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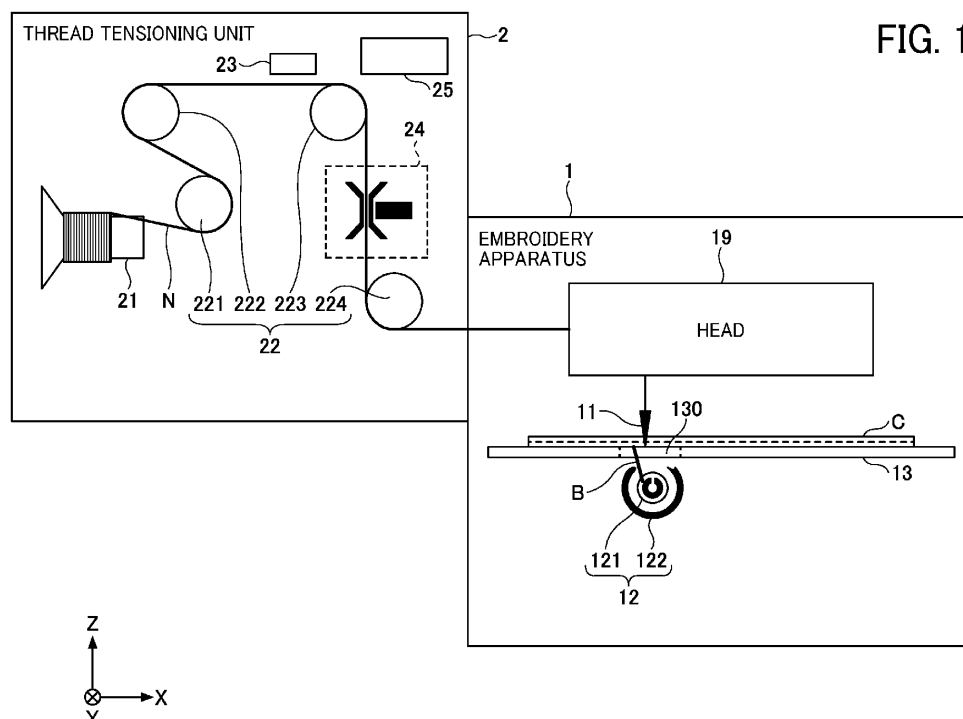
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(54) **THREAD TENSIONING UNIT, EMBROIDERY APPARATUS, DYEING APPARATUS, DYEING EMBROIDERY SYSTEM, THREAD TENSIONING METHOD, AND CARRIER MEDIUM**

(57) A thread tensioning unit (20) for adjusting tension of an upper thread to be fed to an embroidery apparatus is provided at a preceding stage of the embroidery apparatus. The thread tensioning unit includes a feeding mechanism (22), a speed detection mechanism (23, 23A), and a tensioning mechanism (25, 25A). The

feeding mechanism (22) feeds the upper thread. The speed detection mechanism (23, 23A) detects a feeding speed of the upper thread. The tensioning mechanism (25, 25A) adjusts the tension of the upper thread according to a detected feeding speed of the upper thread detected by the speed detection mechanism.



**FIG. 1**

## Description

### BACKGROUND

#### Technical Field

**[0001]** Embodiments of the present disclosure relate to a thread tensioning unit, an embroidery apparatus, a dyeing apparatus, a dyeing embroidery system, a thread tensioning method, and a carrier medium.

#### Related Art

**[0002]** As a technology of controlling an embroidery apparatus, for example, Japanese Unexamined Patent Application Publication No. 2008-289522 describes a technology for performing embroidery using a continuous upper thread whose color changes such that a color change point of the upper thread is not exposed on the surface of the embroidery. In the technology, embroidery data is created for performing embroidery such that the color change point of the upper thread whose color changes is not visible from the upper side.

**[0003]** In such an embroidery apparatus, there is a problem that sewing unevenness may occur due to a change in the tension balance between an upper thread and a lower thread caused by a change in the embroidery speed, or the consumption amount of the upper thread changes due to the change in the tension balance, so that sewing unevenness may occur or a color change may appear.

**[0004]** Hence, in order to restrain the occurrence of sewing unevenness, Japanese Unexamined Patent Application Publication No. H05-068764 proposes disposing an electromagnet so as to be able to come into contact with and separate from a bobbin case, to adjust and set the tension of a lower thread in accordance with various sewing speeds.

**[0005]** However, even if the sewing unevenness can be restrained by adjusting the tension of the lower thread as in Japanese Unexamined Patent Application Publication No. H05-068764, the tension of the upper thread changes due to a change in the embroidery speed. Accordingly, the positional deviation is not eliminated particularly in the case of using a continuous upper thread whose color changes.

**[0006]** In view of the above-described circumstances, an object of the present invention is to provide a thread tensioning unit that eliminates a positional deviation of a color of an upper thread in an embroidery apparatus when a continuous upper thread whose color changes is used as the upper thread.

### SUMMARY

**[0007]** In order to solve the above problem, in one aspect of the present invention, there is provided a thread tensioning unit for adjusting tension of an upper thread

to be fed to an embroidery apparatus. The thread tensioning unit is provided at a preceding stage of the embroidery apparatus. The thread tensioning unit includes a feeding mechanism, a speed detection mechanism, and a tensioning mechanism. The feeding mechanism feeds the upper thread. The speed detection mechanism detects a feeding speed of the upper thread. The tensioning mechanism adjusts the tension of the upper thread according to a detected feeding speed of the upper thread detected by the speed detection mechanism.

**[0008]** According to one aspect of the present disclosure, a thread tensioning unit can eliminate the positional deviation of a color of an upper thread in an embroidery apparatus when a continuous upper thread whose color changes is used as the upper thread.

### BRIEF DESCRIPTION OF THE DRAWINGS

**[0009]** The aforementioned and other aspects, features, and advantages of the present disclosure would be better understood by reference to the following detailed description when considered in connection with the accompanying drawings, wherein:

FIG. 1 is a schematic side view of an embroidery apparatus attached with a thread tensioning unit according to a first embodiment of the present invention;

FIG. 2 is a schematic block diagram of the embroidery apparatus attached with the thread tensioning unit according to the first embodiment of the present invention;

FIG. 3 is a schematic diagram illustrating an example of stitches on the upper side and the lower side of an upper thread and a lower thread with respect to a cloth;

FIG. 4 is a schematic cross-sectional view of a plurality of states of stitches formed by upper and lower threads on a cloth;

FIG. 5 is a diagram illustrating a tensioning mechanism of the thread tensioning unit according to the first embodiment;

FIGS. 6A, 6B, and 6C are diagrams illustrating a speed detection mechanism of the thread tensioning unit according to the first embodiment;

FIG. 7 is a functional block diagram of a computing mechanism of the embroidery apparatus and the thread tensioning unit in a first control example of the present invention;

FIG. 8 is a flowchart of thread-tension adjustment during embroidery according to the first control example of the present invention;

FIG. 9 is a functional block diagram of a computing mechanism of an embroidery apparatus and a thread tensioning unit in a second control example of the present invention;

FIG. 10 is a flowchart of thread-tension adjustment during embroidery according to the second control

example of the present invention;

FIG. 11 is a schematic side view of an embroidery apparatus attached with a thread tensioning unit according to a variation of the first embodiment of the present invention;

FIG. 12 is a schematic side view of an embroidery apparatus attached with a thread tensioning unit according to a second embodiment of the present invention;

FIG. 13 is a schematic side view of a dyeing embroidery system in which an embroidery apparatus attached with a thread tensioning unit and a dyeing apparatus are combined, according to a third embodiment of the present invention;

FIG. 14 is a schematic side view of a dyeing embroidery system in which a dyeing apparatus attached with a thread tensioning unit and an embroidery apparatus are combined, according to a fourth embodiment of the present invention; and

FIG. 15 is a schematic side view of an integrated dyeing embroidery apparatus according to a fifth embodiment of the present invention.

**[0010]** The accompanying drawings are intended to depict embodiments of the present disclosure and should not be interpreted to limit the scope thereof. The accompanying drawings are not to be considered as drawn to scale unless explicitly noted.

#### DETAILED DESCRIPTION

**[0011]** In describing embodiments illustrated in the drawings, specific terminology is employed for the sake of clarity. However, the disclosure of this patent specification is not intended to be limited to the specific terminology so selected and it is to be understood that each specific element includes all technical equivalents that operate in a similar manner and achieve similar results.

**[0012]** Although the embodiments are described with technical limitations with reference to the attached drawings, such description is not intended to limit the scope of the disclosure and all of the components or elements described in the embodiments of this disclosure are not necessarily indispensable.

**[0013]** Hereinafter, embodiments of the present invention are described with reference to the drawings. In the following drawings, the same components are denoted by the same reference numerals, and redundant description may be omitted.

#### First embodiment

**[0014]** First, a thread tensioning unit and an embroidery apparatus are described with reference to FIGS. 1 and 2. FIG. 1 is a schematic side view of an embroidery apparatus 1 attached with a thread tensioning unit according to a first embodiment of the present invention. FIG. 2 is a schematic block diagram of the embroidery

apparatus 1 to which the thread tensioning unit according to the first embodiment of the present invention is attached.

**[0015]** As illustrated in FIG. 1, a thread tensioning unit 2 according to an embodiment of the present invention is attached to an upstream side of the embroidery apparatus 1 in a feeding direction of thread, which may be hereinafter referred to as a thread feeding direction. In FIG. 1, the thread tensioning unit 2 is closely attached to the embroidery apparatus. On the other hand, the thread tensioning unit 2 may be coupled to the embroidery apparatus 1 at a predetermined distance such that the thread tensioning unit 2 is not too far away from the embroidery apparatus 1. The thread tensioning unit 2 is electrically connected to the embroidery apparatus 1 via wired or wireless communication to exchange data with the embroidery apparatus 1.

**[0016]** The embroidery apparatus 1 illustrated in FIG. 1 includes a needle 11, a lower-thread rotator 12, a stage 13, and an embroidery head 19. In the needle 11, an upper thread N is passed through a needle hole at the needle tip. The needle 11 is vertically movable with respect to a cloth C.

**[0017]** The lower-thread rotator 12 includes a lower-thread bobbin 121 around which the lower thread B is wound and a hook 122. The lower-thread bobbin 121 and the hook 122 rotate in conjunction with the movement of the needle 11. The lower-thread rotator 12 also includes, for example, a cylindrical inner shuttle that accommodates the lower-thread bobbin 121, a bottomed cylindrical outer shuttle, and a cylindrical case integrated with the hook 122. FIG. 1 illustrates an example in which the lower-thread bobbin 121 is of a vertical rotation type (a vertical full-rotary shuttle type or a vertical half-rotary shuttle type) in which the rotation direction is the vertical direction. In some embodiments, the lower-thread bobbin 121 may be of a horizontal rotation type (a horizontal shuttle type) in which the rotation direction is the horizontal direction.

**[0018]** The stage 13 is a table for holding the cloth C and has a hole 130 through which the needle 11 passes. The stage 13 is movable in the X direction and the Y direction to feed the cloth C.

**[0019]** Hereinafter, the width direction of the embroidery apparatus 1 is referred to as X, the depth direction of the embroidery apparatus 1 is referred to as Y, and the height direction (vertical direction) of the embroidery apparatus 1 is referred to as Z.

**[0020]** The embroidery head 19 is provided with a computing mechanism 15 (see FIG. 2). The computing mechanism 15 controls the movement (hand movement) of the needle 11 through which the upper thread N passes and the movement of the stage 13, so that the embroidery head 19 performs embroidery on the cloth C using the upper thread N and the lower thread B fed in accordance with the feeding of the upper thread N in the embroidery apparatus 1.

**[0021]** The thread tensioning unit 2 includes an upper-

thread spool 21, a feeding mechanism 22, a speed detection mechanism 23, a tensioning mechanism 24, and a computing mechanism 25. The thread tensioning unit 2 is disposed at a preceding stage of the embroidery apparatus 1 and is a unit for adjusting the tension of the upper thread to be fed to the embroidery apparatus 1.

**[0022]** The upper-thread spool 21 is an upper-thread supplier around which the upper thread N is wound. In the example illustrated in FIG. 1, the feeding mechanism 22 includes four feeding rollers 221, 222, 223, and 224 and feeds the upper thread N. The number of feeding rollers of the feeding mechanism 22 is not limited to any particular number and may be any suitable number.

**[0023]** The speed detection mechanism 23 detects the speed (feeding speed) of the upper thread C. The tensioning mechanism 24 is disposed downstream from the speed detection mechanism 23 in the thread feeding direction and adjusts the tension of the fed upper thread C in accordance with the feeding speed of the upper thread C detected by the speed detection mechanism 23.

**[0024]** The computing mechanism 25 controls the tension adjustment of the upper thread N by the tensioning mechanism 24 in response to the feeding speed of the upper thread N detected by the speed detection mechanism 23 in cooperation with the embroidery apparatus 1.

**[0025]** In the present disclosure, examples of the "thread" including the upper thread and the lower thread include glass fiber thread; wool thread; cotton thread; synthetic fiber thread; metallic thread; mixed thread of wool, cotton, polymer, or metal; and linear object (linear member or continuous material) to which yarn, filament, or liquid is applied. Examples of the "thread" also include braided cord and flatly braided cord.

