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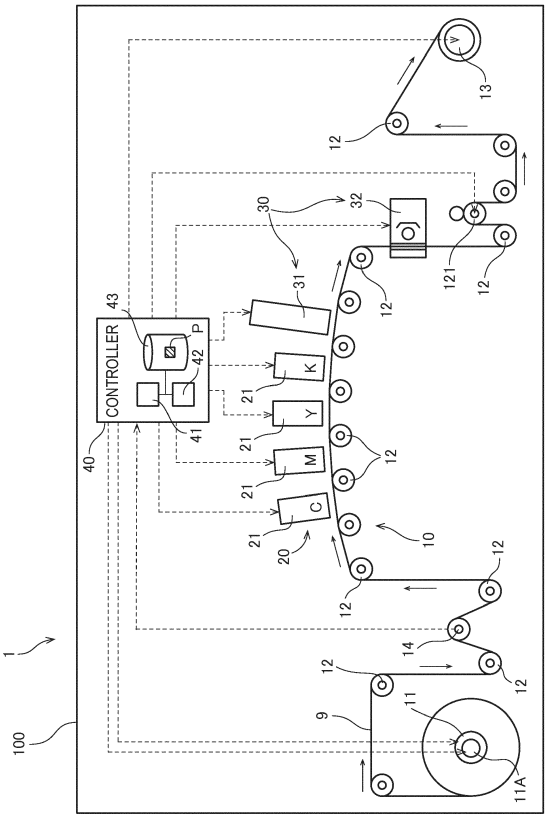
(54) PRINTING APPARATUS AND PRINTING METHOD

(57) A printing apparatus (1) includes a controller (40) for applying tension to a base material (9) to be printed thereon while applying brake torque to an unwinding roller (11) around which the base material (9) is wound, and a tension sensor (14) for detecting the tension applied to the base material (9). The controller (40) acquires information related to the base material (9). The controller (40) exercises first control for rotating the unwinding roller (11) with a constant acceleration, if the acquired information is included in a first condition. The controller (40) exercises control for rotating the unwinding roller (11) with an acceleration slower than the constant acceleration and/or with an S-shaped acceleration, if the acquired information is not included in the first condition.

Fig.1



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Description

BACKGROUND OF THE INVENTION

Field of the Invention

[0001] The present invention relates to a printing apparatus and a printing method which transport an elongated strip-shaped base material to be printed thereon while applying tension to the base material to print on the base material.

Description of the Background Art

[0002] A printing apparatus which records an image on an elongated strip-shaped base material to be printed thereon by ejecting inks from a plurality of heads while transporting the base material has heretofore been known. For good printing results, it is necessary for the printing apparatus of this type to exercise control so that the tension applied to the base material approaches a target value, thereby transporting the base material while applying appropriate tension to the base material.

[0003] A transport apparatus which transports a material to be recorded thereon while applying constant tension to the material is disclosed in Japanese Patent Application Laid-Open No. 2015-61807. This transport apparatus disclosed in Japanese Patent Application Laid-Open No. 2015-61807 changes the tension applied to the material, depending on the type and width of the material. The material to be recorded thereon has different expansion and contraction properties, depending on the type thereof. Thus, changing the tension applied to the material to be recorded thereon, depending on the type of the material, as disclosed in Japanese Patent Application Laid-Open No. 2015-61807 causes constant tension to be applied to the material at all times, thereby improving recording quality.

[0004] After a base material of the type susceptible to expansion and contraction is drawn out at the start of the transport thereof, there are cases in which variations in tension increases or the expansion/contraction phenomenon of the base material occurs when the tension applied to the base material is controlled during the subsequent transport. Large variations in tension give rise to problems such that it takes time to cause the tension of the base material to converge to the target value and such that print quality is lowered. Japanese Patent Application Laid-Open No. 2015-61807 is unable to solve these problems.

SUMMARY OF THE INVENTION

[0005] It is therefore an object of the present invention to provide a printing apparatus and a printing method which suppress variations in tension of a base material to be printed thereon during the transport thereof to improve the printing quality of the base material.

[0006] To solve the aforementioned problem, a first aspect of the present invention is intended for a printing apparatus for transporting an elongated strip-shaped base material to be printed thereon while applying tension to the base material to print on the base material. The printing apparatus comprises: a roller around which a base material to be printed thereon is wound; a transport part for unwinding the base material from the roller to transport the base material; a tension controller for applying brake torque to the roller to apply tension to the base material unwound from the roller; a printing part for printing on the base material under tension; and a tension sensor for detecting the tension applied to the base material, the transport part including an acquisition part for acquiring information related to the base material, and an acceleration controller for accelerating the base material until the transport speed of the base material reaches a predetermined speed when the transport of the base material is at rest, wherein the acceleration controller exercises first control for accelerating the base material with a constant acceleration, if the information acquired by the acquisition part is included in a first condition, and wherein the acceleration controller exercises second control for accelerating the base material with an acceleration slower than the constant acceleration, third control for accelerating the base material with an S-shaped acceleration, or fourth control for accelerating the base material with an acceleration slower than the constant acceleration and for accelerating the base material with an S-shaped acceleration, if the information acquired by the acquisition part is not included in the first condition.

[0007] A second aspect of the present invention is intended for the printing apparatus of the first aspect, wherein the information related to the base material includes the thickness of the base material; and the thickness of the base material is not less than a threshold value under the first condition.

[0008] A third aspect of the present invention is intended for the printing apparatus of the second aspect, wherein the information related to the base material includes the width of the base material; and the width of the base material is not less than a threshold value under the first condition.

[0009] A fourth aspect of the present invention is intended for the printing apparatus of the third aspect further comprising: a storage part for storing the type of the base material and the thickness and width of the base material in association with each other; and an input part for inputting the type of the base material, wherein the acquisition part acquires the thickness and width of the base material corresponding to the type inputted via the input part from the storage part.

[0010] A fifth aspect of the present invention is intended for the printing apparatus of the third or fourth aspect, wherein the information related to the base material includes the winding diameter of the base material wound around the roller; and the winding diameter of the base material is not less than a threshold value under the first

condition.

