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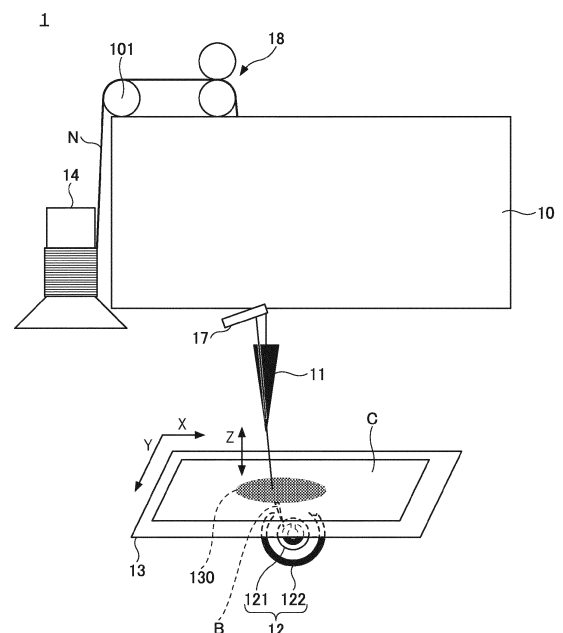
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(54) **EMBROIDERY APPARATUS, DYEING EMBROIDERY APPARATUS, AND DYEING EMBROIDERY SYSTEM**

(57) An embroidery apparatus (1) includes a needle (11), a conveyance roller (18), a detector (17), and a roller controller (16). The conveyance roller (18) conveys a thread to be fed to the needle while pressing the thread. The detector (17) is disposed in a vicinity of the needle and configured to detect a color of the thread being embroidered. The roller controller (16) adjusts at least one of a pressure or a conveyance speed of the conveyance roller, based on a number of stitches indicating how many times the needle has been sewn on a cloth and the color of the thread detected by the detector.

FIG. 1



Description

BACKGROUND

Technical Field

[0001] Embodiments of the present disclosure relate to an embroidery apparatus, a dyeing embroidery apparatus, and a dyeing embroidery system.

Related Art

[0002] In recent years, there has been known a technique of dyeing (coloring) a thread in a preceding stage of an embroidery machine in an in-line type apparatus.

[0003] 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. In this technology, the actual consumption speed of the upper thread is calculated from the state of progress of the embroidery by detecting the position of a needle in the embroidery apparatus, and the embroidery is adjusted according to a speed variation of the consumption of the upper thread occurring in the embroidery apparatus.

[0004] In Japanese Unexamined Patent Application Publication No. 2008-289522, it is possible to match the estimated position of the color change of the thread based on the dyeing data with the actual position of the color change of the thread in the embroidery apparatus. However, when elongation or shrinkage of the thread occurs during dyeing of the thread, during subsequent color fixation, or during conveyance after dyeing while the thread is being fed from the dyeing device to the embroidering section, or when the balance of attraction between the upper thread and the lower thread at the stitches of the embroidered cloth changes, the position of the color change of the thread set by the dyeing data may deviate from the actual position of the color change of the thread when the thread reaches the needle of the embroidery apparatus.

[0005] For this reason, even if the embroidery data is set so that the color change point is not visible as in Japanese Unexamined Patent Application Publication No. 2008-289522, the upper thread may expand or contract during or after dyeing, or the tension balance between the upper thread and the lower thread may fluctuate to cause an error in the feed amount of the upper thread. As a result, the position of the color change point of the upper thread may shift when the upper thread reaches the needle. If the embroidery is continued in this state, it is considered that a color change point of the upper

thread is exposed to the upper surface side in the embroidery region on the cloth, or a color boundary position in the embroidery region is changed, so that an image of the embroidery pattern may be distorted.

SUMMARY

[0006] Therefore, in view of the above-described circumstances, an object of the present invention is to provide an embroidery apparatus that restrains the occurrence of the positional deviation of the color of a thread that is caused by the expansion and contraction of the thread occurring before the thread reaches the needle or the tension balance between the upper thread and the lower thread in stitches.

[0007] In order to solve the above-described problem, in one aspect of the present invention, an embroidery apparatus includes an embroidery apparatus that includes a needle, a conveyance roller, a detector, and a roller controller. The conveyance roller conveys a thread to be fed to the needle while pressing the thread. The detector is disposed in a vicinity of the needle and configured to detect a color of the thread being embroidered. The roller controller adjusts at least one of a pressure or a conveyance speed of the conveyance roller, based on a number of stitches indicating how many times the needle has been sewn on a cloth and the color of the thread detected by the detector.

[0008] In another aspect of the present invention, a dyeing embroidery system includes a dyeing apparatus to dye a thread with a color that changes and the embroidery apparatus. The embroidery apparatus is disposed at a subsequent stage of the dyeing apparatus.

[0009] In still another aspect of the present invention, a dyeing embroidery apparatus includes a dyeing unit, a conveyance roller, an embroidery unit, and a roller controller. The dyeing unit includes a dyeing device to dye a thread with a color that changes. The conveyance roller conveys the thread dyed by the dyeing device and fed to a needle while pressing the thread. The embroidery unit performs embroidery on a cloth using the thread fed from the conveyance roller. The embroidery unit includes the needle and a detector. The detector is disposed in a vicinity of the needle to detect a color of the thread being embroidered. The roller controller adjusts a pressure or a conveyance speed of the conveyance roller, based on a number of stitches indicating how many times the needle has been sewn on the cloth and the color of the thread detected by the detector.

[0010] In yet still another aspect of the present invention, a dyeing embroidery system includes a dyeing apparatus, an embroidery apparatus, and a roller controller. The dyeing apparatus dyes a thread. The embroidery apparatus performs embroidery on a cloth using the thread dyed by the dyeing apparatus. The dyeing apparatus includes a dyeing device that dyes the thread with a color that changes and a conveyance roller to convey the thread dyed by the dyeing device while pressing the

thread. The embroidery apparatus includes a needle and a detector. The detector is disposed in a vicinity of the needle to detect a number of stitches indicating how many times the needle has been sewn on the cloth and the color of the thread being embroidered. The roller controller adjusts a pressure or a conveyance speed of the conveyance roller, based on the number of stitches and the color of the thread detected by the detector. The roller controller is disposed in the dyeing apparatus, the embroidery apparatus, or a higher-level control apparatus connected to the dyeing embroidery system.

[0011] According to an aspect of the present invention, the embroidery apparatus can restrain the occurrence of the positional deviation of the color of the thread that is caused by the expansion and contraction of the thread occurring before the thread reaches the needle and the tension balance between the upper thread and the lower thread in stitches.

BRIEF DESCRIPTION OF THE DRAWINGS

[0012] 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 view of an embroidery apparatus according to a first embodiment of the present invention;

FIG. 2 is a schematic block diagram of the embroidery apparatus of FIG. 1;

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. 5A is a diagram illustrating a detector according to an embodiment of the present invention; FIG. 5B is a diagram illustrating a detector according to another embodiment of the present invention;

FIGS. 6A and 6B are schematic diagrams illustrating adjustment of nipping rollers according to different embodiments of the present invention;

FIG. 7 is a functional block diagram of a control section of an embroidery apparatus according to a first control example;

FIG. 8 is a flowchart of the first control example;

FIG. 9 is a chart illustrating an example of a correlation table for correcting the consumption amount of a thread and the thread tension used in the first control example;

FIG. 10 is a functional block diagram of a control section of an embroidery apparatus according to a second control example;

FIG. 11 is a flowchart of the second control example;

FIG. 12 is a chart illustrating an example of a correlation table for correcting the consumption amount and the conveyance speed of a thread used in the second control example;

FIG. 13 is a functional block diagram of a control section of an embroidery apparatus according to a third control example;

FIG. 14 is a flowchart of the third control example;

FIG. 15 is a chart illustrating an example of a correlation table between the conveyance speed of a thread and the thread tension for correction used in the third control example;

FIG. 16 is a diagram illustrating an example of a test pattern to be detected for creating a correlation table; FIG. 17 is a diagram illustrating another example of a test pattern to be detected for creating a correlation table;

FIG. 18 is a schematic view of a dyeing embroidery apparatus according to a second embodiment of the present invention;

FIG. 19 is a schematic side view of a dyeing embroidery system according to a third embodiment of the present invention;

FIG. 20 is a schematic side view of a dyeing embroidery system according to a fourth embodiment of the present invention; and

FIG. 21 is a schematic block diagram of a dyeing embroidery system according to a fourth embodiment of the present invention.

[0013] 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

[0014] 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.

[0015] 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.

[0016] 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.

[0017] A description is given of a first embodiment of the present invention.

[0018] First, an embroidery apparatus 1 is described with reference to FIGS. 1 and 2. FIG. 1 is a schematic view of an embroidery apparatus 1 according to a first embodiment of the present invention. FIG. 2 is a schematic block diagram of the embroidery apparatus 1 according to the first embodiment of the present invention.

[0019] The embroidery apparatus 1 illustrated in FIG. 1 includes a needle 11, a lower-thread rotator 12, a stage 13, an upper-thread spool 14, a detector 17, nipping rollers 18, and an embroidery head 10.

[0020] 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.

[0021] The lower-thread rotator 12 includes a lower-thread bobbin 121 serving as a lower-thread supplier 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.

[0022] 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.

[0023] 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.

[0024] The upper-thread spool 14 is an upper-thread supplier, around which the upper thread N is wound, to supply the needle thread N to the needle 11. In the present embodiment, the upper thread N supplied from the upper-thread spool 14 is imparted in advance with a color that changes in the conveyance direction.

[0025] The detector 17 is a sensor for simultaneously detecting (1) the vertical movement of the needle 11 and (2) the color of the thread, and is disposed in the vicinity of the needle 11, for example, in the embroidery head 10. The detector 17 detects the number of stitches corresponding to how many times the needle 11 has been raised and lowered or how many stitches have been advanced, and simultaneously detects the color of the thread at the position of the needle hole of the needle 11. For example, the detector 17 simultaneously detects the number of stitches and the color of the thread N at the position of the needle hole of the needle 11 at the needle drop timing at which the needle 11 sticks into the cloth C.

[0026] The nipping rollers 18 are conveyance rollers (pressing conveyance rollers) that convey the upper thread N supplied from the upper-thread spool 14 and fed to the needle 11 while applying pressure to the upper thread N. In the embroidery apparatus 1, in addition to the nipping rollers 18, other rollers such as a roller 101 may be provided as means for conveying the upper thread N.

[0027] The embroidery head 10 is provided with a needle vertical driving unit 193 that drives the needle 11 up and down and a computing mechanism 16 (see FIG. 2). The embroidery head 10 controls the movement (handling) of the needle 11 through which the upper thread N passes and the movement of the stage 13, thereby performing embroidery on the cloth C using the upper thread N and the lower thread B that is fed in accordance with the feeding of the upper thread N.

[0028] 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.

[0029] As illustrated in FIG. 2, the embroidery apparatus 1 includes an embroidery-data creating unit 15, the computing mechanism 16, a driver 191, a drive motor 192, a needle vertical driving unit 193, a lower-thread rotation driving unit 194, an X-axis driving unit 195, and a Y-axis driving unit 196 that serve as a section related to drive control. In this section, at least the detector 17, the driver 191, the drive motor 192, and the needle vertical driving unit 193 are built in the embroidery head 10 above the needle 11 or attached to the embroidery head 10. Further, as indicated by a dotted line, the embroidery-data creating unit 15 and the computing mechanism 16 may also be built in the embroidery head 10.

[0030] The embroidery-data creating unit 15 acquires an embroidery image (embroidery file) from which the embroidery data is generated, creates the embroidery data based on the embroidery image, and outputs the embroidery data to the computing mechanism 16 and the driver 191.

[0031] Here, the embroidery image is image data (image information or embroidery design data) serving as an original of an embroidery pattern on a cloth. The embroidery-data creating unit 15 according to the present embodiment separates the embroidery image into colors (RGB values), sets the sewing order so as to realize the embroidery pattern on the cloth in consideration of the color positions of a thread that has been dyed in advance so as to change colors, and creates embroidery data for forming stitches on the cloth.

[0032] The embroidery data is data (paired data) obtained by combining data of coordinates at which the needle is moved and items to be executed at the coordinates (what is to be executed at each position). 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.

[0033] The computing mechanism 16 calculates the assumed consumption amount of the upper thread based on the embroidery data, and outputs a control signal for adjusting the pressing force or the conveyance speed of the nipping rollers 18 to a roller pressing unit 183 or a rotary motor 187 as necessary with reference to the progress state of how many stitches have been advanced, which is detected by the detector 17, and the color detection timing.

[0034] When the following first control example and third control example are executed, the roller pressing unit 183 adjusts the pressing force of the nipping rollers 18 to adjust the tension of the thread held in the nip. Alternatively, when the following second control example and third control example are executed, the computing mechanism 16 adjusts the rotation speed of the rotary motor 187 to adjust the conveyance speed of the thread N by the nipping rollers 18.

[0035] The driver 191 drives and controls the drive motor 192 based on the embroidery data.

[0036] The needle vertical driving unit 193 is also referred to as a balance and converts the rotational movement of an upper shaft connected to the drive motor 192 into the vertical movement to drive the up-and-down movement of the needle 11 through which the upper thread N is passed.

[0037] The lower-thread rotation driving unit 194 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.

[0038] The X-axis driving unit 195 and the Y-axis driving unit 196 are stage movement drive units serving as 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.

[0039] The needle vertical driving unit 193, the lower-thread rotation driving unit 194, the X-axis driving unit 195, and the Y-axis driving unit 196 serve as a drive mechanism that is driven in conjunction with one drive motor 192. 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 192. 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.

[0040] Tension of Upper Thread and Lower Thread

[0041] 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 upper thread is smaller than the tension of the lower thread.

[0042] 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. Further, when the needle 11 is 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 C, thereby forming a stitch on the cloth C.

[0043] 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.

[0044] 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.

[0045] 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 consumption amount (use amount) of the upper thread is smaller than expected, and the consumption speed of the upper thread N is slower.

[0046] 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. Consequently, if the state in which the tension of the upper thread is small continues, the consumption amount (use amount) of the upper thread N is larger than expected, and the consumption speed of the upper thread N is faster.

[0047] As described above, the consumption speed of the upper thread N depends on the amount of the upper thread N that turns around to the back side of the cloth C. As illustrated in parts (b) and (c) of FIG. 4, in a situation where the turnaround amount is different from the predicted amount, there is a large difference between the predicted amount of consumption of the upper thread and the cumulative amount of consumption of the thread accumulated while the embroidery is continued. The consumption of a thread is set according to the color of the upper thread, or the dyeing of the upper thread is performed with respect to the predicted position of the thread consumption. Accordingly, if a colored thread is not arranged at a correct position, the position of the color after embroidering is shifted, the color change point of the upper thread is exposed to the upper surface side, or the image of an embroidery pattern on a cloth is distorted.

[0048] Therefore, in the present invention, the amount of consumption of the upper thread up to the color change position is detected, and the tension of the upper thread or the conveyance speed of the upper thread is adjusted so as to reduce the difference from the predicted amount of consumption up to the color change position, thereby adjusting the amount of consumption of the upper thread.

[0049] As a method of detecting the difference in the consumption amount of the needle thread N, the actual consumption amount of the upper thread based on the actually detected detection information and the estimated thread consumption amount predicted from the embroidery data are compared with each other while referring to information indicating how far the embroidery has advanced (coordinate position information calculated by the detector 17).

Detector

[0050] FIG. 5A is a diagram illustrating a detector ac-

cording to an embodiment of the present invention. FIG. 5B is a diagram illustrating a detector according to another embodiment of the present invention. In FIGS. 5A and 5B, the embroidery head 10 and the lower-thread rotator 12 are omitted. FIG. 5A illustrates an example of an integral-type detector 17 according to an embodiment of the present invention. FIG. 5B illustrates a separate-type detector 17A according to another embodiment of the present invention.

[0051] The detector 17 illustrated in FIG. 5A is, for example, a color laser sensor. A color laser sensor is a type of photoelectric sensor that emits light from a light projecting unit and detects light reflected by a detection object by a light receiving unit. The color laser sensor can detect the amount of received light of each of red, blue, and green, thus allowing determination of the color of the object (the colors of the needle and the thread).

[0052] As illustrated in FIG. 5A, the detector 17 sets the needle drop position where the needle N sticks into the cloth C as the irradiation range of the object, and detects the time and color at the moment at which the needle 11 sticks into the cloth C. Thus, the detector 17 can detect the number of stitches by counting the number of needle drops, and can simultaneously detect the color of the thread at the timing used for forming a stitch on the cloth.

