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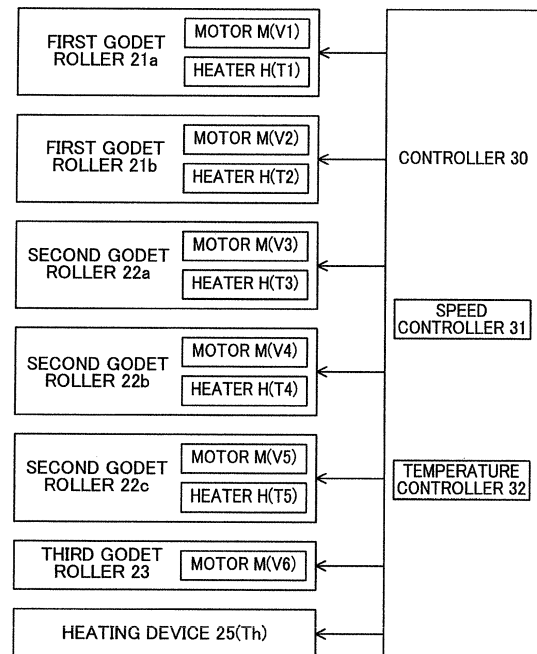
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(54) **SPUN YARN DRAWING APPARATUS**

(57) An object of the present invention is to enable a wider range of control of physical properties of yarns. When relaxation heat treatment is performed, yarn feeding speeds of second godet rollers 22a, 22b, and 22c are controlled so that between every two second godet rollers which are adjacent to each other in a yarn running direction, the yarn feeding speed of the second godet roller located downstream in the yarn running direction is lower than the second godet roller located upstream in the yarn running direction, and temperatures of the second godet rollers 22a, 22b, and 22c are controlled so that the temperature of the heating roller 22c located most downstream in the yarn running direction is higher than or equal to the temperature of each of the remaining heating rollers 22a and 22b. When heat treatment under tension is performed, the yarn feeding speeds of the second godet rollers 22a, 22b, and 22c are controlled so that between every two second godet rollers which are adjacent to each other in the yarn running direction, the yarn feeding speed of the second godet roller located downstream in the yarn running direction is higher than the second godet roller located upstream in the yarn running direction, and the temperatures of the second godet rollers 22a, 22b, and 22c are controlled so that the temperature of the heating roller 22a located most upstream in the yarn running direction is higher than or equal to the temperature of each of the remaining heating rollers 22b and 22c.

FIG.3



Description

BACKGROUND OF THE INVENTION

[0001] The present invention relates to a spun yarn drawing apparatus configured to draw yarns spun out from a spinning apparatus.

[0002] For example, Patent Literature 1 (Japanese Unexamined Patent Publication No. 2014-77221) discloses a spun yarn drawing apparatus configured to draw yarns such as polyethylene terephthalate (PET) yarns spun out from a spinning apparatus. The spun yarn drawing apparatus includes: at least one first roller; and a plurality of second rollers which are provided downstream of the first roller in a yarn running direction. Each second roller has a yarn feeding speed higher than that of the first roller, and functions as a heating roller. The yarns spun out from the spinning apparatus are drawn between the first roller and the second roller, and the thus drawn yarns are heat-set by the second rollers. Physical properties of the yarns are controlled by changing conditions in such a drawing process and a heat-set process.

[0003] Specifically, the boiling water shrinkage (BWS) of the yarns is reduced by setting the yarn feeding speeds of the second rollers so that between every two second rollers adjacent to each other in a yarn running direction, the yarn feeding speed of the second roller located downstream in the yarn running direction is lower than that of the second roller located upstream in the yarn running direction, to perform relaxation heat treatment in which the yarns are heat-set in a relaxed state. Meanwhile, the Young's modulus ("modulus") of the yarns is increased by setting the yarn feeding speeds of the second rollers so that between every two second rollers adjacent to each other in the yarn running direction, the yarn feeding speed of the second roller located downstream in the yarn running direction is higher than that of the second roller located upstream in the yarn running direction, to perform heat treatment under tension in which the yarns are heat-set in a stretched state.

SUMMARY OF THE INVENTION

[0004] As described above, in the spun yarn drawing apparatus described in Patent Literature 1, the physical properties of the yarns are adjusted by changing the yarn feeding speeds of the second rollers thereby to change the tension of the yarns during the heat-set process. However, through such change in the yarn feeding speeds of the second rollers alone, there has been a limit on the range of the control of the physical properties.

[0005] In view of the above problem, an object of the present invention is to provide a spun yarn drawing apparatus which enables a wider range of control of physical properties of yarns.

[0006] According to the first aspect of the present invention, a spun yarn drawing apparatus configured to draw a yarn spun out from a spinning apparatus includes:

at least one first roller; three or more second rollers located downstream of the first roller in a yarn running direction, each of which second rollers functions as a heating roller and has a yarn feeding speed higher than that of the first roller; a speed controller configured to control the yarn feeding speeds of the three or more second rollers; and a temperature controller configured to control temperatures of the three or more second rollers. The speed controller controls the yarn feeding speeds of the three or more second rollers so that between every two second rollers which are adjacent to each other in the yarn running direction, the yarn feeding speed of the second roller located downstream in the yarn running direction is lower than the yarn feeding speed of the second roller located upstream in the yarn running direction; and the temperature controller controls the temperatures of the three or more second rollers so that the temperature of the second roller located most downstream in the yarn running direction is higher than or equal to the temperature of each of the remaining second rollers.

[0007] According to the first aspect of the present invention, the yarn is drawn between the first roller and the second roller, and the yarn feeding speeds of the three or more second rollers are controlled so that between every two second rollers which are adjacent to each other in the yarn running direction, the yarn feeding speed of the second roller located downstream in the yarn running direction is lower than the yarn feeding speed of the second roller located upstream in the yarn running direction. Thus, performed is relaxation heat treatment in which the yarn is heat-set in a relaxed state. In this process, as the yarn travels downstream in the yarn running direction, the relaxed state of the yarn is enhanced. In addition, the temperature of the second roller located most downstream in the yarn running direction is higher than or equal to the temperatures of the remaining second rollers. Therefore, the yarn is strongly heated in the situation where the relaxed state of the yarn has been enhanced and its molecules have a high mobility. By controlling the temperatures of the second rollers in addition to the yarn feeding speeds of the second rollers as described above, molecular chains are effectively relaxed, and thereby effects of the relaxation heat treatment are enhanced than before. This enables a wider range of control of physical properties of the yarn.

[0008] It is preferable that the temperature controller controls the temperatures of the three or more second rollers so that between every two second rollers which are adjacent to each other in the yarn running direction, the temperature of the second roller located downstream in the yarn running direction is higher than or equal to the temperature of the second roller located upstream in the yarn running direction.

[0009] With this arrangement, the more downstream in the yarn running direction the yarn travels, that is, the more the relaxed state of the yarn is enhanced, the more strongly the yarn is heated. This surely and effectively enhances the effects of the relaxation heat treatment.

[0010] It is more preferable that the temperature controller controls the temperatures of the three or more second rollers so that between every two second rollers which are adjacent to each other in the yarn running direction, the temperature of the second roller located upstream in the yarn running direction is lower than the temperature of the second roller located downstream in the yarn running direction.

[0011] As described above, to enhance the effects of the relaxation heat treatment, it is only required that the temperature of the second roller located most downstream in the yarn running direction is higher than or equal to each of the temperatures of the remaining second rollers. That is, each of the temperatures of the remaining second rollers may be identical to the temperature of the second roller located most downstream in the yarn running direction. However, in the situation where the yarn is little relaxed, the molecular chains cannot be efficiently relaxed even though the yarn is strongly heated, and therefore the effect brought by the heating is smaller for the yarn traveling upstream in the yarn running direction. Thus, by controlling the temperatures of the second rollers so that between every two second rollers which are adjacent to each other in the yarn running direction, the temperature of the roller located upstream in the yarn running direction is lower than that of the roller located downstream in the yarn running direction, useless heating is reduced, and the physical properties of the yarn are efficiently controlled.