**[0026]** As illustrated in FIG. 2, the embroidery apparatus 1 includes an embroidery-image acquiring unit 14, a computing mechanism 15, a driver 16, a drive motor 17, a needle vertical driving unit 181, a lower-thread rotation driving unit 182, an X-axis driving unit 183, and a Y-axis driving unit 184 as portion related to drive control. At least the driver 16, the drive motor 17, and the needle vertical driving unit 181 are built in the embroidery head 19 above the needle 11. The embroidery-image acquiring unit 14 and the computing mechanism 15 may also be built in the embroidery head 19.

**[0027]** The embroidery-image acquiring unit 14 acquires an embroidery image from which embroidery data is created. The computing mechanism 15 creates embroidery data based on the embroidery image and sends the embroidery data to the driver 16. The computing mechanism 15 will be described in detail with reference to FIGS. 6A, 6B, and 6C. The driver 16 drives and controls the drive motor 17 based on the embroidery data.

**[0028]** Here, the embroidery image is image data (embroidery design data) serving as an original of an embroidery pattern on a cloth. The computing mechanism 15 decomposes an embroidery image being image information into different colors, determines the color of a thread to be used and the continuous length of each color

on a thread based on the size of the embroidery pattern on the cloth, and creates embroidery data for forming stitches on the cloth with the thread of the determined color.

**[0029]** The embroidery data is "data obtained by combining data of coordinates at which the needle is moved and items to be executed at the coordinates". Specifically, the items to be executed at the coordinates include: (1) the needle is inserted into the cloth to catch the upper thread, the needle is returned to the surface of the cloth, and then the needle is moved to the next position to be inserted; (2) the embroidery is ended or interrupted (including switching to another needle and cutting the thread to move to a distant place where the embroidery is not continuous); and (3) the needle is moved to the initialization position (alignment position). As a file of embroidery data, formats such as ".dst" and ".pes" are generally known.

**[0030]** The needle vertical driving unit 181 is also referred to as a balance and converts the rotational movement of an upper shaft connected to the drive motor 17 into the vertical movement to drive the up-and-down movement of the needle 11 through which the upper thread N is passed.

**[0031]** The lower-thread rotation driving unit 182 rotates the lower-thread rotator 12 in conjunction with the vertical movement of the needle 11 by the rotational movement of a lower shaft connected to the upper shaft via, for example, a belt, a cam, and a crank.

**[0032]** The X-axis driving unit 183 and the Y-axis driving unit 184 are cloth feeders and drive the movement of the stage 13, on which the cloth C is placed, in the X direction and the Y direction in conjunction with the vertical movement of the needle 11 and the rotation of the lower-thread rotator 12 by the rotational movement of the lower shaft. The cloth C may be fed by moving the entire stage 13 or by moving a feed dog provided on the hole 130 formed in the stage 13.

**[0033]** The needle vertical driving unit 181, the lower-thread rotation driving unit 182, the X-axis driving unit 183, and the Y-axis driving unit 184 serve as a drive mechanism 18 that is driven in conjunction with one drive motor 17. Accordingly, the vertical movement of the needle 11, the rotational movement of the lower-thread rotator 12, and the X-and-Y movement of the cloth C on the stage 13 are generated by the rotation of the drive motor 17. For example, one vertical movement of the needle 11 is performed in conjunction with one or an integral number of rotational movements of the lower-thread rotator 12.

#### Tension of Upper Thread and Lower Thread

**[0034]** FIG. 3 is a schematic diagram illustrating an example of stitches on the upper side and the lower side of an upper thread and a lower thread with respect to a cloth. Part (a) of FIG. 3 is a top view and part (b) of FIG. 3 is a bottom view. FIG. 4 is a diagram illustrating the

balance between the upper thread and the lower thread in stitches on the cloth. In FIG. 4, part (a) illustrates a case where the tension balance between the upper thread and the lower thread is proper, part (b) illustrates a case where the tension of the upper thread is larger than the tension of the lower thread, and part (c) illustrates a case where the tension of the lower thread is larger than the tension of the upper thread.

**[0035]** In the embroidery apparatus 1, when the needle 11 descends and penetrates the cloth C, the upper thread N is also drawn into the back side of the cloth C together with the needle 11. Thereafter, when the needle 11 rises, is pulled out from the cloth C, and returns to the front side of the cloth C, the upper thread N forms a loop on the back side of the cloth C due to the frictional force between the upper thread N and the cloth C, and remains on the back side of the cloth C. At this time, the hook 122 is caught by the loop-shaped upper thread N by the rotation of the lower-thread rotator 12, and the lower thread B passes through the loop of the upper thread N. When the needle 11 is further raised above the cloth C, the position where the upper thread N and the lower thread B cross each other is pulled up to the cloth, thereby forming a stitch on the cloth C.

**[0036]** An example of the stitches thus formed is illustrated in FIG. 3. FIG. 3 is an enlarged view of stitches embroidered by pattern stitching (satin stitching) so as to fill the surface from top to bottom. In part (b) of FIG. 3 depicting the back side, the catching portions between the upper thread N and the lower thread B surrounded by the dotted line is illustrated loosely for easy understanding of the relationship between the threads. However, actually, the upper thread N and the lower thread B are in contact with each other at the catching portions to pull each other.

**[0037]** FIG. 4 is a cross-sectional view of a region indicated by an alternate long and short dash line in FIG. 3. In the cross section of the stitches illustrated in FIG. 3, when the tension balance between the upper thread and the lower thread is proper, the cross section is as illustrated in part (a) of FIG. 4.

**[0038]** In the stitches formed in this manner, when the tension of the upper thread N is large, the upper thread N pulls the lower thread B as illustrated in part (b) of FIG. 4. Accordingly, the amount of the upper thread N turned to the back side of the cloth C is smaller than that in the case of the proper balance illustrated in part (a) of FIG. 4. That is, the length BL of the lower thread on the back side is long and the length NL of the upper thread is short. Consequently, if the state in which the tension of the upper thread is large continues, the usage amount of the upper thread becomes smaller than expected.

**[0039]** On the other hand, when the tension of the upper thread is smaller as illustrated in part (c) of FIG. 4, the upper thread N is pulled by the lower thread B. Accordingly, the amount of the upper thread N going around to the back side of the cloth C is larger than that in the case of the proper balance illustrated in part (a) of FIG.

4. That is, the length BL of the lower thread on the back side is short, and the length NL of the upper thread is long. Accordingly, if the state in which the tension of the upper thread is small continues, the usage amount of the upper thread becomes larger than expected.

#### Tensioning Mechanism

**[0040]** Next, the adjustment of the tension of the thread is described with reference to FIG. 5. FIG. 5 is a diagram illustrating the tensioning mechanism 24 in the thread tensioning unit 2 according to an embodiment of the present invention.

**[0041]** The tensioning mechanism 24 includes a pair of tensioning plates 241 and 242 that sandwich the upper thread N, a tension application rod 243, and a spring 244.

**[0042]** The tensioning plates 241 and 242 sandwich the upper thread N with a reference pressure to apply a predetermined tension to the upper thread N. The pressing force applied by the tension application rod 243 is adjusted according to the detected feeding speed of the upper thread N, thus allowing adjustment of the tension of the upper thread N.

**[0043]** For example, when the tension application rod 243 is retracted from the reference position, the tension of the upper thread N being fed is reduced due to a reduction in the force with which the upper thread N is sandwiched between the tensioning plates 241 and 242. On the other hand, when the tension application rod 243 is pushed in beyond the reference position, the clamping force of the tensioning plates 241 and 242 increases. Thus, a strong force is applied at the clamping position, so that the tension of the upper thread N during feeding increases.

**[0044]** In FIG. 5, the spring 244 is schematically indicated by an arrow. However, the spring 244 is, for example, a coil spring that applies an elastic force to the outside. The spring 244 applies an elastic force in a direction in which the pair of tensioning plates 241 and 242 are expanded. Accordingly, when the tension application rod 243 moves in the direction in which the push-in is weakened, the tensioning plates 241 and 242 move in directions in which the clamping interval is expanded by the biasing force of the spring 244 so as to weaken the clamping force.

**[0045]** On the other hand, when the tension application rod 243 moves in the direction in which the push-in is strengthened, the tensioning plates 241 and 242 are pushed by the tension application rod 243 is against the biasing force of the spring 244. Accordingly, the tensioning plates 241 and 242 move in directions in which the interval is narrowed so as to strengthen the clamping force.

**[0046]** With such tension adjustment, the feed amount, which is the feeding speed of the upper thread N immediately before being fed to the embroidery apparatus 1, is adjusted.

**[0047]** As another example of the adjustment, at the

reference time, the tensioning plates 241 and 242 are in a non-contact state with the upper thread N, and thus the tension is not applied. Only when the detected feeding speed is higher than the estimated feeding speed of the embroidery apparatus 1, the tensioning plates 241 and 242 may be controlled to sandwich the upper thread N to increase the tension.

#### Mechanism of Speed Detection

**[0048]** FIGS. 6A, 6B, and 6C are diagrams illustrating a method of detecting the speed of the upper thread N in the thread tensioning unit 2 in the first embodiment. FIGS. 6A and 6B are diagrams illustrating an optical sensor 23A of the speed detection mechanism 23. FIG. 6C is a diagram illustrating a rotary encoder 26 of the speed detection mechanism 23.

**[0049]** The speed detection mechanism 23 formed with the optical sensor 23A illustrated in FIGS. 6A and 6B detects the color of the upper thread N, thus allowing direct reading of the moving speed of the upper thread N.

**[0050]** In the detection method illustrated in FIG. 6A, the upper thread N has a portion having a color different from that of the other portion and serving as a mark. The optical sensor 23A detects the mark when the mark passes through a position facing the optical sensor 23A, thereby detecting the feeding speed of the upper thread N from the detection timing.

**[0051]** In the detection method illustrated in FIG. 6B, the upper thread N is provided with different colors continuously in the feeding direction. The optical sensor 23A detects a boundary between different colors when the boundary passes through a position facing the optical sensor 23A, thereby detecting the feeding speed of the upper thread N from the detection timing. For example, in the case of the upper thread N whose color changes one after another, the color change speed is monitored by the timing at which each of the boundaries between different colors passes, and the feeding speed of the upper thread N is detected.

**[0052]** In the detection method illustrated in FIG. 6C, the detection of feed length of the upper thread N is not associated with the color. In this example, the speed detection mechanism is a sensor provided on a roller that rotates with the feeding of the upper thread.

**[0053]** For example, the feeding roller 223 is provided with a rotary encoder 26 serving as an accompanying rotation sensor. The rotary encoder 26 includes an encoder wheel 261 and an encoder sensor 262. The encoder wheel 261 rotates together with the feeding roller 223. The encoder sensor 262 reads a slit of the encoder wheel 261. In the thread tensioning unit 2, the number of feeding rollers in the feeding mechanism 22 may be any number. FIG. 6C illustrates an example in which the feeding roller 225 is provided in the preceding stage of the feeding roller 223.

**[0054]** In such a configuration, as the upper thread N is fed, the feeding roller 223 that guides the upper thread

N rotates and the encoder wheel 261 of the rotary encoder 26 rotates. Accordingly, an encoder pulse proportional to the linear velocity of the upper thread N is generated and output from the encoder sensor 262.

**[0055]** The detection-speed calculation unit 259 (see FIG. 7) disposed on the computing mechanism 25 calculated the feeding speed of the upper thread N from the rotation amount indicated by the encoder pulse generated along with the rotation of the feeding roller 223.

**[0056]** Even if the speed detection mechanism 23 has any configuration of the above-described optical sensor 23A or the rotary encoder 26, the feeding speed of the upper thread N can be acquired in the thread tensioning unit 2 according to an embodiment of the present invention. In any configuration of the above-described optical sensor 23A and the rotary encoder 26, the speed detection mechanism 23 is disposed upstream from the tensioning mechanism 24 in the feeding direction of the upper thread N.

#### Functional Block (1)

**[0057]** FIG. 7 is a functional block diagram of computing mechanisms of the embroidery apparatus 1 and the thread tensioning unit 2 in a first control example of the first embodiment. Each of the computing mechanism 15 and the computing mechanism 25 is a control device and is implemented by an information processing device such as a central processing unit (CPU), an application specific integrated circuit (ASIC), or a field programmable gate array (FPGA).

**[0058]** The computing mechanism 15 of the embroidery apparatus 1 includes an embroidery-data creation unit 151, a thread-consumption calculation unit 152, and a thread-feeding-speed estimation unit 153.

**[0059]** The embroidery-data creation unit 151 creates embroidery data based on an embroidery image that is the acquired image data. As described above, the embroidery data is data for embroidery in which data of coordinates for moving the needle and what to do at the positions of the coordinates are paired.

**[0060]** The thread-consumption calculation unit 152 calculates the thread consumption based on the embroidery data.

**[0061]** Based on the thread consumption amount, the thread-feeding-speed estimation unit 153 estimates an assumed feeding speed (also referred to as an estimated feeding speed or a predicted feeding speed) of the upper thread at that point in time. The assumed feeding speed of the upper thread N increases when, for example, the distance between stitches is long and the embroidery in which the movement distance of the cloth C on the stage 13 is long continues. The assumed feeding speed of the upper thread N decreases when the distance between stitches is short and the embroidery in which the movement distance of the cloth C on the stage 13 is short continues.

**[0062]** The computing mechanism 25 of the thread ten-

sioning unit 2 includes a tension-initial-value setting unit 251, a speed-deviation calculation unit 252, an adjustment-threshold storage unit 253, a tension-adjustment-necessity determination unit 254, and a tension-adjustment-amount setting unit 255. In a case where the speed detection mechanism 23 of the thread tensioning unit 2 only detects the timing and does not have a function of calculating the feeding speed (for example, in the case of the configuration of FIG. 6C), the computing mechanism 25 may include a detected-speed calculation unit 259 that calculates the feeding speed of the thread from the timing detected by the speed detection mechanism 23.