[0053] Alternatively, the detector 17 constituted by one color laser sensor may be used only for color detection, and the number of stitches corresponding to the current position may be called from the driver 191 that drives based on the embroidery data. In such a case, the color laser sensor 171 may detect the color at the needle drop timing when the needle 11 sticks into the cloth C, and the number of stitches and the color of the thread may be associated with each other by the computing mechanism 16 in the subsequent stage.

[0054] In the separate-type detector 17A illustrated in FIG. 5B, the means for counting the number of stitches and the means for detecting the color of the thread are implemented by separate detection units. The means for detecting the color of the thread (first detection unit) is an optical sensor 171 such as a color laser sensor, which is a sensor capable of detecting at least the color of the thread, similarly to the detector 17.

[0055] In this configuration, a stitch sensor 172 is provided as means for counting the number of stitches (second detection unit). The stitch sensor 172 is a sensor for detecting the vertical movement of the needle 11 and is provided, for example, on a needle bar that holds the needle 11. The stitch sensor 172 detects the number of stitches corresponding to how many times the needle 11 has moved up and down, that is, how many stitches have been advanced by the needle 11.

[0056] In the detector 17A, the color laser sensor 171 detects the color at the needle drop timing at which the needle 11 sticks into the cloth C detected by the stitch sensor 172, so that the number of stitches and the color of the thread at the position of the needle hole of the

needle can be simultaneously detected.

[0057] As a result, according to any of the detection methods, the color of the thread on the needle 11 used for embroidery, in particular, the transition of the color of the thread can be grasped in real time without a temporal error during the embroidery operation.

Nipping rollers

[0058] FIGS. 6A and 6B are schematic diagrams illustrating adjustment of nipping rollers according to different embodiments of the present invention. FIG. 6A is a schematic diagram illustrating nipping rollers 18 used in a first control example. FIG. 6B is a schematic diagram illustrating nipping rollers 18A used in a second control example and a third control example.

[0059] In the example illustrated in FIG. 6A, the nipping rollers 18 are opposed rollers, including a pressing roller 181 and a roller 182, facing each other. The pressing roller 181 is pressed by the roller pressing unit 183 to nip a thread N between the roller 182 and the pressing roller 181 while pressing the thread N, thereby forming a nip in a nipping region.

[0060] In the nipping rollers 18 having this configuration, the pressing force P of the pressing roller 181 by the roller pressing unit 183 is adjusted based on the number of stitches and the position of the color of the thread detected by the detector 17. Thus, the pressure of the nipping rollers 18, that is, the tension of the thread N held in the nip is adjusted.

[0061] In this example, the roller 182 illustrated in FIG. 6A is a driven roller to which no rotational driving force is applied. Alternatively, in some embodiments, the roller 182 may be a driving roller to which a rotational driving force is applied. However, in the adjustment of the first control example, even if the roller 182 is the driving roller, the conveyance speed is not adjusted according to the detection result of the detector 17.

[0062] The nipping rollers 18 capable of adjusting the tension and the detector 17 for simultaneously detecting the number of stitches and the position of the color of the thread can be combined in this manner to adjust the feed amount of the thread N from the nipping rollers 18 to the needle 11 in real time in accordance with the consumption amount of the thread. Thus, the correction of the color shift of the thread N can be controlled before a large shift occurs.

[0063] In the example illustrated in FIG. 6B, the nipping rollers 18A are opposed rollers, including a pressing roller 184 and a drive roller 185, facing each other. The pressing roller 184 is pressed by a roller pressing unit 186 to nip a thread N between the pressing roller 184 and the drive roller 185, thereby forming a nip in a nipping region. Further, in this configuration example, the drive roller 185 is connected to the rotary motor 187 that transmits a rotational driving force.

[0064] In the nipping rollers 18A having this configuration, the rotation speed of the drive roller 185 by the rotary

motor 187 is adjusted based on the number of stitches and the position of the color of the thread by the detector 17, thereby adjusting the conveyance speed (also referred to as supply speed or speed) of the thread. For the roller pressing unit 186 illustrated in FIG. 6B, in the adjustment in the second control example, the pressing force P is fixed at a constant value during the embroidery operation, and the adjustment according to the detection result of the detector 17 is not performed.

[0065] The nipping rollers 18A capable of adjusting the conveyance speed and the detector 17 for simultaneously detecting the number of stitches and the position of the color of the thread can be combined in this manner to adjust the feed amount of the thread N from the nipping rollers 18 to the needle 11 in real time in accordance with the consumption amount of the thread. Thus, the correction of the color shift of the thread N can be controlled before a large shift occurs.

[0066] In the third control example, control is performed by combining adjustment of the pressing force P of the pressing roller 181 by the roller pressing unit 183 and adjustment of the rotation speed of the drive roller 185 by the rotary motor 187 according to the case.

[0067] According to embodiments of the present invention, for example, there are three control methods for adjusting the nipping rollers for adjusting the color position of the thread. Hereinafter, the functional configuration of each control is described with reference to FIGS. 7 to 14.

First Control Example

[0068] FIG. 7 is a functional block diagram of a control section of an embroidery apparatus according to the first control example. Each of the embroidery-data creating unit 15 and the computing mechanism 16 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).

[0069] The computing mechanism 16 of the present control example includes a stitch-by-stitch thread-color prediction unit 601, an assumed-thread-consumption calculation unit 602, an embroidery-progress determination unit 603, an actual-thread-consumption calculation unit 604, a thread-consumption-progress calculation unit 605, a tension setting unit 606, and a correlation storage unit 607.

[0070] The stitch-by-stitch thread-color prediction unit 601 acquires the embroidery data from the embroidery-data creating unit 15, accumulates the movement distance in the coordinate data, from the coordinate data when the needle 11 moves relative to the cloth C and the number of stitches (the number of vertical movements) of the needle included in the embroidery data, and predicts the color of the thread used for embroidery located at the needle tip of the needle 11 at the needle drop timing of the stitch. That is, the thread color is predicted for each

stitch (for each number of up-and-down movements of the needle). Then, in response to a call from the embroidery-progress determination unit 603, the thread color predicted in association with the number of stitches is output.

[0071] The assumed-thread-consumption calculation unit 602 serving as a thread-consumption estimation unit estimates the cumulative estimated needle thread consumption (consumption length) at the current stitch data point, based on the coordinate data of the needle 11 per stitch included in the embroidery data and the stitch data (data indicating how many stitches have been advanced) acquired from the embroidery-progress determination unit 603. That is, the assumed thread consumption amount associated with the stitch data is calculated. The assumed consumption amount 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 consumption amount 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.

[0072] The embroidery-progress determination unit 603 acquires, in real time, stitch data (the number of stitches) that is data indicating how many stitches have been advanced, that is, which stitch is currently being sewn, output from the detector 17. Further, the embroidery-progress determination unit 603 acquires the color of the thread positioned at the needle tip of the needle 11 in the stitch in real time, which is output from the detector 17. Thus, the current embroidery position data (position in the embroidery data) indicating to what extent the embroidery has been advanced in the embroidery data is calculated.

[0073] That is, the embroidery-progress determination unit 603 compares, in the stitches, the target thread color calculated from the embroidery data with the actual thread color detected by the detector 17 to calculate the current embroidery position in the embroidery data.

[0074] The actual-thread-consumption calculation unit 604 serving as a thread-consumption calculation unit calculates the actual consumption of the needle thread N, based on the current embroidery position in the embroidery data calculated by the embroidery-progress determination unit 603 and the actual thread color detection timing.

[0075] Here, even if the color is detected every stitch by the detector 17, what can be actually detected as the change of the thread color is the boundary of the thread color or the position of the change of the thread color such as a portion provided with a marker (also referred to as the position of the thread color change or the color change position).

[0076] Therefore, assuming that the upper thread and the lower thread are set so as to have a tension balance as illustrated in FIG. 4A at the start of embroidery when the upper thread is not expanded or contracted during

conveyance from the upper-thread spool 14 to the needle 11, "the consumption length of the thread until the actual color change = the consumption length of the thread until the assumed color change" is obtained when the detection timing of the actual color coincides with the detection timing of the assumed color change.

[0077] However, even if the upper thread and the lower thread are set so as to have a tension balance as illustrated in FIG. 4A at the start of embroidery, the upper thread may be stretched during conveyance from the upper-thread spool 14 to the needle 11. In such a case, the distance to the color change position of the upper thread set in advance becomes longer. Alternatively, the upper thread passed through the needle may be strongly pulled in the embroidery operation due to, for example, a large amount of movement to the position where the needle is to be inserted or a large number of interruptions, and the tension of the upper thread may be large due to attraction between the upper thread and the lower thread. In such a case, as illustrated in FIG. 4B, the amount of turnaround of the upper thread in stitches is reduced, and the amount of consumption of the upper thread is reduced. Accordingly, the distance to the color change position of the upper thread becomes longer. Therefore, in such a case, the detection timing until the actual color change is later than the detection timing until the assumed color change, and "the consumption length of the thread until the actual color change > the consumption length of the thread until the assumed color change" is satisfied.

[0078] On the other hand, in the case where the shrinkage of the upper thread occurs during the conveyance from the upper thread spool 14 to the needle 11, the distance to the color change position of the upper thread N set in advance becomes shorter. Alternatively, when the amount of movement to the position where the needle is to be inserted is small, the tension of the upper thread passed through the needle is weak in the embroidery operation, and the tension of the upper thread is small in the attraction between the upper thread and the lower thread, as illustrated in FIG. 4C, the amount of turnaround of the upper thread in stitches increases and the amount of consumption of the upper thread increases. Accordingly, the distance to the color change position in the upper thread becomes short. Therefore, in such a case, the detection timing until the actual color change is earlier than the detection timing until the assumed color change, and "the consumption length of the thread until the actual color change < the consumption length of the thread until the assumed color change" is satisfied.

[0079] The thread-consumption-progress calculation unit 605 compares the thread consumption length until the actual color change with the thread consumption length until the assumed color change to determine whether the current embroidery is advanced or delayed with respect to the target thread consumption.

[0080] The tension setting unit 606 serving as a tension adjusting unit refers to the correlation data stored in the correlation storage unit 607, sets the corrected pressing

force according to the difference (deviation amount) of the consumption amount, and outputs a control signal to the roller pressing unit 183, thereby adjusting the tension applying amount to the thread N in the nipping rollers 18, which is the pressure of the nipping rollers 18.

[0081] For example, when "the consumption length of the thread until the actual color change > the consumption length of the thread until the assumed color change", that is, when the actual upper thread is delayed, the region of the thread until the color change is extended, or the tension of the upper thread in the stitch is strong and the consumption amount of the upper thread is small due to the embroidery operation. For this reason, the pressing force at the nipping rollers 18 and the tension of the thread are weakened to increase the supply speed of the upper thread and the amount of turnaround (feed amount) of the upper thread at the stitches, thus increasing the consumption of the thread.

[0082] On the other hand, in the case of "the consumption length of the thread until the actual color change < the consumption length of the thread until the assumed color change", that is, in the case where the upper thread is advanced, the upper thread is contracted, or the tension of the upper thread in the stitch is weak due to the embroidery operation, and the upper thread consumption amount is large. Therefore, the pressing force and the tension of the nipping rollers 18 are increased to reduce the supply speed of the upper thread. Thus, the turnaround amount (feed amount) of the upper thread in the stitch is reduced to reduce the consumption of the thread.

[0083] Detecting and adjusting the tension in this manner allows the correction of the color shift to be controlled in real time without causing a time delay until the adjustment after the detection as much as possible. Here, since the trigger of the tension adjustment in the present control example is the detection of the color change, the tension adjustment is performed, for example, at the timing immediately after the stitch in which the consumption length of the thread until the actual color change is longer than estimated and the color change is detected later than estimated.

[0084] On the other hand, when the consumption length of the thread until the actual color change is shorter than estimated and the color change is detected earlier than estimated, the tension adjustment is performed at the timing immediately after the stitch at which the assumed consumption length estimated reaches the color change.

[0085] The problem of expansion and contraction of the upper thread during conveyance from the upper-thread spool 14 to the needle 11 is more likely to occur as the distance from the upper-thread spool 14 to the needle 11 is longer. Accordingly, the advantageous effect of this control to the positional deviation due to the expansion and contraction of the upper thread is more likely to be exhibited in an apparatus including the dyeing device illustrated in FIGS. 18 to 21 than in the configuration of the first embodiment illustrated in FIG. 1.

[0086] In the computing mechanism 16 illustrated in FIG. 7, elements other than the embroidery-progress determination unit 603 serve as the roller controller 6, and have functions that can be provided on a higher-level control device in a third embodiment described later.

[0087] Here, the control of the consumption amount of the upper thread and the tension of the upper thread in the first control example is described with reference to FIGS. 8 and 9.

[0088] FIG. 8 is a flowchart of the first control example. FIG. 9 illustrates an example of a correlation table for correcting the consumption amount of thread and the thread tension used in the first control example.

[0089] In the flow of FIG. 8, first, in step S101, a tension of an initial value is set.

[0090] In step S102, the computing mechanism 16 of the embroidery apparatus 1 reads embroidery data. In the case of a configuration having a dyeing device as illustrated in FIGS. 18 to 21 described later, the dyeing device reads dyeing data at this timing.

[0091] In step S103, the computing mechanism 16 calculates the expected consumption (assumed consumption amount) of the thread until the first color change. Specifically, in the embroidery apparatus 1, the amount of thread consumed per stitch varies depending on the distance by which the current embroidery position moves from the previous embroidery position. Therefore, the estimated thread consumption, which is the expected cumulative thread consumption, is a cumulative amount of consumption of variable stitches.

[0092] For example, when the thread consumption amount in each stitch is set to 0 mm in stitch 1, 3 mm in stitch 2, 2 mm in stitch 3, 1 mm in stitch 4, and 4 mm in stitch 5, the expected cumulative thread consumption amount is 0 mm up to stitch 1, 3 mm up to stitch 2, 5 mm up to stitch 3, 6 mm up to stitch 4, and 10 mm up to stitch 5.

[0093] In this example, if the expected thread color values are red from 0 to 4 mm and blue from 5 to 10 mm, it is predicted that the first color change occurs in stitch 3 because the first color change in the embroidery data is at the position of 5 mm.

[0094] In step S104, the embroidery operation is started. At this time, when one of the nipping rollers 18 is the roller 182 as a driving roller, the thread is fed to the embroidery position at a default feed speed.

[0095] When the detector 17 (or 17A) detects that the color of the thread at the embroidery position has changed in step S105, the actual consumption amount of the thread until the color change is calculated in step S106.

[0096] In step S107, whether the estimated consumption amount (assumed consumption amount) of the thread calculated in step S 102 matches the actual consumption amount of the thread detected and calculated in steps S105 and S106 is compared, and a difference amount is detected.

[0097] For example, in the above-described example, when red is detected in the stitch 3 and a color change

to blue is detected in the stitch 4 and subsequent stitches, the actual consumption amount of the upper thread is more delayed than estimated. On the other hand, when the color change to blue is detected before the stitch 2, the actual consumption amount of the upper thread is more advanced than estimated.

[0098] When the estimated consumption amount of the thread and the actual consumption amount of the thread do not coincide with each other in step S107 (estimated consumption amount of thread $\neq$ actual consumption amount of thread), in step S108, the nipping pressure, which is a tension value, is adjusted in accordance with a difference (also referred to as deviation amount or difference amount) between the estimated consumption amount of the thread and the actual consumption amount of the thread to adjust the tension of the upper thread.

[0099] When the tension value is set in step S108, the correlation table illustrated in FIG. 9 is referred to. As illustrated in FIG. 9, when the consumption length of the thread until the actual color change is longer than estimated, the current embroidery is delayed with respect to the target thread consumption. Therefore, the correction value is set so as to weaken the tension of the thread with respect to the current value.

[0100] On the other hand, if the thread consumption length until the actual color change is shorter than estimated, the current embroidery is advanced with respect to the target thread consumption (assumed thread consumption amount). Therefore, the correction value is set so as to increase the thread tension with respect to the current value.

[0101] At this time, it is preferable to set the correction amount of the tension of the thread according to the type of the thread. For example, in the case of a thick thread (second thread type), the change in tension is increased, and in the case of a thin thread (first thread type), the change in tension is decreased.