[0012] Further, it is preferable that a heating device configured to heat the yarn is provided in at least one of sections each of which is between two second rollers adjacent to each other in the yarn running direction out of the three or more second rollers.

[0013] The thus provided heating device improves the performance of the heat treatment, and enables the yarn to be heat-set well.

[0014] It is more preferable that the heating device is disposed between the two second rollers which are located most downstream in the yarn running direction.

[0015] With this arrangement, the yarn which has been relaxed is further heated by the heating device. As a result, the effects of the relaxation heat treatment are further enhanced. This enables a still wider range of control of the physical properties of the yarn.

[0016] It is preferable that the spun yarn drawing apparatus further includes a thermal insulation box which houses at least one of the three or more second rollers, and that the heating device is disposed inside the thermal insulation box.

[0017] Because the heating device is disposed inside the thermal insulation box, the loss of heat from the heating device is reduced, which improves the effects of the heat treatment by the heating device.

[0018] In contrast to the above, the spun yarn drawing apparatus may further include a thermal insulation box which houses at least one of the three or more second rollers, and the spun yarn drawing apparatus may be

arranged such that the heating device is disposed outside the thermal insulation box.

[0019] The above arrangement, in which the heating device is disposed outside the thermal insulation box, allows the size of the heating device to be increased irrespective of the size of the thermal insulation box. With this, the heating performance of the heating device is easily improved.

[0020] It is preferable that the speed controller controls the yarn feeding speeds of the three or more second rollers so that tension of the yarn traveling between every two second rollers which are adjacent to each other in the yarn running direction is not less than 0.05 g/de.

[0021] If the tension of the yarn is less than 0.05 g/de, yarn swaying may occur, which possibly causes undesirable winding of the yarn around the rollers and/or yarn breakage. These problems are avoided or reduced by controlling the tension of the yarn to be not less than 0.05 g/de.

[0022] According to the second aspect of the present invention, a spun yarn drawing apparatus configured to draw a yarn spun out from a spinning apparatus includes: at least one first roller; three or more second rollers located downstream of the first roller in a yarn running direction, each of which second rollers has a yarn feeding speed higher than that of the first roller, out of the three or more second rollers, one or more second rollers functioning as heating rollers at least except the second roller located most downstream in the yarn running direction; a speed controller configured to control the yarn feeding speeds of the three or more second rollers; and a temperature controller configured to control temperatures of the one or more second rollers functioning as the heating rollers out of the three or more second rollers. The speed controller controls the yarn feeding speeds of the three or more second rollers so that between every two second rollers which are adjacent to each other in the yarn running direction, the yarn feeding speed of the second roller located downstream in the yarn running direction is higher than the yarn feeding speed of the second roller located upstream in the yarn running direction; and the temperature controller controls the temperatures of the one or more second rollers functioning as the heating rollers out of the three or more second rollers so that the temperature of the second roller located most upstream in the yarn running direction is higher than or equal to the temperature of each of the remaining second rollers.

[0023] According to the second aspect of the present invention, the yarn is drawn between the first roller and the second roller, and the yarn feeding speeds of the three or more second rollers are controlled so that between every two second rollers which are adjacent to each other in the yarn running direction, the yarn feeding speed of the second roller located downstream in the yarn running direction is higher than the yarn feeding speed of the second roller located upstream in the yarn running direction. Thus, performed is heat treatment under tension in which the yarn is heat-set in a stretched

state. In this process, as the yarn travels downstream in the yarn running direction, the stretched state of the yarn is enhanced. In addition, the temperature of the second roller located most upstream in the yarn running direction is higher than or equal to the temperatures of each of the remaining second rollers. Therefore, the yarn is strongly heated in the situation where the stretched state of the yarn is at a lower level and its molecules have a high mobility. Further, since the increase in the temperature of the yarn by the second rollers located downstream in the yarn running direction is suppressed, relaxation of stretched molecular chains is prevented. By controlling the temperatures of the second rollers in addition to the yarn feeding speeds of the second rollers as described above, crystallization is effectively facilitated and the relaxation of the stretched molecular chains is prevented. Thus, effects of the heat treatment under tension are enhanced than before. This enables a wider range of control of the physical properties of the yarn.

[0024] It is preferable that the temperature controller controls the temperatures of the one or more second rollers functioning as the heating rollers out of the three or more second rollers so that between every two second rollers which are adjacent to each other in the yarn running direction, the temperature of the second roller located upstream in the yarn running direction is higher than or equal to the temperature of the second roller located downstream in the yarn running direction.

[0025] With this arrangement, the more upstream in the yarn running direction the yarn travels, the more strongly the yarn is heated. In other words, the yarn is strongly heated in the situation where crystallization has not yet proceeded and thus the molecules have a high mobility. This surely and efficiently enhances the effects of the heat treatment under tension.

[0026] It is more preferable that the temperature controller controls the temperatures of the one or more second rollers out of the three or more second rollers so that between every two second rollers which are adjacent to each other in the yarn running direction, the temperature of the second roller located downstream in the yarn running direction is lower than the temperature of the second roller located upstream in the yarn running direction.

[0027] As described above, to enhance the effects of the heat treatment under tension, it is only required that the temperature of the second roller located most upstream in the yarn running direction is higher than or equal to each of the temperatures of the remaining second rollers. That is, each of the temperatures of the remaining second rollers may be identical to the temperature of the second roller located most upstream in the yarn running direction. However, after the yarn has been well-stretched, the crystallization cannot efficiently proceed even though the yarn is strongly heated, and therefore the effect brought by the heating is smaller for the yarn traveling downstream in the yarn running direction. Further, because the increase in the temperature of the yarn by the second rollers located downstream in the

yarn running direction is suppressed, the relaxation of the stretched molecular chains is prevented. Thus, by controlling the temperatures of the second rollers so that between every two second rollers which are adjacent to each other in the yarn running direction, the temperature of the roller located downstream in the yarn running direction is lower than that of the roller located upstream in the yarn running direction, useless heating is reduced, and the relaxation of the stretched molecular chains is prevented. Thus, the physical properties of the yarn are efficiently controlled.

[0028] Further, it is preferable that the speed controller controls the yarn feeding speeds of the three or more second rollers so that tension of the yarn traveling between every two second rollers which are adjacent to each other in the yarn running direction does not exceed 1 g/de.

[0029] If the tension of the yarn exceeds 1 g/de, yarn breakage and/or fluff may occur. These problems are avoided or reduced by controlling the tension of the yarn so that the tension does not exceed 1 g/de.

[0030] In both of the first and second aspects of the present invention, it is preferable that the speed controller controls the yarn feeding speeds of the three or more second rollers so that a difference in the yarn feeding speed between every two second rollers which are adjacent to each other in the yarn running direction does not exceed 30 m/min.

[0031] With this arrangement, the tension of the yarn is properly kept, to prevent undesirable winding of the yarn around a roller and/or yarn breakage.

[0032] In the present invention, controlling the temperatures in addition to the yarn feeding speeds of the three or more second rollers enables a wider range of control of the physical properties of the yarn.

BRIEF DESCRIPTION OF THE DRAWINGS

[0033]

[FIG. 1] FIG. 1 is a front elevation of a spun yarn winding machine including a spun yarn drawing apparatus of an embodiment of the present invention.

[FIG. 2] FIG. 2 is a profile of the spun yarn winding machine including the spun yarn drawing apparatus of the embodiment of the present invention.

[FIG. 3] FIG. 3 is a control block diagram of the spun yarn drawing apparatus.

[FIG. 4] FIG. 4 is a front elevation of a spun yarn winding machine including a spun yarn drawing apparatus of another embodiment.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0034] The following will describe an embodiment of the present invention. FIG. 1 is a front elevation of a spun yarn winding machine including a spun yarn drawing apparatus of an embodiment of the present invention. FIG.

2 is a profile of the spun yarn winding machine including the spun yarn drawing apparatus of the embodiment of the present invention. FIG. 3 is a control block diagram of the spun yarn drawing apparatus.