**[0063]** The tension-initial-value setting unit 251 sets an initial value of the tension based on the calculated assumed feeding speed of the thread, and applies the set initial value of the tension to the tension application rod 243 of the tension adjusting mechanism 24 at the start of embroidery.

**[0064]** The speed-deviation calculation unit 252 calculates a deviation amount of the thread feeding speed (detected feeding speed) detected by the speed detection mechanism 23 of the thread tensioning unit 2 or the thread feeding speed calculated by the detection-speed calculation unit 259 from the assumed feeding speed predicted by the thread-feeding-speed estimation unit 153 of the embroidery apparatus 1.

**[0065]** The adjustment-threshold storage unit 253 stores a threshold value of the amount of deviation of the detected feeding speed from the assumed speed, which requires the adjustment of the tension.

**[0066]** The tension-adjustment-necessity determination unit 254 compares the deviation amount calculated by the speed-deviation calculation unit 252 with the threshold value of the deviation amount stored in the adjustment-threshold storage unit 253, and determines whether the tension adjustment is necessary.

**[0067]** When the tension-adjustment-necessity determination unit 254 determines that the tension adjustment is necessary, the tension-adjustment-amount setting unit 255 sets an adjustment amount (application force) of the tension of the upper thread N to be adjusted by the tension application rod 243 of the tensioning mechanism 24.

#### First Control Example

**[0068]** FIG. 8 is a flowchart of thread-tension adjustment during embroidery according to a first control example of the present invention.

**[0069]** In step S101, the embroidery apparatus 1 acquires an embroidery image.

**[0070]** In step S102, the computing mechanism 15 of the embroidery apparatus 1 generates embroidery data and calculates an assumed feeding speed of the upper thread, which is an expected feeding speed of the upper thread.

**[0071]** In step S103, the computing mechanism 25 of the thread tensioning unit 2 sets an initial value of the

tension of the upper thread from the calculated assumed feeding speed of the thread.

**[0072]** In step S104, the feeding of the upper thread is started while applying the initial value of the tension set in the thread tensioning unit 2, and the embroidery is started by the embroidery apparatus 1.

**[0073]** In step S105, the feeding speed of the upper thread N is detected by the speed detection mechanism 23 of the thread tensioning unit 2.

**[0074]** In step S106, a deviation between the assumed feeding speed of the upper thread calculated in step S102 and the feeding speed of the upper thread detected in step S105 is calculated. In this flow, the deviation amount is calculated by comparing the assumed feeding speed estimated at that point in time during embroidery with the immediately-preceding detected feeding speed. In step S107, it is determined whether the deviation amount calculated in step S106 is equal to or larger than a predetermined value (threshold value for adjustment).

**[0075]** In step S107, when the deviation amount calculated in step S106 is equal to or larger than the predetermined value (YES in step S107), the thread tensioning unit 2 adjusts the tension of the upper thread N. At this time, when the detected feeding speed of the upper thread N is faster than the assumed feeding speed of the upper thread, the tension of the upper thread N is weakened. On the other hand, when the detected feeding speed of the upper thread is lower than the assumed feeding speed, the tension of the upper thread N is adjusted to increase.

**[0076]** On the other hand, in step S107, when the deviation amount calculated in step S106 is less than the predetermined value (NO in step S107), the tension of the upper thread N is not adjusted, and the upper thread feeding and the embroidery operation are continued with the tension of the initial value.

**[0077]** The adjustment from step S105 to step S108 is performed until the embroidery data is completed in step S109.

**[0078]** When the embroidery data is completed in step S109, the embroidery in the embroidery apparatus 1 and the thread feeding in the thread tensioning unit 2 are finished in step S110.

**[0079]** As described above, in this control example, the tension of the upper thread N is adjusted in response to the difference between the expected feeding speed of the upper thread N estimated from the input embroidery data and the detected feeding speed of the upper thread N detected by the speed detection mechanism 23. For example, in the embroidery apparatus 1, when the lower-thread bobbin 121 is rotated in accordance with the intervals of the vertical movement of the needle 11 according to the assumed feeding speed by the drive motor 17 that is the single drive source as described above, the upper thread N and the lower thread B are adjusted to be properly balanced in stitches.

**[0080]** Here, at a timing at which the amount of the upper thread used in the embroidery apparatus 1 signif-

icantly changes, such as a timing at which the length of the stitch significantly changes, the assumed feeding speed of the upper thread in the embroidery apparatus 1 rapidly changes. However, due to the inertia force of the rotation of the upper-thread spool 21, the feeding speed of the upper thread N immediately after unwinding is not rapidly changed. The tension of the upper thread N is adjusted based on the amount of deviation between the assumed feeding speed and the actual feeding speed that occurs at that time. Accordingly, the upper thread N having a tension close to the tension associated with the assumed feeding speed can be fed to the needle 11 that moves up and down in conjunction with the rotation of the lower-thread bobbin 121. Thus, the balance between the upper thread N and the lower thread B in stitches can be maintained.

**[0081]** Such control can eliminate the positional deviation of the color due to the tension in the embroidery apparatus 1 when the upper thread whose color continuously changes is used by the thread tensioning unit 2.

## Functional Block (2)

**[0082]** FIG. 9 is a functional block diagram of computing mechanisms of the embroidery apparatus 1 and the thread tensioning unit 2 in a second control example of the first embodiment. Each of the computing mechanisms 15A and 25A is a control device and is implemented by an information processing device (computer) such as a CPU, an ASIC, or an FPGA.

**[0083]** The computing mechanism 15A of the embroidery apparatus 1 in the present control example has an embroidery-data creation unit 151 that can be executed. The embroidery-data creation unit 151 creates embroidery data based on an embroidery image that is the acquired image data. In this control example as well, the computing mechanism 15A may have a thread-consumption calculation function and a thread-feeding-speed prediction function. However, in this control example, information on the thread feeding speed on the embroidery apparatus 1 is not linked to the thread tensioning unit 2.

**[0084]** The computing mechanism 25A of the thread tensioning unit 2 includes a tension-initial-value setting unit 251A, a tension-adjustment-necessity determination unit 254A, a tension-adjustment-amount setting unit 255A, and a variation threshold storage unit 256. In a case where the speed detection mechanism 23 of the thread tensioning unit 2 only detects the timing and does not have a function of calculating the feeding speed (for example, in the case of the configuration of FIG. 6C), the computing mechanism 25 may include a detected-speed calculation unit 259 that calculates the feeding speed of the thread from the timing detected by the speed detection mechanism 23.

**[0085]** The tension-initial-value setting unit 251A according to the present control example sets the initial value of the tension based on the embroidery data cre-

ated by the embroidery apparatus 1.

**[0086]** The variation threshold storage unit 256 stores a predetermined range that defines an upper-limit threshold value and a lower-limit threshold value of the variation amount of the detected feeding speed in which the tension needs to be adjusted.

**[0087]** The tension-adjustment-necessity determination unit 254A compares the detected feeding speed with the threshold value of the amount of change in the feeding speed stored in the variation threshold storage unit 256, and determines whether the tension adjustment is necessary.

**[0088]** When it is determined that the tension adjustment is necessary, the tension-adjustment-amount setting unit 255A sets an adjustment amount (applying force) of the tension of the upper thread N applied to the tension application rod 243 of the tensioning mechanism 24 according to the detected thread feeding speed.

## Second Control Example

**[0089]** FIG. 10 is a flowchart of thread-tension adjustment during embroidery according to the second control example of the present disclosure. Differences from FIG. 8 are mainly described below. In this control example, the estimation of the feeding speed for tension adjustment is not performed in the embroidery apparatus. The amount of deviation of the current feeding speed of the upper thread from the assumed feeding speed is not calculated in the thread tensioning unit 2.

**[0090]** In this control example, embroidery data is created in step S202. At this time, the assumed feeding speed is not calculated.

**[0091]** In step S203, the computing mechanism 25A of the thread tensioning unit 2 sets the initial value of the tension of the upper thread from the embroidery data generated by the embroidery apparatus 1A.

**[0092]** After the start of embroidery, the thread tensioning unit 2 detects the feeding speed of the upper thread in step S205, for example, for each predetermined time or each predetermined feeding distance, and determines in step S206 whether the variation amount in the detected feeding speed is greater than a predetermined range. When the variation is out of the predetermined range (YES in step S206), the tension of the upper thread is adjusted according to the feeding speed of the upper thread in step S207.

**[0093]** At this time, when the detected feeding speed of the upper thread is higher than the predetermined range, that is, when the detected feeding speed of the upper thread is higher than the upper limit of the threshold value of the variation amount, the tension of the upper thread is weakened. On the other hand, when the feeding speed of the upper thread is lower than the predetermined range, that is, when the detected feeding speed of the upper thread is lower than the lower limit of the threshold value of the variation amount, the tension of the upper thread is adjusted to increase.

**[0094]** In general, the tension of the upper thread tends to increase as the feeding speed of the upper thread increases. For this reason, in this control example, the computing mechanism 25 adjusts the tension of the upper thread according to the feeding speed of the upper thread detected by the speed detection mechanism 23. More specifically, the feeding speed of the upper thread is detected, and the tension of the upper thread is adjusted to decrease when the speed of conveyance of the upper thread is high and to increase when the feeding speed of the upper thread is low. Thus, the upper thread and the lower thread in the stitches in the embroidery apparatus 1 can be balanced.

**[0095]** Such control can eliminate the positional deviation of the color due to the tension in the embroidery apparatus 1 when the upper thread whose color continuously changes is used by the thread tensioning unit 2.

**[0096]** Here, the feeding speed of the upper thread is changed by being pulled or slackened when the length of a stitch is largely changed from the previous stitch at the position of the needle 11. However, the position detected by the speed detection mechanism 23 is a position on the upstream side slightly away from the needle 11. The change of stitches occurring on the downstream side in the feeding direction is detected on the upstream side slightly after the change of stitches. Thus, adjustment is performed according to the detection result. Accordingly, in this control example, a slight delay occurs in the tension adjustment position on the upper thread N by the feeding distance from the detection position to the needle 11 in the period from the tension variation on the embroidery side to the tension adjustment in the upper thread N.

**[0097]** However, in this control example, after execution of the initial setting of the tension of the upper thread, the computing mechanism 25A of the thread tensioning unit 2 does not need to communicate with the computing mechanism 15A of the embroidery apparatus 1 during the embroidery operation, and the exchange of data is completed in the thread tensioning unit 2. Thus, the control can be simplified. Accordingly, it is preferable that the first control example and the second control example can be appropriately selected in accordance with the required accuracy of the positional deviation of color and the control load.

#### Variations

**[0098]** FIG. 11 is a schematic side view of an embroidery apparatus attached with a thread tensioning unit according to a variation of the first embodiment of the present invention. In the configuration of FIG. 1, the upper-thread spool 21 is disposed in the thread tensioning unit 2. However, in the present variation, an upper-thread spool 101 is disposed in an embroidery apparatus 1A.

**[0099]** In the present variation, the thread tensioning unit 2A feeds an upper thread N unwound from the upper-thread spool 101 disposed in the embroidery apparatus 1A and adjusts the tension of the upper thread N during

feeding.

**[0100]** In the configuration illustrated in FIG. 1, the thread tensioning unit 2 is disposed on the lateral side of the embroidery apparatus 1. However, in this variation, the thread tensioning unit 2A is disposed above the embroidery apparatus 1A. Note that, in some embodiments, the thread tensioning unit may be provided below the embroidery apparatus.

**[0101]** Each of the thread tensioning unit 2 illustrated in FIG. 1 and the thread tensioning unit 2A illustrated in FIG. 11 is attached to the embroidery apparatus 1 or 1A to allow adjustment of the tension of thread. Each of the thread tensioning unit 2 according to the first embodiment and the thread tensioning unit 2A according to the variation of the first embodiment can be distributed independently of the embroidery apparatus and can be retrofitted to a commercially available embroidery apparatus.

#### Second Embodiment

**[0102]** FIG. 12 is a schematic side view of an embroidery apparatus attached with a thread tensioning unit according to a second embodiment of the present invention. An embroidery apparatus 1B according to the present embodiment includes a thread tensioning unit 102 and an embroidery unit 103.

**[0103]** In the present embodiment, the thread tensioning unit 102 adjusts the tension of the upper thread as in the first embodiment. Similar to the embroidery apparatus 1 of FIG. 1, the embroidery unit 103 performs embroidery on a cloth C using an upper thread N fed from the thread tensioning unit 102 and a lower thread B fed according to the feeding of the upper thread N.

**[0104]** In the present embodiment, since the thread tensioning unit 102 and the embroidery unit 103 are disposed in the same apparatus, the functions of the computing mechanism 15 and the computing mechanism 25 illustrated in FIG. 7 can be integrated into one computing device (for example, a computing mechanism 15B).

#### Third Embodiment (dyeing embroidery system)

**[0105]** FIG. 13 is a schematic side view of a dyeing embroidery system in which an embroidery apparatus 1C and the dyeing apparatus 3 are combined, according to a third embodiment of the present invention. In the dyeing embroidery system 300 according to the present embodiment, the dyeing apparatus 3 that applies a color that changes in the feeding direction to the upper thread unwound from the upper thread spool is provided in the preceding stage of the embroidery apparatus 1C. In the present embodiment, a thread tensioning unit 102C is disposed in the embroidery apparatus 1C. However, an upper-thread spool is disposed in the dyeing apparatus 3 on the upstream side of the thread tensioning unit 102C in the thread feeding direction.