[0102] In FIG. 9, a correlation table is illustrated as an example of the correlation stored in the correlation storage unit 607. Alternatively, another correlation such as a correlation equation may be used. Further, the correlation table corresponding to the thread type as illustrated in FIG. 9 may be different depending on the temperature or humidity.

[0103] In this way, the tension value of the thread in step S108 is adjusted and the nipping pressure of the nipping rollers 18 is controlled by the roller pressing unit 183 with the adjusted tension value. Thus, the tension of the upper thread is adjusted.

[0104] On the other hand, when the expected consumption amount of the thread is equal to the actual consumption amount of the thread in step S107, the embroidery operation is continued with the initial value of the tension, and the process proceeds to step S109.

[0105] In step S109, it is determined whether the embroidery data includes a next color change scheduled in the upper thread. In the case of YES in step S109, the expected consumption amount (assumed consumption

amount) of the thread until the next color change is calculated in step S110.

[0106] Thereafter, the embroidery operation is continued, and the process returns to step S105. When the detector 17 (or 17A) detects again that the color of the thread at the embroidery position has changed, the process of steps S105 to S110 are repeated until the next color change is not scheduled.

[0107] In step S109, if the next color change is not scheduled in the needle thread (NO in step S109), the embroidery is continued until the end of the embroidery data.

Second Control Example

[0108] FIG. 10 is a functional block diagram of a control section of an embroidery apparatus according to a second control example.

[0109] A computing mechanism 16A of the present control example includes a stitch-by-stitch thread-color prediction unit 601, an assumed-thread-consumption calculation unit 602, an embroidery-progress determination unit 603, an actual-thread-consumption calculation unit 604, a thread-consumption-progress calculation unit 605, a rotation-speed setting unit 608, and a correlation storage unit 609. Hereinafter, differences from the first control example are mainly described.

[0110] In this control example, the rotation speed of the drive roller 185 is adjusted as the adjustment of the nipping rollers 18A. Therefore, the rotation-speed setting unit 608 serving as a speed adjusting unit refers to the correlation data stored in the correlation storage unit 609 and sets the rotation speed so as to be corrected according to the difference (deviation amount) from the estimated value of the thread consumption amount. To rotationally drive the drive roller 185 at the set rotation speed, a control signal is output to the rotary motor 187 to adjust the conveyance speed of a thread N.

[0111] The control of the consumption amount of the upper thread and the supply speed of the upper thread in the second control example is described with reference to FIGS. 11 and 12. FIG. 11 is a flowchart of the second control example. FIG. 12 illustrates an example of a correlation table for correcting the consumption amount and the conveyance speed of the thread used in the third control example.

[0112] Differences of the flow of FIG. 11 from that of FIG. 8 are mainly described. In this control example, when the estimated consumption amount of the thread does not coincide with the actual consumption amount of the thread in step S207, the rotation speed of the drive roller 185 is controlled by the rotary motor 187 in accordance with the difference (deviation amount) between the estimated consumption amount of the thread (estimated consumption amount) and the actual consumption amount of the thread in step S208 to adjust the conveyance speed of the thread by the nipping rollers 18A.

[0113] Here, when the conveyance speed of the thread

is adjusted in step S208, a correlation table illustrated in FIG. 12 is referred to. As illustrated in FIG. 12, in a case where the consumption length of the thread until the actual color change is longer than estimated, the current embroidery is delayed with respect to the target thread consumption. Therefore, a correction value is set for correcting the speed of the thread to be faster than the current speed. When the consumption length of the thread until the actual color change is long, the color region of the thread is extended, or as illustrated in FIG. 4B, the tension of the upper thread in the stitch is strong due to the embroidery operation and the turnaround amount of the thread is small. Therefore, the conveyance speed is increased to weaken the tension of the thread, and as illustrated in FIG. 4C, the turnaround amount (feed amount) of the upper thread is increased and the consumption of the thread increases.

[0114] On the other hand, when the consumption length of the thread until the actual color change is shorter than estimated, the current embroidery is advanced with respect to the target thread consumption. Therefore, as the correction of the conveyance speed of the thread, a correction value is set for correcting the speed of the thread to be slower than the current speed. In the case where the consumption length of the thread until the actual color change is short, the color region of the thread is as illustrated in FIG. 4C, the tension of the upper thread in the stitch is weak due to the embroidery operation, and the turnaround amount of the thread is large. Therefore, the conveyance speed is reduced to increase the tension of the thread, and as illustrated in FIG. 4B, the turnaround amount (feed amount) of the upper thread is reduced and the consumption of the thread decreases.

[0115] In FIG. 12, a correlation table is illustrated as an example of the correlation stored in the correlation storage unit 607. Alternatively, another correlation such as a correlation equation may be used. Further, such correlation tables corresponding to the thread type may be prepared according to temperature and humidity.

Third Control Example

[0116] FIG. 13 is a functional block diagram of a control section of an embroidery apparatus according to a third control example. In the first control example, the pressing force (nipping pressure) of the nipping rollers 18 is controlled. In the second control example, the thread conveyance speed is controlled by the rotation speed of the nipping rollers 18A. In this third control example, both of the first control example and the second control example may be combined.

[0117] A computing mechanism 16B of the present control example includes a stitch-by-stitch thread-color prediction unit 601, an assumed-thread-consumption calculation unit 602, an embroidery-progress determination unit 603, an actual-thread-consumption calculation unit 604, a thread-consumption-progress calculation unit 605, a rotation-speed setting unit 608, a correlation stor-

age unit 610, and a tension setting unit 606B.

[0118] In the present embodiment, the correlation storage unit 610 has a correlation table between the conveyance speed and the thread tension used for correction, in addition to the correlation table illustrated in FIG. 9 or 12.

[0119] Here, the control of the consumption amount of the upper thread, the tension of the upper thread, and the supply speed in the third control example is described with reference to FIGS. 14 and 15. FIG. 14 is a flowchart of the second control example. FIG. 15 illustrates an example of a correlation table between the thread conveyance speed and the thread tension for correction used in the third control example.

[0120] Differences of the flow of FIG. 14 from the flows of FIGS. 8 and 11 are mainly described. In this control example, when the estimated consumption amount of the thread does not coincide with the actual consumption amount of the thread in step S307, the process proceeds to step S308. At S308, it is determined whether a difference (deviation amount) between the estimated consumption amount of the thread and the actual consumption amount of the thread is equal to or greater than a threshold value.

[0121] When the deviation amount is equal to or larger than the threshold value in step S308, the process proceeds to step S309. In step S309, the tension value of the thread is adjusted, and the nipping pressure of the nipping rollers 18 is controlled by the roller pressing unit 183 with the adjusted tension value, thereby adjusting the tension of the upper thread.

[0122] When the deviation amount is less than the threshold value in step S308, the process proceeds to step S310. In step S310, the rotation speed of the drive roller 185 is controlled by the rotary motor 187 according to the difference (deviation amount) between the estimated consumption amount (assumed consumption amount) of the thread and the actual consumption amount of the thread. Thus, the conveyance speed of the thread by the nipping rollers 18A is adjusted.

[0123] Here, if the rotation speed of the drive roller 185 is largely changed in order to largely change the tension, the following of the change of the tension may be delayed mechanically and electrically. Therefore, when the deviation amount of the thread consumption amount is large, it is preferable to directly adjust the tension. On the other hand, when the rotation speed of the drive roller 185 is changed to be small, fine adjustment is more effective for the tension of the upper thread than in the case where the tension is directly adjusted. Therefore, when the deviation amount of the thread consumption amount is small, it is preferable to adjust the rotation speed and finely adjust the conveyance speed of the upper thread.

[0124] As illustrated in FIG. 15, when it is desired to increase the thread conveyance speed for the purpose of correction, the thread conveyance speed can be increased by reducing the pressing force (pressure of the nipping rollers 18) and setting the tension of the thread

to be weak. That is, in the case where the consumption length of the thread until the actual color change is longer than estimated and the thread is stretched, or in the case where the pulling of the upper thread in the stitch is strong due to the embroidery operation and the turnaround amount is small, the conveyance speed of the thread is increased or the tension is reduced as the correction.

[0125] On the other hand, when it is desired to reduce the thread conveyance speed for correction, the thread conveyance speed can be reduced by increasing the pressing force and setting the thread tension to be strong. For example, in a case where the consumption length of the thread until the actual color change is shorter than estimated and the thread is shrunk, or in a case where the tension of the upper thread in the stitch is weak and the turnaround amount is large due to the embroidery operation, the conveyance speed of the thread is reduced or the tension is increased as the correction.

[0126] The correlation storage unit 610 stores two types of correlation tables including at least the correlation table between the thread conveyance speed and the thread tension as illustrated in FIG. 15, such as the correlation table illustrated in FIG. 9 and the correlation table illustrated in FIG. 15, or the correlation table illustrated in FIG. 12 and the correlation table illustrated in FIG. 15.

[0127] Accordingly, adjustment can be performed by appropriately switching between adjustment of the thread conveyance speed and adjustment of the thread tension. For example, as illustrated in the flow of FIG. 14, when the deviation amount of the thread consumption amount is small, the conveyance speed of the thread is adjusted. When the deviation amount is large, the tension of the thread is adjusted.

[0128] In FIG. 15, a correlation table is illustrated as an example of the correlation stored in the correlation storage unit 610. Alternatively, another correlation such as a correlation equation may be used. Further, such correlation tables corresponding to the thread type may be prepared according to temperature and humidity.

Test Pattern

[0129] In order to set the correlation tables and correlation equations illustrated in FIGS. 9, 12, and 15, it is necessary to grasp the correlation in advance. Therefore, it is preferable to detect the correlation in advance using a test pattern. FIGS. 16 and 17 are diagrams illustrating examples of test patterns to be detected for creating a correlation table.

[0130] FIG. 16 is a diagram illustrating examples of a test pattern created by satin stitching for filling a surface. The test pattern illustrated in FIG. 16 is formed by setting a diagonal line from the upper left to the lower right as the advancing direction of embroidery, designating the stitch direction as a downward right direction indicated by the arrow, passing the thread between adjacent sides and between diagonal vertices, and performing satin stitching while filling the quadrangle. Pat (a) of FIG. 16

illustrates an example of a test pattern on the cloth in the case where the color change is as estimated. Part (b) of FIG. 16 illustrates another example of the test pattern on the cloth in the case where the color change is later than estimated. Part (c) of FIG. 16 illustrates still another example of the test pattern on the cloth in the case where the color change is earlier than estimated.

[0131] In the case where the color change appears later as illustrated in part (b) of FIG. 16, it is considered that the thread consumption length up to the thread change is longer than estimated, and thus the upper thread extends until the upper thread reaches the needle N, or the upper thread is strongly pulled in the stitch due to the embroidery operation and the turnaround amount of the thread is small. Therefore, when the test pattern appears as illustrated in part (b) of FIG. 16, the tension of the thread is gradually changed from the current state so as to be weakened, and a test pattern embroidered again is created. The correction value (change amount) of the tension necessary for the color change to come to the appropriate position as illustrated in part (a) of FIG. 16 is detected and stored.

[0132] In the case where the color change appears faster as illustrated in part (c) of FIG. 16, it is considered that the thread consumption length up to the color change is shorter than estimated, and thus the upper thread is shrunk before reaching the needle N, or the tension of the upper thread in the stitch is weak due to the embroidery operation and the turnaround amount of the upper thread is large. Therefore, when the test pattern appears as illustrated in part (c) of FIG. 16, the tension of the thread is gradually changed from the current state so as to be increased, and a plurality of test patterns embroidered again are created. The correction value of the tension necessary for the color change to come to the appropriate position as illustrated in part (a) of FIG. 16 is detected and stored.

[0133] FIG. 17 is a diagram illustrating examples of test patterns created by straight stitching a rectangular wave. The test patterns illustrated in FIG. 17 are described below in the case where the embroidery proceeds from left to right. For example, straight stitching is used in under-stitching and consumes the thread less and slower than satin stitching. In each test pattern of FIG. 17, a marker is provided on the thread.

[0134] Part (a) of FIG. 17 illustrates an example of a test pattern on the cloth in the case where the position of the marker is as estimated. Part (b) of FIG. 17 illustrates another example of the test pattern on the cloth in the case where the position of the marker is later than estimated. Part (c) of FIG. 17 illustrates still another example of the test pattern on the cloth in the case where the position of the marker is earlier than estimated.

[0135] When the marker appears later as illustrated in part (b) of FIG. 17, it is considered that the upper thread is stretched or the upper thread is strongly pulled in the stitch due to the embroidery operation and the turnaround amount of the upper thread is small. When the test pattern

appears as illustrated in part (b) of FIG. 17, the tension of the thread is gradually reduced from the current state to create a plurality of test patterns again. A correction value of the tension necessary for the marker to come to the proper position as illustrated in part (a) of FIG. 17 is detected and stored.

[0136] In the case where the marker appears earlier as illustrated in part (c) of FIG. 17, it is considered that the upper thread is contracted, or the tension of the upper thread in the stitch is weak due to the embroidery operation and the turnaround amount of the upper thread is large. When the test pattern appears as illustrated in part (c) of FIG. 17, the tension of the thread is gradually increased from the current state to create a plurality of test patterns again. A correction value of the tension necessary for the marker to come to the proper position as illustrated in part (a) of FIG. 17 is detected and stored.

[0137] In the above description of the test pattern, the correction of the tension has been described. In the case of examining the correlation of the correction by the conveyance speed, it is also preferable to change the conveyance speed and create a plurality of test patterns and detect and store the correction value of the conveyance speed in advance.

[0138] FIGS. 9, 12, and 15 illustrate examples in which the correction values are correlated so as to change linearly. On the other hand, the amount of consumption per stitch changes according to the method in which the embroidery is sewn. Therefore, the correlation data of the tension adjustment with respect to the difference in the thread consumption amount and the correlation data of the conveyance speed adjustment with respect to the difference in the thread consumption amount may be set for each sewing method.

[0139] For example, in a case where a pattern is formed by satin stitching or folding stitching in which an embroidery region on an actual cloth is stitched so as to be adjacent to and overlap with the preceding stitch and the following stitch in order to fill the region as in the test pattern of FIG. 16, the same region might not be visually confirmed even if the same region in the same color is slightly shifted during embroidery. For this reason, for example, the adjustment of the tension and the conveyance speed with respect to the nipping rollers is set such that the correction amount gradually changes so that the subsequent stitches after the correction gradually return to an appropriate position with respect to the previous stitch in which the deviation is detected.

[0140] On the other hand, in the case where the pattern is formed in the embroidery region on the actual cloth by the straight stitching in which all the stitches are exposed without overlapping each other as in the test pattern of FIG. 17, it is necessary to quickly adjust the position because the positional deviation is conspicuous. Therefore, in the adjustment of the tension and the conveyance speed with respect to the nipping rollers, the correction amount is set to a rapid change so that the stitch immediately returns to an appropriate position in the subse-

quent stitches after the correction with respect to the previous stitch in which the deviation is detected.

Second Embodiment

[0141] FIG. 18 is a schematic view of a dyeing embroidery apparatus according to a second embodiment of the present invention. In the dyeing embroidery apparatus 2, a dyeing unit 22 is provided in the preceding stage of an embroidery unit 21 having an embroidering function. The dyeing unit 22 applies a color that changes in the conveyance direction to the upper thread unwound from the upper-thread spool.

[0142] The dyeing embroidery apparatus 2 according to the present embodiment includes the embroidery unit 21, the dyeing unit 22, and a controller 23, and is an in-line integrated-type apparatus.

[0143] The embroidery unit 21 performs embroidery on a cloth C using a needle 211. As illustrated in FIG. 18, the embroidery unit 21 includes the needle 211, a stage 213 serving as an embroidery feed unit, and a detector 217. The needle 211 and the detector 217 are mounted on an embroidery head 201. Although schematically illustrated in FIG. 18, the embroidery unit 21 according to the present embodiment has a configuration and functions equivalent to those of the embroidery apparatus 1 according to the first embodiment except for the embroidery-data creating unit 15 and the computing mechanism 16.

[0144] In the present embodiment, an upper-thread spool 221 is provided not in the embroidery unit 21 but in the dyeing unit 22 on the upstream side in the conveyance direction.

[0145] The dyeing unit 22 includes the upper-thread spool 221, a dyeing device 222, and nipping rollers 228. The upper-thread spool 221 is an upper thread supplier, around which the upper thread N is wound, to supply an upper thread N to the needle 211 via the dyeing device 222 and the nipping rollers 228. In the present embodiment, the thread N unwound from the upper-thread spool 221 is white or monochromatic.