[0035] As shown in FIGs. 1 and 2, a spun yarn winding machine 1 includes a spun yarn drawing apparatus 2 and a take-up winder 3. The spun yarn winding machine 1 is configured so that: yarns Y spun out and continuously supplied from a spinning apparatus 4 located above the spun yarn drawing apparatus 2 are drawn by the spun yarn drawing apparatus 2; and the yarns Y are fed to the take-up winder 3 to be wound up by the take-up winder 3. Examples of the yarns Y include PET yarns which require preliminary heating before being drawn. Note that, oil is applied by an oiler guide (not illustrated) to the yarns Y spun out from the spinning apparatus 4.

[0036] The spun yarn drawing apparatus 2 is configured to draw the yarns Y spun out from the spinning apparatus 4, and the details thereof will be described later.

[0037] The take-up winder 3 is provided below the spinning apparatus 4. The take-up winder 3 is configured to wind the yarns Y, which are supplied from the spinning apparatus 4 via the spun yarn drawing apparatus 2, on respective bobbins B, to form packages P. The take-up winder 3 includes: guide rollers 5 and 6; a plurality of fulcrum guides 7; two winding units 8; and the like.

[0038] Each of the guide rollers 5 and 6 is a drive roller rotationally driven by a motor which is not illustrated. The yarns Y fed from the spun yarn drawing apparatus 2 are fed, by the guide rollers 5 and 6, to the fulcrum guides 7 located below the guide rollers 5 and 6.

[0039] Above each of the two winding units 8, the fulcrum guides 7 are arranged in a front-back direction at intervals each of which is substantially the same as the length of each of the bobbins B. The fulcrum guides 7 are provided so as to respectively correspond to traverse guides 12 which will be described later, and each fulcrum guide 7 functions as a fulcrum when the corresponding yarn Y is traversed in the front-back direction by the corresponding traverse guide 12.

[0040] Each winding unit 8 includes: a main body frame 9; a disc-shaped turret 10 rotatably provided to the main body frame 9; two bobbin holders 11 each of which extends in the front-back direction while being supported by the turret 10 in a cantilever manner, and onto each of which bobbin holders 11, the bobbins B are attached along in its axial direction; the traverse guides 12 configured to traverse the yarns Y; a contact roller 13 which is movable in an up-down direction relative to the main body frame 9, and is configured to come into contact with and move away from the bobbins B attached to each bobbin holder 11; and the like.

[0041] In the winding unit 8, one of the bobbin holders 11 is rotated by a not-illustrated motor, to rotate the bobbins B attached onto this bobbin holder 11, and thereby the yarns Y are wound on the rotating bobbins B. In this process, the yarns Y to be wound on the bobbins B are traversed about the respective fulcrum guides 7 in the

axial direction of the bobbins B by the respective traverse guides 12 located above the bobbins B.

[0042] Then, the yarns Y having been traversed about the respective fulcrum guides 7 by the respective traverse guides 12 are wound on the respective bobbins B, to form the packages P. While the yarns Y are thus wound on the respective bobbins B, the contact roller 13 comes into contact with outer circumferential surfaces of the package P, and rotates while applying a predetermined contact pressure to the packages P, to properly shape the packages P. After fully wound, the packages P attached to the bobbin holder 11 are pushed toward the front by a not-illustrated pusher, to be detached from the bobbin holder 11.

[0043] Now, the spun yarn drawing apparatus 2 will be described. The spun yarn drawing apparatus 2 includes: first godet rollers 21a and 21b; second godet rollers 22a, 22b, and 22c; a third godet roller 23; a thermal insulation box 24; a heating device 25, an interlacing device 26; and the like. The spun yarn drawing apparatus 2 is located below the spinning apparatus 4.

[0044] The first godet rollers 21a and 21b and the second godet rollers 22a, 22b, and 22c are disposed inside the thermal insulation box 24. The first godet rollers 21a and 21b are located above the second godet rollers 22a, 22b, and 22c. The first godet roller 21b is located higher than and leftward of the first godet roller 21a. The second godet roller 22b is located higher than and rightward of the second godet roller 22a. The second godet roller 22c is located lower than and rightward of the second godet roller 22b. The third godet roller 23 is disposed outside the thermal insulation box 24, and is located higher than and rightward of the second godet roller 22c. The yarns Y are wound onto the thus arranged godet rollers 21a, 21b, 22a, 22b, 22c, and 23 in this order at winding angles within 360 degrees, to define a yarn path.

[0045] The godet rollers 21a, 21b, 22a, 22b, 22c, and 23 are drive rollers each rotationally driven by a motor M (FIG. 3). Of these, the first godet rollers 21a and 21b and the second godet rollers 22a, 22b, and 22c are heating rollers each having a heater H (FIG. 3) inside thereof. Meanwhile, the third godet roller 23 is a non-heating roller which does not include a heater. Yarn feeding speeds and temperatures of the godet rollers 21a, 21b, 22a, 22b, 22c, and 23 are controlled by a controller 30 shown in FIG. 3.

[0046] As shown in FIG. 3, the controller 30 includes a speed controller 31 and a temperature controller 32. The speed controller 31 controls the motors M of the godet rollers 21a, 21b, 22a, 22b, 22c, and 23, and thereby controls yarn feeding speeds V1, V2, V3, V4, V5, and V6 of the godet rollers 21a, 21b, 22a, 22b, 22c, and 23. The temperature controller 32 controls the heaters H of the first godet rollers 21a and 21b and of the second godet rollers 22a, 22b, and 22c, and thereby controls temperatures T1, T2, T3, T4, and T5 of the first godet rollers 21a and 21b and of the second godet rollers 22a, 22b, and 22c. The temperature controller 32 also controls a

temperature T_h of the heating device 25 which will be described later.

[0047] The controller 30 is configured to allow an operator to set conditions such as the yarn feeding speeds and the temperatures through an input means such as a not-illustrated keyboard. Functions of the speed controller 31 and the temperature controller 32 included in the controller 30 are implemented by hardware such as a microprocessor and software such as a program, which cooperate with each other. Note that, the speed controller 31 and the temperature controller 32 are separately named herein to represent their respective functions. The speed controller 31 and the temperature controller 32 do not always have to be formed independently from each other in terms of a physical aspect. Alternatively, the speed controller 31 and the temperature controller 32 may be provided individually for each of the godet rollers 21a, 21b, 22a, 22b, 22c, and 23.

[0048] Referring back to FIG. 1, the thermal insulation box 24 is a box of a substantially rectangular parallelepiped shape, and is made of heat insulating material. The thermal insulation box 24 houses the first godet rollers 21a and 21b, the second godet rollers 22a, 22b, and 22c, and the heating device 25. The thus provided thermal insulation box 24 reduces the loss of heat generated by the first godet rollers 21a and 21b, the second godet rollers 22a, 22b, and 22c, and the heating device 25 to the outside of the thermal insulation box 24, and this enables heat retention in the thermal insulation box 24. Inside the thermal insulation box 24, there is provided a heat insulating wall 28 between: the first godet rollers 21a and 21b; and the second godet rollers 22a, 22b, and 22c. This heat insulating wall 28 makes it less likely that the temperatures of the first godet rollers 21a and 21b and the temperatures of the second godet rollers 22a, 22b, and 22c influence each other.

[0049] On an upper surface of the thermal insulation box 24 (above the first godet roller 21a), there is provided a slit 24a through which the yarns Y are introduced into the thermal insulation box 24. The yarns Y are introduced into the thermal insulation box 24 through the slit 24a, and then wound onto the first godet roller 21a. Meanwhile, at a lower portion of a right surface of the thermal insulation box 24 (rightward of the second godet roller 22c), there is provided a slit 24b through which the yarns Y are led out of the thermal insulation box 24. The yarns Y fed from the second godet roller 22c are led out of the thermal insulation box 24 through the slit 24b, and then wound onto the third godet roller 23.

[0050] The heating device 25 is a contactless heater utilizing heat radiation, such as an infrared heater. The heating device 25 is disposed between the two second godet rollers 22b and 22c which are located most downstream in the yarn running direction (i.e., between the second most downstream roller and the most downstream roller in the yarn running direction). The heating device 25 is configured to heat the yarns Y fed from the second godet roller 22b to the second godet roller 22c.