**[0106]** The dyeing apparatus 3 includes, for example, an upper-thread spool 31 around which the upper thread

N is wound, a dyeing unit 32, a fixing unit 33, and a post-processing unit 34.

**[0107]** In the dyeing apparatus 3, the upper thread N drawn from the upper-thread spool 31 is guided by rollers 351 and 352, passes through the thread tensioning unit 102C of the embroidery apparatus 1C, and is continuously routed to the embroidery unit 103.

**[0108]** The dyeing unit 32 includes a plurality of discharge heads 321K, 321C, 321M, and 321Y and a plurality of individual maintenance units 322K, 322C, 322M, and 322Y. The plurality of discharge heads 321K, 321C, 321M, and 321Y, which may be collectively referred to as discharge heads 321, discharge and apply liquids of colors to the upper thread N pulled out and fed from the upper-thread spool 31. The plurality of individual maintenance units 322K, 322C, 322M, and 322Y, which may be collectively referred to as maintenance units 322, perform maintenance of the discharge heads 321K, 321C, 321M, and 321Y, respectively.

**[0109]** The plurality of discharge heads 321K, 321C, 321M, and 321Y are discharge heads that discharge colors different from each other. For example, the discharge head 321K discharges droplets (ink) of black (K), the discharge head 321C discharges droplets of cyan (C), the discharge head 321M discharges droplets of magenta (M), and the discharge head 321Y discharges droplets of yellow (Y). The above-described order of colors is an example. In some embodiments, the colors may be arranged in an order different from the above-described order.

**[0110]** In FIG. 13, an example in which the discharge heads 321K, 321C, 321M, and 321Y of four colors are provided is illustrated. However, an embodiment of the present invention is not limited to the example. Since it is sufficient to dye a continuous upper thread with a plurality of colors that change in the feeding direction, the number of heads may be any number as long as heads corresponding to a plurality of colors (in other words, at least two colors) are provided. Furthermore, in the dyeing unit 32, a discharge head that discharges colorless liquid droplets for coating the upper thread may be included on the most downstream side.

**[0111]** The maintenance units 322K, 322C, 322M, and 322Y, respectively, are disposed below the discharge heads 321K, 321C, 321M, and 321Y of the respective colors. As a maintenance recovery operation, the maintenance units 322K, 322C, 322M, and 322Y, for example, cap the discharge heads 321K, 321C, 321M, and 321Y when the discharge heads 321K, 321C, 321M, and 321Y are not in use, receive dummy discharge of liquid droplets from the discharge heads 321K, 321C, 321M, and 321Y, perform suction circulating operation of the nozzles in a state in which a dummy discharge receptacle is close to the heads, and perform a wiping operation of the nozzles.

**[0112]** The dyeing unit 32 in the dyeing apparatus 3 illustrated in FIG. 13 represents a configuration example of a liquid discharge type in which the upper thread N is dyed by discharging ink from the discharge head 321.

Note that, in some embodiments, the dyeing unit 32 may be a dyeing unit of a coating type that sandwiches an upper thread N with, for example, rollers to apply ink for dyeing.

**[0113]** The fixing unit 33 performs a fixing process (drying process) of the ink discharged from the dyeing unit 32 on the upper thread N. The fixing unit 33 includes heating means, such as an infrared irradiator or a warm-air blower, and heats and dries the upper thread N.

**[0114]** The post-processing unit 34 includes, for example, a cleaner that cleans the upper thread N and a lubricant applying unit that applies a lubricant to a surface of the upper thread N.

**[0115]** Note that the dyeing apparatus 3 according to an embodiment of the present invention includes at least the dyeing unit 32 that applies a colored liquid to the upper thread N and may not include the fixing unit 33 and the post-processing unit 34.

**[0116]** The dyeing apparatus 3 further includes a computing mechanism 36 to control dyeing. The computing mechanism 36 is electrically connected to the computing mechanism 15C disposed in the embroidery apparatus 1C. The computing mechanism 36 creates, based on the embroidery image acquired by the embroidery apparatus 1C, dyeing data including data on color and dyeing length for the upper thread N and outputs the dyeing data to the dyeing unit 32. The dyeing unit 32 dyes the upper thread N with the color and the dyeing length corresponding to the dyeing data. Further, a colorless liquid may be discharged to coat the dyed upper thread N.

**[0117]** In the thread tensioning unit 102 according to the present embodiment, when the optical sensor 23A illustrated in FIGS. 6A and 6B is applied to the speed detection mechanism 23, the optical sensor 23A detects the position of the color applied by the dyeing apparatus 3 on the upper thread N. In this case, the speed detection mechanism 23 acquires the feeding speed of the upper thread N from the timing at which the position of the color serving as the mark at the position of the predetermined feed length applied by the dyeing apparatus 3 or the boundary of the color change is detected.

#### Fourth Embodiment (dyeing embroidery system)

**[0118]** FIG. 14 is a schematic side view of a dyeing embroidery system 300D in which a dyeing apparatus attached with a thread tensioning unit and an embroidery apparatus are combined, according to a fourth embodiment of the present invention.

**[0119]** In the dyeing embroidery system according to the third embodiment, the thread tensioning unit 102C is built in the embroidery apparatus 1C. However, as in the present embodiment, a thread tensioning unit 302 may be built in a dyeing apparatus 3D. In this case, a computing mechanism of the thread tensioning unit 302 may be integrated with a computing mechanism 36D of the dyeing apparatus 3D.

**[0120]** As described above, in the dyeing embroidery

system according to an embodiment of the present invention, the thread tensioning unit may be disposed in the dyeing apparatus as in the fourth embodiment or may be disposed in the embroidery apparatus as in the third embodiment.

#### Variation of System

**[0121]** In the third embodiment and the fourth embodiment, the example in which the thread tensioning unit is disposed in the dyeing apparatus or the embroidery apparatus has been described. However, in a dyeing embroidery system having a dyeing function and an embroidery function, the thread tensioning unit may not be disposed in any of the dyeing apparatus and the embroidery apparatus.

**[0122]** In such a configuration, the thread tensioning unit 2A having no upper-thread spool according to an embodiment of the present invention, which can be distributed independently, may be set between a commercially available dyeing apparatus and a commercially available embroidery apparatus. Thus, the thread tensioning function can be retrofitted to the dyeing embroidery system.

#### Fifth Embodiment (Dyeing Embroidery Apparatus)

**[0123]** FIG. 15 is a schematic side view of an integrated dyeing embroidery apparatus according to a fifth embodiment of the present invention. A dyeing embroidery apparatus 3E according to the present embodiment is an integrated dyeing embroidery apparatus in which a dyeing apparatus and an embroidery apparatus are disposed in one housing. The dyeing embroidery apparatus 3E includes a thread tensioning unit 20. In this case, a computing mechanism of the thread tensioning unit 20 may be integrated with a computing mechanism 36E of a dyeing unit 30 and/or an embroidery unit 10.

**[0124]** Although some embodiments and examples of the present invention have been described above, the present invention is not limited to the above-described embodiments and examples. The present invention can be variously modified or changed in light of the appended claims.

**[0125]** The present invention can be implemented in any convenient form, for example using dedicated hardware, or a mixture of dedicated hardware and software. The present invention may be implemented as computer software implemented by one or more networked processing apparatuses. The processing apparatuses include any suitably programmed apparatuses such as a general purpose computer, personal digital assistant, mobile telephone (such as a WAP or 3G-compliant phone) and so on. Since the present invention can be implemented as software, each and every aspect of the present invention thus encompasses computer software implementable on a programmable device. The computer software can be provided to the programmable device

using any conventional carrier medium (carrier means). The carrier medium includes a transient carrier medium such as an electrical, optical, microwave, acoustic or radio frequency signal carrying the computer code. An example of such a transient medium is a TCP/IP signal carrying computer code over an IP network, such as the Internet. The carrier medium may also include a storage medium for storing processor readable code such as a floppy disk, hard disk, CD ROM, magnetic tape device or solid state memory device.

#### Claims

1. A thread tensioning unit (20) for adjusting tension of an upper thread to be fed to an embroidery apparatus, the thread tensioning unit being configured to be provided at a preceding stage of the embroidery apparatus, the thread tensioning unit comprising:

a feeding mechanism (22) configured to feed the upper thread,  
a speed detection mechanism (23, 23A) configured to detect a feeding speed of the upper thread;  
a tensioning mechanism (25, 25A) configured to adjust the tension of the upper thread according to a detected feeding speed of the upper thread detected by the speed detection mechanism.

2. The thread tensioning unit according to claim 1,

wherein the tensioning mechanism is configured to decrease the tension of the upper thread when the feeding speed of the upper thread is higher than a predetermined range, and  
wherein the tensioning mechanism is configured to increase the tension of the upper thread when the feeding speed of the upper thread is lower than the predetermined range.

3. The thread tensioning unit according to claim 1,

wherein the embroidery apparatus is configured to calculate, from input embroidery data, an expected thread consumption amount and an assumed feeding speed of the upper thread associated with the expected thread consumption amount, and  
wherein the tensioning mechanism is configured to adjust the tension of the upper thread in response to a difference between the assumed feeding speed of the upper thread and the detected feeding speed of the upper thread detected by the speed detection mechanism.

4. The thread tensioning unit according to claim 1,

- wherein the tensioning mechanism is configured to decrease the tension of the upper thread when the detected feeding speed of the upper thread is faster than the assumed feeding speed of the upper thread, and  
 wherein the tensioning mechanism is configured to increase the tension of the upper thread when the detected feeding speed of the upper thread is lower than the assumed feeding speed of the upper thread.
5. The thread tensioning unit according to any one of claims 1 to 4, wherein the speed detection mechanism includes an optical sensor configured to directly read a moving speed of the upper thread.
6. The thread tensioning unit according to claim 5, wherein the speed detection mechanism includes a sensor configured to detect a color of the upper thread, and wherein the speed detection mechanism is configured to detect a position of a color serving as a mark or a change speed of the color in the upper thread and calculate the feeding speed of the upper thread.
7. The thread tensioning unit according to any one of claims 1 to 4, wherein the speed detection mechanism includes:  
 a sensor disposed on a roller configured to rotate with feeding of the upper thread; and  
 a speed calculation unit configured to calculate a feeding speed of the upper thread from a rotation speed of the roller detected by the sensor.
8. The thread tensioning unit according to any one of claims 1 to 7, wherein the speed detection mechanism is disposed upstream from the tensioning mechanism in a feeding direction of the upper thread.
9. A dyeing apparatus (3) comprising:  
 the thread tensioning unit (20) according to any one of claims 1 to 8; and  
 a dyeing unit (30) provided at a preceding stage of the thread tensioning unit and configured to dye the upper thread.
10. An embroidery apparatus (2) comprising:  
 the thread tensioning unit (20) according to any one of claims 1 to 8; and  
 an embroidery unit configured to perform embroidery on a cloth with the upper thread fed
- from the thread tensioning unit and a lower thread fed in response to feeding of the upper thread,  
 wherein the thread tensioning unit includes:  
 a feeding mechanism (22) configured to feed the upper thread;  
 a speed detection mechanism to detect a feeding speed of the upper thread;  
 and a tensioning mechanism configured to adjust the tension of the upper thread in response to the feeding speed of the upper thread.
11. A dyeing embroidery system, comprising:  
 a dyeing apparatus configured to dye an upper thread;  
 a thread tensioning unit configured to adjust a tension of the upper thread; and  
 an embroidery apparatus configured to perform embroidery on a cloth with the upper thread fed from the thread tensioning unit and a lower thread fed in accordance with feeding of the upper thread,  
 wherein the dyeing apparatus includes a dyeing unit configured to apply a color that changes in a feeding direction of the upper thread to the upper thread,  
 wherein the thread tensioning unit includes:  
 a feeding mechanism (22) configured to feed the upper thread;  
 a speed detection mechanism disposed downstream from the dyeing unit in the feeding direction of the upper thread and configured to detect a feeding speed of the upper thread; and  
 a tensioning mechanism configured to adjust the tension of the upper thread in accordance with the feeding speed of the upper thread, and  
 wherein the thread tensioning unit is disposed in one of the dyeing apparatus and the embroidery apparatus.
12. The dyeing embroidery system according to claim 11,  
 wherein the speed detection mechanism includes a sensor configured to detect the color of the upper thread applied by the dyeing unit, and  
 wherein the sensor is configured to detect a location of a color serving as a mark applied by the dyeing unit or a change speed of the color to calculate the feeding speed of the upper

thread.