[0146] The dyeing device 222 dyes the thread N unwound from the upper-thread spool 221 with colors that change in the conveyance direction by a liquid discharge method. The dyeing device 222 has a configuration capable of dyeing a thread using inks of four colors of black (K), cyan (C), magenta (M), and yellow (Y). In embodiments of the present invention, a continuous upper thread may be dyed with a plurality of colors that change in the conveyance direction. Therefore, the number of colors that can be dyed by the dyeing device 222 may be any number as long as the colors correspond to at least two or more colors.

[0147] The nipping rollers 228 are conveyance rollers that convey the thread N dyed by the dyeing device 222 while pressing the thread N and feeds the thread N to the needle 211 of the embroidery unit 210. The nipping rollers 228 have a configuration and function equivalent

to those of the nipping rollers 18 (or 18A) illustrated in FIG. 6. The nipping rollers 228 can adjust the pressing force when the first control example and the third control example are performed, and can adjust the conveyance speed when the second control example and the third control example are performed.

[0148] The detector 217 in the embroidery unit 21 is provided in the vicinity of the needle 211, and detects the number of stitches (sewing operation information) indicating how many times the needle 211 has been sewn on the cloth, and the color of the thread N being embroidered.

[0149] The control unit 230 sends a control signal for instructing adjustment of the nipping pressure or speed of the nipping rollers 228 to the nipping rollers 228 according to the number of stitches and the detection timing of the color of the thread detected by the detector 217 of the embroidery unit 21.

[0150] In the configuration of the present embodiment, after the thread exits from the upper-thread spool 221, the thread is dyed by the dyeing device 222 and then fed to the embroidery unit 21. Accordingly, since the conveyance distance of the thread from the upper-thread spool 221 to the needle 211 is longer than that in the first embodiment, elongation or contraction of the thread is likely to occur during dyeing of the thread N while the thread N is fed from the dyeing device 222 to the embroidery head 201 or during conveyance after dyeing.

[0151] Therefore, the nipping rollers 228 are adjusted in real time according to the detection result as described above. Such a configuration can restrain the occurrence of the positional deviation of the color of the thread in the embroidery unit 210 due to the elongation and contraction of the thread that occurs before the thread N reaches the needle 211.

[0152] Note that a fixing device 33 and a post-processing device 34 illustrated in FIG. 19 may be provided on the downstream side of the dyeing device 222 in the conveyance direction of the thread and on the upstream side of the nipping rollers 228 in the integrated-type dyeing embroidery apparatus according to the present embodiment.

Third Embodiment

[0153] FIG. 19 is a schematic side view of a dyeing embroidery system 100 according to a third embodiment of the present invention. In this system, a dyeing apparatus 3 that applies colors, which change in the conveyance direction, to an upper thread wound from an upper-thread spool is provided in the preceding stage of an embroidery apparatus 1C. Unlike FIG. 18, the dyeing apparatus 3 and the embroidery apparatus 1C are not integrated.

[0154] The dyeing apparatus 3 includes, for example, an upper-thread spool 31 around which an upper thread N is wound, a dyeing device 32, a fixing device 33, and a post-processing device 34.

[0155] In the dyeing apparatus 3, the upper thread N drawn from the upper-thread spool 31 is guided by a roller 351 and a roller 352, passes through the dyeing device 32 and nipping rollers 18C, and is continuously routed to a needle 11 of an embroidery head 10.

[0156] The dyeing device 32 includes a plurality of heads 321K, 321C, 321M, and 321Y and a plurality of individual maintenance units 322K, 322C, 322M, and 322Y. The plurality of heads 321K, 321C, 321M, and 321Y, which may be collectively referred to as 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 heads 321K, 321C, 321M, and 321Y, respectively.

[0157] The plurality of heads 321K, 321C, 321M, and 321Y are discharge heads that discharge different colors. For example, the head 321K discharges droplets (ink) of black (K), the head 321C discharges droplets of cyan (C), the head 321M discharges droplets of magenta (M), and the 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. In FIG. 13, an example in which the 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 conveyance 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.

[0158] The maintenance units 322K, 322C, 322M, and 322Y, respectively, are disposed below the 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 heads 321K, 321C, 321M, and 321Y when the heads 321K, 321C, 321M, and 321Y are not in use, receive dummy discharge of liquid droplets from the 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.

[0159] The dyeing device 32 in the dyeing apparatus 3 illustrated in FIG. 19 or the dyeing device 222 illustrated in FIG. 18 represents a configuration example of a liquid discharge type in which the upper thread N is dyed by discharging ink from the head 321. Note that, in some embodiments, the dyeing device 32 (or 222) may be a dyeing device of a coating type in which ink is applied by sandwiching an upper thread N with, for example, rollers.

[0160] The fixing device 33 performs a fixing process (drying process) of the ink discharged from the dyeing device 32 on the upper thread N. The fixing device 33 includes heating means, such as an infrared irradiator or

a warm-air blower, and heats and dries the upper thread N.

[0161] The post-processing device 34 includes, for example, a cleaner that cleans the upper thread N and lubricant applying means that applies a lubricant to a surface of the upper thread N.

[0162] Note that the dyeing apparatus 3 according to an embodiment of the present invention includes at least the dyeing device 32 that applies a colored liquid to the upper thread N and may not include the fixing device 33 and the post-processing device 34.

[0163] The nipping rollers 18C according to the present embodiment are conveyance rollers (pressing conveyance rollers) that convey the thread N dyed by the dyeing apparatus 3 while applying pressure thereto and sends the thread N to the needle 11 of the embroidery head 10. The nipping rollers 18C have a configuration and function equivalent to those of the nipping rollers 18 (or 18A) illustrated in FIG. 6. The nipping rollers 18C can adjust the pressing force when the first control example and the third control example are performed, and the nipping rollers 18C can adjust the conveyance speed when the second control example and the third control example are performed.

[0164] The detector 17 in the embroidery apparatus 1C is provided in the vicinity of the needle 11, and detects the number of stitches (sewing operation information) indicating how many times the needle 11 has been sewn on the cloth, and the color of the thread N being embroidered.

[0165] A computing mechanism 16 mounted in the embroidery head 10 adjusts the nipping pressure or speed at the nipping rollers (conveyance rollers) 18C according to the number of stitches and the detection timing of the color of the thread detected by the detector 17.

[0166] In the configuration of the present embodiment, after the thread exits from the upper-thread spool 31, the thread is dyed in the dyeing device 32, is subjected to fixing and post-processing steps, and is then fed to the embroidery unit. Accordingly, since the conveyance distance of the thread from the upper-thread spool 31 to the needle 11 is longer than that in the first embodiment or the second embodiment, elongation or contraction of the thread is likely to occur during dyeing of the thread N while the thread N is fed from the dyeing device 32 to the embroidery head 10 or during conveyance after dyeing.

[0167] Therefore, the pressure or conveyance speed of the nipping rollers 18C are adjusted in real time according to the detection result as described above. Such a configuration can restrain the occurrence of the positional deviation of the color of the thread in the embroidery apparatus 1C due to the elongation and contraction of the thread that occurs before the thread N reaches the needle 11.

Fourth embodiment

[0168] FIG. 20 is a schematic side view of a dyeing

embroidery system according to a fourth embodiment of the present invention. In the present embodiment, a host control apparatus 4, which is a higher-level apparatus, is connected to a dyeing embroidery system 100D. The host control apparatus 4 is an information processing apparatus such as a computer. The host control apparatus 4 is electrically connected to an embroidery apparatus 1D and a dyeing apparatus 3D via wired or wireless communication so as to exchange information between the embroidery apparatus 1D and the dyeing apparatus 3D.

[0169] In the system according to the present embodiment, nipping rollers 38 are disposed not in the embroidery apparatus 1D but in the dyeing apparatus 3D. As illustrated in FIGS. 19 and 20, the nipping rollers 18C and the nipping rollers 38 may be disposed in either the dyeing apparatus or the embroidery apparatus.

[0170] FIG. 21 is a schematic block diagram of a dyeing embroidery system according to a fourth embodiment of the present invention. A host control apparatus 4 includes an embroidery-data-and-dyeing-data creation unit 41 and a computing unit 42 in an executable manner.

[0171] The host control apparatus 4 includes the embroidery-data-and-dyeing-data creation unit 41 and the computing unit 42. The embroidery-data-and-dyeing-data creation unit 41 acquires an embroidery image from which embroidery data is created, creates embroidery data based on the embroidery image and dyeing data corresponding to the embroidery image and the embroidery data, and outputs the embroidery data and the dyeing data to the computing unit 42.

[0172] Specifically, the embroidery-data-and-dyeing-data creation unit 41 according to the present embodiment separates the embroidery image into colors (RGB values), determines the color of a thread to be used and the duration of each color on the thread so that sewing can be performed in a smooth order, based on the size of an embroidery pattern on a cloth, and creates embroidery data so that stitches are formed on the cloth using the thread of the determined color. Further, the embroidery-data-and-dyeing-data creation unit 41 creates dyeing data including information on the blending amount of each color of KCMY used for realizing the color of the thread included in the embroidery data and the continuous length of each color in the discharge head of KCMY colors.

[0173] The computing unit 42 of the host control apparatus 4 can communicate with a computing mechanism 36 in the dyeing apparatus 3D. The computing unit 42 outputs dyeing data to the computing mechanism 36. The computing mechanism 36 controls the dyeing device 32, the fixing device 33, and the post-processing device 34 based on the dyeing data.

[0174] The computing unit 42 can communicate with a computing mechanism 16D of the embroidery apparatus 1D and outputs the embroidery data to the computing mechanism 16D. The computing mechanism 16D drives and controls a driver 191 based on the embroidery data.

[0175] The computing unit 42 also has the function of

the roller controller 6 (or 6A or 6B) except for the embroidery-progress determination unit 603 in the computing mechanism 16 illustrated in FIGS. 7, 10, or 13.

[0176] Therefore, the computing unit 42 calculates the difference (deviation amount) in the consumption amount of the thread (or the consumption speed of the thread) based on the information of the current embroidery position obtained by the computing mechanism of the embroidery apparatus 1D based on the detection information by the detector 17, and sets the pressure to the nipping rollers 38 (or the pressure of the nipping rollers 38) or the conveyance speed based on the difference.

[0177] The computing unit 42 outputs a control signal indicating the set pressing force or rotation speed to the computing mechanism 36 of the dyeing apparatus 3D, and the computing mechanism 36 instructs a roller pressing unit 383 or a rotary motor 387 at the set pressing force or rotation speed. Thus, the adjustment of the tension of the thread by the pressing force of the nipping rollers or the adjustment of the conveyance speed of the thread by the rotating speed can be performed in real time.

[0178] Such control can restrain the occurrence of the positional deviation of the color of the thread in the embroidery apparatus 1D due to the elongation and contraction of the thread that occurs in the dyeing apparatus 3D before the thread N reaches the needle 11.

[0179] Although some embodiments and control configurations of the present invention have been described above, embodiments of the present invention are not limited to the above-described embodiments and examples. Various modifications and changes are possible in light of the above teachings, without departing from the scope of the present invention.

Claims

1. An embroidery apparatus (1) comprising:

a needle (11);
a conveyance roller (18) configured to convey a thread to be fed to the needle while pressing the thread;
a detector (17) disposed in a vicinity of the needle and configured to detect a color of the thread being embroidered; and
a roller controller (16) configured to adjust at least one of a pressure or a conveyance speed of the conveyance roller, based on a number of stitches indicating how many times the needle has been sewn on a cloth and the color of the thread detected by the detector.

2. The embroidery apparatus (1) according to claim 1, wherein the detector (17) includes a color laser sensor configured to detect the number of stitches and the color of the thread at a position of a needle hole

of the needle, simultaneously at a needle drop timing at which the needle sticks into the cloth.

3. The embroidery apparatus (1) according to claim 1, wherein the detector (17A) includes:

an optical sensor (171) configured to detect a color; and
a stitch sensor (172) configured to detect the number of stitches and a needle drop timing at which the needle sticks into the cloth, and

wherein the detector is configured to cause the optical sensor to detect the color of the thread at the needle drop timing detected by the stitch sensor, to simultaneously detect the number of stitches and the color of the thread at a position of a needle hole of the needle.

4. The embroidery apparatus (1) according to any one of claims 1 to 3, further comprising a plurality of nipping rollers (18), including the conveyance roller, configured to nip and convey the thread.

5. The embroidery apparatus (1) according to claim 4, wherein the roller controller (6) includes:

a thread-consumption estimation unit (603) configured to estimate an assumed consumption amount of the thread in an embroidery operation, the assumed consumption amount being obtained from embroidery data based on an embroidery image input in advance and the number of stitches;

a thread-consumption calculation unit (604) configured to calculate an actual consumption amount of the thread in the embroidery operation, the actual consumption amount being obtained from a detected number of stitches and a detection timing of the color of the thread;

a correlation storage unit (607) configured to store in advance a correlation between a correction amount of a tension of the thread and a difference between the assumed consumption amount of the thread and the actual consumption amount of the thread; and

a tension adjusting unit (606) configured to adjust a pressure of the plurality of nipping rollers based on the difference between the assumed consumption amount of the thread and the actual consumption amount of the thread.

6. The embroidery apparatus (1) according to claim 5, wherein the tension adjusting unit (606) is configured to:

- decrease the tension of the thread nipped between the plurality of nipping rollers when the actual consumption amount of the thread until a color change of the thread is larger than the assumed consumption amount of the thread until the color change of the thread, and increase the tension of the thread nipped between the plurality of nipping rollers when the actual consumption amount of the thread until a color change of the thread is smaller than the assumed consumption amount of the thread until the color change of the thread.
7. The embroidery apparatus (1) according to any one of claims 1 to 4, wherein the roller controller (6) includes:
- a thread-consumption estimation unit (603) configured to estimate an assumed consumption amount of the thread in an embroidery operation, the assumed consumption amount being obtained from embroidery data based on an embroidery image input in advance and the number of stitches;
- a thread-consumption calculation unit (604) configured to calculate an actual consumption amount of the thread in the embroidery operation, the actual consumption amount being obtained from a detected number of stitches and a detection timing of the color of the thread;
- a correlation storage unit (607) configured to store in advance a correlation between a correction amount of a conveyance speed of the thread and a difference between the assumed consumption amount of the thread and the actual consumption amount of the thread; and
- a speed adjusting unit (608) configured to adjust the conveyance speed of the thread at the conveyance roller based on the difference between the assumed consumption amount of the thread and the actual consumption amount of the thread.
8. The embroidery apparatus (1) according to claim 7, wherein the speed adjusting unit (608) is configured to:
- increase the conveyance speed of the conveyance roller when the actual consumption amount of the thread until a color change of the thread is larger than the assumed consumption amount of the thread until the color change of the thread; and
- decrease the conveyance speed of the conveyance roller when the actual consumption amount of the thread until a color change of the thread is smaller than the assumed consumption amount of the thread until the color change of the thread.
9. The embroidery apparatus according to any one of claims 5 to 8, wherein the correlation storage unit (607) is configured to store in advance a correlation with the correction amount for each of a plurality of thread types.
10. The embroidery apparatus according to any one of claims 5 to 9, wherein the embroidery apparatus is configured to create a test pattern on a cloth using a continuous thread that changes in color, and wherein the detector is configured to:
- detect the number of stitches and a position of the color of the thread in the test pattern; and store, in the correlation storage unit, a correlation table or a correlation calculation formula between a consumption speed of the thread and the correction amount of the tension of the thread.
11. A dyeing embroidery system (100, 100D) comprising:
- a dyeing apparatus (3, 3D) configured to dye a thread with a color that changes; and the embroidery apparatus (1, 1C, 1D) according to any one of claims 1 to 10, wherein the embroidery apparatus is disposed at a subsequent stage of the dyeing apparatus.
12. A dyeing embroidery apparatus (2) comprising:
- a dyeing unit (22) including a dyeing device (222) configured to dye a thread with a color that changes;
- a conveyance roller (228) configured to convey the thread dyed by the dyeing device and fed to a needle (211) while pressing the thread;
- an embroidery unit (21) configured to perform embroidery on a cloth using the thread fed from the conveyance roller (228), the embroidery unit including:
- the needle (211); and
- a detector (217) disposed in a vicinity of the needle (211) and configured to detect a color of the thread being embroidered; and
- a roller controller (23) configured to adjust a pressure or a conveyance speed of the conveyance roller, based on a number of stitches indicating how many times the needle has been sewn on the cloth and the color of the thread detected by the detector.
13. A dyeing embroidery system (100D) comprising:

a dyeing apparatus (3D) configured to dye a thread;
 an embroidery apparatus (1D) configured to perform embroidery on a cloth using the thread dyed by the dyeing apparatus,
 the dyeing apparatus (3D) including:

a dyeing device that dyes the thread with a color that changes; and
 a conveyance roller (38) configured to convey the thread dyed by the dyeing device while pressing the thread,

the embroidery apparatus (1D) including:
 a needle (11); and
 a detector (17) disposed in a vicinity of the needle and configured to detect a number of stitches indicating how many times the needle has been sewn on the cloth and the color of the thread being embroidered; and

a roller controller (42) configured to adjust a pressure or a conveyance speed of the conveyance roller, based on the number of stitches and the color of the thread detected by the detector, wherein the roller controller is disposed in the dyeing apparatus, the embroidery apparatus, or a higher-level control apparatus connected to the dyeing embroidery system.