[0051] The interlacing device 26 is configured to entangle filaments constituting each yarn Y using fluid jetting nozzles to provide cohesion between the filaments, for preventing an increase in distance between fibers and/or separation of fibers. The interlacing device 26 is disposed between the second godet roller 22c and the third godet roller 23.

[0052] Now, referring back to FIG. 1, a drawing process of the yarns Y on the spun yarn drawing apparatus 2 will be described in detail. The temperature T_1 of the first godet roller 21a and the temperature T_2 of the first godet roller 21b are controlled by the temperature controller 32 to be equal to the glass transition temperature of the yarns Y or higher (for example, in the case of PET yarns, on the order of 80 to 100 degrees centigrade). With this, preliminary heating is performed to increase the temperature of the yarns Y before drawn to the glass transition temperature or higher. Note that the glass transition temperature differs depending on the type of polymers, and therefore the temperatures T_1 and T_2 of the first godet rollers 21a and 21b are set depending on the material of the yarns Y.

[0053] Further, the yarn feeding speed V_1 of the first godet roller 21a and the yarn feeding speed V_2 of the first godet roller 21b are controlled by the speed controller 31, for example, to be on the order of 1500 to 3000 m/min. Specifically, to compensate a reduction in tension due to internal stress relaxation of the yarns Y caused by heating of the yarns Y by the first godet roller 21a, the speed controller 31 controls the yarn feeding speeds V_1 and V_2 so that the yarn feeding speed V_2 of the first godet roller 21b is slightly higher (by several tens of meters/min) than the yarn feeding speed V_1 of the first godet roller 21a. Provided however, the above arrangement does not have to be always needed.

[0054] The yarn feeding speed V_3 of the second godet roller 22a, the yarn feeding speed V_4 of the second godet roller 22b, and the yarn feeding speed V_5 of the second godet roller 22c are controlled by the speed controller 31 so that the yarn feeding speeds V_3 to V_5 are higher than the yarn feeding speeds V_1 and V_2 of the first godet rollers 21a and 21b, for example, to be on the order of 4500 to 5500 m/min. With this, the yarns Y are drawn between the first godet roller 21b and the second godet roller 22a. Here, it is preferable that the speed controller 31 controls the yarn feeding speeds V_3 , V_4 , and V_5 of the second godet rollers 22a, 22b, and 22c so that each of the differences in the yarn feeding speed between the rollers 22a and 22b and between the rollers 22b and 22c does not exceed 30 m/min. With this arrangement, the tension of the yarns Y is properly kept, to prevent undesirable winding of the yarns Y around a roller and/or yarn breakage.

[0055] The temperature T_3 of the second godet roller 22a, the temperature T_4 of the second godet roller 22b, and the temperature T_5 of the second godet roller 22c are controlled by the temperature controller 32 so that the drawn yarns Y are heat-set (for example, to be on

the order of 120 to 180 degrees centigrade). Similarly, the temperature T_h of the heating device 25 is also controlled by the temperature controller 32 so that the drawn yarns Y are heat-set (for example, on the order of 120 to 180 degrees centigrade). Providing the three or more second godet rollers enables further enhancement of the relaxed state and stretched state of the yarns Y in later-described relaxation heat treatment and heat treatment under tension, respectively, while preventing a rapid change of the tension of the yarns Y.

[0056] The yarn feeding speed V6 of the third godet roller 23 is adjusted to make the tension of the yarns Y on the interlacing device 26 suitable for imparting entanglement to each yarn Y.

[0057] With the thus structured spun yarn drawing apparatus 2, the yarns Y spun out from the spinning apparatus 4 are preliminarily heated by the first godet rollers 21a and 21b to the glass transition temperature or higher, then the yarns Y are drawn between the first godet roller 21b and the second godet roller 22a, and heat-set by the second godet rollers 22a, 22b, and 22c. Now, the higher the draw ratio in the process of drawing the yarns Y is, the higher the strength and the Young's modulus are, but the lower the elongation is. Meanwhile, the lower the draw ratio is, the lower the strength and the Young's modulus are, but the higher the elongation is. That is, physical properties of the yarns Y are adjusted by adjusting the draw ratio of the yarns Y.

[0058] However, it has been difficult to produce, for example, super low shrinkage yarns having an extremely low boiling water shrinkage, e.g., approximately 5% or lower, and high modulus yarns of which 10-percent strength (a strength at 10 percent elongation, used as a substituting characteristic for Young's modulus) is approximately more than 70% of the breaking strength, due to the following reasons. To decrease the boiling water shrinkage, it is conceivable to increase the temperature in the heat-set process, that is, to increase the temperatures of the second godet rollers 22a, 22b, and 22c. However, if the temperatures are increased too much, for example, to 200 degrees centigrade or higher, deterioration of the yarns Y (decrease in strength and elongation) and/or yarn breakage occur more commonly. Thus, there has been a limit on the decrease of the boiling water shrinkage. Meanwhile, the Young's modulus is increased by increasing the draw ratio in the process of drawing of the yarns Y. But if so, the elongation decreases too much, which causes yarn breakage and/or fluff more commonly. Thus, there has been a limit on the increase of the Young's modulus. However, in the spun yarn drawing apparatus 2, the yarn feeding speeds and the temperatures of the three second godet rollers 22a, 22b, and 22c are controlled independently from one another. This enables production of the super low shrinkage yarns and the high modulus yarns. The following will describe its principle.

(Production of super low shrinkage yarns by relaxation heat treatment)

[0059] The yarn feeding speeds V3, V4, and V5 of the second godet rollers 22a, 22b, and 22c are controlled by the speed controller 31 so that between every two second godet rollers which are adjacent to each other in the yarn running direction, the yarn feeding speed of the roller located downstream in the yarn running direction is lower than that of the roller located upstream in the yarn running direction, i.e., so that $V3 > V4 > V5$ is satisfied. Thereby, the relaxation heat treatment in which the yarns Y are heat-set in the relaxed state is performed. With this relaxation heat treatment, the degree of molecular orientation in amorphous regions decreases, which decreases the boiling water shrinkage of the yarns Y. Simultaneously, the temperatures T3, T4, and T5 of the second godet rollers 22a, 22b, and 22c are controlled by the temperature controller 32 so that the temperature T5 of the second godet roller 22c which is located most downstream in the yarn running direction is higher than or equal to each of the temperatures T3 and T4 of the remaining second godet rollers 22a and 22b, i.e., so that $T3 \leq T5$ and $T4 \leq T5$ are satisfied.

[0060] With the above control, as the yarns Y travel downstream in the yarn running direction, the relaxed state of the yarns Y is enhanced. In addition, the temperature T5 of the second godet roller 22c which is located most downstream in the yarn running direction is higher than or equal to each of the temperatures T3 and T4 of the remaining second godet rollers 22a and 22b. Therefore, the yarns Y are strongly heated in the situation where the relaxed state of the yarns Y has been enhanced and their molecules have a high mobility. By controlling the temperatures T3, T4, and T5 of the second godet rollers 22a, 22b, and 22c in addition to the yarn feeding speeds V3, V4, and V5 of the second godet rollers 22a, 22b, and 22c as described above, molecular chains are effectively relaxed. Thus, effects of the relaxation heat treatment are enhanced than before. This enables a wider range of control of the physical properties of the yarns Y. Thus, without increasing the temperatures of the second godet rollers 22a, 22b, and 22c to the extent that deterioration and/or yarn breakage of the yarns Y occur, for example, the decrease of the boiling water shrinkage is achievable by virtue of the enhancement of the effects of the relaxation heat treatment. This enables production of the super low shrinkage yarns.