[0011] A sixth aspect of the present invention is intended for the printing apparatus of any one of the first to fifth aspects, wherein after the first control, the second control, the third control, or the fourth control is exercised, the tension controller increases the brake torque of the roller if the tension detected by the tension sensor is less than a target value determined depending on the type of the base material, and decreases the brake torque of the roller if the tension detected by the tension sensor is greater than the target value.

[0012] A seventh aspect of the present invention is intended for the printing apparatus of the sixth aspect further comprising a judging part for judging whether a varied value of the tension detected by the tension sensor is less than a threshold value or not if the information acquired by the acquisition part is not included in the first condition, wherein the tension controller fixes the brake torque of the roller if the judging part judges that the varied value is not less than the threshold value.

[0013] An eighth aspect of the present invention is intended for the printing apparatus of the sixth aspect further comprising a judging part for judging whether a varied value of the tension detected by the tension sensor is less than a threshold value or not if the information acquired by the acquisition part is not included in the first condition, wherein the tension controller acquires the winding diameter of the base material wound around the roller to define a torque calculated from the acquired winding diameter and the target value as the brake torque of the roller if the judging part judges that the varied value is not less than the threshold value.

[0014] A ninth aspect of the present invention is intended for a method of transporting an elongated strip-shaped base material to be printed thereon while applying tension to the base material to print on the base material through the use of a printing apparatus, the printing apparatus including a roller around which a base material to be printed thereon is wound, a transport part for unwinding the base material from the roller to transport the base material, a tension controller for applying brake torque to the roller to apply tension to the base material unwound from the roller, a printing part for printing on the base material under tension, and a tension sensor for detecting the tension applied to the base material. The method comprises the steps of: a) acquiring information related to the base material; and b) accelerating the base material until the transport speed of the base material reaches a predetermined speed, the steps a) and b) being performed when the transport of the base material is at rest, wherein first control for accelerating the base material with a constant acceleration is exercised in the step b), if the information acquired by the acquisition part is included in a first condition, and wherein second control for accelerating the base material with an acceleration slower than the constant acceleration, third control for accelerating the base material with an S-shaped acceleration, or fourth control for accelerating the base material with an acceleration slower than the constant acceleration and for accelerating the base material with an S-shaped acceleration is exercised in the step b), if the information acquired by the acquisition part is not included in the first condition.

[0015] The first to ninth aspects of the present invention are capable of suppressing variations in tension of the base material being transported. This provides good print quality.

BRIEF DESCRIPTION OF THE DRAWINGS

[0016]

Fig. 1 is a diagram showing a configuration of a printing apparatus according to one preferred embodiment of the present invention;
Fig. 2 is a block diagram showing an electrical configuration of the printing apparatus;
Fig. 3 shows data about information related to a base material to be printed thereon;
Fig. 4 is a flow diagram showing an operation for a transport process in the printing apparatus;
Fig. 5 is a graph showing the transport speed of the base material under normal control and under acceleration-varied control; and
Fig. 6 is a flow diagram showing an operation for a tension adjustment process.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

< 1. Configuration of Printing Apparatus>

[0017] Fig. 1 is a diagram showing a configuration of a printing apparatus 1 according to one preferred embodiment of the present invention. Fig. 2 is a block diagram showing an electrical configuration of the printing apparatus 1. The printing apparatus 1 is an apparatus which prints a multi-color image on an elongated strip-shaped base material 9 to be printed thereon by ejecting inks from a plurality of head units 21 toward the base material 9 while transporting the base material 9. Examples of the base material 9 include paper and film.

[0018] The printing apparatus 1 includes a transport mechanism 10, an image recorder 20, a light irradiator 30, a controller 40, and an input part 50. Of these components, at least the transport mechanism 10, the image recorder 20, and the light irradiator 30 are housed in an apparatus housing 100. The input part 50 accepts manipulations from a user. The user inputs various necessary pieces of information including information related to the base material 9 and the like via the input part 50.

[0019] The transport mechanism 10 is a mechanism for transporting the base material 9 in a transport direction along the length of the base material 9. The transport mechanism 10 includes an unwinding roller 11, a plurality of transport rollers 12, a winding roller 13, and a tension sensor 14.

[0020] The base material 9 is wound around the unwinding roller 11. Nip rollers 121 to be described later draw out the base material 9 wound around the unwinding roller 11, whereby the unwinding roller 11 rotates. The unwinding roller 11 has a rotary shaft provided with a powder brake 11A. The powder brake 11A is controlled by the controller 40 to be described later to produce brake torque of the unwinding roller 11. The powder brake 11A applies the brake torque to the unwinding roller 11, whereby the rotation of the unwinding roller 11 is suppressed.

[0021] The transport rollers 12 include the nip rollers 121 to be described later. The base material 9 is drawn out from the unwinding roller 11, and is transported along a transport path formed by the transport rollers 12. Each of the transport rollers 12 rotates about a horizontal axis to guide the base material 9 downstream along the transport path. The transported base material 9 is wound and collected on the winding roller 13.

[0022] The base material 9 is moved substantially horizontally under the image recorder 20 in a direction in which the head units 21 are arranged. During this movement, a recording surface of the base material 9 faces upwardly (toward the head units 21).

[0023] The nip rollers 121 are disposed downstream from the light irradiator 30 to be described later along the transport path. The nip rollers 121 serve as a draw-out part for drawing out the base material 9 from the unwinding roller 11. As shown in Fig. 2, the nip rollers 121 are connected to a motor 121A serving as a power source. The motor 121A is driven by a driving circuit 121B receiving a signal from the controller 40. The nip rollers 121 are rotated by driving the motor 121A.

[0024] The nip rollers 121 rotate to transport the base material 9 while contacting the opposite surfaces of the base material 9 to hold the base material 9 therebetween. This causes the base material 9 to be drawn out from the unwinding roller 11, so that the unwinding roller 11 rotates. At this time, the powder brake 11A is caused to produce the brake torque, so that the rotation of the unwinding roller 11 is suppressed. This causes the rotation speed of the unwinding roller 11 to differ slightly from the rotation speed of the nip rollers 121 during the transport of the base material 9. As a result, tension is applied to the base material 9 to prevent slack or wrinkles in the base material 9 during the transport.