14. The dyeing embroidery system (100D) according to claim 13,

wherein the dyeing apparatus includes a fixing device (33) configured to perform a heat drying process on the thread dyed by the dyeing device, and
 wherein the conveyance roller is disposed downstream from the fixing device in a conveyance direction of the thread.

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FIG. 1

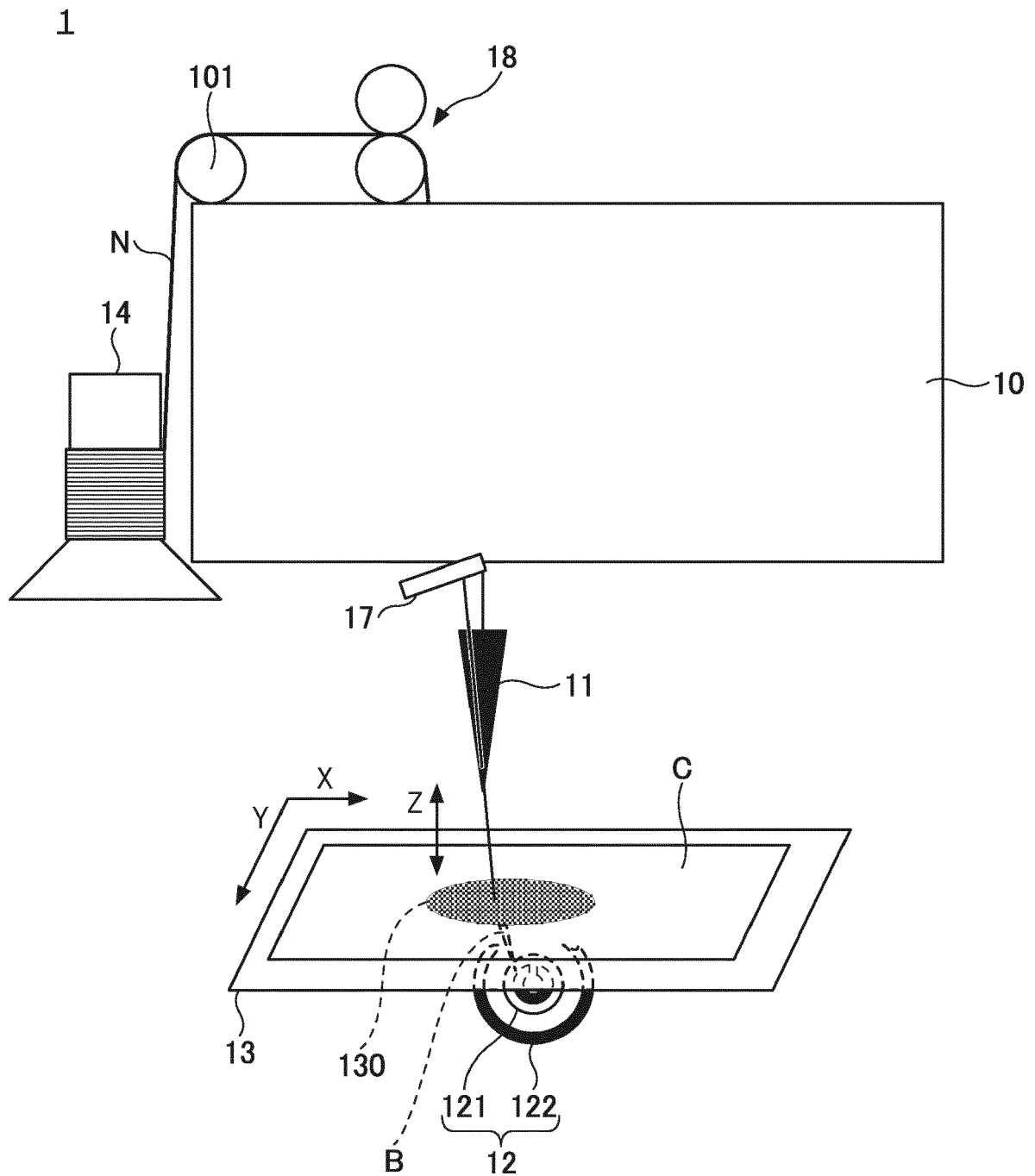


FIG. 2

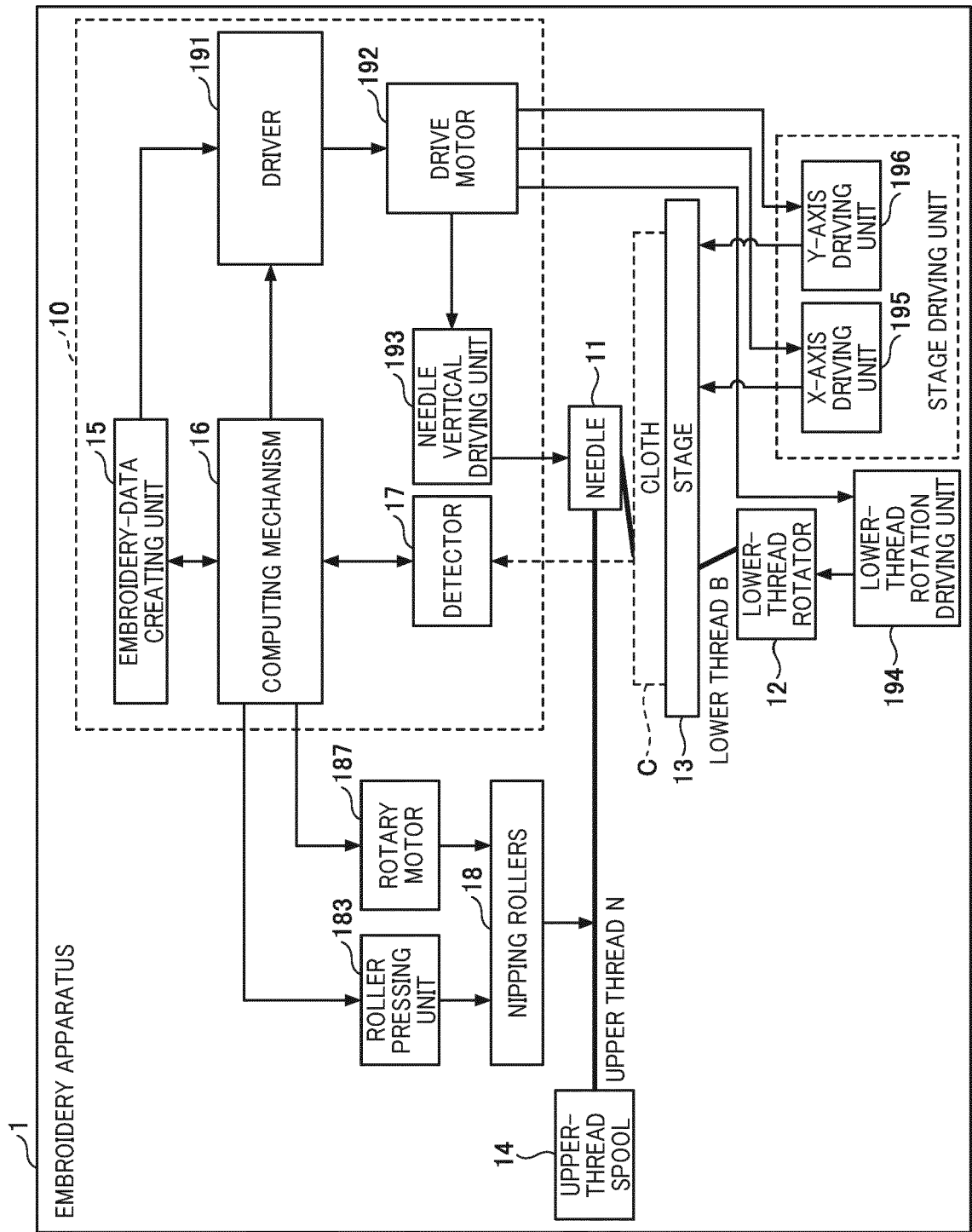


FIG. 3

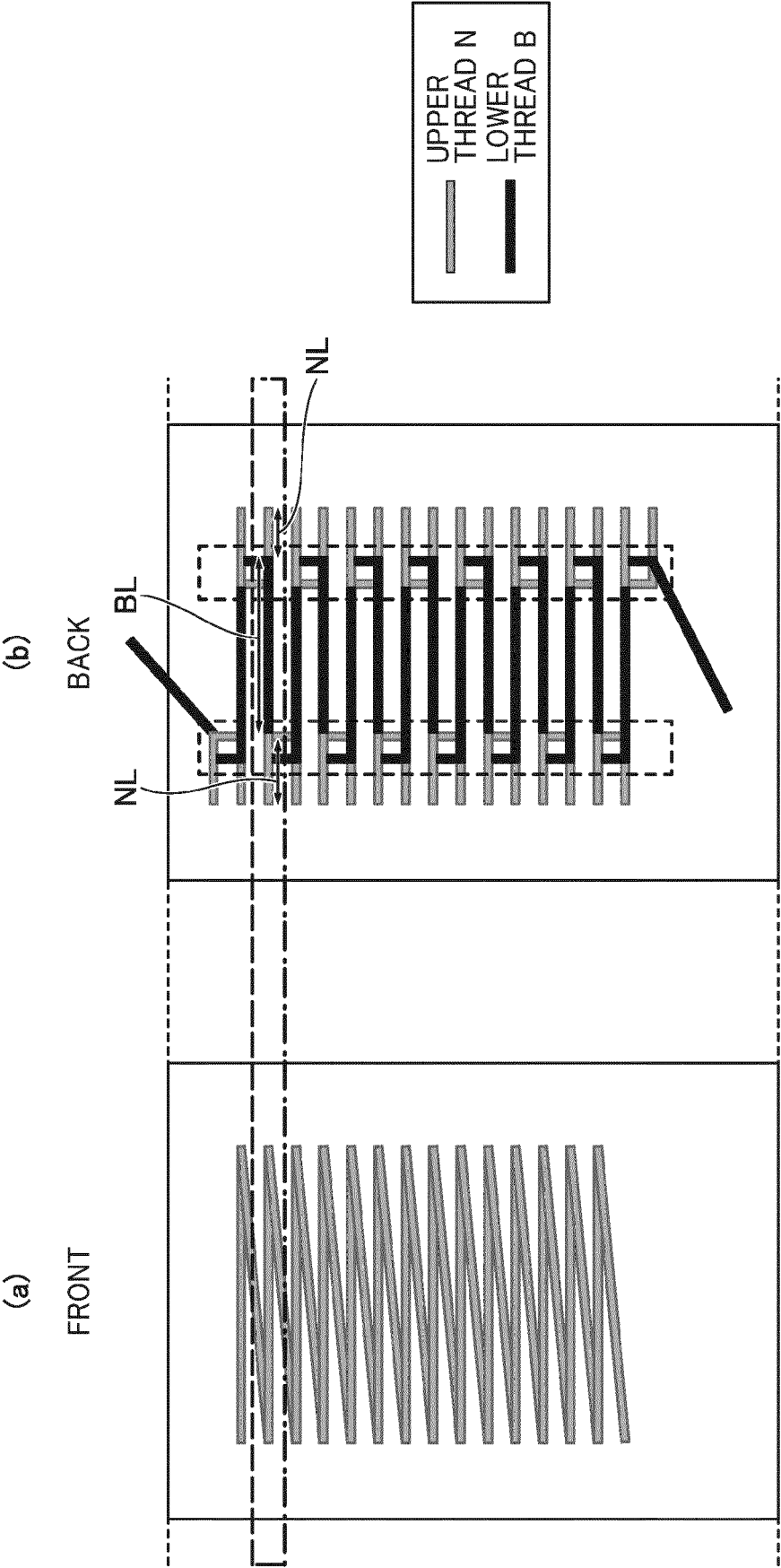


FIG. 4

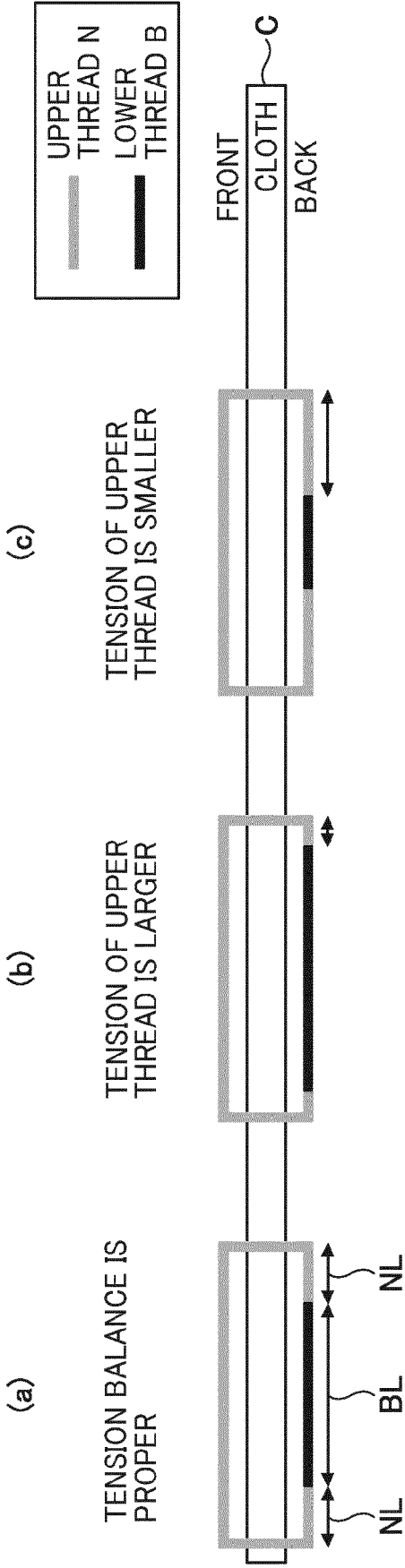


FIG. 5A

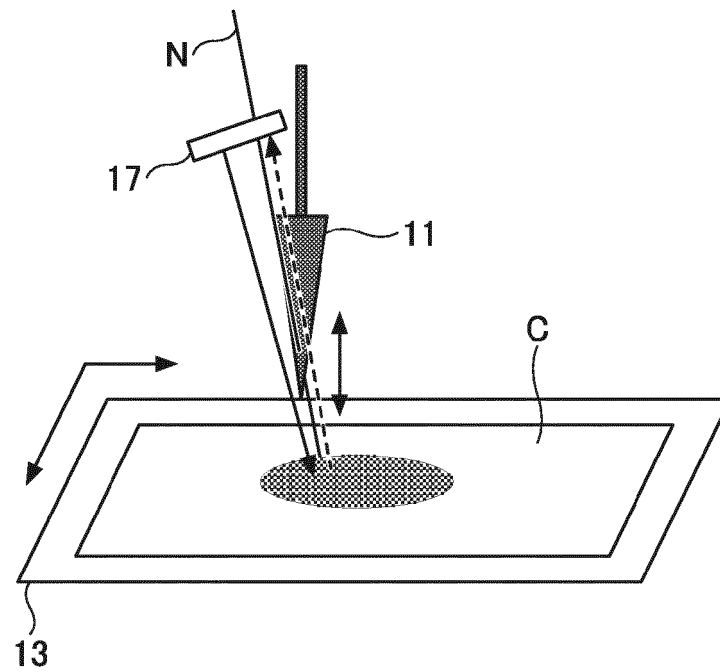


FIG. 5B

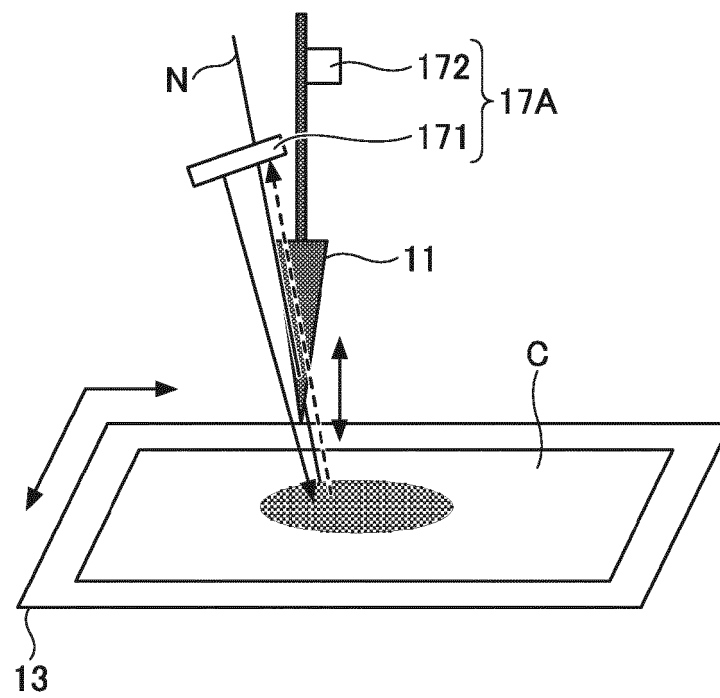


FIG. 6A