[0061] It is more preferable that the temperature controller 32 controls the temperatures T3, T4, and T5 of the second godet rollers 22a, 22b, and 22c so that, between every two second godet rollers which are adjacent to each other in the yarn running direction (between the second godet rollers 22a and 22b and between the second godet rollers 22b and 22c), the temperature of the second godet roller which is located downstream in the yarn running direction is higher than or equal to the temperature of the second godet roller which is located up-

stream in the yarn running direction, i.e., so that $T3 \leq T4 \leq T5$ is satisfied. With this arrangement, the more downstream in the yarn running direction the yarns Y travel, that is, the more the relaxed state of the yarns Y is enhanced, the more strongly the yarns Y are heated. This surely and effectively enhances the effects of the relaxation heat treatment.

[0062] Now, to enhance the effects of the relaxation heat treatment, it is only required that the temperature T5 of the second godet roller 22c which is located most downstream in the yarn running direction is higher than or equal to each of the temperatures T3 and T4 of the remaining second godet rollers 22a and 22b. That is, each of the temperatures T3 and T4 of the remaining second godet rollers 22a and 22b may be identical to the temperature T5 of the second godet roller 22c which is located most downstream in the yarn running direction. However, in the situation where the yarns Y are little relaxed, the molecular chains cannot be efficiently relaxed even though the yarns Y are strongly heated, and therefore the effect brought by the heating is smaller for the yarns Y traveling upstream in the yarn running direction. Thus, by controlling the temperatures T3, T4, and T5 of the second godet rollers 22a, 22b, and 22c so that the between every two second godet rollers which are adjacent to each other in the yarn running direction, the temperature of the roller which is located upstream in the yarn running direction is lower than that of the roller located downstream in the yarn running direction, i.e., so that $T3 < T4 < T5$ is satisfied, useless heating is reduced, and the physical properties of the yarns Y are efficiently controlled.

[0063] Further, in the present embodiment, the heating device 25 configured to heat yarns Y is provided in at least one of sections each of which is between two second godet rollers adjacent to each other in the yarn running direction (in at least one of sections between the second godet rollers 22a and 22b and between the second rollers 22b and 22c). This improves the performance of the heat treatment, and enables the yarns Y to be heat-set well.

[0064] Particularly, in the present embodiment, the heating device 25 is provided between the two second godet rollers 22b and 22c which are located most downstream in the yarn running direction. Thus, the yarns Y which have been relaxed are further heated by the heating device 25. As a result, the effects of the relaxation heat treatment are further enhanced. This enables a still wider range of control of the physical properties of the yarns Y.

[0065] Further, in the present embodiment, because the heating device 25 is disposed inside the thermal insulation box 24, the loss of heat from the heating device 25 is reduced, which improves the effects of the heat treatment by the heating device 25.

[0066] Furthermore, in the present embodiment, the speed controller 31 controls the yarn feeding speeds V3, V4, and V5 of the second godet rollers 22a, 22b, and 22c

so that the tension of the yarns Y traveling between every two second godet rollers which are adjacent to each other in the yarn running direction is not less than 0.05 g/de. If the tension of the yarn Y is less than 0.05 g/de, yarn swaying may occur, which possibly causes undesirable winding of the yarns Y around the rollers and/or yarn breakage. These problems are avoided or reduced by controlling the tension of the yarns to be not less than 0.05 g/de.

(Production of high modulus yarns by heat treatment under tension)

[0067] The yarn feeding speeds V3, V4, and V5 of the second godet rollers 22a, 22b, and 22c are controlled by the speed controller 31 so that between every two second godet rollers which are adjacent to each other in the yarn running direction, the yarn feeding speed of the roller located downstream in the yarn running direction is higher than that of the roller located upstream in the yarn running direction, i.e., so that $V3 < V4 < V5$ is satisfied. Thereby, the heat treatment under tension in which the yarns Y are heat-set in the stretched state is performed. With this heat treatment under tension, the degree of molecular orientation in the amorphous regions increases, which increases the Young's modulus of the yarns Y. Simultaneously, the temperatures T3, T4, and T5 of the second godet rollers 22a, 22b, and 22c are controlled by the temperature controller 32 so that the temperature T3 of the second godet roller 22a which is located most upstream in the yarn running direction is higher than or equal to each of the temperatures T4 and T5 of the remaining second godet rollers 22b and 22c, i.e., so that $T3 \geq T4$ and $T3 \geq T5$ are satisfied.

[0068] With the above control, as the yarns Y travel downstream in the yarn running direction, the stretched state of the yarns Y is enhanced. In addition, the temperature T3 of the second godet roller 22a which is located most upstream in the yarn running direction is higher than or equal to each of the temperatures T4 and T5 of the remaining second godet rollers 22b and 22c. Therefore, the yarns Y are strongly heated in the situation where the stretched state of the yarns Y is at a lower level and their molecules have a higher mobility. Further, since the increase in the temperature of the yarns Y by the second godet rollers 22b and 22c located downstream in the yarn running direction is suppressed, relaxation of stretched molecular chains is prevented. By controlling the temperatures T3, T4, and T5 of the second godet rollers 22a, 22b, and 22c in addition to the yarn feeding speeds V3, V4, and V5 of the second godet rollers 22a, 22b, and 22c as described above, crystallization is effectively facilitated and the relaxation of the stretched molecular chains is prevented. Thus, effects of the heat treatment under tension are enhanced than before. This enables a wider range of control of the physical properties of the yarns Y. By enhancing the effects of the heat treatment under tension in this way, the increase of the Young's modulus

is achievable. Therefore, an excessive increase of the draw ratio is not needed to increase the Young's modulus. This enables production of the high modulus yarns with a lower risk of yarn breakage and/or fluff caused by an excessive decrease in the elongation of the yarns Y (with the elongation kept at an appropriate level).

[0069] It is more preferable that the temperature controller 32 controls the temperatures T3, T4, and T5 of the second godet rollers 22a, 22b, and 22c so that between every two second godet rollers which are adjacent to each other in the yarn running direction (between the second godet rollers 22a and 22b and between the second godet rollers 22b and 22c), the temperature of the second godet roller which is located upstream in the yarn running direction is higher than or equal to the temperature of the second godet roller which is located downstream in the yarn running direction, that is, so that $T3 \geq T4 \geq T5$ is satisfied. With this arrangement, the more upstream in the yarn running direction the yarns Y travel, the more strongly the yarns Y are heated. In other words, the yarns Y are strongly heated in the situation where crystallization has not yet proceeded and thus the molecules have a high mobility. This surely and efficiently enhances the effects of the heat treatment under tension.

[0070] Now, to enhance the effects of the heat treatment under tension, it is only required that the temperature T3 of the second godet roller 22a which is located most upstream in the yarn running direction is higher than or equal to each of the temperatures T4 and T5 of the remaining second godet rollers 22b and 22c. That is, each of the temperatures T4 and T5 of the remaining second godet rollers 22b and 22c may be identical to the temperature T3 of the second godet roller 22a which is located most upstream in the yarn running direction. However, after the yarns Y have been well-stretched, the crystallization cannot efficiently proceed even though the yarns Y are strongly heated, and therefore the effect brought by the heating is smaller for the yarns Y traveling downstream in the yarn running direction. Further, because the increase in the temperature of the yarns Y by the second godet rollers 22b and 22c which are located downstream in the yarn running direction is suppressed, the relaxation of the stretched molecular chains is prevented. Thus, by controlling the temperatures T3, T4, and T5 of the second godet rollers 22a, 22b, and 22c so that between every two second godet rollers which are adjacent to each other in the yarn running direction, the temperature of the roller which is located downstream in the yarn running direction is lower than that of the roller located upstream in the yarn running direction, i.e., so that $T3 > T4 > T5$ is satisfied, useless heating is reduced, and the relaxation of the stretched molecular chains is prevented. Thus, the physical properties of the yarns Y are efficiently controlled.

[0071] Further, in the present embodiment, the speed controller 31 controls the yarn feeding speeds V3, V4, and V5 of the second godet rollers 22a, 22b, and 22c so that the tension of the yarns Y traveling between every

two second godet rollers which are adjacent to each other in the yarn running direction does not exceed 1 g/de. If the tension of the yarn Y exceeds 1 g/de, yarn breakage and/or fluff may occur. These problems are avoided or reduced by controlling the tension of the yarns Y so that the tension does not to exceed 1 g/de.