[0025] The tension sensor 14 measures the tension applied to the base material 9 being transported. The tension sensor 14 includes a roller disposed between and above two horizontally arranged transport rollers 12. A downward load is imposed on the roller of the tension sensor 14 by the base material 9 running around the two transport rollers 12. The tension sensor 14 includes a piezoelectric element or a load cell not shown which measures the load imposed on the roller. The tension sensor 14 outputs an analog voltage proportional to the measured value. This analog voltage is amplified by an amplifier not shown, and the amplified analog voltage is inputted to the controller 40.

[0026] The image recorder 20 is a mechanism for ejecting ultraviolet ray curable inks toward the base material 9 being transported by the transport mechanism 10. The image recorder 20 includes the four head units 21 arranged in the transport direction of the base material 9. The four head units 21 eject ink droplets of respective colors, i.e. C (Cyan), M (Magenta), Y (Yellow), and K (Black), which are color components of a multi-color image toward the recording surface of the base material 9. The head units 21 are disposed fixedly with respect to the apparatus housing 100.

[0027] The light irradiator 30 includes a first light irradiator 31 positioned downstream from the image recorder 20 as seen in the transport direction, and a second light irradiator 32 downstream from the first light irradiator 31 as seen in the transport direction. The first light irradiator 31 directs light including ultraviolet rays, for example, from a plurality of LED light sources toward the recording surface of the base material 9. This places the inks on the base material 9 in a semi-cured state. The second light irradiator 32 directs light including ultraviolet rays, for example, from a metal halide lamp toward the recording surface of the base material 9. The amount of light from the second light irradiator 32 at the time of light emission is greater than the amount of light from the first light irradiator 31 at the time of light emission. Thus, when irradiated with light from the second light irradiator 32, the inks on the base material 9 are completely cured and fixed on the recording surface of the base material 9.

[0028] The controller 40 is a means for controlling the operations of the components in the printing apparatus 1. The controller 40 is formed by a computer including an arithmetic processor 41 such as a CPU, a memory 42 such as a RAM, and a storage part 43 such as a hard disk drive. As indicated by broken lines in Fig. 1, the controller 40 is electrically connected to the unwinding roller 11, the powder brake 11A, the winding roller 13, the tension sensor 14, the four head units 21, the first light irradiator 31, the second light irradiator 32, and the nip rollers 121 described above. The controller 40 temporarily reads a computer program P stored in the storage part 43 onto the memory 42. The arithmetic processor 41 performs arithmetic processing based on the computer program P, so that the controller 40 controls the operations of the aforementioned components. Thus, the printing process in the printing apparatus 1 proceeds. The controller 40 is an example of a tension controller according to the present invention. The arithmetic processor 41 performs arithmetic processing, whereby the controller 40 functions as an "acquisition part" and an "acceleration controller" according to the present invention.

[0029] Data required for operation control, e.g. information related to the base material 9, is stored in the storage part 43. Fig. 3 shows data about information related to the base material 9. The type of the base material 9, the width and thickness of the base material 9, and a target tension value (referred to hereinafter as a target

value) are associated with each other in the data shown in Fig. 3. The target value is an ideal tension value to be provided to the base material 9 during the printing. The base material 9 has different expansion and contraction properties, depending on the type thereof. For this reason, the base material 9 is transported while tension having a corresponding target value is applied to the base material 9 during the transport of the base material 9. This improves printing quality independently of the type of the base material 9. This data may be previously stored in the storage part 43 before shipment from the factory or be inputted by a user via the input part 50, as appropriate.

<2. Transport Process>

[0030] Upon starting the printing process, the printing apparatus 1 starts the transport of the base material 9 wound around the unwinding roller 11. At this time, the base material 9 is transported under tension. Then, inks are ejected from the head units 21 of the image recorder 20 toward the base material 9 being transported, based on a designated piece of image data. The process of transporting the base material 9 will be described below.

[0031] Fig. 4 is a flow diagram showing an operation for the transport process in the printing apparatus 1. The unwinding roller 11, the nip rollers 121, and the like are at rest at the start of the transport process shown in Fig. 4.

[0032] The controller 40 judges whether the type of the base material 9 has been inputted via the input part 50 or not (Step S1). For the input of the type of the base material 9, a number assigned to each type or the name of each type may be inputted. If the type of the base material 9 has not yet been inputted (NO in Step S1), the controller 40 is on standby pending the input of the type of the base material 9.

[0033] If the type of the base material 9 has been inputted (YES in Step S1), the controller 40 acquires base material information about the base material 9 corresponding to the inputted type (Step S2). The base material information includes the thickness and width of the base material 9 and the winding diameter of the base material 9 wound around the unwinding roller 11.

[0034] The controller 40 acquires the thickness and width of the base material 9 corresponding to the inputted type from the data stored in the storage part 43 and shown in Fig. 3. The controller 40 also computationally calculates the winding diameter of the base material 9. The controller 40 acquires the angular speed of the unwinding roller 11 and the transport speed of the base material 9 to calculates the winding diameter of the base material 9 with the use of these parameters. The controller 40 stores the calculated values of the winding diameter one by one in the storage part 43. Storing the winding diameter allows the winding diameter to be acquired even when the transport is resumed after once suspended. A sensor may be used to measure the winding diameter of the base material 9.

[0035] The controller 40 judges whether the acquired base material information about the base material 9 is included in a first condition or not (Step S3). An example of the first condition is that "the thickness, width, and winding diameter of the base material 9 are not less than threshold values". The threshold values are previously set values of the thickness, width, and winding diameter. The threshold values are also reference values based on which the base material 9 is judged to be susceptible to expansion and contraction, and are values obtained by experiment.

[0036] If the base material information about the base material 9 is included in the first condition (YES in Step S3), the controller 40 judges that the expansion/contraction phenomenon of the base material 9 is less prone to occur, thereby starting the transport of the base material 9 under normal control (Step S4). On the other hand, if the base material information about the base material 9 is not included in the first condition (NO in Step S3), the controller 40 judges that the expansion/contraction phenomenon of the base material 9 is prone to occur, thereby starting the transport of the base material 9 under acceleration-varied control (Step S5).

[0037] The normal control and the acceleration-varied control will be described. Fig. 5 is a graph showing the transport speed of the base material 9 under the normal control and under the acceleration-varied control.