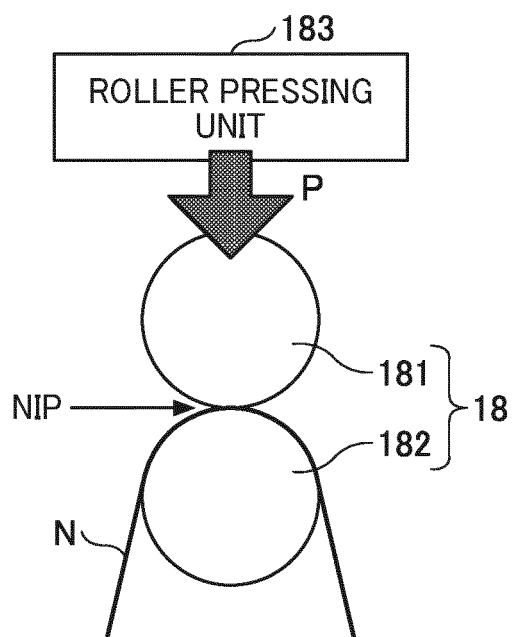


FIG. 6B

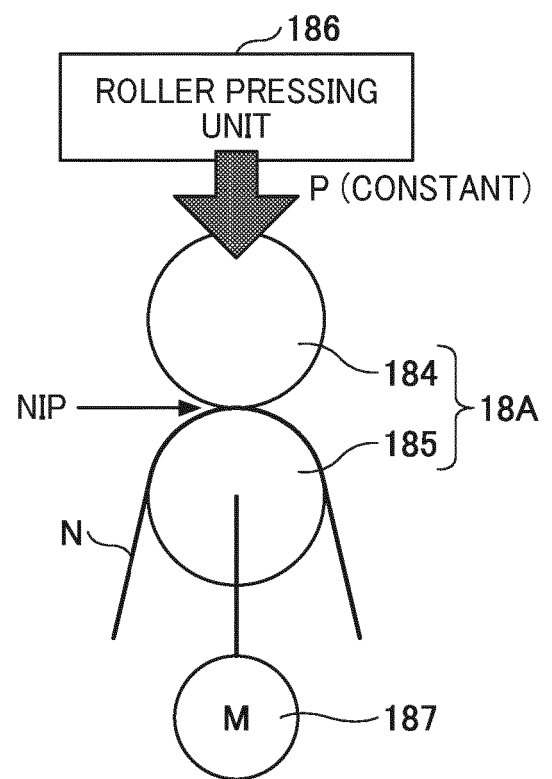


FIG. 7

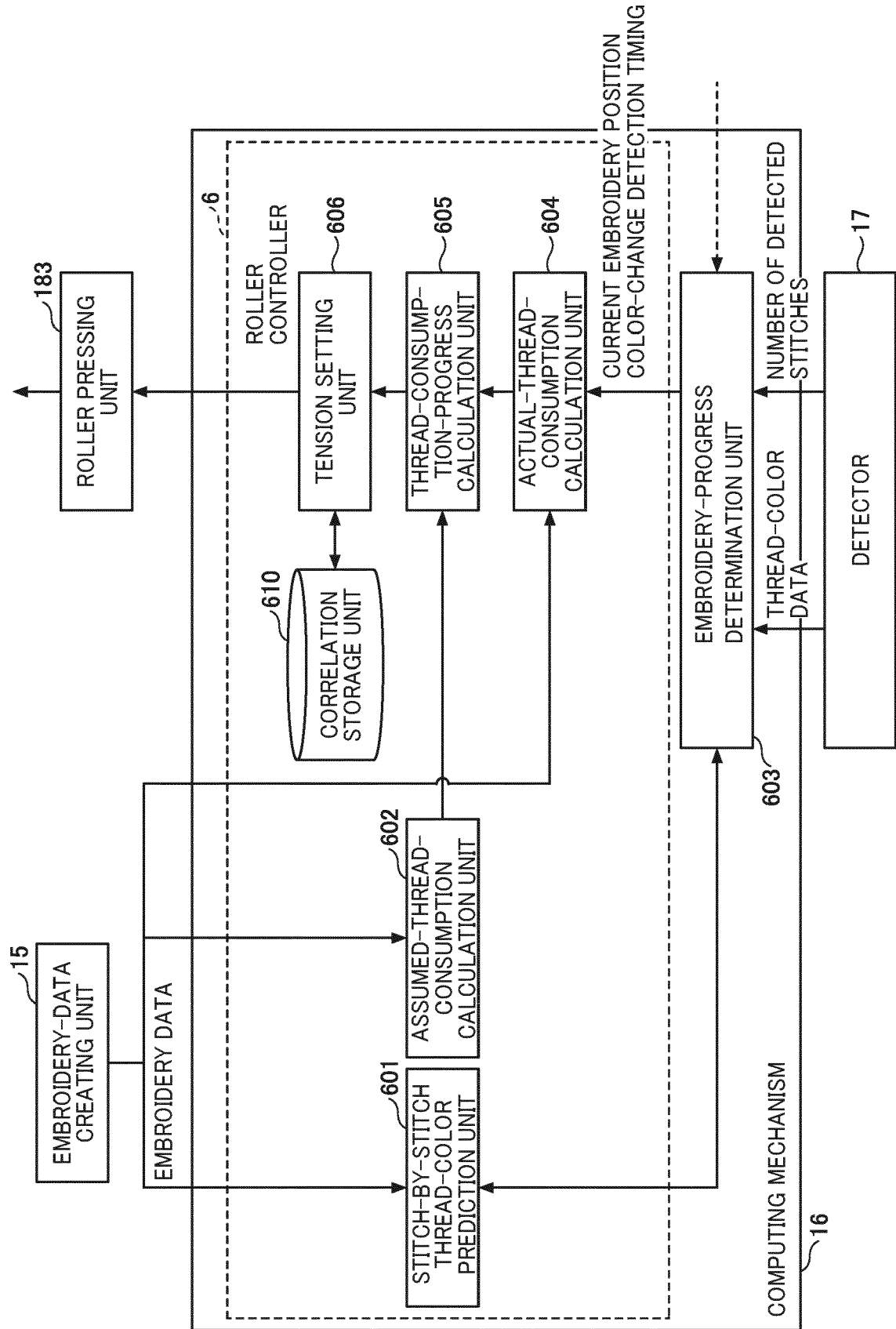


FIG. 8

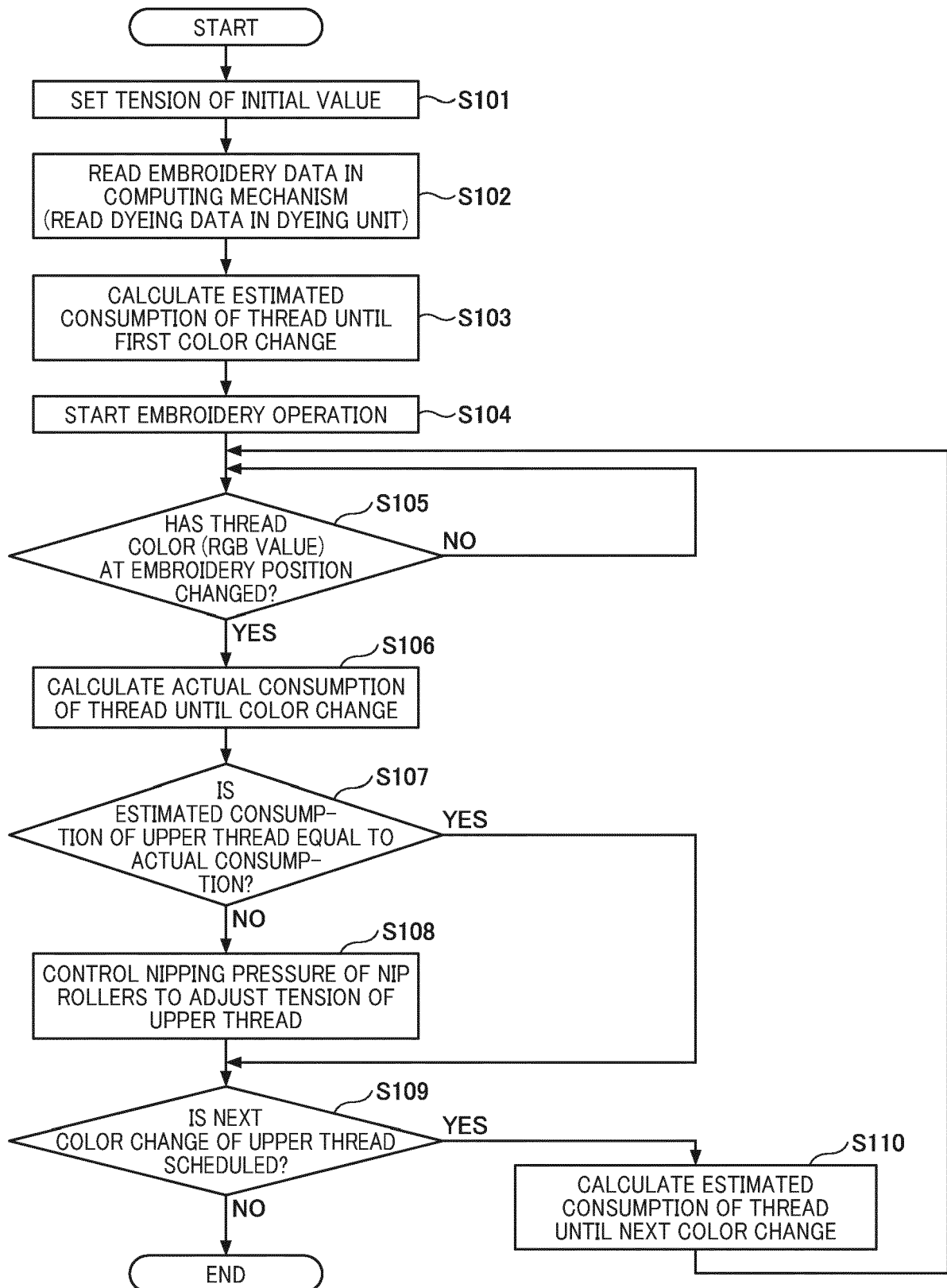


FIG. 9

			FIRST THREAD TYPE	SECOND THREAD TYPE
ESTIMATED THREAD CON- SUMPTION UNTIL COLOR CHANGE (mm)	THREAD CONSUMPTION UNTIL COLOR CHANGE (mm)	DEVIATION IN PROGRESS OF THREAD CONSUMPTION (mm)	CORRECTION AMOUNT OF THREAD TENSION (%)	CORRECTION AMOUNT OF THREAD TENSION (%)
1000	1050	50mm DELAY	-10%	-20%
	1045	45mm DELAY	-9%	-18%
	1040	40mm DELAY	-8%	-16%
	...	...	...	...
	1005	5mm DELAY	-1%	-2%
	1000	NO DELAY	±0%	±0%
	995	5mm ADVANCE	+1%	+2%
	...	...	...	...
	965	35mm ADVANCE	+7%	+14%
	960	40mm ADVANCE	+8%	+16%
	955	45mm ADVANCE	+9%	+18%