[0072] As described above, in the heat treatment under tension, after the yarns Y have been well-stretched, crystallization cannot efficiently proceed even though the yarns Y are strongly heated. Thus, the effect brought by heating is smaller for the yarns Y traveling downstream in the yarn running direction. For this reason, brought is a smaller effect when the yarns Y are heated by the heating device 25 disposed between the two second godet rollers 22b and 22c which are located most downstream in the yarn running direction. Instead, there is a possibility that a problem occurs, which is the relaxation of the stretched molecular chains. Thus, in the heat treatment under tension, activation of the heating device 25 is not needed, so power supply to the heating device 25 is shut down. To effectively use the heating device 25 in the heat treatment under tension, it is preferable to dispose the heating device 25 as upstream as possible in the yarn running direction. For example, it is optimum to locate the heating device 25 between the two second godet rollers 22a and 22b which are located most upstream in the yarn running direction.

[Other embodiments]

[0073] While a preferred embodiment of the invention has been described, the present invention is not limited to the embodiment above, and it is evident that many alternatives, modifications and variations will be apparent to those skilled in the art, within the scope of the claims, as described below.

[0074] In the above-described embodiment, there are provided the two first godet rollers 21a and 21b as rollers on which the yarns Y before drawn travel; however, the number of such rollers is not limited to two, as long as at least one such roller is provided.

[0075] In the above-described embodiment, the first godet rollers 21a and 21b on which the yarns Y before drawn travel are heating rollers. However, depending on the type of yarns to be produced, for example, for producing nylon yarns which are able to be drawn at normal temperature, non-heating rollers each of which does not include a heater may be used as the first godet rollers 21a and 21b, or the first godet rollers 21a and 21b respectively including the heaters may be used in a non-heating state established by shutting down the power supply to the heaters.

[0076] In the above-described embodiment, there are the three second godet rollers 22a, 22b, and 22c as rollers configured to heat-set the drawn yarns Y; however, the number of such rollers is not limited to three, as long as three or more such rollers are provided.

[0077] In the above-described embodiment, all the first

godet rollers 21a and 21b, the second godet rollers 22a, 22b, and 22c, and the heating device 25 are disposed inside the thermal insulation box 24; however, this arrangement is not always essential. For example, the heating device 25 may be disposed in a manner shown in FIG. 4.

[0078] FIG. 4 is a front elevation of a spun yarn winding machine including a spun yarn drawing apparatus of another embodiment. The components same as those in the above-described embodiment are given the same reference signs as in FIG. 1. In this embodiment, the second godet roller 22c which is located most downstream in the yarn running direction and the heating device 25 are disposed outside the thermal insulation box 24, and the second godet roller 22c is housed in a thermal insulation box 27 which is different from the thermal insulation box 24. In the above-described embodiment, the godet rollers 21a, 21b, 22a, 22b, and 22c are housed in the thermal insulation box 24, and this imposes a limit on the space for disposing the heating device 25. In this regard, disposing the heating device 25 outside the thermal insulation box 24 allows an increase of the size of the heating device 25, irrespective of the size of the thermal insulation box 24. With this, the heating performance of the heating device 25 is easily improved. Further, when the heat treatment under tension is performed using the spun yarn drawing apparatus 2, the second godet roller 22c may be configured as the non-heating roller instead of the heating roller. The heating device 25 may be housed in the thermal insulation box 27 or may be housed in another thermal insulation box separately provided for the heating device 25.

[0079] In the above-described embodiment, the heating device 25 is disposed between the two second godet rollers 22b and 22c which are located most downstream in the yarn running direction to further enhance the effects of the relaxation heat treatment; however, the position of the heating device 25 is not limited to this. In addition, there may be provided a plurality of heating devices 25.

Claims

1. A spun yarn drawing apparatus configured to draw a yarn spun out from a spinning apparatus, the spun yarn drawing apparatus comprising:

at least one first roller;
three or more second rollers located downstream of the first roller in a yarn running direction, each of which second rollers functions as a heating roller and has a yarn feeding speed higher than that of the first roller;
a speed controller configured to control the yarn feeding speeds of the three or more second rollers; and
a temperature controller configured to control temperatures of the three or more second rollers,

ers, wherein:

the speed controller controls the yarn feeding speeds of the three or more second rollers so that between every two second rollers which are adjacent to each other in the yarn running direction, the yarn feeding speed of the second roller located downstream in the yarn running direction is lower than the yarn feeding speed of the second roller located upstream in the yarn running direction; and

the temperature controller controls the temperatures of the three or more second rollers so that the temperature of the second roller located most downstream in the yarn running direction is higher than or equal to the temperature of each of the remaining second rollers.

2. The spun yarn drawing apparatus according to claim 1, wherein the temperature controller controls the temperatures of the three or more second rollers so that between every two second rollers which are adjacent to each other in the yarn running direction, the temperature of the second roller located downstream in the yarn running direction is higher than or equal to the temperature of the second roller located upstream in the yarn running direction.
3. The spun yarn drawing apparatus according to claim 2, wherein the temperature controller controls the temperatures of the three or more second rollers so that between every two second rollers which are adjacent to each other in the yarn running direction, the temperature of the second roller located upstream in the yarn running direction is lower than the temperature of the second roller located downstream in the yarn running direction.
4. The spun yarn drawing apparatus according to any one of claims 1 to 3, wherein a heating device configured to heat the yarn is provided in at least one of sections each of which is between two second rollers adjacent to each other in the yarn running direction out of the three or more second rollers.
5. The spun yarn drawing apparatus according to claim 4, wherein the heating device is disposed between the two second rollers which are located most downstream in the yarn running direction.
6. The spun yarn drawing apparatus according to claim 5, further comprising a thermal insulation box which houses at least one of the three or more second rollers, wherein the heating device is disposed inside the thermal insulation box.

7. The spun yarn drawing apparatus according to claim 5, further comprising a thermal insulation box which houses at least one of the three or more second rollers, wherein the heating device is disposed outside the thermal insulation box.

8. The spun yarn drawing apparatus according to any one of claims 1 to 7, wherein the speed controller controls the yarn feeding speeds of the three or more second rollers so that tension of the yarn traveling between every two second rollers which are adjacent to each other in the yarn running direction is not less than 0.05 g/de.

9. A spun yarn drawing apparatus configured to draw a yarn spun out from a spinning apparatus, the spun yarn drawing apparatus comprising:

at least one first roller;

three or more second rollers located downstream of the first roller in a yarn running direction, each of which second rollers has a yarn feeding speed higher than that of the first roller, out of the three or more second rollers, one or more second rollers functioning as heating rollers at least except the second roller located most downstream in the yarn running direction;

a speed controller configured to control the yarn feeding speeds of the three or more second rollers; and

a temperature controller configured to control temperatures of the one or more second rollers functioning as the heating rollers out of the three or more second rollers, wherein:

the speed controller controls the yarn feeding speeds of the three or more second rollers so that between every two second rollers which are adjacent to each other in the yarn running direction, the yarn feeding speed of the second roller located downstream in the yarn running direction is higher than the yarn feeding speed of the second roller located upstream in the yarn running direction; and

the temperature controller controls the temperatures of the one or more second rollers functioning as the heating rollers out of the three or more second rollers so that the temperature of the second roller located most upstream in the yarn running direction is higher than or equal to the temperature of each of the remaining second rollers.

10. The spun yarn drawing apparatus according to claim 9, wherein the temperature controller controls the temperatures of the one or more second rollers functioning as the heating rollers out of the three or more

second rollers so that between every two second rollers which are adjacent to each other in the yarn running direction, the temperature of the second roller located upstream in the yarn running direction is higher than or equal to the temperature of the second roller located downstream in the yarn running direction.

11. The spun yarn drawing apparatus according to claim 10, wherein the temperature controller controls the temperatures of the one or more second rollers out of the three or more second rollers so that between every two second rollers which are adjacent to each other in the yarn running direction, the temperature of the second roller located downstream in the yarn running direction is lower than the temperature of the second roller located upstream in the yarn running direction.