13. A thread tensioning method for adjusting a tension of an upper thread fed to an embroidery apparatus, the method comprising: 5
- feeding the upper thread;
  - detecting a feeding speed of the upper thread;
  - and
  - adjusting the tension of the upper thread in response to the feeding speed of the upper thread detected by the detecting. 10
14. A carrier medium carrying computer readable code for controlling a computer to carry out the thread tensioning method according to claim 13. 15

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FIG. 1

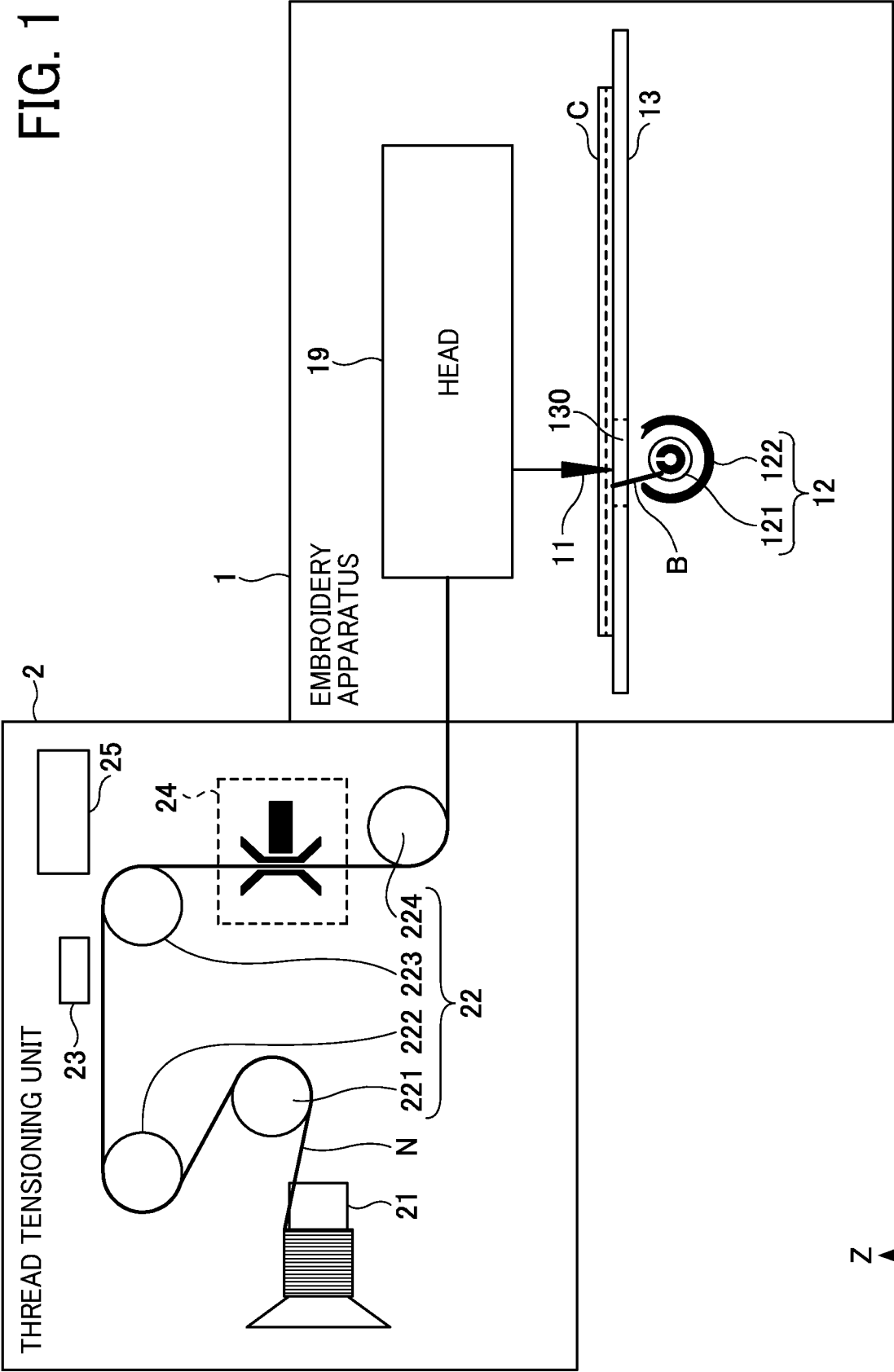


FIG. 2

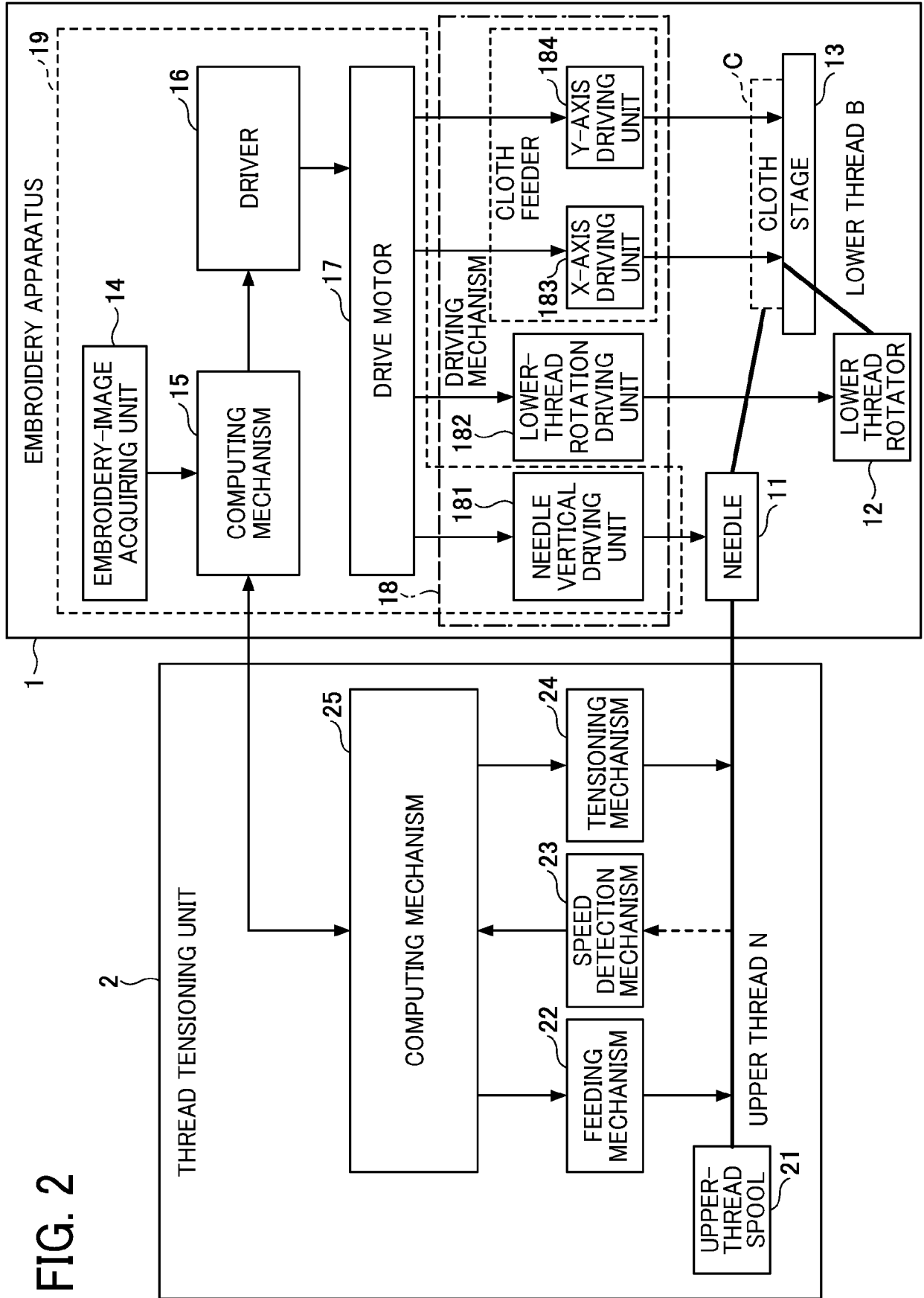


FIG. 3

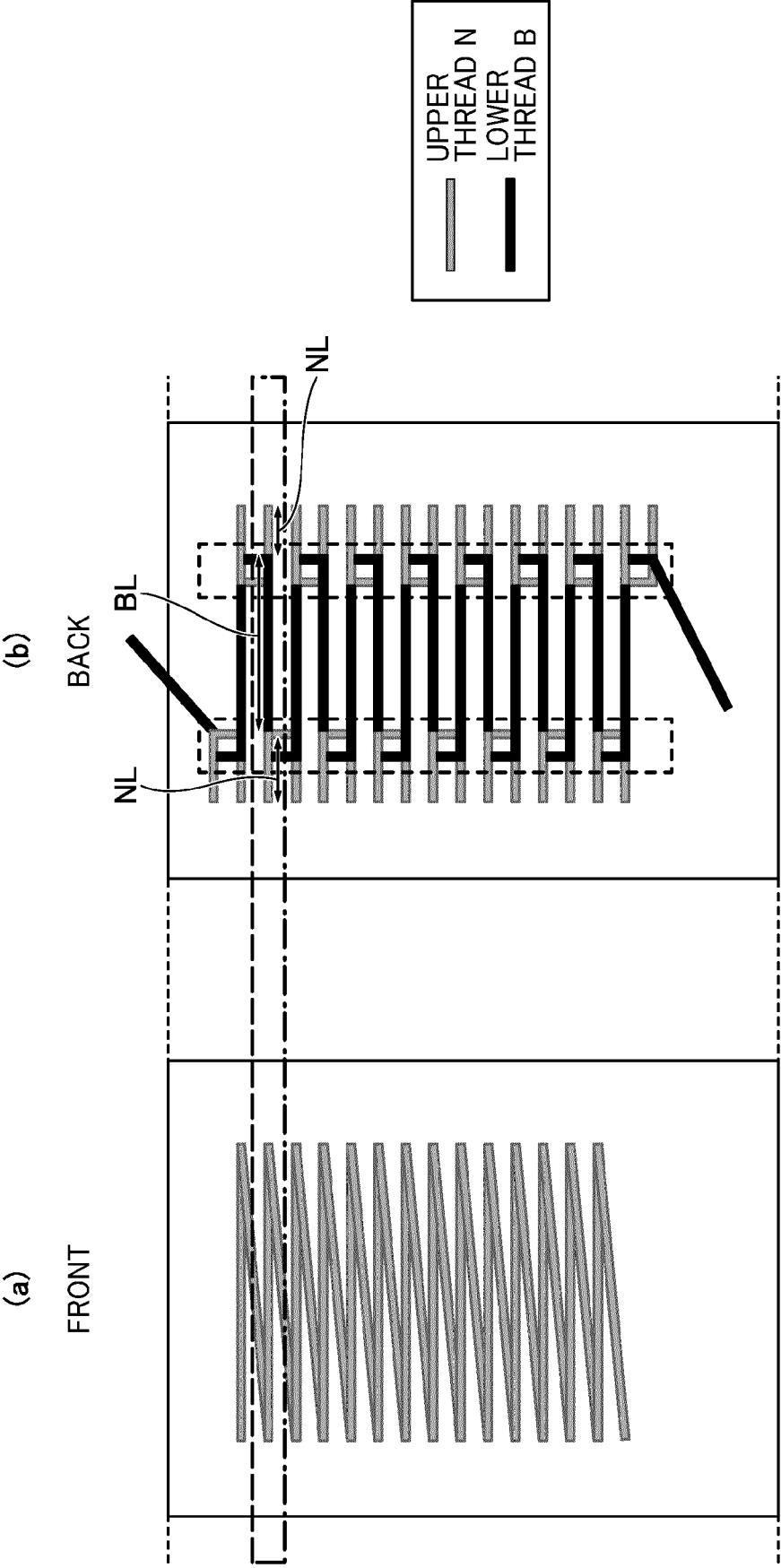


FIG. 4

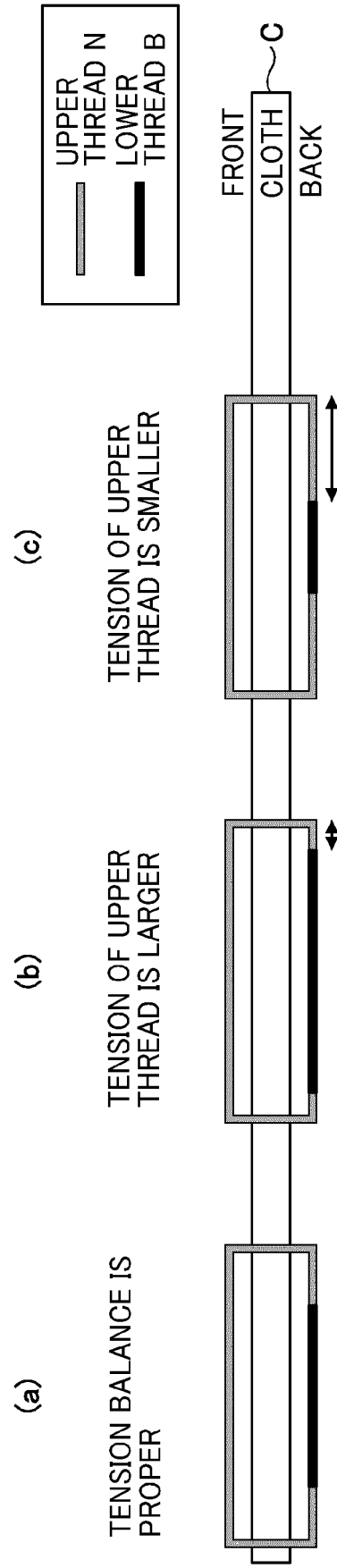


FIG. 5

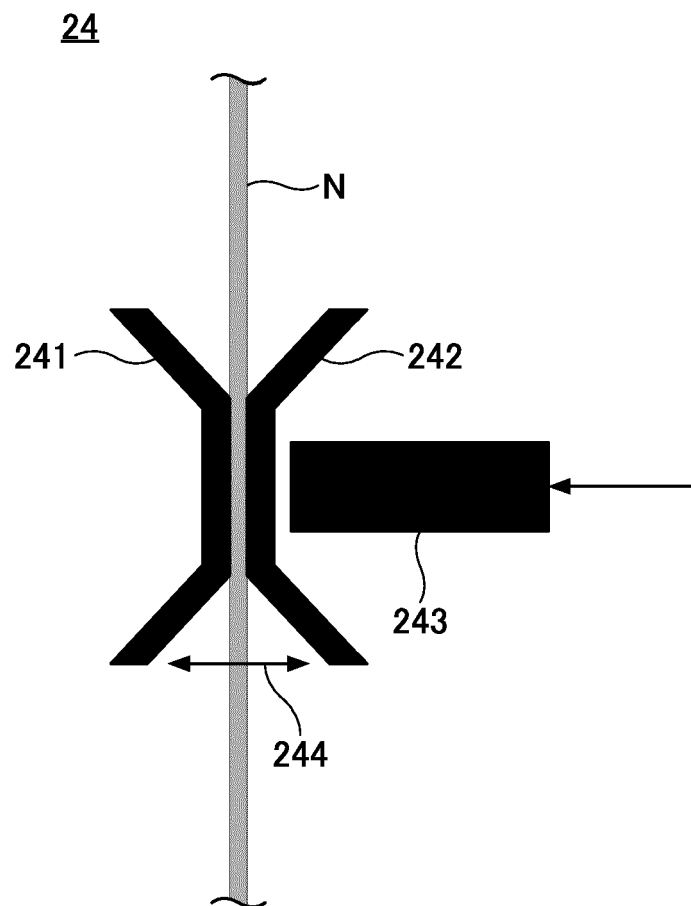


FIG. 6A

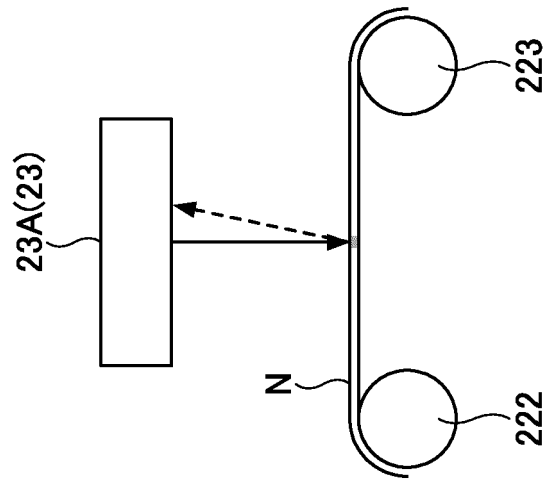


FIG. 6B

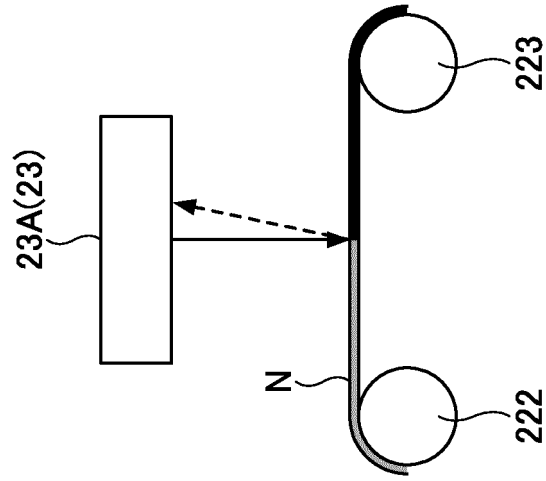


FIG. 6C

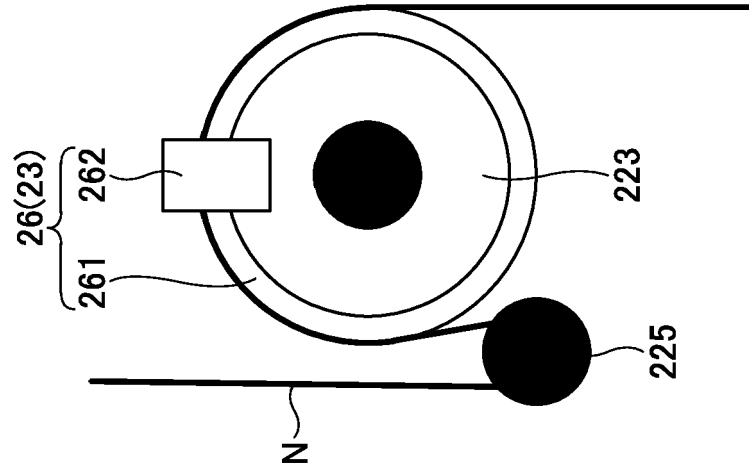


FIG. 7

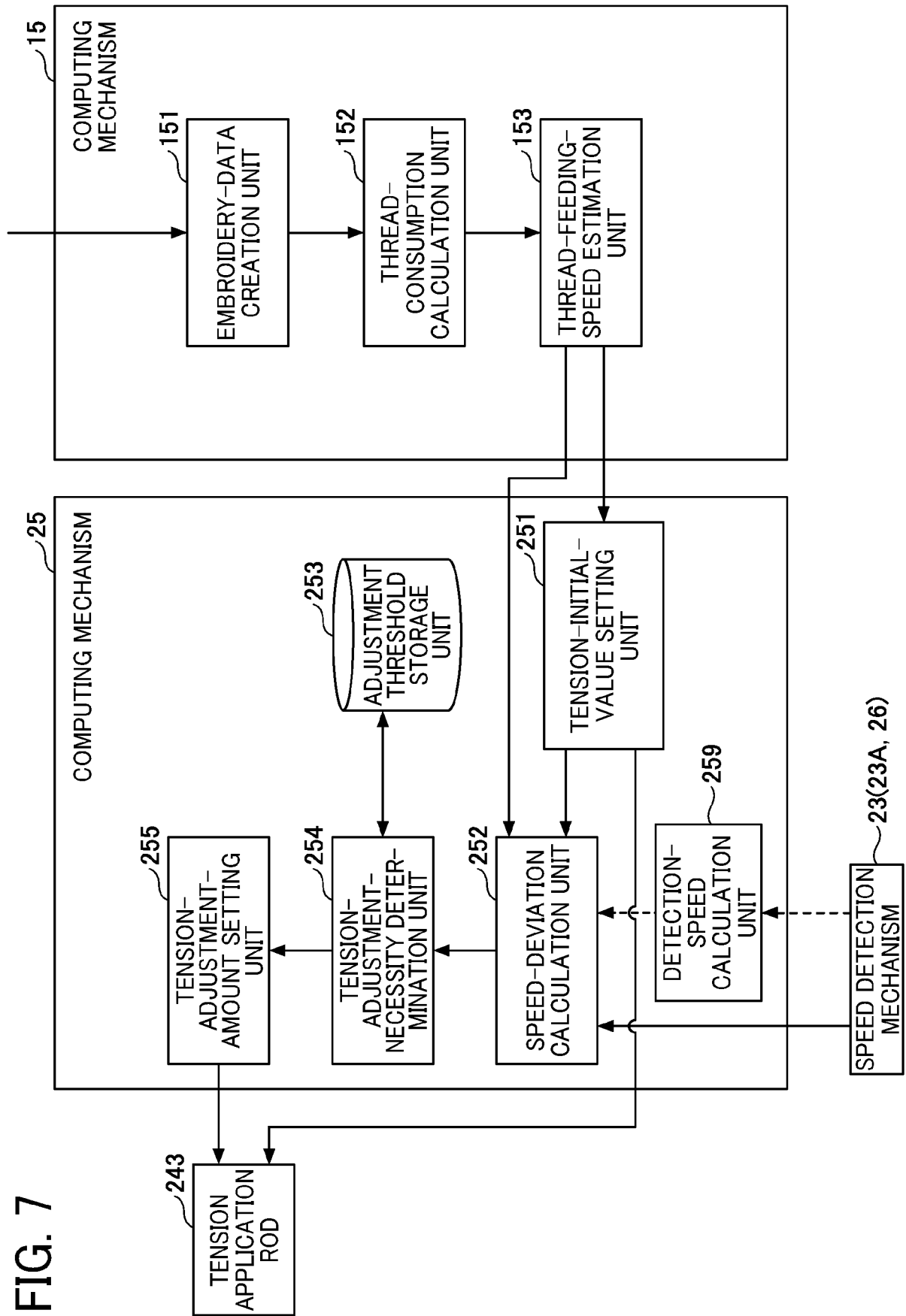


FIG. 8

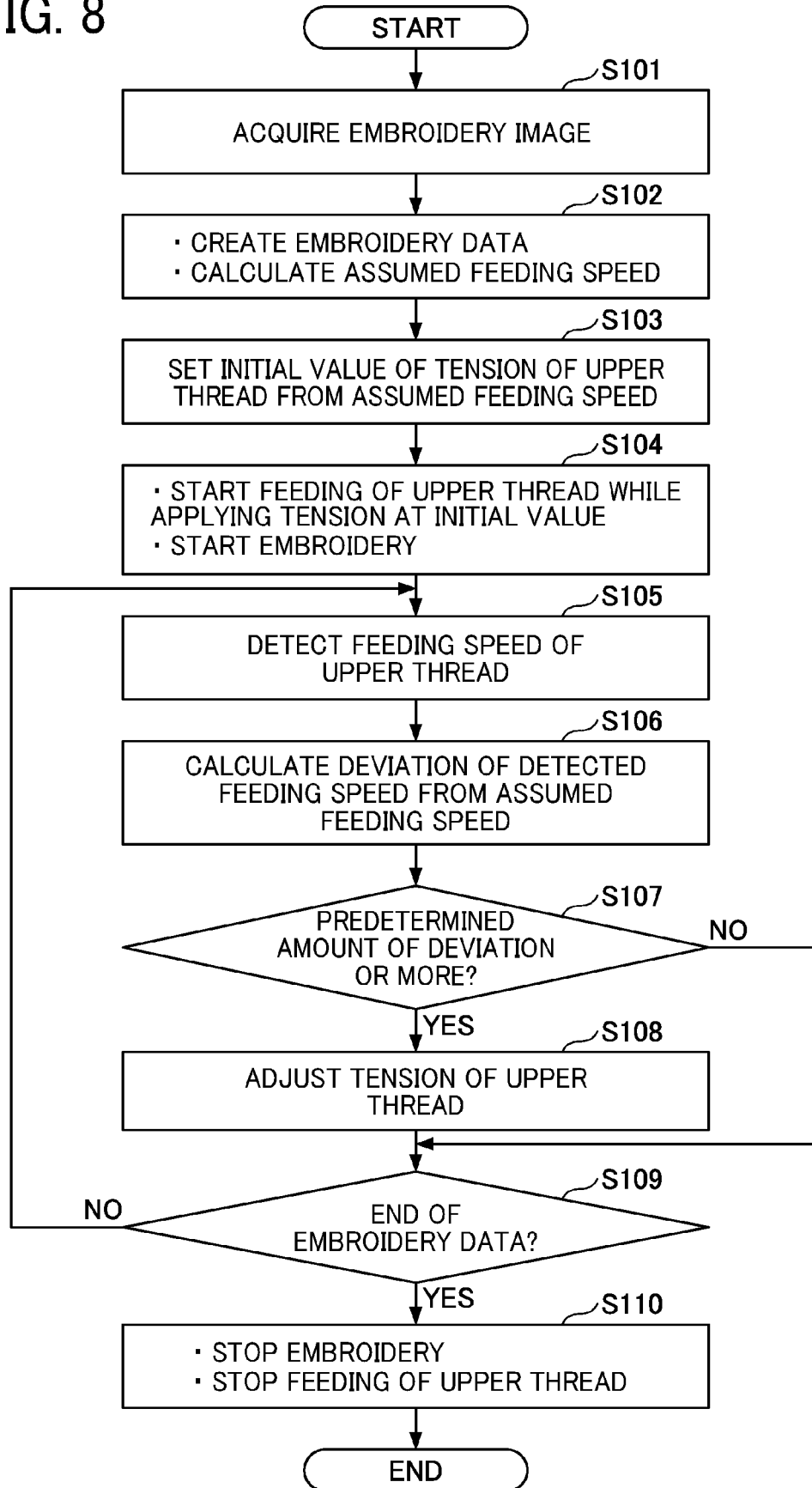


FIG. 9

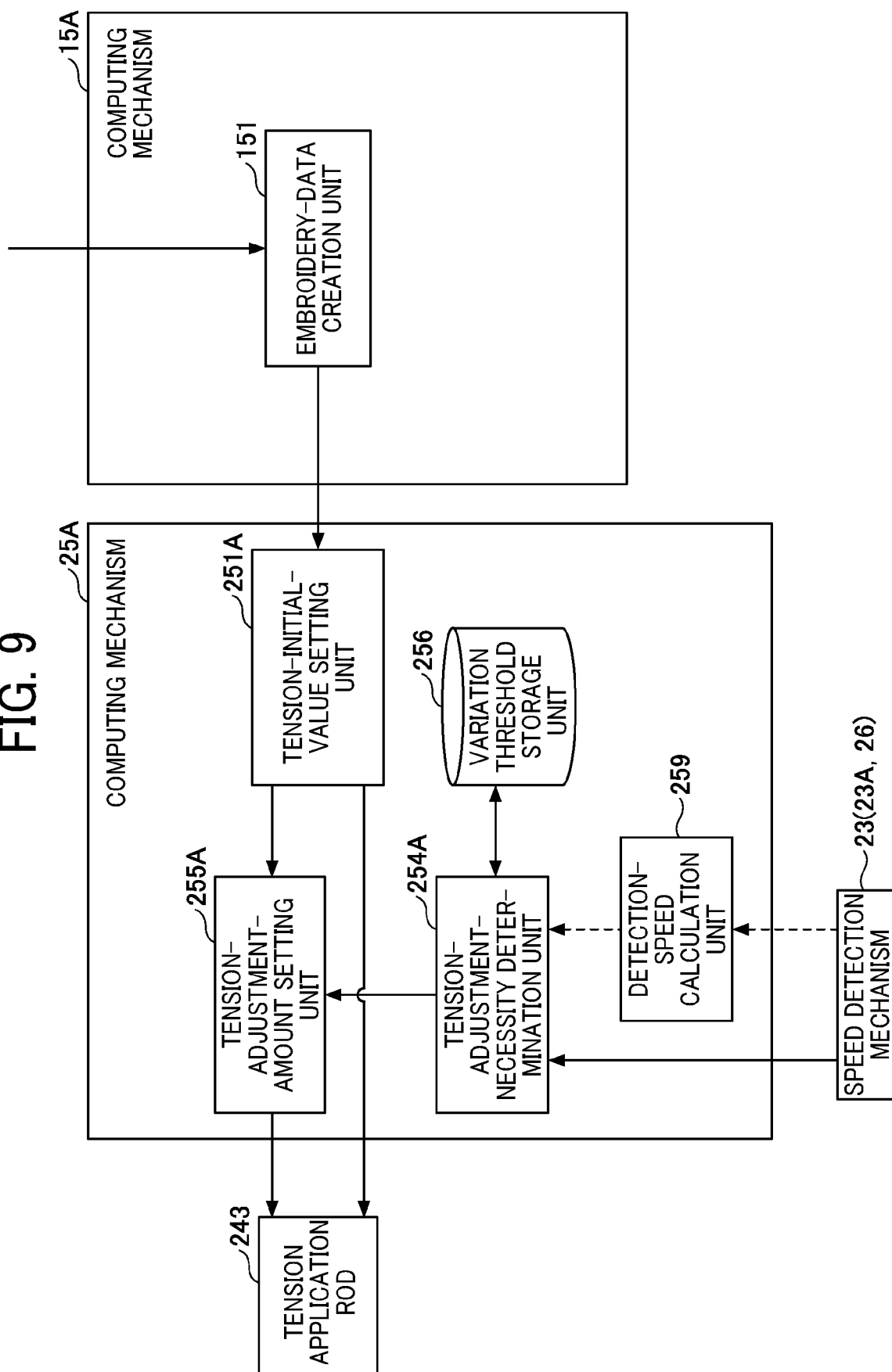


FIG. 10

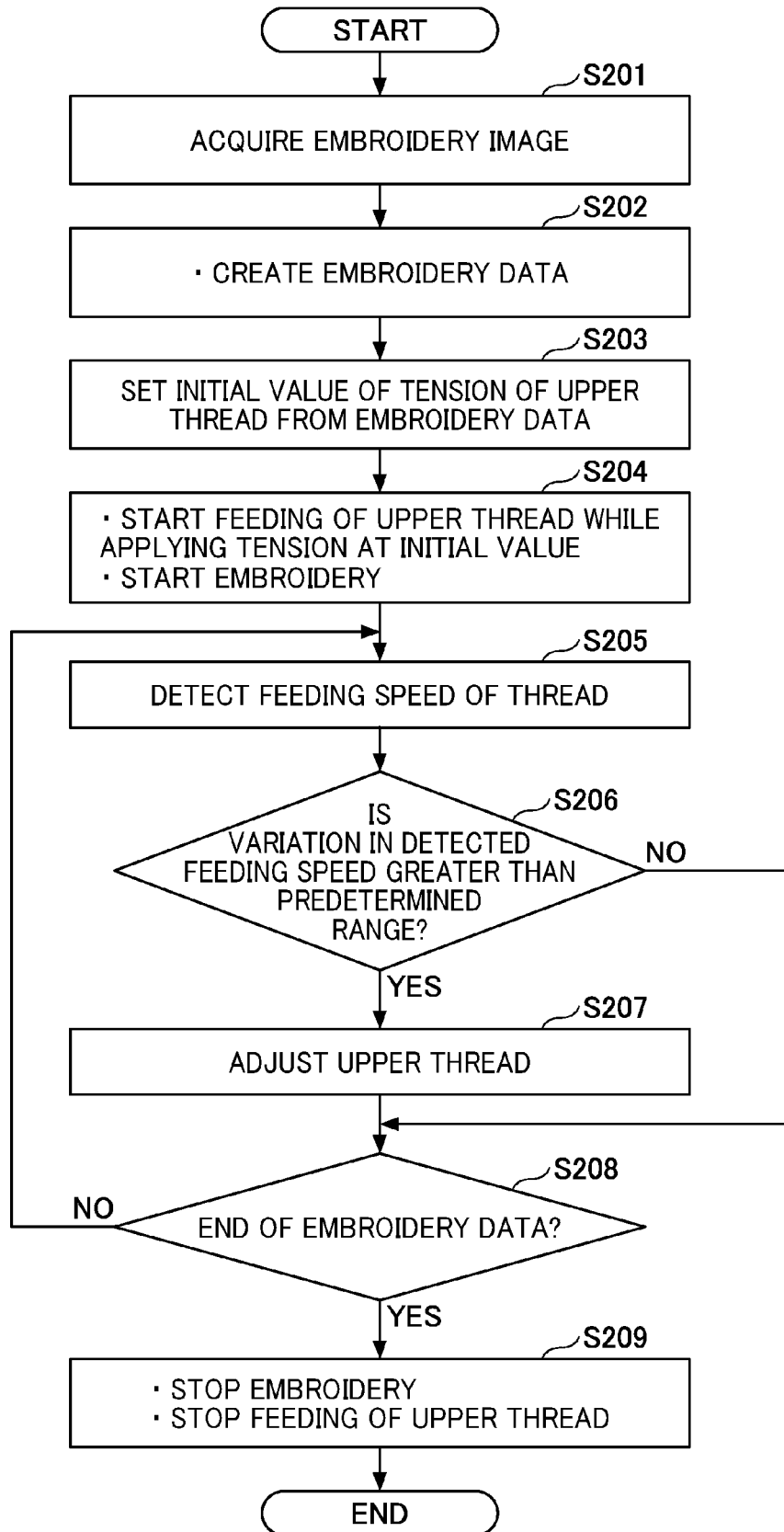


FIG. 11

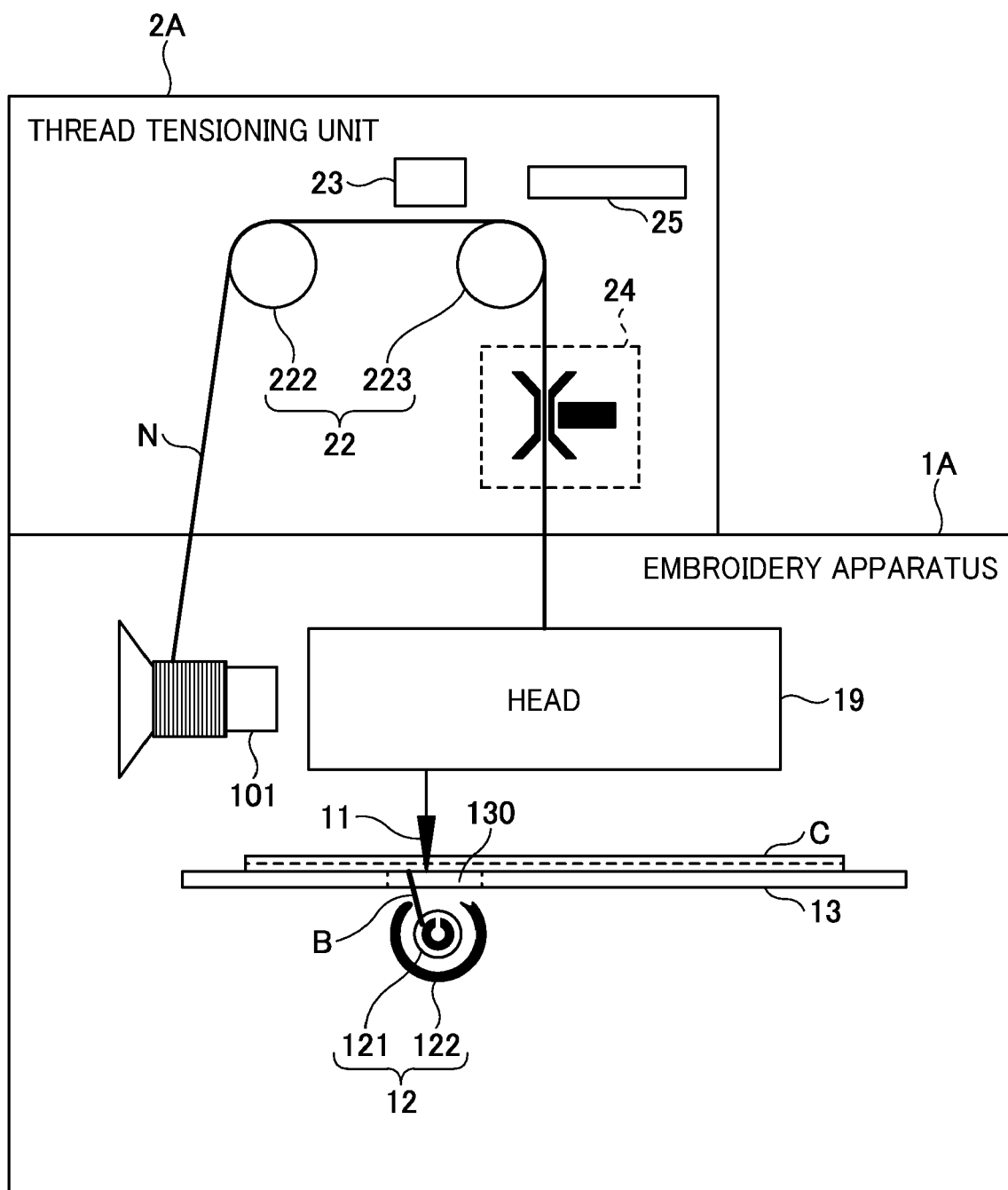


FIG. 12

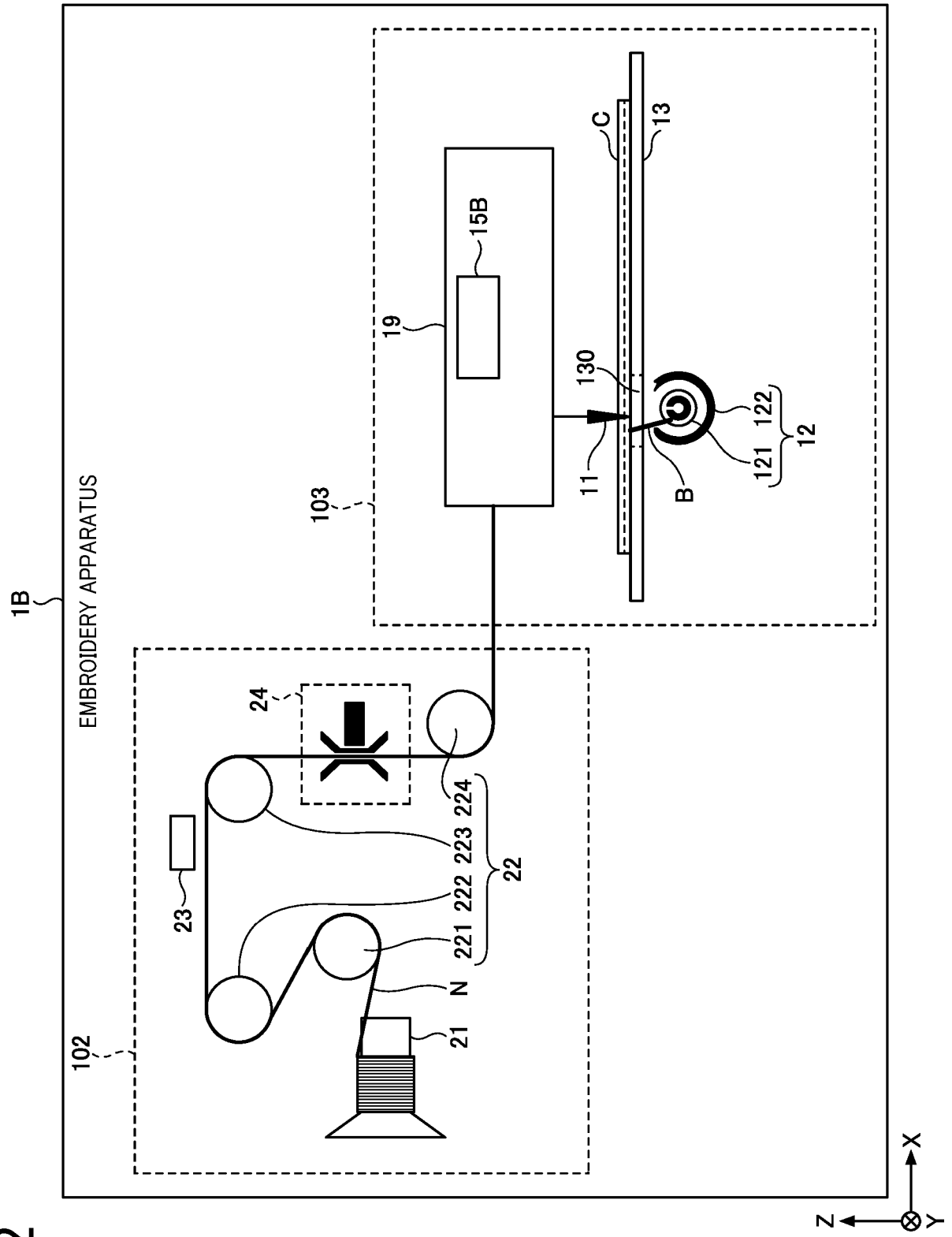


FIG. 13

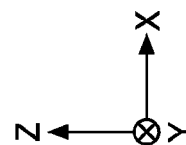
