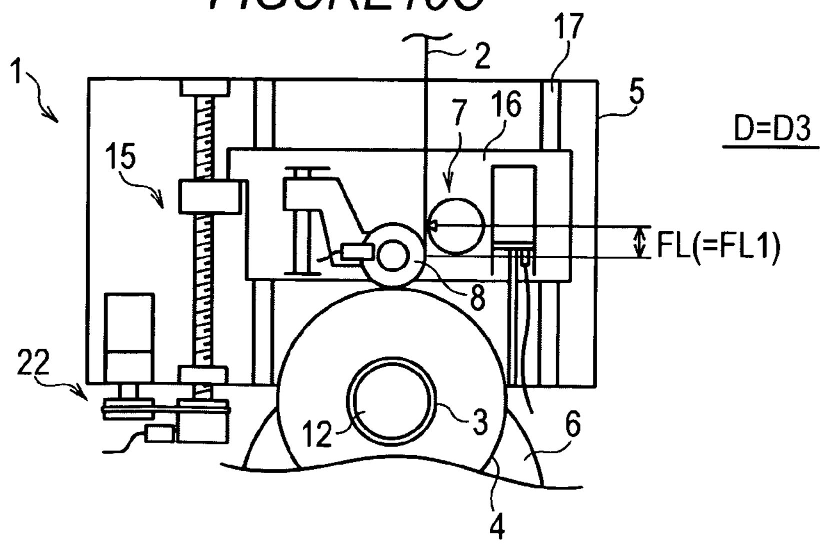


FIGURE11

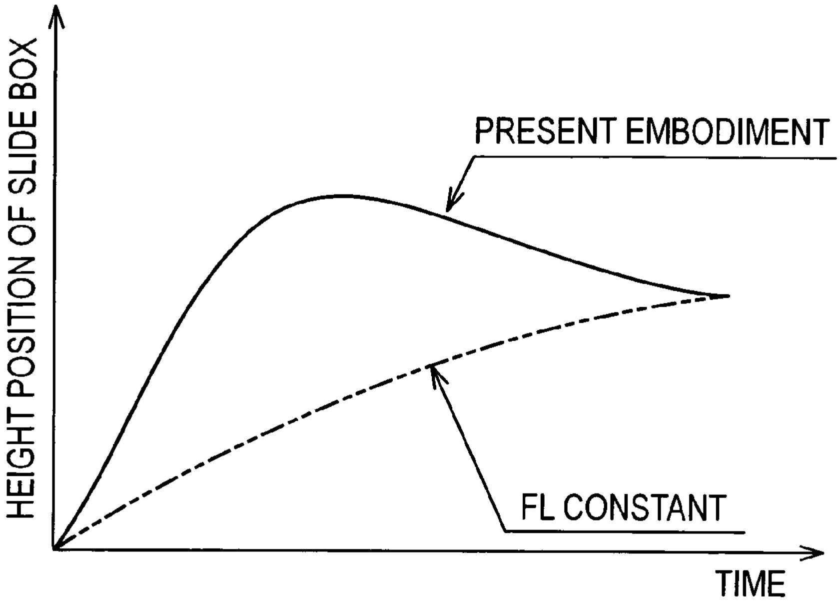


FIGURE12

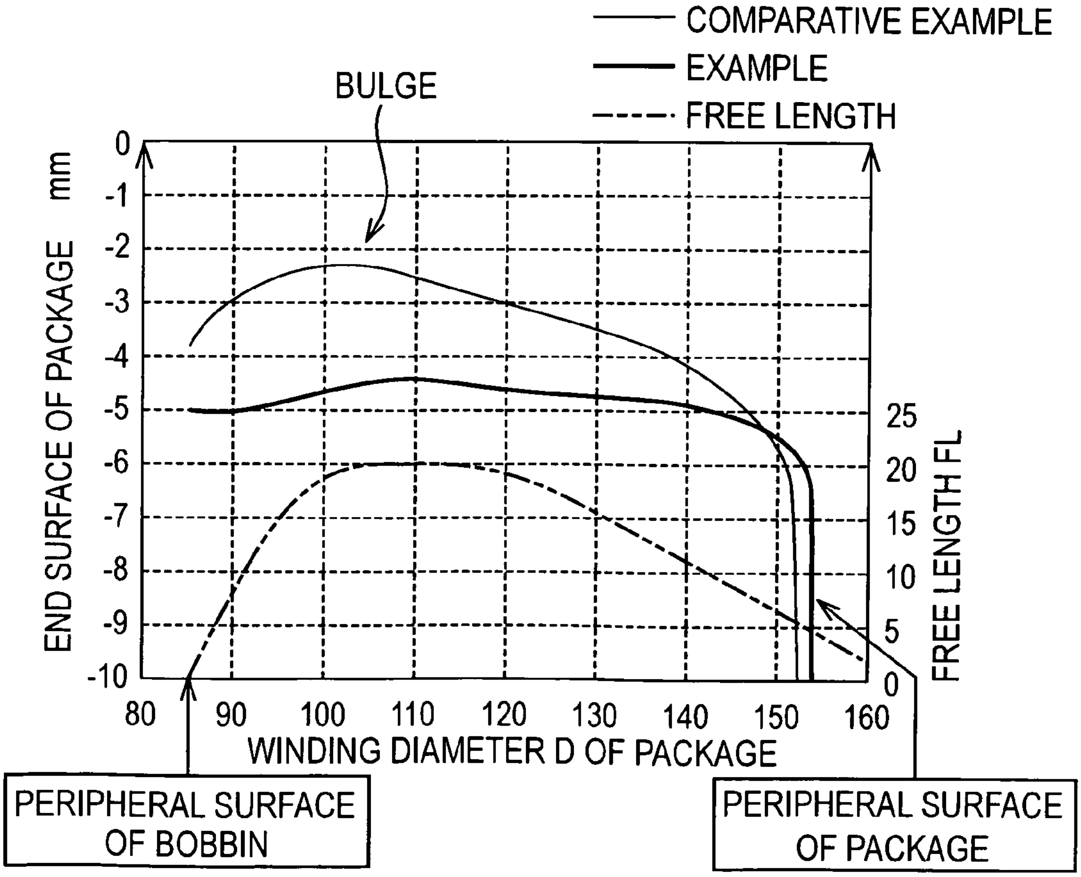


FIGURE13

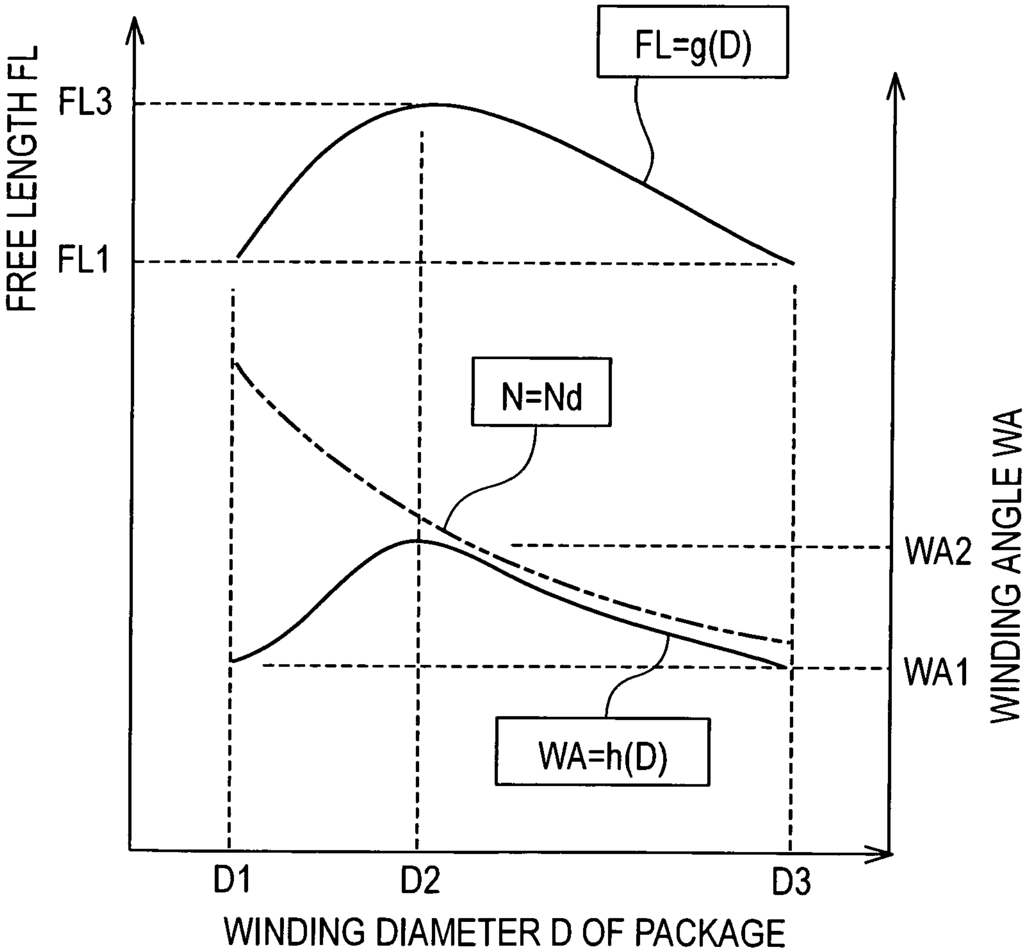
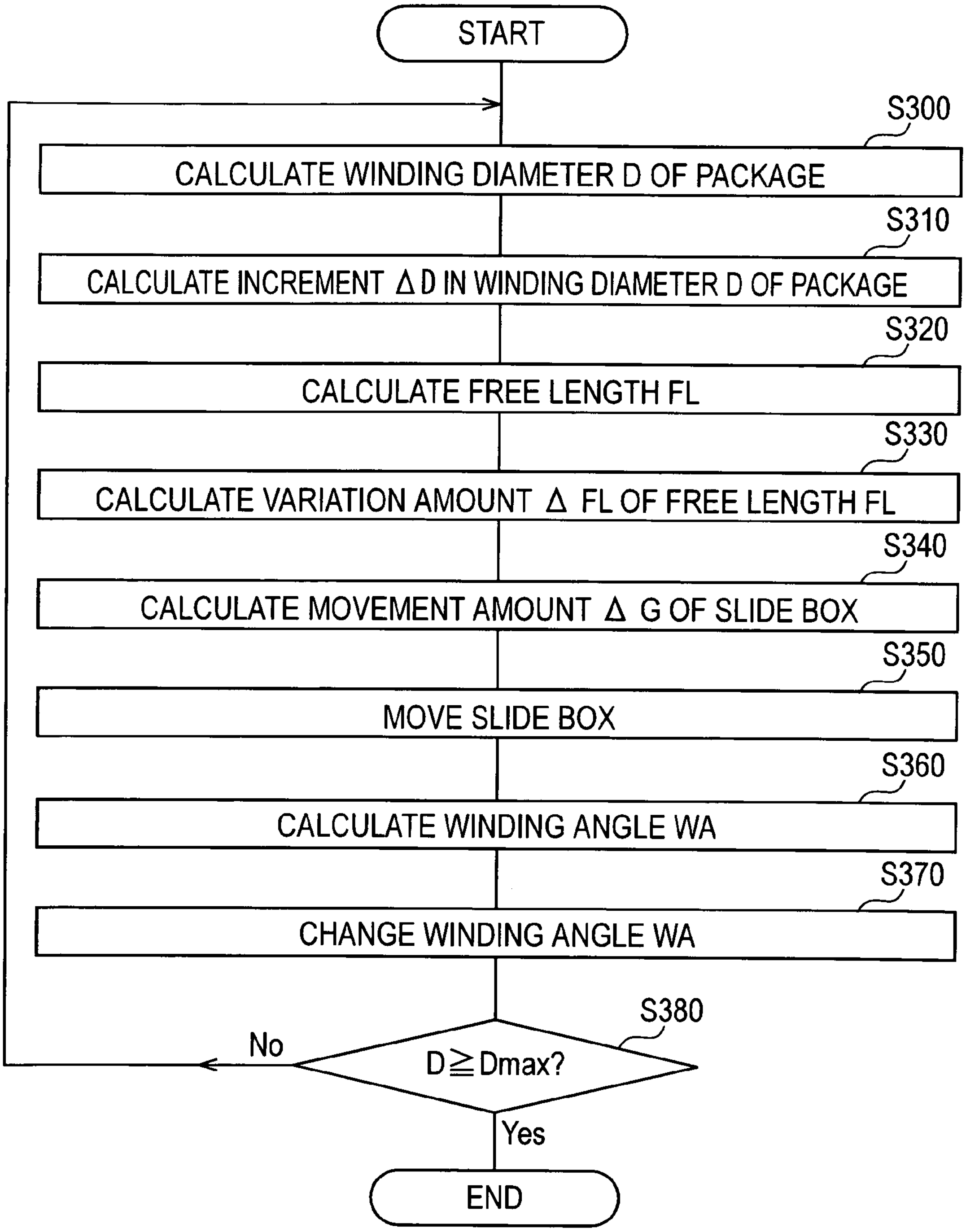

FREE LENGTH FL
FL3
FL1
FL=g(D)
N=Nd
WA=h(D)
WA2
WA1
WINDING ANGLE WA
D1
D2
D3
WINDING DIAMETER D OF PACKAGE

FIGURE14


START
S300
CALCULATE WINDING DIAMETER D OF PACKAGE
S310
CALCULATE INCREMENT ΔD IN WINDING DIAMETER D OF PACKAGE
S320
CALCULATE FREE LENGTH FL
S330
CALCULATE VARIATION AMOUNT Δ FL OF FREE LENGTH FL
S340
CALCULATE MOVEMENT AMOUNT Δ G OF SLIDE BOX
S350
MOVE SLIDE BOX
S360
CALCULATE WINDING ANGLE WA
S370
CHANGE WINDING ANGLE WA
S380
D≧Dmax?
No
Yes
END

REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- JP 9071367 A **[0002] [0003] [0010] [0011] [0016] [0018] [0039] [0064]**