12. The spun yarn drawing apparatus according to claim 10 or 11, wherein the speed controller controls the yarn feeding speeds of the three or more second rollers so that tension of the yarn traveling between every two second rollers which are adjacent to each other in the yarn running direction does not exceed 1 g/de.

13. The spun yarn drawing apparatus according to any one of claims 1 to 12, wherein the speed controller controls the yarn feeding speeds of the three or more second rollers so that a difference in the yarn feeding speed between every two second rollers which are adjacent to each other in the yarn running direction does not exceed 30 m/min.

FIG. 1

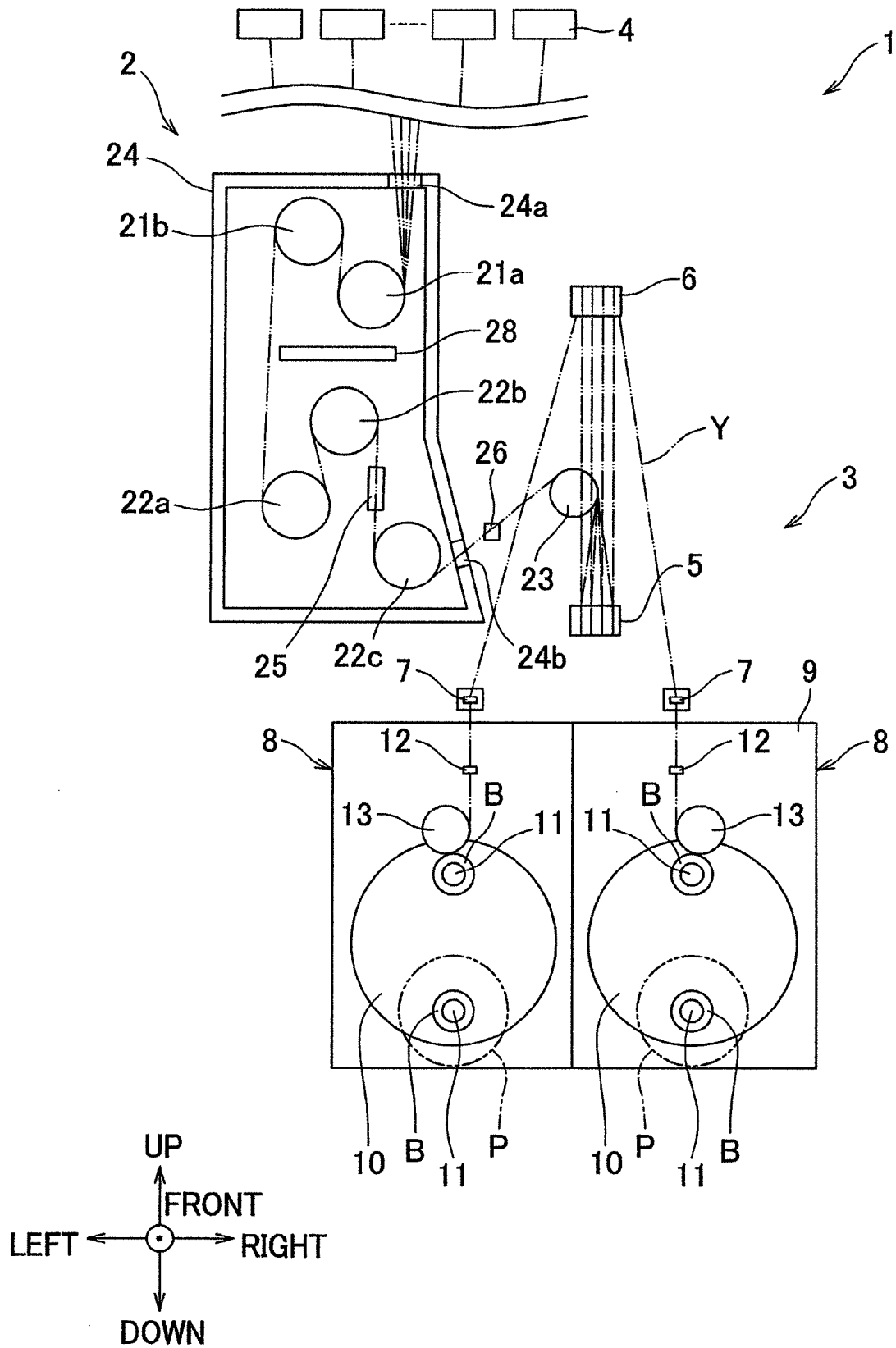


FIG.2

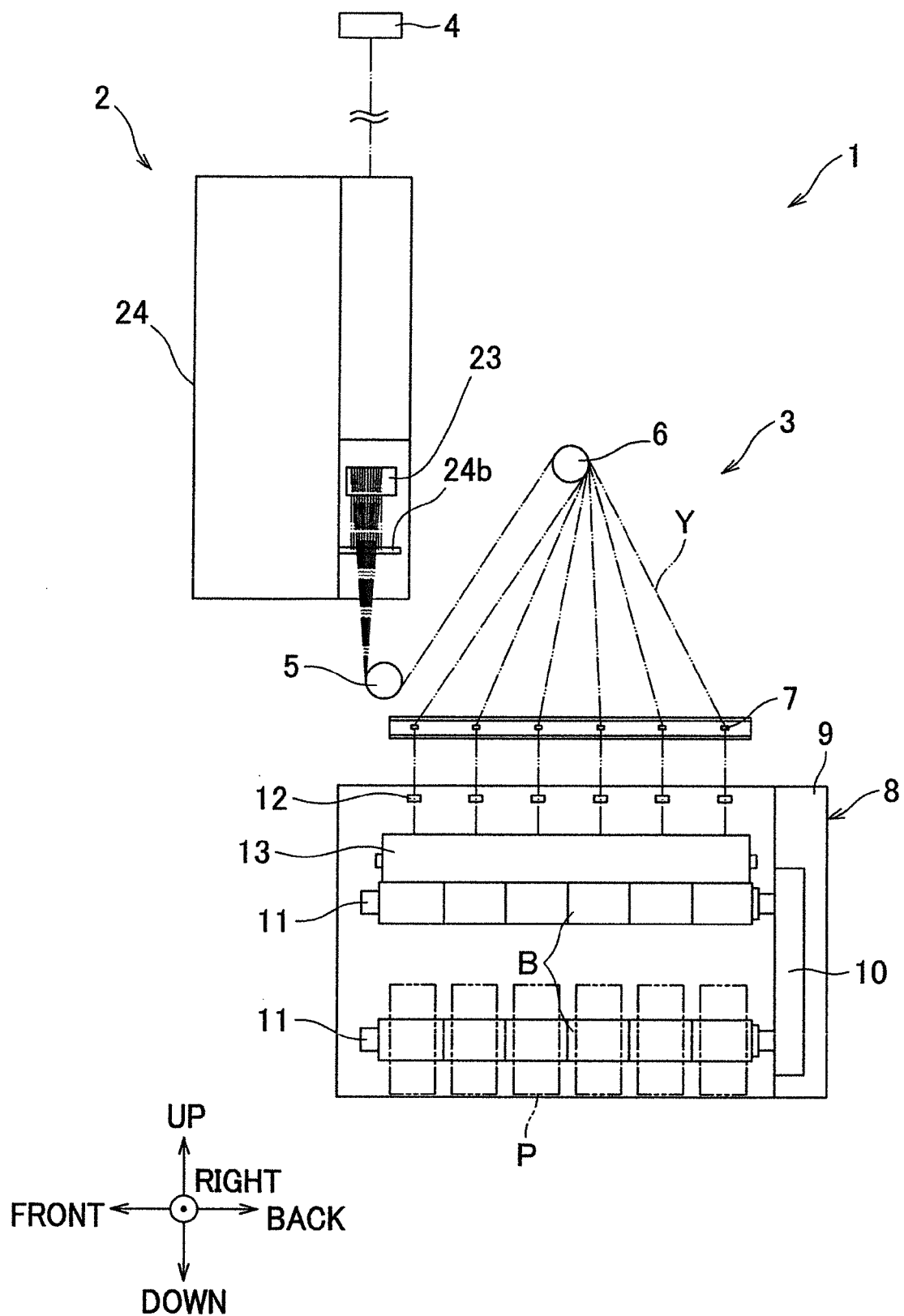


FIG.3

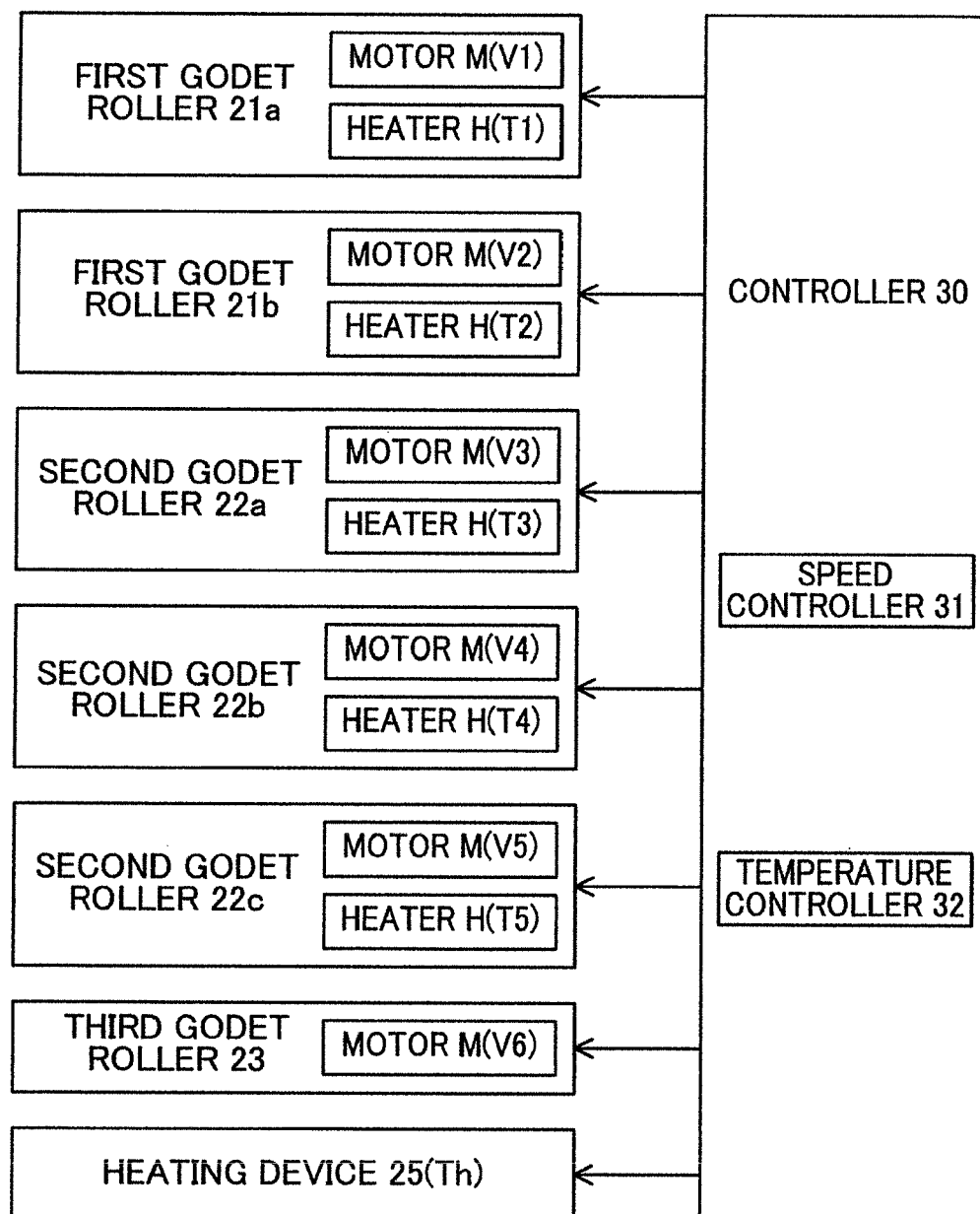
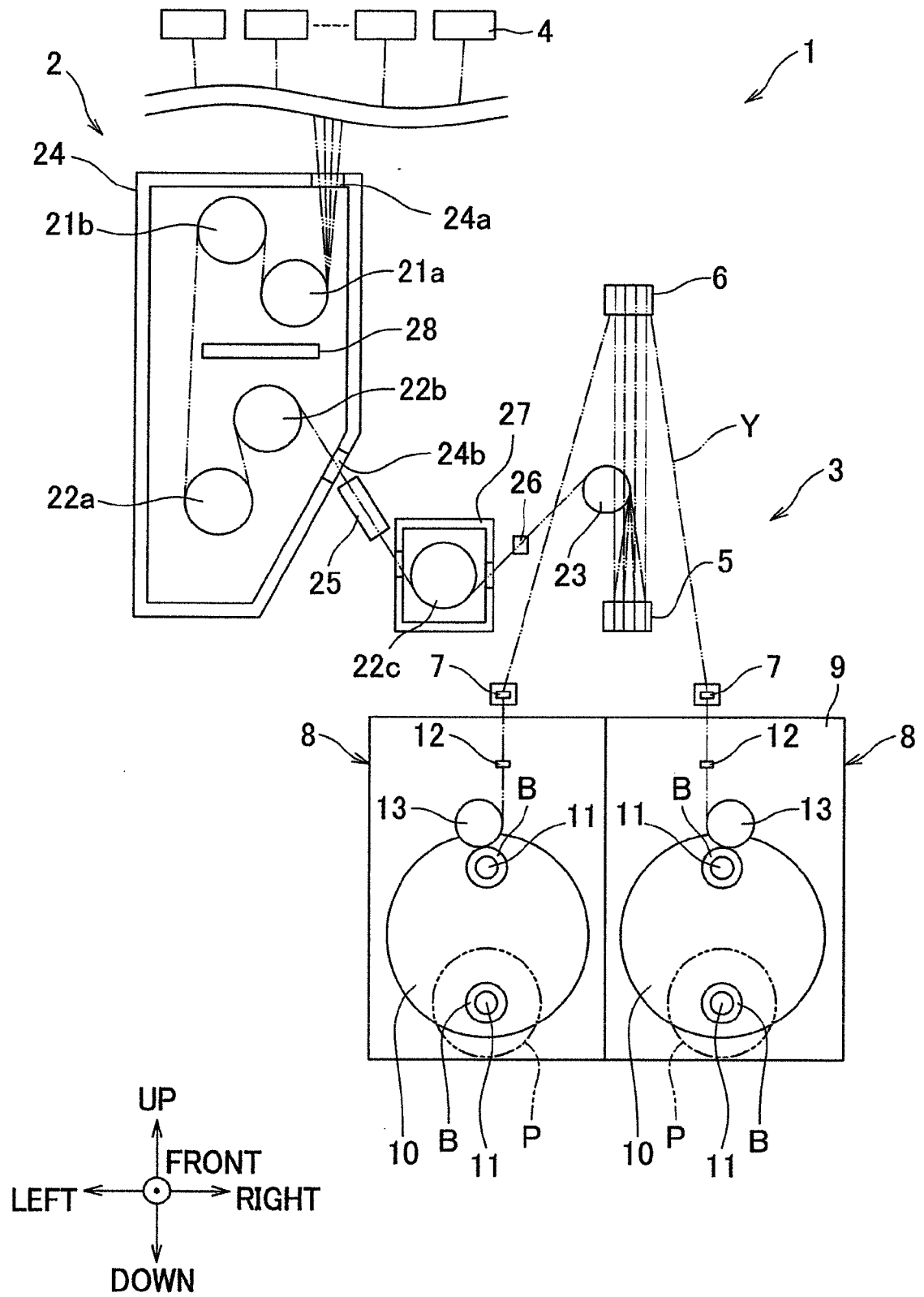


FIG.4





EUROPEAN SEARCH REPORT

Application Number
EP 15 19 0144

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