[0038] The normal control is control (first control) for transporting the base material 9 with a constant acceleration. The controller 40 controls the driving of the nip rollers 121 to start the transport of the base material 9. At this time, the controller 40 accelerates the rotation of the nip rollers 121 until the transport speed of the base material 9 reaches a predetermined speed. In this case, a plotted line for the transport speed of the base material 9 is bent at an acceleration start time t1 and at an acceleration end time t2, as indicated by the solid line in the graph of Fig. 5. That is, the transport speed of the base material 9 changes abruptly at the acceleration start time t1 and at the acceleration end time t2. If the normal control is exercised over the base material 9 in which the expansion/contraction phenomenon is prone to occur, variations in tension of the base material 9 is increased.

[0039] The acceleration-varied control is control (fourth control) for transporting the base material 9 with an acceleration slower than the constant acceleration used under the normal control and for transporting the base material 9 with an S-shaped acceleration. Under the acceleration-varied control, the nip rollers 121 are rotated with an S-shaped acceleration. That is, the acceleration of the nip rollers 121 is gradually increased and thereafter gradually decreased. Thus, a plotted line for the transport speed of the base material 9 is curved at the acceleration start time t1 and at an acceleration end time t3, as indicated by the broken line in the graph of Fig. 5. In this case, the transport speed of the base material 9 changes gradually at the acceleration start time t1 and at the acceleration end time t3.

[0040] The controller 40 starts to transport the base material 9 with an acceleration slower than the acceleration of the base material 9 used under the normal control. Because of the slower acceleration, the time required until the transport speed of the base material 9 reaches the predetermined speed, i.e. the time interval between the acceleration start time t1 and the acceleration end time t3, under the acceleration-varied control is longer than that under the normal control. The time interval between the times t1 and t3 under the acceleration-varied control is twice the time interval between the times t1 and t2 under the normal control in the present preferred embodiment. In this case, tension is applied gradually to the base material 9 drawn out from the unwinding roller 11, so that variations in tension of the base material 9 are small at the start of the transport. Thus, the acceleration-varied control exercised over the base material 9 in which the expansion/contraction phenomenon is prone to occur reduces variations in tension of the base material 9.

[0041] The base material 9 has different expansion and contraction properties, depending on the type thereof, e. g. the thickness or width thereof. In a tension adjustment process to be described later, the tension applied to the base material 9 being transported is adjusted to the target value. At this time, there is apprehension that the variations in tension of the base material 9 increase if the acceleration of the base material 9 changes abruptly at the start of the transport. This results in lowered print quality. To prevent this, the expansion/contraction phenomenon of the base material 9 after the start of the transport is suppressed by gradually changing the acceleration of the base material 9 at the start of the transport as in Step S5 when the base material 9 is susceptible to expansion and contraction.

[0042] Referring again to the process in Fig. 4, the controller 40 controls the tension of the base material 9 (Step S6). Under this control, the controller 40 drives the powder brake 11A to vary the brake torque so that the value measured by the tension sensor 14 agrees with the target value. It is not necessary that the value measured by the tension sensor 14 is in perfect agreement with the target value. For example, the value measured by the tension sensor 14 may be within $\pm 5\%$ of the target value.

[0043] The controller 40 judges whether the transport speed has reached the predetermined speed after the start of the transport of the base material 9 in Step S4 or S5 or not (Step S7). If the transport speed of the base material 9 has not reached the predetermined speed (No in Step S7), the controller 40 exercises the tension control while accelerating the transport speed of the base material 9 until the predetermined speed is reached.

[0044] If the transport speed of the base material 9 has reached the predetermined speed (YES in Step S7), the controller 40 performs the tension adjustment process to be described later while printing by means of the image recorder 20 (Step S8). Then, the controller 40 judges whether to complete the transport of the base material 9 or not (Step S9). To complete the transport (YES in Step S9), the controller 40 completes this process. Not to complete the transport (NO in Step S9), the controller 40 performs the tension adjustment process in Step S8.

[0045] Fig. 6 is a flow diagram showing an operation for the tension adjustment process. The controller 40 adjusts the tension applied to the base material 9 being transported (Step S11). Specifically, the controller 40 makes a comparison between the value measured by the tension sensor 14 and the target value. If the value measured by the tension sensor 14 is greater than the target value, the controller 40 decreases the brake torque of the powder brake 11A. If the value measured by the tension sensor 14 is less than the target value, the controller 40 increases the brake torque of the powder brake 11A. This causes the value measured by the tension sensor 14 to approach the target value.

[0046] Next, the controller 40 judges whether the base material information about the base material 9 acquired in Step S2 is included in the first condition or not (Step S12) in the same manner as in Step S3. If the base material information about the base material 9 is not included in the first condition (NO in Step S12), i.e. if the base material 9 is susceptible to expansion and contraction, the controller 40 judges whether the variations in tension of the base material 9 being transported are less than a threshold value or not (Step S13). Specifically, if the value measured by the tension sensor 14 falls outside the $\pm 5\%$ range of the target value, the controller 40 judges that the variations in tension of the base material 9 being transported are not less than the threshold value.

[0047] If the variations in tension of the base material 9 are not less than the threshold value (NO in Step S13), the controller 40 fixes the brake torque of the powder brake 11A (Step S14). This decreases the variations in tension of the base material 9 being transported.

[0048] On the other hand, if the base material information about the base material 9 is included in the first condition (YES in Step S12) or if the variations in tension of the base material 9 being transported are less than the threshold value (YES in Step S13), the controller 40 performs the process in Step S9 of Fig. 4.

[0049] In the case of stopping the transport of the base material 9, the base material 9 is subjected to an S-shaped deceleration in the same manner as the S-shaped acceleration executed at the start of the transport, so that the transport thereof is stopped when the base material 9 is susceptible to expansion and contraction.

[0050] As described above, this printing apparatus 1 slows down the acceleration of the base material 9 at the start of the transport to reduce changes in tension applied to the base material 9 when the base material 9 is susceptible to expansion and contraction. This suppresses the expansion/contraction phenomenon of the base material 9 transported after the start of the transport.

<3. Modifications>

[0051] While the main preferred embodiment according to the present invention has been described hereinabove, the present invention is not limited to the aforementioned preferred embodiment.