FIG. 10

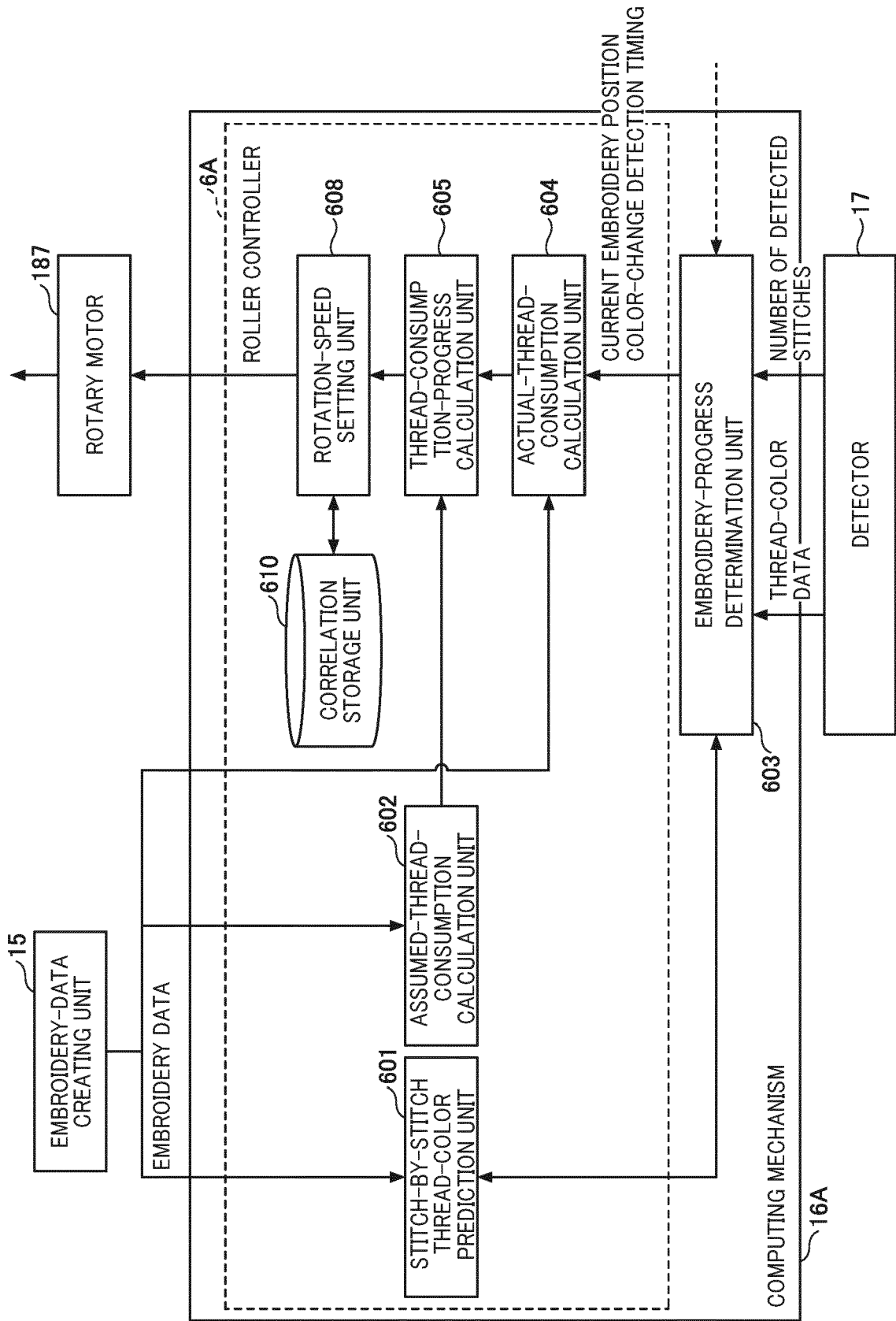


FIG. 11

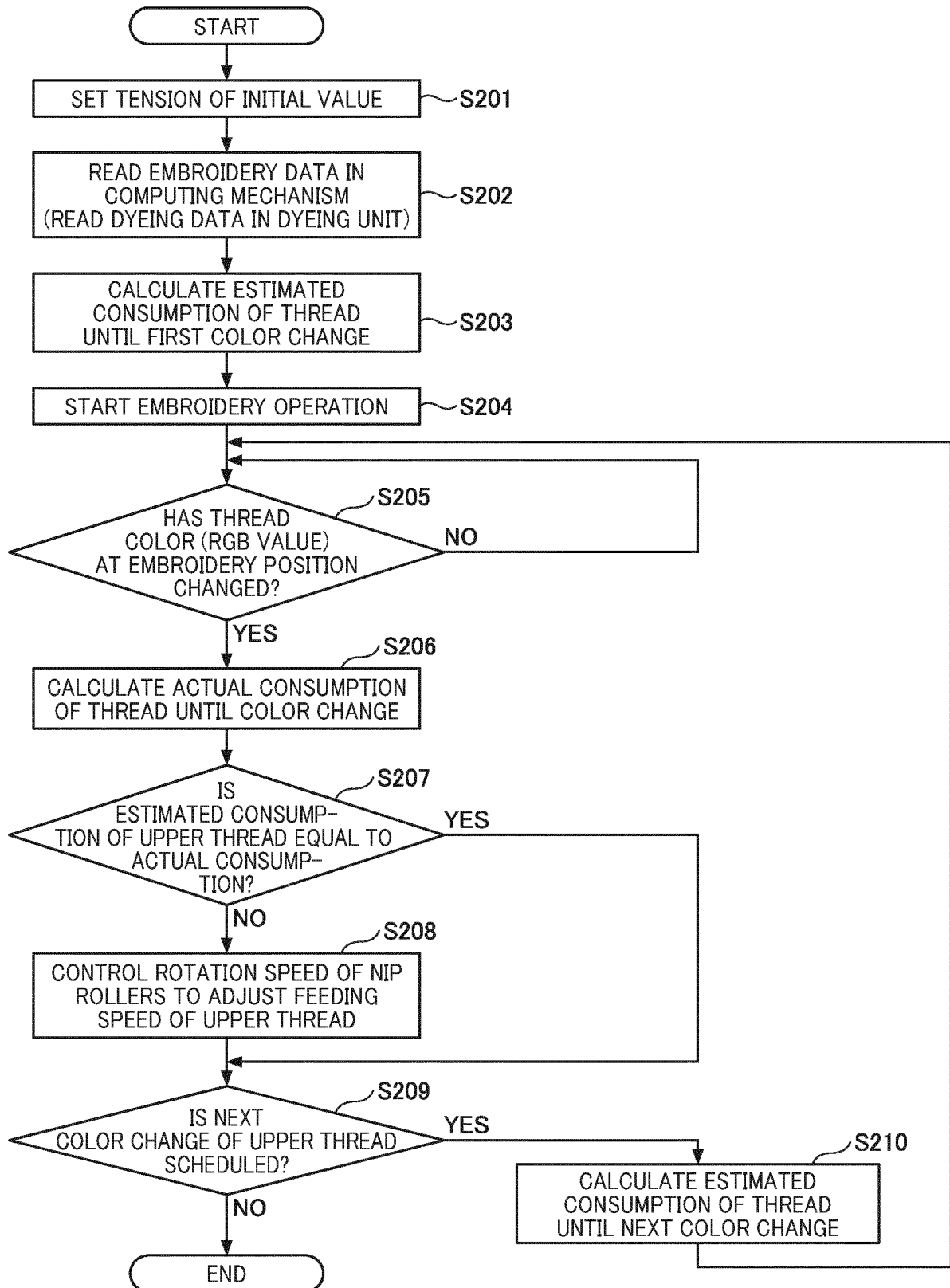


FIG. 12

			FIRST THREAD TYPE	SECOND THREAD TYPE
ESTIMATED THREAD CONSUMPTION UNTIL COLOR CHANGE (mm)	THREAD CONSUMPTION UNTIL COLOR CHANGE (mm)	DEVIATION IN PROGRESS OF THREAD CONSUMPTION (mm)	SET CONVEYANCE SPEED (%)	SET CONVEYANCE SPEED (%)
1000	1050	50mm DELAY	+10%	+20%
	1045	45mm DELAY	+9%	+18%
	1040	40mm DELAY	+8%	+16%
	...	...	...	...
	1005	5mm DELAY	+1%	+2%
	1000	NO DELAY	±0%	±0%
	995	5mm ADVANCE	-1%	-2%
	...	...	...	...
	965	35mm ADVANCE	-7%	-14%
	960	40mm ADVANCE	-8%	-16%
	955	45mm ADVANCE	-9%	-18%

FIG. 13

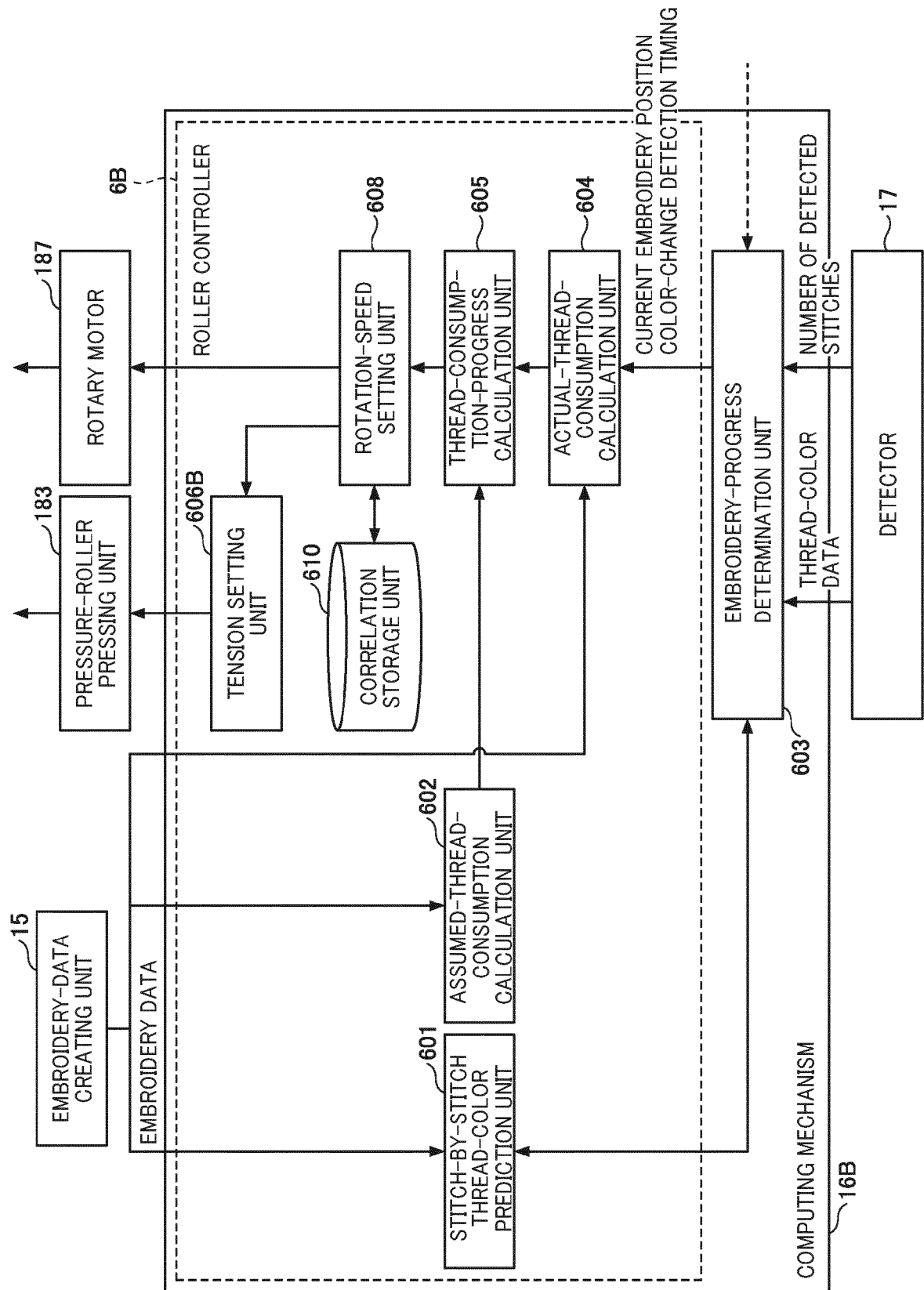


FIG. 14

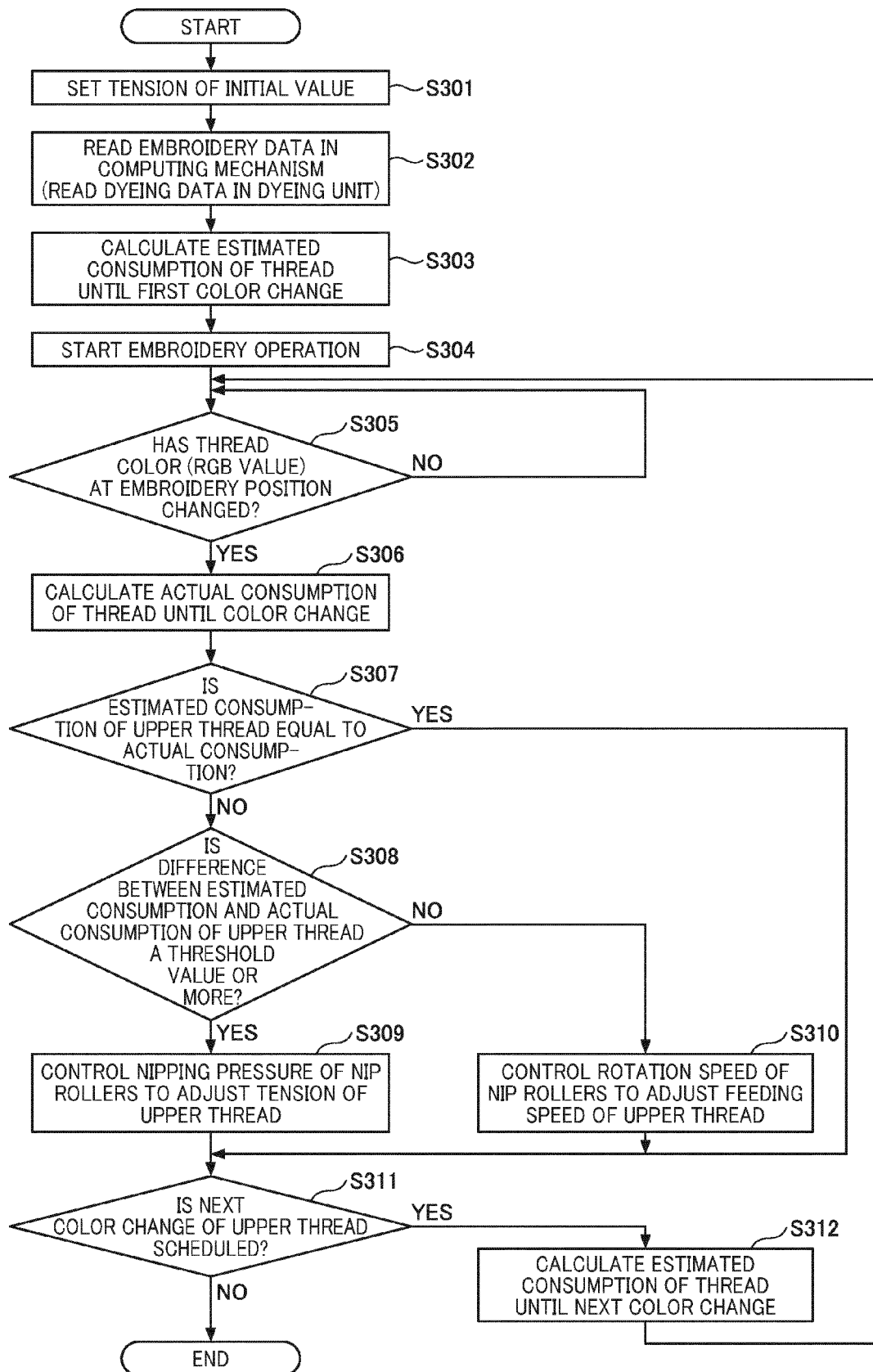


FIG. 15

	FIRST THREAD TYPE	SECOND THREAD TYPE
THREAD CONVEYANCE SPEED	THREAD TENSION	THREAD TENSION
200	90	75
190	91	77
180	92	71
...	...	...
110	99	93
100	100	95
90	101	97
...	...	...
30	107	109
20	108	101
10 OR LOWER	109	103