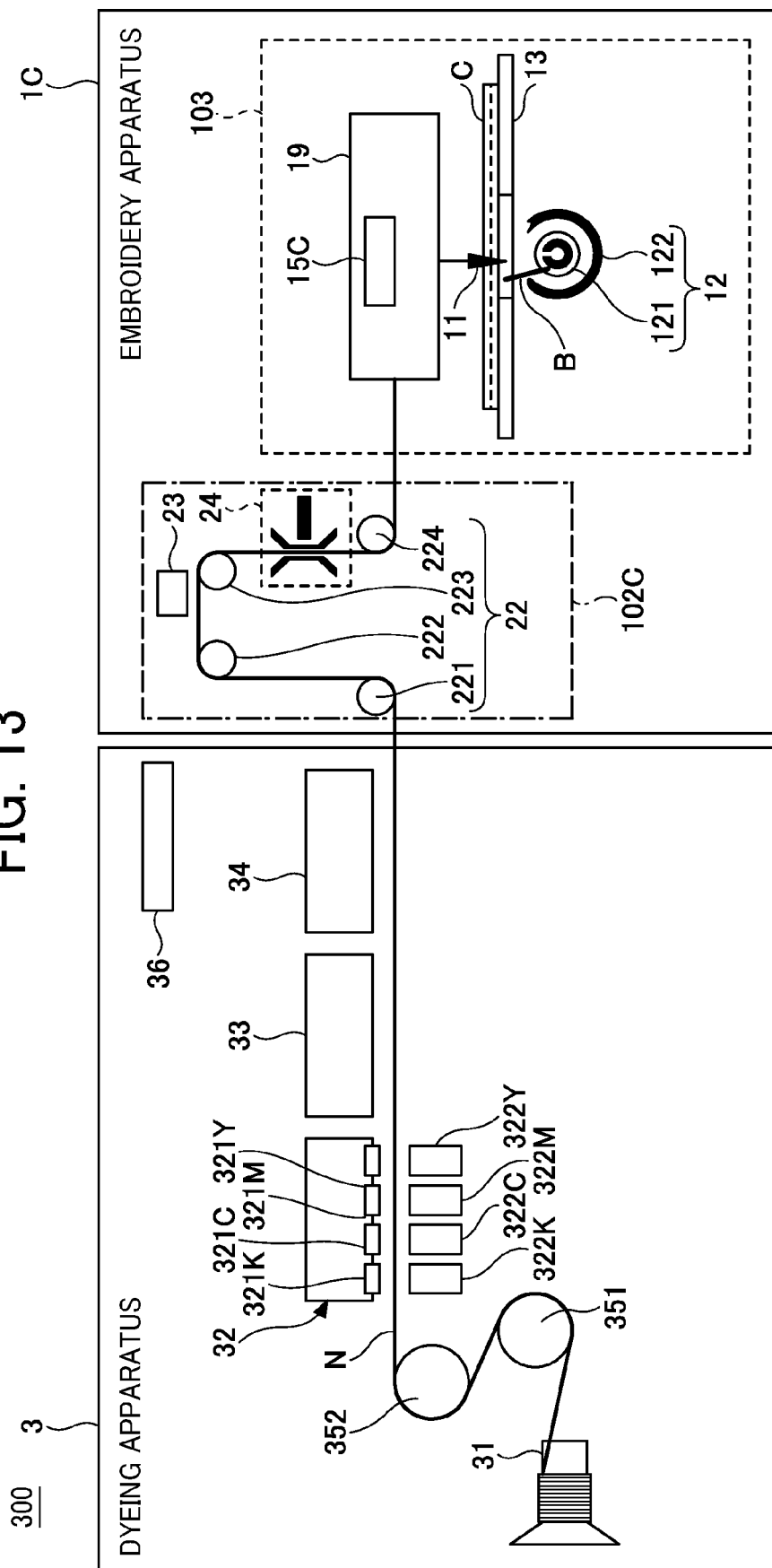


FIG. 14

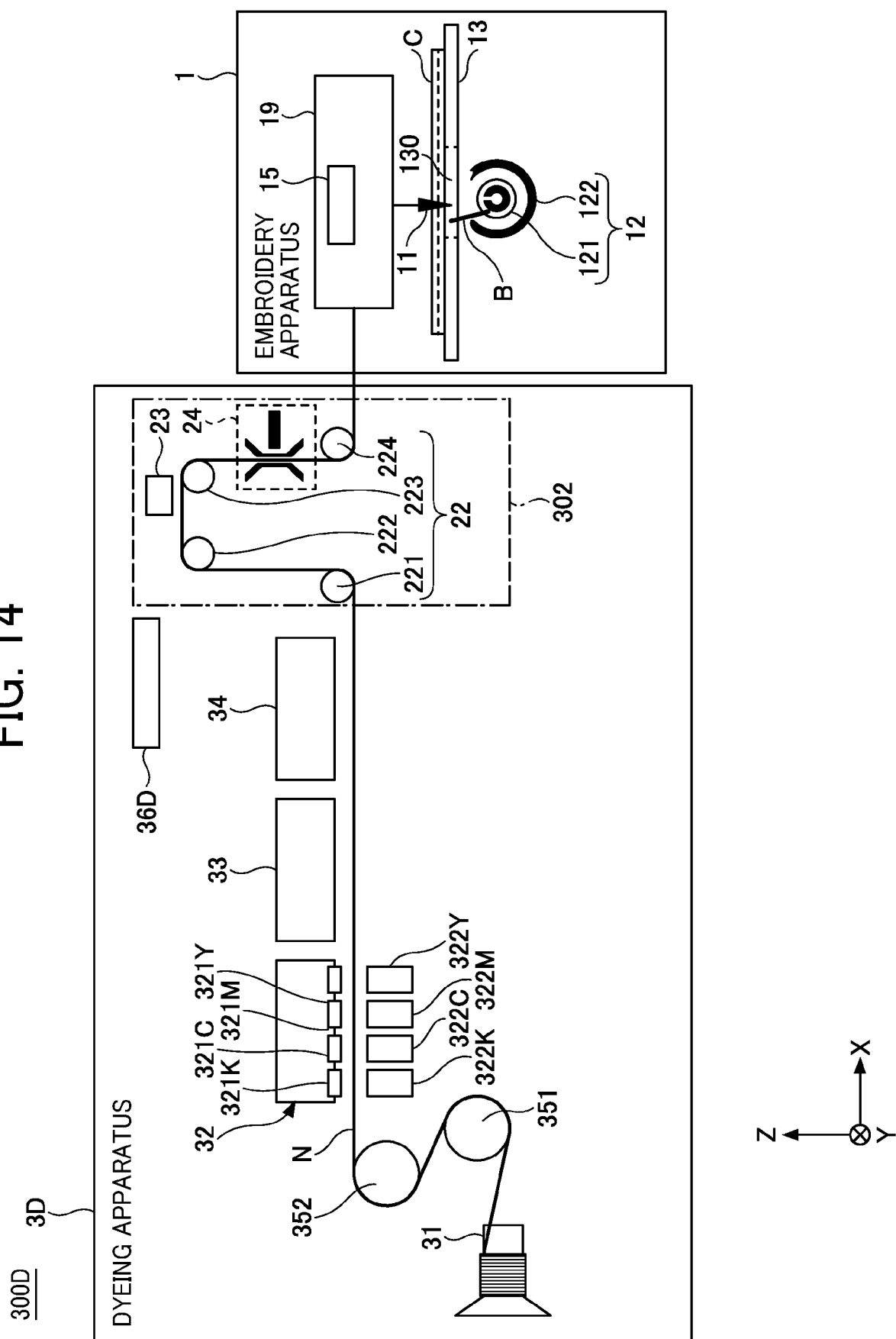
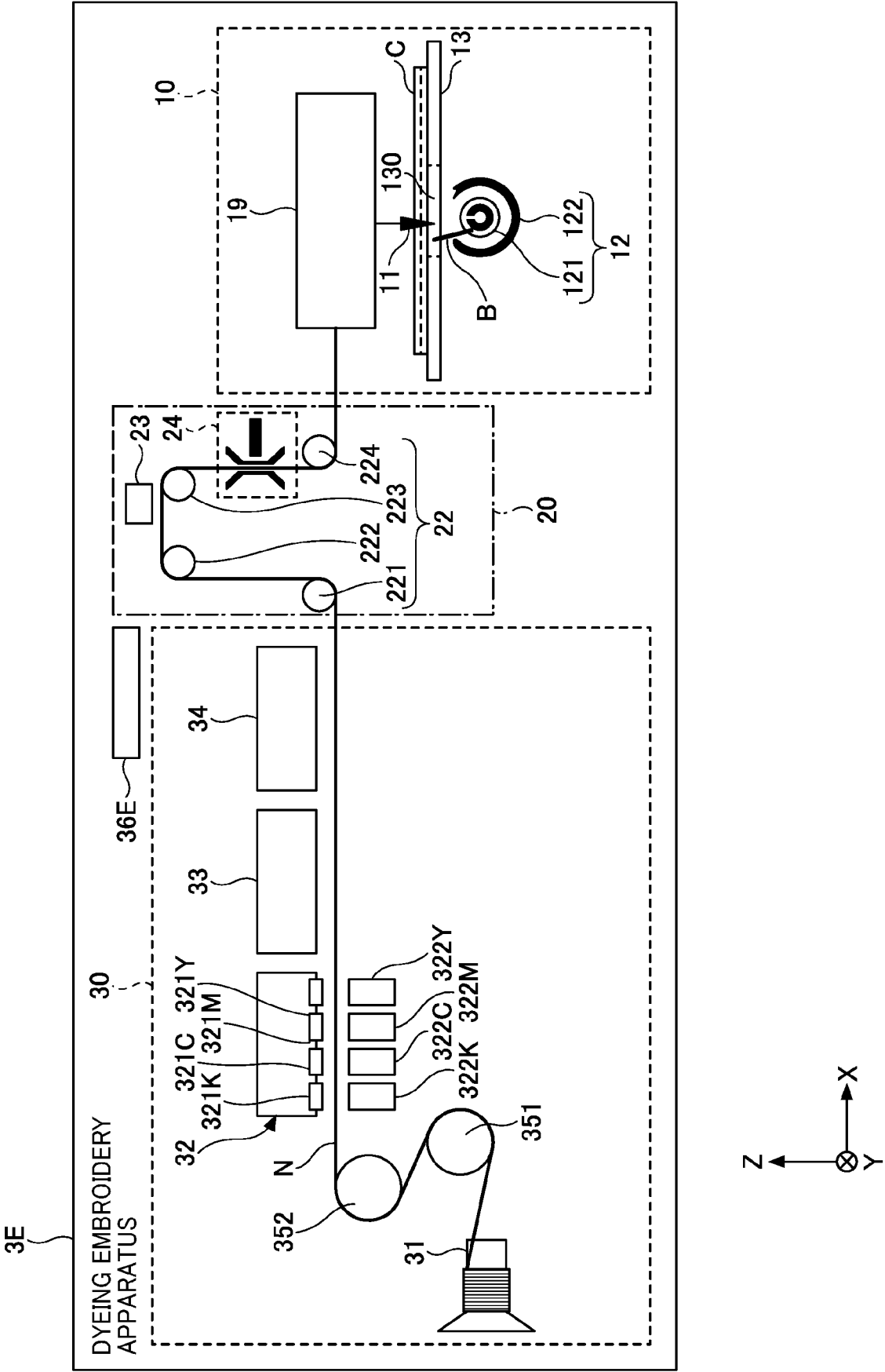


FIG. 15





## EUROPEAN SEARCH REPORT

Application Number

EP 21 19 9677

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| DOCUMENTS CONSIDERED TO BE RELEVANT                                                                                                                                                                                                                    |                                                                                                                                    |                                                                                                                                                                                                                                                                                       |                                                          |
|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------|
| Category                                                                                                                                                                                                                                               | Citation of document with indication, where appropriate, of relevant passages                                                      | Relevant to claim                                                                                                                                                                                                                                                                     | CLASSIFICATION OF THE APPLICATION (IPC)                  |
| X                                                                                                                                                                                                                                                      | WO 2018/059738 A1 (ADIANT LUXEMBOURG HOLDING SARL [LU])<br>5 April 2018 (2018-04-05)                                               | 1, 2, 4,<br>10, 13, 14                                                                                                                                                                                                                                                                | INV.<br>D05B47/04<br>D05C11/08<br>D05C11/24<br>D06B11/00 |
| Y                                                                                                                                                                                                                                                      | * page 5, line 10 - line 14; claims 6, 7 *<br>* page 6, line 28 - page 10, line 9;<br>figures 1-12 *                               | 9, 11                                                                                                                                                                                                                                                                                 |                                                          |
|                                                                                                                                                                                                                                                        | -----                                                                                                                              |                                                                                                                                                                                                                                                                                       |                                                          |
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