[0052] In the aforementioned preferred embodiment, the brake torque of the powder brake 11A is fixed in Step S14 of Fig. 6. However, the brake torque may be varied to apply tension having the target value to the base material 9, thereby reducing the variations in tension of the base material 9 being transported. Specifically, the winding diameter of the base material 9 is acquired, and a required torque of the powder brake 11A is calculated by multiplying the acquired winding diameter (radius) by the target value of the base material 9. Then, the obtained torque is defined as the brake torque of the powder brake 11A. This applies the tension having the target value to the base material 9. In this case, it is not necessary to acquire the value measured by the tension sensor 14.

[0053] In the aforementioned preferred embodiment, the acceleration-varied control is exercised when the base material 9 is susceptible to expansion and contraction. However, the acceleration-varied control is not limited to this. For example, the acceleration-varied control may be control (second control) for transporting the base material 9 with an acceleration slower than the constant acceleration used under the normal control. In this case, the base material 9 need not be transported with the S-shaped acceleration. Alternatively, the acceleration-varied control may be control (third control) for transporting the base material 9 with the S-shaped acceleration. In this case, the acceleration may be the same as the constant acceleration used under the normal control. In other words, the time interval between the start of acceleration and the end of acceleration may be the same as the time interval between the times t1 and t2 under the normal control with reference to Fig. 5. Further, any one of the second control, the third control, and the fourth control may be exercised as the acceleration-varied control, depending on the type of the base material 9.

[0054] Although the base material information is stored in the storage part 43 in the aforementioned preferred embodiment, the thickness and width of the base material 9 may be inputted via the input part 50 each time the printing process is performed. In the aforementioned preferred embodiment, the base material 9 is judged to be susceptible to expansion and contraction when all of the thickness, width, and winding diameter of the base material 9 are less than the threshold values. However, the base material 9 may be judged to be susceptible to expansion and contraction independently of the width and winding diameter of the base material 9 when the thickness of the base material 9 is less than the threshold value. Alternatively, the base material 9 may be judged to be susceptible to expansion and contraction independently of the winding diameter of the base material 9 when the thickness and width of the base material 9 are less than the threshold values.

[0055] Also, which control is to be exercised, the normal control or the acceleration-varied control, may be previously determined for each type of the base material 9 independently of the thickness or the like of the base material 9, and either the normal control or the acceleration-varied control may be exercised depending on the inputted type of the base material 9.

[0056] In the tension adjustment process shown in Fig. 6, the variations in tension are observed in Step S13 if the base material information about the base material 9 is not included in the first condition in Step S12. However, the variations in tension may be observed if the winding diameter of the base material 9 is less than the threshold value although the thickness and width of the base material 9 are not less than the threshold value, and the brake torque may be fixed if the variations in tension are large.

[0057] The numerical values in the aforementioned preferred embodiment are merely examples. The present invention is not limited to these values.

[0058] The configuration of the details of the printing apparatus 1 may be different from that shown in the figures of the present invention. The components described in the aforementioned preferred embodiment and in the modifications may be combined together, as appropriate, without inconsistencies.

[0059] While the invention has been described in detail, the foregoing description is in all aspects illustrative and not restrictive. It is understood that numerous other modifications and variations can be devised without departing from the scope of the invention.

Claims

1. A printing apparatus for transporting an elongated strip-shaped base material to be printed thereon while applying tension to said base material to print on said base material, said printing apparatus comprising:

   a roller around which a base material to be printed thereon is wound;
   a transport part for unwinding said base material from said roller to transport said base material;
   a tension controller for applying brake torque to said roller to apply tension to said base material unwound from said roller;
   a printing part for printing on said base material under tension; and
   a tension sensor for detecting the tension applied to said base material,
   said transport part including
   an acquisition part for acquiring information related to said base material, and
   an acceleration controller for accelerating said base material until the transport speed of said

base material reaches a predetermined speed when the transport of said base material is at rest,
wherein said acceleration controller exercises first control for accelerating said base material with a constant acceleration, if the information acquired by said acquisition part is included in a first condition, and
wherein said acceleration controller exercises second control for accelerating said base material with an acceleration slower than said constant acceleration, third control for accelerating said base material with an S-shaped acceleration, or fourth control for accelerating said base material with an acceleration slower than said constant acceleration and for accelerating said base material with an S-shaped acceleration, if the information acquired by said acquisition part is not included in said first condition.

2. The printing apparatus according to claim 1, wherein:

the information related to said base material includes the thickness of said base material; and
the thickness of said base material is not less than a threshold value under said first condition.

3. The printing apparatus according to claim 2, wherein:

the information related to said base material includes the width of said base material; and
the width of said base material is not less than a threshold value under said first condition.

4. The printing apparatus according to claim 3, further comprising:

a storage part for storing the type of said base material and the thickness and width of said base material in association with each other; and
an input part for inputting the type of said base material,
wherein said acquisition part acquires the thickness and width of said base material corresponding to the type inputted via said input part from said storage part.

5. The printing apparatus according to claim 3 or 4, wherein:

the information related to said base material includes the winding diameter of said base material wound around said roller; and
the winding diameter of said base material is not less than a threshold value under said first condition.

6. The printing apparatus according to any one of claims 1 to 5, wherein
after said first control, said second control, said third control, or said fourth control is exercised, said tension controller increases the brake torque of said roller if the tension detected by said tension sensor is less than a target value determined depending on the type of said base material, and decreases the brake torque of said roller if the tension detected by said tension sensor is greater than said target value.

7. The printing apparatus according to claim 6, further comprising
a judging part for judging whether a varied value of the tension detected by said tension sensor is less than a threshold value or not if the information acquired by said acquisition part is not included in said first condition,
wherein said tension controller fixes the brake torque of said roller if said judging part judges that the varied value is not less than the threshold value.

8. The printing apparatus according to claim 6, further comprising
a judging part for judging whether a varied value of the tension detected by said tension sensor is less than a threshold value or not if the information acquired by said acquisition part is not included in said first condition,
wherein said tension controller acquires the winding diameter of said base material wound around said roller to define a torque calculated from the acquired winding diameter and said target value as the brake torque of said roller if said judging part judges that the varied value is not less than the threshold value.