FIG. 16

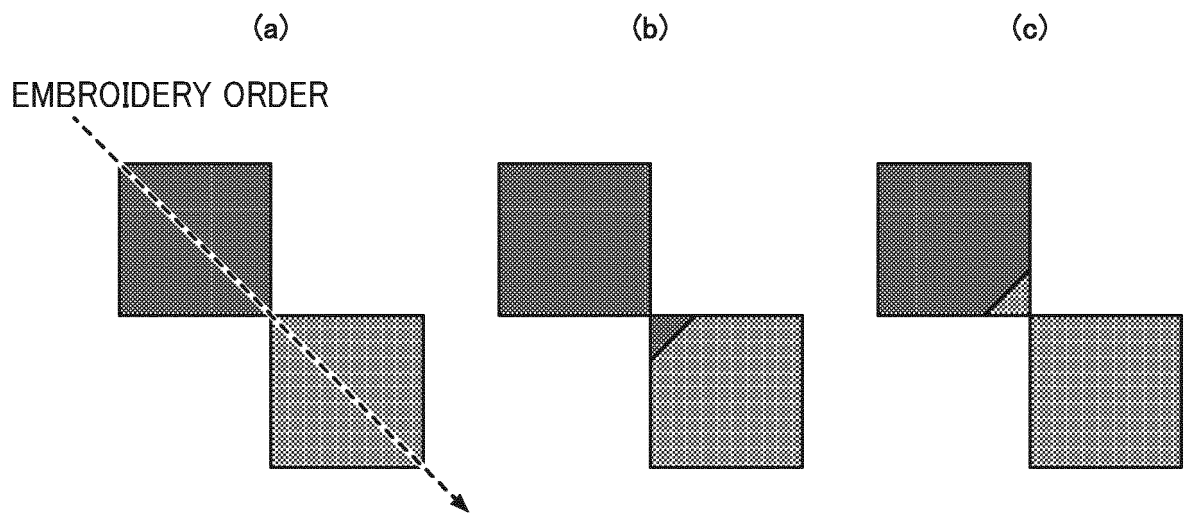


FIG. 17

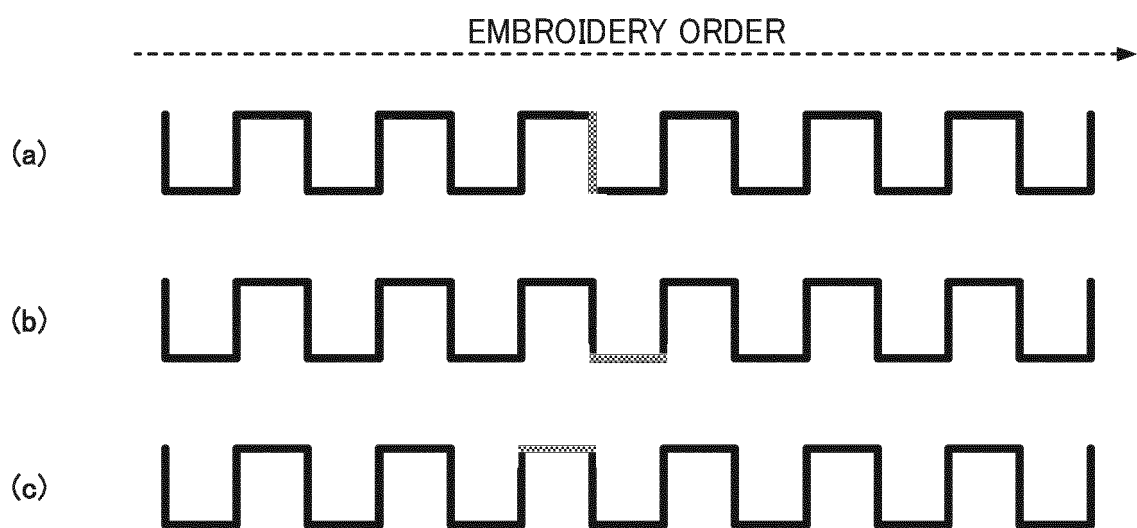


FIG. 18

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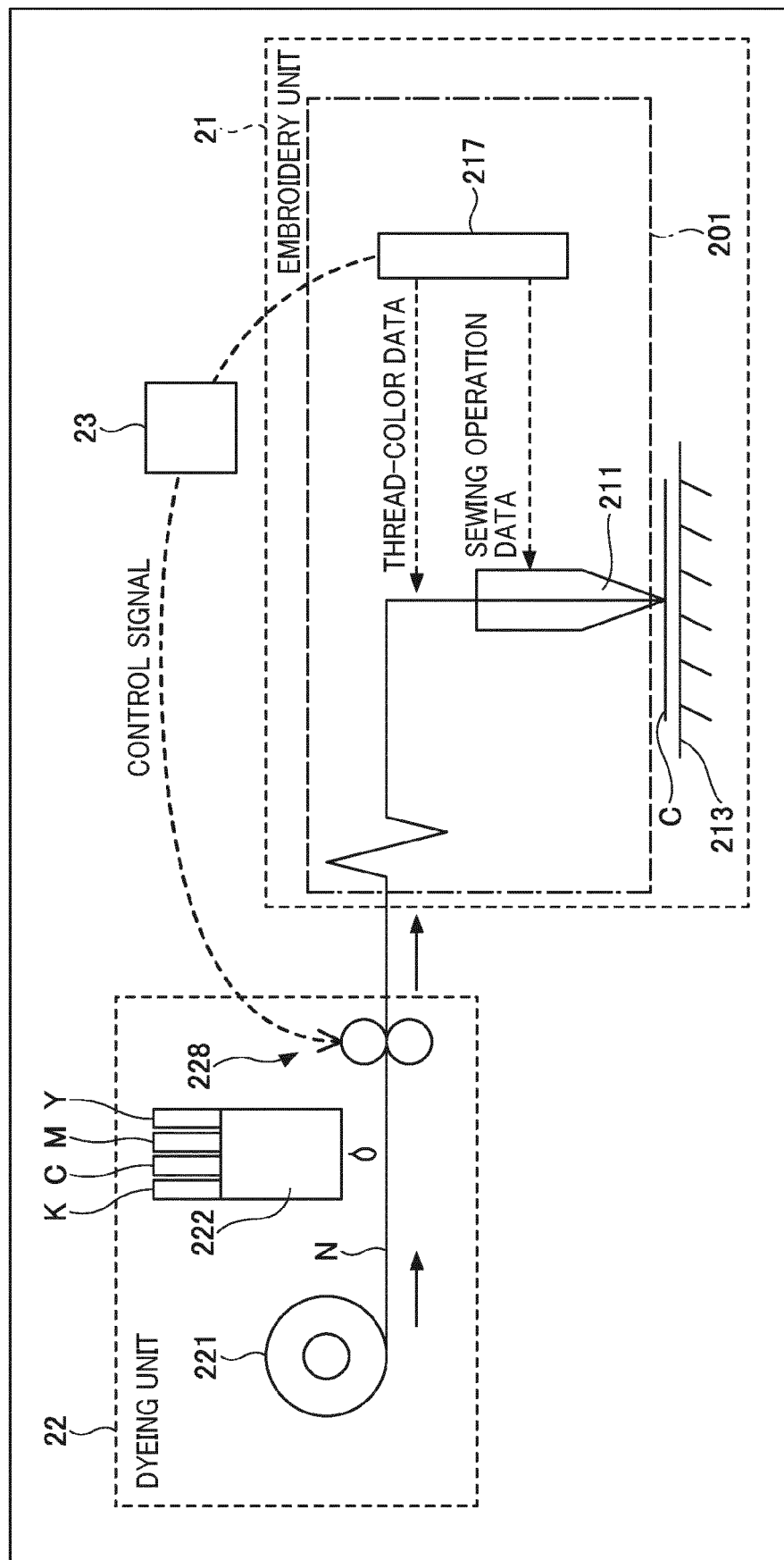


FIG. 19

100

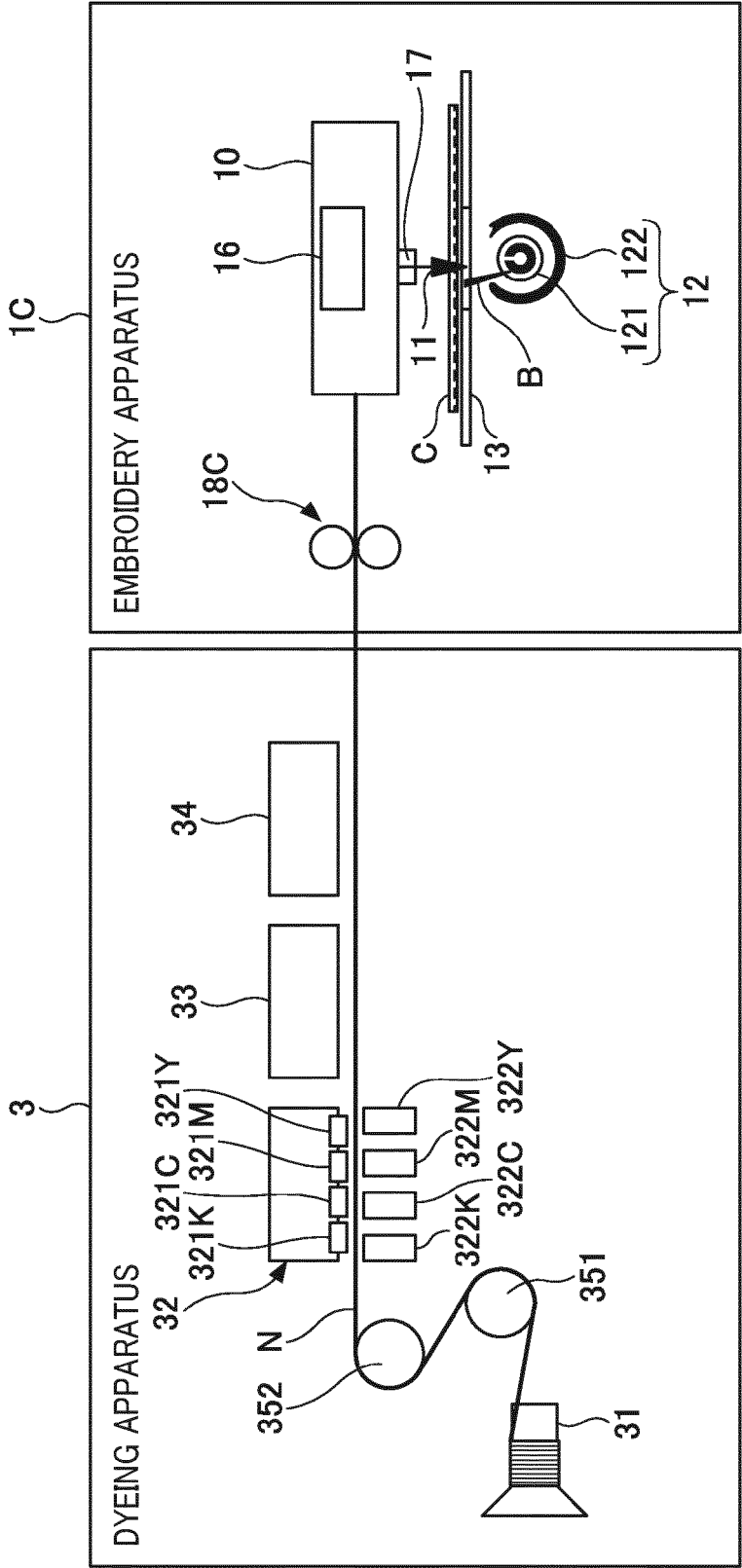


FIG. 20

100D

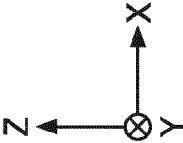
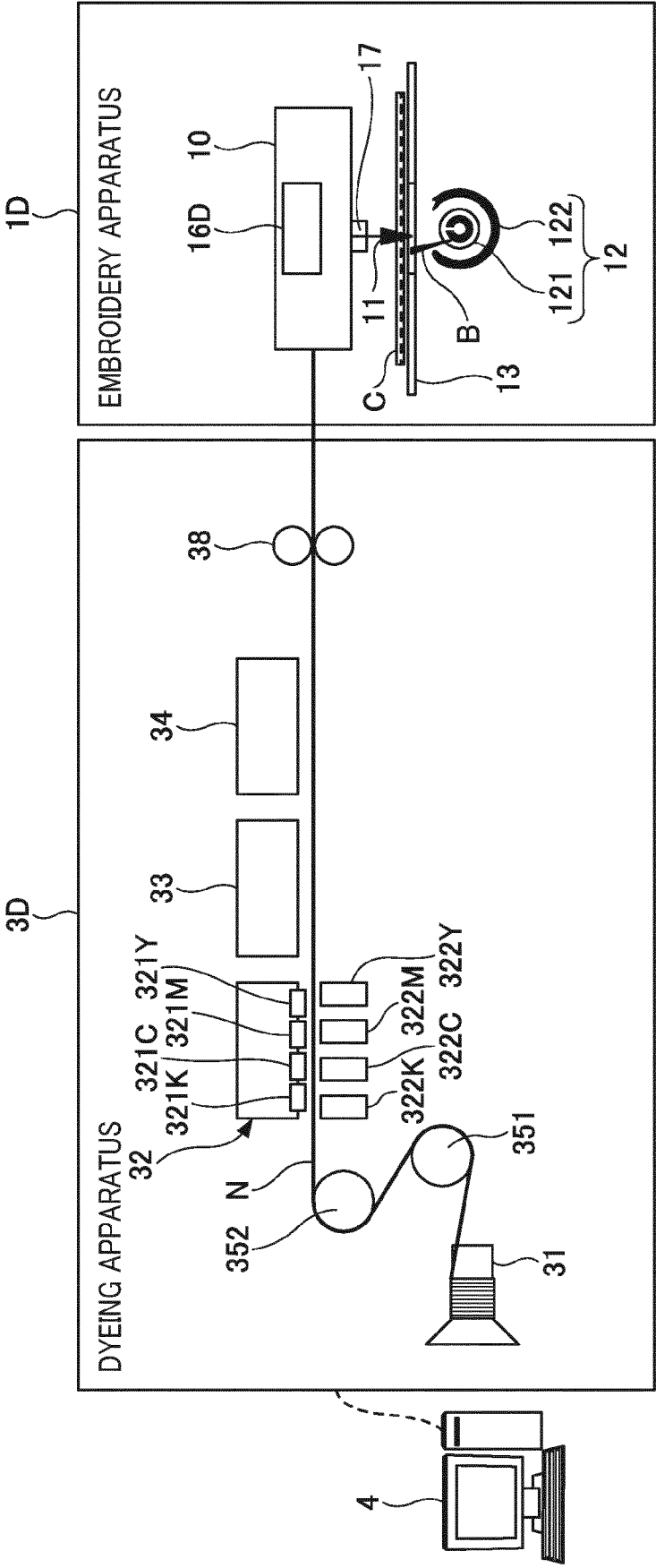
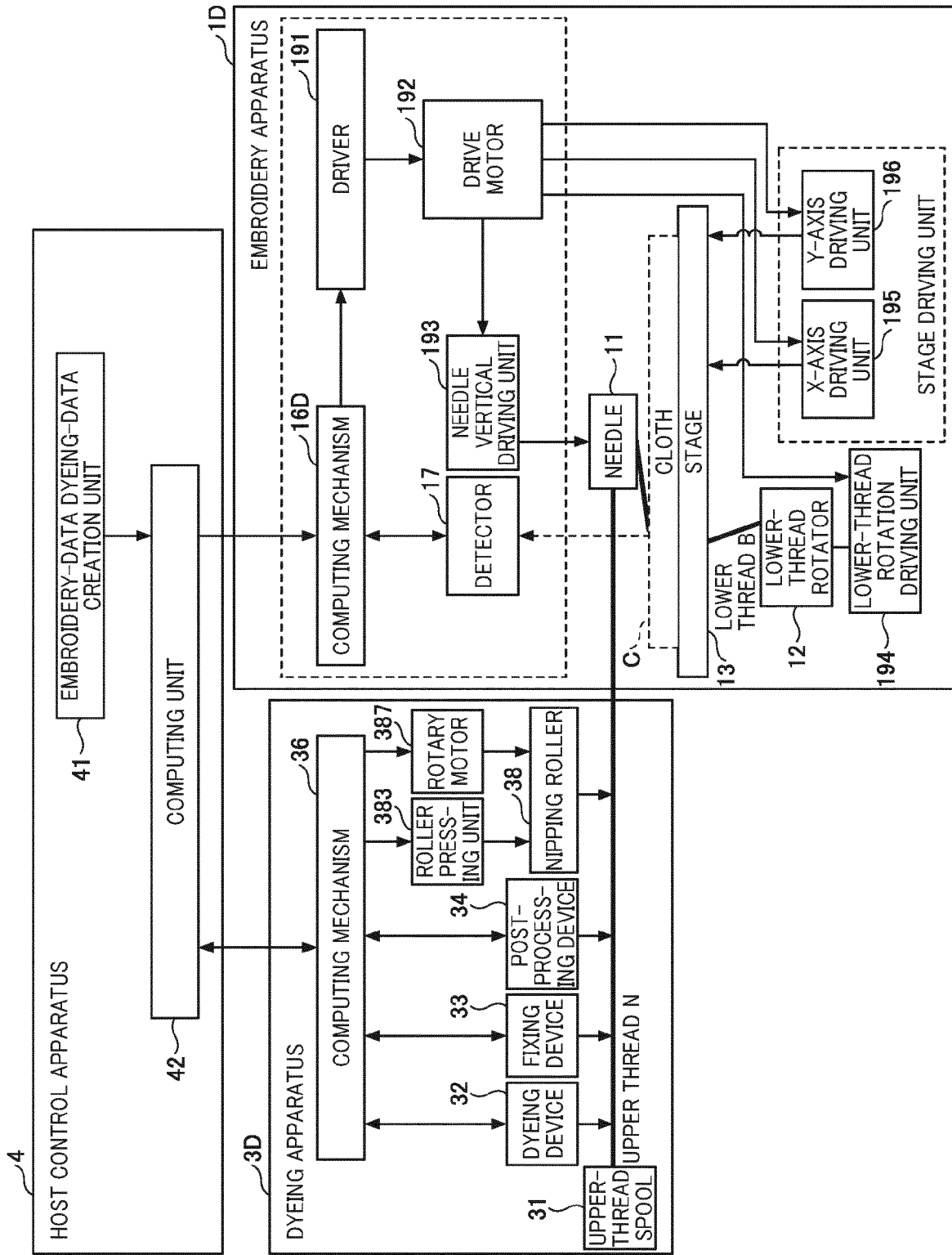


FIG. 21





EUROPEAN SEARCH REPORT

Application Number

EP 21 19 9735

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EPO FORM 1503 03.82 (P04C01)

DOCUMENTS CONSIDERED TO BE RELEVANT			
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
A	JP H06 304359 A (CANON KK) 1 November 1994 (1994-11-01) * paragraph [0008] - paragraph [0026]; figures 1-6 *	1-14	INV. D05B47/04 D05B67/00 D05C11/08 D05C11/24
A	JP 2009 273675 A (DATSUKUSU KK) 26 November 2009 (2009-11-26) * paragraph [0042] - paragraphs [0045], [0059], [0060]; figures 2-4 *	1-14	
A	WO 2017/013651 A1 (TWINE SOLUTIONS LTD [IL]) 26 January 2017 (2017-01-26) * paragraphs [0085], [0086]; figures 1, 2 *	1-14	
			TECHNICAL FIELDS SEARCHED (IPC)
			D05B D05C
The present search report has been drawn up for all claims			
Place of search Munich		Date of completion of the search 10 February 2022	Examiner Braun, Stefanie
CATEGORY OF CITED DOCUMENTS X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document		T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons & : member of the same patent family, corresponding document	

ANNEX TO THE EUROPEAN SEARCH REPORT ON EUROPEAN PATENT APPLICATION NO.

EP 21 19 9735

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This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report. The members are as contained in the European Patent Office EDP file on
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10-02-2022

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