9. A method of transporting an elongated strip-shaped base material to be printed thereon while applying tension to said base material to print on said base material through the use of a printing apparatus, said printing apparatus including a roller around which a base material to be printed thereon is wound, a transport part for unwinding said base material from said roller to transport said base material, a tension controller for applying brake torque to said roller to apply tension to said base material unwound from said roller, a printing part for printing on said base material under tension, and a tension sensor for detecting the tension applied to said base material, said method comprising the steps of:

a) acquiring information related to said base material; and
b) accelerating said base material until the transport speed of said base material reaches a predetermined speed,

said steps a) and b) being performed when the transport of said base material is at rest,

wherein first control for accelerating said base material with a constant acceleration is exercised in said step b), if the information acquired by said acquisition part is included in a first condition, and

wherein second control for accelerating said base material with an acceleration slower than said constant acceleration, third control for accelerating said base material with an S-shaped acceleration, or fourth control for accelerating said base material with an acceleration slower than said constant acceleration and for accelerating said base material with an S-shaped acceleration is exercised in said step b), if the information acquired by said acquisition part is not included in said first condition.

Fig.1

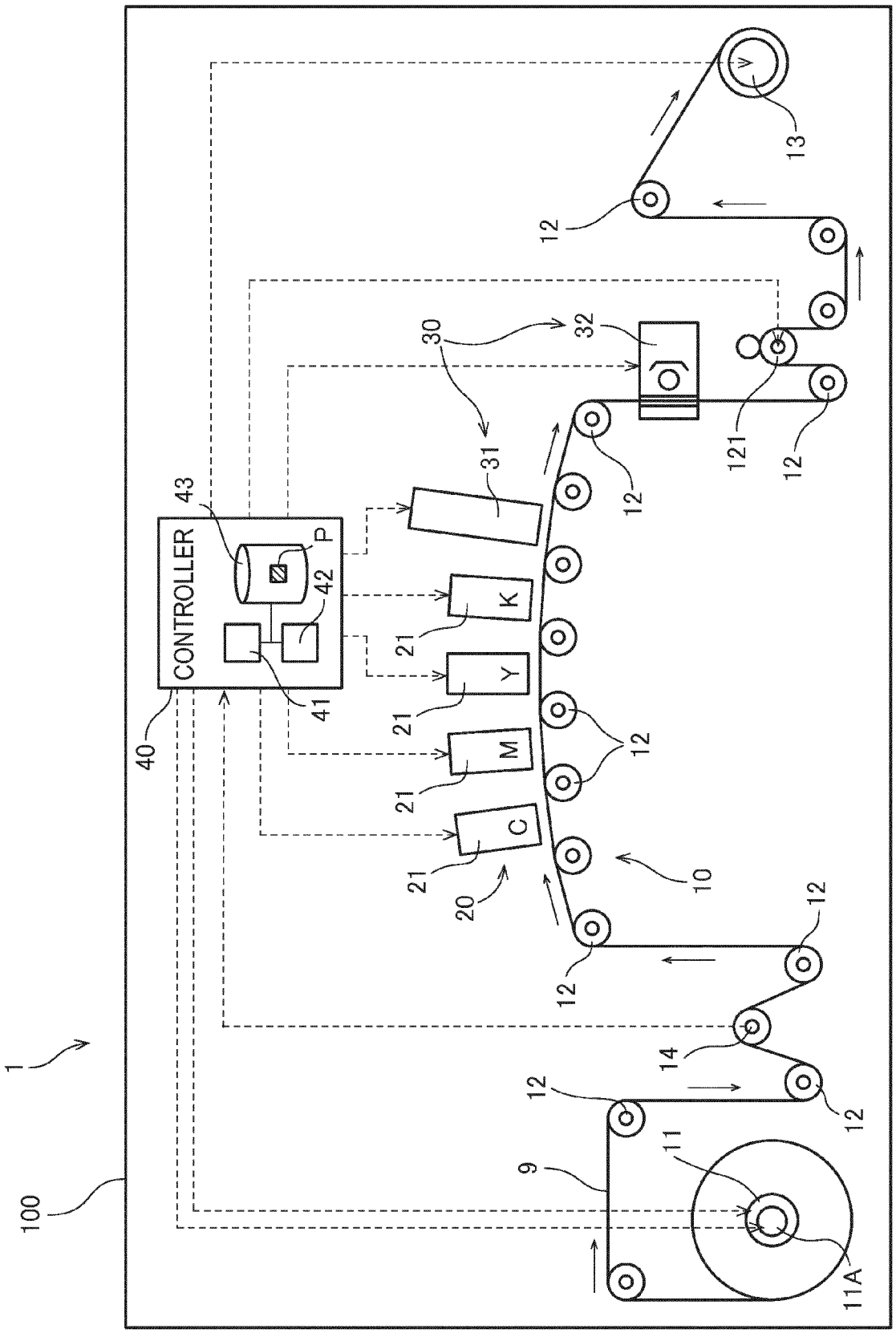

1
100
CONTROLLER
P
40
41
42
43
K
Y
M
C
21
20
10
9
11
11A
12
13
14
30
31
32
121

Fig.2

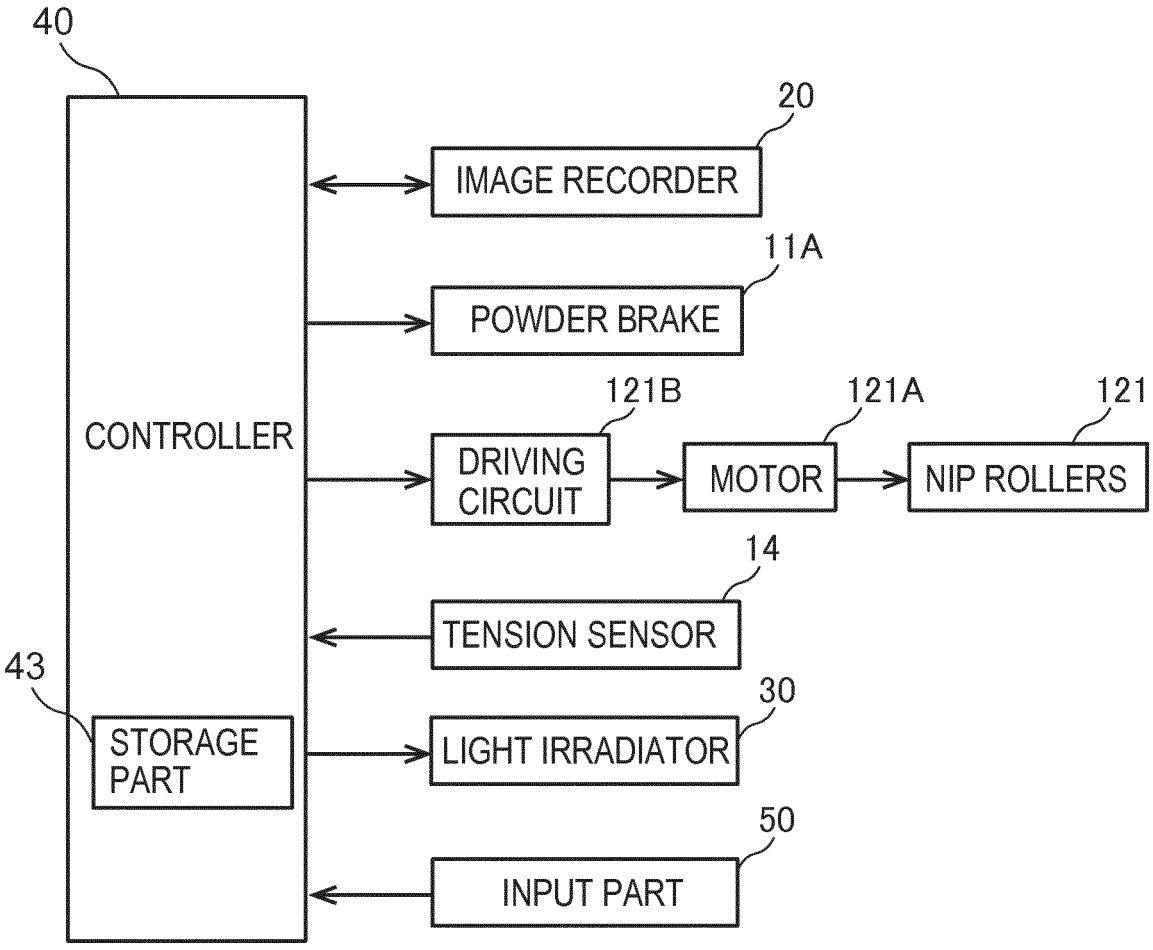

40
CONTROLLER
43
STORAGE PART
20
IMAGE RECORDER
11A
POWDER BRAKE
121B
DRIVING CIRCUIT
121A
MOTOR
121
NIP ROLLERS
14
TENSION SENSOR
30
LIGHT IRRADIATOR
50
INPUT PART

Fig.3

Type	WIDTH(mm)	THICKNESS (mm)	TARGET TENSION VALUE(N)
A	300	0.12	100
B	200	0.10	80
⋮	⋮	⋮	⋮

Fig.4

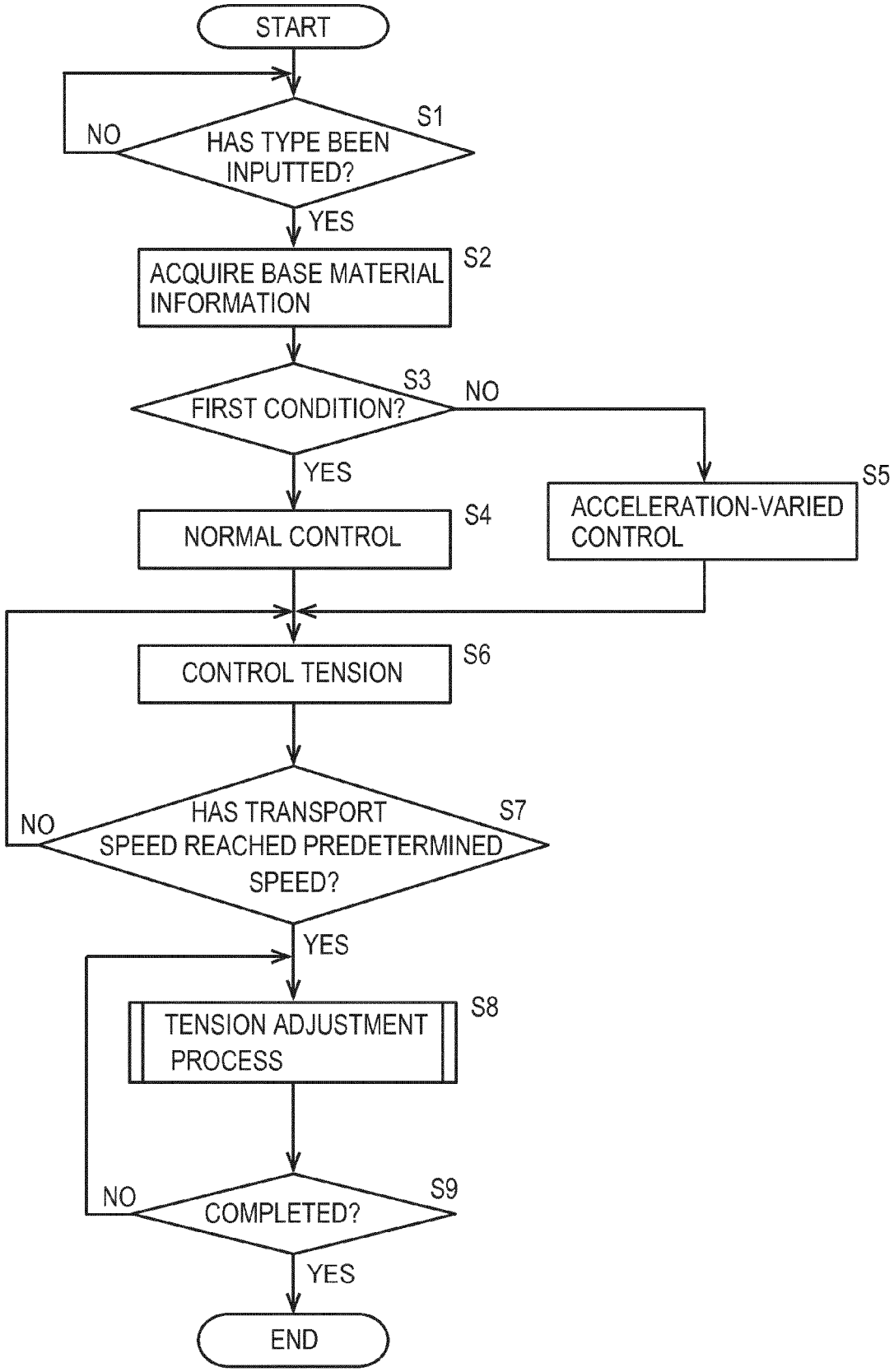

START
S1
NO
HAS TYPE BEEN INPUTTED?
YES
S2
ACQUIRE BASE MATERIAL INFORMATION
S3
FIRST CONDITION?
NO
YES
S4
NORMAL CONTROL
S5
ACCELERATION-VARIED CONTROL
S6
CONTROL TENSION
S7
NO
HAS TRANSPORT SPEED REACHED PREDETERMINED SPEED?
YES
S8
TENSION ADJUSTMENT PROCESS
S9
NO
COMPLETED?
YES
END

Fig.5

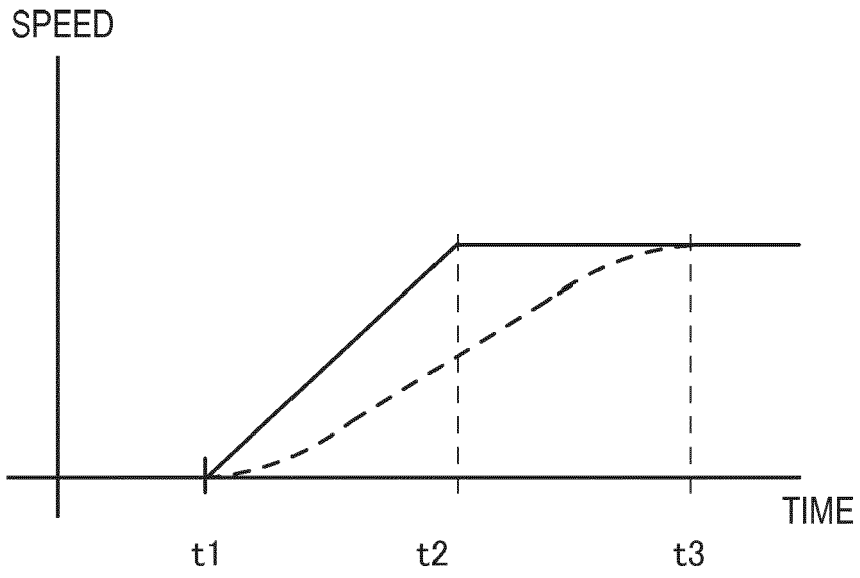
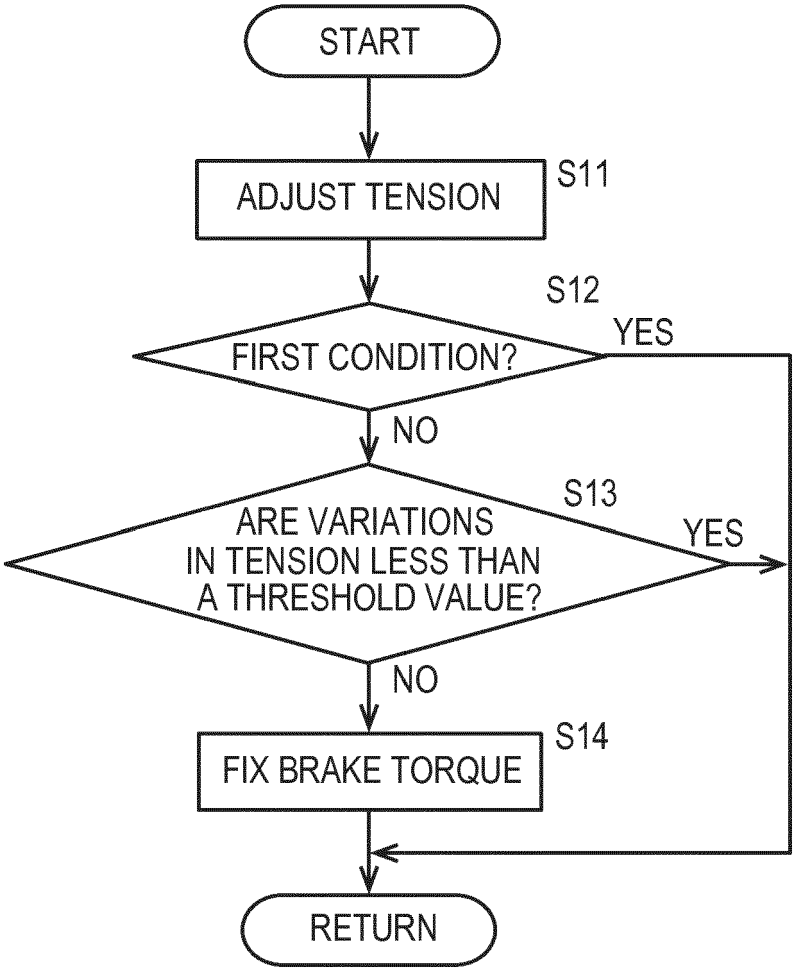


Fig.6


START
ADJUST TENSION
S11
S12
FIRST CONDITION?
YES
NO
S13
ARE VARIATIONS IN TENSION LESS THAN A THRESHOLD VALUE?
YES
NO
FIX BRAKE TORQUE
S14
RETURN

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EUROPEAN SEARCH REPORT

Application Number
EP 18 18 6453

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
X,D	JP 2015 061807 A (SEIKO EPSON CORP) 2 April 2015 (2015-04-02)	1-6,9	INV. B41J11/00 B41J15/16 B41J11/42
A	* paragraphs [0033] - [0054]; figures 4-8 *	7,8	
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A	* paragraphs [0016] - [0022], [0052] - [0058], [0083]; figures 1, 2, 6 *	7,8	
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TECHNICAL FIELDS SEARCHED (IPC)

B41J

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
The Hague	8 February 2019	Gaubinger, Bernhard

CATEGORY OF CITED DOCUMENTS

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08-02-2019

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For more details about this annex : see Official Journal of the European Patent Office, No. 12/82

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